SOTICS 2013

The Third International Conference on Social Eco-Informatics

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SOTICS 2013

Foreword

The Third International Conference on Social Eco-Informatics (SOTICS 2013), held between November 17-22, 2013 in Lisbon, Portugal, continued a series of events bridging different social and informatics concepts by considering digital domains, social metrics, social applications, services, and challenges.

The systems comprising human and information features form a complex mix of social sciences and informatics concepts embraced by the so-called social eco-systems. These are interdisciplinary approaches on social phenomena supported by advanced informatics solutions. It is quit intriguing that the impact on society is little studied despite a few experiments. Recently, also Google was labeled as a company that does not contribute to brain development by instantly showing the response for a query. This is in contrast to the fact that it has been proven that not showing the definitive answer directly facilitates a learning process better. Also, studies show that e-book reading takes more time than reading a printed book. Digital libraries and deep web offer a vast spectrum of information. Large scale digital libraries and access-free digital libraries, as well as social networks and tools constitute challenges in terms of accessibility, trust, privacy, and user satisfaction. The current questions concern the trade-off, where our actions must focus, and how to increase the accessibility to e-Social resources.

We take here the opportunity to warmly thank all the members of the SOTICS 2013 Technical Program Committee, as well as the numerous reviewers. The creation of such a broad and high quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and efforts to contribute to SOTICS 2013. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

Also, this event could not have been a reality without the support of many individuals, organizations, and sponsors. We are grateful to the members of the SOTICS 2013 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that SOTICS 2013 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the field of social eco-informatics.

We are convinced that the participants found the event useful and communications very open. We hope that Lisbon, Portugal, provided a pleasant environment during the conference and everyone saved some time to enjoy the charm of the city.

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***Abstract*—This paper considers four strands of thinking emerging from Cambridge University, Engineering Design Centre; Sydney University, Complex Civil Systems Group and the Advanced Research and Assessment Group. It considers the synthesis of the machine and the organization in mechorganics; it examines the Lodestone concept as a means for instrumenting social awareness; it considers the role variety plays in collaboratively influencing complex systems, over time, and coordinating and controlling them, in time. Finally, it examines the needs for assaying information and data as a means of providing the social transparencies needed for real time verification and validation. From this, it posits the needs for simple empirical standards and setting/vetting organizations that encourage good behavior and discourage bad. These standards' organizations provide for the governance and assurances necessary for packet-markets to form where prices can be assured, products verified, exchanges made and fees / taxes abstracted.**

Keywords-mechorganics; lodestone; instrumenting; packet-markets; governance; metadetics; synthesis; assaying.

I. INTRODUCTION

Cyber may consist of two sub-systems identified and classified as being **"**Coordination Rule and Control (CRC)" and "Collaboration and Social Influence (CSI)" [1, 2]. These system attributes provide the necessary and "requisite variety" [3] to enable both control, "in time", and influence [4-8], "over time". In this regard, Cyber may consist of two poles:

> 'A technologically bounded, largely immeasurable, strongly scientific, stochastic *coordination*, *rule* and *control* space; comprising virtual-media and the display of data dealing with the *real* communication of *facts*; and the *conceptualization* of alternative possibilities, themselves capable of generating hard physical and soft more *social* effects and *collaboratively influencing* them'[9].

"Mechorganics" is postulated to have 1) a thematic *systems* identity (defined by its *networked* disciplines) and 2) a *critical* and *functional* education base [10, 11]. It is not seen either as 'a reversion of digital data back to an analogue form' [12] or some form of 'Golem' warned of by Wiener [13]. Mechorganics is based on "designing humanity back into the loop" [14, 15] and: 'the *synergistic* combination of *civil* mechanical *systems* engineering, social network dynamics, ICT and the management of *interconnected* knowledge, information (and data) *infrastructures* in the *designing* and *composing* of *adaptive* (resilient and sustainable) organizations' [14].

The "Lodestone" concept arose from a concern that the "Cyber-pole" applying Coordination, Rule and Control (CRC) was being emphasized at the expense of the whole and specifically the pole dealing with collaboration and social influence. The result, it was conjectured, was twofold: first, that government was becoming irrelevant to many social-media users and, secondly, that this was creating a vacuum in which less benign influences might flourish. For example, studies of social networking and identity have shown that there is a strong tendency to connect like-to-like [16]. This narrowing focus potentially reduces societal *variety* and makes people less tolerant to alternative ideas and *ontologies* than their 'non-digital forebears'. They may, in actual fact, become non-democratic, *xenonetworks* (from xenophobia, xenonetworks are 'social networks with a strong dislike or fear of other networks or ideas that appears foreign or strange to them') [2], extremely hostile to alternative ideas

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(and that they might be wrong). Discussion at the time was focused (as it remains largely today) on finding information 'keystones', 'architectures', 'protocols' or 'gateways' not so much to assist people identify good information from bad but to control. A problem with each of these concepts is that they obtrusively and exclusively focus on the stable, static (hence keystone) and ergodic, as opposed to the dynamic and non-ergodic. The "Information Lodestone" concept recalled the semi-mythical lodestones of antiquity that enabled ancient mariners both to determine / 'fix' their position and simultaneously steer a safe course. The objective is to design a non-obtrusive, dynamic instrument. In this respect, we are commencing work with Health and manufacturers of sensitive materials, to model and identify data / information flows and the potential for leaks along complicated, sensitive lines-of-communication in which knowledge assurances, e.g., for operating on patients, are essential. Other work is being undertaken to teach life systems management skills to young people, with an emphasis on either *metamatics* (the mathematics of cyber-social and cyber-physical systems) or *metadetics*, as defined in this paper. We consider this to be exciting work, on the cutting edge of our science, essential to enabling the emerging Knowledge Enterprise Economies of the 21st Century.

This paper is divided into three sections. In section one, the cyber-system is considered as it relates to the individual and at the social level. In the next section, means for instrumenting the Cyber are posited. Finally, inclusive designs and *standards* to enable people to *sensemake* within new and emerging cyber and synthetic ecologies are posited.

II. CYBER AS A SOCIAL BEING

The informal motto of the Lodestone Project was suggested as 'conscius in res' or "sense-in-being", relating to Badiou's [17] understanding of "being", when he states: 'what happens in art, in science, in true (rare) politics, and in love (if it exists), is the coming to light of an indiscernible of the times, which, as such, is neither a known or recognized multiple, nor an ineffable singularity, but that which detains in its *multiple-being* all the common traits of the collective in question: in this sense, it is the *truth* of the *collective's being*'. The idea of *multiple-beings* holds within it the traits of the social being at the heart of most systems and organizations. It is their truths and trusts that "detain the common traits of the collective in question". When these trusts dissipate or are allowed to wither, the organization may remain as a physical entity (when a building becomes statue) but its essence and being – its "ineffable singularity" – is no longer [18]. It is conjectured that, by dealing with cyber exclusively as an info-techno construct, many organizations lost sight of their "social being".

Considering the Cyber as two poles, it is suggested that one has more info/techno-socio traits; the other more socio-info/techno, in which, building on work by Harmaakorpi et al. [19][17], it is posited that: 'Info-Techno-Socio systems seek to program (as opposed to programme) the relationship between technical *processes* and humans by *digitizing performance fidelity* and coding for repeatable *risk free* procedures in computer-control-spaces so that *data* and *communication* do not [temporally] contradict each other ' [20]. By contrast: 'Socio-Info-Techno systems stress the *reciprocal interrelationship* between humans and computers to foster *improved shared awareness* for *agilely* shaping the *social programmes of work*, in such a way that *humanity* and *ICT [control] programs* do not contradict each other ' [20].

The two systems are also considered in terms of their signatures, where I-T-S systems are considered as strong-signal systems [21-24], in which: '*System Information* and *Communication* are the key variables', after, Castells [25] and Sokol [26]. And weak-signal S-I-T systems [21-24], in which: '*Influence* (through shared awareness) and *Control* (through switching) of *Information* and *Communication* are the key variables', after Castells [25].

Most of us intuitively know the type of organization we would wish to be working for. Warren and Warren (1977) considered this in terms of "organizational health" and concluded that 'healthy organizations' have 'a critical capacity for solving problems', [27]. They identified three dimensions of *connectedness* (see also Thibaut and Kelley [28]): *identification* with the organization (they referred to as neighborhood); interstitial *interaction* within the organization and existential *linkages* outside the organization.

Considerations of health apply equally to organizations working with/in the Cyber and their capacity for "problem solving" and so controlling, in time, and influencing, over time. It is contended that successful companies are constantly "balancing" between the *exploitative* (delivered *in time* by coordination, rule and control) and the *explorative* (delivered *over time* through collaborative social influence). The capacity for balancing between coordination & control (the exploitative) and collaboration and influence (the explorative) to keep an organization "in kilter" is known as "ambidexterity" [29]. It is suggested that this ability to *dynamically balance* between the *exploitative* and the *explorative* is indicative of a systems ability to "problem solve" and, therefore, of its health.

As humans learn, it is contended that they develop a critical capacity for problem solving based upon their individual social system model. This capacity for systems and critical thinking can be taught and is seen as a necessary pre-requisite for understanding and dealing with complexity. In this regard, from Lever et al. [30], it is considered that:

> **Systems Thinking** may be the ability to determine appropriate options for leading, managing, designing, engineering and modeling complex systems, taking adequate *empirical* account of different system types, configurations, dynamics and constraints, and;

Critical Thinking may be the ability to ask the right questions and make useful sense of information that is technically complex, incomplete, contradictory, uncertain, changing, *non-ergodic* and subject to competing claims and interests.

After Dreyfus & Dreyfus [31], it is suggested we all have an individual 'meta-datum' that *reference* what is posited as our "metadetic spheroid" [31-33]. This gives rise to concepts of "metadetic-datum", with similarities to a geodetic datum used to "reference" the spheroidal model of the earth being applied, e.g., World Geodetic System (WGS) 84. Individual metadetic spheroids may be broadly similar. How they are referenced – in other words their datum – is seen to affect how humans' process information and what they perceive. A metadetic-spheroid is an individual's model (no matter how incomplete) of the sociodetic-spheroidal "beings" / organizations they inhabit; see Fig. 1. The meta-datum achieves the best "fit" of an individual's metadetic-spheroid to what may be described as its "sociodetic-spheroid" describing the overall model of the related social system.

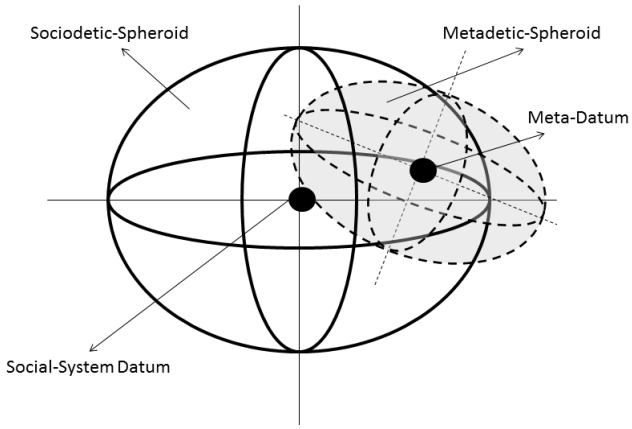

Figure 1. Sociodetic / Metadetic Spheroids and Datums

Bunge [34] maintains that 'perception is personal; whereas knowledge is social'. An individual's perception of their "sociodetic spheroidal system" is incomplete. Only by "collaboratively connecting" with "others" metadetic spheroids may an individual begin to "map" the sociodetic spheroidal whole. It is this process of "collaborative sensemaking" that moves what is effectively static, positional information and data to the social and dynamical knowledge of "being".

Markov chains applied within Bayesian Belief Networks [35] were considered by Logan and Moreno [36] in terms of 'Meta-State-Vectors' referenced to 'Meta-Data' [31-33]. Meta-State-Vectors (MSVs) relate to the idea of some information containing "indicators" that will be identified immediately against an individual's metadetic-datum without the need for preamble / additional processing. MSVs are therefore distinguishable from serial information; from which 'expert' human processors 'can form diagnostic hypotheses and draw rational conclusions from system patterns [and] *critical* reflection of their own meta-datum' [31]. In terms of collaboration and shared awareness, this should enable individuals to 'make better use of one another's expertise' [37], particularly if 'authenticated' [38], validated and verified.

In a social system, there also exists the risk of knowledge blindness or "blind knowledge" [39, 40]. Models of "info/techno-socio exchange" and "socio-info/techno knowledge capture" therefore need to differentiate 'between the active physical and technological capture of data and information' [41, 42] and the socio-info/techno exchange of knowledge [43-48]. To understand how the best "fit" is to be achieved between the info/techno-socio "machine" and the socio-info/techno organizational "being", it is necessary to identify the system's ecology and its purpose / role within it. If an organization's purpose is to problem solve, then how it maps its sociodetic spheroid and positions its datum will determine its health and future fitness judged by its ability to 'test for both success and failure' [49].

III. INSTRUMENTING THE CYBER

At the turn of the millennium, the old UK Defence Research Agency (DERA) was undertaking trials of networked soldiers at the British Army Training Unit in Suffield (BATUS), Canada. Soldiers had all been issued with GPS. As reported to the first author, the result was "digital" in terms of the troops' movement, which was recorded as being "stop and go". Troops would stop, find out where they were, report their position and then move. The researcher removed GPS from the soldiers and caused them to return to map and compass. The result was dramatic. Soldiers began to interpret their datum against the map and to use their senses to determine progress. They used the compass to provide analogue direction and their bearing to dynamically align their datum.

After the Heisenberg principle, Price [50] suggests that 'it is impossible to determine simultaneously both the position and momentum of a particle with any great degree of accuracy or certainty'. This led the first author to surmise a potential metaphor for the modern age: 'that we *know* precisely where we are but we no longer *know* where we are going'. Although causality is hard to attribute [51], it may be possible to apply the Heisenberg principle as a useful rule-of-thumb when designing dynamic (non-ergodic) systems by suggesting that:

> 'the more precisely one measures a position, the less able one may *identify* change, over time, and vice versa'[18].

This has specific implications for system designs noting the predilection in recent years to emphasize metrication and the setting of targets / goals etc. for managing organizations. Reported separately [18, 52], instead of improving shared

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awareness, the excess of information and targets required as a form of control can detract from work [53] and so collaboration and shared awareness. This suggested that reducing collaborative and shared awareness impacts negatively an organization's ability to problem solve. *Ipso facto*, these *exploitative* type organizations become unhealthy and potentially, even, risky places to be.

In addressing the failures of government and collective (collegial) intelligence prior to 9/11 and the Iraq War, the US 9/11 Commission [54] and the (Lord) Butler Enquiry [55] in the UK identified the failure of governance specifically in terms of the *digital ecologies*, then in existence. What they saw was that essential information existed, but that it was being missed, mislaid and, critically, not *shared*. Furthermore, they saw confusion between data, information and communication networks (essentially ICT) and what was being identified and abstracted in terms of *knowledge* and actionable intelligence that could be appropriately *shared* and *used* across government, in real time. Busy Secretary's of State, Ministers, government officials / business / industry / financial leaders and project / programme directors, managers, administrators, users, agents and other consumers of *actionable intelligence* were being overwhelmed in a deluge of data and information technology, process and methodology that was quite literally *blinding them* to what was vital; what was strategic; what was operational; what was routine; what was base level knowledge (against which change and perturbations might 'show up' (be *envisioned*)) and what was simply background *noise*. Organizational structures had not simply atrophied but had become 'tuned out' – no longer able to select between the vital *weak-signals* of innovation, adaptation and change (as threat or opportunity) and the *strong-signals* of method and process [21-23, 56, 57]. Recommendations arising from 9/11 [54, 55] and the Global Financial Crisis were three fold: firstly has been to require greater transparency e.g., between the banks, investors, borrowers and governments; secondly, has been to demand greater regulation and thirdly, to move away from the need to know control model towards what has been described as the three needs model – need to know; need-to-share; need-to-use (3NM) [42].

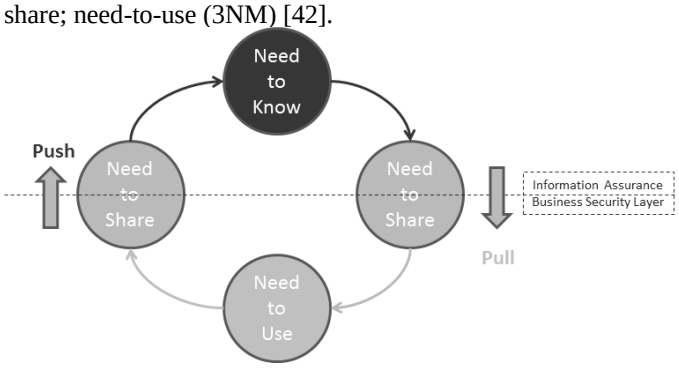

Figure 2. Three Needs Model (3NM)

Knowledge blindness [40] was also seen in the run-up to the Global Financial Crisis (GFC), when public and private organizations / individuals capable of identifying alternative *futures* were no longer able to communicate / be listened to: 'It is remarkable that the advanced research and assessment group…put the danger of a global financial collapse into the [UK] draft national security strategy [in 2005/6], but were told to take it out, presumably for political reasons, before it occurred' [58].

In this respect, Szilard's warning that 'information is expensive to acquire and use' [59] and Bunge's recognition that 'knowledge was social' [34] had been potentially lost in the *noise* of new IT, methods and processes. The Lodestone project was conceived from this confusion and a recognition that 'today's economy and society is totally reliant on technology as an enabling force for all economic and societal activities' [60]. It identified the potential of societal cascades in which 'a failure of a very small fraction of nodes in one network may lead to the complete fragmentation of a system of several interdependent networks' [61]. The series of cascades considered at the time (2009/10) included UK strategic failure in Iraq and Afghanistan [62] and the global financial crisis. Significantly, an undermining in binding societal trusts and assurances were seen simultaneously to be occurring / had the potential to occur, such as the UK MPs honors and expenses scandals; connecting to the phone hacking scandal that implicated media, police and politicians; to the failure of the BBC to protect young and vulnerable people; to the 2010 UK student riots and the 2011 "London" riots. Each of these cascades began / was exacerbated in the Cyber as, potentially, they will also be resolved.

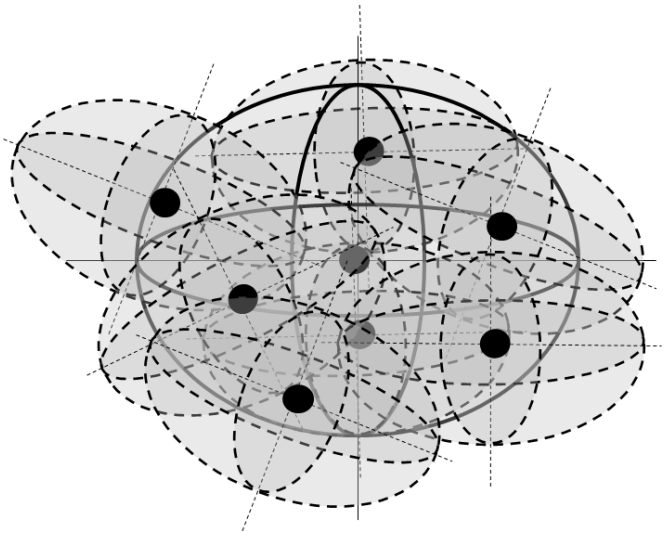

Figure 3. Multiple Meshed Sociodetic / Organisational System Model

Consequently, it was seen as being necessary 'to protect…information infrastructure technologies…a strategic

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core [of] which must be maintained i.e., the Critical National Infrastructure (CNI) / Critical Information Infrastructure (CII)'. It was recognized that 'small incremental changes and / or large-scale modifications can drastically shape and reshape both the economy and its society with known and often unknown consequences, due to ever-increasing interconnectivities and growing complexities … especially, the information technologies that have come to pervade virtually all aspects of life' [63] – hence "societal cascades". This led to the development of an 'Assurance Case Approach methodology for individual CII assets to input into the larger Business Information Environment', 'the development of a *Mesh* case that can be visualized as the 3-D atomic structure of a molecule' and which 'provides a lateral approach for interdependencies between individual assurance cases' [60]. The "multiple" mesh envisioned represents the sociodetic spheroidal "being" described by Fig. 3 and relates to both interdependencies and assurances to provide overarching confidence in the system whole. Protecting the system whole and providing for resilience and responsiveness required a flexible, adaptive and *ambidextrous* CSI 'approach over time and real-time', CRC mechanisms for interacting directly with 'dynamic information ecosystems' [60], in time.

IV. SETTING CYBER STANDARDS

Regulations and controls can be antithetical to creating a shared aware and collaborative ecology and enabling the necessary transparencies for encouraging good behavior and discouraging bad [52]. The three needs model aims to create an information assurance / business security layer between the user (pull) and the knowledge (push) custodian [42], see Fig. 2. There are significant challenges to the managing of information and data allowing for successful, inclusive means for identifying / testing when information and data has been tampered with, changed, added to or where leakage points may occur. Examples include the loss (probably through accounting errors and multiple packet switching) of sensitive materials, e.g., in the explosives industry for products that have to be accounted for to the milligram. Similarly, limited information and data tracking (including asset tracking) e.g., in the health service, means that safety critical equipment can become mislaid or misapplied; so placing patients at risk. During the recent Europe-wide meat scandal an inability to track information and data and test / verify it for validity at key stages of the supply chain, enabled graft and fraud to take place across the whole.

Throughout history, successful economies have been based upon the accurate and reliable "assaying" of materials, such as metals (gold) and food. These social transfer points also became the opportunity for reliable trade and pricing moments and so taxation. Scales and weights were regularly tested and subject to daily public scrutiny – they created *transparencies* for encouraging good behavior and identifying bad. Similar open-social "assaying standards" that can be used to assess information and data in terms of its goodness, purity and proof are harder to find. And there is not a simple and readily available *instrument* such as a "scale and weights" or "map and compass" that can be applied unobtrusively at different stages of often complex supply chains to verify and validate information & data flows and leakages. This does four things: it limits transparencies; so encouraging graft / crime; consequently reducing the opportunities for legitimate business / taxation and discouraging good behavior.

In his theory of the firm, Coase [64] argues that the reason for firms forming is to enable 'employer and employee relations with regard to cost', which 'were necessary to understanding the working of firms and organizations'. He suggested that 'governance is chosen in a cost effective degree to infuse order, thereby to mitigate conflict and realize mutual gain' [64]. It follows that regulations and controls that fail to 'mitigate conflict and realize mutual [collaborative] gain' create unhealthy ecologies by limiting organizational problem solving capacities [52]. In his Law of Requisite Variety, Ashby [3] maintains that 'only variety can *control* variety' and that 'for every control one needs a controller'. Reported separately [18, 52, 65], 'organizations under control, may never be more shared aware than the sum of their links'. By contrast, organizations that enable collaborative social influence can 'generate, on average, 12.5% more [linkages] than formally specified' [18]. Furthermore, these organizations can adapt, over time, to different levels of control. In other words, these 'new' linkages also provide the 'variety necessary to *control* variety' – so meeting Ashby's Law of Requisite Variety.

V. A NEW METADETIC

In setting Cyber Standards, the issue appears two fold. First, to create inclusive standards through 'the *synergistic* combination of *civil* mechanical *systems* and the management of *interconnected* knowledge, information (and data) *infrastructures* in the *designing* and *composing* of *adaptive* (resilient and sustainable) organizations' [14], that readily encourage openness and transparencies and can be easily *assayed*. Secondly, is for these standards to encourage collaborative shared awareness, from which new controls and pricing opportunities and markets may emerge. Thus, inclusive standards for information / data "packet-switching" may create opportunities for "packet-marketing" and so for pricing and taxation. This returns to *standards* acting as social *instruments* that, through their very "being", can *synthesize* the info-techno and socio to create opportunities both for collaborative *exploration* and *exploitative* control – or *ambidexterity*. It is suggested that creating socially inclusive and acceptable *standards* for *assaying* the goodness of information and data enables this *synthesis*. This leads potentially into a third area to do with the synthesizing of Cyber Standards, introduced in Section III and by Figs. 1 and

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3. It is suggested that how social reference-standards are designed to be inclusive of the machine and the organization and are best "fitted" to their organizational (sociodetic) systems, may potentially be considered as the subject of "metadetics".

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UK Admiralty and Defence Research Establishments 1842-1991. Advanced Research Assessment Group (ARAG) 2003-2009. CESG. Royal Australian Navy (1913-2013).

REFERENCES

[1] D. Walker, S. Reay Atkinson, and L. Hossain, "Collaboration Without Rules - A New Perspective on Stability Operations", Presented at IEEE Cyber Conference, 14-16 Dec, 2012, IEEE: Washington.

[2] S. Reay Atkinson, S. Feczak, A. Goodger, N.H.M. Caldwell, and L. Hossain, "Cyber-internet: a potential eco-system for innovation and adaptation", in European Alliance for Innovation: Internet as Innovation Eco-System Summit and Exhibition 2012, 4-6 Oct, .2012, EAI: Riva del Garda: Italy.

[3] R. Ashby, An Introduction to Cybernetics, 1957, London: Chapman and Hall.

[4] D. Cartwright, "Influence, leadership, control", in Handbook of Organizations, J.G. March, Editor, 1965, Rand McNally: Chicago. pp 1-47.

[5] P.A. David, "Path Dependence - A Foundational Concept for historical Social Science". Cliometrica -The Journal of Historical Economics and Econometric History, 2007. 1(2), Summer 07.

[6] R.A. Dahl, "The Concept of Power". Behavioral Science, 1957. 2:3, July: p. 201.

[7] L. Hossain, M. D'Eredita, and R.T. Wigand, "Towards a Product Process Dichotomy for Understanding Knowledge Management, Sharing and Transfer Systems" in Organizations. Submitted to Information Technology and People, 2002.

[8] D.H. Wrong, "Some Problems in Defining Social Power". The American Journal of Sociology, 1968. Vol. 73, No. 6 (May), pp. 673-681.

[9] S. Reay Atkinson, "Cyber-: Envisaging New Frontiers of Possibility". UKDA Advanced Research and Assessmnent Group, 2009. Unpublished, Occasional Series, 03/09.

[10] L.O. Dahlgren, "Undervisningen och det meningsfulla lärandet (The Teaching of Meaningful Learning)", 1995, Linköping University.

[11] M. Grimheden, and M. Hanson., "Mechatronics - the evolution of an academic discipline in engineering education". Mechatronics, 2005. 15, pp. 179-192.

[12] K.D. Bollacker, "Avoiding a Digital Dark Age". American Scientist, 2010. Volume 98, pp. 106-110.

[13] N. Wiener, God and Golem, Inc. 1964, Cambridge, MA: MIT Press.

[14] L. Hossain, S. Reay Atkinson, M. D'Eredita, and R.T. Wigand. "Towards a Mech-Organic Perspective for Knowledge Sharing Networks in Organizations". in UK Academy for Information Systems. 2013. Worcester College University of Oxford, 8-20th March.

[15] S. Reay Atkinson, "An Age of Evolutionary Step Change", in Think-Piece, 2012, University of Sydney: Complex Civil Systems Research Group.

[16] M.C. Larsen, "Understanding Social Networking: On Young People's Construction and Co-Construction of Identity Online", in Proceedings of Internet Research 8.0: Lets Play, 2007, Association of Internet Reserearchers: Vancouver.

[17] A. Badiou, Being and Event, ed. T.O. Feltham, 2005, London: Continuum.

[18] S. Reay Atkinson, "Engineering Design Adaptation Fitness in Complex Adaptive Systems", 2011, Cambridge University Engineering Department, EDC: Cambridge, UK.

[19] V. Harmaakorpi, I. Kauranen, and A. Haikonen, "The Shift in the Techno-socio-economic Paradigm and Regional Competitiveness", in The 43rd Conference of European Regional Sciences Association (ERSA), 27-31 Aug, 2003, Helsinki University of Technology: Lahti Center, Jyväskylä, Finland.

[20] S. Reay Atkinson, A. Goodger, N.H.M. Caldwell, and L. Hossain., "How lean the machine: how agile the mind". The Learning Organization, 2012. Vol. 19 Iss: 3, pp. 183 - 206.

[21] H.I. Ansoff, "Managing Strategic Surprise Response to Weak Signals". California Management Review, 1975. Vol. XVIII, No. 2, pp. 21-33.

[22] B. Coffman, "Weak Signal Research, Part I: Introduction". 1997 [cited 2010 13 Oct]; Available from: http://www.mgtaylor.com/mgtaylor/jotm/winter97/wsrintro.htm., last accessed May 2011.

[23] E. Hiltunen, "Weak Signals in Organizational Futures Learning", 2010, Helsinki School of Economics A-365.

[24] E. Hiltunen, "Good sources of weak signals: a global study of where futurists look for weak signals". Journal of Futures Studies, 2008. Vol. 12 No. 4, pp. 21-44.

[25] M. Castells, "The Information Age. Economy, Society and Culture", in Volume I, The Rise of the Network Society, 1996, Blackwell Publishers: Oxford.

[26] M. Sokol, "The Knowledge Economy: a critical view", in paper presented at the Regional Studies Association International Conference,12-15 April, 2003: Pisa.

[27] R.B. Warren, and D.I. Warren, The Neighborhood Organizer's Handbook, 1977, South Bend, Ind: University of Notre Dame Press.

[28] J.W. Thibaut, and H.H. Kelley, The Social Phsychology of Groups, 1959, New York, London: John Wiley, Chapman Hall.

[29] Z-L. He, and P-K. Wong, "Exploration vs. Exploitation: An Empirical Test of the Ambidexterity Hypothesis". Organization Science, 2004. Vol. 15, No. 4, July-August, pp. 481-494.

[30] T. Lever, H. Ainsworth, G. McGarry, S. Ludewig, and S. Reay Atkinson, "Project Management Professional and Academic, Complex Critical and Systems Thinking Competency Matrix (CCSTCM™)", in Unpublished, CCSTCM™, S. Reay Atkinson, Editor, 2012, Complex Civil Systems Research Group and Project Management Programme: University of Sydney, Faculty of Engineering and IT, School of Civil Engineering.

[31] H.L. Dreyfus, and S.E. Dreyfus, Mind Over Machine, 1987, New York: The Free Press.

[32] G. Chaitin, Meta Math, 2005, New York: Pantheon Books.

[33] P.A. Corning, "Book Review Essay: From Complexity to Life: On the Emergence of Life and Meaning", in Technological Forecasting and Social Change (2003), N. Gregersen, Editor, 2004, OUP: Oxford.

[34] M.A. Bunge, "Ten Modes of Individualism - None of Which Works - And Their Alternatives". Philosophy of the Social Sciences, 2000. 30(3), pp. 384-406.

[35] S. Russell, and P. Norvig, Artificial Intelligence A Modern Approach, 1995, Upper Saddle River, New Jersyey: Prentice Hall.

 ISBN: 978-1-61208-312-4

[36] B. Logan, and P.J. Moreno, "Factorial Hidden Models for Speech recognition: Preliminary Experiments, in Technical Report Series", CDR 97/7, September, Cambridge-Research-Laboratory, Editor, 1997, Cambridge University: Cambridge.

[37] H. Mintzberg, D. Dougherty, J. Jorgensen, and F. Westley, "Some surprising things about collaboration - knowing how people connect makes it work better". Organizational Dynamics, 1996. Spring, pp. 60-71.

[38] R.L. Ackoff, "From data to wisdom". Journal of Applied Systems Analysis, 1989. Vol. 15, pp. 3-9.

[39] R. Dawkins, The Blind Watchmaker, 1986, London: Penguin Books.

[40] L. Perros-Meilhac, P. Duhamel, P. Chevalier, and E. Moulines, "Blind Knowledge Based Algorithms based on second order statistics", in ICASSP, 1999, IEEE Proceedings, Vol 5, Mar, pp. 2901-2904: Phoenix, Arizona.

[41] D. Rus, and D Subramanian, "Customizing Information Capture and Access". ACM Transactions on Information Systems, 1997. Vol. 15, No. 1, Jan, pp. 67-101.

[42] S. Reay Atkinson, S. Lesher, and D. Shoupe, "Information Capture and Knowledge Exchange: The Gathering Testing and assessment of Information and Knowledge through Exploration and Exploitation", in 14th ICCRTS: C2 and Agility, 2009, CCRP: Washington.

[43] W. Bijker, T. Hughes, and T. Pinch."The social construction of Technological Systems", 1987, Cambridge, MA: MIT Press.

[44] K. Henderson, On Line and On Paper, 1999, Cambridge, MA: MIT Press.

[45] A. Martinelli, M. Meyer, and N. von Tunzelmann, "Becoming an entrepreneurial university? A case study of knowledge exchange relationships and faculty attitudes in a medium-sized, research-oriented university". Journal of Technology Transfer, 2007. (2008), Vol. 33, DOI 10.1007/s10961-007-9031-5, pp. 259-283.

[46] Y. Cengeloglu, S. Khajenoori, and D. Linton, "A Framework for Dynamic Knowledge Exchange Among Intelligent Agents", in AAAI Technical Report FS-94-02, 1994, AAAI: Palo Alto, CA.

[47] S. Hagen, "From tech transfer to knowledge exchange", Ch 10, in European universities in the marketplace, the Authors Volume Compilation, 2008, Portland Press Ltd.

[48] B. Latour, "Visualization and Cognition: Thinking with Eyes and Hands. Knowledge and Society", 1986. Studies in the Sociology of Culture of Society Past and Present, Vol. 6, pp. 1-40.

[49] J.K. DeRosa, A-M. Grisogono, A.J. Ryan, and D.O. Norman, "A Research Agenda for the Engineering of Complex Systems", in IEEE International Systems Conference, SysCon, 2008, IEEE, pp. 15-22.

[50] H. Price, Time's Arrow: New Directions for the Arrows of Time, 1996, Oxford, UK: OUP.

[51] H. Price, Causation, Physics, and the Constitution of Reality: Russell's Republic Revisited, 2007, Ed. R. Corry, Oxford, UK: OUP.

[52] S. Reay Atkinson, S. Tavakolitabaezavareh, D. Walker, L. Liu, and L., Hossain, "Securing the bolts before the horse has bolted: A new perspective on Managing Collaborative Assurance", in The IEEE, 2013 Conference on Security Management, Aug2013: Las Vegas.

[53] L. Dabbish, and R. Kraut, "Controlling interruptions: Awareness displays and social motivation for coordination", in ACM Conference on Computer-Supported Cooperative Work, 2004: Chicago, USA.

[54] National Commission of Terrorist Attacks (NCTA), "9/11 Commission Report". 2004 [cited 2007 June]; Available from: http://www.9-11commission.gov/report/911Report.pdf., last accessed Mar 2010.

[55] Lord Butler, "Review of Intelligence on Weapons of Mass Destruction", in Report of a Committee of Privy Counsellors, Chairman: The Rt Hon The Lord Butler of Brockwell KG GCB CVO, 2004, Ordered by the House of Commons, 14th July: London.

[56] M. Granovetter, "The strength of weak ties". American Journal of Sociology, 1973. 78(6), pp. 1360-1380.

[57] M. Hansen, "The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits". Administrative Science Quarterly, 1999, pp. 82-111.

[58] B. Jenkin MP, "Speaking in the House of Commons". Hansard, 2010. Column 699,1 Mar, http://www.publications.parliament.uk/pa/cm200910/cmhansrd/cm100301/debtext/100301-0010.htm, last accessed June 2013.

[59] L. Szilard, "On the Increase of Entropy in a Thermodynamic System by the intervention of Intelligent Beings - the Critique" (Rapoport A. and M. Knoller trans.). Behavioral Science, 1964 (1929). 9, pp. 302-310.

[60] A.C. Goodger, N.M.M. Caldwell, and J.T. Knowles. "What Does the Assurance Case Approach deliver for Critical Information Infrastructure Protection in Cybersecurity?" in System Safety 2012 - The 7th International IET System Safety Conference, incorporating the Cyber Security Conference 2012. Edinburgh, 15 Oct: IET.

[61] S.V. Buldyrev 2, R. Parshani, G. Paul, H.E. Stanley, and S. Havlin, "Catastrophic cascade of failures in interdependent networks". Nature, 2010. 464, 15 April 2010 (Received 22 December 2009; Accepted 17 February 2010), pp. 1025-1028.

[62] Public Administration Select Committee (PASC), "Who Does UK National Strategy?", in PASC, 12 Oct, 2010, House of Commons London.

[63] P. Dickens, Global Shift - Reshaping The Global Economic Map in the 21st Century, 2003, London: Sage Publications.

[64] R.H. Coase, "The Nature of the Firm". Economica, 1937. New Series, Vol. 4, No.16, Nov, pp. 386-405.

[65] S. Reay Atkinson, A.M. Maier, N.H.M. Caldwell, and P.J. Clarkson, "Collaborative trust networks in engineering design adaptation", in International Conference of Engineering Design, ICED11, 2011: Technical University of Denmark, Lyngby.

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Predicting Social Interactions from Different Sources of Location-based Knowledge

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***Abstract*—Recent research has shown that digital online geo-location traces are new and valuable sources to predict social interactions between users, e.g. , check-ins via FourSquare or geo-location information in Flickr images. Interestingly, if we look at related work in this area, research studying the extent to which social interactions can be predicted between users by taking more than one location-based knowledge source into account does not exist. To contribute to this field of research, we have collected social interaction data of users in an online social network called My Second Life and three related location-based knowledge sources of these users (monitored locations, shared locations and favored locations), to show the extent to which social interactions between users can be predicted. Using supervised and unsupervised machine learning techniques, we find that on the one hand the same location-based features (e.g. the common regions and common observations) perform well across the three different sources. On the other hand, we find that the shared location information is better suited to predict social interactions between users than monitored or favored location information of the user.**

Keywords*—*Social Interaction Prediction; Location-Based Social Networks; Link Prediction; Virtual Worlds

I. INTRODUCTION

There is no doubt that tomorrow's world will be mobile and social. It is therefore not surprising that recent research has rigorously followed this trend to study new methods to predict social ties or links between people in such an environment. Interestingly, if we look at related work in this area (e.g. [1], [2], [3]), research studying the extent to which social links can be predicted between users typically takes just one knowledge source into account, e.g. , online social network data from Facebook, or location-based social network data from FourSquare. To contribute to this emergent and still sparse field of research, we have recently started a project (see [4], [5], [6]) with the overall goal to predict links and tie strength between users from various sources of social and mobile data. Since it is nearly impossible to obtain a complete dataset containing both kinds of knowledge sources in the real world, we focused our experiments on a virtual environment called My Second Life. This allowed us to easily mine any kind of information needed for such a type of a project on a large scale. So far, we have studied the extent to which partnership [6] and in general interactions can be predicted [5] by looking at homophilic features such as for instance common interests, common groups, or common-places visited and network topological features where we investigated common friends features such as Adamic Adar or Jaccard's coefficient. Interestingly, we find that the location information of users is to a great extent useful to predict tie strength for the interactions between them in the virtual world of Second Life, most of the time outperforming online social network features. While we only used one particular type of location-based knowledge source about users, namely monitored locations, in our previous research, in this paper we are interested to overall study three different types of knowledge sources: monitored locations, shared locations and favored locations. We employed 10 different features to predict social interactions between users and unveil what type of location-based knowledge source and what types of features were most valuable. Overall, we would like to answer the following research questions in this paper:

RQ1. Are there any statistically significant differences between the users having and not having social interaction with each other based on the features induced from our three different kinds of location-based knowledge sources?

RQ2. Which features perform best across those three types of location-based knowledge sources?

RQ3. What kind of knowledge sources is in the end the most valuable to predict social interactions between users?

To answer the first question we analyzed the datasets with statistical methods according to our features. This evaluation showed that there were significant differences between user-pairs with a social interaction and users without a social interaction across all computed features and all three sources of location information. For instance, user-pairs with a social interaction share more common regions compared to user-pairs without social interaction. To answer the second research question, we employed Collaborative Filtering for each feature independently to predict the social interactions between the users to find the most valuable features. Among others we found that common regions and common observations of two users were a good indicator for a social interaction between them. For the last question we combined the best features for each region source and showed that the user's Shared Locations were more valuable to predict social interactions than Monitored or Favored locations.

In detail the paper is structured as follows: In Section II, we shortly discuss related work in the area. In Section III, we introduce the collected datasets and the features to predict social interactions between users in Section IV. The setup of the experiments is depicted in Section V followed by the results in Section VI. Finally, Section VII, discusses the findings and concludes the paper.

II. RELATED WORK

Approaches by Liben *et al.* [7] or Hasan *et al.* [8] for link prediction using features obtained from online social networks

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where greatly enhanced with the advent of user's location data. One of the first studies in this field was conducted by Cranshaw *et al.* [2] who combined the interaction of the online social network *Facebook* with the location-based social network of *Loccaccino*. They introduced various metrics to compute users homophily and found a significant correlation between social interactions and location-based features. Similar observations were made by Thelwall *et al.* [9] who revealed significant homophily between interacting users in *MySpace* and even inferred an real-life friendship from the online social network. This goes inline with Bischoff *et al.* [3] who found relations between connections in *Last.FM* and visited music concerts based on demographic, structural and taste-related attributes. Scellato *et al.* [1] investigated in the location-based social network of *Gowalla* and found 30% of newly created links as "place friends". Research by Wang *et al.* [10] follows this direction. They investigated in the prediction of social relations using mobility data obtained from mobile phones and found mobile information significantly outperforming simple network measures. Another paper by Scellato *et al.* [11] focuses on the structural differences between the three location-based social networks of *Brighknight*, *Foursquare*, and *Gowalla*. In contrast to our work, they did not have different location sources for one single online social network and their focus was on the actual spatial distance between user.

III. Data Sets

Our experiments were based on a social interaction dataset of users in an online social network and three independent location-based knowledge sources: *Monitored Locations*, *Shared Locations*, and *Favored Locations* from a virtual world. In particular, we focused in our experiments on a virtual environment called Second Life, where we could easily mine the necessary information needed for the experiments on a large scale (see [4], [5], [6] for more details).

A. Social Interaction Dataset

The online social network *My Second Life* was introduced by Linden Labs, the company behind Second Life, in July 2011. It is a social network that can be compared to Facebook regarding postings and check-ins but aims only at residents of the virtual world: just as in Facebook, residents can interact with each other sharing text messages, and comment or love (similar to a "like" in Facebook) these messages. Figure 1 depicts a typical profile of a user with postings, comments, and loves from others. A user's profile can be accessed with a unique URI derived from the user name and we attempted to download the profile data of over 400,000 users with a web-crawler. We extracted their interaction partners and downloaded the missing profiles iteratively. With this approach, we found 152,509 profiles with interactions on their profile and identified 1,084,002 postings, 459,734 comments and 1,631,568 loves.

B. Location-based Dataset

To predict the social interactions between users we employed location information obtained from three different sources of data.

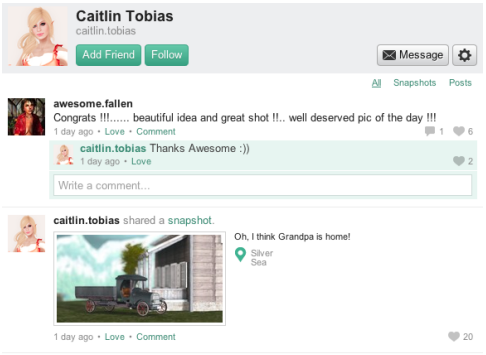

Fig. 1. User profile of an Second Life resident in the online social network My Second Life showing a posting, a shared snapshot with location information (Silver Sea), and a comment.

a) Monitored Locations: As in the real life, residents of Second Life can host events in the virtual world for other residents and publicly announce this information on an event calendar. We implemented a web-crawler that harvested this calendar periodically to extract all events with accurate event-location and start time. Based on this information we have implemented 15 avatar-bots that visited these events with an interval of 15 minutes and collected the accurate location of the participating users. Starting in March 2012 we were able to collect 262,234 events over a period of 12 months yielding in a dataset of nearly 19 million data samples, i.e. user-location tuples, of over 410,616 different users in 4,132 unique locations.

b) Shared Locations: Users of *My Second Life* can not only interact with each other using postings, comments, or loves, they can also share location information about their current in-world location through in-world pictures. The idea of sharing these locations can be compared to pictures uploaded to *Flickr* or *Facebook* enriched with GPS information (see Figure 1). Overall, we identified 496,912 snapshots in 13,583 unique locations on 45,835 profiles.

c) Favored Locations: Every user of Second Life can specify up to 10 so-called "Picks" on it's profile representing the favorite locations of users. Users can enhance these picks with a picture and personal text note. These favored locations are visible to other users and hence it can be easily accessed with a Web browser using a URI derived from the user's name. We found 191,610 profiles, sharing 811,386 locations in 25,311 unique regions.

Figure 2 depicts the number of observations of the collected users for the three location sources. Both, Shared and Monitored Locations show power law qualities which is in contrast to the Favored Locations due to Linden's limitations of 10 picks per user.

IV. Features

Based on the collected location-based user data we induced overall 10 different features in order to measure the homophily between the users and to predict social interactions between them [2], [5], [6]. For the reminder of this paper the sequence of observations $O(u)$ of a user u are denoted as 1) $O_m(u)$ for Monitored Locations, 2) $O_s(u)$ for Shared Location, and 3)

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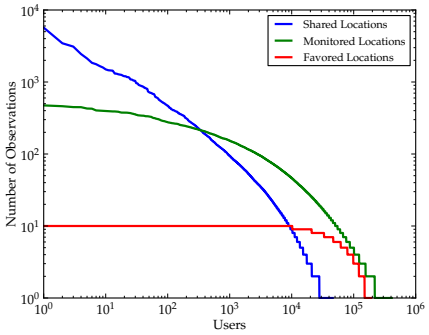

Fig. 2. The number of user observations in the three different location-based knowledge sources.

$O_f(u)$ for Favored Locations. In contrast, the set of locations where a user was observed is defined as $P(u) = \{\rho \in O(u)\}$. The actual features we used in our experiments are as follows:

a) Common Locations $R_C(u,v)$*:* The simplest metric to determine the homophiliy between two users u and v is the number of regions they have visited in common. In particular this can be computed as $R_C(u,v) = |P(u) \cap P(v)|$.

b) Total Locations $R_T(u,v)$*:* Analogous to the common regions, one can also define the regions two users have in total and use it as a homophilic feature $R_T(u,v) = |P(u) \cup P(v)|$.

c) Jaccard's Coefficient $R_{JC}(u,v)$*:* A combination of the common regions of two users and their total regions is the overlap of locations which is defined as the fraction of common locations and locations visited by both users [2]. This feature is also known as Jaccard's Coefficient $R_{JC}(u,v) = \frac{|P(u) \cap P(v)|}{|P(u) \cup P(v)|}$.

d) Location Observations $R_O(u,v)$*:* Another feature taken from Cranshaw [2] is the location observations that is similar to the Jaccard's Coefficient between two users. It is computed as the number of locations two users have in common divided by the sum of locations either user have $R_O(u,v) = \frac{|P(u) \cap P(v)|}{|P(u)| + |P(v)|}$.

e) Location User-Count $R_U(u,v)$*:* The following three features were first introduced by Cranshaw *et al.* [2] and try model the location diversity of regions two users visited in common. The first and most simple feature to include the popularity of a region is the overall number of observations of unique users at a certain region. According to this we calculated the mean user-count $R_{U,\mu}(u,v)$ and the standard deviation of the mean $R_{U,\sigma}(u,v)$ of all regions two users visited in common $P(u) \cap P(v)$.

f) Location Frequency $R_F(u,v)$*:* The second feature taken from [2] is similar to the previous feature of counting users at a certain location. We computed the frequency defined as the overall observations of users at a certain location. Again we calculated the mean frequency $R_{F,\mu}(u,v)$ and the according standard deviation $R_{F,\sigma}(u,v)$ of the frequency of regions two users u and v have in common.

g) Location Entropy $R_E(u,v)$*:* A refinement of the two previous features, is the entropy that also takes the probabilities of observations at a location L into account. The probability that a user has visited a certain region is defined as the number of observations of the actual users divided by the overall number of observations at this regions. Let $O_{u,L}$ be the observations of a user u at a location L and O_L be all observations at the location L. The probability can then be computed as $prob_L(u) = \frac{|O_{u,L}|}{|O_L|}$. Based on this we can compute the entropy of a certain location L as $E_L = -\sum_{u \in U_L} P_L(u) \cdot log(P_L(u))$ with U_L representing all users observed a the location L. With this definition we computed the mean entropy $R_{E,\mu}(u,v)$ of the locations two users visited in common and the according standard deviation of the mean $R_{E,\sigma}(u,v)$.

V. Experimental Setup

We conducted different kinds of experiments to study the social interactions between users based on the three different sources of location information.

In order to conduct these experiments, we created a network from the social interactions obtained from the online social network of Second Life. In this network, nodes represented the users and edges indicate the social interactions between them. These edges were considered as unweighted and so we add an edge between two users no matter how often they communicated with each other. Further we did not distinguish the actual type of interaction and considered text messages, comments and loves equally. This finally yielded in a network of 152,509 users connected by 270,567 edges. Formally, this can be written as $G'_O\langle V'_O, E'_O\rangle$ with V'_O representing the users with an interaction on their feed and $e = (u,v) \in E'_O$ if user u interacted with user v (comment, posting, love). Then we enriched the nodes with the observations $O(u)$ from all three location data sources and removed nodes from the network if this data was not available in all three sources. Formally this new network can be defined as $G_O\langle V_O, E_O\rangle$ where $V_O = \{u \mid u \in V'_O,\ u \in O_M,\ u \in O_S,\ u \in O_F\}$ and $e = (u,v) \in E_O$ if user u interacted with user v (comment, posting, love). This reduced the network size to 14,508 nodes and 23,446 edges. For the actual experiments we followed Guha *et al.* [12] who suggest to create a balanced set of user-pairs with an interaction and without interaction for the prediction task. In particular we randomly selected 15,000 user-pairs with interaction $\{e^+ = (u,v) | (u,v) \in E_O, u \text{ and } v \in V_O\}$ connecting users V_O^+. The remaining 15,000 edges without interaction in between were created by selecting random user-pairs from the network without interaction $\{e^- = (u,v) | (u,v) \notin E_O, u \text{ and } v \in V_O\}$. Using this network we computed the features described in Section IV for all 30.000 user-pairs and each location source separately. This network-setup implies a baseline of 0.5 for the prediction task in case of random guessing whether a user-pair has interactions or not.

A. Analysis of Homophily

In the first experiment we analyzed similarities and dissimilarities of user-pairs with interaction e^+ and user-pairs without interaction e^- for each location source separately. We computed the mean values of the features and the according standard error in either sources separately. Using a one-sampled Kolmogorov-Smirnov and a Anderson-Darling test showed that none of the distributions of the features was from the family of normal distribution. As a consequence

and similarly to Bischoff [3], we compared the variances of all features between interacting and non-interacting user-pairs with a Levene test ($p < 0.01$). To test for significant differences of the means, we employed a Mann-Whitney-Wilcoxon test in case of equal variances and a two-sided Kolmogorov-Smirnov test in case of unequal variances.

B. Feature Engineering

In order to utilize the supervised machine learning algorithms to predict whether or not a user-pair interacted with each other, we had to determine the features that are most suited for this task. To assess the impact of each feature separately we used a simple Collaborative Filtering algorithm for a first rough overview and implemented a method proposed by Liben *et al.* [13]: For every user in the network we created ranked lists of the remaining users in the network based on the homophily obtained from the single features. To evaluate the performance of this approach we compared lists with different length to the actual interaction partners of each user. This was computed as the fraction of correctly identified interaction partners divided by the length of the overall retrieved users also referred to as the *positive predictive value* or *precision*. To validate the results of this approach we additionally employed the built-in Information Gain and the Correlation-Based Feature Subset Selection of the WEKA learning suite [14] to find the most valuable features for supervised learning.

C. Predicting Social Interactions with Supervised Learning

Based on the most valuable features determined for every region source separately, we tried to predict whether two users have a social interaction in the online social network. We combined features selected by the Correlation-Based Feature Subset Selection for each location source separately and obtained the three feature sets used for supervised learning algorithms. Due to the split into 15,000 user-pairs with interactions and 15,000 user-pairs without interactions we reduced the experiment to a binary classification problem. To compare the different location-based knowledge sources against each other, we applied the WEKA machine learning suite onto the combined set of features obtained with feature engineering for each region source separately. To do so, we applied three learning algorithms: "Logistic Regression" as it can be easily interpreted, and "Random Forest" and "Support Vector Machine" as both of them are suited for high-dimensional data. For the verification of the results provided by the machine learning tool, we used a ten-fold approach for the split of training set and test set.

VI. Results

In this Section we present the results of the conducted experiments.

A. Analysis of Homophily

We computed the mean values and standard errors for all features of 15,000 user-pairs with interactions and 15,000 user-pairs without interactions in the online social network. Table I summarizes the differences for features applied to all three sources of location-based information.

TABLE I. Means and standard errors of features applied to the three sources of location data comparing user-pairs with and without interactions ($^{*}p < 0.1$, $^{**}p < 0.01$, and $^{***}p < 0.001$).

	Features	Have Interactions	Have No Interactions
Monitored Locations	$R_C(u,v)^{***}$	0.49 ± 0.01	0.12 ± 0.00
	$R_{U,\mu}(u,v)^{***}$	179.02 ± 1.49	211.51 ± 2.55
	$R_{U,\sigma}(u,v)^{***}$	188.64 ± 1.17	215.04 ± 1.48
	$R_{E,\mu}(u,v)^{***}$	1.52 ± 0.00	1.60 ± 0.01
	$R_{E,\sigma}(u,v)^{***}$	0.53 ± 0.00	0.56 ± 0.00
	$R_{F,\mu}(u,v)^{***}$	637.50 ± 6.22	755.68 ± 10.96
	$R_{F,\sigma}(u,v)^{***}$	787.40 ± 5.66	894.85 ± 7.71
	$R_{JC}(u,v)^{***}$	0.05 ± 0.00	0.01 ± 0.00
	$R_O(u,v)^{***}$	0.04 ± 0.00	0.01 ± 0.00
	$R_T(u,v)^{***}$	12.24 ± 0.10	10.03 ± 0.07
Shared Locations	$R_C(u,v)^{***}$	1.01 ± 0.02	0.02 ± 0.00
	$R_{U,\mu}(u,v)^{***}$	22.78 ± 0.23	38.10 ± 3.23
	$R_{U,\sigma}(u,v)^{***}$	28.91 ± 0.25	37.09 ± 1.52
	$R_{E,\mu}(u,v)^{**}$	0.80 ± 0.00	0.86 ± 0.02
	$R_{E,\sigma}(u,v)^{***}$	0.44 ± 0.00	0.46 ± 0.01
	$R_{F,\mu}(u,v)^{***}$	92.99 ± 0.82	144.85 ± 11.18
	$R_{F,\sigma}(u,v)^{*}$	160.61 ± 1.14	180.70 ± 7.31
	$R_{JC}(u,v)^{***}$	0.03 ± 0.00	0.00 ± 0.00
	$R_O(u,v)^{***}$	0.02 ± 0.00	0.00 ± 0.00
	$R_T(u,v)^{***}$	63.70 ± 0.59	15.11 ± 0.19
Favored Locations	$R_C(u,v)^{***}$	0.11 ± 0.00	0.00 ± 0.00
	$R_{U,\mu}(u,v)^{***}$	12.90 ± 0.33	18.57 ± 1.76
	$R_{U,\sigma}(u,v)^{***}$	13.23 ± 0.37	22.26 ± 2.17
	$R_{E,\mu}(u,v)^{**}$	0.71 ± 0.01	0.81 ± 0.03
	$R_{E,\sigma}(u,v)^{***}$	0.40 ± 0.00	0.51 ± 0.02
	$R_{F,\mu}(u,v)^{**}$	16.17 ± 0.37	21.55 ± 1.92
	$R_{F,\sigma}(u,v)^{**}$	15.79 ± 0.40	25.01 ± 2.28
	$R_{JC}(u,v)^{***}$	0.02 ± 0.00	0.00 ± 0.00
	$R_O(u,v)^{***}$	0.02 ± 0.00	0.00 ± 0.00
	$R_T(u,v)^{***}$	8.04 ± 0.03	6.95 ± 0.03

1) Monitored Locations: On average user-pairs with interaction could be found in 0.5 common regions $R_C(u,v)$, had over 12 total regions $R_T(u,v)$, and Jaccard's Coefficient $R_{JC}(u,v)$ and observations $R_O(u,v)$ of around 0.05. For user-pairs with interaction we furthermore found an average user count $R_{U,\mu}(u,v)$ of over 179, an entropy $R_{E,\mu}(u,v)$ of 1.52 and a user frequency $R_{F,\mu}(u,v)$ of 637 for commonly visited regions. For user-pairs without interaction we observed less commonly visited regions and total regions as well as Jaccard's Coefficient and observations. In contrast, for features based on the location diversity, i.e. entropy, frequency, and user-count, we observed higher values. With the tests described in Section V we found significant differences for all applied features.

2) Shared Locations: The characteristics of the features applied to the Shared Locations were similar to the features applied to the Monitored Locations. For user-pairs with interaction we observed around 1 common region $R_C(u,v)$, 63 total regions $R_T(u,v)$, and a Jaccard's Coefficient $R_{JC}(u,v)$ and observations $R_O(u,v)$ in the same regions of around 0.03. For common regions we observed a average user-count $R_{U,\mu}(u,v)$ of 22, region entropy $R_{E,\mu}(u,v)$ of 0.8, and region frequency $R_{F,\mu}(u,v)$ of 92. Similar to the Monitored Locations dataset we observed higher values for common regions, Jaccard's Coefficient, observations, and total regions for user-pairs with interaction, whereas frequency, user-count and entropy were lower.

3) Favored Locations: Again we observed similar results as already described for the previous locations dataset but due to the reduced number of picks per user the absolute values were lower. We observed 0.11 common regions $R_C(u,v)$ for users interacting with each other, respectively 0.02 for observations

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$R_O(u,v)$ and Jaccard's Coefficient $R_{JC}(u,v)$. In contrast these values were nearly 0 for user-pairs without interaction. Interacting users had around 8 total regions $R_T(u,v)$ whereas user-pairs without interaction had only around 7 total regions. For features that model the location diversity ($R_E(u,v)$, $R_F(u,v)$, $R_U(u,v)$) we again observed lower values for users interacting with each other if compared to users without interaction.

B. Feature Engineering

For a rough estimation of the predictability of interactions we employed a Collaborative Filtering algorithm using features applied to the three location-based knowledge sources. Previous results of the analysis of homophily showed that user-pairs with interactions had higher values for common regions, total regions, Jaccard's Coefficient and observations. Hence, we rank this features in this experiment in descending order. Contrary, features based on the location diversity ($R_E(u,v)$, $R_F(u,v)$, $R_U(u,v)$) showed significantly lower values for interacting user-pairs and so we ranked them in ascending order. In addition to Collaborative Filtering, we used WEKA's Information Gain algorithm for verification of these results and finally a Correlation-Based Feature Subset Selection to find valuable features for further prediction. In Table II we present the results of Collaborative Filtering and the according values of the Information Gain algorithm for the features applied to the three location sources.

1) Monitored Locations: The Collaborative Filtering approach unveiled a high predictive power for common regions $R_C(u,v)$, total regions $R_T(u,v)$, respectively Jaccard' Coefficient $R_{JC}(u,v)$ and common observations $R_O(u,v)$ for different list lengths. However, features modeling location diversity like user-count, entropy, frequency of user's common regions performed inferior. This results were inline with the Information Gain algorithm that showed similar results for the computed features. Additionally, Correlation-Based Feature Subset Selection identified these features as most valuable.

2) Shared Locations: Collaborative Filtering exposed common region $R_C(u,v)$, Jaccard's Coefficient $R_{JC}(u,v)$, and observations $R_O(u,v)$ as most valuable. These three features plus the total number of regions $R_T(u,v)$ were also identified as best features using the Information Gain algorithm. Similarily, the Correlation-Based Feature Subset Selection algorithm unveiled Jaccard's Coefficient $R_{JC}(u,v)$, common observations $R_O(u,v)$, and the total number of regions $R_T(u,v)$ as the most valuable features in the set.

3) Favored Locations: Similar to the previous result the Collaborative Filtering approach identified the common regions $R_C(u,v)$, Jaccard's Coefficient $R_{JC}(u,v)$ and common observations $R_O(u,v)$ as most valuable. Information Gain additionally puts the total number of regions $R_T(u,v)$ on the list which is also inline with the previous result. Finally, Correlation-Based Feature Subset Selection found common regions $R_C(u,v)$, Jaccard's Coefficient $R_{JC}(u,v)$ and the total number of regions $R_T(u,v)$ to be best suited for further prediction tasks.

C. Predicting Social Interactions

Based on the results of the previous experiment we used the features identified by Correlation-Based Feature Subset Selection for predicting whether two users have an interaction with each other or not. One can find these features highlighted in bold letters in Table II for different region sources. We combined these individual features to feature-sets for every location source separately and predicted the interaction between user-pairs with three different learning algorithms. We utilized *Logistic Regression*, *Support Vector Machine* (SVM), and *Random Forest* and used the Area under the ROC curve (AUC) as main evaluation metric. In Table III the results of these evaluations are shown and one can see that *Logistic Regression* outperforms the two remaining algorithms on each of the three location-datasets. In particular, we found that the feature-set applied to the Shared Location dataset predicted interactions between users with 0.849 AUC which is a boost of +34.9% if compared to baseline for random guessing. For the remaining two region sources we observed a predictability of around 0.63 which is +13% over baseline. Random Forest and SVM showed similar results but performed inferior.

TABLE II. FEATURE ENGINEERING WITH INFORMATION GAIN AND COLLABORATIVE FILTERING METHODS. HIGHLIGHTED FEATURES WERE IDENTIFIED USING CORRELATION-BASED FEATURE SUBSET SELECTION.

	Features	Info Gain	Collaborative Filtering		
			Pre@5	Pre@10	Pre@20
Monitored Locations	$\mathbf{R_C(u,v)}$	0.048	0.081	0.062	0.048
	$R_{U,\mu}(u,v)$	< 0.01	0.047	0.041	0.039
	$R_{U,\sigma}(u,v)$	< 0.01	0.046	0.040	0.037
	$R_{E,\mu}(u,v)$	< 0.01	0.025	0.029	0.029
	$R_{E,\sigma}(u,v)$	< 0.01	0.046	0.037	0.033
	$R_{F,\mu}(u,v)$	< 0.01	0.047	0.043	0.037
	$R_{F,\sigma}(u,v)$	< 0.01	0.046	0.040	0.035
	$\mathbf{R_{JC}(u,v)}$	0.051	0.071	0.063	0.052
	$\mathbf{R_O(u,v)}$	0.051	0.071	0.063	0.052
	$\mathbf{R_T(u,v)}$	0.012	0.077	0.043	0.023
Shared Locations	$R_C(u,v)$	0.211	0.280	0.252	0.208
	$R_{U,\mu}(u,v)$	< 0.01	0.133	0.119	0.104
	$R_{U,\sigma}(u,v)$	< 0.01	0.185	0.161	0.137
	$R_{E,\mu}(u,v)$	< 0.01	0.122	0.089	0.074
	$R_{E,\sigma}(u,v)$	< 0.01	0.192	0.164	0.129
	$R_{F,\mu}(u,v)$	< 0.01	0.115	0.099	0.091
	$R_{F,\sigma}(u,v)$	< 0.01	0.109	0.108	0.101
	$\mathbf{R_{JC}(u,v)}$	0.208	0.221	0.187	0.157
	$\mathbf{R_O(u,v)}$	0.208	0.221	0.187	0.157
	$\mathbf{R_T(u,v)}$	0.234	0.159	0.121	0.107
Favored Locations	$\mathbf{R_C(u,v)}$	0.040	0.104	0.085	0.060
	$R_{U,\mu}(u,v)$	< 0.01	0.079	0.075	0.055
	$R_{U,\sigma}(u,v)$	< 0.01	0.082	0.074	0.058
	$R_{E,\mu}(u,v)$	< 0.01	0.082	0.076	0.056
	$R_{E,\sigma}(u,v)$	< 0.01	0.086	0.077	0.057
	$R_{F,\mu}(u,v)$	< 0.01	0.081	0.075	0.055
	$R_{F,\sigma}(u,v)$	< 0.01	0.074	0.071	0.056
	$\mathbf{R_{JC}(u,v)}$	0.040	0.108	0.086	0.059
	$R_O(u,v)$	0.040	0.108	0.086	0.059
	$\mathbf{R_T(u,v)}$	0.020	0.002	0.002	0.003

VII. DISCUSSION AND CONCLUSION

In this paper we have harvested data from different sources of the virtual world of Second Life: First we collected social interaction data between users from the online social network *My Second Life* and second, we collected data from three different and independent location sources, i.e. locations monitored while users were attending events, locations they explicitely share, and their favorite locations. For every single location source we computed 10 features representing the homophily of user-pairs and employed them to predict whether two users had social interaction with each other or not. This section concludes the paper and tries to give answers to the research questions from Section I and provides possible explanations for the results derived from the conducted experiments.

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TABLE III. PREDICTING INTERACTIONS BETWEEN USER-PAIRS WITH SUPERVISED LEARNING BASED ON COMBINED FEATURES OF DIFFERENT LOCATION SOURCES.

Feature Set	Logistic	SVM	Random Forest
Monitored Locations	**0.632**	0.605	0.618
Shared Locations	**0.849**	0.791	0.846
Favored Locations	**0.630**	0.593	0.628

RQ1. To answer the first research question, we evaluated the differences between user-pairs that had an interaction in the online social network and user-pairs without this interaction. This analysis revealed statistically significant differences for nearly all features: User-pairs with interactions on average visited more common regions and had more common observations together. In contrast to this, they visited regions with a lower user-count, frequency, and entropy which can be interpreted as sign of intimacy: Users with interactions already know each other and therefore they meet in places that are less frequented by other users. We could observe this for all three data sources but due to the diverse datasets the characteristics were different: the Shared Locations dataset showed more distinct tendencies than, for instance the picks dataset with the given limit of 10 picks per user.

RQ2. To answer the second research question we employed Collaborative Filtering to predict the social interactions between the users based on 10 different features independently across all location sources. We found that the most valuable features over all the location-based knowledge sources were the number of common regions $R_C(u, v)$, the Jaccard's Coefficient $R_{JC}(u, v)$, and the total number of regions of two users $R_T(u, v)$. Although these characteristics were similar over all sources, we observed differences in the Information Gain. Features applied to the Shared Locations seemed best suited for predicting interactions as the Information Gain was higher if compared to Favored or Monitored Locations.

RQ3. Considering the Information Gain of features applied to the three location sources, we already had the premonition that data obtained from a user's Shared Locations has the highest potential to predict interactions. Indeed, a detailed look at the combined feature sets to predict interactions unveiled that this dataset worked best among all sources. We believe that this is for the following two reasons: First, users can share message from everywhere within the virtual world over their social network and the data collection approach does not miss any data. Second, users explicitly share locations and places they like and spend time in. Other users that visit their profiles because they already know each other, see these locations, and also visit them. This can be seen as an explicit promotion of Shared Locations of a user. We believe that Monitored Location data performed inferior as we only have a clipping of the actual user's visited regions due to limited resources. A similar explanation can be made for the picks data source but here the limiting factor was not the lack of crawling resources but the restriction of 10 picks per user. Overall, the three different learning algorithms applied to the datasets were stable and show similar results over all three sources – Logistic Regression showed the best results whereas Support Vector Machine and Random Forrest were inferior.

For future work we plan to also incorporate the number of social interactions in our predictive model to better account for the strengths of social ties between the users. Furthermore, we plan to account for the variation of time, which we did not consider in this paper.

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REFERENCES

[1] S. Scellato, A. Noulas, and C. Mascolo, "Exploiting place features in link prediction on location-based social networks," in *Proceedings of the 17th ACM SIGKDD international conference on Knowledge discovery and data mining*. ACM, 2011, pp. 1046–1054.

[2] J. Cranshaw, E. Toch, J. Hong, A. Kittur, and N. Sadeh, "Bridging the gap between physical location and online social networks," in *Proceedings of the 12th ACM international conference on Ubiquitous computing*. ACM, 2010, pp. 119–128.

[3] K. Bischoff, "We love rock'n'roll: analyzing and predicting friendship links in Last. fm," in *Proceedings of the 3rd Annual ACM Web Science Conference*. ACM, 2012, pp. 47–56.

[4] M. Steurer, C. Trattner, and F. Kappe, "Success factors of events in virtual worlds a case study in second life," in *Network and Systems Support for Games (NetGames), 2012 11th Annual Workshop on*. IEEE, 2012, pp. 1–2.

[5] M. Steurer and C. Trattner, "Predicting interactions in online social networks: an experiment in second life," in *Proceedings of the 4th International Workshop on Modeling Social Media*, ser. MSM '13. New York, NY, USA: ACM, 2013, pp. 5:1–5:8.

[6] ——, "Acquaintance or partner? predicting partnership in online and location-based social networks," in *Proceedings of the 2013 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining*. ACM/IEEE, 2013.

[7] C. X. Ling, J. Huang, and H. Zhang, "Auc: a statistically consistent and more discriminating measure than accuracy," in *IJCAI*, vol. 3, 2003, pp. 519–524.

[8] M. Al Hasan, V. Chaoji, S. Salem, and M. Zaki, "Link prediction using supervised learning," in *SDM06: Workshop on Link Analysis, Counter-terrorism and Security*, 2006.

[9] M. Thelwall, "Homophily in myspace," *Journal of the American Society for Information Science and Technology*, vol. 60, no. 2, pp. 219–231, 2009.

[10] D. Wang, D. Pedreschi, C. Song, F. Giannotti, and A.-L. Barabasi, "Human mobility, social ties, and link prediction," in *Proceedings of the 17th ACM SIGKDD international conference on Knowledge discovery and data mining*. New York, NY, USA: ACM, 2011, pp. 1100–1108.

[11] S. Scellato, A. Noulas, R. Lambiotte, and C. Mascolo, "Socio-spatial properties of online location-based social networks," *Proceedings of ICWSM*, vol. 11, pp. 329–336, 2011.

[12] R. Guha, R. Kumar, P. Raghavan, and A. Tomkins, "Propagation of trust and distrust," in *Proceedings of the 13th international conference on World Wide Web*. ACM, 2004, pp. 403–412.

[13] D. Liben-Nowell and J. Kleinberg, "The link-prediction problem for social networks," *Journal of the American society for information science and technology*, vol. 58, no. 7, pp. 1019–1031, 2002.

[14] M. Hall, E. Frank, G. Holmes, B. Pfahringer, P. Reutemann, and I. Witten, "The WEKA data mining software: an update," *ACM SIGKDD Explorations Newsletter*, vol. 11, no. 1, pp. 10–18, 2009.

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The Social Responsibility of Online Charge-free Service Providers

Accountability for use of the term "free"

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***Abstract*—In an autonomous market economy that has long been separated from other economies, price-signal information such as profit, cost, productivity, or competition tends to be regarded as a matter of concern, and other information regarded only as noise. In the current business environment, where market-economy principles have spread globally, the majority of business scholars and practitioners seem to believe that only price-signal information is relevant and significant for business organizations. This is epitomized by excessive greed demonstrated by some hedge funds, based on their belief in a neo-liberal law of the jungle. The development of Information and Communication Technology (ICT) has made it possible for business organizations to handle huge amounts of personal data (now referred to as big data) to streamline business operations and enhance customer satisfaction. It has also shortened the life cycle of products and services. Business people in this environment feel it is not fair to handle personal/privacy information data properly, unless it generates short-term profits. In fact, many business people, especially in Japan, consider personal data/privacy protection to be a cost factor and view regulations as an impediment to industry development. This study examines whether privacy could be adequately protected in this socio-economic environment.**

Keywords-personal data/privacy protection; market system; corporate governance; charge free; dilemma.

I. RESEARCH BACKGROUND AND OBJECTIVE

One of the main research-question for this study was "Is the claim of online charge-free services true?" The current market economy is based on price, and price is decided by supply and demand. According to Adam Smith [1], an invisible hand determines optimal price. Why then, are there numerous online charge-free service providers in the digital world? People are fascinated by the magical words "charge free".

There is a system behind charge-free services. People who need services provide their personal data, which have enormous value. Service providers insist that personal data will be managed very carefully, but they are also concerned with maximising profits. Thus, "charge free" does not mean that value is not exchanged because value is not only represented by price systems; rather, this means that privacy equals money.

Recently, the information technology is developing unpredictably fast. A visible or invisible hand (technology and software) could control the optimal price, and also people's mind.

II. STATISTICS-ORIENTED MARKETING METHOD

Research by the Academy of Management (AOM) [2], which always uses a statistics-oriented marketing method, has demonstrated that online charge-free services providers transfer collected personal data to marketing and advertising companies. These data-research companies calculate consumer demand using a statistics-oriented marketing method to identify exact needs. Personal data are obtained by online charge-free services providers, because of consumer fascination with the magical words "charge free".

This recent way of thinking is a neo-liberal idea based on rational expectation theory in which an agent's expectations equal true statistically expected values. An examination of corner advertisements on "Facebook" webpages revealed that companies placed advertisements that exactly fit the consumer profile of the "Facebook" holder. These advertising firms use rational expectation theory.

If the market system were working fair, then the neo-liberalistic idea could fit onto this rational expectation theory. However, there is an idea of counter party, such as the social market economy in Northern Europe.

III. THE PROBLEM WITH THE CURRENT MARKET ECONOMY, AND SUGGESTION FOR THIS SITUATION

A. Corporate Governance

Corporate governance is distinct from management in that it is concerned with how corporate entities are governed rather than with how business entities within those companies are managed. Corporate governance addresses issues facing the board of directors, such as interaction with top management, and relationships with others interested in the affairs of the company, including owners, creditors, debt financers, analysts, auditors, and corporate regulators. Corporate governance affects performance through involvement with strategy formulation and policy making and with corporate conformance through top management supervision and accountability to the stakeholders [3].

In general, there are three theoretical tendencies about corporate governance. Firstly, it is shareholders value theory [4], which has been dominant also, aimed maximizing their

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wealth. The opposite and alternative theory is stakeholder value theory, which includes not only shareholders interest but also stakeholders. Currently, another variety of corporate governance theories [5] has been developed, such as enlightened shareholder value [6] or stewardship theory [7], and so on. This current situation of this tendency shows that one more dimension has been added to business activity, namely the moral one [8]. Such a corporate governance theory includes this ethical idea, which is affecting not only performance but also decision-making.

B. *The Case of Edward Snowden*

This case shows a good example about the failure of bureaucracy. The organization of bureaucracy is good example when we think about the function of governance. Individual privacy protection distracts from the prevention of international terrorism. Government is also seeking their rent from the people.

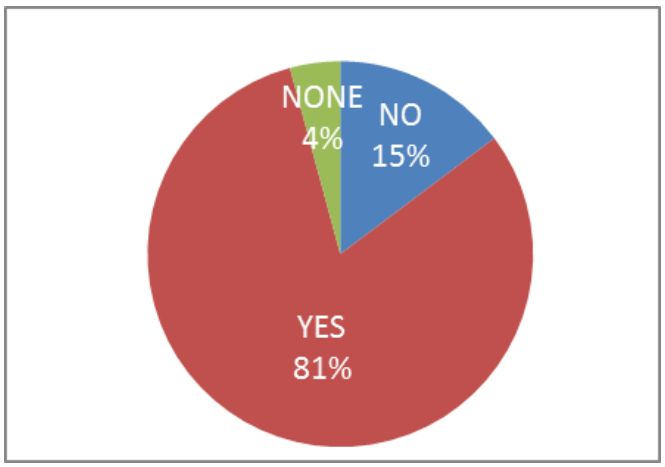

Figure 1. Responses from 92 people to the question, "Is privacy protection important?" .

Edward Snowden is an American, a former technical contractor for the United States National Security Agency (NSA), and former employee of the Central Intelligence Agency (CIA), who leaked details of several top-secret US and British government programs to the press. Does a democratic ideal entail ensuring people's freedom? This is a highly controversial question.

Following the Snowden case, I conducted a survey of 92 male and female students in my lecture at Meiji University asking their opinions on the necessity of privacy (see Figure 1). Results of the survey indicated that 81% of respondents valued privacy protection above freedom. These results not only represent a controversial point of view, but also illustrate a fascinating contrast to the popularity of online charge-free service providers. In fact, the point is that we need to explain what "charge-free" means. It shows that there is insufficient disclosure of information from online service providers.

C. *Dillemma*

Internet users need to be more careful when submitting their personal data to the databases of charge-free service providers. Government agencies could easily access these personal data using regulations, such as the US Patriot Act [9].

The conflict between personal freedom and privacy has always presented a dilemma. One example was mercantilism (absolutism) versus physiocracy in the 16th century [10]. The father of price theory, Adam Smith, resolved this dilemma using the price system and the invisible hand [11]. Mercantilism proposed economic internationalization, and Smith wanted to find a compromise with economic localization, which becomes available through the use of internet (techno-globalization and localization both ways).

This dilemma between freedom and privacy is also illustrated by considering the example of secrecy at Swiss banks (German word; "Bankgeheimnis"). Following World War II, Switzerland developed a bank system that carefully protected bank account privacy, even from prosecutors. This created a tax-haven problem, with people sending their fortunes to Swiss banks to evade their tax duty [12]. These are not "charge-free" services.

D. *Varieties of capitalism*

References to "varieties of capitalism" point to the coexistence of two types of capitalism, such as Liberal Market Economies (LME) and Coordinated Market Economies (CME). The phrase "varieties of capitalism" reflects a new framework for understanding institutional similarities and differences. There is a discussion about the two types or models of capitalism [13]. This suggests the possibility of multiple and divergent forms of capitalism.

This governance point of view, the people's freedom and privacy must be recognized by contemporary capitalism. Therefore, governance should not follow only one "best way", but should be open to the idea of "varieties of capitalism", becoming more diverse and open to many best ways.

Also, corporate governance is affected by two capitalism ideas. Boubaker et al. [8] argues that the ethical idea from the profit-oriented companies is the only way to sustain their activities.

IV. CONCLUSION

This paper discussed the social responsibility of online charge-free service providers. There is a consumer fascination with magical words "charge free". Therefore, online charge-free service providers need to be more accountable about their use of the word "free".

Finally, we need to mention that the several private security companies for the digital world, such as "VeriSign" [14], that provide consultation services to private companies on how to introduce and operate a privacy policy. Many profit-oriented companies feel they do not need to implement fair handling of personal data and proper protection of personal data/privacy. However, an examination of one's "Facebook" page or the Snowden case does not support this

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perspective. This private security companies are also profit-oriented companies.

This paper discussed the following:

1) Research Background and Objective: Research question; "Is the claim of online charge-free services true?" There is a profit system behind the charge-free claim. Service providers sell privacy data to advertising companies, which means the charge-free unidentical no value.

2) Statistics-oriented marketing method: The rational expectation theory estimate in which the agent's expectations constitute true statistically expected values. However, it impose many preconditions, such as the fair market condition. Therefore, it is important to accept the idea of social market economy.

3) Problems of the current market economy and suggestion of this situation:

a) Corporate Governance: There are three theoretical tendencies about corporate governance, such as shareholders value theory, stakeholder value theory and enlightened shareholder value or stewardship theory. Those current tendency shows that the moral is important for business activity.

b) The Case Study of Edward Snowden: People value privacy protection above freedom!? If this is a case one question will come up, why the neo-liberal law has been spreaded out globally. This is a highly controversial question.

c) Dilemma: Swiss banks create a tax-haven problem, where individuals hide their fortunes to avoid their tax duty. These are not "charge-free" services and offer a good example of this dilemma.

d) Varieties of capitalism: Rather than converging on one best way, the idea of "varieties of capitalism" suggests seeking divergence into many best ways.

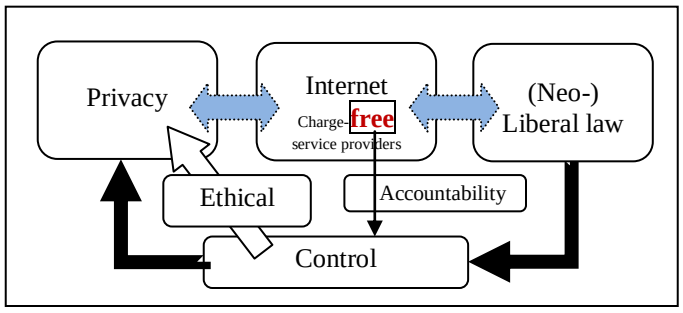

Figure 2. Conceptual diagram

This paper also discussed the coordination between people's rights (privacy protection) and the power of the state (against freedom or control). Increased regulation of online charge-free service providers is needed to promote and insure social responsibility (see Figure 2). There has always been a fascination with the magical words "charge free". However, when considered from the economic viewpoint of free market, where always under the condition of hard competition and strict regulation. Therefore, online charge-free service providers need to be more accountable for the use of the term "free". Also be fair handling of personal data or proper protection of personal data/privacy unless it generates short-term profits.

Figure 2 shows the concept of this paper. If personal privacy is protected, internet technology could ease this protection instead there control. The main dilemma would be easier to solve if online charge-free providers would be more ethical also accountable for use of magical word "charge-free". It is also very important to think about how to best regulate these service providers because it will require international coordination among regulatory systems, i.e., a hybrid system that accommodates many best ways of practicing capitalism.

REFERENCES

[1] A. Smith, "An Inquiry into the Nature and Causes of the Wealth of Nations" Volume 1 Paperback, Liberty Fund, Inc. USA, 1982.

[2] D. Malhotra and F. Lumineau, "Trust and Collaboration in the Aftermath of Conflict: The Effects of Contract Structure," Academy of Management Journal, vol. 54, no. 5, pp. 981–998. 2011,

[3] R. I. Tricker, "International Corporate Governance," Prentice Hall, p. xi, Blackwell Pub, USA, 1994.

[4] M. C. Jensen, "Value Maximization, Stakeholder Theory, and the Corporate Objective Function," Harvard Business School, USA, Working Paper No. 01-01, 2001.

[5] M. Aoki, "Corporations in Evolving Diversity: Cognition, Governance, and Institutions (Clarendon Lectures in Management Studies)," Oxford University Press, USA, 2010.

[6] D. Millon, "Enlightened Shareholder Value, Social Responsibility, and the Redefinition of Corporate Purpose Without Law," Washington & Lee Public Legal Studies Research Paper Series, Working Paper, Virginia, 2010.

[7] R. I. Tricker, "Corporate Governance: Practices, Procedures and Powers in British Companies and Their Boards of Directors," Ashgate Publishing Limited, UK, 1984.

[8] S. Boubaker, B. D. Nguyen, D. K. Nguyen, "Corporate governance : recent developments and new trends", Springer, Cambridge., S. Andreadakis, "Enlightened Shareholder Value: Is It the New Modus Operandi for Modern Companies?", pp. 415-432, 2012.

[9] O. J. Kirkaldy, "Privacy & the New Panopticon: Lawful Access and The Race Between Law and Technology in the War on Terror", University of Alberta, Edmonton, Alberta, 2008.

[10] K. Saeki, "Made a mistake in Adam Smith's calculation," PHP Books, Japan, 2009.

[11] K. Saeki, "Prediction of J. M. Keynes," PHP Books, Japan 1999.

[12] P. A. Hall and D. Soskice, "Varieties of Capitalism: The institutional foundations of comparative advantage," Oxford University Press, New York, 2001.

[13] C. Buechenbacher, "Tatsachen ueder das Schweizerische Bankgeheimnis," Marcel H. Huber, Zürich, 1977.

[14] Yohko Orito, Kiyoshi Murata and Yasunori Fukuta, "Do Online Privacy Policies and Seals Affect Corporate Trustworthiness and Reputation?," International Review of Information Ethics, vol. 19, pp. 52-65, 2013.

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Decision Markets for Continuously Reflected Collective Decisions

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***Abstract*—The application of the market metaphor to forecasting uncertain future events exhibits appealing characteristics such as forecast accuracy and being considered attractive by most users. Based on the demonstrated success of such so called prediction markets as an accurate forecasting mechanism, the market metaphor has been applied to related domains such as decision making and decision support in order to benefit from its attractive characteristics. However, not all of those characteristics still hold in these application areas. We currently develop Liquid Decision Making (LDM), a market based approach for group decision making. This article reports on three design principles that we devised to address the aforementioned challenges, namely the principles of a collaborative decision making situation, a personal involvement of the participants with the decision at hand and dual incentives provided to the users. A prototypical implementation of this LDM mechanism has been tested for decision making in a scenario building seminar. There, participants gathered, categorized and ranked driving factors for their relevance for scenarios to be developed for the topic of *personalized mobility in 2050*. In this setting, the design principles of the mechanism were deemed to be viable for addressing the challenges of attracting and retaining participants.**

***Keywords*—decision making; market design; incentives**

I. INTRODUCTION

Decisions often need to be made, or benefit from being made, by a group of people as they contribute with different perspectives, knowledge and evaluation criteria. The alternatives of the pending decision thereby often need to be considered over a prolonged period of time in order to gather as much relevant information as possible and to allow for informed opinions to be formed. In such circumstances, not all consequences of all available alternatives can be comprehensively considered due to time and informational limitations. Additionally, group members may be heterogeneous in their assessment criteria for the decision alternatives. Engaging a large and heterogeneous group of people to produce a joint result is a main theme of social media [1]. One of these social media methods is the application of the market metaphor. In such decision making situations as delineated above, the market metaphor poses a promising alternative to conventional group decision making approaches. Economic markets have been attributed the ability of efficiently aggregating information from people and representing it in the resulting price [2]. The goal in the application of the market metaphor to decision making is to jointly achieve a decision. The market metaphor thereby offers continuous participation, revisability of one's assessments, immediate feedback on one's actions, anonymity and an intuitive representation of the users' assessments in the market prices. It furthermore encourages decisiveness and first-mover behavior as hesitant and indecisive participants may lose influence due to increasing prices and unwisely spent money. In a market based decision making approach, the decision is represented by a market and the decision alternatives are traded as stocks on that market. Participants buy shares of their favored decision alternatives and sell shares of the unwanted alternatives. At market end, the highest ranking stock of that market is chosen as the jointly determined decision alternative.

Any mechanism based on continued contributions by participants needs to attract and retain users. Markets are no exceptions. In the application as a forecasting mechanism in so called prediction markets, attracting and retaining users is achieved by rewards such as real or play money or reputation that can be granted to participants based on forecast accuracy. There, every participant's ambition to maximize his reward by providing an accurate forecast of the outcome serves the goal of the organizer of attaining such an accurate forecast. Hence, prediction markets are incentive compatible in game theoretic terms. In a decision making situation, however, such performance based rewards are likely to bias the contributions of the participants towards predicting market results instead of contributing their true assessments. This phenomenon is known as the Keynesian beauty contest in which participants try to guess the actions of others and adapt their behavior accordingly [3]. Results of such markets then reflect the average evaluation of the average assessments of participants rather than the aggregation of their true opinions on the respective topics.

Thus, other measures for attracting and retaining users are desirable. We currently develop our LDM mechanism for group decision making that utilizes the market metaphor [4]. To address the aforementioned challenges, we formulated the following principles for the design of LDM. The collaborative decision principle emphasizes the collaborative nature of the LDM approach as people utilize it for jointly determining a decision alternative. It aims at attracting people by the ability to collaboratively identify the decision outcome rather than by speculative prospects. The principle of user involvement ensures that people care for the actual outcome of the market. The more they are personally involved with the result of the market, the more they should be willing to care about the resulting decision alternative and to participate in the market in the first place. The principle of dual incentives caters to the demand of attracting and retaining users by providing push and pull style information to the participants. Market information pushed to participants on a regular basis should encourage users to participate repeatedly. The availability of up-to-date market information on demand should also contribute to the

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level of participation.

Despite these design principles, users may nevertheless participate not according to the market goal of achieving a joint decision. Thus, LDM furthermore incorporates an approach for determining the sincerity of the single contributions by a price perturbation mechanism [5].

The design principles of LDM are introduced in Section II. Furthermore, our prototypical implementation of LDM is delineated. Based on this prototype, a case study has been designed and executed (see Section III-A). The results of the case study are examined in Section III-B. Related work is surveyed in Section IV. Section V concludes and highlights future work for LDM design and potential applications.

II. The Liquid Decision Making Mechanism

In this section, the design principles of LDM are introduced and a prototypical implementation for testing their adequacy is highlighted.

A. The Liquid Decision Making Design Principles

Attracting and retaining participants are special challenges in the application of the market metaphor to decision making. Among the benefits of the market metaphor are the capability of accommodating a large group of people and the potential for continued participation over a prolonged period of time. However, these benefits need to be made palatable for prospective users for them to actually participate. LDM on the one hand seeks to allow group members to contribute their assessments of the single decision alternatives and on the other hand to provide them with incentives for repeated participation. The design follows the principles of a collaborative decision goal achieved with the market metaphor, involvement of the participants with the decision outcome at hand and dual incentives for participation in order to meet those goals. The design principles aim at encouraging certain behavior in participants. These considerations result form observations from the literature and own case studies. Participants in prediction markets are typically assumed to be utility maximizing and to derive this utility from the benefits they expect in return for their participation. We decided to keep up with this assumption and to investigate how we need to design LDM for directing the utility maximizing behavior in helpful lines with respect to the decision making goal.

1) The Collaborative Decision Principle: Markets naturally provide incentives for speculation and gambling by their utilization of real or play money as a voting medium and the associated potential for gains and losses. Participants may primarily follow such speculative considerations in order to gain money instead of bearing the actual decision in mind. Such trading is comparable to technical trading which only deals with trends and correlations without considering the fundamental values of the respective stocks [6]. The collaborative decision principle emphasizes the collaboration of people to find a joint decision alternative using the market metaphor and, to this end, acknowledge the market result as the chosen alternative for the decision. Thus, LDM reduces sources of utility maximizing behavior that do not contribute to the achievement of a joint decision by omitting market information that may fuel market gambling or speculative market trading behavior. People should be drawn to participate rather by the topic than by the market mechanism.

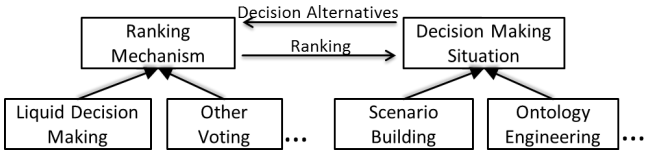

Fig. 1: The integration of the market metaphor with decision making

Fig. 1 depicts this principle as the integration of a decision making effort with a ranking mechanism. There, the decision alternatives are ranked using some mechanism and the resulting ranking is returned to the decision making effort for further processing.

2) The User Involvement Principle: With prediction markets, participants can be rewarded for accurately forecasting a future event. Thus, they are likely to care for providing an accurate forecast. Decision markets cannot rely on such accuracy metrics as there is no external event defining an objective measure. Thus, other means for encouraging meaningful contributions are desirable. The principle of user involvement regards the degree of personal relationship the participants exhibit with respect to the decision outcome. Personal involvement here denotes how much a user is affected by the resulting decision outcome. The more involved, that is, affected, a user is with the decision outcome, the more utility he is likely to derive from the actual outcome. Maximizing this utility would then consist of contributing meaningfully to the selection of a decision alternative and to observe the process and to react to the actions of others. Thus, the user involvement principle stipulates the application of LDM in situations with a significant degree of participants' involvement with the decision outcome. In this way, users should perceive the mechanism as attractive and continually come back. Prediction markets correspond to the common notion of crowd sourcing, that is, the division of an extensive task among many people and of aggregating their partial results. These participants typically only care for their allocated work share and for achieving the associated reward. With LDM on the contrary, a potentially large group of people participates specifically in order to achieve the overall goal of making a collective decision.

3) The Dual Incentives Principle: Decision markets enable participants to take an active part in determining a decision alternative and to revise their assessments of the alternatives during that process. However, people often need to be incentivized to participate in such a decision making effort. LDM has been designed with dual incentives in mind for both attracting and retaining users. For attracting people to participate for the first time, the goal of this principle is to feature a decision that participating in is beneficial for prospective users. This benefit then needs to be highlighted comprehensibly to participants. For retaining users, that is, encouraging their repeated participation, this principle encompasses the provision of up-to-date market information to participants. Up-to-date information supports the striving for utility maximization. This information should be both available on request by the participants and pushed out to participants as a periodic reminder of the decision making effort. In this way,

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participants receive information on the status of the market and their favored alternatives in particular and are encouraged to visit LDM on a regular basis.

B. The Liquid Decision Making System

We currently develop a prototypical LDM system for investigating market-based decision making. This system formed the basis for examining the adequacy of the introduced design principles. The system is realized as a web-based software in order to facilitate an ease of use without the need for a local installation, a low entry barrier due to a familiar web interface and a distributed participation. The software allows for surveying the available cash reserve, the tradable decision alternatives, their prices and rankings, for trading in the single decision alternatives, for proposing additional decision alternatives, for accepting or rejecting the proposals as well as functionality for commenting on trading actions and decision alternatives and for ranking a comment's helpfulness.

The design principles are realized in the following new functionalities of LDM. For emphasizing its collaborative nature, only little information is offered which could fuel speculative behavior or gambling. In this case, the LDM system does not calculate the portfolio worth of each participant and does not compile a user ranking from it. The lack of this striking cue on the ranking of participants should contribute to lowering the temptation of gambling behavior in the market. Furthermore, the system provides a ranked list of the decision alternatives so that every participant can identify the currently selected joint decision alternative. Fig. 2 depicts such a ranking utilizing a bold font for the collectively chosen decision alternatives.

The involvement of the users is ensured on the one hand by providing a meaningful decision to participants. On the other hand, additional functionality may also increase the involvement of users. To foster the involvement of users, the LDM system offers functionality for commenting on the single decision alternatives and on trading actions by the users. Comments can also be rated by participants for their helpfulness. This is to stimulate further engagement with the single decision alternatives. In this way, their involvement should be intensified.

The formulated dual incentive principle summarizes present market functionality as a specific requirement for addressing the decision market design challenges. It is reflected in the LDM system in two ways. First, the goal and utilization

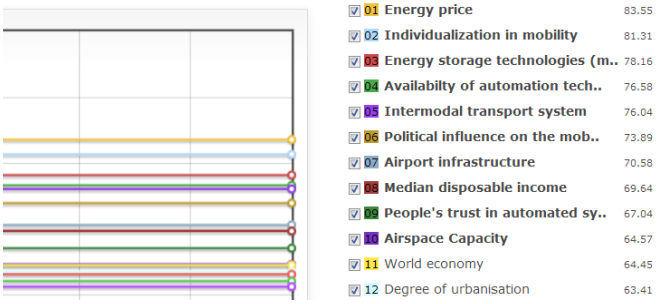

Fig. 2: Detail of the price chart and factor ranking indicating the collectively chosen factors in bold face from the case study

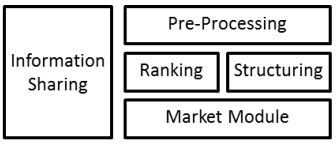

Fig. 3: Architecture of the prototypical LDM implementation

of the result are clearly stated on the system website in order to attract participants for their sincere opinions. Second, up-to-date information is provided to participants, including an overview on the general market status and the decision alternatives and the respective holdings in particular. This information is provided to participants as a push notification realized by a newsletter and a pull notification in the form of a LDM system dashboard. The newsletter acts as a periodic reminder to return to the system and contains information on the development of the market status since the last issue.

The emphasis on collaborative decision making is also reflected in the system's architecture. The domain-specific collaboration part and the market-specific trading part are separated into different modules (see Fig. 3). The preprocessing module is responsible for the contribution mechanism for new factors and their examination by the organizer. This preprocessing module allows the contribution of factors to a public queue. This queue is then processed by designated participants for admission or rejection. Reasons can be given for each. Then, the ranking and structuring takes place. Both of these modules utilize the market functionality of the underlying market module. The information sharing module is responsible for commenting and comment rating.

Many decision alternatives may need to be considered in LDM. Thus, participants may spread over the single alternatives and hence may not find matching counterparts for trading. LDM therefore employs the market maker approach with a central entity acting as a middle man for trading. With such a market maker, trades can be executed by participants at any time with an immediate response from the system [7].

III. The Liquid Decision Making Case Study

Determining the adequacy of a given approach requires a systematic investigation. A first step in such a series of analyses is a case study for collecting qualitative experience with the proposed approach. In the following, the design, execution and evaluation of a case study are presented, which has been executed for testing the effectiveness of the design principles and the applicability with a scenario building process.

A. The Case Study Design and Execution

LDM has been tested in conjunction with a two week university seminar on scenario building at the Technische Universität München, termed *Szenario-Börse* (engl. scenario stock exchange). The topic of this seminar was the development of future scenarios for a personalized mobility in the year 2050. Nine bachelor students participated in the seminar by choice in partial fulfillment of their curriculum. The goal for the students was to learn the methodology of scenario building and to apply it to the topic of personalized mobility. The goal of the scenario building methodology is to produce

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a couple of consistent scenarios for a topic concerning the future based on a selected set of influencing factors. The methodology basically includes the identification, gathering and assessment of potential influencing factors, the selection of the most relevant factors, the generation of initial scenarios based on the selected influencing factors and the formulation of plausible pictures of the future [8].

The goal of this case study was to investigate the application of LDM with the scenario building methodology and the impact of our design principles. For the application of LDM with the scenario building, we chose to utilize LDM for making the decisions regarding the gathering, assessment and selection of the influencing factors as an input for the further building of the scenarios. We furthermore employed LDM to gather the experience that the students had gained with the factors after the scenarios had been generated.

The ranking functionality of LDM was utilized for ranking the influencing factors according to their relevance in the generation of the single scenarios as well as for categorizing the factors with respect to the predefined categories of society, technology, environment, economy, politics, values and air transport. In order to provide sufficient time for identifying and gathering factors, we started the decision making system three weeks prior to the actual scenario building seminar. For that pre-seminar period, we expanded the number of participants by 11 additional people from the organizing institutions in order to bring in more diverse knowledge on the subject. During that period, the tasks of the participants comprised the contribution of new factors, the ranking of existing factors and the assessment of their categorizations as well as commenting on factors and trading actions and rating the helpfulness of those comments. Suggested factors were queued and processed by the organizer of the seminar for admission. All participants were given an introductory written tutorial on the system functionality and their tasks prior to the opening of the Szenario-Börse. Participants were required to register with the system in order to track their market actions, cash reserve and share holdings. Anonymity was guaranteed by freely selectable user names. Upon registration, each participant received the same initial endowment of play money that was not redeemable in real currency. According to Servan-Schreiber et al., play money should not significantly impact market results [9].

At the beginning of the scenario building seminar, two trading sessions were held with only the nine students participating as they would have to work with the chosen factors. They were granted additional money for finally selecting the 10 most relevant factors that were to be used as input to the further development of the scenarios. After the second trading session, the market was still open for trading in the factors, however, the scenarios were built based on the 10 highest ranking factors as determined after the second session. At the end of the scenario building seminar, the LDM system was utilized in a third trading session for enabling the participants to reflect their insights on the relevancy of the factors that they gained during the scenario building seminar. After the end of the scenario building seminar, a user survey was conducted for gathering feedback on various aspects of the LDM approach.

B. Evaluation and Discussion of the Case Study Results

The goal of this case study was to investigate the application of LDM in a decision making situation and to gather qualitative experience with our devised design principles in the context of the scenario building seminar. The evaluation of the success of the design principles is based on the post-seminar survey among the students, their qualitative feedback during the seminar and on experience from prior LDM installments that did not fully respect these principles. Overall, LDM was applied successfully with the scenario building methodology, the design principles seemed to be promising for achieving their aspired results in the design of LDM and the prototypical system deemed useful. Participants made use of the continuous nature of the LDM system as is reflected in the total number of 1545 trades, with a maximum of 333 trades, a minimum of 3 trades and a mean of 71 trades per person. The ratings in the following refer to the survey using a Likert scale ranging from 1 (does not apply) to 5 (completely applies). The prototypical implementation of LDM was rated by participants as relatively easy to use (mean of 3.1) and as providing relevant information with a mean of 3.1.

The application of LDM to scenario building was successful as participants of the scenario building seminar achieved a joint selection of the most relevant factors. This was validated by the organizer of the seminar who confirmed the relevance of the selected factors. Furthermore, participants appraised the results immediately after the factor finalization as valuable. In the post-seminar survey, they were also satisfied with the factor selection approach with a mean of 3.0 and they rated the adequacy of the selected factors with a mean of 3.3. 25 additional factors were contributed with 18 of them accepted for trading. Finally, the three future scenarios created by the students were rated very well by the organizer of the seminar.

The factors for the scenario building were collaboratively ranked using the Szenario-Börse for their relevance. In the provided information in the Szenario-Börse, the emphasis was on the joint decision making goal rather than on market gambling. Overall, participants rated the provided information to be relevant for the joint goal with a mean of 3.1. They furthermore did not object to the produced factor selection in a discussion session right after the selection and accepted the result as the jointly produced input to the further scenario generation. Two participants criticized the lack of more in-depth market information similar to tools for stock market brokers. The demand for more market-related information is an indicator for the effect of the collaborative decision principle as applied in this case study. The relationship between personal involvement, provided quality of market information and gambling should be interesting to investigate in further, more controlled, experiments in more detail.

The students had to work with the factors further in the scenario building process that were determined by the Szenario-Börse. In this way, they had a personal interest in selecting meaningful factors for further processing. This user involvement was perceived as a motivation for trading with a mean of 3.2 by the students. The produced scenarios were also highly acclaimed by the seminar organizer. This points to the importance of providing a tangible personal involvement and thus meaning for participants in such a mechanism. The third trading session aimed at aggregating the knowledge that the

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students gained during the generation of the single scenarios. However, the result of this third session had no personal impact for them and the achievement of the group goal. According to comments in the post seminar survey, users were more drawn to gambling efforts in this session than in the trading period prior to the selection of the relevant factors. This apparently underlines the importance of the user involvement principle for the design of LDM. The LDM system also provided functionality for commenting on decision alternatives and trade actions. This was utilized for 30 comments during the Szenario-Börse. Presumably, this relatively low utilization was due to a low interest in the opinion of the other participants or the expectation to discuss matters in person at the beginning of the actual seminar. For future work, it may be helpful to provide additional incentives for providing helpful comments such as additional money.

In this case study, the Szenario-Börse provided a meaningful decision as the students had to work with the resulting factors further on in the scenario building process. According to the survey, this served as an incentive to participate in the Szenario-Börse with a mean of 3.3, which is also reflected in the average logins of two to five times a week. They furthermore liked the immediate price feedback with a mean of 3.3. Thus, attracting and retaining users seem to have worked.

IV. Related Work

The market metaphor has been applied in several domains and has been investigated from several points of view. This section puts the work at hand in the context of existing work.

A. Related Market Applications

The design of LDM rests on the involvement of the participants, the provision of decision aligned incentives and the setting of a joint decision making goal. Historically, the market metaphor has first been applied in prediction markets for forecasting the outcome of uncertain future events [10]. There, the price mechanism aggregates individual forecasts into a joint prediction of the most likely outcome of the uncertain event [11]. Such prediction markets typically exhibit the characteristics of principal-agent situations in which the principal needs some work to be carried out and offers agents a reward for executing this work properly [12]. In contrast to LDM, agents are not personally involved with the task set out by the principal, incentives are based on the agents' performance in the market mechanism and optimizing this performance is aligned with meeting the goals of the principal.

Hanson first proposes the utilization of the market metaphor for making conditional predictions in what he calls *decision markets* [13]. There, participants forecast the likelihood of future outcomes conditional on the implementation of certain actions. Berg and Rietz as well as Chen investigate conditional prediction markets as a basis for making decisions in order to influence the actual outcome of the future event [14][15]. Abramowicz and Henderson focus on conditional prediction markets in a corporate setting and their forecast accuracy as well as on enhancements in the information flows in a corporate environment [16]. In these settings, the goal of the market application shifts from a pure prediction to the support of selecting strategic actions, however, the principal-agent characteristics still apply.

The information aggregation capabilities of the market metaphor are also utilized for selecting all sorts of innovations and ideas in so called *preference markets*. Such preference markets are used to select ideas in a corporate setting [17][18], to gather product feature preferences [19] and to select innovations for corporate research portfolios [20]. In such preference market settings, the market metaphor is typically employed in a principal-agent fashion. In particular, participants are not personally involved with the topics at hand and are rewarded based on their in-market performance, e. g. , the highest-valued portfolio. Thus, participants are found to engage in beauty contests and trade according to two different motivations, namely truthful reporting and market speculation. This, however, does not contribute to the revealing of the participants' true assessments. Kamp et al. devise a model of influencing factors for such situations [21]. In their model, the nature of the incentives plays a central role for influencing the behavior of participants. They conclude that incentives should be aligned with the market purpose to avoid feeding speculative behavior.

Chen et al. investigate the provision of proper incentives in conditional prediction markets for decision making. In their principal-agent situation, the agents are rewarded based on which action is finally chosen. The agents thus have incentives to influence the principal on which action to take [23]. They design a market mechanism that discourages trying to profit from real world influence. In LDM, participants directly influence the selected decision alternative via the market result without a principal making the final decision. Thus, there is no need for exerting real world influence on some principal. Furthermore, our LDM design assumes a personal involvement of participants and hence meaningful contributions. Nevertheless, participants may not contribute meaningfully for some reason. We thus designed an approach for uncovering the origins of price formations [4] and tested the pertinence of this approach in a lab study [5].

B. Related Decision Making Approaches

The market approach of LDM allows each participant to express his preference for a given *stock* (representing an alternative in a decision to be made) through trading actions. This makes a participant's preference for trading a stock the single decision criterion. Based on the resulting prices of all participants' trading behaviors, a ranking of the decision alternatives is then produced. A number of different prioritization strategies as well as different decision criteria are applied by decision making methods and are discussed in the literature. The Analytical Hierarchy Process (AHP) is a framework for multi-criteria decision-making developed by Thomas L. Saaty [24]. AHP is applied in many different domains, including software engineering [25] and strategic business planning [26]. Using AHP includes the definition of several criteria that are evaluated for each decision alternative by each stakeholder using a scale ranging from 0 to 1. The different assessments are then aggregated into a single indicator using the approach of AHP. AHP provides a rational approach to decompose a decision problem into sub-problems that can be evaluated by the decision makers. An important objective of the LDM mechanism is to enable collaborative decision making. Using a multi-criteria approach such as AHP to decompose a decision problem, serves this objective to some extent. But as Hall and Davis [27] are pointing out, the interpretation of such

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criteria is framed by the different value-based perspectives of the decision makers. When reaching out to a large group of heterogeneous decision makers, the involved perspectives may address different domains, including technical, social and economic aspects. It is thus obvious that a single set of criteria cannot reflect the perspectives of all decision makers in such contexts. The use of a single decision criterion in LDM may lack some of the accuracy as found in multi-criteria decision methods such as AHP, but it enables all decision makers to express their particular perspective into a buy/sell preference.

V. Conclusion and Future Work

In this article, the design principles of a collaborative decision, personal user involvement and dual incentives have been introduced that we formulated for achieving meaningful results with LDM. The design principles and our prototypical LDM system have been tested in a case study for building scenarios for personalized transport in the year 2050. In this case study, the devised principles seemed to be adequate for the design of LDM and the approach deemed applicable with the scenario building methodology. According to the study findings, an application of LDM should be organized in such a way that users perceive LDM as a means for collaboratively making decisions rather than for gambling, that users are involved with the resulting decision as a proper incentive for meaningful participation and that dual incentives are provided for attracting and retaining users with the mechanism.

We plan the following strands of future work. Based on the experience gained from the case study regarding the scenario building process, we plan to refine the design principles of LDM, for example in strengthening user involvement through competitive and collaborative elements and in providing additional retaining incentives that encourage continued participation. Further investigations, particularly in controlled experiments, should help establish the precise impact of the single design principles. Second, we envision the application of LDM for collaborative ontology engineering. There, contributions and opinions of many stakeholders need to be gathered and reconciled in order to form a joint ontology. In this reconciliation process, conflicts, both on the logical and collaborative level, are likely to occur. The application of the market metaphor as a conflict resolution mechanism in collaborative ontology engineering by ranking the available conflict resolutions using decision markets seems to be a feasible approach.

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References

[1] A. Doan, R. Ramakrishnan, and A. Y. Halevy, “Crowdsourcing Systems on the World-Wide Web,” Commun. ACM, vol. 54, April 2011, pp. 86–96.

[2] F. A. Hayek, “The Use of Knowledge in Society,” American Economic Review, vol. 35, no. 4, 1945, pp. 519–530.

[3] J. M. Keynes, The General Theory of Employment, Interest, and Money. Macmillan Cambridge University Press, 1936.

[4] S. Leutenmayr, F. Bry, T. Schiebler, and F. Brodbeck, “Work in Progress: Do They Really Mean It? Assessing Decision Market Outcomes,” in Proceedings of 4. Workshop Digitale Soziale Netze, 41. Jahrestagung der Gesellschaft für Informatik, Berlin, Germany, 2011.

[5] S. Leutenmayr and F. Bry, “Liquid Decision Making: An Exploratory Study,” in Proceedings of the 13th International Conference on Information Integration and Web-based Applications and Services, ser. iiWAS ’11. New York, NY, USA: ACM, 2011, pp. 391–394.

[6] J. J. Murphy, Technical Analysis of the Financial Markets: a Comprehensive Guide to Trading Methods and Applications, ser. New York Institute of Finance Series. New York Institute of Finance, 1999.

[7] R. Hanson, “Logarithmic Market Scoring Rules for Modular Combinatorial Information Aggregation,” Journal of Prediction Markets, vol. 1, no. 1, 2007, pp. 3–15.

[8] H. D. Jouvenel, “A Brief Methodological Guide to Scenario Building,” Technological Forecasting and Social Change, vol. 65, no. 1, 2000, pp. 37–48.

[9] E. Servan-Schreiber, J. Wolfers, D. M. Pennock, and B. Galebach, “Prediction Markets: Does Money Matter?” Electronic Markets, vol. 14, no. 3, 2004, pp. 243–251.

[10] R. Forsythe, F. Nelson, G. R. Neumann, and J. Wright, “Anatomy of an Experimental Political Stock Market,” The American Economic Review, vol. 82, no. 5, 1992, pp. 1142–1161.

[11] J. Wolfers and E. Zitzewitz, “Prediction Markets,” Journal of Economic Perspectives, vol. 18, no. 2, 2004, pp. 107–126.

[12] J.-J. Laffont and D. Martimort, The Theory of Incentives. Princeton, New Jersey: Princeton University Press, 2002.

[13] R. Hanson, “Decision Markets,” *IEEE Intelligent Systems*, vol. 14, no. 3, 1999, pp. 16–19.

[14] J. Berg and T. Rietz, “Prediction Markets as Decision Support Systems,” Information Systems Frontiers, vol. 5, no. 1, 2003, pp. 79–93.

[15] Y. Chen, “Markets as an Information Aggregation Mechanism for Decision Support,” Ph.D. dissertation, Pennsylvania State University, School of Information Science and Technology, 2005.

[16] M. Abramowicz and M. T. Henderson, “Prediction Markets for Corporate Governance,” Notre Dame Law Review, vol. 82, no. 4, 2007.

[17] C. A. LaComb, J. A. Barnett, and Q. Pan, “The Imagination Market,” Information Systems Frontiers, vol. 9, no. 2-3, 2007, pp. 245–256.

[18] E. Bothos, D. Apostolou, and G. Mentzas, “Idea Selection and Information Aggregation Markets,” in Engineering Management Conference, 2008, pp. 1–5.

[19] E. Dahan, A. Soukhoroukova, and M. Spann, “New product development 2.0: Preference Markets – How Scalable Securities Markets Identify Winning Product Concepts and Attributes,” Journal of Product Innovation Management, vol. 27, no. 7, 2010, pp. 937–954.

[20] C. Gaspoz, J. Ondrus, and Y. Pigneur, “Comparison of Multi-criteria and Prediction Market Approaches for Technology Foresight,” in Proceedings of the 13th AIM Conference, 2008.

[21] G. Kamp and P. A. Koen, “Improving the Idea Screening Process within Organizations using Prediction Markets: A Theoretical Perspective.” Journal of Prediction Markets, vol. 3, no. 2, 2009, pp. 39–64.

[22] D. R. Raban and D. Geifman, “Designing Online Information Aggregation and Prediction Markets for MBA Courses,” Interdisciplinary Journal of E-Learning and Learning Objects, vol. 5, 2009, pp. 247–262.

[23] Y. Chen, I. Kash, M. Ruberry, and V. Shnayder, “Decision Markets with Good Incentives,” in Internet and Network Economics, ser. Lecture Notes in Computer Science, N. Chen, E. Elkind, and E. Koutsoupias, Eds. Springer Berlin / Heidelberg, vol. 7090, 2011, pp. 72–83.

[24] T. L. Saaty, The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. McGraw-Hill, 1980.

[25] J. Karlsson and K. Ryan, “A Cost-Value Approach for Prioritizing Requirements,” Software, IEEE, vol. 14, no. 5, 1997, pp. 67–74.

[26] R. K. Singh, “Prioritizing the Factors for Coordinated Supply Chain using Analytic Hierarchy Process (AHP),” Measuring Business Excellence, vol. 17, no. 1, 2013, pp. 80–97.

[27] D. J. Hall and R. A. Davis, “Engaging Multiple Perspectives: A Value-based Decision-Making Model,” Decision Support Systems, vol. 43, no. 4, 2007, pp. 1588–1604.

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Deregulation in the Field of Games on Chance/on-line Gambling – in Favour of Citizens

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Abstract— **When we discuss the games on chance regulatory framework, we cannot miss one of its major parts: the on-line gambling issues. The regulation of this area is of outmost importance because of its social impact, such as protection of minors, protection of consumers, large possibility of addiction problems and money laundering. At the moment, there is no compliance with these rules at the European Union (EU) level. The only source of secondary law in this area, at the moment, is the European Court of Justice case law. Problems with on-line gambling have been rising permanently since the Internet became more and more popular. This area has been one of the fastest growing industries in the past ten years. Along with that, the questions of cross-border gambling issues are arising as well. Gambling is recognized as one of the fastest growing social problems. This article explores the possibility of protecting citizens/consumers from bad influences that are caused by on-line gambling. We are certain that one of the possibilities is to comply and regulate the rules dealing with this issue. The EU Law gambling sector is regulated by the rules of free movement of services and, according to those provisions, the operators are authorized to provide services from one European member state to another. The Member states can restrict that freedom only by overriding reasons in the public interest. According to the recent trends, the restrictions imposed to on-line gambling by each member state vary from being lawful to being illegal. This article gives an overview of the current situation in the EU legislation and stresses out the suggestions on what type of regulation is the best for EU citizens.**

Keywords-games on chance; on-line gambling; EU regulation; freedom to provide services; EU law.

I. INTRODUCTION

This paper is focused on on-line gambling, bearing in mind that, in most European Union member states, a restrictive regime governs the gambling, consisting of prohibitions, state operations, monopolies or restrictive licensing regimes, depending on the type of gambling [1].

Games on chance are of special interest for the states and, of course, for the citizens. Regarding the state, there is a benefit from the high income that comes from the taxes, but, on the other hand, it should be regulated and supervised. Closely connected to the games on chance are potential criminal issues like money laundering, addiction and illegal activities. In Europe, after a decade of market liberalization, which has been specially underlined through the technological development, organizing the games on chance is still exempt from the scope of Services directive on the Internal Market. This means that the EU member states are entitled to organize and, therefore, to restrict that freedom only by overriding reasons in the public interest (like consumer protection), public health and prevention of fraud under the subsidiary principle. Also, the Treaty on the Functioning of the European Union (TFEU) [6] principles of equal treatment, non-discrimination and proportionality should be taken into consideration when justifying the restrictions of free movement.

There are currently two different regimes of the national regulatory framework within the member states applied in the area of gambling: one based on licensed operators providing services within a strictly regulated framework and another on a strictly controlled monopoly (state owned, or otherwise) [7]. Different regulatory regimes applied to various traditional forms of off-line gambling can cause situations of legal uncertainty, which, among possible regimes, can be applied to on-line gambling [1]. According to the recent trends, restrictions imposed to the online gambling in each member state vary from being lawful to being illegal. In six member states, on-line gambling is illegal (Cyprus, Germany, Estonia, Greece, the Netherlands and Poland) and seven member states impose prohibitions on specific types of on-line gambling, such as on-line casinos and on-line games (Belgium, France, Finland, Hungary, Lithuania, Portugal and Slovakia) [8]. Some jurisdictions also distinguish home state providers established on their territory and foreign providers, and the regulation may apply only to home state providers or only to foreign providers, or to both [1]. The regulators are also entitled to make a distinction between gambling services provided domestically only and services provided to

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residents in foreign jurisdictions (outgoing services). Some regulators prohibit gambling services from being provided domestically, but allow gambling operators established on its territory to provide such services to foreign jurisdiction only (outgoing services) [3]. These differences are described in the Table I, where the regulatory matrix for different situations within the games on chance regulatory framework is given. The situations detected differ whether the service is provided by home state or foreign providers and also for whom the service is provided, whether for home state or for foreign consumers.

TABLE I. REGULATORY MATRIX

Regulatory matrix		
	Home state providers	***Foreign providers***
Home state consumers	Home state services prohibition/monopoly /license	Incoming services prohibition/license
Foreign consumers	Outgoing services Prohibition/license/	Xxx

Traditionally, land based casinos have been restricted to particular territory and the regulatory controls have been applied to that territory, which is not possible to achieve with on-line gambling [16].

The prohibition aims at preventing the risk of social harms, such as gambling addiction, gambling by minors, association with crime and money laundering, consumer fraud. From the economic point of view, the restrictions usually form barriers of entry and possibility to operate on the market for on-line gambling. The result is reduced supply. According to the authors, the restrictions are only effective in minimizing the supply if they are effectively enforced and enforcement may be hampered by the gambling operator avoiding the operation from abroad, lack of resources and/or technological circumvention [19].

Gambling as a state monopoly is always under (or must be under) control of activities and taken steps are usually in favour of accomplishing the regulatory objectives [1]. The "monopolist" is usually under the regulation forced to give a part of his profits for founding charitable, cultural and sporting activities. The problem arising in practice is that state lotteries, for example, are state owned companies and it is questionable and must be very well regulated how to organize these founding, bearing in mind strict rules on competition and state aids.

When regulating on-line gambling, a few policy choices have been developed in order to limit the gambling on state monopoly, to charitable entities, outright prohibition, to license the private gambling operators on liberalized market [1]. Usual practice in member states is to prohibit gambling, except to extend expressly allowed by the law [5].

This article is structured in four sections. The structure is following a development of regulation in the area of games on chance, with special emphasis at on-line gambling. The article describes practice of the ECJ and gives an overview of the EU current regulatory activities in the area.

II. ECJ CASE LAW

One of the most important regulators in the area of games on chance at EU level is the European Court of Justice. The period after the judgement in the Gambelli case (Case C-243/01 Criminal Proceedings against Pier Giorgio Gambelli and others [2003] ECR I-13031) [9] , that was a turning point for the period that came after, we can realize the ECJ practice development in accordance with growing liberalization of the services in the area of games on chance. The reasons for justification of restrictions that were accepted by the ECJ in the period before the Gambelli case are not accepted any more. The margin of discretion for the member states in relation to restrictions for the free provision of services in this area is tightened up [18].

After a number of judgements in the previous period, ECJ in Gambelli case underlined that restrictions deriving from the national legislation, which prohibits the activities even through collection of bets in the area of sport, are considered as restriction that can be justified only by taking into account its goal and proportionality. For the first time, the ECJ underlined the thesis that restrictions, which were imposed by the member states, could not be justified if the same member state at the same time is pursuing a policy of substantial expansion of betting and gaming at national level. If participation in lotteries, games of chance and betting are encouraged by a member state aiming at deriving the benefit for itself, that state cannot rely on a need to uphold the public order in order to justify the restrictive measures.

If the member state gains profit from those activities, then that profit has to be acquired as only an incidental and not as a primary benefit. The ECJ states that the restrictions may be justified if they are required for consumer protection and for the preservation of social order, taking into account moral, religious and cultural factors and moral and financial consequences for individuals and society.

Furthermore, the main objective of such restrictions must reflect an overriding reason of general interest, such as a reducing of gaming opportunities. The procurement of finances for public funds, on the other hand, cannot constitute justification. The restrictions may not go beyond what is necessary to attain that objective and must be applied in a non-discriminatory manner.

In the Gambelli case, the ECJ states that it is for the national court to consider whether the principle of non-discrimination has been complied with, and whether, in practice, the conditions for running betting operations can be more easily satisfied by home state operators than by foreign operators. If so, those conditions are discriminatory.

This justification of the national measures that cannot be justified only by reasons from the Art 46 TEC (now Art 52 TFEU) or by the reasons from the ECJ case law, is

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developed by a detailed analysis of such restriction from the aspects of proportionality and not going beyond necessary to attain the objective. This analysis that began with the Gambelli case was developed in a number of judgements that followed.

In Placanica case (Case C-338/04 Criminal Proceedings against Placanica and Others [2007] ECR I-01891) [10], one of the most important judgements in the area of on-line games in that period, the ECJ judgement concerned legality of criminal sanctions for persons in Italy that dealt with collection of bets without possessing a licence and police authorizations for the company that had registered seat outside the member state (Italy). The ECJ points out that legislation, which prohibits – on pain of criminal penalties – the pursuit of activities in the betting and gaming sector without a licence or a police authorisation issued by the State, places restrictions on the freedom of establishment and the freedom to provide services. However, those restrictions can be justified by moral, religious or cultural reasons, as well as the morally and financially harmful consequences for the individual and for society associated with betting and gaming. Anyhow, the restrictions must nevertheless satisfy the conditions concerning their proportionality.

III. HARMONIZATION ACTIVITIES AT EU LEVEL

Beside the fact that the judgements of the ECJ are the source of secondary law and give solutions to the problems in this field, an inconsistent application at the national level gives legal uncertainty [1]. The EU Commission makes an effort to harmonize national laws in the area of on-line gambling that has been abandoned and the Commission has made steps in bringing the infringement proceedings against the EU member states when there are inconsistencies in the national regulation systems (The European Commission has taken steps against the Netherlands with respect to sports betting, Sweden with respect to poker tournaments and sports betting, Germany with respect to Internet gambling and advertising prohibitions, France and Greece with respect to sports betting, Denmark, Finland and Hungary with respect to sports betting and Austria and Italy concerning casino advertising and sports betting).

The Resolution of European Parliament on the Integrity of on-line gambling [11], besides the fact that ECJ case law considers gambling as a service of an economic activity, states that those are activities of a very special nature, due to the social and public order and health care aspects linked to them. The Resolution emphasizes that pure internal market approach is not appropriate because of highly sensitive matter and requires of the Commission to pay special attention to the views of ECJ. That leads to the third period of ECJ practice case law. In that period, the ECJ is coming back again to the principles that are similar to the principles from the period before the Gambelli case. In the area of freedom to provide services in the gaming sector, the member states again recall the public interest as a justification for their restrictions in the area of free provision of services that are provided by the citizens from other states and, at the same time, they are encouraging those activities organized by the state aiming at securing the profits for the state [4].

If the national measure, which restricts free movement, is not discriminatory on the basis of nationality or the place of establishment, i.e. it is equally applicable on home state and foreign services providers, then its restrictions can be justified by the list of public policy reasons. The restrictions defined by the member states can be imposed as licences or authorizations or in a way of giving exclusive right for organizing the games on chance like state monopoly. Or, it can even be completely prohibited to organize the games on chance in a certain state. Just a need for efficient regulation in the area of games on chance deems for the supervision by the state on their territory. National authorities in the gaming sector have to provide licensing at the transparent, objective and non-discriminatory criteria in line with ECJ case law and control, if service providers comply with specific demands for licensing, and to provide regulatory framework through efficient measures at the national level [12].

From the ECJ case law it is obvious that the restrictions can be justified by overriding public interest requirements such as consumer protection, preventing overspending, preventing gambling addiction, preventing fraud and other crime, preserving public order and barring gambling from being a source of private profit. However, the Court has also held that financial objectives such as providing for the financing of charitable and cultural purposes or increasing tax revenues were not legitimate grounds for justifying restrictive measures [2].

IV. CONCLUSION

We cannot expect that the regulation of games on chance at European level will enable total liberalization of the games on chance market. However, member states should stop to recall overriding public interest reasons as justifications in the sector of games on chance and, at the same time, covering the real goal of their regulation, which is a protection from the foreign concurrence.

In fact, the number of procedures that the Commission has taken in the last period against the member states because of their non compliance with European law and restrictions in the area of games on chance, leads to this conclusion(http://ec.europa.eu/internal_market/services/gambling_en.htm). The Swiss Institute Study [5] was prepared as a model for harmonization of laws in that sector at the European Level, giving a detailed analysis of the national jurisdictions that regulate games on chance within the EU member states.

This analysis shows that the regulation framework in the area of games on chance is mainly governed by the

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legislation which aims to protect public interest. To achieve the goal of protecting the public interest, member states often impose regulatory and other obstacles for provision of services in the area of games on chance that are contrary to the European Law.

According to the authors, when considering the cross-border on-line gambling, as there are different cultures on gambling issues in the EU, besides the regulations, there must be common political solutions as well. Measures to prevent negative consequences of gambling must be provided (The Swiss Study indicates that the risk of developing compulsive gambling is 5-7 times higher if you play poker on the computer than if you go in the ordinary casino). So, there is a reason why the on-line gaming operators must comply with the regulatory framework of the state where the consumer lives and, as stated before, there should be a political, rather than legal, clarification how to solve the problems on the European on-line gaming market [15].

Regarding the role of authority on the Internal Market, the Internal Market Information System (IMI) has already indicated good results as a flexible tool for administrative cooperation between member states. Thus, it should be considered whether IMI is right for administrative cooperation on gambling, which can provide cross-border exchange of information between public authorities. It is already used for two areas of professional qualifications and services. The benefits of IMI can be seen as benefits for member states and benefits for competent authorities. The benefits for member states are: no IT costs, adaptable to any administrative structure, secure transfer of data, compliant with data protection rules, single system to manage. For competent authorities: easy-to-use, no language problems, direct link within the EEA, clear procedure and fast response, help desk support, training material. In the area of gambling, IMI can work for administrative cooperation on gambling. There are several examples of possible cooperation, such as exchange of information on licence holders mutual assistance in case of suspected fraud, notification of national conditions imposed on licence holders and alerts in cases of unlicensed operators (illegal practice). The basic requirements for administrative cooperation through IMI include: there must be an agreement in the area of cooperation, there should be a legal basis for exchange of personal data, identification of authorities involved and technical adaptations to the IMI system (IMI, DG for internal market and services, market, www.imi net).

The conclusion should be, by taking into consideration all the aforementioned, that the answer can be given after a detailed economic analysis of regulatory framework and the cost-benefit analysis which should lead for a more balanced approach or, in other words, to see whether a measure goes beyond what is necessary to achieve the specified policy aims.

As the authors stated before in this article, in the area of off-line gambling/ the tendencies are in the line with market liberalization and for the on-line gambling we need regulations. It is far more difficult to supervise and control on-line games on chance and effects of on-line gambling on consumer regarding the time of use, age of consumer and incomes of service provider. In that context, as we have already concluded, a special state policy is required concerning the consequences on the consumer. This service may have a common policy at EU level, as well as the realisation at member states level.

REFERENCES

[1] J. Hornle and B. Zammit, “Cross-border Online Gambling Law and Policy,” Edward Elgar, Publilshing Limited, UK, 2010.

[2] J. Hőrnle, “Online gambling in the European Union: a Tug of War without a winner?, Queen Mary University of London, Legal studies research paper, No 48/2010

[3] E. Schriever, Conflict and Co-ordination between Diverse Regulatory Envoronment, 2004 in Swiss Institute of Comparative Law, Cross-Border Gambling on the Internet

[4] J. Hojnik, „Cross border gambling:Reconciliation of controlled expansion and genuine diminution of gambling“, Conference proceedings from Jean Monnet Conference, University of Maribor, Faculty of Law, ed. Rajko Knez, Maribor, 2009

[5] Swiss Institute of Comparative Law, Study of gambling services in the Internal Market of the European Union, Final Report, 14 June 2006 available at http://ec.europa.eu/internal_market/gambling/docs/study1_en.pdf [retrieved: September, 2013]

[6] Treaty on the functioning of the European Union, consolidated version from 30.3.2010, OJ C 83/47

[7] Green paper on-line gambling in the Internal Market, SEC (2011) 321 final, European Commission, Bruxelles 24.3.2011 COM (2011) 128 final

[8] The Council Presidency Progress Report of 27 November 2008 available at http://register.consilium.Europa.eu/pdf/en/08/st16/st16022.en08.pdf

[9] Case C-243/01 Criminal Proceedings against Piergiorgio Gambelli and others [2003] ECR I-13031

[10] Case C-338/04 Criminal Proceedings against Placanica and Others [2007] ECR I-01891

[11] Resolution on the Integrity of Online Gambling of 10 March 2009, P6_TA(2009)0097 and Report oft he Commission on the Internal Market and Consumer Protection (A6-0064/2009)

[12] Council of the European Union Conclusions on the framework for gambling and betting in the EU member states 3057th COMPETITIVENESS (Internal Market, Industry, Research and Space) Council meeting Brussels, 10 December 2010 Available at http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/intm/118398.pdf

[13] http://ec.europa.eu/internal_market/services/gambling_en.htm retrieved [September, 2013]

[14] Study of gambling services in the internal marketed of the European union, Final Report 14 June 2006 http://ec.europa.eu/internal_market/services/docs/gambling/study1_en.pdf [September, 2013]

 ISBN: 978-1-61208-312-4

[15] C. Schaldemose, "Regulating gambling: the role of the authority" 12.10.2010

[16] ECA European Casino association: (Online) Gambling in Europe-What is at stake, available at www.europeancasinoassociation.org [September, 2013]

[17] Online Gaming A Gamble or a sure bet?, KPMG International available at www.kpmg.com [September 2013]

[18] A. Kaburakis, Europeana Union Law, Gambling and Sport Betting – European Court of Justice, Member State Case law and Policy, in Sports, Betting Law and Policy, eds. P. Anderson, I. Blackshaw, R. Siekmann and J. Soek, J., Heidelberg, Germany, Springer Verlag. December, 2011, pp. 27-97. Available at http://ssrn.com/abstract=1977342 [September, 2013].

[19] S. Planzer, and H. Wardle, The Comparative Effectiveness of Regulatory Approaches and the Impact of Advertising on Propensity for Problem Gambling, October 1, 2011). Responsible Gambling Fund, 2011, pp. 1-87. Available at http://ssrn.com/abstract=2045052 [September, 2013].

[20] A. Kaburakis, ECJ Jurisprudence and Recent Developments in EU Sport Betting, EU sport, Law and Policy, eds. S. Gardiner, R. Parrish, and R. Siekmann, Hague, Netherlands: T.M.C. ASSER International Sports Law Centre Press, (April 30, 2009), available at SSRN http://ssrn.com/abstract=1496639 [September, 2013].

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The Impact of Technological Development on the use of Technical Product Documentation.

A Multimethod-Multisource Approach to Identify Customers' Communication Behavior and the Implications on new Requirements for Virtual Support Systems.

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***Abstract*—Late technological developments show strong impacts on customers' communication behavior. While only years ago customers perused printed manuals in case of technical problems, they now request new ways for support. It is of crucial importance for businesses to identify these changes in communication behavior and to adopt their support offers to match customers' expectations. This paper utilizes a multimethod-multisource approach to give insights into the new importance of technical documentation as link between customer support and product marketing. After indicating the ongoing change in media consumption, creators of technical documentations as well as product users are analyzed regarding the usage scenarios of technical product documentation. Finally, major implications for businesses are built on customers' changed requirements of virtual support systems.**

Keywords-technical documentation; product support; communication behavior; customer support systems; technological development

I. INTRODUCTION

Consequences of late developments in the areas of information and telecommunication systems are still taking place in various application fields. Technical communication [1] in form of different kinds of documentations and manuals plays a major role for the adoption of new products and is thereby strongly influenced by these technical developments [2]. While only years ago every newly acquired product obtaining some level of technical complexity (like the consumer electronics industry) required bulky manuals, hence product enclosures only aim to support customers by guiding them through first installation processes. Especially in the software industry these changes can conspicuously be observed. Product packaging for software like image processing applications or operating systems contained often one or two CDs as carrier medium but required thousands of sites of printed manuals resulting to boxes with several ponds of weight [3]. Thanks to digitalized content and developments in product usability, modern software products require far less printed documents or no need for printed manuals is given any more at all. In other branches like the automobile industry these potentials are not fully released yet. Still many car manufacturers deliver their vehicles with a set of diverse and impersonalized booklets and manuals, consisting of sections referencing extras and features that are not even integrated in the specific car. So how do developments in information technology affect technical documentation and how will businesses have to react on those changes?

A. Marketing aspects of technical documentation

Technical communication includes both company-internal as well as external information regarding the product. Technical documentation is defined as the pool of information that is specifically handed to the user [4]. From a customer's point of view any kind of documentation fulfills one single need: to gather the relevant information required with as little afford as possible [5]. Thereby two main triggers for the demand of support can be spotted. First, in an early phase within the product lifecycle support to learn how to handle the product is required. Later on this changes to more problem-orientated support scenarios when product failures are to overcome. While customers therefore only notice the functional aspects of product support, businesses have to consider every touch point with its' customers from a marketing point of view as well [6]. The importance of customer support is already acknowledged in marketing literature, determining forms of product accompanying documents as instruments of marketing [4]. By the ongoing transition from classic printed documents to alternative digitalized variants companies are forced to adopt their format of customer and product support. It is of crucial importance to not only offer up-to-date products but also adequate support for existing as well as potential future customers. The structure of the paper is described in the following section.

II. RESEARCH GAP AND METHODLOGY

The increasing importance of technical documentation for marketing purposes forces businesses to react according to their customers' changes in communication behavior. Businesses have to identify the new roles of communication technologies for customers and how they utilize these technologies. Thereby businesses gain the opportunity to adopt their marketing communication activities in an appropriate way to offer relevant information wherever and however the customer expects the information. This paper contributes to an ongoing research project regarding new marketing potentials in modern customer support by the

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utilization of state-of-the-art application of information systems. The paper plays a crucial role within this research process as one key question relates to the change in users' communication behavior. Only by the identification and adaption of customers' communication behavior in support cases are businesses enabled to build adequate information systems. We therefore analyze the impact of new communication technologies to allow implications on how customers expect businesses to place their support mechanism.

To assure relevant as well as rigorous implications a mixed methods research approach was chosen. By utilizing a variety of research methods (multisource and multimethod) a higher quality on an evidence of results is given [7].

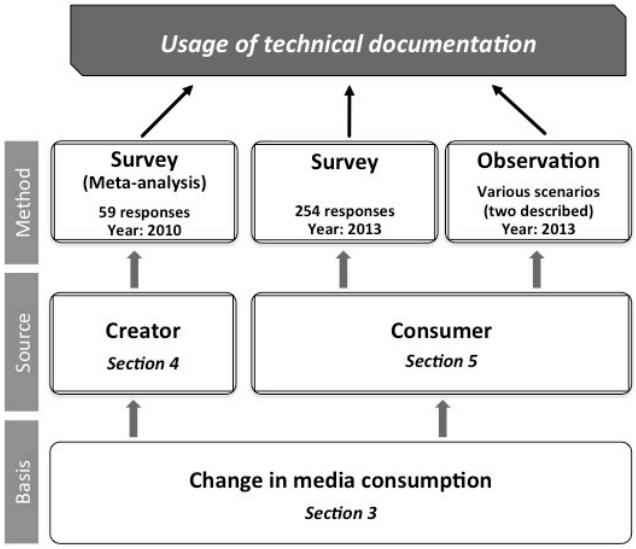

Figure 1. Research methodology

Figure 1 shows the applied research methodology. The basis for all changes in communication behavior lies in the adoption of new technologies. Section 3 focuses on these developments by a detailed analysis of relevant indicators for the last years. In section 4, insights on how the usage of technical documentation is developing from the perspective of content creators is given by applying a meta-analysis of a survey that was conducted in 2010. As the main focus of a study on customer behavior is the customer himself the fifth section focuses on statements and observations regarding the user. Results of an online survey are presented to show customer opinions as well as a research observation was performed to allow a comparison between customers' statements and their actual behavior.

III. TECHNOLOGY AS ENABLER

Developments in technology build the foundation for changes in customers' usage behavior. Therefore it is of relevance to monitor and build awareness for such developments as only by analyzing these data and indicators trends can be identified. In cases of technology monitoring it is of high importance not only to highlight current statistics directly related to a specific topic but also to include close-by areas. This allows a more holistic view and the implication of tendencies, which may impact a specific field of interest. Some of the analyzed data shows therefore no direct relation to technical documentation, but by the holistic view on these studies implications for further developments in the concrete field can be given.

A. Customers are online and mobile

The most influential transition in the last decades was the rise of the Internet. As more and more people gather their information online or use the Internet in its many other ways, businesses are expected to be reachable in the web. While in the year 2000 less than 400 Million people were online this number increased to around 2.5 Billion in 2012 [8]. As an example in Germany more than 76% of all age groups are online in 2013 [9]. Besides the rise in online rates also the medium to get online is of importance for content providers. The worldwide traffic caused by mobile devices increased from 6,25% in the end of 2010 to more than 23% in the last quarter of 2012 [10]. Smartphones and tablet computers are becoming more and more popular for daily online routines, with leads to about 70% Germans using their smartphone to access the Internet on a daily basis [11].

B. Changes in media consumption

These developments caused be the pervasion of the Internet had tremendous impacts on various business models. Especially business models dealing with reproducible digital data had to be adopted. The music as well as the movie industry was directly affected but also the television and radio market is still changing. All forms of printed newspapers, magazines, books and of course manuals exist in some kind of duality between an online and an offline version. Depending on the target group these changes seem more or less dramatically. Results of the ARD/ZDF Longtime Study on Mass-communication [12] allow two different propositions. First, more different ways to consume media emerge, and secondly the usage behavior is highly dependent on the age.

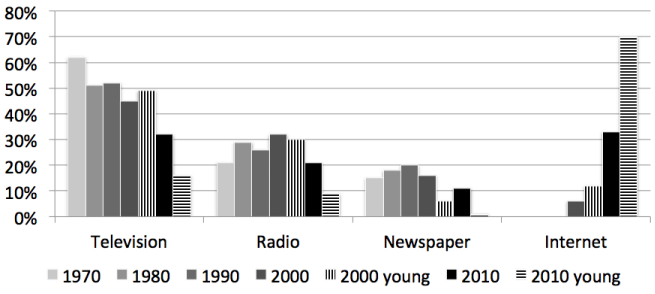

Figure 2. Change in media consumption [Q9]

Figure 2 shows results of this study. A transition of media consumption from the three classic forms of TV,

radio and newspapers to online content can be determined. More interesting is the separation in overall and young survey participants as these numbers show that younger customers are mainly reachable by online channels.

C. Social communities are still growing

Again the Longtime Study on Mass-communication [12] gives detailed insights on how people use the Internet. Besides typical leisure activities like watching videos or sharing photos also functional aspects are still relevant. In fact gathering information and gaining knowledge is the most utilized private usage scenario with Wikipedia and various forms of online communities at highest ranks. Especially social networks like Facebook play a major role for most Internet users. Regardless if a company decides to utilize such networks for marketing purposes, customers do communicate product-related issues in the public. The traditional thinking in sender and recipients becomes obsolete due to social interactivity between users. Communication Space models [13] better describe these settings where companies lose some kind of control regarding their communicated messages. Improper support may therefore directly influence potential customers on their decision as existing customers state their experienced treatments. Hence, every company-performed action may initiate a new reaction, which could get communicated to the public.

D. Merging physical and virtual world

The last significant change affecting technical documentation and product support from a technological point of view is the merging between the physical and the virtual world. Technologies start from simple Quick-Response (QR) Codes, where an image is scanned and interpreted to perform an action, to radio-frequency technologies like Near-Field-Communication (NFC). While research often focuses on the technical differences between QR-codes and the NFC technology the latter allows much wider fields of potential applications. Active two-way communication could enable display-less products to transport messages or status codes to smartphones where an output could then be displayed. Products showing error-codes where the user has to look up the meaning of the code would be simplified in many ways. In 2015, more than 250 Million smartphones integrating the NFC technology will be sold leading to more than 25% of all sell-through smartphones [14].

Augmented Reality as one of the most advanced fields of application allows a direct merging of both worlds on the device's display by adding an additional layer on top of the cameras output. Thereby the display not only shows a live picture on what the camera is filming but also identifies specified objects or schemas and shows some extra information regarding these elements. Hence, for technical documentation this merging is of high interest, as many physical products without displays require manuals in form of virtual contents such as text or video instructions. By utilizing a bridging technology users would be able to receive context-sensitive information depending on the product version or support situation.

IV. WRITERS AS CREATORS OF TECHNICAL DOCUMENTATION

Developments and numbers in the last section are gathered by various research institutions and organizations and represent facts in technical and societal incidents. To allow feasible implications for technical documentation also opinions of experts in the area seem beneficial. A study on technical documentation by Broda [15] in 2010 analyzed survey answers of experts and technical writers. Technical writers create all forms of technical documents, for company-internal usage as well as for customer usage.

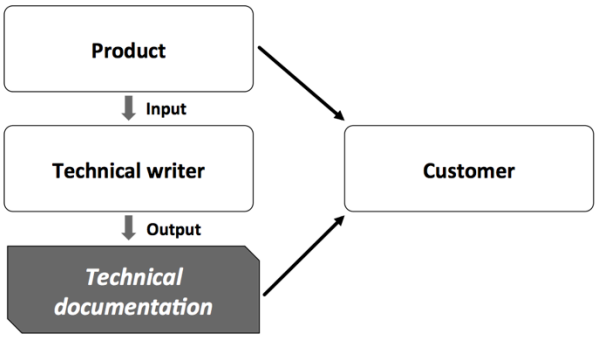

Figure 3. The role of technical writers

Figure 3 shows the important role of technical writers as they take the product as an input to produce various forms of technical documents as an output. Technical writing is therefore associated to the scientific field of translation science as writers translate product features into customer-orientated manuals. As already mentioned in the first section technical documentation is gaining importance in the field of marketing because such manuals directly transport company information to the customer. Technical writers therefore are more and more required to closely interact with marketing personnel or are even organized within the marketing department itself.

A. Results

Broda received 59 entirely filled out questionnaires. 10 out of the 59 were entitled as experts in the field of technical documentation, 49 were service providers for technical documentation. Another 13 service providers did not finish the survey and are therefore marked as incomplete. The survey took place in Germany from August to September 2010. The study focused on aspects of technical documentation in mobile environments as on smartphones or tablet computers. Overall practitioner gave more skeptic answers then experts, which leads to the assumption that current limitations also occur at the level of the creation of documentation. Typical limitations of surveys have to be

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considered such as bias effects. While experts may answer in a more general context, answers from service providers directly relate to their work. Two main results can be highlighted: there are obstacles to overcome for new technologies entering the technical documentation market and the content representation is expected to depend on the usage intention.

B. *Obstacles to overcome for new technologies*

Participants were asked to list the three main reasons why printed standard documentation will not vanish in the next years. 40 participants voted with "legal issues" as top answer (see Figure 4). Highly restricted countries like Germany or Austria still require some kind of printed and product-accompanying form of documentation. The second most significant reason is the availability of documents. While printed manuals are in physical possession of the customer and can be attached in cases of reselling, participants worry about these aspects for digital versions.

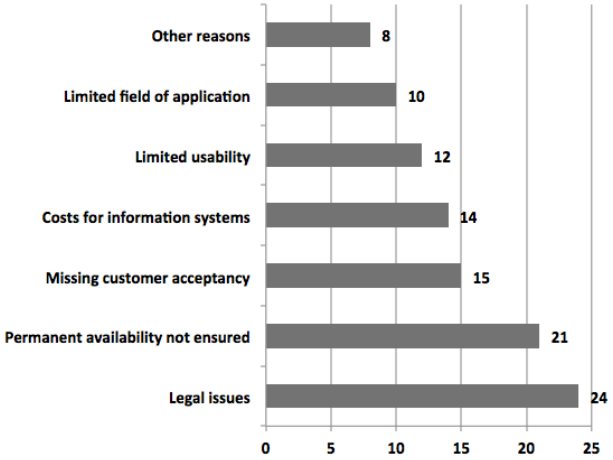

Figure 4. Obstacles to overcome for new technologies

C. *Adequate application of content representation*

Secondly, the study gives also insights on how content could be represented for different usage scenarios of product support. This information is especially beneficial as the participants are the most significant target group for such a complex question. Experts as well as practitioners both have knowledge on the advantages and disadvantages of these representation forms and are therefore empowered to match both entities.

Unsurprisingly of low relevance are audio representations, with the classic text and pictures at the very top as Figure 5 shows (ratings between 0 and 5). Augmented Reality is expected to be beneficial in total but especially for maintenance activities. Screen casts are an example for a very diverse form of information representation. While suitable for teaching materials there is no, match for more product-related content.

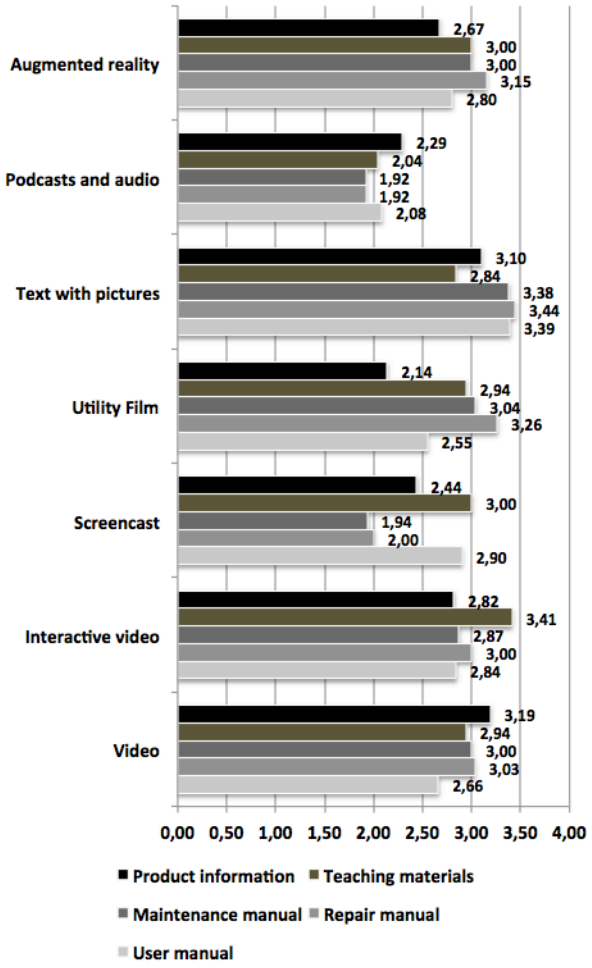

Figure 5. Forms of documentation and suggested content representation

V. USING TECHNICAL DOCUMENTATION

Even more important than content creators are opinions of actual users. Therefore, an online survey was conducted to identify current usage behaviors related to technical documentation as well as to get impressions on customers' attitude on professional product support. Like in other social science research methods also participants of surveys intend to naturally bias their answers. To allow the forming of implications from a customer behavior analysis a multimethod approach was undertaken. Parallel to the survey a method to detect the actual behavior in form of an observation was required. Google Trends [16] as a feature of the worlds most popular search engine Google allows the comparison of different search terms. By utilizing this tool an observation on how users perform their search in problem situation was conducted. The combination of both research methods pictures a change in communication behavior.

A. *Survey results*

The survey took place in Austria with a total response of 254 questionnaires. Average age was 25.7 years (standard

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deviation 7.64) with 71% female and 29% male participation. Results for this research paper are grouped into three categories: (1) dependence of used support method on product type, (2) online search behavior and (3) obstacles for online support systems.

1) Dependence of used support method on product type

Results in Figure 6 highlight that the type of product (software or non-software) strongly influences the utilization of support methods. While in the software industry help systems can easily be integrated within the product, non-software product may not facilitate such mechanism. The media format discontinuity for using online support systems on physical products plays a major role here.

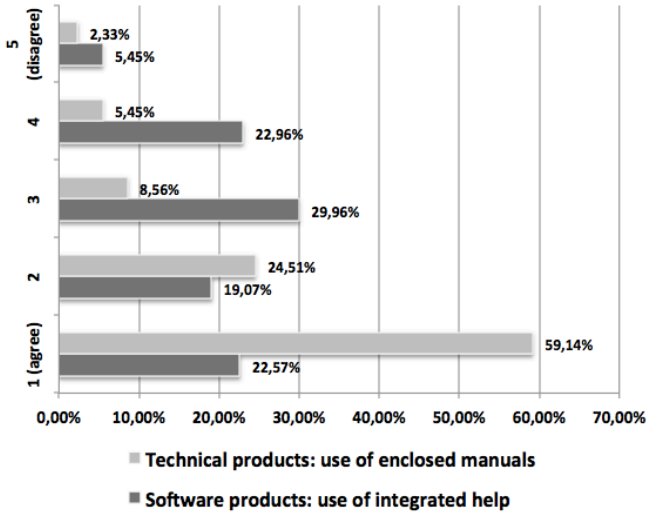

Figure 6. Use of support method is depending on product type.

2) Online search behavior

The second important result of the survey relates to the customers' behavior when requesting support online. While from a traditional perspective a strong relation between product and manufacturer is given in support cases, customers rely on generic search engine providers to find adequate solutions for their problems. Figure 7 shows that with more than 50% of all participants more users rather use such a search engine than to directly visit a support site provided by the manufacturer. This means a tremendous change for support service providers as search engines are operated by an algorithm and can therefore hardly be manipulated by content providers.

3) Obstacles for online support systems

While customers are aware of online support systems and how to search for requested information, they seem also familiar with some limitations of online platforms. For the majority the permanent availability of support is of high importance. On the one hand customers have to be connected to the Internet to use online services, on the other hand customers rely on the availability of the support service itself.

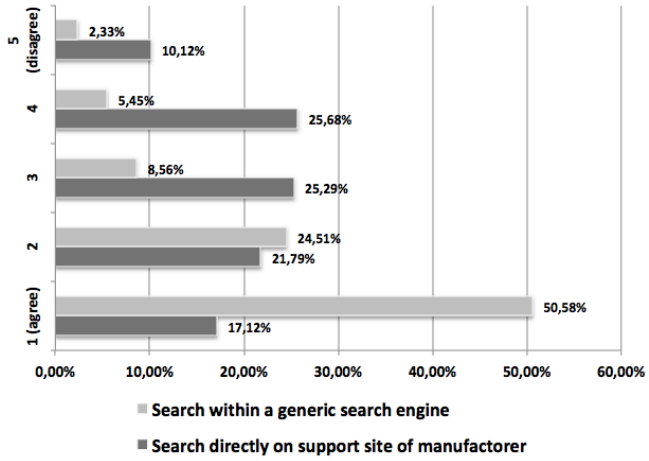

Figure 7. Search engines are used before manufactorers' support site.

Printed manuals or documents in digital form are in possession of the customer and guarantee this requirement. As Figure 8 illustrates, participants could not clarify if support platforms may entirely replace traditional manuals.

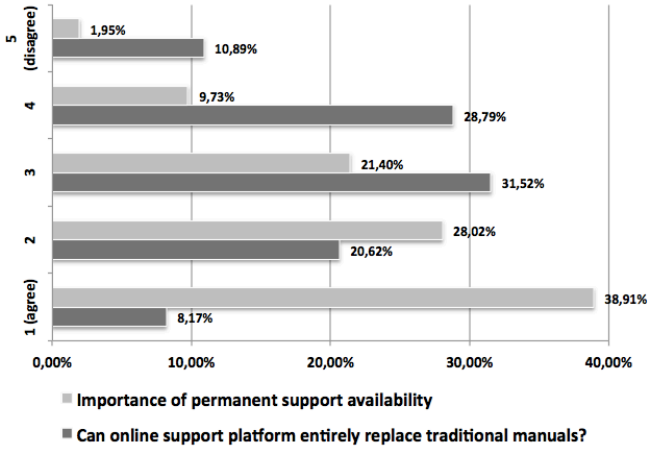

Figure 8. Availability as trigger for traditional manuals.

B. Observations

In a second attempt Google Trends was used to ensure rigor and relevance of the empirical survey data. While obstacles of online support can barely be acknowledged by such a method, differentiations in usage scenarios depending on product type (see point 1 in empirical results) as well as implications for general search behavior (point 2 in empirical results) are more feasible. In a first test a software-related problem was simulated to see how customers search in case of software problems. Second, a technical non-software product was chosen. Apple's Iphone 4 was the subject of interest in these queries, as the product is known for a problem with its integrated antenna affecting the phone's reception. When the problem first occurred

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customer did not know that it was caused by a manufacturing error. This incident builds a perfect occasion for an observation as customers were in a typical product support situation. Both products do not include an extended amount of manuals since the software comes with an integrated system and Apple represents products of high usability. As Google Trends allows the comparison between terms in form of percentage relations only, no absolute numbers of search queries can be given.

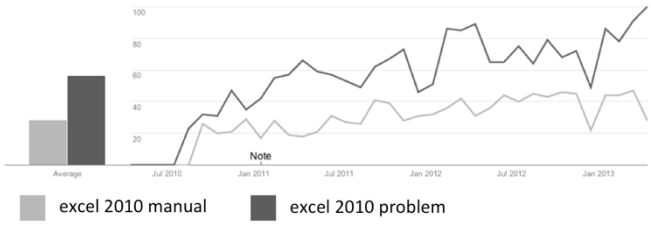

Figure 9. Context-sensitive search outnumbers the demand for manuals (geographic location: United States).

The software-test was processed by querying for a typical Microsoft Excel problem. While traditional manuals do not provide context-sensitive help, search engines are used to query for an answer directly related to a problem. Therefore, while searching for the traditional manual would indicate the need for technical documentation in the typical structure, customers intend to directly enter the question resulting into endless search query variations. As Figure 9 shows even a comparison between the search terms *manual* and *problem* demonstrates more queries for the latter. Including the variations of real appended problem situations would outnumber requests for traditional manuals.

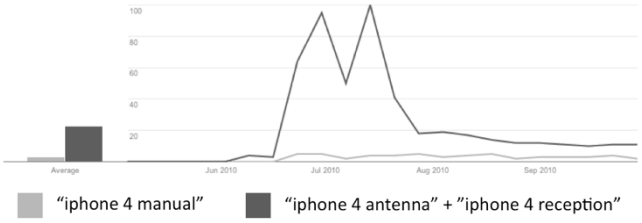

Figure 10. Search engines directly link to support content (geographic location: United States).

Figure 10 highlights an online search behavior. Again customers directly enter their problem into the generic search engine without any demand for manuals.

VI. IMPLICATIONS AND FURTHER RESEARCH

Businesses have to adopt their external communication to meet customers' demand for product support. Results show the traditional user manual devolves into online support systems where context-sensitive and location-independent information is made available. Users directly transform their support questions into queries, which implies that businesses have to build their support offerings search-engine-optimized. Additionally the media format discontinuity is an obstacle to overcome by utilizing linking technologies between the physical and virtual world. At last the availability of support plays a major role for customers, which businesses have to ensure.

This publication is a crucial contribution to marketing as well as information systems research. Both disciplines put the customer into the center of attention. Further research will be done to identify how virtual online support systems have to be implemented to match requirements of customers as well as businesses.

REFERENCES

[1] J. Redish, "Technical Communication and Usability: Intertwined Strands and Mutual Influences Commentary", IEEE Transactions on Professional Communication, vol. 53, no. 3, 2010, pp. 191-201.

[2] J. Hennig and M. Tjarks-Sobhani, Usability and technical documentation, Lübeck, Schmidt-Römhild, 2007.

[3] Amazon, http://www.amazon.com/IBM-Warp-Connect-3-0-Bonus/dp/B0023R30V4/ref=sr_1_3?ie=UTF8&qid=1373794258&sr=8-3&keywords=ibm+os%2F2+warp (last visited July 14, 2013).

[4] D. Gebert, Instruction manuals as a marketing tool, Wiesbaden, Forkel, 1988.

[5] B.S. Wiese, J. Sauer, and B. Rüttinger, "Consumers' use of written product information" in Ergonomics, vol. 47, no. 11, 2004, pp. 1180-1194.

[6] M. Bruhn and G. M. Ahlers, "Customer Touch Points – Tasks and method of multi-channel communication" in Handbook Multi-Channel-Marketing, Wiesbaden, Gabler, 2007, pp. 393-425.

[7] J. W. Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, Los Angeles, SAGE Publications, 2009.

[8] ITU World Telecommunication, ICT Indicators, worldwide, 2000 to 2012 via Statista.

[9] TNS Infratest, D21-Digital-Index, Germany, 2001 to 2013, via Statista.

[10] Walker Sands, Q4 2012 Mobile Traffic Report, worldwide, Q4 2010 to Q4 2012, via Statista.

[11] Tomorrow Focus AG, Mobile Effects 2013-1, Germany, January 2013, via Statista.

[12] ARD/ZDF, Longtime Study Mass-communication, Germany, 1970-2012.

[13] T. Puchleitner and M. Harnisch, "Communication Technology as Enabler for the Communication Space", in P. Kommers and P. Isaías, Proceedings of the IADIS International Conference e-Society 2012, Berlin, 2012, pp. 265-272.

[14] Pyramid Research Global Telecom Insider, NFC-Enabled Smartphones to Account for 28% of Global Market by 2015.

[15] S. Broda, Mobile technical documentation, Lübeck, Schmidt-Römhild, 2011.

[16] Google, http://www.google.com/trends/explore (last visited August 22, 2013).

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Facebook Applications' Installation and Removal: A Temporal Analysis

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***Abstract*—Facebook applications are one of the reasons for Facebook attractiveness. Unfortunately, numerous users are not aware of the fact that many malicious Facebook applications exist. To educate users, to raise users' awareness and to improve Facebook users' security and privacy, we developed a Firefox add-on that alerts users to the number of installed applications on their Facebook profiles. In this study, we present the temporal analysis of the Facebook applications' installation and removal dataset collected by our add-on. This dataset consists of information from 2,945 users, collected during a period of over a year. We used linear regression to analyze our dataset and discovered the linear connection between the average percentage change of newly installed Facebook applications and the number of days passed since the user initially installed our add-on. Additionally, we found out that users who used our Firefox add-on become more aware of their security and privacy installing on average fewer new applications. Finally, we discovered that on average 86.4% of Facebook users install an additional application every 4.2 days.**

***Keywords*-Social Network Analysis, Social Network Privacy, Social Network Security, Facebook Application.**

I. INTRODUCTION

In the last decade, online social networks have gained enormous popularity. Over a billion users worldwide are using these networks [18] to share information, communicate with friends, play games, etc. [6]. Recently, J.B. Duggan [12] discovered that 67% of adults in the United States use online social networks. These results demonstrate a 2% increase in comparison to a previous report [20]. The exponential growth of social networks created a reality where there are social networks for almost every usage. These vary from social networks for connecting with business colleagues like LinkedIn [7] and Xing [9] to social networks for animal lovers, such as Dogster [2], Catster [1] and YummyPets [10]. The biggest online social network is Facebook, [3] which has more than 1.11 billion monthly active users as of March 2013 [6]. The median Facebook user is 22 years old [8], and has 138 friends on average [6]. Facebook users have made 140.3 billion friend connections and used over 1.13 trillion likes [8]. Moreover, every 60 seconds Facebook users post 510,000 comments, update 293,000 statuses, and upload 136,000 photos [22]. One of the main reasons for Facebook popularity is its third-party applications [26]. The Facebook application platform popularity is growing rapidly; for example, more than 20 million Facebook applications are installed every day [24]. There are many different kinds of Facebook applications, such as utility, productivity, and even educational applications [5]. According to Nazir et al. [21], the most popular applications are games; approximately 230 million people play games on Facebook every month [13]. The most popular games such as "Candy Crush Saga" have more than 2.7 million daily active users [19].

In recent years, hackers and spammers have found Facebook applications to be an efficient platform for spreading malware and spam. Moreover, recent research has found that at least 13% of applications on Facebook are malicious [26]. Recently, Rahman et al. [26] described in their study that spammers use Facebook applications to lure their victims into clicking on specific malicious links. Additionally, hackers can take advantage of Facebook application platform properties to: (a) find their next potential targets across a large base of potential users [26], (b) use the trust between friends to infect more users [23], (c) exploit the application developers API [4] to collect information, such as personal information, photos, tags, posts, chat threads, etc., and (d) use the user's credentials to publish posts or to spread spam, advertising and phishing under the name of a legitimate user [17].

To deal with this problem, we developed an add-on that is part of the Social Privacy Protector (SPP) [15], [16]. The purpose of this add-on is to educate and to increase user awareness about the threat that lurks in social applications. Our add-on notifies users of their current number of applications. By notifying the users, we encourage removal of third-party applications that are not in use by the user.

In this study, we utilize a dataset that was collected by our dedicated Firefox add-on. It contains information about 44,541 different occasions collected from 2,945 users between May 2012 and June 2013. Each entry in our dataset consists of the user id, application number and date.

In our previous study [16], we presented preliminary statistics on this dataset. We analyzed this dataset and discovered that users who used the SPP add-on for application removal, removed more than 50% of all their installed applications one day after its installation. These results indicate that in many cases the installed applications are unwanted or unneeded applications. In this study, we perform a temporal analysis of the installed application data that was collected for a longer period of time red than in our previous study. We discovered that within the first week after the add-on's initial use, the user's number of applications decreased by 12.1% (see Table I) on average. Moreover, the application removal rate continued to grow up to 27.7% (see Table I) by an average of 63 days after the initial use. According to the results presented in this study, we can conclude that using our add-on made many users become more aware of the existence of unnecessary applications on their Facebook profiles.

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The remainder of this paper is organized as follows. In Section II, we give a brief overview on different related solutions that help users in social networks protect themselves from malicious applications. In Section III, we describe our methodology for analyzing the information and how we used linear regression to predict the application number. In Section IV, we present our study's initial results. Finally, in Section V, we present our conclusions regarding the change in awareness that resulted from our add-on notifications and offer future research directions.

II. Related Work

Recent reports [27], [28] have indicated that due to the growth of social network popularity, there also has been a massive rise in malicious activity and security threats to online social network users. In recent years, social network users, social network operators, security companies, and academic researchers have proposed solutions to increase the security and privacy of social networks users. In the remainder of this section, we describe notable solutions in the area.

A. Detecting Malicious Applications

Detection is the most standard way to deal with security and privacy problems. There are many works on this topic and many different ways to detect malware. For example, Rahman et al. [25] presented MyPageKeeper, a Facebook application that protects Facebook users from socware. MyPageKeeper is based on a Support Vector Machine (SVM) classifier that uses a main feature specific keyword occurrence in a post made by an application. MyPageKeeper was able to identify socware posts and alert the user with 97% accuracy, but was unable to detect malicious applications. Websense Defensio [11] is a Facebook application from Websense that monitors posts in a user's profile and determines whether they are legitimate, spam, or malicious. Defensio also uses SVM to detect malicious posts and in addition they could delete them. Abu-Nimeh et al. [11] used Defensio as a platform to study malicious links. They found that about 9% of the studied posts were spam or malicious. In 2012, Rahman, et al. [26] improved his previously mentioned work. Rahman, et al. developed the FRAppE: A tool that can identify malicious applications by using the application information as features. Some examples include the number of permissions required, the domain reputation of redirect URI, and others. FRAppE can detect malicious applications with 99.5% accuracy and a low false negative rate 4.1%.

B. Increasing User Awareness of the Threat

Another approach is informing the user about possible threats that can jeopardize his or her security and privacy. By using this approach, it is possible to stimulate users to react and to protect themselves. This tactic is about teaching users what kind of threats exist and how they should protect themselves.

In 2012, Xu et al. [29] chose to redesign the Facebook application authentication dialogue to increase user awareness of the permissions that are required by applications. Recently, Fire et al. [15] presented the SPP software, a Firefox add-on and a Facebook application. This software contains three protection layers, which improve user privacy by implementing different methods. (1) *The friends layer* - suggests friends who might pose a threat and then restricts these friends' exposure to the user's personal information. (2) *The privacy settings layer* is based upon different types of social network usage profiles. (3) *The application layer* - alerts users to the number of installed applications on their Facebook profiles.

In our previous study [16], we presented initial results, which were based on a dataset from 1,676 users collected between the 27th of June, 2012, and the 10th of November, 2012. In this study, we perform a temporal analysis on our complete dataset, which contains information from 2,945 users between May 2012 and June 2013. Unlike our previous study, this is the first study where we focused on analyzing user application installation and removal from different aspects for long periods of time.

III. Methods and Experiments

Our study's main goal is to study how awareness affects installation and removal of social applications. To perform our research, we collected data from the Facebook online social network by using the SPP Firefox add-on (see Figure 1), which collected the following information: (1) *Hashed User Id*, (2) *Installed Application Number* - the number of installed Facebook applications on the user's Facebook account, and (3) *Date* - the date when the information was collected. To avoid duplicate entries, we collected only one entry for each user per day. Our final collected dataset included 2,947 Facebook users with unique hashed user ids across 351 different days between the months of May 2012 and June 2013. On average, we obtained information of 63 days and 15.1 entries per user. In addition, we discovered that Facebook users have a mean of 41.86 applications.

Fig. 1: Warning about installed applications.

To perform temporal analysis of our dataset we carried out the following steps. First of all, we divided all the users into two groups as follows: (1) *Regular Users* - users whose number of installed Facebook applications did not decrease between the initial and last use of the add-on (2) *Add-on Users* - users who decreased the number of installed Facebook application between their initial and last use of the add-on. Next, for each user, we calculated $AppChangeRatio(u, d)$: the ratio between the change in the number of applications user, u, had after, d, days and the number of applications that, u, had when the add-on was initially installed. $AppChangeRatio(u, d)$ was calculated only for the first 63 days after the add-on was initially installed, where 63 days is the average add-on use period. The formal definition of the $AppChangeRatio$

function is as follows:

$$AppChangeRatio(u,d) := ACR(u,d) := \frac{AppNum(u,0)\text{-}AppNum(u,d)}{AppNum(u,0)} \quad (1)$$

Where $AppNum(u,d)$ is a function that returns the number of applications user, u, had at a day, d, after the add-on installation. Then, for each day, d, we calculated the average $ACR(u,d)$ for each group as follows:

$$AvgAppChange(u,d) := AvgAC(u,d) := \frac{\sum_{u \in Users} ACR(u,d)}{|Users|} \quad (2)$$

We performed *t-test* to reject the null hypothesis, which states that the mean number of applications of the *Regular Users* and the *Addon Users* is identical and the observed differences are merely random. To find correlation between the application number and time, we conducted a linear regression experiment for each of the groups. The independent variable is the number of days passed since the initial install. The dependent variable is the percentage change in the applications number since the initial install.

Lastly, we tested if there are specific days of the week when users install or remove more applications as opposed to other days. To test this we calculated the average change in application number for every day of the week, w, for all the users, u. The change in application number is the calculation of difference in the number of applications between sequel days, we defined *AppNumDelta* as:

$$AppNumDelta(u,d) := ANDelta(u,d) := AppNum(u,d) - AppNum(u,d+1) \quad (3)$$

The results were divided into two cases:

$$I(w) = \frac{\sum_{\{wday(d)=w|ANDelta(u,d)>0\}} ANDelta(u,d)}{|\{u \in Users|wday(d)=w \wedge ANDelta(u,d)>0\}|} \quad (4)$$

$$R(w) = \frac{\sum_{\{wday(d)=w|ANDelta(u,d)\leq 0\}} ANDelta(u,d)}{|\{u \in Users|wday(d)=w \wedge ANDelta(u,d)\leq 0\}|} \quad (5)$$

where $wday(d)$ returns the day of the week for d. $I(w)$ is the average number of applications installed on that day of the week, w, and $R(w)$ is the average number of applications removed on that day of the week, w.

IV. Results

At the end of our analysis, our *Regular Users* group consisted of 2,545 users and the *Add-on Users* group consisted of 400 users, out of which 52 (13%) also used our Friends Analyzer application, which is responsible for identifying a user's friends, who may pose a threat to the user's privacy. Therefore, we can classify these 52 users as privacy concerned users. Further, this suggests that less than 2% of all Facebook users are highly aware of their privacy.

TABLE I: The Percentage Change in the Applications Number

Group	After 1 Day	After 7 Days	After 63 Days
Regular Users	2.02%	11.9%	40.7%
Add-on Users	-5.4%	-12.2%	-27.7%

Afterward, we performed a Welch Two Sample t-test to prove the assumption of difference between the two groups. The t-test confirms that the *Add-on Users* ($\mu = 0.236$, $\sigma_{dev} = 0.12$) and the *Regular Users* ($\mu = -0.19$, $\sigma_{dev} = 0.05$) have a significant difference in their mean values $t = 25.936$, $p - value < 2.2e - 16$. Next, we used the linear regression method to find the correlation between the change ratio in number of applications and period of time in days.

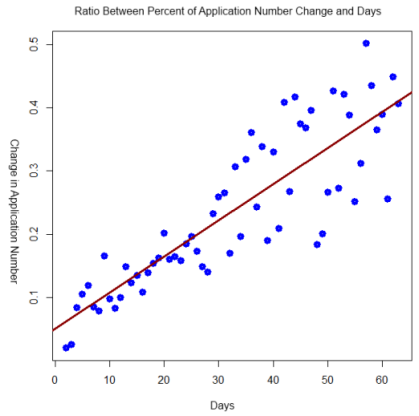

Fig. 2: The ratio between the percentage change in the applications number and days passed for the *Regular Users*. The solid line equation - $ApplicationChangePercent = 0.006Days + 0.05$

As a result of the difference we have shown between the two groups, we divided the linear regression into two cases: (1) *Regular Users* - users whose number of applications increased or did not change (see Figure 2), (2) *Add-on Users* - Users whose number of applications decreased (see Figure 3).

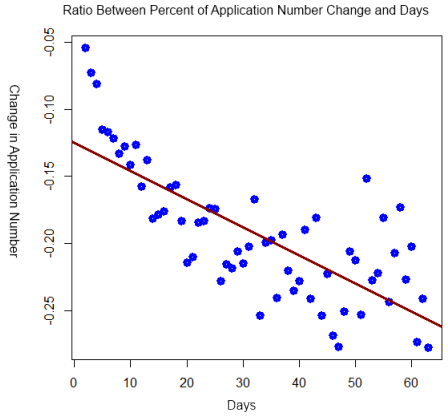

Fig. 3: The ratio between the percentage change in the number of applications and days passed of the *Add-on Users*. The solid line equation - $ApplicationChangePercent = -0.002Days - 0.125$

Using linear regression, we received the following regres-

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sion equations (see Figure 2 and 3):

$$RegularUsers : ApplicationChangePercent = 0.006Days + 0.05 \quad (6)$$

where $R^2 = 0.736,\ and\ p - value = 2.2e - 16.$

$$AddonUsers : ApplicationChangePercent = -0.002Days - 0.125 \quad (7)$$

where $R^2 = 0.57,\ and\ p - value = 1.351e - 12$
According to the linear regression results, the average Facebook user application number increases linearly over time, and the user installs about 7.15 applications each month.

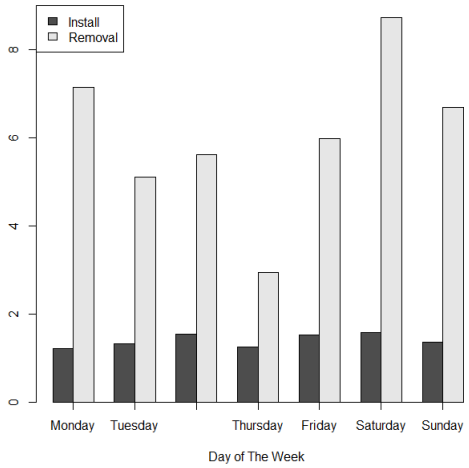

Fig. 4: Average application install and removal per day of the week.

In addition, we tested if there is a specific day of the week when users install or remove more applications than normal. We discovered that for both cases there is more activity on Saturdays and a significantly lower removal rate on Thursdays (see Figure 4).

V. Conclusions

In this study, we presented our initial methods and results in studying online social network applications with an aim of improving users safety and awareness. According to our results, it is possible to predict the number of applications a casual user has with high accuracy. Moreover, we discovered that users install many applications every month, and the average user installs approximately 7.15 applications each month. Currently, there are several malicious applications available. Rahman et al. states [26] that at least 13% of Facebook applications are malicious. By joining these two statistics together, we shockingly conclude that on average a Facebook user installs more than ten malicious applications each year. Our results show a possible solution to this problem. After the installation of our add-on, users become more aware of the number of installed applications they had. Users removed on average 12.1% of their applications after the first week, and they continued to remove even more applications afterward. Furthermore, by using the equations we discovered, it is possible to classify users who are not aware of the number of applications they have.

In addition, we discovered that users install and remove more applications on Saturdays. We assume this is due to many users being at home instead of working on this day of the week. It is possible to use these results to notify users more often, in ways that are more noticeable and on specific dates regarding the danger of installing applications. For example, we can configure our add-on to give more alerts and add special alerts on Saturday.

The study presented in this paper is a work in progress with many available future directions. By gathering additional information about what kind of applications users tend to restrict, we can develop an algorithm for application removal recommendations. Moreover, when the same applications are restricted by many users, we can conclude with high likelihood that these applications are fake applications and recommend to Facebook and our users to remove these applications from the social network and their accounts. Another possible future direction is discovering the point in time when the *Add-on Users'* application numbers start increasing again, and at that point, to give the user a special warning regarding his or her number of applications.

References

[1] Catster. http://www.catster.com/. [Retrieved: 9, 2013].
[2] Dogster. http://www.dogster.com/. [Retrieved: 9, 2013].
[3] Facebook. http://newsroom.fb.com/Key-Facts. [Retrieved: 9, 2013].
[4] Facebook apis. https://developers.facebook.com/docs/reference/apis. [Retrieved: 9, 2013].
[5] Facebook app center. https://www.facebook.com/appcenter/category/apps/?platform=web. [Retrieved: 9, 2013].
[6] Facebook newsroom. http://newsroom.fb.com/Key-Facts. [Retrieved: 9, 2013].
[7] Linkedin. http://www.linkedin.com/. [Retrieved: 9, 2013].
[8] One billion key metrics. http://newsroom.fb.com/imagelibrary/downloadmedia.ashx?MediaDetailsID=4227&SizeId=-1. [Retrieved: 9, 2013].
[9] xing. http://www.xing.com/. [Retrieved: 9, 2013].
[10] Yummypets. http://www.yummypets.com/. [Retrieved: 9, 2013].
[11] S. Abu-Nimeh, T. Chen, and O. Alzubi. Malicious and spam posts in online social networks. Computer, 44(9):23–28, 2011.
[12] M. Duggan and J. Brenner. The demographics of social media users2012. Pew Research Center, 2013.
[13] G. Finn. Facebooks mobile and web app hub, app center, officially launches. http://marketingland.com/facebooks-mobile-web-app-hub-app-center-officially-launches-13609. [Retrieved: 9, 2013].
[14] M. Fire, R. Goldschmidt, and Y. Elovici. Online social networks: Threats and solutions survey. arXiv preprint arXiv:1303.3764, 2013.
[15] M. Fire, D. Kagan, A. Elishar, and Y. Elovici. Social privacy protector-protecting users' privacy in social networks. In SOTICS 2012, The Second International Conference on Social Eco-Informatics, pages 46–50, 2012.
[16] M. Fire, D. Kagan, A. Elyashar, and Y. Elovici. Friend or foe? fake profile identification in online social networks. arXiv preprint arXiv:1303.3751, 2013.
[17] H. Gao, J. Hu, C. Wilson, Z. Li, Y. Chen, and B. Y. Zhao. Detecting and characterizing social spam campaigns. In Proceedings of the 10th ACM SIGCOMM conference on Internet measurement, pages 35–47. ACM, 2010.
[18] Itu. Trends in telecommunication reform 2012: Smart regulation for a broadband world. Technical report, 2012.
[19] I. Lunden. Facebook says it now has 235m monthly gamers, app center hits 150m monthly visitors. http://techcrunch.com/2012/08/14/facebook-says-it-now-has-235m-monthly-gamers-app-center-hits-150m-monthly-users/. [Retrieved: 9, 2013].

 ISBN: 978-1-61208-312-4

[20] M. Madden and K. Zickuhr. 65% of online adults use social networking sites. Technical report, 2011. [Retrieved: 9, 2013].

[21] A. Nazir, A. Waagen, V. S. Vijayaraghavan, C.-N. Chuah, R. M. D'Souza, and B. Krishnamurthy. Beyond friendship: modeling user activity graphs on social network-based gifting applications. In Proceedings of the 2012 ACM conference on Internet measurement conference, pages 467–480. ACM, 2012.

[22] D. Noyes. Top 20 valuable facebook statistics updated june 2013 . http://zephoria.com/social-media/top-15-valuable-facebook-statistics/. [Retrieved: 9, 2013].

[23] C. Patsakis, A. Asthenidis, and A. Chatzidimitriou. Social networks as an attack platform: Facebook case study. In Networks, 2009. ICN'09. Eighth International Conference on, pages 245–247. IEEE, 2009.

[24] C. Pring. social media statistics for 2012. http://thesocialskinny.com/100-social-media-statistics-for-2012/. [Retrieved: 9, 2013].

[25] M. S. Rahman, T.-K. Huang, H. V. Madhyastha, and M. Faloutsos. Efficient and scalable socware detection in online social networks. In Proceedings of the 21st USENIX conference on Security symposium, Security'12, pages 32–32, Berkeley, CA, USA, 2012. USENIX Association.

[26] M. S. Rahman, T.-K. Huang, H. V. Madhyastha, and M. Faloutsos. Frappe: detecting malicious facebook applications. In Proceedings of the 8th international conference on Emerging networking experiments and technologies, pages 313–324. ACM, 2012.

[27] Sophos. Security threat report 2013. Technical report, 2013.

[28] Websense. 2013 threat report. Technical report, 2013.

[29] H. Xu, N. Wang, and J. Grossklags. Privacy by redesign: Alleviating privacy concerns for third-party applications. In ICIA, 2012.

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Vis-a-Vis Verification: Social Network Identity Management Through Real World Interactions

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***Abstract*—Online services, particularly those aimed at a specific user base such as a company's employees, face the problem of identity management. Especially when the service constitutes some kind of social network, i.e., the validity of the users' identities matters, secure and reliable means for identity verification and authentication are required. In this paper, we propose a novel identity management concept based on a) verification through physical presence and b) authentication through ownership. Our approach being a hybrid solution between a centralized authority and decentralized trust management is settled on a sweet spot between security and convenience for the users.**

Keywords*—identity management systems; authentication; social network services; mobile computing

I. INTRODUCTION

Nowadays, with about 2.8 billion people using the Internet worldwide [1] and over 1.1 billion people participating in the world's largest online social network Facebook [2], online service providers have a clear need for identity management, i.e., *administration*, *verification*, *authentication* and *authorization* of virtual identities and their real-world counterparts.

Especially when a service's users are linked to their real-world identity (i.e., the service constitutes some kind of online social network) and more so, when the service furthermore requires a high level of security, a key part of identity management is to verify that a virtual account really belongs to the real-world person it is supposed to be linked to, and to provide a secure and intuitive means of authentication. Typically in such services, a user Alice would decide for or against granting certain permissions to a virtual user Bob based on whether she wants to grant those permissions to the real-world Bob. Thus, she has to be sure that the user account really belongs to the real-world Bob (verification), and that nobody else can make requests on behalf of that account (authentication).

There are several ways of verifying a user's real-world identity, which to date either are easy to implement/use but quite easy to attack, or are reasonably secure but introduce a huge overhead in the general process of account creation. In the same way, currently used authentication procedures differ in potential for security breaches on the one, and intuitivity on the other hand.

With the now near ubiquitous usage of smartphones, we see huge potential to improve upon the currently used ways of identity verification and authentication in online services. In this work, we present an approach that is based on two key ideas

- New user accounts are verified to belong to a certain real-world identity by requiring an interaction of an existing user with the new user in the real world.
- The users employ their personal smartphone as the credential for authentication, i.e., the security token is stored on the users' smartphone.

Our approach constitutes a hybrid system. There is a central authority which is the root of the system's trust relations and is controlled by the organisation employing the system. In order to avoid the typical overhead of sophisticated identity verification, verification tasks are distributed among the system's existing users. Consequently, our system provides a high degree of trustworthiness of the user accounts while keeping the introduced overhead at a reasonable level. To the best of our knowledge, to date, no other approach has settled on that sweet spot between security and convenience/ease-of-use.

The rest of the paper is structured as follows. In Section II, we give an overview of various concepts for identity verification and authentication, together with their individual strengths and weaknesses. In Section III, we discuss related work which is or could be used similar to our approach. In Section IV, we present our system for identity verification and authentication. After that, we describe a real implementation of our concept which has been deployed for production usage (Section V). In Section VI, we describe some scenarios how our approach could be used, and in Section VII, we conclude with an outlook at future work.

II. IDENTITY MANAGEMENT

Identity management of online services comprises several sub-topics like authorization and management of user accounts. The focus of this work specifically lies on *identity verification* and *authentication*. We define identity verification as the process to check the real-world identity of a person and to connect this identity to a virtual account. Authentication then requires some kind of credential to prove that a request is made by that virtual account (i.e., on behalf of the real person).

A. Identity Verification

There are several mechanisms to verify an online identity, i.e., to link a virtual account to a real-world person. These

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mechanisms can be categorized into three groups, namely *verification through another online identity provider*, *verification through a second communication channel* and *verification through physical presence*.

1) Verification through another online identity provider: The idea of this mechanism is to rely on a third party to verify a new user account. The typical and most widely used example is to require an existing email address when a new account shall be created. To confirm the email address, the online service sends a message to the registrant containing a confirmation link. By clicking the link, the new user can ensure that he is the real owner of the email address. In this case, one relies upon the third party to have checked the identity of the potential user. Thus, it depends on the third party whether the real-world identity is verified, and even if so, typically the real-world identity is not handed over to other parties, leaving the online service with the email address only.

An email address of course is only a very weak personal detail for a real identity. Another approach is to rely on real identity providers. For example, online services like Facebook.com, plus.google.com, or LinkedIn.com manage user profiles which are verified to some degree. These services can be used either through proprietary interfaces (e.g., *Facebook Login* [3]), or by employing standardised mechanisms like OpenID [4].

Verification through a third party often is the most convenient method of identity verification, both for the end user and the online service provider. The main drawback is the dependence on the trustworthiness of the third party.

2) Verification through a second communication channel: Another approach is the integration of a second communication channel into the verification procedure, typically using an endpoint which requires or inherently is linked to a more sophisticated identity verification like a mobile phone number or a postal address.

When using a mobile phone number, the online service e.g., can send a randomly generated unique token as a text message to the phone. The user then has to enter that token into a form at the online service, which ensures the provider that the user really is the owner of that specific phone number.

A similar procedure can be performed by sending the token in a letter to the user's postal address. Though this alternative takes several days to complete, the online service can obtain a verification of the user's name and residency.

Again, one relies on a third party to verify the identity of a new user. However, e.g., mobile phone providers are required by law to verify the identity of their customers in most countries, leading to a higher trustworthiness of those third parties compared to the previous approach (II-A1).

3) Verification through physical presence: The most sophisticated variant of identity verification is verification through physical presence, i.e., the user whose identity has to be checked is in direct proximity of authorized personnel of the online service provider or a trusted third party which acts on behalf of the provider.

Depending on whether the verifying person already knows the to-be-verified user or not, the new user might have to provide official identity documents like passports or ID cards to prove its identity.

Physical verification by the online service provider itself can be regarded as the most secure option. However, it is often unfeasible to establish a dedicated verification entity at the provider and to manually check the identity of maybe thousands of users. Therefore, services like *Postident* [5] by German logistics company *Deutsche Post* exist which provide personal identity verification for third parties. In this case, a new user could verify its online account in one of the many stores of the logistics company.

Summing up the alternatives, verification through another online identity provider can be regarded as the most convenient but also most insecure variant. Verification through a second channel like the mobile phone network or old-school snail mail is more reliable due to law-enforced requirements or the sheer characteristics of the channel (e.g., name and postal address is correct when the letter arrives). However, it is also less convenient and more costly for the participants. Finally, verification through physical proximity provides the most secure procedure at the cost of increased effort for both the online service provider and the end user.

B. Authentication

Within the scope of online services, authentication can be defined as the act of confirming the origin of a request, i.e., from which user or account the request was sent. One can distinguish between three categories (*factors*) of authentication, namely authentication by *something you know* (*knowledge*), by *something you are* (*inherence*), and by *something you have* (*ownership*).

1) Something you know: This authentication factor involves some kind of secret only the respective user knows. Typical examples are passwords or pass phrases, personal identification numbers (PIN), or challenge response procedures (i.e., asking a question only the user can answer). This way of authentication usually can be implemented without much overhead at the provider, but is prone to security breaches resulting from users employing secret credentials too easy to guess or infer from other knowledge. Furthermore, this method can be attacked through phishing [6].

2) Something you are: This means of authentication is based on the behavioral and/or biological characteristics of an individual. Typical methods are to recognize fingerprint, face, voice or retinal pattern. Using inherent characteristics of a human being is convenient for the user because she does not have to remember a secret, but often is complex to implement, error prone and furthermore, the user might be unwilling to share such personal details with a provider.

3) Something you have: In this case, authentication is based on the possession of a key, smart card, security token and the like. In the scope of online services, using this method has the advantage that longer and much more complex security tokens can be used, compared to an ordinary password a user has to know by heart. Implementation usually is straight-forward at the provider, and this method furthermore is very intuitive for the users since it resembles the real-world usage of ordinary

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keys. However, users might be unwilling to carry additional hardware such as smart cards with them.

Comparing the three methods, authentication based on ownership is the best compromise between security on the one hand, and intuitivity for the users on the other hand. However, using a dedicated hardware component might not be feasible. The latter can be prevented when using a user's smartphone to store the token [7].

C. Problem statement

Today, most online services rely on a verification procedure based on third party identity providers, typically only requiring a valid email address, and employ username-password-credentials for authentication (i.e., something you know). As we have explained, verification through physical presence and authentication via something you have would be a very promising combination regarding security and intuitivity and would therefore be a superior solution to those mechanisms currently most widely used. However, existing ideas result in increased inconvenience for the end-user and more complexity at the provider.

In this work we present a solution that uses that exact combination of identity verification by physical presence and authentication by something you have, which at the same time keeps the typical overhead at a feasible and usable level.

III. Related work

As seen in the previous section, there is a multitude of ways and combinations online services can perform identity verification and authentication. In this section, we focus on systems that resemble our approach with regard to the employed concepts.

Public Key Infrastructures (PKI) are the most widely used method conceptually comparable to our approach. Digital certificates are issued and verified by a Certificate Authority (CA), which can then be used to authenticate oneself. Dependent on the CA and the type of certificate, obtaining this credential requires the verification of one's real-world identity [8]. PKIs are used in conjunction with Secure Socket Layer (SSL) to ensure secure communication, which in general results in increased complexity leading to vulnerabilities, e.g., with regard to validation of SSL certificates within non-browser environments [9]. However, the main disadvantage is that PKIs in its current form are mostly aimed at organisations and corporations, and distribution of certificates to individual users often is not possible to employ with only a reasonable overhead. Since PKIs allow for hierarchical relationships between the CAs among themselves (i.e., one CA may vouch for another), the resulting structure can be regarded as a tree, which is similar to our approach.

An alternative to the rather centralized trust model of a PKI, which relies exclusively on CAs, is the Web of Trust concept. The latter is a decentralized approach to certificate signing, requiring the users to ensure their respective identities among themselves, often based on personal encounters [10]. PGP and GnuPG are well known implementations of this concept, which allow people to exchange messages securely with mutual authentication [11].

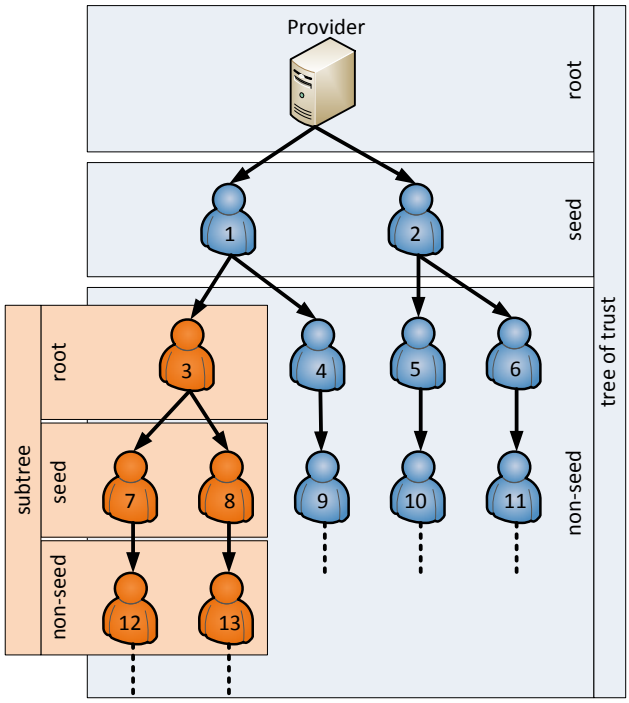

Fig. 1. Participants forming a tree of trust, consisting of three levels root, seed and non-seed. Each subtree also is a tree of trust in itself.

A core concept of the Vis-a-Vis system is the so-called *tree of trust* (see Section IV-D). There are similarly named concepts in other areas which should not be confused with our approach. Presti [12] defines a "tree structure of trust" within the scope of Trusted Computing. In this case, the tree's nodes represent the components of the whole Trusted Computing platform, i.e., from the hardware modules up to the applications. Verbauwhede and Schaumont [13] take a similar approach by partitioning different abstraction levels of electronic embedded systems (e.g., the software level or the circuit level) into secure and non-secure parts. They call the resulting structure a "tree of trust", too. Although both approaches regard trees as a suitable structure for representing trust relationships, they are aimed at different scopes than our system.

IV. Vis-a-Vis

In the following, we describe the Vis-a-Vis concept for identity verification and authentication.

A. Authentication

In order to authenticate the users in the Vis-a-Vis system, a notion of the "something you have" principle is used. The idea is based on the omnipresence of mobile devices such as smartphones or tablets, and the assumption that such devices (or specific accounts on them in case of multi user systems) belong to one and only one user. The device is like a key in the physical world. Authenticating the device therefore suffices to authenticate the respective user.

Technically, authentication is performed by issuing a secret, unique token to each device in the system, which then is

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included in all requests of the device to the backend (i.e., the provider). To prevent leaking the token, communication between mobile devices and the backend has to be encrypted (e.g., by using SSL). To authenticate the backend itself, traditional means such as SSL certificates can be used.

B. Participants

Vis-a-Vis is a *hybrid system* with some core components being central elements and most of the other participants self-organizing in a decentralized manner. As such, it is not intended as a single web-wide system but to be deployed individually at organizations. A schematic overview is depicted in Figure 1.

The *Vis-a-Vis provider* is the central entity representing the respective organization. It is fully trusted by default since it manages the whole system. At the moment, there is no interaction beyond provider boundaries and thus, there is no need for further, mutual verification of different Vis-a-Vis providers among themselves.

Providers are responsible to activate *seed users*. These users are verified directly by the provider, by any means regarded secure enough for the given scenario, e.g., by authorized personell such as system administrators verifying a user's identity in person (on-location) or by sending activation information via snail mail. Seed users are fully trusted by the provider.

In order to distribute the verification overhead among the participating entities, seed users can further activate *non-seed users*. The identity of non-seed users is verified by seed users through physical proximity, i.e., seed users may decide to hand over the activation token (from mobile device to mobile device) based on existing knowledge (seed user already knows the new user) or based on official documents (seed user checks e.g., ID card or passport).

Non-seed users are also allowed to activate new users - in the same manner as seed users - resulting in further non-seed users. As a consequence, non-seed users differ in their distance from the root node (*distance from root*, see Section IV-E), a measure which can be used to quantify the trustworthiness of a user.

C. Protocol

Adding new users to the system is performed in several steps (see Figure 2). First, an online identity (i.e., an account) has to be created for the new user at the provider (step 1). This step can be triggered by the user itself, by the provider (which is reasonable when the future users are known upfront, such as within a company) or by an existing user. It is important to note that in this step, only the account is created (i.e., prepared). It is neither yet activated nor linked to the user's device, i.e., it is not usable, yet.

In order to activate the account, the user needs a one-time key which is generated by the provider. This one-time key can only be given to the new user by the provider itself or by an existing user - the latter case being the more interesting (step 2). Thus, an existing user wanting to activate a new user requests the new user's one-time key from the provider (step 3 and 4) and then forwards it to the new user (step 5). The forwarding has to be done in a way requiring

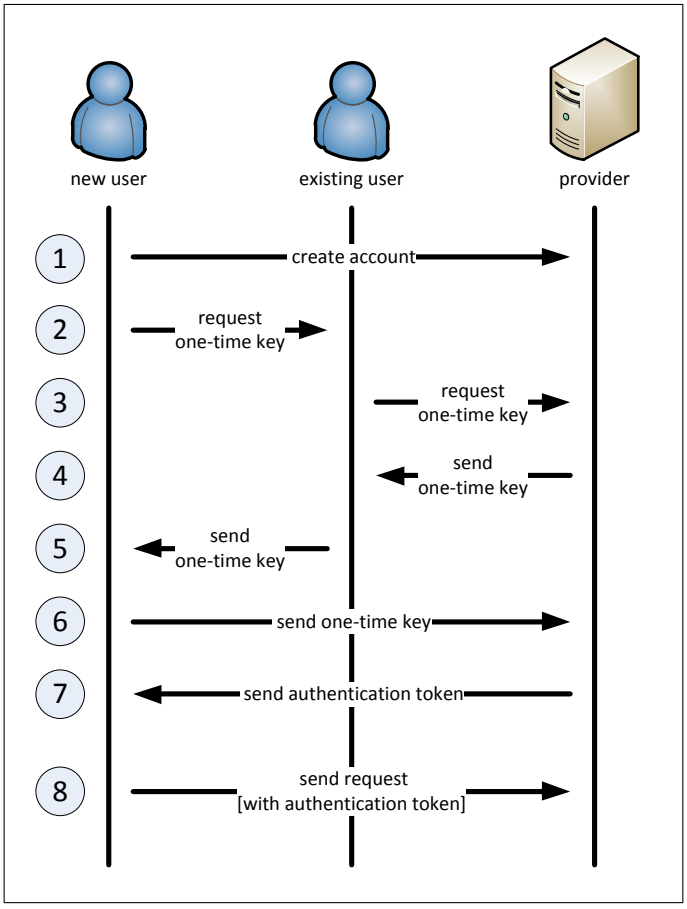

Fig. 2. The Vis-a-Vis protocol.

physical proximity (i.e., "vis-a-vis"), e.g., transfer via Near Field Communication (NFC) or optical codes like QR codes.

After receiving the one-time key, the new user sends the key directly to the provider (step 6). The provider now checks whether it is the correct key for the respective user and, when confirmed, sends an authentication token back to the new user (step 7). The user includes this token in all subsequent requests to the backend to confirm its authenticity (step 8).

D. Tree of trust

Performing the above protocol using the described participants results in a tree-like structure. Since this structure describes the evolved trust relations between the users, we can formally define a *tree of trust*

$$T = (V, E) \tag{1}$$

with nodes V and edges E as a rooted tree with *root node* $r \in V$ (the Vis-a-Vis provider), an arbitrary number of *seed nodes* (seed users)

$$S = \{s : s \in V \wedge (r, s) \in E\} \tag{2}$$

and an arbitrary number of *non-seed nodes* (non-seed users) $\bar{S} = V \setminus S$. Each *rooted subtree*

$$T' = (V', E') \tag{3}$$

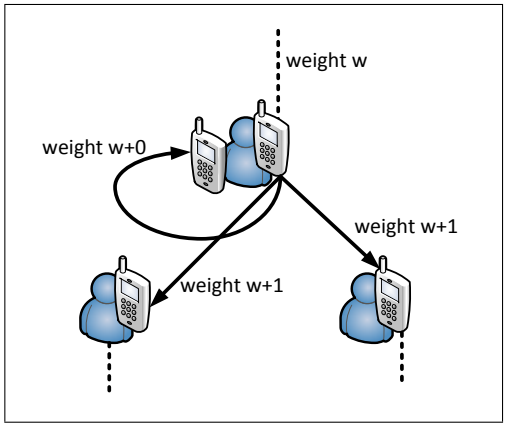

Fig. 3. Part of a weighted tree of trust, showing activation of new users (with decreasing trustworthiness) as well as self-activation with edge weight 0 (i.e., no loss of trustworthiness).

with $E' \subseteq E$ and $V' = \{v' : v' \in V \wedge (\exists v'' \in V' : (v'', v') \in E' \vee (v', v'') \in E')\}$ is also a tree of trust, i.e., each node can be regarded as the root of its own tree of trust containing users which have been activated by itself or its descendants.

Trees of trust are an analogy to the idea of the web-of-trust. The difference is that trees of trust represent a hierarchy of users allowing for a more intuitive assignment of capabilities with regard to some metric (see Section IV-E) whereas in a meshed graph the structure of trust relationships is harder to grasp.

E. Distance from root D_r

There is a single path $P(x, y)$ between each two nodes x and y in the tree, defined as

$$P(x, y) = (v_1, \ldots, v_n) \tag{4}$$

with $v_i \in V, v_1 = x, v_n = y, (v_i, v_{i+1}) \in E$. Based on that we define a measure *distance from root* D_r as

$$D_r(v) = |P(r, v)| \tag{5}$$

A user's distance from its tree's root is a measure for the user's trustworthiness. This measure can be considered when assigning rights or capabilities, e.g., one might limit the length of an *activation chain*, i.e., the path from the tree's root to the user, to a constant C, i.e., $D_r(v) < C : \forall v \in V$.

F. Weighted Tree of Trust

Often it might be desirable to establish a more flexible scheme to assign a trust value to the nodes, considering not only the length of the path from them to the root node but also impact factors like the trustworthiness of the used activation channel.

Furthermore, in some scenarios it is useful to not regard the users as the tree's nodes but their individual devices. Users often possess several mobile devices and it is advisable to issue individual authentication tokens to each device: In case a token is compromised, one can revoke the token without affecting the user's other devices.

Activating a new device by oneself would reduce the trust value of the new device when using the distance from root measure. This can be the desired behaviour, but more often the same person should have the same capabilities on each of its devices.

This problem is solved by introducing weights on the tree's edges (see Figure 3), i.e., each edge (x, y) is assigned a weight w_{xy} correlating to the trustworthiness of the edge itself. Thus, one can define a new trust measure $Trust$ as

$$Trust(v) = \sum \{w_{v_i v_{i+1}} : (v_i, v_{i+1}) \in P(r, v)\} \tag{6}$$

When setting the weight of all edges to 1, $Trust(v) = D_r(v)$.

Using the $Trust$ measure one can allow activation of one's own devices without loss of (calculated) trustworthiness by setting the edge weight to 0. On the other hand, one can also assign edge weights > 1 to mark "more insecure" activations.

V. Implementation

We have implemented and deployed the proposed concept in a real production environment at an educational institution. In this section, we will briefly describe the technical implementation of the various components.

The technical part of the Vis-a-Vis provider has been realised as a backend service, which is programmatically accessed through a REST interface. It furthermore provides a web interface which is intended for account creation. We employ a weighted tree of trust (see Section IV-F), i.e., regarding the users' devices as the tree's nodes and allowing for self-activation of more than one device. Devices are running a custom application, which stores the authentication token and furthermore is used to access protected content provided by the institution.

When a new user wants to create an account, she does so using a dedicated account creation web interface of the Vis-a-Vis provider. Thereby, the user has to provide some personal credentials like name and date of birth, as well as its affiliation to certain groups or departments of the institution. When submitting the registration request, a QR code containing a unique account ID is shown. The user has to scan that code with her smartphone running our custom application, which results in an association of the user's device to the newly created account. It has to be noted that at that point in time, only the association is created, the account itself is not activated, i.e., the user cannot access any protected content, yet.

After that, the user has two choices. She either proceeds to print out a document, containing her account credentials including the associated account ID, which she then has to sign and to provide to authorized personnel at the institution. The latter now check the provided credentials, verify the identity of the new user and then can activate the associated account. The user now can access the protected content and has become a seed user, as she was verified by the Vis-a-Vis provider itself. The seemingly cumbersome usage of printed documents is introduced because at the given institution, it is legally required that the to-be-created seed users sign a consent form. Thus, the Vis-a-Vis system is integrated into the existing workflow.

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The alternative way of activating an account is via an existing user. The system is configured to allow existing users to activate new users which belong to the same group. In our mobile application, existing users can browse through and select users which they can activate. They can request the needed one-time key from the provider, which then is encoded in a QR code. The new user can scan this code, resulting in the described protocol being carried out (see Section IV-C). Consequently, the new user has become a non-seed user.

VI. Applications

The Vis-a-Vis concept is predestined to be used at any organisation with a hierarchical structure such as companies, educational institutions, clubs or small project teams. In the following, we describe two use cases, in which our system perfectly fits the inherent structure of the scenario.

A. Use in Companies

A company usually is organised in a hierarchical way, composed of departments and teams, where permissions often should be assigned in accordance to that structure. This perfectly fits the basic building blocks of the Vis-a-Vis system, where senior employees might activate other employees. The hybrid approach of the Vis-a-Vis system ensures that some kind of central authority is present and thus, that seed users can be trusted. Each principal of the respective hierarchy level acts as the responsible seed user of his subordinates. As an example, the CEO of a company would act as a main seed user and unlock its subordinate head of department. In the following, department heads can activate their subordinate team leaders, and so on.

The resulting tree of trust can be used to assign permissions and capabilities, not only based on the user's role but also on her distance to the last directly verified user (which can be measured by the distance from root metric).

B. Use in schools

Another interesting use case is constituted by educational institutions, e.g., schools. This in fact is the scenario in which we have already deployed the system. Within a school, several roles exist, such as teachers, students and parents. These roles are subject to a predetermined hierarchy with different permissions. Furthermore, it is of highest relevance that user identities are verified, i.e., parents and teachers can be sure that they are corresponding with each other.

In this case, initially only the director of a school might have access to the system. As a director representing the highest authority within the school, he has the ability to unlock teachers as seed users. These in turn have the privilege to unlock students which belong to their assigned classes. Students can then activate their parents and give them the permission to access the school network, too.

A key benefit in this use case are the decreasing administrative costs because of the convenient but secure delegation of activation responsibilities.

In case a written agreement from the parents is required by law, the Vis-a-Vis concept is also employable, with parents being authorized directly by the school management (and therefore becoming seed users). Parents then are able to activate further family members by themselves.

VII. Conclusion and future work

In this paper, we presented a novel approach to combine the concept of identity verification through physical presence with the authentication factor ownership, i.e., authentication by something you have. We defined a structure called tree of trust, on which a distance from root metric can be calculated. The latter is a measure for a node's trustworthiness, i.e., it can be used as a parameter for permission assignment. By extending the concept to weighted trees of trust, one can also allow for self-activation of further devices as well as activation by more insecure means, resulting in a lower trustworthiness value. The system perfectly fits scenarios which inherently exhibit some kind of hierarchy and require a central authority, but in which identity verification tasks should be distributed among the system's users.

In future work, it might be interesting to investigate the integration of proximity proofs, i.e., to check whether the transmission of the one-time key really has taken place vis-a-vis, i.e., in direct physical proximity. This would further increase the system's security and the reliability on the trustworthiness of activated accounts.

References

[1] International Telecommunications Union, "Key ict data for the world," http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx, 2013, last accessed date: 2013-07-18.

[2] "Facebook key facts," http://newsroom.fb.com/Key-Facts, 2013, last accessed date: 2013-09-18.

[3] "Facebook login," https://developers.facebook.com/docs/facebook-login/, 2013, last accessed date: 2013-09-18.

[4] "Openid," http://openid.net/, last accessed date: 2013-09-18.

[5] "Postident," http://www.deutschepost.de/dpag?lang=de_EN &xmlFile=1016309, last accessed date: 2013-09-18.

[6] N. Chou, R. Ledesma, Y. Teraguchi, D. Boneh, and J. C. Mitchell, "Client-side defense against web-based identity theft," in *Proceedings of the 11th Annual Network and Distributed System Security Symposium*, 2004.

[7] T. V. N. Rao and K. Vedavathi, "Authentication using mobile phone as a security token," *International Journal of Computer Science & Engineering Technology*, vol. 1, no. 9, pp. 569–574, October 2011.

[8] Coulouris, J. Dollimore, and T. Kindberg, *Distributed Systems: Concepts and Design (4th Edition) (International Computer Science)*. Boston, MA, USA: Addison-Wesley Longman Publishing Co., Inc., 2005.

[9] M. Georgiev, S. Iyengar, S. Jana, R. Anubhai, D. Boneh, and V. Shmatikov, "The most dangerous code in the world: validating ssl certificates in non-browser software," in *Proceedings of the 2012 ACM conference on Computer and communications security*, 2012, pp. 38–49.

[10] J. Golbeck, B. Parsia, and J. Hendler, "Trust networks on the semantic web," in *Cooperative Information Agents VII*, ser. Lecture Notes in Computer Science, M. Klusch, A. Omicini, S. Ossowski, and H. Laamanen, Eds. Springer Berlin Heidelberg, 2003, vol. 2782, pp. 238–249.

[11] P. R. Zimmermann, *The official PGP user's guide*. Cambridge, MA, USA: MIT Press, 1995.

[12] S. L. Presti, "A tree of trust rooted in extended trusted computing," in *Proceedings of the Second Conference on Advances in Computer Security and Forensics Programme*, 2007, pp. 13–20.

[13] I. Verbauwhede and P. Schaumont, "Design methods for security and trust," in *Design, Automation & Test in Europe Conference & Exhibition*, 2007, pp. 1–6.

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Feature Frequency Inverse User Frequency for Dependant Attribute to Enhance Recommendations

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***Abstract*—Recommender system provides relevant items to users from huge catalogue. Collaborative filtering and content-based filtering are the most widely used techniques in personalized recommender systems. Collaborative filtering uses only the user-ratings data to make predictions, while content-based filtering relies on semantic information of items for recommendation. The aim of this work is to introduce the semantic aspect of items in a collaborative filtering process in order to enhance recommendations. Many works have addressed this problem by proposing hybrid solutions. In this paper, we present another hybridization technique that predicts users preferences for items based on their inferred preferences for semantic information of items. For this, we propose a new approach to build user semantic model by using TF-IDF measure and we provide solution to reduce the dimension of data. Applying our approach to real data, the MoviesLens 1M dataset, significant improvement can be noticed compared to usage only approach, Content only approach and hybrid algorithm.**

***Keywords*—hybrid recommender system; collaborative filtering; TF-IDF.**

I. INTRODUCTION

Recommender Systems (RS) provide relevant items to users from a large number of choices. Several recommendations techniques exist in the literature. Among these techniques, there are those that provide personalized recommendations by defining a profile for each user. In this work, we are interested in personalized recommender systems where the user model is based on an analysis of usage. This model is usually described by a user-item ratings matrix, which is extremely sparse ($\geq 90\%$ of missing data).

Collaborative Filtering (CF) and Content-Based (CB) filtering are the most widely used techniques in RS. The fundamental assumption of CF is that if users X and Y rate n items similarly and hence will rate or act on other items similarly [1]. CB filtering assumes that each user operates independently and user will be recommended items similar to the ones he preferred in the past [2]. The major difference between CF and CB recommender systems is that CF uses only the user-item ratings data to make predictions and recommendations, while CB relies on item content (semantic information) for recommendations. However, CF and CB techniques must face many challenges like the data sparsity problem, the scalability problem for large datasets with the increasing numbers of users.

To overcome the disadvantages of both techniques and benefit from their strengths, hybrid solutions have emerged. In this paper, we present a new approach taking into account the semantic information of items in a CF system. In our approach, we design a new hybridization technique, which predicts user preferences for items based on their inferred preferences for item content; and presents a solution to the sparsity and scalability problems. Our system consists of two components: the first builds a new user model, *the user semantic model*, by inferring user preferences for item content; the second computes predictions and provides recommendations by using the user semantic model in a user-based CF algorithm to calculate the similarity between users. The originality of this work is in the building of the user semantic model. Indeed, assuming that items are represented by structured data in which each item is described by a same set of attributes, we build a *user semantic attribute model* for each relevant attribute. With this aim, we define two classes of attributes: *dependent* and *non dependent* and we propose a suited algorithm for each class. User semantic model is then deducted from the horizontal concatenation of all user semantic attribute model. In previous works [3], [4] we have presented solutions based on machine learning algorithm to build a user semantic attribute model for non dependent attribute. In this work, we present a new approach for building a user semantic attribute model for dependent attribute based on TF/IDF measure. Due to the high number of attribute values, and to reduce the expensiveness of user similarity computing, we propose also a solution to reduce the size of the user semantic attribute model. We compare our results to the standards user-based CF, item-based CF, CB and hybrid algorithms. Our approach results in an overall improvement in prediction accuracy.

The rest of paper is organized as follows: Section II summarizes the related work. User semantic model is described in Section III. Section IV describes our approach to build user semantic attribute model for non dependent attribute. Section V describes the recommendation component of our system. Experimental results are presented and discussed in Section VI. Finally, we conclude with a summary of our findings and some directions for future work.

II. RELATED WORK

RS have become an independent research area in the middle 1990s. CF is the most widespread used technique in RS, it was the subject of several researches [5], [6]. In CF, user will be recommended items that people with similar tastes and preferences liked in the past [7]. CB is another important technique; it uses techniques developed in information filtering research [8]. CB assumes that each user operates independently and recommends items similar to the

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ones he preferred in the past. To overcome the disadvantages of both techniques and benefit from their strengths, several RS use a hybrid approach by combining CF and CB techniques. The Fab System [9] counts among the first hybrid RS. Many systems have been developed since [10]. Most of these hybrid systems do not distinguish between attributes and treat their values in a same way. Moreover, because of the huge number of items and users, calculating the similarity between users in CF algorithm became very expensive in time computing. Dimension reduction of data is one of the solution to reduce the expensiveness of users similarity computing. Mobasher et al. [11] combine values of all attributes and then apply a Latent Semantic Analysis (LSA) to reduce dimension of data. Sen et al. [12] are inferring user preferences for only one attribute, the item' tags, without reducing dimension. Manzato [13] computes a user semantic model for only the movie genre attribute and applies a Singular Value Decomposition (SVD) to reduce the dimension of data. In our approach, we compute a user semantic attribute model for each relevant attribute and we propose a low cost solution to reduce the data dimension.

III. USER SEMANTIC MODEL

Pazzani et al. [8] have identified three alternative item representations. Item can be represented by *structured data* in which there is a small number of attributes, each item is described by the same set of attributes, and there is a known set of values that each attribute may have, for instance, the attributes of a movie can be *title*, *genres*, *actors* and *director*; *unstructured data* such as *news articles*, *abstract of movie*, *description of restaurant*, is an unrestricted text in which there are no attribute names with well-defined values; or *semi-structured data* in which there are some attributes with a set of restricted values and some free-text. In this paper, we are interested only to items described by structured data. The others representations will be addressed in future work. In the following, we will use the term *feature* to refer to an attribute value, for instance *Documentary*, *Musical* and *Thriller* are features of *movie genre* attribute.

A. Dependent and non Dependent attribute

In structured representation, each attribute has a set of restricted features. However, the number of features can be related or not to the number of items. That is why we have defined two classes of attributes:

- **Dependent attribute**: attribute, which having very variable number of features. This number is closely related to the number of items. So, when the number of items is increasing, the number of features is increasing also. For example: *directors* and *actors of movies*, *user tags*.
- **Non dependent attribute**: attribute, which having a very few variable number of features, and this number is not related to the number of items. Thus, the increasing number of items has no effect on the number of features. For example: *movie genres*, *movie origin* and *cuisine of restaurants*.

In addition, all attributes do not have the same degrees of importance to users. There are attributes more relevant than others. For instance, the *movie genre* can be more significant, in the evaluation criteria of user, than the *origin*. Experiments that we have conducted (see Section VI) confirmed this hypothesis. In this paper, we assume that relevant attributes will be provided by a human expert. Therefore, for each relevant attribute A, we build a *user semantic attribute model* that predicts the users preferences for its features. This model is described by a matrix Q_A (users in lines and features of A in columns). In our approach, we design a suited algorithm for building the *user semantic attribute model* for each class of attribute. For non dependent attribute, due to the low number of features, we have used a clustering algorithm. Section III-B briefly described the operating principle of our solution that have been addressed in previous works [3], [4]. For dependent attribute, we have explored techniques issues from retrieval and information filtering research, Section IV presents our solution for building the *user semantic attribute model* for dependent attribute that is the aim of this paper. The user semantic model for all relevant attributes, described by the matrix Q, is the result of the horizontal concatenation of all user semantic attribute models Q_A.

B. User semantic model for non dependent attribute

Let us denote by S the set of items, U the set of users, s a given item $\in S$, u a given user $\in U$ and a rating value $r \in \{1, 2, ..., 5\} \equiv R$. U_s the set of users that rating the item s, then we define the rating function for item s by $\delta_s : u \in U_s \longmapsto \delta_s(u) \in R$. We denote also by F_A the set of features of attribute A, f a given feature $\in F_A$ and S_f the set of items associated to feature f. For instance if we consider the *movie genre* attribute, S_{action} is the set of all action movies.

An item s is represented by its usage profile vector $s_{up} = (\delta_s(u) - \overline{\delta_u})_{(u=1..|U|)}$, where $\overline{\delta_u}$ is the average rating of all rated items by user u. The idea is to partition all items described by their usage profile in K clusters, each cluster is labeled by a feature $f \in F_A$ (or a set of features).

The number K of clusters and the initial center of each cluster is computed by the initialization step of the clustering algorithm. In initial step, each cluster C_k consists of items in $\bigcup_{f\ labeling\ C_k} S_f$ and labeled by the set of corresponding features; so its center is the mean of its items described by their usage profile vector s_{up}. Moreover, an attribute can be mono valued or multivalued depending on the number of features that can be associated to a given item s. For example, the attribute *movie genre* is multivalued because a movie can have several genres while *movie origin* is a mono valued attribute because a movie has only one origin. Thus, if an attribute is multivalued, s can belong to several clusters C_k, while for mono valued attribute, an item should belong only to one cluster. Therefore, for multivalued attribute, the clustering algorithm should provide non disjointed clusters (a fuzzy clustering), whereas, for mono valued attribute, the clustering algorithm should provide disjointed clusters.

After running the clustering algorithm, we obtain K cluster centers; each center k is described by a vector $c_k = (q_{k,u})_{(u=1..|U|)}$. Thus, the user semantic attribute model is described by the matrix $Q_A = (q_{u,k})_{(u=1..|U|,\ k=1..K)}$.

With non dependent attribute, the number of associated features is low, this is why the clustering is suitable. More-

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over, the user semantic attribute model allows an important reduction of dimension and so reduce the expensiveness of user similarity computing. In [4], we have used the Fuzzy CMean Algorithm on the movie genre attribute, we have obtained good performance because the user semantic attribute model has no missing values and all similarities between users were able to be computed. In [3], we have used the KMean clustering algorithm on the movie origin attribute. Because of the missing values in the user item rating matrix, we have proposed an algorithm for the initialization step of the KMean clustering using a movie origin ontology. We obtained good results compared to user-based CF but not as good as the genre attribute.

IV. User semantic model for dependent attribute

For a dependent attribute A, the set F_A of its features can be important and it augments with the increasing of the set of items S. In this paper, we present our solution to compute a user semantic attribute model for dependent attribute. Due to the high number of attribute features in this case, and with the aim to reduce the expensiveness of user similarity computing, we propose also a solution to reduce the dimension based on features selection.

In addition to the formalism used in Section III-B, we denote by F_{A_s} the set of features $f \in F_A$ associated to item s and by S_u the set of items $s \in S$ rated by user u. We define the feature function for item $s \in S$ as $\beta_s : f \in F_A \mapsto 1 if\ f \in F_{A_s}(f\ associated\ to\ item\ s),\ 0\ otherwise$, the item-feature matrix is so equal to $(\beta_s(f))_{s \in S\ and\ f \in F_A}$. We denote also, the rating function of user u as $\delta_u : s \in S_u \mapsto \delta_u(s) \in R$; and the user frequency function as $freq_u : f \in F_A \mapsto freq_u(f) \in \mathbb{N}$. The frequency matrix $F = (freq_u(f))_{u \in U\ and\ f \in F_A}$ is provided by computing $freq_u(f)$ for all users $u \in U$ and all features $f \in F_A$. In the following sections, we propose 4 methods for computing the frequency function $freq_u$.

A. Computing the frequency function for all items

In this case, the frequency function $freq_u(f)$ consists of counting the number of times, the user u rated an item associated to feature f. The formula is given by (1).

$$freq_u(f) = \sum_{s \in S_u} \beta_s(f) \tag{1}$$

B. Computing the weighted frequency function for all items

In (1), all items are treated in a identical way. In this case, we introduce the evaluation of item by user in the frequency function. Thus, the feature function is weighted by the user rating function δ_u. For instance, if $\delta_u(s1) = 4$, $\beta_{s1}(f) = 1$ and $\delta_u(s2) = 2$, $\beta_{s2}(f) = 1$ the frequency of feature f for user u is 5 in this case and 2 in (1).

$$freq_u(f) = \sum_{s \in S_u} \beta_s(f) \times \delta_u(s) \tag{2}$$

C. Computing the frequency function for relevant items

In this case, we consider only relevant items for user u. Let us denote $S_{u_{relevant}} = \left\{ s \in S_u / \ \delta_u(s) \geq \overline{\delta_u} \right\}$ the set of relevant items for user u and $\overline{\delta_u}$ is average rating function of user u over all items in S_u. The use of the average rating function instead of a threshold offers two advantages: first, it avoids adding a new parameter, the threshold value. Secondly, it allows a personalized frequency, because it takes into account the variation between users ratings.

$$freq_u(f) = \sum_{s \in S_{u_{relevant}}} \beta_s(f) \tag{3}$$

D. Computing the weighted frequency function for relevant items

In this case, the feature function is weighted by the rating of only relevant items $s \in S_{u_{relevant}}$.

$$freq_u(f) = \sum_{s \in S_{u_{relevant}}} \beta_s(f) \times \delta_u(s) \tag{4}$$

E. Reduction of dimension of data

For dependent attribute, the number of feature is correlated to the number of items, and so it can be very elevated and even higher than the number of items. Thus, the semantic user attribute model can have dimension greater than the user rating matrix thereby aggravating the scalability problem. In order to reduce the dimension of the user semantic attribute model, we propose a reduction method based on selecting a subset of relevant features from the original set F_A. We choose to reduce the number of features without using an expensive algorithm like LSA or SVD, but by selecting features having a number of ratings greater than a given threshold μ.

So, we define the number of feature ratings function η as:

$$\eta : f \in F_A \mapsto \sum_{u \in U} \sum_{s \in S_u} \beta_s(f)$$

$\eta(f)$ provides the number of ratings associated to f. $F_{A_\mu} = \{ f \in F_A \ / \ \eta(f) \geq \mu \}$ is the set of selected features for attribute A having a number of ratings greater than μ. Thus, only features in F_{A_μ} are used to compute the frequency matrix F.

F. User semantic attribute model

One of the best-known measures for specifying keyword weights in Information Retrieval is the TF-IDF (Term Frequency/Inverse Document Frequency) [14]. It is a numerical statistic, which reflects how important a word is to a document in a corpus. In our case, we replace document by user and term by feature, so we obtain a Feature Frequency Inverse User Frequency(FF-IUF) that is defined as:

$$FF(f,u) = \frac{freq_u(f)}{max_j freq_u(j)} \tag{5}$$

where the maximum is computed over the $freq_u(j)$ of all feature $j \in F_{A_\mu}$ assigned to user u.

The measure of Inverse User Frequency IUF is usually defined as:

$$IUF(f) = \log \frac{|U|}{U_f} \tag{6}$$

where U_f is the number of users assigned to feature f (ie $freq_u(f) \neq 0$). Thus, the FF-IUF weight of feature f for user u is defined as:

$$\omega(u,f) = FF(f,u) \times IUF(f) \tag{7}$$

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In summary, for building the user semantic attribute matrix Q_A for a dependent attribute A; first, we define the selected set of features F_{A_μ} to reduce the dimension; second, we compute the frequency matrix F over features $\in F_{A_\mu}$ by using one of the formula from (1) to (4); third, we compute the FF-IUF on this matrix to obtain the matrix Q_A. In Section VI, we will study the performance of each solution. For reasons of clarity, we have called the algorithm using the formula in (1) as FFIUF-NW-NR (no weighted no relevant), in (2) as FFIUF-W-NR (weighted and no relevant), in (3) as FFIUF-NW-R and in (4) as FFIUF-W-R.

V. Recommendation

To compute predictions for the active user u_a, we use the user-based CF algorithm [5]. User-Based CF predicts the rating value of active user u_a on non rated item $s \in S$, it is based on the k-Nearest-Neighbors algorithm. A subset of nearest neighbors of u_a are chosen based on their similarity with him or her, and a weighted aggregate of their ratings is used to generate predictions for u_a. Equation 8 provides formula for computing predictions.

$$p(u_a, s) = \overline{\delta_{u_a}} + L \sum_{v \in V} sim(u_a, v)(\delta_v(s) - \overline{\delta_v}) \qquad (8)$$

where $L = \frac{1}{\sum_{v \in V} |sim(u_a, v)|}$ and V is the set of the nearest neighbors (most similar users) to u_a that have rated item s. V can range anywhere from 1 to the number of all users.

$$sim_(u, v) = \frac{\sum_k (q_{u,k} - \overline{q_u})(q_{v,k} - \overline{q_v})}{\sqrt{\sum_k (q_{u,k} - \overline{q_u})^2} \sqrt{\sum_k (q_{v,k} - \overline{q_v})^2}} \qquad (9)$$

The function $sim(u, v)$ provides the similarity between users u and v and is computed by using the Pearson Correlation (9). In the standard user-based CF algorithm, the users-items rating matrix $(\delta_u(s)_{(u \in U,\, s \in S)})$ is used to compute users' similarities. In our algorithm for computing the similarities between users we use instead the user semantic matrix Q. As we have already mentioned, the matrix Q is the horizontal concatenation of user semantic attribute model of each relevant attribute.

Although we apply a user-based CF for recommendation, our approach is also a model-based method because it is based on a new user model to provide ratings of active user on non rated items. Our approach resolves the scalability problem for several reasons. First, the building process of user semantic model is fully parallelizable (because the computing of user semantic attribute model is done in independent way for each other) and can be done off line. Second, this model allows a dimension reduction since the number of columns in the user semantic model is much lower than those of user item rating matrix, so, the computing of similarities between user is less expensive than in the standard user-based CF. In addition, our approach allows inferring similarity between two users even when they have any co-rated items because the users-semantic matrix has less missing values than user item ratings matrix. Thus, our approach provides solution to the neighbor transitivity problem emanates from the sparse nature of the underlying data sets. In this problem, users with similar preferences may not be identifies as such if they haven't any items rated in common.

VI. Performance Study

In this section, we study the performance of our algorithm, User Semantic Collaborative Filtering (USCF in plots), against the standards CF algorithms: User-Based CF(UBCF), and Item-Based CF(IBCF); standard CB algorithm and an hybrid algorithm. We evaluate these algorithms in terms of predictions accuracy by using the Mean Absolute Error (MAE) [15], which is the most widely used metric in CF research literature. It computes the average of the absolute difference between the predictions and true ratings in the test data set, lower the MAE is, better is the prediction. When comparing results to CB algorithm, we use instead the F1 metric $(2 \times Recall \times Precion/Recall + Precision)$ [15] because CB doesn't provide prediction.

We have experimented our approach on real data from the MovieLens1M dataset of the MovieLens recommender system [16]. The MovieLens1M provides the usage data set and contains 1,000,209 explicit ratings of approximately 3,900 movies made by 6,040 users. For the semantic information of items, we use the HetRec 2011 dataset [17] that links the movies of MovieLens dataset with their corresponding web pages at Internet Movie Database (IMDb) and Rotten Tomatoes movie review systems. We use *movie genre* and *movie origin* as non dependent attributes, *movie director* and *movie actor* as dependent attributes.

We have filtered the data by maintaining only users with at least 20 ratings, and available features for all movies. After the filtering process, we obtain a data set with 6020 users, 3552 movies, 19 genres, 44 origins, 1825 directors and 4237 actors. The usage data set has been sorted by the timestamps, in ascending order, and has been divided into a training set (including the first 80% of all ratings) and a test set (the last 20% of all ratings). Thus, ratings of each user in test set have been assigned after those of training set. It should be noted that the building of user semantic attribute model for the non dependent attributes *genre* and *origin* have been addressed respectively in previous works [3], [4]. Therefore, we will not detail the experiments conducted for these attributes in this paper. If it is not specified, the number of nearest neighbors is equal to 60 because it provides the best results.

A. Performance Evaluation of the four methods for computing the frequency function

In Figure 1, the MAE has been plotted with respect to the μ threshold parameter (the minimum number of ratings associated to a feature). It compares the 4 algorithms described in Section IV for computing the frequency function, on *director* (Figure 1(a)) and *actor* (Figure 1(b)) attributes. In both case, the plots have the same look, the MAE decreases until a specific value of the number of selected features $|F_{A_\mu}|$ and then grows up; however, FFIUF-W-R algorithm results in an overall improvement in accuracy. We note for both figures, that the reduction of dimension has a slightly effect on improving the accuracy. Indeed, for the director attribute the MAE without reduction (1825 features) is equal to 0.7113 while the best value is equal to 0.7098 obtained by 601 features, so a reduction about 67%. Although the improvement of accuracy isn't elevated, the reduction of dimension is considerable and so allows to reduce the cost of users similarity computing.

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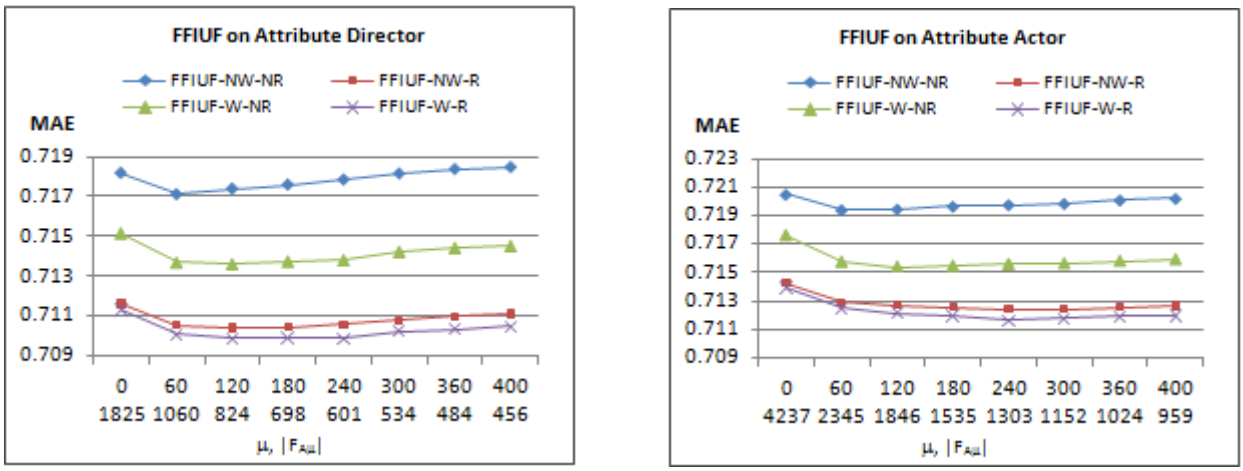

(a) (b)

Fig. 1 Performance evaluation of the four FFIUF algorithms for director (a) and actor (b) attributes.

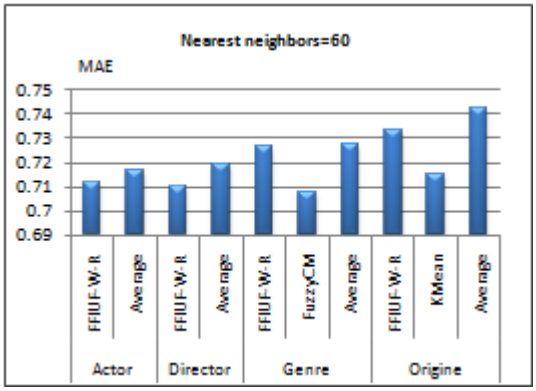

Fig. 2. Impact of user semantic attribute building algorithm on prediction accuracy.

B. Impact of attributes classes on prediction accuracy

Figure 2 compares algorithms for building user semantic attribute model in term of MAE. The *Average* algorithm (Average in plot) is building user semantic attribute model by computing the average of user ratings by feature ($q_{(u,f)} = AVG\{\delta_u(s)/s \in S_u \; and \; f \in F_{A_s}\}$); *Fuzzy C Mean* algorithm (FuzzyCM in plot) is a fuzzy clustering used for non dependent and multivalued attribute (here *genre*) and *KMean* algorithm (KMean in plot) is used on non dependent and mono valued attribute (here *origin*). When analyzing this figure we note first, that *Average* algorithm provides, for all attributes, the worst performance compared to all other algorithms. Second, if we applied the *FFIUF-W-R* algorithm to non dependent attribute the performance compares unfavorably against the dependent attribute, while the best performance is attained by *FuzzyCM* algorithm on genre attribute and the difference is important (0.7079 for FuzzyCM and 0.7268 for FFIUF-W-R). This allows to deduct that, using a suited algorithm for each attribute class provides best performance than applying the same algorithm for all attributes. Third, the *origin* attribute has the worst performance compared to the other three attributes and this for all algorithms; this is confirm our hypothesis that all attributes don't have the same relevance to users. The attribute *origin* can be less significant in the choice of users than the *genre*, *actor* or *director*, which is intuitively understandable.

C. Comparative results of USCF against CF and CB recommender system

Figure 3 depicts the recommendation accuracy of USCF in contrast to those produced by pure CB (CB in plots) recommender system (Figure 3(a)) using the $F1$ metrics to measure the recommendation accuracy; and standard Item-Based CF (IBCF) and User-Based CF (UBCF) (Figure 3(b)). Pure CB algorithm exploits information derived only from item features. Thus, we create an item-item similarity matrix based on Cosinus similarity applied on item-feature matrix computed on corresponding attribute shown in the plot. In Figure 3(a), recommendations are computed for 60 nearest neighbors. We note that our algorithm USCF results in an overall improvement in accuracy against CB, and this for all combinations of attributes. In Figure 3(b), MAE has been plotted with respect to the number of neighbors (similar users) in the k-nearest-neighbor algorithm. In all cases, the MAE converges between 50 and 60 neighbors, however, USCF results in an overall improvement in accuracy. In addition, the best performance is achieved by the combination *genre-director-actor*. This improvement can be explained by many reasons. First, taking into account the semantic profile of items in a CF recommendation process. Second, for non dependent attribute, user semantic model is built according to a collaborative principle; ratings of all users are used to compute the semantic profile of each user. It is not the case of the Average algorithm; this may explain its results despite taking into account the semantic aspect. Third, the choice of the attribute can have significant influence on improving the accuracy. Lastly, users semantic model Q has few missing values, so, it allows inferring similarity between two given users even when they have any items rated in common.

VII. Conclusion and Future Work

The approach presented in this paper is a component of a global work, which the aim, is to introduce the semantic aspect

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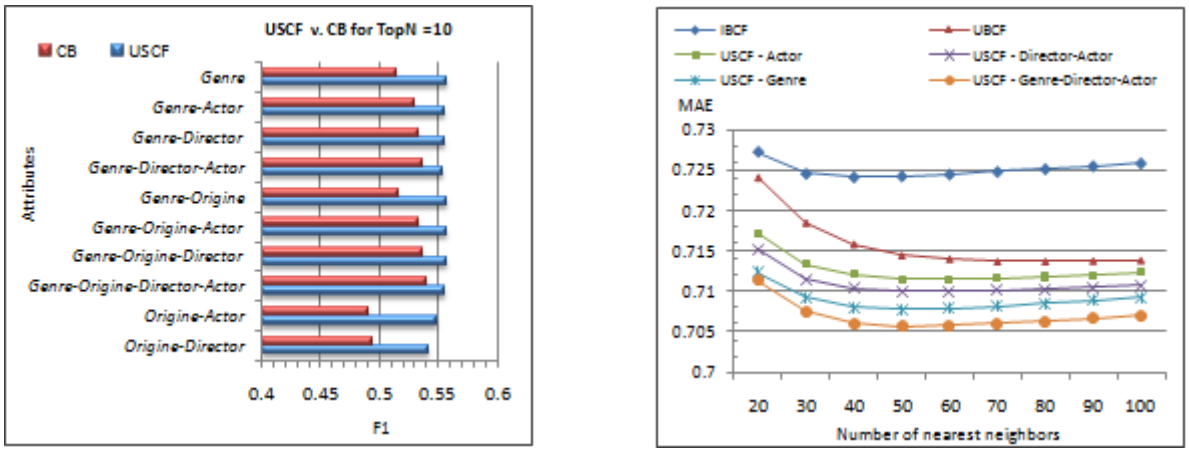

(a) (b)

Fig. 3 Evaluation of USCF against CB in terms of F1 (a) against standards CF in terms of MAE (b).

of items in a CF process in order to enhance recommendations and to resolve the scalability problem by reducing the dimension. For this purpose, we have designed a new hybridization technique, which predicts users' preferences for items based on their inferred preferences for semantic information. We have defined two classes of attributes: *dependent* and *non dependent* attribute, and presented a suited algorithm for each class for building user semantic attribute model. The aim of this paper is to present our approach for building user semantic attribute model for dependent attribute. We have defined an algorithm based on the TF-IDF measure and have proposed a solution to reduce a dimension by selecting the most relevant features. Our approach provides solutions to the scalability problem, and alleviates the data sparsity problem by reducing the dimensionality of data. The experimental results show that USCF algorithm improves the prediction accuracy compared to usage only approach (UBCF and IBCF), Content only approach (CB) and hybrid algorithm (Average). In addition, we have shown that applying FFIUF on non dependent attribute, decreases significantly the prediction accuracy compared to results obtained with machine learning algorithms. Furthermore, we have experimentally shown that all attributes don't have the same importance to users. Finally, experiments have shown that the combination of relevant attributes enhances the recommendations.

An interesting area of future work is to use machine learning techniques to infer relevant attributes. We will also further study the extension of the user semantic model to non structured data when items are described by free text. Lastly, study how our approach can provide solution to the cold start problem in which new user has few ratings and CF cannot provide recommendation because similarities with others users cannot be computed.

REFERENCES

[1] X. Su and T. M. Khoshgoftaar, "A survey of collaborative filtering techniques," *Adv. Artificial Intellegence*, 2009.

[2] P. Lops, M. de Gemmis, and G. Semeraro, "Content-based recommender systems: State of the art and trends," in *Recommender Systems Handbook*, 2011, pp. 73–105.

[3] S. Ben Ticha, A. Roussanaly, A. Boyer, and K. Bsaïes, "User semantic preferences for collaborative recommendations," in *13th Int. Conf. on E-Commerce and Web Technologies - EC-Web*. Vienna, Austria: Springer, September 2012, pp. 203–211.

[4] S. Ben Ticha, A. Roussanaly, and A. Boyer, "User Semantic Model for Hybrid Recommender Systems," in *The 1st Int. Conf. on Social Eco-Informatics - SOTICS*. Barcelona, Espagne: IARIA, October 2011.

[5] P. Resnick, N. Iacovou, M. Suchak, P. Bergstrom, and J. Riedl, "Grouplens: an open architecture for collaborative filtering of netnews," in *The 1994 ACM conf. on Computer supported cooperative work*, Chapel Hill, North Carolina, USA, 1994, pp. 175–186.

[6] B. M. Sarwar, G. Karypis, J. A. Konstan, and J. Riedl, "Item-based collaborative filtering recommendation algorithms," in *The 10 Int. WWW Conf.*, Hong Kong, China, May 2001, pp. 285–295.

[7] G. Adomavicius and A. Tuzhilin, "Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions," *IEEE Trans. Knowl. Data Eng.*, vol. 17, no. 6, pp. 734–749, 2005.

[8] M. Pazzani and D. Billsus, "Content-based recommendation systems," in *The Adaptive Web*, ser. Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2007, vol. 4321, pp. 325–341.

[9] M. Balabanovic and Y. Shoham, "Fab: Content-based, collaborative recommendation," *Commun. ACM*, vol. 40, no. 3, pp. 66–72, 1997.

[10] R. D. Burke, "Hybrid web recommender systems," in *The Adaptive Web*, ser. Lecture Notes in Computer Science, vol. 4321. Springer, 2007, pp. 377–408.

[11] B. Mobasher, X. Jin, and Y. Zhou, "Semantically enhanced collaborative filtering on the web," in *1st European Web Mining Forum*, vol. 3209, Cavtat-Dubrovnik, Croatia, September 2003, pp. 57–76.

[12] S. Sen, J. Vig, and J. Riedl, "Tagommenders: connecting users to items through tags," in *The 18th Int Conf. on WWW*, Madrid, Spain, April 2009, pp. 671–680.

[13] M. G. Manzato, "Discovering latent factors from movies genres for enhanced recommendation," in *The 6th ACM conf. on Recommender systems - RecSys*, Dublin, Ireland, September 2012, pp. 249–252.

[14] G. Salton, *Automatic Text Processing*. Addison-Wesley, 1989.

[15] J. L. Herlocker, J. A. Konstan, L. G. Terveen, and J. Riedl, "Evaluating collaborative filtering recommender systems," *ACM Trans. Inf. Syst.*, vol. 22, no. 1, pp. 5–53, 2004.

[16] MovieLens, "http://www.movielens.org," [retrieved: september, 2013].

[17] HetRec2011, in *2nd Int Workshop on Information Heterogeneity and Fusion in Recommender Systems*. The 5th ACM Conf. RecSys, 2011.

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Correlation Between Transport and Occurrence of Dengue Cases in Bahia

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***Abstract*— Dengue is a public health problem that presents complexity in its dissemination. The physical means of spreading and the dynamics of the spread between the municipalities need to be analyzed to guide effective public policies to combat this problem. This study shows a correlation between the exponent of Criticality present in Self-Organized Criticality (SOC) and the number of buses per week, identifying municipalities that exert important roles in the spread of dengue in Bahia, confirming transport as a physical means for the diffusion of dengue.**

Keywords-dengue; correlation; transport; self-organized criticality; SOC; randomization; Bahia

I. INTRODUCTION

Many factors were responsible for the resurgence of epidemic dengue fever and dengue hemorrhagic fever in the last years of the 20th century. Demographic and social changes such as population growth, urbanization and modern transport contribute to the increased incidence and geographic expansion of dengue.

The prevalence of this public health problem is greater in tropical areas of Asia and the Americas. The epidemiological situation in Latin America is similar to the reality found in Southeast Asia a few years ago, where there is circulation of multiple serotypes, and therefore the increase in the number of cases of classic dengue and dengue hemorrhagic fever.

In 2002, Latin American countries have reported a number greater than 1 million cases of dengue, with approximately 17,000 of these, cases of dengue hemorrhagic fever, resulting in 225 deaths [1]. Dengue is a major cause of mortality and morbidity in the tropics [2].

The history of dengue in Bahia began in 1987 when it was recorded for the serotype DEN-1, in the municipality of Ipupiara, which resulted in a local epidemic [3] [4]. Focusing on isolated urban area in the municipality measures to combat the epidemic has intensified, acting in intense combat Aedes aegypti, being controlled before reaching neighboring municipalities [5].

In 1995, the municipality of Prado, southern Bahia, identified the first case of DEN-2, we starting an epidemic. The same was not contained and has spread to other municipalities in Bahia [3]. The Aedes aegypti is present in 99.5% of the municipalities of Bahia, and has been reported from the four serotypes: DENV-1, DENV-2, DENV-3 and DEN-4. Preventive actions undertaken to combat epidemic outbreaks, were not sufficient to control the dengue epidemic, which gradually spreads throughout the country and even to other countries of Latin America [6] [7].

Bahia with an area of 567 295 km², its size surpasses countries like France with an area of 543,965 km² to 504,030 km² and Spain. Its composition is 417 municipalities that are linked by 22 Federal Highway (BR) and 11 State Highways (BA) [8]. As a network of ground transportation, the main route of migration between these municipalities is also the primary means of spreading of dengue in the state. In order to better understand the dengue transmission dynamics in Bahia, we use the social networking tools.

This paper is organized as follows: The next section demonstrates the methodology applied, the third section will comment on the results, and the fourth section will finalize with a conclusion.

II. METHODOLOGY

The construction methodology of the Transport Network (Transbahia) was made from the analysis of road maps of Bahia, the lifting of federal highways (BR) and state highways (BA) that connect the municipalities. In the creation of the Transportation Network in Bahia (Figure 1), we used the basic principles of graphs, where each of the 417 municipalities was represented by a vertex (node), and 7368 km of roads that connect the municipalities are represented by an edge connecting these vertices.

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Based on road maps, the graph was assembled by the Program for Large Network Analysis (PAJEK) [9]. Only municipalities were considered, discarding the villages and districts, since, in both instances, the records are held by a municipal health department.

In order to make the transport networks, the follow steps were made:

1. Four hundred and seventeen municipalities were geographically divided in Bahia;
2. Each node is labeled with the corresponding name of the municipality;
3. Each node received a number, which was used in the correlation between municipalities;
4. Based on road maps each direct link between municipalities is represented by an edge in the graph;
5. The distance in Km between two counties was represented by the network weight, which is the third element representative;
6. To facilitate visualization, were placed coordinates for the vertical and horizontal axis, allowing the spatial distribution of the network (Figure 1).

Figure 1 - Transport Network in Bahia.

According to 2010 national transport company (CNT), surface conditions of these roads are in working condition.

By analyzing Dengue in Bahia with 417 municipalities, only 45 municipalities (10.79%), according to the Ministry of Health through the National Dengue Control (NPDC), were prioritized.

The deployment priority is defined based on population and epidemiological aspects: capital cities, metropolitan areas, municipalities with a population ≥ 50,000 inhabitants, and cities with high immigration (i.e., borders, ports, tourism core) [10].

The Ministry of Health, in 2013, invested U$6.6 million for actions to combat dengue in Bahia. This investment is aimed at improving measures to combat dengue in the state, being allocated to all 417 municipalities in the state, according to the State Department of Health (Sesab).

However, there are municipalities where the rate of occurrence is larger; they are considered hubs, to be connected with several other municipalities and these should be treated differently.

To construct the Bahia transport network attacked (TransBahiaAtac), the cities with degree higher than 5 were deleted from the TransBahia Network (Figure 2): Bom Jesus da Lapa, Barra, Buritirama, Vitória da Conquista, Jacobina, Santo Antônio de Jesus, Jequié, Brumado, Itaberaba, Santa Inês, Valença, Caetité, Condeúba, Boquira, Sítio do Mato.

Without these municipalities, the network was divided in smaller groups, a fact that could facilitate the control of outbreaks. With this procedure, the network becomes disconnected, with 61 connected components, mostly made up of groups below 10 municipalities.

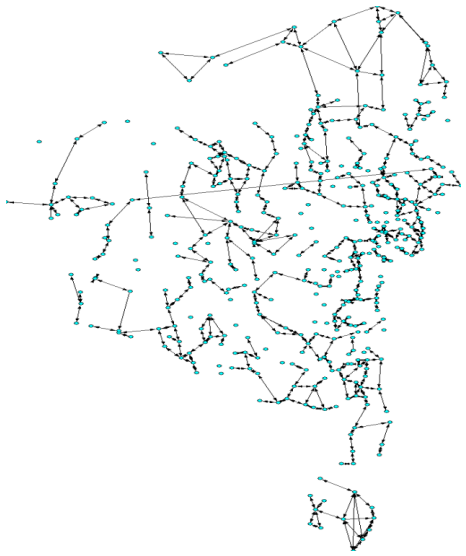

Figure 2 –Transport network without cities with degree higher than 5.

III. EXPONENT OF CRITICALITY PRESENT IN SELF-ORGANIZED CRITICALITY (SOC)

The variability of the frequency of occurrence in the number of dengue cases among different municipalities is caused by climatic diversity in the state of Bahia, for complex effects of migration and other environmental effects [11]. This suggests the existence of interdependence in the occurrence of dengue among municipalities regarding the cases distribution. To evaluate this possibility, we calculate the curves of the probability occurrence of dengue cases in each county. Figure 3 shows an example in logarithmic scale of the probability distribution for the Camaçari county.

Through the database SINAN data were mined, so that occurrences were grouped by cities and presented with a total daily of reported cases of occurrences per day.

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For all studied cities, we constructed histograms of occurrences obtained from the dengue epidemiological time series. The frequency of occurrence for each city follows a power law. This behavior is characteristic of systems that obey the so-called self-organized criticality (SOC). Figure 3 shows the histogram of the City of Camaçari; in red, we present the apparent linear fitting with a power exponent δ = -2,34.

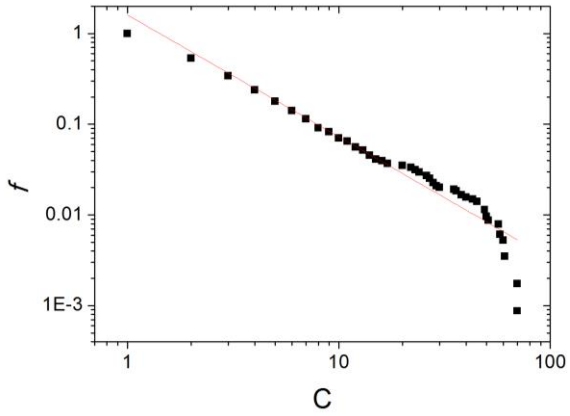

Figure 3 - Cases of Dengue 2000-2009 in Camaçari.

SOC is a phenomenon found in systems that reach a critical condition during a process of natural evolution, without any external intervention. During his critical condition, this system can undergo reactions stimulated by unpredictable changes or minimum noise [12].

In order to understand this behavior, we estimate the power laws exponents for each county of Bahia. Table 1 shows the values of the exponents of the 20 most populated municipalities with dengue cases (we considered the population in 2000, the year that starts the database). Observe that all coefficients have values less than three, which represent power laws with long tails (decay slower than exponential). We can also observe that the values of the Pearson correlation coefficient R [13], Table 1, indicate significant fittings.

IV. CONCLUSIONS

It is also observed that the exponents of criticality in the municipalities are related to the number of intercity buses that circulate per week in the municipalities; the relationship is shown in Figure 4.

In order to evaluate the significance of this correlation was applied an randomization analysis for Spearman correlation [14], with 100,000 randomizations of the data [15], we found a probability of only 0.00057 of the original correlation is due to chance, i.e., only 0.057% of the results had correlations greater or equal to the original correlation [16]. The graph in Figure 5 shows the comparison between the distribution of the correlation values found to 100,000 randomizations and the correlation of the original data. Thus, it was observed that there is significant correlation between the exponents of criticality (γ) and the numbers of buses that run weekly in the municipalities in Bahia.

TABLE 1 - SOC DENGUE IN THE 20 MOST POPULOUS MUNICIPALITIES OF BAHIA.

Municipalities	*Pop2000*	*V*	*R*
Salvador	13070250	-1.72247	-0.9794
Feira de Santana	2443107	-1.83679	-0.9883
Vitória da Conquista	480949	-2.11216	-0.9884
Ilhéus	262494	-1.68614	-0.9856
Itabuna	222127	-1.39189	-0.9612
Juazeiro	196675	-1.72127	-0.9683
Camaçari	174567	-2.34184	-0.9791
Jequié	161727	-1.35729	-0.9532
Barreiras	147202	-1.87011	-0.9529
Alagoinhas	131849	-1.68449	-0.9053
Lauro de Freitas	130095	-1.97261	-0.9461
Teixeira de Freitas	113543	-2.88574	-0.9703
Paulo Afonso	107486	-2.49014	-0.9569
Porto Seguro	96499	-1.95101	-0.9589
Simões Filho	95721	-1.6881	-0.9447
Eunápolis	94066	-2.187	-0.9409
Serrinha	84120	-2.69064	-0.9526
Valença	83206	-2.2753	-0.9299
Sto Antônio de Jesus	77509	-2.17783	-0.9546
Candeias	77368	-1.88646	-0.9402

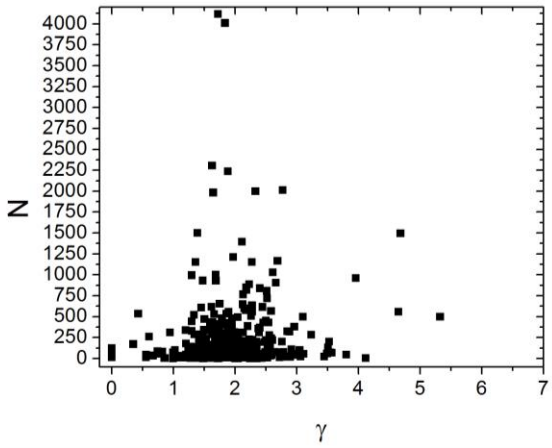

Figure 4 - Number of intercity buses as function of exponent for all 417 municipalities in Bahia.

The significant correlation between the critical exponent and the number of intercity buses suggests that the hole in outbreaks dynamic is governed by the transport network flux. With this result, we can propose preventive actions directed to the topology of the network. Thus, for example, an action in road hubs changes a possible generalized epidemic in local outbreaks. The elimination of the hubs of the network could represent the concentration of federal

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resources to combat dengue in few cities with more simplified treatments.

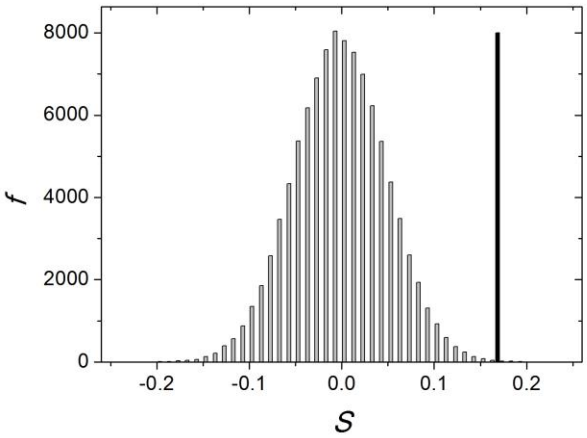

Figure 5 – Distribution of Spearman correlations in randomizations compared with the observed correlation.

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REFERENCES

[1] R. Nogueira, H. Schatzmayr, A. Santos, F. Cunha, R. Coelho,J. Souza, L. Guimarães, F. Araújo, E. Simone, T. Baran, M. Teixeira, G. Miagostovich, and M. Pereira. Dengue virus type 3, Brazil, 2002. Emerg Infect Dis, 11:1376–1381, 2005.

[2] D. J. Gubler, and M. Meltzer. Impact of dengue/dengue haemorrhagic fever on the developing world. Adv Virus Res 53:35–70, 1999.

[3] J. P. Dias, Relatório sobre a situação de dengue no Estado da Bahia, 1994-1997. Revista Baiana de Saúde Pública 22:49-67, 1998.

[4] K. B. F. Marzochi, Dengue in Brazil. Situation, transmission and control - a proposal for ecological control. Memórias do Instituto Oswaldo Cruz 89:235-245, 1994.

[5] K. Mota. Dengue na Bahia: estudo soro-epidemiológico na população da cidade de Ipupiara. Dissertação de Mestrado, Universidade Federal da Bahia, Salvador, BA, 1998.

[6] G. Kuno, I. Gomez and D. J. Gubler. Detecting artificial antidengue IgM complexes using a enzymelinked immunosorbent assay. American Journal of Tropical Medicine and Hygiene 36:153-159, 1987.

[7] G. Kuno. Review of the factors modulating dengue transmission. Epidemiologic Reviews 17:321-335, 1995.

[8] Companhia Nacional de Transportes. Pesquisa CNT de Rodovias 2011 [retrieved: June, 2013] (http://pesquisarodovias.cnt.org.br/Paginas/Edicao-011.aspx)

[9] W. Nooy, A. Mrvar, and V. Batagelj: Exploratory Social Network Analysis with Pajek, Revised and expanded second edition, CUP Amazon, 2011.

[10] Ministerio da Saùde [retrieved: June, 2013] (http://*portal.saude.gov.br/portal/arquivos/pdf/bahia_tudo.pdf)*

[11] H. L. Vasconcelos, J. M. S. Vilhena, and G. J. A. Caliari. Response of ants to seletive logging of a central Amazonian forest. Journal of Applied Ecology 37: 508-514, 2000.

[12] P. S. Addison. Fractal And Chaos - An illustrated Course - Institute of Physics Publishing, Chapter 5, London, 1997.

[13] S. Spiegel. Medidas de correlação e suas provas de significância. In:Estatística não-paramétrica para as ciências do comportamento. Tradução Alfredo Alves de Faria. São Paulo: McGraw-Hill do Brasil Ltda. pp.220-270, 1977.

[14] S. Siegel. Estatística não-paramétrica: para as ciências do comportamento. São Paulo: McGraw-Hill do Brasil Ltda. pp.305, 1975.

[15] B. F. J. Manly, Randomization, Bootstrap and Monte Carlo Methods in Biology, Flórida: Chapman & Hall, 460p, 2006.

[16] D. N. Viola, Detecção e modelagem de padrão espacial em dados binários e de contagem. Tese de Doutorado em Estatística e Experimentação Agronômica. USP: Escola Superior de Agricultura "Luiz de Queiroz". Piracicaba, 2007.

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Social Networks for Knowledge Management

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Abstract—**Online social networks have changed the way many people communicate and interact as private individuals and employees. Sharing and communication through this medium has become, for many, a daily habit. Many of these networks provide a simple way to seek and find knowledge and expertise from both friends and strangers. Information technology has been used in many ways to support knowledge management initiatives. However the use of social networking technology has been little explored. It is thus argued that combining knowledge management systems with social networking technology would bridge this gap. Social software is becoming part of a standard arsenal of tools deployed within companies, tools that may help knowledge management. Evidence is presented from a review of relevant literature and through a survey, conducted via online social networks, asking respondents' usage of social networking for knowledge management purposes in both their private lives and also work-related practices. It shows that personal networks are often used as a medium to seek knowledge for personal and for organisational motives. The results confirm that online social networks, and their enterprise counterparts, are aiding knowledge management initiatives. Knowledge appears to be flowing through online social networks. Findings also include the confirmation of Dunbar's number, and reaffirming the strength of "weak ties" as originally proposed by Granovetter. The paper proposes the new concept of *temporary ties* that are aided through social networks. It also describes the work in progress and findings so far on the use of social networking technology and habits for aiding knowledge management initiatives.**

Keywords- knowledge management, knowledge management systems, social networking, strong ties, weak ties, temporary ties

I. INTRODUCTION

Knowledge management (KM) is generally taken as the systematic and organisationally specified process for acquiring, organising and effectively communicating knowledge of employees to other employees so that they can be more effective and productive in their work [1]. KM is applied where the interaction between people, technology, and techniques allow an organization to manage its knowledge by facilitating knowledge creation, knowledge validation, knowledge presentation, knowledge distribution, and knowledge application activities. All these aim to maximise business value by delivering what is needed at critical points when it is needed (Bhatt, 2011).

To aid KM initiatives, knowledge management systems (KMS) are often introduced. The aim of KMS is to enable the formation, communication and utilisation of knowledge [2]. Meso and Smith [3] propose two predominant perspectives of what constitutes KMS; the technical perspective and the socio-technical perspective. On one hand, the technical perspective takes the point of view that the technology is the KMS [3]. On the other hand, the socio-technical perspective recognises that technology alone does not make up a KMS and that most importantly people form part of the KMS. This paper takes the stance of the socio-technological view, and further argues that, the users are not simply part of the system but are critically central to it [4].

According to Aristotle, humans are by nature social animals: through socialisation, knowledge has been transferred from generation to generation since the very first days of communication. Technology now provides for the human need to be socially connected. Online social networks have proliferated and become a conventional communication medium for teenagers and adults alike (Evans, 2011). These systems have seen an unusually high user take-up for varying reasons. Most of the current online social networks (SN) allow friends to connect to each other and form virtual networks (e.g., Facebook, LinkedIn). Others enable the connection between total strangers, usually formed on mutual interest or experience, with connections being unidirectional or bidirectional, depending on the users' choice (e.g., Twitter).

An immediate advantage of using a social network is the possibility of the compilation of a user-updated digital address book of friends or acquaintances. However, social networks also provide a user with the ability to publicly display a profile, exposing to varying extents, personal interests, experience and expertise. Moreover user's *walls* or *streams*, which are a list of user's actions, updates, etc., provide a real-time feed of personal information to their friends and followers. These facilities engender and are supported by habits of SN users to keep their information up to date. This paper argues that KM initiatives stand to benefit from these new habits by introducing more social aspects in their KMS.

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Arguably, informational systems categorised as KMS have hindered the practice through their lack of social elements. Separate research [5] shows that social interaction and network ties are indeed associated with greater knowledge acquisition for companies. This paper argues that online SNs are aiding companies to acquire new knowledge through employees' personal networks. The primary evidence comes from an online survey, published and shared mainly through SNs. Findings from the survey show that there are new tendencies of individuals and employees using their personal social networks to aid their knowledge. Connections are happy to help or refer connections to other users, which thanks to SNs are only a couple of clicks away. Personal expertise is exposed through *profiles* and this appears to be aiding network connections to learn more about one's interest and knowledge. Weak ties still prove to be an important source of new knowledge. SNs also appear to be facilitating the shifting, between ties, from strong to weak, or vice-versa, depending on personal situations. This concept is defined by this research as *temporary ties*.

Section II discusses related work. Section III discusses socialisation in knowledge management and Section IV argues the use of social networks for knowledge management. Section V highlights the design and execution of the survey conducted. Section VI discusses the survey findings. Section VII presents a conclusion of the paper whilst proposing further research.

II. RELATED WORK

Social networking literature pre-dates today's modern tools and online SN. Maguire [6] points out how networks are formed on the basis of rewards, costs of participation, and social context; these factors continuously change whilst relationships are maintained as long as the costs of maintaining the network relationships do not exceed the rewards. Marin and Wellman [7] define a SN as "a set of socially relevant nodes connected by one or more relationships". For example, in the case of Facebook, socially relevant relationships form based on real life relationships, whilst in the case of Twitter, social relevancy would emerge based on interest and friendship. These often overlap and intertwine. The reasons why people decide to connect with others is out of scope of this research, however it is acknowledged that a relationship forms on a base of real world relationships or personal rewards and benefits. On such basis ties are formed.

Seminal work by Granovetter [8] posits that strong ties, i.e., the connections that are more similar to us, contribute a limited amount of new knowledge whereas weak ties may serve as a bridge to new knowledge. Thus weak ties hold a *greater* potential for new knowledge than strong ties would. Maguire [6] points out how "when new knowledge or unusual information is required, a network is often used with at least some weak ties that bridge other networks. One or more weak ties to different type of networks increase the likelihood of encompassing different opinions and information". Knowledge management thus stands to benefit in many and multiple ways through the interaction and exploitation of users' online activity, *sharing*, and their established networks.

Sharing has always been a crucial task for knowledge management. Yet knowledge sharing is a complex activity as knowledge held by a person cannot be completely codified and shared (Johnson et al, 2002 – cited in Bick et al., 2012). In Nonaka and Takeuchi's work [9], famously known as the SECI model, depicted in Figure 1, socialisation is the first step in the effort of knowledge sharing. The SECI model has wide implications on KMSs that merely try to use informational systems to capture knowledge for knowledge sharing without much effort on the socialisation aspect. KMS implementing social elements in their design seem to be preferred by users. Zammit and Woodman [4] argue that KMS take-up is drastically improved when social elements are introduced. The tools and techniques they implemented were mainly aimed to improve knowledge sharing and expertise localisation, often leading to face-to-face socialisation, which ultimately aided the KMS adoption. Arguably this ties in with the huge usage of public online SNs where users find it rewarding to maintain information as complete and up-to-date, even in real time.

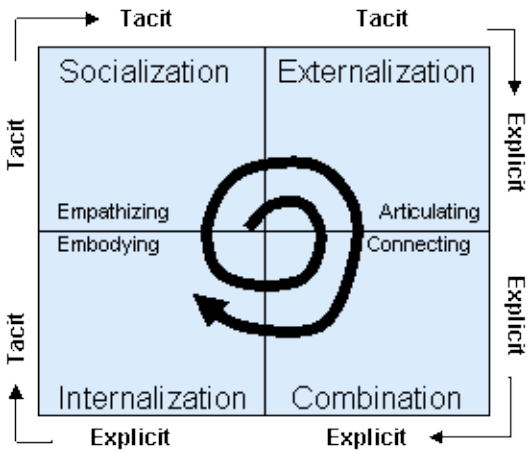

Figure 1 – SECI model (Nonaka & Tackeuchi, 1995)

The field of computer science and information systems is only now beginning to investigate the properties of SNs and the role of computer mediation for successful knowledge sharing (Mislove et al, 2007; Hossain et al, 2012). By contrast, other disciplines, including the social and behavioural sciences, economics, marketing and industrial engineering, have long been studying online SNs [10]. Although knowledge sharing in social networks can be observed on a daily basis, the effect of general social networking, and hence SNs, on KM has been little explored [11].

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III. SOCIALISATION IN KNOWLEDGE MANAGEMENT

Socialisation is a key stage in the knowledge transfer and hence in KM. From the SECI model [9], it emerges that the transfer of knowledge originates through socialisation. The SECI model proposes knowledge transfer as a spiral model starting in a 2 x 2 matrix in which existing knowledge can be of either form, i.e., tacit or explicit, and the objective of knowledge transfer is to convey knowledge.

On a daily basis, one may observe socialisation happening in the workplace through the so-called "water-cooler" conversations, or other official team-building activities [12]. Successful KM concepts and elicitation methods, such as Communities of Practice [13], Collaborative Innovation Networks [14], Storytelling, Knowledge Cafés, Cynefin [15], and KMS development methodologies such as the Five-Phase Methodology [16] all have a major feature in common; socialisation is central to their method and socialisation is given importance over the technology used.

Delmonte and Aronson [17] analyse the correlation between socialisation and KMS success factors finding that there is a significant relationship between social interaction within an organisation and KMS success. Other empirical research also suggests the importance of the social environment in the enhancement of collaboration activities [12]. This is also corroborated in other findings, which denote that a sole technology approach to knowledge management has serious limitations [18].

However, the view that KMS are a subclass of information systems still persists [19] and KMS development is often oriented towards information systems development [20]. Information systems are weak in interpreting information and high level communication [21] and tend to view the class of users as an external entity to the system. Contrastingly in KMS this should not be the case. Yahya and Goh [12] argue that the interpretation of information is the corner stone for KM. If so, then it is the human that makes it a knowledge system, and thus, systems need not only enable and aid knowledge management, but also aid socialisation in order to achieve better knowledge management.

In the situation of knowledge socialisation, knowledge can be considered to be flowing among the parties, and techniques for socialisation are creating knowledge flows. Socialisation is thus important in the context of KM initiatives and attendant KMS. Surprisingly, very little emphasis is found on this aspect in the KMS literature.

Social software development is prospering and a number of public sites have seen record number of users signing-up. Software is also available for enterprises to setup there own social networks, often referred to as enterprise social networks, and other software packages, such as customer management systems, are also including social elements in their systems. Britaniu and Orzea [22] posit that public social networks sites can be regarded as settings for knowledge transfer, sharing and knowledge dissemination [22].

Arguably traditional KMS development focuses on the capturing and dissemination of knowledge, to the detriment of the social aspect in knowledge transfer. A system aimed at the capture and dissemination of knowledge, analysed under the SECI model, falls within the Externalisation quadrant and aides the Internalisation quadrant. Socialisation and Combination are arguably left out or not aided by information systems branded as KMS. By contrast, a social system, such as an SN, will also include the Socialisation and Combination aspect thus satisfying the spiral of knowledge transfer according to the SECI model.

While socialisation within KMS seems to be improving system take-up, the effect of social networking on KM has been little explored (McLure Wasko & Faraj, 2005; Bebensee et al, 2011; Rashid et al, 2011). This paper looks into how social networking, especially through an electronic medium such as social networks, is an emerging trend and how this trend is helping knowledge management initiatives. This paper places importance on socialisation and collaboration, and the impact that social networks are having on knowledge management efforts in acquiring, capturing, and transferring knowledge.

IV. SOCIAL NETWORKS FOR KNOWLEDGE MANAGEMENT

SNs are shaping our daily lives including our social and working habits. The level of adoption of SNs and the amount of sharing over them is unprecedented. Facebook, for example, is a remarkable case study: it has over one billion monthly active users as of October 2012 [23]. SNs provide a constant stream of status updates, photos, and news from online social circles, often in real-time fashion. These shared updates are of interest to a number of connections to which the posts may constitute a source of knowledge.

The statistics on information management that can represent knowledge sharing are of considerable note. For example, on an average Facebook day [24]:

15% of Facebook users update their own status.
22% comment on another's post or status.
20% comment on another user's photos.
26% "Like" another user's content.
10% send another user a private message.

Based on the above statistics the definition of SN knowledge sharing activity, for purposes of this research, is taken to be an update to a profile, commenting on other posts or status, or private messaging. Based on this definition it emerges that 47% of daily usage on Facebook happens for knowledge sharing. Facebook is huge with over 1 billion users. That gives 470,000,000 knowledge posts. For the sake of argument, if about 10% of this sharing contains valuable knowledge to a user, then 47,000,000 posts contain relevant knowledge. From this rough estimate, the huge potential for knowledge sharing is clear. Of course not all of this knowledge is directly accessible to an

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individual's direct network; however, if an individual user has an average network size of 150 connections, a good number of accessible posts will contain knowledge. Furthermore, considering that these 150 connections might be aware of a person seeking certain knowledge, then the potential growth in knowledge accessibility is exponential. Moreover, the streams of information being posted and shared by a user's network are already pre-filtered by the SN, which, in theory, should reduce information overload – i.e., by social-filtering. As strong ties have same interests, posts from strong ties should strengthen user's knowledge, whilst on the other hand posts from weak ties should increase user's exposure to new knowledge.

Thus, SNs constitute a source of knowledge and are suitable for aiding KM initiatives. SNs provide an electronic platform to maintain a large network of contacts, supporting both the existing social connections, and the formation of new ones [25]. Moreover, these contacts are willing to share knowledge that may provide benefit to their network. Above this, SNs provide an easy direct way to contact connections, and to keep abreast with their updates.

Using the SECI model quadrants to analyse SNs for KM, they appear to provide a means of Socialisation through connecting people, a means of Externalisation of user's knowledge through the sharing of posts, the Combination through receiving users posts which also aids Internalisation. Ellison [25] and Hampton [26] also find that there is a clear trend for those who use Internet and social technologies to receive more support than other people who do not. This is also corroborated in other research (Yli-Renko et al, 2001; Gloor et al, 2008; Hossain et al, 2012; Phelps et al, 2012). For KM this implies that aiding users to maintain more connections would aid the KM initiative.

However, although having more connections seems to be more beneficial, it is contrary to Dunbar's findings [27]. A (non-tech) social study by Dunbar shows that humans are limited in their ability to maintain a network to between 124–153 active connections (Dunbar, 1992; Hill and Dunbar, 2003). SNs nowadays might appear to be disproving this with people having more than 1,000 so-called 'online friends'. Dunbar himself has denounced Facebook 'friends' as something that can't be described as relationships [28]. Having a connection does not imply having active interactions with a person. Since neither Dunbar nor Granovetter [8] had the computing power or the SNs we have today, a number of experiments, to prove or disprove this number using modern SNs have already been run. These, however, have achieved mixed results [28].

To date, no studies have been found on whether, and how users use SNs for knowledge management purposes. To address this gap in published work, this research conducted a survey to assess users' social networking habits in relation to seeking help and finding knowledge. Section V describes the survey followed by the discussion of the findings in section VI.

V. Survey Design and Execution

In order to quantify the usage of SNs for knowledge purposes, this research has run a survey [29] asking the participants about the way they use SNs with respect to their help-seeking tendencies.

The respondents were asked general questions from their age, to which SNs they use, to how often they visit these sites. Furthermore they were asked the amount of connections, or "friends", they have within their network and how well they consider they know these connections. The survey asked respondents about how they seek for help through personal profiles, private messages, or walls. For the purpose of this research this establishes the usage trends of knowledge seeking. Respondents were then asked if they mainly seek help for their personal problems or for work related issues. This helps the research establish whether SNs are being used for seeking work-related knowledge.

Next, respondents were asked whether they have learnt about their contact's area of expertise through SNs or if they knew it beforehand, which helps the research shed light into how users chose to contact whom and what role SNs play. Lastly, the users were asked about their tendencies to provide help to their contacts, showing whether or not users are willing to act as bridges to new knowledge.

The survey was mainly shared online via the researcher's SNs, namely Facebook and Twitter. Sharing the survey solely through two social networks had the risk of collecting the sole view of those networks' users. This was addressed by using a personal connection that is known to shy-away from SNs. Through link-tracking mechanisms it is possible to ascertain that 18.66% of responses came through this source.

To avoid inadvertent bias, the survey did not explicitly define what 'active connections' or 'acquaintances' are. The respondents were left to use commonplace meanings.

VI. Survey Findings

The survey itself is an example of how knowledge can be acquired through SNs. The survey questions may be regarded as a knowledge-seeking effort; the replies regarded as information gathering, the accumulation of which results in new knowledge. In less than 12 hours from the survey being released more than 100 respondents had, not only answered the survey, and shared their knowledge, but also "shared" to their networks. This sharing may be seen as effective new knowledge that would have been otherwise inaccessible, without a considerable amount of effort.

134 respondents answered the survey, with 47.76% of the respondents aged 18-24, 44.03% aged 25-34, 2.24% aged 34-44, 2.99% aged 45-54, and another 2.99% falling within the 55-64 age range. 49.51% of the respondents visit SN sites "Extremely Often". The survey results clearly indicate a shift in culture towards using SNs for knowledge

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management purposes. All respondents have admitted to actively seek help through their contacts with 21.35% of respondents admitted to learning about their contact's area of expertise through SNs. This indicates that users learn more about their weak ties thanks to SNs, opening up possibilities for knowledge from these ties. Qualitative research suggests that perceptions formed on another person through direct interaction, observation or recommendation affects the likelihood of seeking information from them in the future, and thus learning someone's expertise or knowing how to reach him or her quickly, affects the probability of seeking that person for information in the future [29].

Respondents disclosed that SNs prove to be helpful for both personal and professional problems. 80.9% indicate that SNs are helpful with regards to "Common Personal Problems", 71.9% indicate SNs are helpful with "Specific Personal Problems", 76.39% indicate SNs are helpful for "Common Professional Problems" and 69.66% indicate that SNs are helpful with "Specific Professional Problems". Therefore it emerges that users are using their SNs in order to overcome work problems more or less to the same degree to which they use SNs for private problems. Personal SNs are thus being used to the benefit of the employing organisation.

Interestingly, 30.78% of the respondents refer their contact (Contact A) to another contact (Contact Z) in their network for help when they themselves are unable to help. Thus SNs appear to be providing a medium for contacts to act as bridges between unconnected ties. Ref to Figure 2. Haythornthwaite [30] defines the concept of "latent ties" as those social network ties that are ''technically possible but not activated socially'' [30]. Hence SNs are facilitating latent ties to be introduced to the user's network. Similarly SNs appear to enable ties to temporarily shift from being weak ties to becoming strong ties, without much effort. In order to achieve a goal a weak tie may temporarily shift to become a strong tie. Thus *temporary ties* are defined by this research as being those ties that are shifted in one's network to benefit a specific need. Whether these replace a previously strong tie or not, in-line with Dunbar's limit, is unimportant as the behaviour of shifting one's network ties is naturally observable with relationships shifting naturally over time. The concept of shifting ties is novel and further research into this concept may be required.

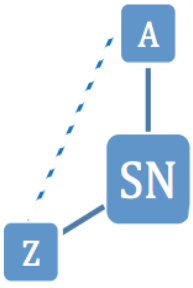

Figure 2 - SN bridging unconnected ties.

As a side-product of the survey, results also indicate that Dunbar's number still holds within SNs. Respondents declared an average total of 663 connections with an average of 206 as "active" connections and 287 as "acquaintances".

The survey has thus exposed that knowledge management is occurring through public online SNs. Albeit in an ad-hoc manner, SNs are providing a medium for communication and knowledge exchange. Knowledge is being sought and directly exchanged, through direct personal messages, or indirectly found through "updates", "streams", "timelines" or "walls". Arguably, previous to SNs, knowledge-seekers needed to actively search for help. For example one would need to remember that contact C knows about topic X and devise a way to communicate with C for help, be it in person, or email etc. This is also true for contact C wanting to share his knowledge. They would need to actively think about who might need what he knows and actively send, or document in a repository, his knowledge.

The findings could be strengthened by running the same survey through separate networks like, for example, starting from Person A where person A is not connected, or is far away from the centre, of the researchers network. However, these findings are believed to be a good representation of the trends in the use of social networking for knowledge-seeking efforts.

VII. CONCLUSION

This paper builds an argument for the use of social networks for knowledge management purposes. Through the reviewing of related work, evidence is exposed that social networking technology may benefit knowledge management initiatives. A gap is exposed on the lack of use of social networking technology within knowledge management initiatives.

To address this gap, a survey is conducted in order to assess the habits of public online social network users in their quest to acquire knowledge. The survey results show that personal social networks are being used for knowledge management purposes, both for personal and professional reasons. This appears to be benefiting the employing organisation by expanding their boundaries.

Social networks are clearly being used for knowledge management purposes. Further research needs to be done within the field of knowledge management to explore the possible benefits of integrating social networking technologies within knowledge management initiatives.

The survey results also reaffirm the strength of weak ties, and that Dunbar's limit seems to still hold. Through this paper the concept of shifting temporal ties are proposed. Through social networking technology it appears that knowledge seekers shift their weak ties closer in an effort to satisfy their knowledge needs. Further research possibilities exist here to explore this concept further.

 ISBN: 978-1-61208-312-4

REFERENCES

[1] J. Hahn and M. R. Subramani, "A Framework of Knowledge Management Systems: Issues and Challenges for Theory and Practice," , Brisbane, 2000.

[2] J. Gonzalez-Reinhart, "Wiki and the Wiki Way: Beyond a Knowledge Management Solution," 2005.

[3] P. Meso and R. Smith, "A resource-based view of organizational knowledge management systems," *Journal of Knowledge Management*, vol. 4, no. 3, 2000, pp. 224-234.

[4] R. Zammit and M. Woodman, "A Case for Repositories in Knowledge Management Systems," in *13th European Conference on Knowledge Management*, Caratgena, 2012, pp. 1289-1297.

[5] H. Yli-Renko, E. Autio, and H. J Sapienza, "Social Capital, Knowledge Acquisition, and Knowledge Exploitation in Young Technology-Based Firms," *Strategic Management Journal*, vol. 22, 2001, pp. 587-613.

[6] L. Maguire, *Understanding Social Networks*.: Sage Publications, Inc., 1983.

[7] A. Marin and B. Wellman, "Social Network Analysis: An Introduction," in *The Sage Handbook Of Social Network Analysis*, John Scott and Peter J Carrington, Eds.: Sage, 2012, pp. 12-25.

[8] M. S. Granovetter, "The Strength of Weak Ties," *American Journal of Sociology*, vol. 78, no. 6, May 1973.

[9] H. Nonaka and I. Takeuchi, *The Knowledge Creating Company: How Japanese Companies*. New York: Oxford Press, 1995.

[10] S. Wasserman and K. Faust, *Social Network Analysis Methods and Applications*, 15th ed., M. Granovetter, Ed. New York: Cambridge University Press, 1994, vol. 15.

[11] T. Bebensee, R. Helms, and M. Spruit , "Exploring Web 2.0 Applications as a Mean of Bolstering up Knowledge Management," *The Electronic Journal of Knowledge Management* , vol. 9, no. 1, 2011, pp. 1-9.

[12] S. Yahya and W. Goh, "Managing Human Resources Towards Achieving Knowledge Management," *Journal of Knowledge Management*, vol. 6, no. 5, 2002, pp. 457 – 468.

[13] E. Wegner, R. McDermott, and W. M. Snyder, *Cultivating Communities of Practice: A Guide to managing knowledge*.: Harvard Business School Publishing, 2002.

[14] P. Gloor, R. Laubacher, S. B. C. Dynes, and Y. Zhao, "Visualization of Communication Patterns in Collaborative Innovation Networks: Analysis of some W3C working groups," in *Proc. ACM CIKM 2003*, 2003, pp. 5-6.

[15] F. C. Kurtz and D J Snowden, "The new dynamics of strategy: Sense-making in a complex and complicated world," *IBM Systems Journal*, vol. 42, no. 3, 2003, pp. 462-283.

[16] M. Woodman and A. Zade, "Towards a Practical Guide for Developing Knowledge Management Systems in Small Organizations," *Electronic Journal of Knowledge Management*, vol. 10, no. 2, 2012, pp. 184-195.

[17] A. J. Delmonte and J. E. Aronson, "The Relatonship Between Social interaction and Knowledge Management System Success," *Journal of Knowledge Management Practice*, August 2004.

[18] L. Damodaran and W. Olphert, "Barriers and facilitators to the use of knowledge management systems," *Behaviour & Information Technology*, vol. 19, no. 6, 2000, pp. 405-413.

[19] M. Alavi and D. Leidner, "Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues," *MIS Quaterly*, vol. 25, no. 1, 2001, pp. 107-136.

[20] A. Moteleb, M. Woodman, and P. Critten, "Towards a Practicle Guide for Developing a Knowledge Management System," in *European Conference on Knowledge Management*, 2009, pp. 559-569.

[21] G. Bhatt, "Knowledge management in organizations: examining the interaction between technologies, techniques, and people," *Journal of Knowledge Management*, vol. 5, no. 1, 2001, pp. 68-75.

[22] C. Bratianu and I. Orzea, "Knowledge Strategies in Using Social Networks," in *European Conference on Knowledge Management*, Cartagena, 2012, pp. 127-134.

[23] Facebook. Facebook. [Online]. HYPERLINK "Newsroom" http://newsroom.fb.com/Key-Facts, [retrieved: December, 2012].

[24] PEW Research Center, "Social networking sites and our lives," PEW Internet, PEW Research Center, 2011.

[25] N. B. Ellison, C. Steinfield, and C. Lampe, "The Benefits of Facebook ‘‘Friends:’’ Social Capital and College Students’ Use of Online Social Network Sites," *Journal of Computer-Mediated Communication*, vol. 12, 2007, pp. 1143-1168.

[26] K. Hampton. New York Times. [Online]. HYPERLINK "Social Media As Community" http://www.nytimes.com/roomfordebate/2012/02/12/the-advantages-and-disadvantages-of-living-alone/social-media-as-community, [retrieved: June, 2012].

[27] R Dunbar, "Neocortex Size as a constraint on group sizes in primates," *Journal of Human Evolution*, vol. 20, 1992, pp. 269-293.

[28] P. Bogolyubov, "The Strength of Ties on Social Networks: An examination of Demographic Determinants," in *European Conference on Knowledge Management*, 2012, pp 93-99.

[29] R. Zammit. Social Networks For KM. [Online]. HYPERLINK "http://bit.ly/sn4km" http://bit.ly/sn4km [retrieved: March, 2013].

[30] S. P Borgatti and R. Cross, "A Relational View of Information Seeking and Learning in Social Networks," *Management Science*, vol. 49, no. 4, pp. 432-445, April 2003.

[31] C. Haythornthwaite, "Social networks and Internet connectivity effects," *Information, Communication & Society*, vol. 8, no. 2, 2005, pp. 125-147.

[32] L. Hossain, S. Reay Atkinson, R. T. Wigand, and S. Carlsson, "Knowledge Sharing through Social Networks," in *The Second International Conference on Social Eco-Informatics*, 2012, pp. 27-34.

[33] R. A. Hill and R. I. M. Dunbar, "Social Network Size In Humans," *Human Nature*, vol. 14, no. 1, 2003, pp. 53-72.

[34] A. Mislove, M. Marcon, K. P. Gummadi, P. Druschel, and B. Bhattacharjee, "Measurement and Analysis of Online Social Networks," in *Internet Measurement Conference*, San Diego, 2007.

[35] M. M. Wasko and S. Faraj, "Why Shoud I Share? Examining Social Capital and Knowledge Contribution in Electronic Network Practice," *MIS Quaterly*, vol. 29, no. 1, March 2005, pp. 35-37.

[36] A. Rashid, W. Wang, and K. Hashim, "Social Networks and its Impact on Knowledge Management," in *International Conference on Control System, Computing and Engineering*, 2011, pp. 227-230.

[37] C. Phelps, R. Heidl, and A. Wadhwa, "Kowledge, Networks, and Knowledge Networks: A Review and Research Agenda," *Journal of Management*, vol. 38, no. 4, July 2012, pp. 1115-1166.

[38] S. Evans. AdAge. [Online]. HYPERLINK " Kickstart Slide Deck" http://adage.com/article/adagestat/stats-day-50-social-media-stats-kickstart-slide-deck/231093/ [retrieved: November, 2011].

[39] M. Bick et al., "Manifesto for a Standard on Meaningful Representations of Knowledge in Social Knowledge Management Environments," in *Multikonferenz Wirtschaftsinformatik,* 2012.

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Remote Anger Management Support using Mobile Technology

An Android Phone Application for persons with Post Traumatic Stress Disorder (PTSD)

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Abstract— **Continuous Anger Level Monitoring (CALM) is a prototype for Android smartphones addressing the needs of persons with Post Traumatic Stress Disorder (PTSD) or emotion/impulse control problems. The application combines physiological monitoring and evidence-based group psychotherapy (Anger Management Therapy, developed by O'Reilly and Shopshire). CALM allows the recording of highly emotional and stressful events and for monitoring of these events by remote therapists. The system helps identify undesirable response behaviors and patterns by creating awareness around one's own behaviors, triggers and coping strategies. The application integrates with the Zephyr BioHarness BT belt to allow for continues physiological monitoring, biofeedback and Respiratory Sinus Arrhythmia (RSA) breathing exercises.**

Keywords: Mobile Mental Health Application, Biofeedback, PTSD, Remote Monitoring, Cognitive Control of Emotions, Anger Management Therapy, Virtual Avatars.

I. INTRODUCTION

Each of us has, at one point or another, experienced difficulty feeling, processing or expressing anger appropriately. For some of us, however—particularly returning veterans attempting to reintegrate into civilian life, sometimes with co-morbidities such as Post Traumatic Stress Disorder (PTSD)—the problem is so serious as to be debilitating ([1], [2], [3], [4]). Studies have associated anger with hyper-arousal symptoms like sleep problems, being "on guard", irritability and difficulty concentrating and as a common symptom of PTSD. Anger is a reaction to perceived environmental threat and a warning sign that consists of 3 components: physical sensations (i.e., increased heart rate), cognitive (i.e., perceived unfairness) and behavioral expressions of anger (i.e., slam a door). We developed a tool that can facilitate and enhance clinical practice in the treatment of anger control issues. Effective treatment of anger in veterans has to address all components of anger - physiology, destructive thinking patterns and behavioral change. The only form of treatment addressing these issues and currently offered at VAs throughout the country is "Anger Management Therapy" developed by Patrick Reilly and Michael Shopshire [5]. The Minneapolis VA Medical Center Mental and Behavioral Health Patient Service Line offers this group based treatment to all Veterans with anger dysregulation who have been clinically determined to be able to benefit from this treatment. It is a 12-session manualized intervention that uses Cognitive Behavioral Therapy (CBT) techniques to teach patients to monitor their anger and identify triggers and cues as well as develop coping strategies and skills.

CALM not only integrates evidence-based therapy specifically targeting "anger", but also remote physiological monitoring. The completely wireless collection (via the Zephyr BioHarness BT3 belt), analysis and storage of physiological data in a single application allows for unobtrusive real-time tracking. In particular, CALM looks at heart rate variability (HRV) because 1) HRV is an excellent marker for cognitive control of emotions [6] and 2) HRV biofeedback in Respiratory Sinus Arrhythmia (RSA) breathing exercises has been shown to reduce symptoms of PTSD [7], chronic stress and anger [8].

CALM is a smart phone application specifically designed to be integrated with ongoing Anger Management Therapy, addressing all components of anger and hostility. The system also provides completely new ways to facilitate and enhance communication and therapeutic work between patients and providers. With CALM we are introducing a well-defined prototype with detailed specifications able to address post-deployment mental health problems and ready to be used for clinical testing. Finally, CALM is not only a phone application, but a patient-therapist system that allows tracking of a number of treatment efficacy and performance metrics in a simple, timesaving, user-friendly and easily modifiable way.

The application provides, for example, an interface for patients to record and track anger events, create awareness of cues and triggers and identify personal coping strategies.

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Furthermore, the application enhances existing Anger Management Therapy by providing feedback (general and specific visualizations of recorded metrics) and motivation (personalization of application, avatars, etc.). Most importantly, CALM provides a meeting point for therapists and patients, allowing common reviews of subjective and objective measures indicative of changes to mental health and personal progress.

In this paper we will explain the overall structure of the system and its components, i.e. evidence-based therapy, the integration of remotely monitored physiological measures and a socially intelligent avatar (section II.), as well as the various functions the application is able to perform (section III.). We will end this paper with the conclusions section (IV.).

II. OVERALL SYSTEM ARCHITECTURE

Only two hardware components are needed in order to provide full functionality to the patient: 1) a mobile phone (to date, we have implemented versions for Android) with installed CALM application, and 2) a physiological monitoring belt (for example, BioHarness BT by Zephyr) with the ability to transfer Bluetooth data between the phone and the monitoring belt.

The data transfer happens between the phone and the monitoring belt; the application transforms the data to provide easy-to-use readings of physiological indicators of mental health and also provides real-time biofeedback if patients choose to do a breathing exercise. Patients, on the other hand, are asked to provide subjective inputs of well-being by answering a few questions. Both objective and subjective metrics are presented back to patients. These metrics can also be shared with a therapist. Figure 1. shows the components required for the CALM application and the information flow between monitoring device, mobile phone application, patient and clinician.

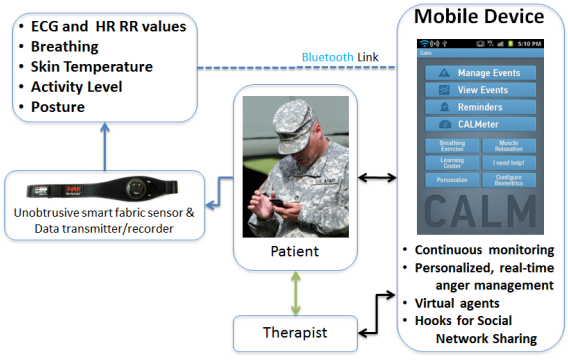

Figure 1. CALM System Architecture

A. *Evidence-based Therapy*

A number of evidence-based therapies address the needs of post-deployment mental health issues. These include: trauma desensitization, hypnotherapy, psychodynamic therapy, image exposure, cognitive restructuring, eye movement desensitization and reprocessing, biofeedback-assisted relaxation, exposure therapy, stress inoculation training, wait-list control condition, individual or group CBT, and possibly other forms. However, CALM's approach focuses on the following criteria:

- Integration with physiological monitoring and biofeedback options
- The ability to provide help remotely
- Specific needs of patients with anger/stress/emotion control issues
- Allows integration with final application and meets technical requirements

Given these criteria, we decided that Anger Management Therapy (AMT) is most suitable to integrate with our system. AMT provides a conceptual framework for addressing specific and concrete emotional states along with strategies for coping with the inability to control emotions (anger), which is the primary symptom among our patient population. The therapy's manual and workbook are suitable for easy integration with biofeedback and physiological monitoring in a phone application.

Specific enhancements that CALM can provide over paper-based delivery of AMT are summarized in Table 1.

TABLE I. BENEFITS OF CALM

Manual-guided AMT	CALM-enhanced AMT
Printed workbook	Phone application can serve as workbook
Homework assignments with pencil and paper	Homework assignments with few taps on phone
Anger Events recorded after they happen	Anger Events can be recorded in real-time
No feedback to patients	Feedback in form of logs and visualizations of objective and subjective data
No feedback to therapist about efficacy of AMT Anger Control Plan and its application to real-life anger events.	Physiological and behavioral efficacy metrics of real-life application of AMT Anger Control Plan
No objective feedback to therapists about frequency of workbook usage, time spent on assignments, how often relaxation exercises are done, etc.	Therapist is able to monitor therapeutic progress outside of group meetings
Simple breathing exercise: no knowledge about effectiveness	HRV-Biofeedback enhanced breathing exercise: guided visualization and real-time HRV biofeedback teach and guide correct RSA breathing [16]/
Anger Control Plan is written on piece of paper	Anger Control Plan is easy to modify and lives in phone.
No build in motivational enhancement	Increased motivation via fun app, reminders and personalized avatars that can be injected with desired human characteristics expressed in language.

While the workbook is divided into several sessions where patients learn about the causes and effects of anger, our application has adapted and enhanced the most important features that patients will need throughout the course of therapy. For example, an "Anger Meter," a way to visualize anger levels, is similar to our idea of the "CALMeter," a way to not only visualize anger levels continuously, but also to

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provide meaningful objective feedback. The application provides audio files of "learning material," which are updated forms of coping strategies, as well as personal customization of the application. Most importantly, in comparison to the workbook, CALM can be used for recording an anger event in a simple and fast way whenever and wherever needed. Another enhancement over conventional Anger Management Therapy is the integration of biofeedback into a breathing exercise. The strongest evidence for Anger Management Group Therapy, however, is that it is the only form of therapy addressing anger control issues offered at VA Medical Centers nationwide.

B. Heart Rate Variability, Biofeedback and RSA Breathing

A growing body of psychological research supports an association between parasympathetically mediated HRV and outcome measures relevant to regulated emotional responding (e.g., coping). Heightened levels of resting respiratory sinus arrhythmia have been associated with greater self-reported emotion regulation and the use of constructive coping strategies, and lower HRV is associated with greater negative emotional arousal in response to stress [10]. Conversely, greater HRV is a physiological indicator of adaptive emotion regulation and a decreased mental load [9]. A meta-analysis of HRV and neuroimaging studies by Thayer et al. [6] links HRV to markers of stress and health, and shows correlations between HRV and brain regions involved in emotion control. Cerebral blood flow increases during emotion control tasks and can peripherally—via the vagal nerve—be linked to HRV. HRV is therefore not only an excellent index for a person's ability to regulate responses to threatening environments, but baseline HRV is a good indicator of mental health since it is depressed in patients suffering from psychopathologies such as PTSD, anxiety and depression.

A typical ECG tracing of the cardiac cycle (heartbeat) consists of a P wave, a QRS complex, a T wave and a U wave, which is normally visible in 50-75% of ECGs. The RR signal is the interval between two R waves and is obtained by detecting the R peak in the QRS complex of an ECG trace. It is a stepwise constant with transitions at the quasi-periodic occurrences of the peak R. There is consensus in the literature that the high-frequency (HF) components of HRV are related to respiratory rhythm and are a marker of vagal modulation [11], and that the low-frequency (LF) components are thought to be under both sympathetic and parasympathetic control. Sympathovagal balance is characterized by the relationship between these two rhythms [12].

HRV analysis is commonly based on non-parametric methods such as Fourier or wavelet frameworks, or parametric methods like Autoregressive Models (AR) [13, 14]. For CALM, the power spectrum of the RR signal in the range of 0.015-0.5 Hz (LF to HF) is computed by describing the RR with a p order AR model. To limit computation time, the signal is downsampled while allowing access to spectral information in the range of interest.

CALM provides visualizations that integrate objective data, such as heart rate, breathing rate and HRV data from use of the BioHarness belt with subjective measurements from the subject. In particular, CALM presents summarized data representing the movement of power from the LF to HF frequency bands of the HRV over time, because HF activity has been found to decrease under conditions of emotional strain and during states of elevated anxiety, in individuals reporting a greater frequency and duration of daily worry and in those suffering from PTSD [8]. HRV and its HF component are reduced whilst the LF component is elevated.

HRV biofeedback and RSA breathing. Biofeedback is the process of displaying involuntary physiological processes and learning to voluntarily influence processes "feed" them back to users by making changes in cognition. This approach provides a transparent and empirical demonstration of consciously manipulating autonomic functions for improving health. Biofeedback instruments measure and transform information from physiological processes into simple, direct and easy-to-read signals. HRV biofeedback training includes instruction in breathing at a frequency related to optimal low-frequency band power, i.e. resonant frequency [7].

The cardiovascular system is characterized by specific resonance frequencies of HRV that exist at a particular frequency for an individual, within the low-frequency range of the HRV spectra. The resonance frequency for an individual lies at the frequency at which the system, when rhythmically stimulated, produces the maximum HRV, usually around 0.1 Hz or about 6 breathing cycles per minute. When a person breathes at about 6 breaths per minute, the respiratory stimulus causing HR to rise occurs precisely at the same time as the baroreflex impulse. This causes a persistence of the augmented HR oscillation at the resonant frequency; only at this frequency are HR and respiration in sync with each other and HR oscillations become very large. HR and blood pressure oscillate in opposite direction and the baroreflex is stimulated with every breath, causing an increase in HR oscillation. Baroreflex training, which uses RSA breathing, can be achieved with HRV biofeedback. CALM provides HRV biofeedback visualization on how to slow down breathing to meet a patient's personal resonance frequency. Patients learn how to the control color and size of a circle using biofeedback.

Breathing exercises carried out over long periods of time

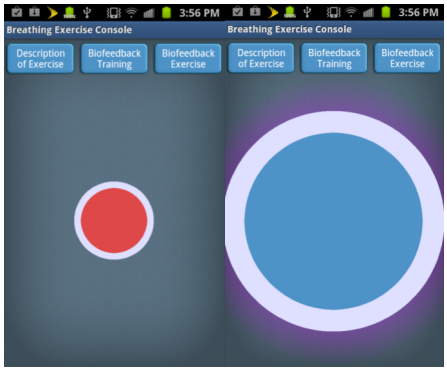

Figure 2. CALM visualizations of RSA breathing exercise

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with HRV biofeedback have been shown to positively affect asthma, hyperventilation, anxiety, depression or pain. Figure 2 indicates how CALM will facilitate breathing exercises, specifically addressing increases in HRV. Patients learn how to control the color, edge size, and radius of a filled circle via biofeedback. The filled circles represent where the HRV data is most powerful: red in the LF range and blue in the HF range. As patients successfully move their HRV towards the desired range, the color will transition from red to blue. The thickness of a white border around the filled area represents patient heart rate. A thinner border corresponds to a faster the heart. The circle's radius represents patient breathing rate, where a larger circle represents a slower breathing rate. A slowly increasing purple glow around the outside of the white edge signifies that a patient is maintaining their biofeedback statistics at a near constant and near optimal value. The time of participation, exercise length, and all biofeedback data are recorded for later analysis.

C. Motivation via Personalization and Avatars

Personalization as motivation. Many forms of psychotherapy require a therapist's guidance precisely because they demand highly individualized approaches. While CALM does not replace a human clinician, its customization features provide a unique selection of settings that fit a particular user's needs. On a therapeutic level, CALM allows users to create a truly personalized Anger Control Plan. Users will be able to modify and add cues, triggers and strategies, add personal notes with written or audio-recorded memos, set reminder features informed by SIFT's Etiquette Engine ™ (shown to increase compliance [15]) or set gender preferences for virtual avatars and audio files. The purpose of CALM's personalization is two-fold: (1) to build a therapeutic alliance between a user and therapist using CALM as a tool for structured communication, and (2) to facilitate pattern recognition for users and their therapists. For example, by recording a user's individual triggers as episodes occur, the user can then share this information with the human therapist. Therapists can retrieve greater detail from these records, rather than purely relying on an individual's recall, making therapists better equipped to tweak a patient's treatment plan. Although the same result may be achieved by patients using a pencil and a notepad, therapists and patients alike agree anecdotally that this method usually fails because (1) it requires patients to recognize anger events as they are occurring and be organized enough to physically have the notepad and pencil on hand, and (2) although they understand the benefits of the recording activity, patients are not always motivated to do it because they do not experience the benefits directly. Often, patients forget to do this type of therapeutic homework assignment, making it difficult to retroactively share important information with their therapists. By facilitating information recording and sharing by providing highly customizable options, CALM connects therapists with users' day-to-day experiences.

Motivation via socially intelligent avatars. Many veterans shy away from face-to-face mental health treatment, but may be open to using more anonymous alternatives (e.g., online forums). To address this, DARPA has recently funded a new project called "SIM Sensai," a virtual therapist that identifies patients who need help most acutely [16]. Virtual therapy and telemedicine are uniquely equipped for wide and cost-effective distribution even to remote locations, especially in environments where care demands can't always be met. The main element of this treatment option is the use of a virtual avatar. While CALM is not intended as virtual therapy, it integrates socially intelligent avatars on the following basis:

1) Avatars, especially those that display socially appropriate behavior (see Figure 3.), can impact human-machine trust which has emerged as having a considerable impact on human-machine performance [17, 18]. Definitions of trust stem from work in sociology associated with human-human trust, and are applicable based on Reeves and Nass' theory that humans regularly anthropomorphize technology, treating machines as social agents. As a result, humans (intentionally or not) react to the social queues displayed by machines. If a machine has been deemed untrustworthy, a human may reject the use of it regardless of its efficiency or reliability [19].

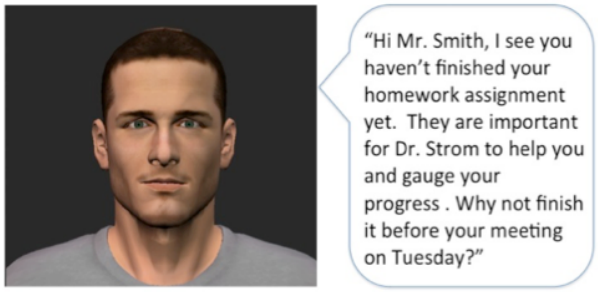

Figure 3. Avatar with adjusted speech level reflective of high-to-medium social distance and imposition.

III. CALM FUNCTIONALITIES

As part of this project, we have implemented and evaluated all features necessary for a fully functioning prototype. Figure 4. provides screenshots for the main functionalities integrated to date. These functionalities include: 1) A CALMeter, allowing the user to record the intensity of an anger event on a scale from 1 to 10, 2) An Anger Control Plan, consisting of the possibility to record the details of a particular anger event, including time, triggers, cue, strategies used, effectiveness of strategies and optional notes, 3) Data Visualizations of subjective recordings of events as well as physiological measures, 4) Breathing and Muscle Relaxation Exercises including Biofeedback, 5) an Education Center providing basic information about anger habits and 6) an Emergency Button.

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Figure 4. Summary of CALM functionalities

For detailed descriptions of all CALM functionalities please contact the authors.

IV. CONCLUSION

This prototype was developed in collaboration with psychotherapists from Minneapolis Veterans Affairs Medical Center (MVAMC) in order to meet the needs of veterans returning from deployment. CALM integrates with ongoing Anger Management Therapy offered at VAs nationwide. Currently, Anger Management Therapy is a manual-based 12-week group therapy. The core of this form of therapy is to become aware of what causes anger. With a mobile application anger triggers, cues and strategies can be recorded in real-time as well as reflected upon later. The application help to gives context a situation that seems difficult to handle – what times of the day or week, which other persons where involved and most importantly how was a situation handled. In addition, physiological measures can provide further cues to recovery progress. For patients, CALM provides opportunities to do therapeutic work at their own pace, it is a cost-effective and widely distributable form of intervention, it can offer support for a large group of people (e.g., in times of disasters of when the resources of clinicians are limited), people who otherwise may not week treatment can be reached and virtual avatars increase motivation and engagement. For clinicians, CALM can help to efficiently and cost-effectively treat a larger number of patients, it increases the realism of the social and environmental components influencing treatment and it offers feedback on efficacy of patient treatment.

To validate and further improve CALM, clinical testing is needed in the future.

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REFERENCES

[1] N. A. Sayer, S. Noorbalochi, P. Frazier, K. Carlson, A. Gravely, M. Murdoch, “Reintegration Problems and Treatment Interests Among Iraq and Afghanistan Combat Veterans Receiving VA Medical Care”, Psychiatric Services, vol. 61(6), June 2010, pp. 589-597.

[2] W. P. Nash, L. Krantz, N. Stein, R. J. Westphal, & B. Litz, “Comprehensive soldier fitness, battlemind, and the stress continuum model: Military organizational approaches to prevention,” American Psychological Association, 2011, pp. 193-214, doi: 10.1037/12323-009.

[3] M. Jakupcak, D. Conybeare, L. Phelps, S. Hunt, H. A. Holmes, B. Felker, M. E. McFall, “Anger, hostility, and aggression among Iraq and Afghanistan war veterans reporting PTSD and subthreshold PTSD,” Journal of Traumatic Stress, vol. 20, 2007, pp. 945–954.

[4] N. A. Sayer, G. Friedemann-Sanchez, M. Spoont, M. Murdoch, L. E. Parker, C. Chiros, R. Rosenheck, "A qualitative study of determinants of PTSD treatment initiation in veterans," Psychiatry, January 2009, pp. 238-255.

[5] P. M. Reilly and M. S. Shopshire, “Anger management group treatment for cocaine dependence: Preliminary outcomes,” The American journal of drug and alcohol abuse, vol. 26, pp. 161–177, 2000.J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp. 68–73.

[6] J. F. Thayer, F. Ahs, M. Fredrikson, J. J. Sollers III, and T. D. Wager, “A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health,” Neuroscience & Biobehavioral Reviews, vol. 36, 2012, pp. 747-756, http://dx.doi.org/10.1016/j.neubiorev.2011.11.009.

[7] P. M. Lehrer, E. Vaschillo, B. Vaschillo, "Resonant frequency biofeedback training to increase cardiac variability: Rationale and manual for training, " Applied Psychophysiology and Biofeedback, vol. 25 (3), 2000, pp. 177–191.

[8] G. Tan, T. K. Dao, L. Farmer, R. J. Sutherland, and R. Gevirtz, “Heart rate variability (HRV) and posttraumatic stress disorder (PTSD): A pilot study,” Applied Psychophysiology and Biofeedback, vol. 36, no. 1, 2011, pp. 27–35.

[9] B. M. Appelhans and L. Luecken, L, “Heart Rate Variability as Index of Regulated Emotional Responding,” Review of General Psychology, vol. 10, 2006, pp. 229-240.

[10] T. F. Denson, J. R. Grisham, and M. L. Moulds, “Cognitive reappraisal increases heart rate variability in response to an anger provocation,” Motivation and Emotion, vol. 35, 2011, pp. 14–22.

[11] P. Nickel and F. Nachreiner, "Sensitivity and Diagnosticity of the 0.1-Hz Component of Heart Rate Variability as an Indicator of Mental Workload", Human Factors, vol. 45(4), 2003, pp. 575–590.

[12] F. Lombardi, A. Malliani, M. Pagnai and S. Cerutti, “Heart rate variability and its sympatho-vagal modulation,” Cardiovascular research, vol. 3292(208), 1996, pp. 208-216.

[13] S. Cerutti and C. Marchesi, “Advanced Methods of Biomedical Signal Processing,” Wiley & Sons, Inc. New Jersey, 2011.

[14] M. Malik, “Heart rate variability: standards of measures, physiological interpretations and clinical use,” Circulation, Vol. 93, , 1996, pp. 1043-1065.

[15] R. Parasuraman and C. Miller, “Trust and etiquette in high-criticality automated systems,” Communications of the Association for Computing Machinery, vol. 47(4), 2006, pp. 51–55.

 ISBN: 978-1-61208-312-4

[16] K. Drummind, “Darpa to Troubled Soldiers: Meet Your New Simulated Therapist,” Wired Magazine, Accessed September 2013: http://www.wired.com/dangerroom/2012/04/darpa-virtual-therapy/

[17] J. D. Lee and K. A. See, "Trust in automation: Designing for appropriate reliance," Human Factors, vol. 46, 2004, pp. 50-80.

[18] B. Reeves and C. Nass, “The Media Equation: How People Treat Computers, Television, and New Media Like Real People and Places,“ Cambridge University Press, 1996.

[19] R. Parasuraman and V. Riley, “Humans and automation: Use, misuse, disuse, abuse,” Human Factors, vol. 39, 1997, pp. 230-253.

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How User Experience Design Can Affect Motivation: A Study on a Real World Sport Application

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Abstract— **Many researchers from different scientific fields are developing new strategies to foster individuals toward a physically more active lifestyle. In most cases, these strategies exploit new generation mobile devices together with social networks to augment their persuasive power. In our research work we focus on the study of the effects of these technologies on people's sport habits. To better study this phenomenon, we are developing a software platform that aims at encouraging people to pursue a more active lifestyle. This work presents an experimentation conducted on *Everywhere Run!*, a mobile application part of the platform, that aims at helping people to stay active behaving like a virtual personal trainer. Very preliminary tests on the impact of the application on users' motivations, show that it is perceived as a valuable motivational tool. These tests have been the starting point for this work that presents an interesting result that is closely related to recent radical changes we made to the graphical design and usability of the software. During a six months period, we observed a considerable increment of the total number of daily trainings. To statistically prove the effectiveness of the redesign, we decided to compare the two versions of the application. The results confirm the effectiveness of the new design and bring us to another important intuition that we will better investigate over a longer period of time in our forthcoming researches: user experience may positively influence users' motivations and their perception of the offered features especially in the long term.**

Keywords—Persuasive Computing; User Experience Design; Human Computer Interaction; Healthy Lifestyle; Running.

I. INTRODUCTION

Several studies demonstrate the importance of a regular physical activity for people well-being (see for example, [2][3][4][5]). Low levels of physical activity are a major risk factor for lower life expectancy, cardiovascular diseases and many other chronic diseases. Former studies put in evidence the benefits of a healthy lifestyle, nevertheless, it does not seem to be enough to encourage people to conduct a healthier lifestyle. This alarming trend is clearly shown by several researches as, for example, by the report of the World Health Organization (WHO) for the years 2008-2010 [6]. The report, along with other similar studies (see, for example, [7]), lists some advices for a better lifestyle. For example:

- Engage in regular physical activity
- Limit the intake of free sugars
- Limit energy intake from total fats and shift fat consumption away from saturated fats to unsaturated fats and towards the elimination of trans-fatty acids
- Increase consumption of fruits, vegetables, legumes, whole grains and nuts

Scientists from different backgrounds and several industrial entities are proposing new persuasive techniques to encourage people in everyday physical activity. These methodologies tend to leverage a fun oriented approach together with new mobile devices to motivate individuals towards healthy habits.

Buttussi et al. [12] propose a classification for this kind of persuasive tools:

- Computer-supported physical games
- Virtual trainers
- Mobile applications and devices

Our researches are focused on the last category since it seems to be the most promising one in terms of the high number of related researches, proposed solutions and encouraging results obtained so far.

Mobile device usage is growing fast and it is somehow affecting people's everyday life. They are relatively inexpensive, versatile, highly portable and are potentially usable at anytime, anywhere.

As an example, Mulas et al. [13] propose a mobile application, called *Everywhere Race!*, that allows users from all over the world to interact and to compete in virtual real time races in different speed-based sports. *Everywhere Run!* (EWRun), as well as *Everywhere Race!*, fosters social interactions. However, its interaction model is different from other similar applications. It focuses on relationships between users and real personal trainers in addition to that, more common, between similar users. In this way, it favours beginner runners to get a tailored workout plan and to start running avoiding common first-time mistakes. A user can request his custom-tailored running plan to a real trainer and he can receive it seamlessly inside the application. At this point, the user as just to start running letting himself be guided by the virtual trainer to run the selected distance at the right pace.

Many researches [9] [10] put in evidence the benefits and the influence of social interactions in sport. The constant support of a real trainer, in addition to make workouts safer, can be much more motivating in the long term too.

Our application is designed to help people to get rid

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of some common deterrents to physical activity like, for example, time constraints rather than gym membership fees. The application allows users to get in touch with a real trainer to get a tailored workout plan they can follow at anytime, anywhere. This results both in more time flexibility and in lower costs for users given that it is not mandatory for them to meet with a real coach. Other solutions, however, try to attract users focusing mainly on their past performance rather than the social and ludic aspects of sport. For many people, this can be a limiting factor especially when the aim is both to attract non-habitual runners and to motivate them in the long term.

With respect to other proposals our approach promotes interactions between users and real trainers through a community of runners. Very preliminary results confirm that users appreciate EWRun functionalities [24] meaning that our work is on the good track. Nevertheless, the data collected from recent application usage statistics suggest that many innovative features are not enough if the whole design has not been realized with a special attention to user experience. Our assertion follows from a recent radical redesign of the application. We moved from a relatively simple and not very user centered design to a better one following usability best practices and the Android design recommendations [8]. These changes resulted in a remarkable application's user growth even if there were no notable functional improvements. This is why we decided to mathematically prove the goodness of the new design with respect to the old one. We performed an A/B test on 40 users through two standard System Usability Scale (SUS) questionnaires [11] (one questionnaire for each design under evaluation [37]).

The encouraging results obtained so far suggest us that the offered functionalities without the proper design are not enough to attract people especially for a long time period. To the best of our knowledge we are the first, in the field of mobile persuasive technologies, to show similar results for a real world application used by hundreds of users everyday. This interesting result bring us to another intuition that we will investigate in the near future over a longer time period: user experience can be crucial to alter individuals' motivation and can deeply influence their perception of the offered functionalities.

The rest of this paper is organized as follows: Section II surveys the state of the art in the field of mobile persuasive computing. Section III briefly describes the application and shows how its design has been changed whereas, Section IV reports the results of the experimentation. Section V concludes the paper.

II. Related Work

In this section, we report some studies and some technological systems designed to help people during daily physical activity.

In [18], IJsselsteijn et al. investigate on intrinsic motivation enhancement. For their studies, they realized a virtual coach system to help users while cycling on a stationary bike. They report a good users reaction to the stimuli provided by the coach and derived some important results about the way the users perceived the informations provided by the virtual coach during the trainings.

Mulas et. al. [13] propose an innovative mobile application called *Everywhere Race!*. The application is designed to motivate people in a wide range of speed-based sport activities. It is the first system that allows users from all over the world to compete against each other in different speed-based sports. The software, in a completely different way than others, allows real time races among participants and makes available a significant set of social functionalities by means of the social network Facebook.

In [19], is presented a game called Your Shape Fitness Evolved designed to help users during indoor workouts. The game, among other features, allows users to design a custom workout, to keep track of training statistics and to challenge other users by means of a virtual community.

Toscos et al. [20] propose an application, called Chick Clique, to help teenage girls to adopt a healthier lifestyle. The software stores informations about the caloric content of popular foods and the amount of steps necessary to burn them. Chick Clique aims at fostering social interactions by means of SMS in order to boost a positive competition among users.

Hoysniemi et al. [17] illustrate the results regarding the experimentation of a famous dance video game called Dance Dance Revolution. The results stress the positive influence of gaming with respect to motivational, physical and social factors.

Chittaro et al. [15] propose a location-based exergame based on the classic Snake mobile game in which the snake is guided by users' movements. The work aims at encouraging users to walk more frequently and at demonstrating the effectiveness of the proposed solution through the adoption of standard questionnaires. Obtained results put in evidence how users' behavior can be influenced by the fun resulting from the game.

Oliveira et al. [22] present a mobile phone application called TripleBeat. The application uses both an accelerometer and an ECG to push runners to achieve predefined goals expressed in terms of heart rates. Their experimentation revealed the importance of a well-designed graphical user interface in order to enforce users' motivations.

Consolvo et al. [21] present a mobile application called Houston. The application makes use of a pedometer to count, to record and to share the results achieved by the user. The authors derived some interesting key design guidelines to be used in this class of mobile applications:

- Users expect to have thorough measures and long term statistical reports of their activities
- Support for social features to improve users' motivation through a friendly competition
- Take into account the comfort of proposed solutions

Consolvo et al. [16] present UbiFit Garden, a mobile system that uses on-body sensing, activity inference and mobile display to encourage people to stay active.
Preliminary results, derived from a three-week field trial, show that users were positively surprised by the novelties the application introduced and their responses help authors to derive some guidelines to be observed to improve their system.

Nike+ [23] is one of the most popular applications to help people during sport activities. Some of its main strengths are: the advanced vocal cues and music system management, the deep use of social networks and the support of a web community where users can create their workouts plans and

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Fig. 1. Application's dashboard.

Fig. 2. Old design workout creation menu.

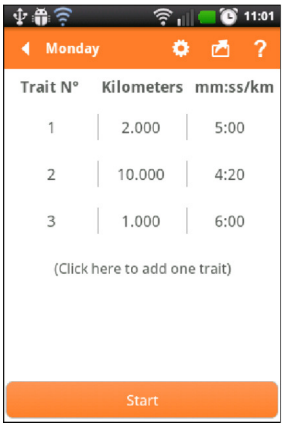

Fig. 3. New design workout creation menu.

interact with other sportsmen.

Along with Nike+, there exist several other commercial examples of such a kind of applications. Just to name a few: Adidas miCoach, Endomondo, MapMyFitness, RunKeeper, Runtastic and many others. All these systems provide more or less the same core functionalities:

- Route and workout data tracking
- Statistical reports
- Results sharing through ad hoc communities or social networks

As previously stated, our work is focused on the relationship between user experience and mobile persuasive technologies. In the next sections we are going to describe how EWRun has been redesigned, the procedure we used to evaluate both the new and old design and the obtained results so far. From our researches on this topic, we have not found similar case studies. This is probably because academic proposals are typically prototypes and do not have a considerable amount of users to conduct comprehensive tests. Commercial products, on the contrary, usually have a huge amount of users and refined designs but, to the best of our knowledge, there are no publicly available studies and results on this subject.

III. EVERYWHERE RUN! REDESIGN

EverywhereRun! [24] is a mobile application designed to support people during their running routines. By means of the application users can design their own regimes or get tailored ones directly from a real personal trainer seamlessly inside the application. EWRun redesign has been inspired by the guidelines proposed in [21] and for this reason, we introduced a new home screen (see Figure 1) that reports all the statistics of user's past trainings such as: the total distance covered, the total number of workouts, the average speeds and so on.

Figure 2 and Figure 3 show the workout creation screen respectively for the old and the new design. Through this screen users can plan relatively complex regimes like the one, called "Monday", showed by the two figures: each training is composed of several "sessions", called "traits", defined in terms of distance and pace (or speed) to keep. The "trait 1" in Figure 3 means the user wants to run 2km at a pace of 5 minutes per kilometer (note: runners generally express speed as the time to run one kilometer or mile). The first trait is followed by "trait 2" where the runner expects to run 10km at a higher pace than before.

Hence, EWRun permits to define quite complex regimes in order to satisfy even the most demanding runners. Both designs offer the same features in terms of training design complexity, although the new one is completely different in terms of usability (note that the following consideration holds for all of the screens of the new design): global application's settings have been made available in this screen whereas many other options, local to the screen, have been moved from the bottom of the screen to the topmost bar as suggested by the new Android design guidelines. This allows us to give more homogeneity to the navigation between screens and to keep many locally available functionalities grouped in the top bar rather than scattered all over the screen.

As previously stated, the virtual personal trainer is the core feature of EWRun. By means of this functionality the application is able both to guide and to motivate the runner during the whole workout in order for him to reach predefined goals (i.e., the goals set by means of the workout creation screen, see Figure 2 or Figure 3). In Figure 4 and Figure 5, it is possible to observe, again for the old and the new design, two ongoing workouts and how the virtual personal trainer feature works.

Figure 4 shows the virtual trainer represented by the orange icon in the left center of the screen. He acts like

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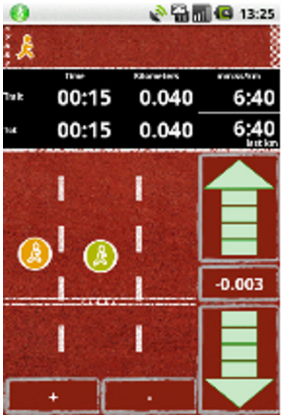

Fig. 4. Old design personal trainer screen.

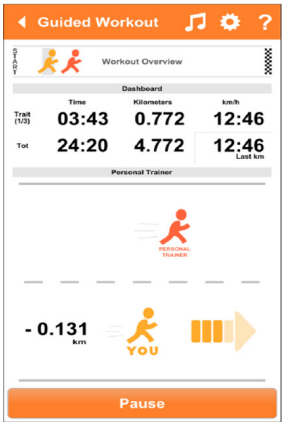

Fig. 5. New design personal trainer screen.

pacemaker (note: a pacemaker has the task to keep the pace for other runners) so that the runner, virtually represented by the green icon in the center of the screen, has just to follow him focusing only on the run. In both designs, the topmost part of the screen contains an horizontal bar to give user an overview of the whole workout (note that the workout length is known a priori since it has been defined in the workout creation screen) with the actual position of the runner with respect to the virtual trainer.

Just below the bar there is a dashboard that reports current speeds, distances and times regarding both the current trait and the whole training session. The two buttons in the bottommost of the screen (only for the old releases) allow to zoom in/out the part of the whole workout depicted in the central part of the screen. This was supposed to make it easier for the user to estimate the current distance to the trainer (see below). In the old design the two big arrows in the right side of the screen suggested to the user if he has respectively to slow down or to speed up. In between the arrows the current distance of the runner to the trainer is clearly indicated. Furthermore, the two arrows will be alternatively filled proportionally to the need of slowing down or speeding up. Hence, the user knows at any moment his current performance level with just a quick glance at the screen. All that can be observed in Figure 4. The figure depicts a runner just 3 meters behind the virtual coach, thus none of the arrows is filled to signal that the user is keeping the proper pace.

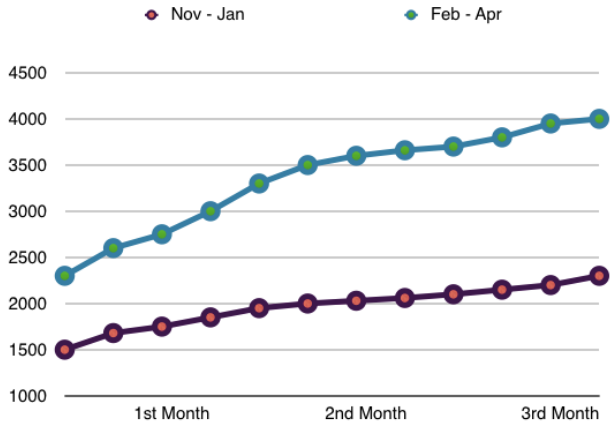

Fig. 6. Number of trainings with old (Nov 2012. to Jan 2013) and new design (Feb. to Apr. 2013).

Now, we are going to further explore the differences between the two designs: in addition to the aforementioned bar at the topmost of the screen (see Figure 5), used both to improve the navigability and to more evenly group both global and local options, we focused our efforts to redesign the portion of the screen that depicts the user and the virtual coach during a training session (i.e., the "personal trainer" area in the lower half of Figure 5). Some advices from EWRun beta testers pushed us to simplify the various components originally present. At first, in addition to a general graphic improvement, we switched the "personal trainer" area from a vertical to an horizontal orientation to be consistent with the whole workout perspective at the topmost of the screen. Secondly, the zoom in/out buttons have been removed since they seem to be useless when used during a training and finally, we removed one of the two arrows. Indeed, now there is only one arrow that changes its orientation accordingly to the current position of the user with respect to the virtual personal trainer. The distance gap between the user and the trainer has been moved near the icon representing the user, in its left. In this way, we try to keep training data as compact as possible by decreasing the total number of graphic elements for a better user experience.

IV. Experimental Results

The new design of *Everywhere Run!*, as previously introduced in Section III, caused a statistically significant user base growth. For this reason, we decided to compare the two designs by means of a standard testing methodology known as A/B testing (see for example, [33]). The description of the experimentation will start by showing the application's usage statistics that inspired us to conduct this study and, afterwards, we will describe in more detail the A/B testing methodology and the mathematical tools we used for the experimentation.

Figure 6 reports the number of weekly workouts (by all users) performed with both application designs. The statistics have been collected over a three months period, from November 2012 to January 2013 for the old design and from February to April 2013 for the new design. In the graphic is clearly shown the number of trainings growing from about 1500 of the 1st of November 2012 to about 2300 (+53%) at the end of January 2013.

In general, there is a positive growth rate but much lower

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when compared to usage statistics for the new design. With the introduction of the new design in February 2013 (again there were no new features offered) the number of trainings passed from about 2300 to about 4000 (+74%).

Now, we are going to explain the A/B test we conducted. A/B testing, also known as split testing, is a widely adopted technique typically used to compare two design variants (A and B) of the same system. Amazon was probably the first industrial entity to adopt this procedure to evaluate the user experience of its marketplace. Differences between version A and version B can range from completely different layout structures to, for example, the font type, the different disposition of a button and so on. The goal of the evaluation is to identify some changes that can increase a certain metric of interest.

To conduct the test, we adopted the System Usability Scale (SUS) questionnaire [11]. SUS is a well known tool (it counts more than 600 citations [35]) used both by industries and by academics. SUS is technology independent and it has been used to test web sites, hardware, consumer software and much more. The questionnaire is composed of 10 questions with 5 response options. Each question is rated using a Likert scale ranging from 0 ("strongly disagree") to 5 ("strongly agree").

We conducted our experiment with a sample of 40 participants that regularly used both application versions. The sample was composed of 34 males and 6 females with an average age of 35.8 years (standard deviation was 10.4 years). All the users regularly practiced sport at an amateur level and they all have had at least a previous experience with applications to support physical activity.

Table I reports the SUS scores for all the testers and the mean of difference scores. The experimentation has followed the method proposed by Sauro et al. [33] to prove what the usage statistics suggest (see Figure 6).

Often, in many research fields (HCI is no exception), the population mean and standard deviation are not known so it is not possible to use the Empirical Rule and *z*-scores [34][33]. Under those circumstances, it is used a paired *t*-test [30] to compare how a limited number of testers perform in two different test conditions. In particular, we use a paired *t*-test to determine if the difference between SUS score means for the two designs is significant or not. To determine the test statistic *t* the following formula is used:

$$t = \frac{D}{\frac{S_d}{\sqrt{n}}} \tag{1}$$

where: D is the mean of the difference scores, S_d is the standard deviation of the difference scores and n is the sample size. In our case (see Table I) D is equal to 26.8, S_d is equal to 15.621 and the sample size (n) is 40. Plugging in all the values in Formula 1 we obtain a value for t equal to 18.85. Is this value statistically significant? To answer to this question we have to look up the *p*-value [36] using the *Student's* distribution table with n-1 (39) degrees of freedom. The table give us 2.415×10^{-13}. This very small value tell us that the SUS scores for the two designs is different with a probability very close to 100%. This result confirms us that the difference is statistically significant but, is it significant enough for users so that they will notice it? The confidence interval around the difference will answer to this question. The formula 2 is used

TABLE I. SUS SCORES

User	New	Old	Difference
1	80	50	30
2	92.5	62.5	30
3	97.5	52.5	45
4	82.5	42.5	40
5	100	65	35
6	100	100	0
7	100	100	0
8	85	42.5	42.5
9	77.5	50	27.5
10	97.5	77.5	20
11	97.5	65	32.5
12	95	40	55
13	95	45	50
14	80	75	5
15	85	72.5	12.5
16	97.5	65	32.5
17	92.5	85	7.5
18	55	52.5	2.5
19	55	52.5	2.5
20	87.5	45	42.5
21	82.5	42.5	40
22	70	45	25
23	82.5	40	42.5
24	95	45	50
25	85	60	25
26	85	65.5	19.5
27	79	47.5	31.5
28	90.5	57.5	33
29	82.5	55	27.5
30	82.5	74	8.5
31	92.5	67.5	25
32	77.5	52.5	25
33	75	75	0
34	97.5	65	32.5
35	85	47.5	37.5
36	87.5	50.5	37
37	75	75	0
38	97.5	70	27.5
39	90	57.5	32.5
40	87.5	47.5	40
Mean	**86.3**	**59.5**	**26.8**

to determine the confidence interval:

$$D \pm t_\alpha \frac{S_d}{\sqrt{n}} \tag{2}$$

where: D is the mean of the difference scores, n is the sample size, S_d is the standard deviation of the difference scores and t_α is the critical value for n-1 degrees of freedom. For a 95% confidence interval and 39 degrees of freedom t_α is equal to 2.07. Plugging in all the values in Formula 2 we get 26.8 ± 5.006. To put it simply, we can be 95% confident the actual difference of scores is between 21.8 and 31.8. These results confirm our initial intuition and demonstrate that the new design usability is better both statistically and in terms of users' perception.

In conclusion, we can affirm that our case study demonstrates how a good user experience can be crucial for users engagement.

V. CONCLUSION AND FUTURE WORK

A remarkable number of studies and mobile solutions have been proposed to push people to a more active and healthy lifestyle. Our work illustrates the results of an experimentation we conducted on 40 real users of *Everywhere Run!*. EWRun has been designed to guide runners step by step during their workouts giving them the possibility to plan quite complex regimes on their own, or to receive a custom-tailored ones

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from a real trainer by means of the application.

As proven by previous studies [24], users appreciate the features of the application, although, a recent radical redesign we made to the application's and the related users' reactions, led us to consider not only the implementation of innovative functionalities but also to keep into great account the user experience design.

During a six months period, we observed a remarkable user growth even if the application offers roughly the same features offered in the past. As a consequence, we decided to compare the two designs. The test has been conducted on 40 real users by means of a standard and well known methodology, which uses a SUS questionnaire.

Obtained results partially confirmed our intuition: innovative features may not be enough effective to motivate users' without a special attention to user experience design. We are probably the first, in the field of mobile persuasive technologies, to report similar results for a real world application used by hundreds of users everyday. These results will be the very first step of our future research activity to better investigate and possibly to verify over a longer time period another fact that seems to be related to this work and deeply linked to the supplied user experience: how user experience design can alter long term users' motivations.

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REFERENCES

[1] "Android," www.android.com, accessed: 2013-05-29.

[2] D. E. Warburton, C. W. Nicol, and S. S. Bredin, "Health benefits of physical activity: the evidence," *Canadian medical association journal*, vol. 174, no. 6, pp. 801–809, 2006.

[3] R. R. Pate, M. Pratt, S. N. Blair, W. L. Haskell, C. A. Macera, C. Bouchard, D. Buchner, W. Ettinger, G. W. Heath, A. C. King *et al.*, "Physical activity and public health," *JAMA: the journal of the American Medical Association*, vol. 273, no. 5, pp. 402–407, 1995.

[4] J. J. Varo, M. A. Martínez-González, J. de Irala-Estévez, J. Kearney, M. Gibney, and J. A. Martínez, "Distribution and determinants of sedentary lifestyles in the european union," *International journal of epidemiology*, vol. 32, no. 1, pp. 138–146, 2003.

[5] A. L. Dunn, B. H. Marcus, J. B. Kampert, M. E. Garcia, H. W. Kohl III, and S. N. Blair, "Comparison of lifestyle and structured interventions to increase physical activity and cardiorespiratory fitness," *JAMA: the journal of the American Medical Association*, vol. 281, no. 4, pp. 327–334, 1999.

[6] WorldHealthOrganization, "Obesity and overweight," www.who.int/mediacentre/factsheets/fs311/en, accessed: 2013-05-29.

[7] ——, "Who-diet," www.who.int/dietphysicalactivity/diet/en, accessed: 2013-05-29.

[8] "Android design guidelines," developer.android.com/design/index.html, accessed: 2013-05-29.

[9] J. Allen, "Social motivation in youth sport," *Journal of Sport and Exercise Psychology*, vol. 25, no. 4, pp. 551–567, 2003.

[10] A. L. Smith, "Peer relationships in physical activity contexts: A road less traveled in youth sport and exercise psychology research," *Psychology of sport and Exercise*, vol. 4, no. 1, pp. 25–39, 2003.

[11] J. Brooke, "Sus-a quick and dirty usability scale," *Usability evaluation in industry*, vol. 189, p. 194, 1996.

[12] F. Buttussi, L. Chittaro, and D. Nadalutti, "Bringing mobile guides and fitness activities together: a solution based on an embodied virtual trainer," in *Proceedings of the 8th conference on Human-computer interaction with mobile devices and services*. ACM, 2006, pp. 29–36.

[13] F. Mulas, P. Pilloni, and S. Carta, "Everywhere race!: A social mobile platform for sport engagement and motivation," in *SOTICS 2012, The Second International Conference on Social Eco-Informatics*, 2012, pp. 63–69.

[14] Facebook, "Facebook," http://www.facebook.com, accessed: 2013-05-29.

[15] L. Chittaro and R. Sioni, "Turning the classic snake mobile game into a location–based exergame that encourages walking," in *Persuasive Technology. Design for Health and Safety*. Springer, 2012, pp. 43–54.

[16] S. Consolvo, D. W. McDonald, T. Toscos, M. Y. Chen, J. Froehlich, B. Harrison, P. Klasnja, A. LaMarca, L. LeGrand, R. Libby *et al.*, "Activity sensing in the wild: a field trial of ubifit garden," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2008, pp. 1797–1806.

[17] J. Hoysniemi, "International survey on the dance dance revolution game," *Computers in Entertainment (CIE)*, vol. 4, no. 2, p. 8, 2006.

[18] W. IJsselsteijn, Y. de Kort, J. Westerink, M. de Jager, and R. Bonants, "Fun and sports: Enhancing the home fitness experience," in *Entertainment Computing–ICEC 2004*. Springer, 2004, pp. 46–56.

[19] "Your shape fitness evolved," your-shape-fitness-evolved.ubi.com/2012, accessed: 2013-05-29.

[20] T. Toscos, A. Faber, S. An, and M. P. Gandhi, "Chick clique: persuasive technology to motivate teenage girls to exercise," in *CHI'06 extended abstracts on Human factors in computing systems*. ACM, 2006, pp. 1873–1878.

[21] S. Consolvo, K. Everitt, I. Smith, and J. A. Landay, "Design requirements for technologies that encourage physical activity," in *Proceedings of the SIGCHI conference on Human Factors in computing systems*. ACM, 2006, pp. 457–466.

[22] R. de Oliveira and N. Oliver, "Triplebeat: enhancing exercise performance with persuasion," in *Proceedings of the 10th international conference on Human computer interaction with mobile devices and services*. ACM, 2008, pp. 255–264.

[23] Nike, "Nike+ gps," nikerunning.nike.com, accessed: 2013-05-29.

[24] F. Mulas, S. Carta, P. Pilloni, and L. Boratto, "Everywhere run!: a virtual personal trainer for supporting people in their running activity," *International Journal of Advanced Computer Science*, vol. 3, no. 2, 2013.

[25] "Runtastic," www.runtastic.com, accessed: 2013-05-29.

[26] "Endomondo," www.endomondo.com, accessed: 2013-05-29.

[27] "Runkeeper," runkeeper.com, accessed: 2013-05-29.

[28] "Mapmyfitness," www.mapmyfitness.com, accessed: 2013-05-29.

[29] "micoach," www.adidas.com/fi/micoach, accessed: 2013-05-29.

[30] Wikipedia, "Student's t-test," https://en.wikipedia.org/wiki/Student's_t-test, accessed: 2013-05-29.

[31] "Everywhere race!" www.everywhererace.com, accessed: 2013-05-29.

[32] "Everywhere run!" www.everywhererun.com, accessed: 2013-05-29.

[33] J. Sauro and J. R. Lewis, *Quantifying the user experience: Practical statistics for user research*. Morgan Kaufmann, 2012.

[34] Wikipedia, "Normal distribution," https://en.wikipedia.org/wiki/Normal_distribution, accessed: 2013-05-29.

[35] J. Sauro, "Measuring usability with the system usability scale (sus)," www.measuringusability.com/sus.php, accessed: 2013-05-29.

[36] Wikipedia, "P-value," http://en.wikipedia.org/wiki/P-value, accessed: 2013-05-29.

[37] "Evwrywhere run!'s sus questionnaire," bit.ly/ewrunsus, accessed: 2013-05-29.

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Dynamics of Roles in the Context of Groups Evolution

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***Abstract*—The paper addresses the analysis of a social system with identified groups and roles assigned to users. The important elements of this representation of a society and its dynamics are, on one hand, the identification of various important users in the whole network or in given groups, and, on the other hand, the events describing how the groups evolved. In this paper, we propose an approach integrating both these areas that would allow us to draw conclusions regarding the influence of important persons on the groups evolution and may make it possible to predict the future of the group on the basis of its current structure.**

***Keywords*—roles dynamics; blogosphere; local roles.**

I. INTRODUCTION

Taking into account a dynamic growth of different forms of social media, where users often express their opinions, it is important to understand the behaviour of users participating in them, identify their importance and predict directions of evolution. For such research, the application of methods of social network analysis became very popular. Considering the size and dynamics of changes, such a network may be perceived as a set of groups, within which users are more strongly connected than with others outside the group. Examples of such connections are discussions on forums or in blogosphere. The variety of subjects results in users belonging to many groups and participating in them with different levels of commitment, playing different roles in them.

Taking into consideration high dynamics of changes, an important question is, why some groups last for a long time and why others are more fugitive. It seems that the kinds of activities of the users within groups may have an influence on the duration of the groups. In this paper, we extend our algorithm for the analysis of the evolution of groups in blogosphere [1], [2] by including role identification in groups [3] and analysis of their evolution.

The organisation of the rest of the paper is as follows. In Section 2, the related works about group extraction and dynamics as well as identified roles of users are presented. Section 3 shows the model of the group dynamics, role identification and introduced R-SGCI method. In Section 4, the data set and performed experiments are described. Section 5 concludes the paper.

II. RELATED WORK

A. Groups extraction

One of the important problems in the analysis of social networks is the identification of the groups constituted by strongly connected nodes in the graph. Many algorithms were proposed so far and it is possible to organise them using different classification rules. One classification detects either non–overlapping or overlapping groups. The significant example of the algorithm which extracts ovelapping groups is the Clique Percolation Method (CPM), based on the identification of k-cliques [4]. The CPM algorithm is also used in the works presented in this paper. Other examples of overlapping approaches are solutions proposed by Shen et al. [5] and Gregory [6]. Examples of solutions working on non–ovelaping communities are algorithms proposed by Girvan and Newman [7] or Blondel et al. [8]. The wider overview of the group identification methods may be found in [9] [10].

B. Dynamics of groups

A typical way of analysing dynamic network is to divide the whole network into a series of static snapshots (called time slots or time steps). Greene et al. [11] presented a general strategy of analysis of dynamics of groups. Firstly, in each time slot the groups are extracted, and then groups from neighbouring slots are matched – it is performed by calculating Jaccard index between these groups and if the value of such a measure is above a predefined threshold, it means that the groups are matched. We [1] proposed Stable Group Changes Identification (SGCI) algorithm, which contains some improvements over earlier mentioned approaches. Instead of Jaccard index, we defined a new measure which has better properties in terms of matching groups with different sizees (Jaccard index is not well-suited for matching groups with significantly different sizes, because in such case the threshold should be very low and, at the same time, very low threshold applied to groups with very similar size could result in those groups being very big and the number of common members is very low, which is not the desired effect).

Another approach to analyse the dynamics of groups is presented in [12] and it is based on the use of CPM algorithm for group extraction. The first step is also finding communities in each time slot, but the process of matching groups from neighbouring time slots is quite different. For each consecutive time steps t and $t+1$, the joint graph is built (the union of graphs from these 2 time steps). Next, in such joint graphs the groups are extracted and if a group from t time slot and a group from $t+1$ time slot are contained inside the same group in the joint graph, it is assumed that these groups are matched.

Another important aspect is the identification of events that can occur in the group lifecycle. The set of events varies in different methods. Palla et al. [12] identified some basic events that can happen to a group: growth, contraction, merging, splitting, birth and death. Takaffoli et al. [13] used only 5 events: form, dissolve, survive, split and merge, but they additionally labelled transitions between groups as: size

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transition (group shrinks or group expands), compactness transition (group becomes more compact or more diffused), persistence transition (number of nodes and edges in group does not change), leader transition (when the node with the highest centrality in group does change).

C. Roles

One of the most popular definition of roles is that given by Wasserman in [14], where a role is identified as a position that has a distinct pattern of relations to other positions. Gleave in [15] distinguished two main methodological approaches to finding roles: interpretative and structural. Interpretative analyses employs methods such as etnography, content analysis, and surveys to capture behaviors and relations within groups. Structural analysis uses Social Network Analysis (SNA) and assumes that role entails a specific structural position. The most general approach to finding roles consists of two main stages [16]: understanding the community in order to identify potential roles, and then the creation of a role with observed characteristics and rules that will allow the classification of individuals into the pre-defined roles. One can distinguish several approaches for identifying social roles. The oldest one is based on equivalence classes [14], where the most appropriate is regular equivalence. Another approach is based on the identification of the core and periphery structure [17] where role is assigned based on membership of a particular area. In approach based on clustering feature vectors, each person is represented by a vector of some of the features that represents its behavior and relationships with the other members of the community and such vector can be clustered [16], so that people with similar characteristics are placed in one group.

III. MODEL

A. Dynamics of groups

A common approach to analyse dynamic networks is to divide the whole range of time into smaller periods (called *time slots* or *time steps*) and, then, in each time slot the static network is analysed.

For experiments we employed SGCI method [1] to analyse the dynamics of groups. The method is composed of four stages: identification of short-lived groups in each separated time interval, identification of group continuation, separation of the stable groups (lasting for a certain time interval) and the identification of types of group changes (transition between the states of the stable group).

Step 1. In each time slot the groups are extracted (such groups are called fugitive groups). Any method of group finding can be used for that purpose (in this paper we utilized the CPM method).

Step 2. In this step, the algorithm identifies transition between groups observed at time *t* and the groups observed at time *t+1* (their successors). Identification is performed by calculating the Modified Jaccard Measure (A and B are examined groups from neighbouring time slots):

$$MJ(A,B) = \begin{cases} 0, & \text{if } A = \emptyset \vee B = \emptyset, \\ max(\frac{|A \cap B|}{|A|}, \frac{|A \cap B|}{|B|}), & \text{otherwise.} \end{cases} \quad (1)$$

and if the calculated value is above a defined threshold (in experiments we assumed the value equals 0.5) and the ratio of groups size

$$ds(A,B) = max(\frac{|A|}{|B|}, \frac{|B|}{|A|}) \quad (2)$$

is no more than a specified value (in tests we used value equals 50), then group B is considered as continuation of the group A.

Step 3. In this step, the algorithm retrieves the stable groups. The stable groups are groups that exist in the required number of consecutive time slots – the groups which are not stable are rejected. In experiments such a number was equal to 3.

Step 4. Transitions between groups from neighbouring time steps are labelled by event names that describe a type of occuring change between groups. In the algorithm the following events are defined (A is the source group and B is the target group in analysed transition; sh and dh are defined thresholds which were set in experiments to values 10 and 0.05 respectively):

- **split** takes place when a group divides into some groups that do not differ considerably (in terms of group size) from the predecessor group:

$$\frac{|A|}{|B|} < sh, \quad (3)$$

- **deletion** occurs when a group disintegrates into some successor groups and in analysed transition successor group is much smaller than the predecessor group

$$\frac{|A|}{|B|} \geq sh, \quad (4)$$

- **merge** happens when many predecessor groups form a successor group in the next time slot and the former groups have size that do not differ significantly from the size of the successor group

$$\frac{|B|}{|A|} < sh, \quad (5)$$

- **addition** occurs when several groups from the previous time slot create a group in the next time slot and in analysed transition the origin group is significantly smaller than the successor group

$$\frac{|B|}{|A|} \geq sh, \quad (6)$$

- **decay** takes place when groups do not exist in the next time slot,
- **constancy** means simple transition with very small change of the group size

$$\frac{abs(|A| - |B|)}{|A|} \leq dh, \quad (7)$$

- **change_size** – simple transition with significant change of group size.

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B. Roles in groups

Users can play different roles on a global level and different ones in each of the group they belong to. In this paper we focus on roles defined on a local level – the level of group. The set of roles we use for analysis in this paper, was proposed by us in [3] and the roles were described there in detail.

We differentiated two kinds of influential people: (i) selfish ones who focus on building only their own position – they comment mostly in their own threads (ii) social ones who also take part in discussions started by other bloggers and comment on their posts.

The roles presented take into account responses from other users on the content the user writes (both in the form of posts and comments). To meet this assumption, we defined *Post* and *Comment Influence* .

Post Influence for author a has the following form (in this definition we use the notation $c(X, cond)$ that means the number of elements in X that every element of X fulfills condition $cond$):

$$PostInf_a = 4 \cdot c(p_a, pr \geq A_p) + 2 \cdot c(p_a, pr \geq A_p/2) + c(p_a, pr \geq A_p/4) - 2 \cdot c(p_a, pr < 1) \quad (8)$$

where p_a – posts of author a; pr – number of comments for a given post excluding the author's comments in his own thread; $A_p = 10 \cdot groupDensity \cdot groupSize$

Comment Influence for author a is calculated in the following way (in this definition we use the notation $w(cond)$ that returns 1 when the condition $cond$ is satisfied, otherwise – 0):

$$ComInf_a = 4 \cdot w(r_a \geq 1.25) + 2 \cdot w(r_a \geq 1) + w(r_a \geq 0.75) - w(cr_a < D_c) - 2w(cr_a < D_c/2) - 4 \cdot w(cr_a < D_c/4) \quad (9)$$

where r is the the number of received comments from other users divided by the number of written comments by given authors;cr is a number of reiceved comments from other users; $D_c = groupSize \cdot groupDensity$.

To define roles we need also another measure $ComEgo$ which is a ratio between comments written in own threads and all comments written by a given user.

Using the above definitions we can describe the set of roles:

1) *Influential User* (*infUser*): $PostInf > 2$ and $ComInf > 0$
   a) *Selfish Influential User*: $ComEgo \geq 0.75$
   b) *Social Influential User*: $ComEgo < 0.75$
2) *Influential Blogger* (*infBlog*): $PostInf > 2$ and $ComInf \leq 0$
   a) *Selfish Influential Blogger*: $ComEgo \geq 0.75$
   b) *Social Influential Blogger*: $ComEgo < 0.75$
3) *Influential Commentator* (*infComm*): $ComInf > 0$ and $PostInf \leq 2$
4) *Standard Commentator* (*comm*): $c(comments) \geq 20$ and $c(posts) \leq 2$
5) *Not Active* (*notActive*): $c(posts) < 1$ and $c(comments) < 2$
6) *Standard Blogger* (*stdBlog*): User that does not match to any from above roles.

The above parameters were adjusted by us by testing with different values of them, comparing obtained results and finally verifying them using knowledge about bloggers.

C. Method of group dynamics analysis based on local roles

We introduced R-SGCI – modified version of SGCI algorithm that takes into account roles played by users in groups. It has additional condition enforcing passing influential roles between groups if they are present in the predecessor group:

$$RM(A, B) = \begin{cases} \frac{|R(A,Inf) \cap |A \cap B||}{R(A,Inf)}, & \text{if } R(A, Inf) > 0, \\ 1, & \text{otherwise.} \end{cases} \quad (10)$$

where $R(A, Inf)$ is a number of users in group A with influential roles. In experiments, we rejected transitions between groups when the value of RM was equal to 0 - it means that if the predecessor group has any users with influential roles then at least one of them should be present in the successor group.

IV. Description of experiments

A. Data set

The examined data set contains data collected from the portal *salon24.pl*, where discussions mostly concern political topics. The data set consists of 26 722 users (11 084 of them have their own blog), 285 532 posts and 4 173 457 comments within the period 1.01.2008 - 31.03.2012. The experiments described were carried out on half of this dataset - from 4.04.2010 to 31.03.2012. The whole period was divided into time slots, each lasting 7 days and neighboring slots overlap each other by 4 days. In the analysed period there are 182 time slots. In every slot the comments model was used, introduced by us in [18] - the users are nodes and relations between them are built in the following way: from user who wrote the comment to the user who was commented on or if the user whose comment was commented on is not explicitly referenced in the comment (by using @ and name of author of comment) the target of the relation is the author of post.

B. Groups and evolution events

In each time slot, the groups were extracted by CPM method – CPMd version from CFinder tool [19], for *k* equals 5. For group evolution we used the SGCI method (described in section III-A).

Fig. 1 shows the summary of groups with different sizes. As we can see, the most numerous part of all groups are the groups with the size equal to 5.

Fig. 2 presents the number of evolution events in the analysed data set. The most popular ones are additions and deletions, which occur when small groups attach to or detach from, respectively, a much larger group. As we could observe in Fig. 1, the smallest groups are the most numerous and due to their small size it is quite easy to find them matching with larger groups, so this could explain the huge number of these events.

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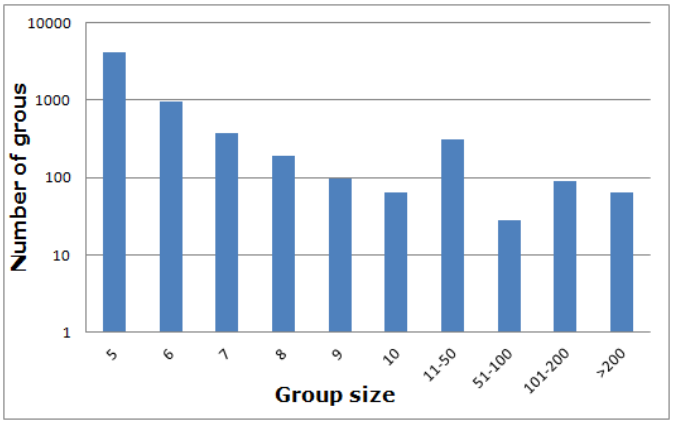

Fig. 1. Summary of sizes of stable groups.

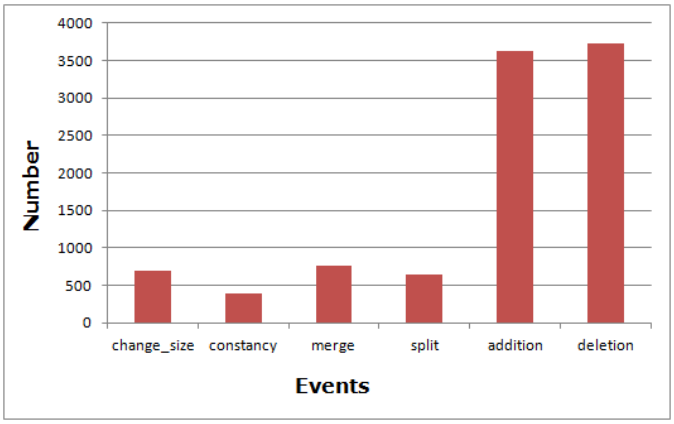

Fig. 2. Summary of events in analysed time slots.

C. Local roles

Table I shows how big a part of all users having a given role in group is present in a group in the consecutive time slot. The difference is most visible in the value of median for roles. During transitions in group evolution the people with the most important roles (Influential Bloggers and Influential Users) almost in every case are also active in the successor group.

TABLE I. FRACTION OF USERS WITH GIVEN ROLE IN GROUP A THAT SUCH USERS PASS TO GROUP IN THE NEXT TIME SLOT.

role	mean	stdDev	median
infComm	0.648	0.395	0.778
comm	0.742	0.302	0.8
stdBlog	0.789	0.256	0.857
infBlogSel	0.85	0.336	1
infBlogSoc	0.885	0.305	1
infUserSel	0.832	0.34	1
infUserSoc	0.936	0.321	1

D. Local roles in transitions between groups

Fig. 3 shows the number and proportion of roles that users have (summed roles in all transitions) when they pass to any group in the next time slot. One can notice that Commentators and Standard Bloggers outnumber other roles. Influential roles constitute less than 10% of all roles.

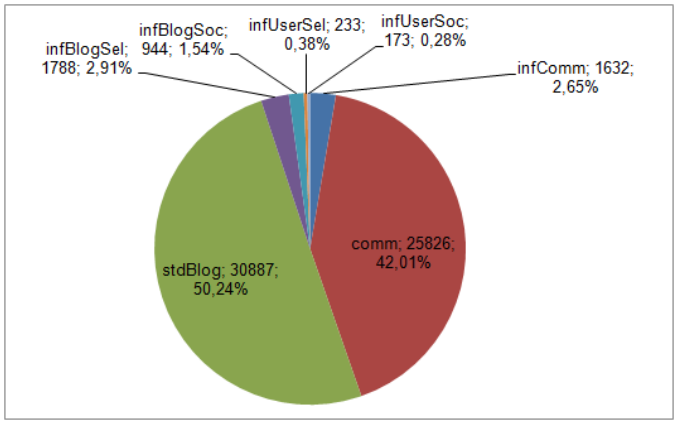

Fig. 3. Local roles passing between groups.

Fig. 4 shows that different roles have different stability i.e. proportion of all cases that a user with a given role in a group will have the same role in a group in the consecutive time slot. The most stable roles are Commentator and Standard Blogger – they rarely become important users. Selfish roles have higher stability than social ones – selfish users only maintain their own threads. Moreover, Influential Blogger Selfish has higher stability than Influential User Selfish and Influential Blogger Social than Influential User Social. We can explain this situation that it takes more effort to play Influential User role than Influential Blogger (apart from writing influential posts, Influential Users have to also write influential comments), so it is harder to hold their roles.

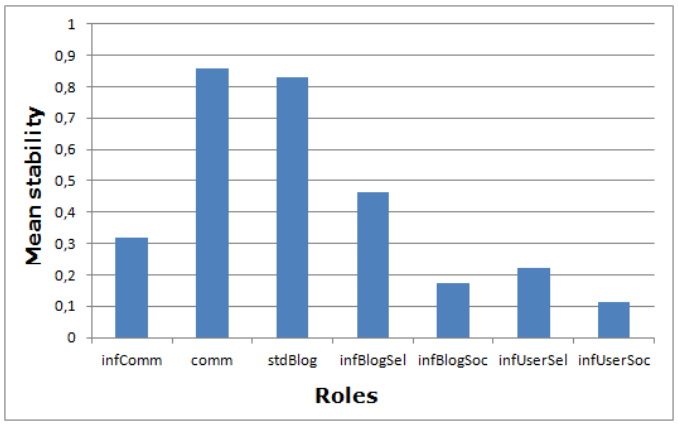

Fig. 4. Stability of roles passing between groups.

Table II describes the transitions between roles i.e. number of occurences that a user with the first role (rows in the table) in a group was present in a group in the consecutive time slot and in that group the user has the second role (columns in the table). We can notice that Commentators and Standard bloggers mostly, after passing to another group, have the same role. Influential Commentators in the majority of cases also pass with the same role, but also quite large part has roles of Commentator or Standard Blogger (which have weaker conditions). Influential Blogger Selfish moves with the same role and also significant part of users with that role

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became Standard Bloggers in groups in the next time slot. Influential Blogger Social passes mostly to Standard Blogger role, but also a large part of them to Influential Blogger Social and Commentators. Influential User Selfish often becomes Standard Blogger, Influential Blogger Selfish or Influential User Selfish. Influential User Social proceeds to role Standard Blogger, and, less, to roles Influential Blogger Social and Influential User Social. In these transitions some more general observations can be formulated:

- most roles, except Commentators and Influential Commentators, pass in most cases to Standard Blogger
- social users, to a large degree, also transfer to social users and selfish users to selfish users
- Influential Users (Selfish and Social) proceed, in almost the same way, to Influential Bloggers and Influential Users, but Influential Bloggers – only to Influential Bloggers.

E. Stability of local roles in evolution events

During experiments it seemed that the overall role stability for different events was very high and does not differ significantly. We looked into detail and it was caused by the fact that the most numerous roles are Commentator and Standard Blogger and they have very high stability for all events, as can be seen in Table III.

Table III presents how many times a user with a given role has the same role in any group in the next time slot for different evolution events and shows how often such a case took places in relation to all transitions of a given role in given event. We can observe that in each event the roles Commentator and Standard Blogger dominate over other ones (in terms of keeping their position). Influential Users frequently hold their role for simple transitions between groups – change size and constancy. Influential Bloggers often play the same role when the transition is one of following types: change size, constancy, merge and split.

F. Method of analysis of group dynamics with local roles

In this section we discuss results obtained with R-SGCI method. In Fig. 5, we can observe that the number of groups differs slightly between the original method (SGCI) and the modified one (R-SGCI). Differences are only in the number of small groups.

Fig. 6 presents the number of events that are obtained using both methods. The biggest difference is in the number of deletion events. It means that if a large group contains influential people and small group detaches from it (deletion event), then in most cases (around 2/3 of cases) the smaller group does not contain influential people.

In Table IV, there is a comparison of density and stability measure for groups acquired by both methods. Decreasing number of events (especially deletion event) and reducing number of small events explains increasing stability (weak events, such as deletion event, lower stability) and decreasing density (small groups are usually significantly more densier than larger ones).

Fig. 5. Comparison of quantity of groups between methods.

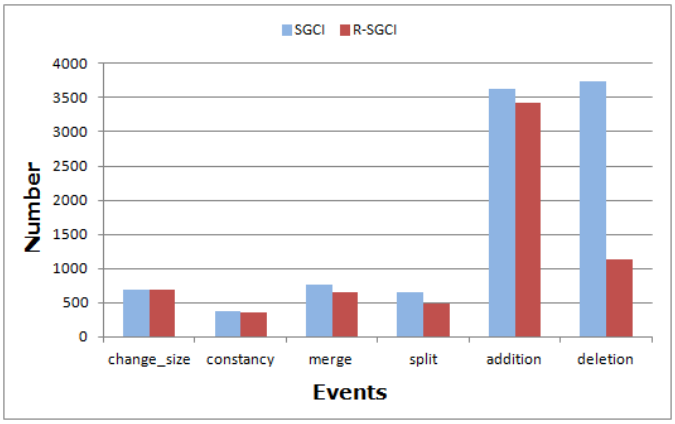

Fig. 6. Comparison of events between methods.

V. CONCLUSION

In the paper, the model of the social system with stable groups and roles is presented and a set of experiments was performed. The obtained results allow us to better understand behaviour of groups. The majority of the identified roles are less significant roles and we assume that only important roles (influential users, influential bloggers or influential commentators) have influence on group evolution. Generally, types of important roles (social, selfish) are preserved and passed to new groups in the next time period. One can also notice that a presence of influential roles significantly increases chances of groups lasting.

Future works may follow in several directions. The first is to analyse how the leaving of significant roles from groups influences the leaving of other group members. The second is an attempt to improve prediction methods taking into consideration important roles belonging to the group. We also plan to conduct experiments on other datasets.

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REFERENCES

[1] B. Gliwa, S. Saganowski, A. Zygmunt, P. Bródka, P. Kazienko, and J. Kozlak, "Identification of group changes in blogosphere," in *ASONAM 2012: IEEE/ACM International Conference on Advances in Social*

TABLE II. NUMBER OF TRANSITION BETWEEN ROLES: SOURCE ROLES ARE IN ROWS, TARGET ROLES – IN COLUMNS.

	infComm	comm	stdBlog	infBlogSel	infBlogSoc	infUserSel	infUserSoc
infComm	654	451	450	14	16	30	16
comm	407	22032	3100	106	157	9	15
stdBlog	483	3135	25772	751	559	104	80
infBlogSel	26	125	742	810	42	36	6
infBlogSoc	20	192	486	46	176	3	21
infUserSel	25	6	73	62	3	58	6
infUserSoc	15	18	75	13	21	11	20

TABLE III. FRACTION OF ALL CASES AND NUMBER OF OCCURENCES (AFTER SLASH) THAT USER WITH GIVEN ROLE HAS THE SAME ROLE IN THE CONSECUTIVE TIME SLOT FOR DIFFERENT EVOLUTION EVENTS.

	change size	constancy	merge	split	addition	deletion
infComm	0.491 / 340	0.554 / 104	0.505 / 74	0.339 / 89	0.514 / 21	0.061 / 26
comm	0.822 / 5862	0.852 / 2077	0.833 / 1806	0.859 / 1933	0.866 / 5087	0.859 / 5267
stdBlog	0.789 / 5559	0.813 / 2011	0.756 / 1489	0.83 / 1698	0.794 / 7392	0.893/7623
infBlogSel	0.607 / 201	0.612 / 67	0.722 / 179	0.613 / 161	0.368 / 101	0.211/101
infBlogSoc	0.3 / 56	0.36 / 18	0.375 / 35	0.245 / 34	0.103 / 14	0.056 / 19
infUserSel	0.392 / 30	0.517 / 15	0.222 / 2	0.152 / 4	0.375 / 3	0.046 / 4
infUserSoc	0.25 / 11	0.4 / 4	0 / 0	0.119 / 3	0.5 / 1	0.012 / 1

TABLE IV. COMPARISON OF MEASURES FOR GROUPS BETWEEN METHODS.

measure	SGCI [mean/stdDev]	R-SGCI [mean/stdDev]
stability	0.124/0.206	0.154/0.227
density	0.694/0.169	0.689/0.175

Networks Analysis and Mining: Istanbul, Turkey, ser. IEEE Computer Society, 2012, pp. 1233–1238.

[2] B. Gliwa, P. Bródka, A. Zygmunt, S. Saganowski, P. Kazienko, and J. Kozlak, "Different approaches to community evolution prediction in blogosphere," in *ASONAM 2013: IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining: Niagara Falls, Turkey*, 2013.

[3] B. Gliwa, A. Zygmunt, and J. Kozlak, "Analysis of roles and groups in blogosphere," in *CORES - 8th International Conference on Computer Recognition Systems*, ser. Advances in Intelligent and Soft Computing, vol. 226. Springer, 2013, pp. 299–308.

[4] G. Palla, I. Derenyi, I. Farkas, and T. Vicsek, "Uncovering the overlapping community structure of complex networks in nature and society," *Nature*, vol. 435, pp. 814–818, 2005.

[5] H. Shen, X. Cheng, K. Cai, and M.-B. Hu, "Detect overlapping and hierarchical community structure in networks," *Physica A: Statistical Mechanics and its Applications*, vol. 388, no. 8, pp. 1706 – 1712, 2009.

[6] S. Gregory, "A fast algorithm to find overlapping communities in networks," in *Machine Learning and Knowledge Discovery in Databases*, ser. Lecture Notes in Computer Science, W. Daelemans, B. Goethals, and K. Morik, Eds. Springer Berlin Heidelberg, 2008, vol. 5211, pp. 408–423.

[7] M. Girvan and M. E. J. Newman, "Community structure in social and biological networks," *Proceedings of The National Academy of Sciences*, vol. 99, pp. 7821–7826, 2002.

[8] V. D. Blondel, J.-L. Guillaume, R. Lambiotte, and E. Lefebvre, "Fast unfolding of communities in large networks," *Journal of Statistical Mechanics: Theory and Experiment*, vol. 2008, no. 10, p. P10008, 2008.

[9] A. Lancichinetti and S. Fortunato, "Community detection algorithms: A comparative analysis," *Phys. Rev. E*, vol. 80, p. 056117, Nov 2009. [Online]. Available: http://link.aps.org/doi/10.1103/PhysRevE.80.056117

[10] L. Tang and H. Liu, *Community Detection and Mining in Social Media*. Morgan & Claypool Publishers, 2010.

[11] D. Greene, D. Doyle, and P. Cunningham, "Tracking the evolution of communities in dynamic social networks," in *Proc. International Conference on Advances in Social Networks Analysis and Mining (ASONAM'10)*, ser. IEEE Computer Society. IEEE, 2010, pp. 176–183.

[12] G. Palla, A. lszl Barabsi, T. Vicsek, and B. Hungary, "Quantifying social group evolution," *Nature*, vol. 446, pp. 664–667, 2007.

[13] M. Takaffoli, J. Fagnan, F. Sangi, and O. Zaiane, "Tracking changes in dynamic information networks," in *Computational Aspects of Social Networks (CASoN), 2011 International Conference on*, 2011, pp. 94–101.

[14] S. Wasserman and K. Faust, *Social Network Analysis: Methods and Applications*. Cambridge University Press, Cambridge, 1994.

[15] E. Gleave, H. Welser, T. Lento, and M. Smith, "A conceptual and operational definition of'social role'in online community," in *System Sciences, 2009. HICSS'09. 42nd Hawaii International Conference on*. IEEE, 2009, pp. 1–11.

[16] V. Junquero-Trabado and D. Dominguez-Sal, "Building a role search engine for social media," in *Proc. of the 21st Int. Conf. companion on World Wide Web*, ser. WWW '12 Companion. NY, USA: ACM, 2012, pp. 1051–1060.

[17] S. P. Borgatti and M. G. Everett, "Models of core/periphery structures," *Social Networks*, vol. 21, no. 4, pp. 375 – 395, 2000.

[18] B. Gliwa, J. Kozlak, A. Zygmunt, and K. Cetnarowicz, "Models of social groups in blogosphere based on information about comment addressees and sentiments," in *Social Informatics - 4th International Conference on Social Informatics, SocInfo, Lausanne, Switzerland*, ser. Lecture Notes in Computer Science, vol. 7710. Springer, 2012, pp. 475–488.

[19] "Cfinder tool," www.cfinder.org, retrieved: 9,2013.

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Investigations to Deploy e-Services for Cocoa Fair-trade Farmers in Africa

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***Abstract*— This paper focuses on the possibility of deploying e-service for fair trade cocoa producers in Africa in order to reach international market audiences of buyers and consumers. We have used a qualitative research methodology to gather information from 110 fair-trade farmers from Nigeria and Ghana. We found that although Africa has an important growing rate of new mobile phone subscribers, e-service could still be difficult to be deployed for fair-trade farmers in Nigeria and Ghana without proxies who would help them to be connected.**

Keywords-Information Technology; Poverty Alleviation; Connection; Mobile Phones; E-service

I. INTRODUCTION

In 1998, only very few people in Sub-Saharan Africa had access to computers and telephones [1]. However, mobile phone users in Africa have experienced a fundamental growth. This growth is concentrated in the urban cities. There has also been a phenomenal growth in the number of computer users. From 2007-2011, it is assumed that a quarter of people in the developing countries were online [2]. There is still some increase in mobile phones usage in Africa [3]. In Africa, mobile phone users use a lot their phone for financial reasons in addition to simply making phone calls [7]. What is still lacking in Africa is broadband access capable of handling much higher volumes of traffic than what is generated by voice services. This type of network infrastructure is traditionally underdeveloped in Africa. The lack of suitable infrastructure has become a significant problem. In Africa, it is not uncommon to see a huge amount of people live mostly in the rural areas and these people living outside the urban towns and cites have not made telephone calls and do not have access to telephony [6]. Recent development concerns undersea fiber optics cable connecting Africa to the world communication networks [4]. Still, one may wonder if cocoa producers mostly dominated by small-scale farmers benefit from this increased access. More precisely, we have studied if fair-trade farmers from Nigeria and Ghana can easily have access to e-services. Do they also experience the digital divide, which underlines disparities in the aggregate ownership of personal computers, access to broadband, telephone usage across demographic settlements intra and inter countries [5].

The following Figure 1 depicts the level of connection and access penetration in Africa compared to the rest of the world, according to [9].

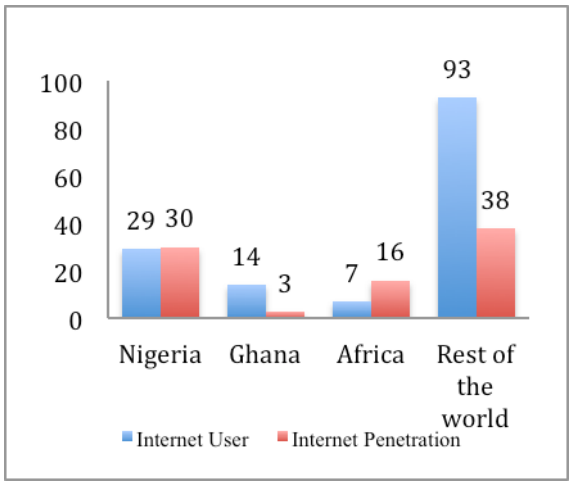

Figure 1. Acces Penetration and Users in Africa [9]

From our perspective, connection in Sub-Saharan Africa is a paradigm shift in urban areas in that, it is not only a medium for dissemination and transmission of information, it is also a social arena for people to exchange ideas (Social Media), a market place, and above all a catalyst in integrating Sub-Sahara Africa to the global exchange system.

This paper investigates the possibility of deploying e-services to the rural fair trade farmers in Nigeria and Ghana. In Section 2, we present our research methodology, which explains how data was collected and analyzed as well as methods used. Section 3 discusses the challenges to e-service in rural cocoa farming Communities in Africa. In Section 4, we conclude and mention our future work.

II. RESEARCH METHODOLOGY

We first present the study area in Nigerian and then the study area in Ghana.

A. Nigeria Study Area

The study was carried out in Oshogbo, South Western part of Nigeria. This geographic zone was selected due to the high density of cocoa producers in this region. The proximity of this region to Lagos, which is the commercial hub of Nigeria, was another reason for the choice.

The Nigeria cocoa board was dissolved in 1986 and replaced with cocoa association of Nigeria and that was the beginning of complete deregulation in Nigeria. Respondents from seven villages around the Oshogbo were picked. A total of 37 cocoa producers were sampled randomly from seven

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villages. They were interviewed using structured questionnaires and they were mainly rural farmers, mainly small scale or family oriented small farmers.

Our concerned was to know if these farmers had access to the Web. We asked if they had mobile phones connected to the Web, if they were connected to any social media or if they had a Web site or Web page for their farm.

We wanted to know if these farmers could easily have access to e-services designed for them.

In urban areas in Nigeria, access to the Web, though it is still very slow, has permeated the society compared to the rural areas where 80% of cocoa farmers live. Nigeria cocoa export has experienced a tremendous growth over the years, ranging from a mere £215.2m in 2006 to a whopping $900.2m in 2012 [8].

Figure 2 below shows that most cocoa producers in Nigeria are still very much backward in having access to mobile phones and none of them had Internet access or a Web site or page.

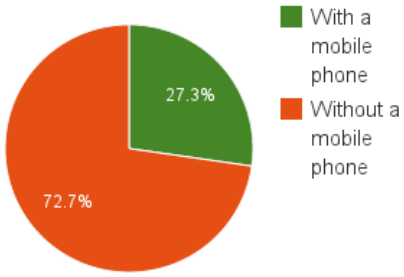

Figure 2. Farmers with and without a mobile phone subscription
Source: from our own fieldwork

B. *Ghana Study Area*

Unlike in Nigeria, Ghana main export is cocoa and Ghana's cocoa business is still very much partially deregulated. Ghana cocoa board, in short (COCOBOD), is still very much on the limelight in cocoa business in Ghana.

This study was conducted in the southern part of Ghana, to be precise in Kumasi rural areas of Obogu1 and Obogu2, Perminase - Bomfa and Odubi. A total of 75 respondents were selected based on densities of people in this locality, as cocoa farmers, and as certified cocoa farmers to two labels.

One important reason for the choice of this study is the fact that Kumasi is the highest region where cocoa is produced in Ghana with about 56% of cocoa produced.

A total of 75 respondents were interviewed using structured questionnaires and the application of focus group. The respondents were mainly from the rural areas randomly selected from five villages mainly fair-trade farmers and UTZ [13] certified farmers. Fair-trade is by definition a labeling organization established to help farmers from the South adequate access to fair market, by meeting production standards to strengthen their economic positions, product sustainability, and to alleviate them from poverty. UTZ Kapeh means "Good Coffee" in Mayan language in Mexico. UTZ certified famers are farmers certified by UTZ organization as standard for cocoa, coffee and tea production with responsible and sustainable production practices that would ultimately lead to poverty alleviation, quality and responsible production process.

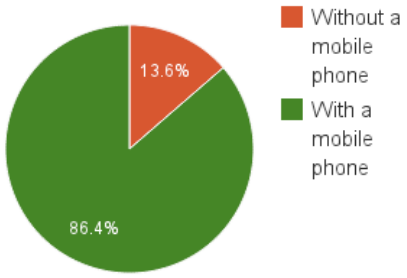

Figure 3. Farmers with and without a mobile phone subscription
Source: from our own fieldwork

Figure 3 above shows that a higher number of farmers in Ghana have mobile phone subscriptions compared to Nigeria but none of them have Internet access or a Web site for their farm. 99.9% of them had no clue about what is a Web site by the way.

III. CHALLENGES TO DEPLOY E-SERVICE IN RURAL COCOA FARMING COMMUNITIES IN AFRICA

Africa has only 7.0% presence online and 15.6% penetration on average [9]. Thus, it is not shocking to find in the previous sections that online access has not taken deep root in Africa, with the exception of South Africa. However, there are more challenges faced by most African countries that still put them away from realizing robust information technology sector.

According to International Telecommunication Union (ITU), "the estimates that the world broadband prices is $77 while the African average is $206 per 100 kilobit per month and also the limited fixed lines in sub-Sahara Africa are problematic as well, increased coverage and lower cost depend largely on the spread of wireless technologies" [10].

The cost of connection in Nigeria is much higher compared to cost of connection in Europe. In Nigeria for instance, mobile phones cost around $35 per month for 250 MB download, which is by all manner of definition expensive for the African middle class left alone the poor rural cocoa farmers.

In Ghana, there are six licensed mobile and Internet service providers. Amongst is MTN, as the dominant in telecommunication and in Nigeria as well. Apart from the

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expensive price paid per minute coupled with mere 250MB upload, the farmers are too poor to shoulder the high cost of connection in Ghana. The poor infrastructure is also another bane. There are areas where people have very weak signal. That has reduced the impact of mobile telephony for those with mobiles in the rural areas, let alone connection where fixed lines are in very drastic short supply.

The lack of fibers optics connection in Africa is another challenge. Most of the connections are on KU-Band and transmission is weak and often interrupted when it rains. Though under sea water fibers optics is currently under construction in Africa that would connect Africa, Europe and Asia, not until the project is completed Africa would still remain the most under connected in the world, with a mere 7% online users.

The poverty level in Sub-Saharan Africa is another problem exacerbating the challenges of connection and the attendant back clash it has on the farmer's participation on social media. A continent, where 70% of its people still live on less than a dollar a day, is still very much not ready to pay the high price for connection [12]. This would continue to put the poor cocoa farmers on the defensive and make them susceptible to exploitation. The implementation of fair-trade traceability through e-services would help both the producer and the consumer facilitate quality, safe and traceable products [11].

IV. Conclusion and Future Work

In the course of this research, we found out that not enough farmers have Internet connections and, even phones. Thus, although Africa has an important growing rate of new mobile phones subscribers, e-services could still be difficult to be deployed for fair-trade farmers in Nigeria and Ghana without proxies who would help them to be connected. This initial study has showed that in order to deploy e-services in those countries, human proxies, meaning people who would be paid an Internet connection to be shared with the farmers, who need access for the e-service, would be mandatory.

Our future work would look at the possibility of a proxy pilot project in Nigeria and Ghana, towards connecting fair-trade farmers to the Internet.

Acknowledgment

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References

[1] W. Marks. K. Kaoru and O. D. Wambogo, "ICT in Sub-Saharan Africa: Success Stories", World Bank, pp. 339 – 342, 2010.

[2] ITU, "World Telecommunication/ICT Indicators Database", 2011.

[3] ITU, "World Telecommunication Indicators Database", 2008.

[4] A. Manka and C.-P. Punam, "Success Stories from a Dynamic Continent", USA, 2010.

[5] S. Sonaike, "The Internet and the Dilemma of Africa Development," *Gazette*, vol. 1, pp. 41 – 61, 2004.

[6] UNDP, "Human Development Report 2001: Making New Technologies Work for Human Development", 2001.

[7] Africa Partnership Forum, "ICT in Africa: Boosting Economic Growth and Poverty Reduction", *Proceeding of the 10th meeting of the Africa Partnership Forum Tokyo Japan*. Tokyo, Japan, 2008.

[8] Daily Independent, "Nigeria realized $900m from export of cocoa, cocoa products in 2012", http://www.dailyindependentnig.com/2013/03/nigeria-realised-900m-from-export-of-cocoa-cocoa-products-in-2012-aganga/ [Accessed: 01-09-2013].

[9] I. W. Stats, "Internet Usage Statistics for Africa," 2013. [Online]. Available: www.http://www.internetworldstats.com/stats1.htm. [Accessed: 01-09-2013].

[10] ITU, "ITU, Telecommunications/ICT markets and trends in Africa 2007," 2007. [Online]. Available: http://www.itu.int/ITU-D/ict/statistics/material/af_report07.pdf Accessed [Accessed: 01-09-2013].

[11] U. O. Linus, "Traceability in Agriculture and food supply chain: A review of basic concepts, technological implications, and future prospects", *Journal: Food, Agriculture and Environment*, Vol. 1, Issue 1, pp. 101 – 106, 2003.

[12] G. Rossi and M. San, "IT Emerging Markets", *IT Professional*, vol. 14, no. 4, pp. 2 – 3, 2012.

[13] UTZ, https://www.utzcertified.org/ [Accessed: 01-09-2013].

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A Survey of Trust and Risk Metrics for a BYOD Mobile Worker World

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***Abstract*—Users increasingly access corporate data from their own devices and public wireless networks such airports Wi-Fi or coworking offices. On one hand, more work is possible, but on the other hand, it is riskier because the devices and locations may be untrustworthy. However, the Bring-Your-Own-Device trend is a fact and it is the reason we survey in this paper how computational trust and risk metrics may help mitigating those new risks in a more dynamic way than in the past. An online survey that we have carried out confirms that users do not take care of security risks as they are communicated today and that new Human Computer Interfaces combined with opportunity-enabled risk management are needed to improve the situation.**

Keywords-trust; risk; Bring-Your-Own-Device

I. INTRODUCTION

Corporate users increasingly use computing environments in many other places than the corporate offices, accessing corporate information from homes, airports, conferences, etc. They are mobile workers who need to access remote corporate assets often from their own devices as part of the Bring-Your-Own-Device (BYOD) trend. Moreover, there are more and more projects where different companies and contractors have to collaboratively work together. Thus, the trustworthiness in both employees and external collaborators, who have no direct employment contract with the company of the Chief Security Officer (CSO), has to be taken into account in a more dynamic way. The computing environments are not fully controlled by the corporate IT administrators and new metrics to dynamically assess the trustworthiness of computing environments are needed.

It is the reason that we survey in this paper how computational trust management may be used to dynamically make access control decisions based on the level of trust and current risk. This work is part of an EU-funded FP7 project called MUSES [1], which aims at combining both the trust in requesting users and the trust in their current computing environments to decide whether or not the request should be granted. The survey has a section on Human Computer Interface (HCI) because reporting the results of those trust and risk metrics evaluations to the end-user in the most appropriate usable ways is very important to influence its future security behavior, especially as the result of an online questionnaire on Wi-Fi risks that we have carried out underlines that even security aware users do not care about the security risks they encounter.

This paper is organized as follows. In Section 2, an overview of computational trust and risk is given. Then, Section 3 explains why traditional risk management based only on threats is not suitable for BYOD mobile worker environments where work opportunities must also be taken into account even outside of the company. Section 4 discusses what kind of new HCI for risk and trust is needed. Section 5 concludes and underlines future work.

II. COMPUTATIONAL TRUST AND RISK OVERVIEW

This section first presents the computational models based on the human notion of trust and then describes the main components of a computational trust engine.

A. Computation Based on the Human Notion of Trust

In the human world, trust exists between two interacting entities and is very useful when there is uncertainty in result of the interaction. The requested entity uses the level of trust in the requesting entity as a mean to cope with uncertainty, to engage in an action in spite of the risk of a harmful outcome. There are many definitions of the human notion trust in a wide range of domains, with different approaches and methodologies: sociology, psychology, economics, pedagogy, etc. These definitions may even change when the application domain changes. However, it has been convincingly argued that these divergent trust definitions can fit together [2]. Romano's definition tries to encompass the previous work in all these domains: *"trust is a subjective assessment of another's influence in terms of the extent of one's perceptions about the quality and significance of another's impact over one's outcomes in a given situation, such that one's expectation of, openness to, and inclination toward such influence provide a sense of control over the potential outcomes of the situation"* [3].

Interactions with uncertain results between entities also happen in the online world. So, it would be useful to rely on trust in the online world as well. However, the terms trust, trusted, trustworthy and the like, which appear in the traditional computer science literature, have rarely been based on these comprehensive multi-disciplinary trust models and often correspond to an implicit element of trust – a limited view of the facetted human notion of trust. Trusted computing is important to try to better know if a computing platform is trustworthy. Krishna and Varadharajan [4] have proposed a model that encompasses the notions of 'hard' and 'soft' trust to determine whether a platform can be trusted for authorisation. Blaze et al. [5] coined the term "decentralized trust management" because their approach separates trust management from application: their PolicyMaker introduced

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the fundamental concepts of policy, credential, and trust relationship. Terzis et al. [6] argued that this model of trust management still relies on an implicit notion of trust because it only describes *"a way of exploiting established trust relationships for distributed security policy management without determining how these relationships are formed"*.

A computational model of trust based on social research was first proposed by Marsh [7]. In social research, there are three main types of trust: interpersonal trust, based on past interactions with the trustee; dispositional trust, provided by the trustor's general disposition towards trust, independently of the trustee; and system trust, provided by external means such as insurance or laws [2]. Trust in a given situation is called the trust context. In Marsh's model, each trust context is assigned an importance value in the range [0,1] and utility value in the range [-1,1]. Any trust value is in the range [-1,1), from very untrustworthy to very trustworthy. In addition, each virtual identity is assigned a general trust value, which is based on all the trust values with this virtual identity in all the trust contexts. Dispositional trust appears in the model as the basic trust value: it is the total trust values in all contexts in all virtual identities with whom the trustor has interacted so far. Risk is used in a threshold for trusting decision making.

A number of other major trust models have followed Marsh's one [8]–[11]. Castelfranchi and Falcone [12] argue for a trust engine based on cognitive science where the main trust evidence type comes from the entity's belief and goals structure rather than probabilistic quantitative views, economics or game theory. Evidence encompasses outcome observations, recommendations and reputation. A trust metric consists of the different computations and communications, which are carried out by the trustor (and his/her network) to compute a trust value in the trustee. Sabater and Sierra [13] also remarked that *"direct experiences and witness information are the 'traditional' information sources used by computational trust and reputation models"*. Depending on the application domain, a few types of evidence may be more weighted in the computation than other types. When recommendations are used, a social network can be reconstructed. Reputation has been defined as follows : *"Reputation is the subjective aggregated value, as perceived by the requester, of the assessments by other people, who are not exactly identified, of some quality, character, characteristic or ability of a specific entity without taking into account direct previous interactions with the entity"* (adapted from [14]). However, to be able to perceive the reputation of an entity is only one aspect of reputation management. The other aspects of reputation management for an entity consist of:

- Monitoring the entity reputation as broadly as possible in a proactive way;
- Analysing the sources spreading the entity reputation;
- Influencing the number and content of these sources to spread an improved reputation.

Golbeck and Hendler [15] studied the problem of propagating trust value in social networks, by proposing an extension of the Friend-Of-A-Friend (FOAF) vocabulary and algorithms to propagate trust values estimated by users rather than computed based on a clear count of pieces of evidence. The propagation of trust in peer-to-peer networks has been studied by Despotovic and Aberer [16] who introduced a more efficient algorithm to propagate trust and recommendations in terms of computational overhead.

B. Evidence-Based Trust and Risk Engine

The EU-funded (SECURE) project [17] represents an example of a trust engine that uses evidence to compute trust values in entities and corresponds to evidence-based trust management systems. As depicted in Figure 1 below, the decision-making component can be called whenever a trusting decision has to be made. Most related work has focused on trust decision-making when a requested entity has to decide what action should be taken due to a request made by another entity, that is, the requesting entity. It is the reason that a specific module called Entity Recognition (ER) [18] is represented to recognise any entities and to deal with the requests from virtual identities. Relying on recognition rather than strong authentication is also better from a privacy point of view because there is no mandatory required link to the real-world identity of the user. Models to trade privacy for trust [19] have even been proposed.

It may happen that the trusting decision is not triggered by any requesting virtual identity, for example, when the user wants to select the most trustworthy used car dealer, or that other type of evidence, such as the level of system trust at time of decision, are more important than the involved virtual identities.

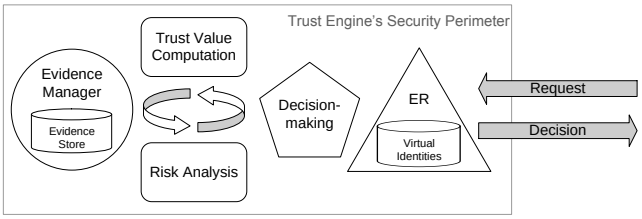

Figure 1. High-level View of a Trust Engine

The decision-making of the trust engine uses two sub-components:

- a trust module that can dynamically assess the trustworthiness of the requesting entity based on the trust evidence of any type stored in the evidence store;
- a risk module that can dynamically evaluate the risk involved in the interaction, again based on the available evidence in the evidence store.

A common decision-making policy is to choose (or suggest to the user) the action that would maintain the appropriate cost/benefit. In the background, the evidence manager component is in charge of gathering evidence (e.g., recommendations, comparisons between expected outcomes of the chosen actions and real outcomes, etc.) This evidence is used to update risk and trust evidence. Thus, trust and risk follow a managed life-cycle.

Dimmock, who took care of the risk module in the SECURE project, concludes in his PhD thesis that more

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work with regard to the risk of the situation must be done and especially with regard to the time element of risk: *"one area that the framework does not currently address in great detail is the notion of time"* [20]. A recent survey of trust models for multi-agent systems still underlines that *"among these trust models, risk received the least attention. The element of risk is a very critical factor for each interaction; hence, there is a need to incorporate more consideration for risk in designing future trust models."* [21]

III. RISK AS PART OF THREAT MODELLING WITH OPPORTUNITIES IN MIND

Risk management is a broad field applied in many other application domains than Information Technology (IT), for example, nuclear power plants, with many different methodologies. Fortunately, in 2005 the European Network and Information Security Agency (ENISA) set up an ad hoc Working Group on "*Technical and Policy Aspects of Risk Assessment and Risk Management"* involving experts from eight Member States who cooperated through regular meetings within eight months. They produced an overview of existing risk methodologies and the relevant players in this field, and comparison of the different methodologies [22]. We have adapted below previous work for our BYOD mobile worker application domain.

A. Threat Modelling

ISO 27005 (information security risk management) underlines that risk management in the information security application domain relies on threat modelling. As Shostack [23] underlines there are three main types of threat modelling approaches:

- Asset-driven threat modelling focuses on the assets that attackers may attack include how they could attack them. Unfortunately digital data can be attacked in many different ways and any piece of software, network or hardware may become considered as assets.
- Attacker-driven threat modelling focuses on understanding the capabilities of the potential attackers would want to attack. It works well for *"a foreign army with a known strategic doctrine, physical world limits, and long-lead-time weapons systems development. This works less well when your adversary is a loosely organized group of anonymous hackers."* [23]
- Design-driven threat modelling is threat modelling based on where the security perimeter of software components where diagrams are drawn at design time to understand what can go wrong with each component following the STRIDE threat model (Spoofing, Tampering, Repudiation, Information disclosure, Denial of Service and Elevation of Privilege) [24] with two tools provided by Microsoft. Microsoft TAM (Threat Analysis and Modelling) is more dedicated to software applications than the more generic Microsoft Security Development Lifecycle (SDL) threat modelling tool (but that requires Visio). In TAM, risk is computed by multiplying the importance level by the probability level, whose levels go from low (1), medium (2) to high (3).

Although in this paper the assets are more related to corporate assets, we define an asset as anything that has value to the owner, which is an adaption of the definition of asset in ISO/IEC IS 13335-1 [25] where owner is replaced by organisation. An asset may be tangible or intangible, hardware, software, data, buildings, infrastructure, but also products, knowledge resources, customer relationships or reputation.

The ISO/IEC Guide 73 [26] defines an event as an occurrence of a particular set of circumstances. The event can be certain or uncertain. The event can be a single occurrence or a series of occurrences. Although this guide uses the term consequence rather than outcome that is the term used in the SECURE trust engine, the ISO/IEC Guide 73 [26] defines that there can be more than one outcome from one event. Outcomes can range from positive to negative and be expressed qualitatively or quantitatively.
According to ISO/IEC IS 13335-1 [25] where negative consequence is replaced by harm, a threat is any action or event with the potential to cause negative outcome(s). *"Sources of threats could be vandalism, espionage or just human mistakes and accidents. In the two first cases the strength of the threat can result from two major factors: the motivation of the threat and the attractiveness of the asset"* [25].

However, one report on the consumerisation of IT from the ENISA [27] underlines a major aspect that has not been taken into account in standard threat methodologies: *"As regards opportunities, due to missing standardised definitions"* [27]. There may be also positive consequences of an action or event and risk management tends to focus on negative outcomes and negative events, i.e., threats. Unfortunately, the BYOD trend is spreading in corporate environments because it brings many opportunities with beneficial outcomes: work from anywhere, fewer unproductive paid times, etc. Thus, based on the ENISA [27] report, we have defined opportunity as any action or event with the potential to cause positive outcome(s). However, this definition deviates from the definition of IT security risk of another ENISA report [22]: *"IT security risk is composed of an asset, a threat and vulnerability: if one of these items is irrelevant, then there is no IT security risk to encounter"* that does not take into account the positive outcomes and opportunities as underlined in the other ENISA report [27]. Concretely taking into account opportunities in addition to threats is a main innovative aspect of our work.

ISO/IEC IS 13335-1 [25] defines vulnerability as a weakness of an asset that can be exploited by one or more threats. *"Vulnerabilities can exist in all parts of an IT system, e.g., in hardware or software, in organizational structures, in the infrastructure or in personnel"* [25].

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We use the ENISA [22] definition of probability: the extent to which an event is likely to occur.

B. Balancing Threats Costs and Benefits of Opportunities

Based on the above remark regarding the importance of allowing opportunities in the BYOD mobile worker application domain and above definitions, we have adapted the definition of risk from ISO/IEC 13335-1 [25] where probability is replaced by potential, owner by organization and opportunities are not taken into account. Hence, risk is the combination of the probability that a given threat will successfully exploit vulnerabilities of an asset or group of assets with the cost of the negative consequences to the owner balanced with the benefit of the positive consequence of an available opportunity.

Then, we have adapted the ENISA [22] definition of an incident: a security incident is an event that has been assessed as having an actual or potentially adverse effect on the security or performance of a system.

The ISO/IEC Guide 73 [26] defines the risk estimation process as the process to assign values to the probability and consequences of a risk. It can consider cost, benefits, the concerns of stakeholders and other variables, as appropriate for risk evaluation. In our MUSES project context, the probability that a user would like to access a company asset when the user makes the request to access such request is 1 because the user has already made the request. The benefit of letting the user accessing the asset could be computed based on the hourly cost of the user, who otherwise could not work, for example, because the user is at an airport without other opportunities to work if she has not access to this company asset. Regarding the value of the asset, it may also be estimated a priori, for example, the value of the confidential documents required for a patent proposal may be estimated a priori (although it may take some time to gather all information regarding how much benefits could be generated from this patent). Unfortunately, estimating the probability of putting in danger the company asset due to all the probable threats due to the vulnerabilities is much more difficult because the list of vulnerabilities and threats may be hard to collect and depending on the company more or less attackers may be trying to attack the current user device.

A second important paradigm shift that happens in MUSES application domain rather than in traditional risk management domains is that MUSES has specific modules that will compute in real-time the current context, including for a mobile device to detect being under attack, and store risk evidence both locally and with other MUSES peers, thus allowing real-time computation of the probabilities of a threat that would successfully exploit a vulnerability and compromise the asset. In traditional risk methodologies, after the risks have been estimated, the risk of a harmful outcome may be so low that it may be taken in order to reap the benefits with high probability or treatments to reduce risks may be considered such as mitigation with new security mechanisms or transfer to another context. For example, in MUSES, the phase of informing the user who is willing to access a company asset from a remote location may be informed that it should rather stop from the Starbucks airport Wi-Fi and go to the nearby airport business lounge, which is known to be more secure. The phase of informing the user is an important part and usually called *"risk communication"* [22]. It is the reason we adopt the two following remaining definitions from ISO/IEC Guide 73:

- Risk Communication: A process to exchange or share information about risk between the decision-maker and other stakeholders. The information can relate to the existence, nature, form, probability, severity, acceptability, treatment or other aspects of risk.
- Risk Treatment: Process of selection and implementation of measures to modify risk. Risk treatment measures can include avoiding, optimizing, transferring or retaining risk.

As our following users online survey about the specific risk of accessing corporate assets from public Wi-Fi shows, new HCI is needed to better communicate the risks to the users and the potential risk treatments they can try to apply.

IV. HUMAN COMPUTER INTERFACE TRUST AND RISK

In this section, we first show the result of our online survey and then give an overview of HCI aspects for trust and risk.

A. Wi-Fi Spoofing Users Online Survey and Weakest Link

During summer 2012, we created a short survey and sent it to a list of users who are subscribed to a marketing database and who are interested in computer programming and speak English or French. 1767 users answered, which is quite a large number of answers. We asked them the following question "Do you know that a Wi-Fi hotspot public access point name can be easily impersonated and that it can be a security risk for you?" They could reply one of the following answers "Yes; No; I don't care" and optionally add a textual comment. 5 of them used that comment option and answered: yes with the following comment "but it is possible to secure the link" ; yes with the following comment "VERY COMMON AND IT CAN CAUSE HAVOC!!!!!"; yes with the following comment "Obvious .. :P"; yes with the following comment "Honeypot :-)"; no with the following comment "Yes, Now i know. :P". Among the English speaking people, 540 replied "yes", 185 replied "no" and 1017 replied "I don't care". Figure 2 below indicates the percentages for each answer type.

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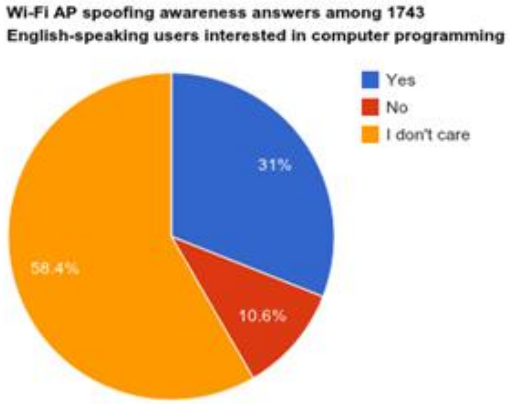

Figure 2. Wi-Fi Spoofing Awareness Results

Although these users are interested in computer programming, it is surprising to see that 58,4% of 1743 English-speaking users did not care about this issue and that 10,6% did not know it. Concerning the comment on securing the connection, few users would know how to really secure their connection. Furthermore, the fact that many of them answered that they do not care, leaves us to think that they would not take the time to secure it if it is not automated, which is not the case today with current Wi-Fi connections. The remaining security risk seems still quite important because even computer aware users do not know or do not bother about this issue although it is a real risk that current approaches do not solve.

Most researchers have come to the conclusion that it is not the security technology that is preventing the user to be safe when online, but the behaviour of the user itself that causes security breaches online. Investigators have gathered information on the behaviour of the user and concluded three main reasons as to why the user does not adhere to security applications.

The first one being that users do not necessarily do what they say they will do. For example, while users say that they will not give their password away or that they do use virus checking software regularly in reality their behaviour is different [28], [29]. Secondly, users perceive security and privacy issues differently than developers do as users do not have the background understanding issues [29]. People generally believe that they are at less risk than others. Likewise, they believe they are better than average drivers, live beyond the average age [30], etc. Therefore, many computer users have the belief that they are at less risk of computer vulnerability than others. Adams and Sasse [31] found out that users are much better at following security policies when they are given explanations on both the real security threats and the goals of the security policies. An immediate reward or instant gratification is seldom present when using security devices. Also, behaviour can also be shaped by negative reinforcement. However, in the case of security when the user does something bad the negative reinforcement can be delayed by days, weeks or even months [32]. Thirdly, the worst dilemma for users and the one that is the hardest to resolve is that from a user perspective, increases in security are most frequently accompanied by a reduction in convenience [29]. When security issues come in the way of the user completing a task, the user often chooses to let go of security to be able to complete the task.

B. Models for Trust and Risk User Interfaces

Latest psychological definitions of trust focusing on behavioural intentions define trust as an internal action similar to choosing, judging or preferring [33]. Hence, trust is a mechanism to reduce complexity since it helps reducing the number of options one has to consider in a given risky situation [34]–[37]: *"a psychological state comprising the intention to accept vulnerability based upon positive expectation of the intentions of behaviour of another."* [38]

Especially (perceived) trustworthiness is often used as synonym for trust and the differentiation of these two terms is not well defined [39]. Trustworthiness is evoked by characteristics of the trustee and therefore could be interpreted as antecedent for trust. Mayer et al. [34] specified these characteristics. They concluded that in fact perceived ability, benevolence and integrity are underlying factors of building up the impression of trustworthiness.

McKnight and Chevarny [40] developed and validated the model of system trust focusing on the user and his trust disposition, beliefs and intentions. Corritore et al. [41] focused on factors that evoke trust: external and situational factors which are located in the environment (e.g., reputation) and perceived factors (credibility, ease of use, risk) which are both hypothesized to lead to trust. Several other authors identified trust rising and influencing factors during a transaction with online services: usability and user satisfaction [42], reputation and size of the online shop [43], belief in integrity, competence and benevolence of the web vendor [44], as well as increased familiarity [45].

Schlosser et al. [46] provide a conceptual framework of the effect of online signals on trusting beliefs and intentions depicted in Figure 3 as well as operationalization to measure the identified factors. Regarding the trustworthiness of devices, Koien [47] notes that, compared to the ethical dimensions on which humans are more or less trustworthy, the trustworthiness of devices is based on the notion of intention and ability: the device intention to work as expected combined with its ability to actually do so. When trying to describe features, characteristics, experience of behaviour of people, there is a distinction of trait-parts of experience and behaviour and state-parts of experience and behaviour. Traits are personal variables that are supposed to be stable, consistent, invariant and dispositional across time and situations. States are situational variables that are supposed to be changing, discriminative, variable and dynamic across time and situations [40].

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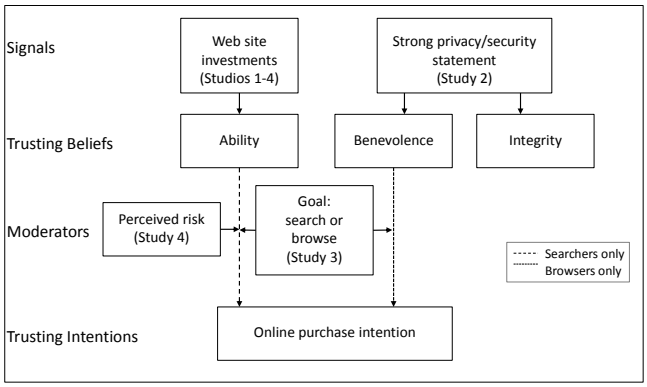

Figure 3. Schlosser's et al.'s Conceptual Framework of the Effect of Online Signals on Trusting Beliefs and Intentions [46]

There are currently no measurement approaches for the construct trust that consider a trait and a state-part of the construct. This leads to a critical psychometric issue: a measure of a (hypothesized) trait variable will always be influenced by the situation (for example: current mood of the participants induced by the surrounding) and also distorted by unsystematic measurement errors (for example: varying instructions or trust-inducing stimuli) [48]. Measuring trust and the related factor trustworthiness, which is seen as a technical property of a system, is hypothesized to evoke trust in a human. Therefore, trust is seen as a latent construct underlying behaviour and can only be assessed indirectly by certain empirical indicators [49].

Fogel and Nemad [50] investigated in their study risky behaviour in social networks. They used the risk averseness scale and the consumer trust scales, both by Pan & Zinkhan [51]. Additionally, they used the privacy behaviour scale [52], the time pressure scale [53], the privacy concerns scale and the perceived ability to control information scale, both by Dinev and Hart [54], the privacy attitude scale [52] and identity information disclosure scale [55]. Persons with social networks profile had significantly higher risk taking score than those without a social network profile. Men had greater risk taking scores than women, but there were no gender differences regarding privacy behaviour or privacy attitudes. Women had higher scores in privacy concerns.

C. User Interfaces Fostering the Sense of Trust and Risk

There are several user interface elements fostering trust in users. Users are used to some icons, e.g., the lock in the browser to show that it is a secure site. But there are no possibilities to show the user which data are shared with whom and if the data is sent to a trustworthy person, institution or website.

When a potential customer visits a Website, the first thing she encounters is the website user interface. This provides the consumer with a first impression about the site and its trustworthiness [56]. Three main targets of online trust are content, services, and people [57]. User interface designers should take care to provide a professional appearance of a vendor's Web site, in order to ease the customers' interaction with the Web site and hence increase the consumers' trust towards the merchant. The presence of some features, such as customization, user control capabilities, and customer support services has an important influence on the customer's perception and experience. In the event of a purchase or rental, the order fulfilment process will be the last and most crucial factor to satisfy the consumer's expectations about a vendor [56].

To increase the trustworthiness in e-commerce various technological tools have been developed to help the user to feel safer when exchanging personal information or buying online. During the PrimeLife project [58], user interfaces providing privacy and security feedback were evaluated. In this process the *"Send Data?"* dialog, an interface-element indicating what data was to be sent to whom for what purpose, was reviewed. The results of this study revealed that the test persons understood the meaning of this dialog, but test persons also said that they do not read the displayed information. They only look for familiar patterns or buttons and do not read the exact text. Although they did not understand some UI elements, the visualisation of the information, using color-coding worked very well [59]. Holtz et al. [60] also evaluated privacy-icons for the PrimeLife project. In order to do so, two icon sets were developed: one for general use and one for specific use in connection with access control functionalities. The outcome of this study reveals that users prefer clear icons with few details.

Icons were originally introduced to quickly and simply show facts, such as exits or fire distinguisher. They then found their way to the computer and some metaphors were used, e.g., icon for an e-Mail, icon for a bin, etc. For security and privacy reasons icons can show the privacy and security level of elements, such as a homepage or similar. A wide range of icon usage is described in [61]. Privacy icons were first introduced by Mary Rundle [62]. Other privacy icon sets are partially inspired by the Creative Commons licenses [63].

The following icons and pictures in Figure 4 should act as examples of different icons and icons set.

Figure 4. Security icons examples [61]

Different approaches to display information creating trust have been undertaken. One promising approach is the use of *"Nutrition Labels"* [64]. Using this approach known by users (also similar to energy labels), it is possible to display the privacy state of a system. Also, the uTRUSTit [65] project deals on how security and privacy information could be displayed to the user. An example of how to display icons and privacy information encountered in the uTRUSTit project follows in Figure 5:

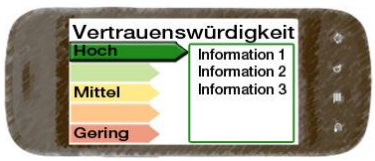

Figure 5. Nutrition labels [65]

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D. Social Trust and Online Reputation User Interfaces

We finish the overview of trust and reputation user interfaces with the state-of-the-art of online reputation interfaces below.

Founded in 1995, eBay [14] has been a very successful online auction market place where buyers can search for products offered by sellers and buy them either directly or after an auction. After each transaction, the buyers can rate the transaction with the seller as *"positive"*, *"negative"* or *"neutral"*. Since May 2008, the sellers have only the choice to rate the buyer experience as *"positive"* or nothing else. Short comments of maximum 80 characters can be left with the rating. Their reputation is based on the number of positive and negative ratings that are aggregated in the Feedback Score as well as the comments if the user reads them. Buyers or sellers can affect each other's Feedback Score by only one point per week. Each positive rating counts for 1 point and each negative counts for -1 point. The balance of points is calculated at the end of the week and the Feedback Score is increased by 1 if the balance is positive or decreased by 1 if the balance is negative. Buyers can also leave anonymous *"Detailed Seller Ratings"* composed of different criteria, such as, *"Item as described"*, *"Communication"*, *"Shipping Time"*, etc. displayed as a number of stars from 0 to 5 stars. Different image icons are also displayed to quickly estimate the reputation of the user, for example, a star whose color depends on the Feedback Score, as depicted in Figure 6. After 90 days, detailed item information is removed. From a privacy point of view, on one hand, it is possible to use a pseudonym, on the other hand, a pretty exhaustive list of what has been bought is available, which is quite a privacy concern. There are different *"Insertion"* and *"Final Value"* fees depending on the item type.

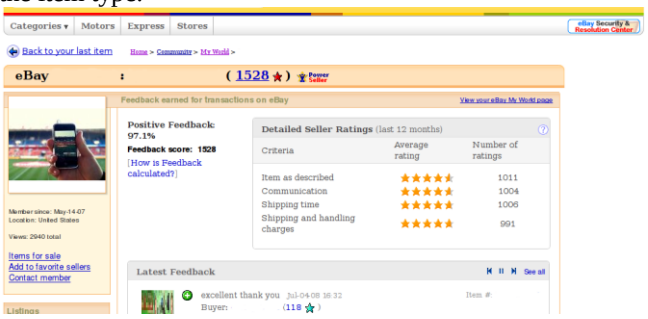

Figure 6. eBay online reputation visual representation [14]

Founded in 2006, Venyo [14] provided a worldwide people reputation index, called the Vindex, based on either direct ratings through the user profile on Venyo Web site or indirect ratings through contributions or profiles on partner Web sites. Venyo was very privacy-friendly because it was not asking the users for their external passwords and it did not crawl the Web to present a user reputation without his or her initial consent. Unfortunately, Venyo got fewer profiles than the other services that were more aggressive and less privacy friendly and was terminated in 2009. At time of rating, the rater specifies a value between 1 and 5 as well as keywords corresponding to the tags contextualizing the rating. The rating is also contextualized according to where the rating has been done. For example, if the rating is done from a GaultMillau restaurant blog article, the tag *"restaurant recommendation"* is automatically added to the list of tags. Venyo provides a reputation history chart as depicted in Figure 7 to help the users monitoring the evolution of their reputation on Venyo's and partner's Web sites. Venyo does not monitor external Web pages or information.

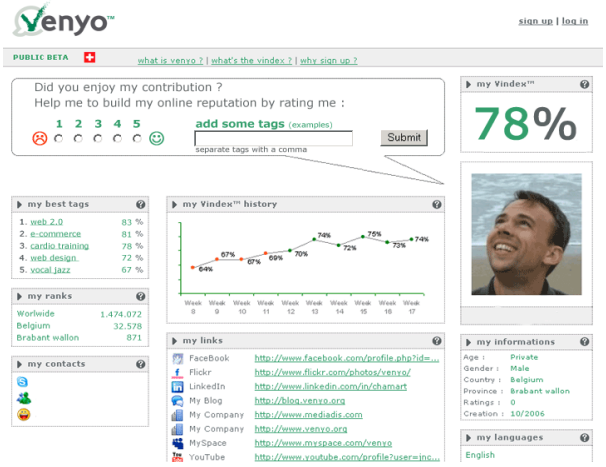

Figure 7. Venyo online reputation user interface [14]

TrustPlus [14] was another decentralized e-reputation calculation service that existed but unfortunately had also to close in April 2012 due to a business model that did not work. TrustPlus had partnered with a few other interesting e-services such as ZoomInfo. Founded in 1999, ZoomInfo is more a people (and company) search directory than a reputation services with more than 42 millions users, 3,8 millions companies and a partnership with Xing.com (a business social network similar to LinkedIn.com). Thanks to its partnership with SageFire, which is a trusted eBay Certified Solution Provider who has access to historical archives of eBay reputation data, TrustPlus was able to display and use eBay's reputation evidence when the users agreed to link their TrustPlus account with their eBay account. The main initial feature of TrustPlus was a Web browser plug-in that allowed the user to see the TrustPlus reputation of an online profile appearing on Web pages on different sites, such as, craiglist.org. At the identity layer, although it is not a recommended security practice, TrustPlus asked the users to type their external accounts passwords, for example, eBay's or Facebook's ones, to validate that they own these external accounts as well as to create their list of contacts. This list of contacts could be used to specify who among the contacts could see the detail of which transactions or ratings. As depicted in Figure 8, TrustPlus rating user interface was pretty complex but with interesting advanced trust features such as circles of trust to facilitate with whom some information would be shared. There were different contexts: a commercial transaction, a relationship and an interaction, for example, a chat or a date.

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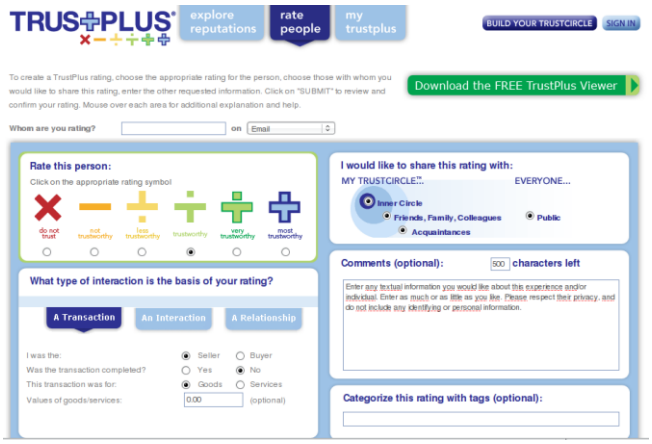

Figure 8. TrustPlus online reputation user interface [14]

Klout [14] was created in 2008 by Joé Fernandez. Instead of computing the reputation of a person mainly based on recommendations from other users, as we have seen above in previous reputation calculation services, Klout analyses the Twitter account of that person. Klout score is based on 3 main criterion:

- True Reach: the number of followers of the user's Twitter account and following the user's tweets
- Amplification: the number of people who share a post (who distribute it to other users)
- Network: the influence of the users composing the True Reach themselves

Klout may integrate other evidence such as posts on other social networks (such as Facebook) or other users who recommend the user by adding a +K to the user on specific topics, meaning that they click on a link provided by Klout saying that the user has influenced them regarding that topic. There are similar metrics that have been created since Klout, for example, Twitalizer (which is a very detailed one focusing on Twitter information), Peerindex, Kred, Identified, PROSkore, Jitterater (acquired by Meltwater), etc. Unfortunately most of those metrics are not open, i.e., it is not really clear how the results have been computed and based on which evidence. Klout initial business models is based on the fact that users with high Klout score in some topic would be rewarded by brands willing to influence that topic and would pay Klout to be able to do that. For example, Virgin Airline gave free airline tickets to users with high Klout score. At time of writing, it is still not possible to reward users outside the USA and its business model has still to prove its viability. Anyway, Klout has gained a decent level of visibility compared to earlier e-reputation calculation services, maybe because many more users use social networks than before, leading to a more viral effect, and e-reputation has become a hot product in traditional marketing companies. Once the Klout account is linked to a user's social network, it can detect automatically when the user sends a new post and check how much buzz it has generated. If another user gives the user a +K, she is informed by email or a notification on her social networks.

V. CONCLUSION

As part of the MUSES project, we are working towards a real time risk and trust engine that will better cope with the new challenges introduced by BYOD and mobile working including new HCI that will better explain the risks encountered by the mobile users especially because our online survey confirms that users do not take care of security risks.

This survey underlines that, from a corporate point of view, the BYOD and mobile working trend clearly challenges traditional IT risk management methodologies. They mainly focus on the negative outcomes where assets could be undermined due to probable threats that would successfully exploit vulnerabilities without taking into account that if the assets could be successful used and no threat would happen, the opportunity to use those assets would bring the benefits of the positive outcomes. There are some benefits in letting work being done in broader situations than the corporate environment and that if this work is not done there are direct loses. In addition, in traditional static threat modeling and risk management methodologies, threats and risks are manually assessed once for all and then either mitigated or accepted by corporate managers. Hence, those traditional approaches do not also fit where context can be evaluated in real time and more should be done if no risk is detected, i.e., the system is not under attack.

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REFERENCES

[1] "Multiplatform Usable Endpoint Security." [Online]. Available: http://www.musesproject.eu. [Accessed: 14-Jul-2013].

[2] D. McKnight and N. L. Chervany, "The Meanings of Trust." MISRC 96-04, University of Minnesota, Management Informations Systems Research Center, 1996.

[3] D. M. Romano, "The Nature of Trust: Conceptual and Operational Clarification," Louisiana State University, PhD Thesis, 2003.

[4] A. Krishna and V. Varadharajan, "A Hybrid Trust Model for Authorisation Using Trusted Platforms," in *Proceedings of the 2011IEEE 10th International Conference on Trust, Security and Privacy in Computing and Communications*, Washington, DC, USA, 2011, pp. 288–295.

[5] M. Blaze, J. Feigenbaum, and J. Lacy, "Decentralized Trust Management," in *the 17th IEEE Symposium on Security and Privacy*, 1996, pp. 164–173.

[6] S. Terzis, C. English, W. Wagealla, and P. Nixon, "Trust Formation Model," 2005.

[7] S. Marsh, "Formalising Trust as a Computational Concept," Department of Mathematics and Computer Science, University of Stirling, RP 1994.

[8] K. Govindan and P. Mohapatra, "Trust computations and trust dynamics in mobile adhoc networks: a survey,"

 ISBN: 978-1-61208-312-4

Commun. Surv. Tutorials IEEE, vol. 14, no. 2, pp. 279–298, 2012.

[9] T. Grandison and M. Sloman, "A Survey Of Trust In Internet Applications." 2000.

[10] D. Z. Kevin Hoffman and C. Nita-Rotaru, "A Survey of Attack and Defense Techniques for Reputation Systems," Purdue University, CSD TR #07-013, 2007.

[11] A. Medić, "Survey of Computer Trust and Reputation Models–The Literature Overview," *Int. J. Inf.*, vol. 2, no. 3, 2012.

[12] C. Castelfranchi and R. Falcone, "Trust is much more than subjective probability: Mental components and sources of trust," in *32nd Hawaii International Conference on System Sciences - Mini-Track on Software Agents*, 2000.

[13] J. Sabater and C. Sierra, "Review on Computational Trust and Reputation Models." Kluwer, 2005.

[14] J.-M. Seigneur, "Reputation Management," in *Computer and Information Security Handbook*, Morgan Kaufmann, 2009.

[15] J. Golbeck and J. Hendler, "Accuracy of Metrics for Inferring Trust and Reputation in Semantic Web-based Social Networks," in *the 14th International Conference on Knowledge Engineering and Knowledge Management*, 2004.

[16] Z. Despotovic and K. Aberer, "Maximum Likelihood Estimation of Peers' Performance in P2P Networks." 2004.

[17] V. Cahill, E. Gray, J.-M. Seigneur, C. Jensen, Y. Chen, B. Shand, N. Dimmock, A. Twigg, J. Bacon, C. English, W. Wagealla, S. Terzis, P. Nixon, G. di M. Serugendo, C. Bryce, M. Carbone, K. Krukow, and M. Nielsen, "Using Trust for Secure Collaboration in Uncertain Environments," *IEEE Pervasive Computing*, vol. July-September, 2003.

[18] J.-M. Seigneur, "Trust, Security and Privacy in Global Computing," Trinity College Dublin, Ph.D. Thesis, 2005.

[19] J.-M. Seigneur and C. D. Jensen, "Trading Privacy for Trust," in *the Second International Conference on Trust Management*, 2004, vol. LNCS 2995.

[20] N. Dimmock, "Using Trust and Risk for Access Control in Global Computing," University of Cambridge, 2005.

[21] V. Balakrishnan and E. Majd, "A Comparative Analysis of Trust Models for Multi-Agent Systems," *Lect. Notes Softw. Eng.*, vol. 1, no. 2, 2013.

[22] "Risk Assessment and Risk Management Methods: Information Packages for Small and Medium Sized Enterprises (SMEs)," ENISA, 2006.

[23] Adam, Shostack, "Reinvigorate your Threat Modeling Process," *MSDN Mag.*, vol. July, 2008.

[24] M. Howard and S. Lipner, "Inside the windows security push," *Secur. Priv. IEEE*, vol. 1, no. 1, pp. 57–61, 2003.

[25] "ISO/IEC 13335-1 Management of information and communications technology security."

[26] "ISO Guide 73 Risk management Vocabulary," ISO, 2009.

[27] J. Clarke, M. Gomez Hidalgo, A. Lioy, M. Petkovic, C. Vishik, and J. Ward, "Consumerization of IT: Top Risks and Opportunities," ENISA, 2012.

[28] A. Patrick, S. Marsh, and P. Briggs, "Designing systems that people will trust," 2005.

[29] C. Nodder, "Users and trust: A microsoft case study," *Secur. Usability*, pp. 589–606, 2005.

[30] P. Slovic, B. Fischhoff, and S. Lichtenstein, "Facts and fears: Understanding perceived risk," *Soc. Risk Assess. Safe Is Safe Enough*, vol. 4, pp. 181–214, 1980.

[31] A. Adams and M. A. Sasse, "Users are not the enemy," *Commun. ACM*, vol. 42, no. 12, pp. 40–46, 1999.

[32] R. West, "The psychology of security," *Commun. ACM*, vol. 51, no. 4, pp. 34–40, 2008.

[33] J. A. Colquitt, B. A. Scott, and J. A. LePine, "Trust, trustworthiness, and trust propensity: a meta-analytic test of their unique relationships with risk taking and job performance.," *J. Appl. Psychol.*, vol. 92, no. 4, p. 909, 2007.

[34] R. C. Mayer, J. H. Davis, and F. D. Schoorman, "An integrative model of organizational trust," *Acad. Manage. Rev.*, pp. 709–734, 1995.

[35] N. Luhmann, *Vertrauen: Ein Mechanismus der Reduktion sozialer Komplexitat*. F. Enke, 1968.

[36] B. Barber, *The logic and limits of trust*. Rutgers University Press New Brunswick, NJ, 1983.

[37] J. D. Lewis and A. Weigert, "Trust as a social reality," *Soc. Forces*, vol. 63, no. 4, pp. 967–985, 1985.

[38] D. M. Rousseau, S. B. Sitkin, R. S. Burt, and C. Camerer, "Not so different after all: A cross-discipline view of trust.," *Acad. Manage. Rev.*, vol. 23, no. 3, pp. 393–404, 1998.

[39] K. J. Blois, "Trust in business to business relationships: an evaluation of its status," *J. Manag. Stud.*, vol. 36, no. 2, pp. 197–215, 1999.

[40] D. H. McKnight and N. L. Chervany, "What trust means in e-commerce customer relationships: an interdisciplinary conceptual typology," *Int. J. Electron. Commer.*, vol. 6, pp. 35–60, 2002.

[41] C. L. Corritore, R. P. Marble, S. Wiedenbeck, B. Kracher, and A. Chandran, "Measuring online trust of websites: credibility, perceived ease of use, and risk," presented at the AMCIS, 2005.

[42] C. Flavián, M. Guinalíu, and R. Gurrea, "The role played by perceived usability, satisfaction and consumer trust on website loyalty," *Inf. Manage.*, vol. 43, no. 1, pp. 1–14, 2006.

[43] S. L. Jarvenpaa, N. Tractinsky, and L. Saarinen, "Consumer Trust in an Internet Store: A Cross-Cultural Validation," *J. Comput.-Mediat. Commun.*, vol. 5, no. 2, pp. 0–0, 1999.

[44] P. Palvia, "The role of trust in e-commerce relational exchange: A unified model," *Inf. Manage.*, vol. 46, no. 4, pp. 213–220, 2009.

[45] D. Gefen, "E-commerce: the role of familiarity and trust," *Omega*, vol. 28, no. 6, pp. 725–737, 2000.

[46] A. E. Schlosser, T. B. White, and S. M. Lloyd, "Converting web site visitors into buyers: how web site investment increases consumer trusting beliefs and online purchase intentions," *J. Mark.*, pp. 133–148, 2006.

[47] G. M. Køien, "Reflections on Trust in Devices: An Informal Survey of Human Trust in an Internet-of-Things Context," *Wirel. Pers. Commun.*, vol. 61, no. 3, pp. 495–510, 2011.

[48] D. Danner, D. Hagemann, A. Schankin, M. Hager, and J. Funke, "Beyond IQ: A latent state-trait analysis of general intelligence, dynamic decision making, and implicit learning," *Intelligence*, vol. 39, no. 5, pp. 323–334, 2011.

[49] E. L. Hamaker, J. R. Nesselroade, and P. Molenaar, "The integrated trait–state model," *J. Res. Pers.*, vol. 41, no. 2, pp. 295–315, 2007.

[50] J. Fogel and E. Nehmad, "Internet social network communities: Risk taking, trust, and privacy concerns," *Comput. Hum. Behav.*, vol. 25, no. 1, pp. 153–160, 2009.

[51] Y. Pan and G. M. Zinkhan, "Exploring the impact of online privacy disclosures on consumer trust," *J. Retail.*, vol. 82, no. 4, pp. 331–338, 2006.

[52] T. Buchanan, C. Paine, A. N. Joinson, and U.-D. Reips, "Development of measures of online privacy concern and

 ISBN: 978-1-61208-312-4

protection for use on the Internet," *J. Am. Soc. Inf. Sci. Technol.*, vol. 58, no. 2, pp. 157–165, 2007.
[53] B. Mittal, "An integrated framework for relating diverse consumer characteristics to supermarket coupon redemption," *J. Mark. Res.*, pp. 533–544, 1994.
[54] T. Dinev and P. Hart, "Internet privacy concerns and their antecedents-measurement validity and a regression model," *Behav. Inf. Technol.*, vol. 23, no. 6, pp. 413–422, 2004.
[55] F. Stutzman, "An evaluation of identity-sharing behavior in social network communities," *J. Int. Digit. Media Arts Assoc.*, vol. 3, no. 1, pp. 10–18, 2006.
[56] I. Araujo and I. Araujo, "Developing trust in internet commerce," in *Proceedings of the 2003 conference of the Centre for Advanced Studies on Collaborative research*, 2003, pp. 1–15.
[57] J. Golbeck, "Trust on the world wide web: a survey," *Found. Trends Web Sci.*, vol. 1, no. 2, pp. 131–197, 2006.
[58] J. Camenisch, *Privacy and identity management for life*. Springerverlag Berlin Heidelberg, 2011.
[59] J. Angulo, S. Fischer-Hübner, T. Pulls, and U. König, "HCI for policy display and administration," in *Privacy and Identity Management for Life*, Springer, 2011, pp. 261–277.
[60] L.-E. Holtz, H. Zwingelberg, and M. Hansen, "Privacy policy icons," in *Privacy and Identity Management for Life*, Springer, 2011, pp. 279–285.
[61] M. Hansen, "Putting privacy pictograms into practice-a european perspective," *GI Jahrestag.*, vol. 154, pp. 1–703, 2009.
[62] M. Rundle, "International data protection and digital identity management tools," in *IGF 2006: Privacy Workshop, Athens, at http://ssrn. com/abstract*, 2006, vol. 911607.
[63] A. Raskin, *Privacy Icons: Alpha Release*. 2010.
[64] P. G. Kelley, J. Bresee, L. F. Cranor, and R. W. Reeder, "A nutrition label for privacy," in *Proceedings of the 5th Symposium on Usable Privacy and Security*, 2009, p. 4.
[65] C. Hochleitner, C. Graf, D. Unger, M. Tscheligi, and I. Center, "Making Devices Trustworthy: Security and Trust Feedback in the Internet of Things," 2012.

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Individual Opinions Versus Collective Opinions in Trust Modelling

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***Abstract*—Social web permits users to acquire information from anonymous people around the world. This leads to a serious question about the trustworthiness of the information and the sources. During the last decade, numerous models were proposed to adapt social trust to social web. These models aim to assist the user in becoming able to state his opinion about the acquired information and their sources based on their trustworthiness. Usually, opinions can be based on two mechanisms to acquire knowledge: evaluating previous interactions with the source (individual knowledge), and word of mouth mechanism where the user relies on the knowledge of his friends and their friends (collective knowledge). In this paper, we are interested in the impact of using each of these mechanisms on the performance of trust models. Subjective logic (SL) is an extension of probabilistic logic that deals with the cases of lack of evidence. It supplies framework for modelling trust on the web. We use SL in this paper to build and compare two trust models. The first one gives priority to individual opinions, and uses collective opinions only in the case of absence of individual opinions. The second considers only collective opinions permanently, so it always provides the most complete knowledge that leads to improving the performance of the model.**

***Keywords*—Trust modelling, Subjective logic, Recommender system, Collective trust**

I. INTRODUCTION

Web 2.0 provides a highly connected social environment. It allows data exchange among anonymous people from all around the world. Acquiring information from such sources raises the question about its reliability and trustworthiness. Modelling social trust into computational trust appeared to overcome the trustworthiness problem (for both information and resources). Today, computational trust is integrated in many domains and contexts such as social networks, recommender systems [1], [2], file sharing [3], etc.

We consider social trust as the belief of an individual, called truster, that another individual, called trustee, has the competence and the willingness to either execute a task to the favour of the truster, or to assist him to execute it. The assistance can simply be recommending another individual to execute the task. The truster tries to acquire information and constructs his own belief about the trustee before deciding to cooperate with him.

Building truster's opinion about the trustee is mainly derived by two means; the first is by exploiting previous interactions between both of them, so the truster relies on his own knowledge about the trustee (individual opinion). The second uses the word of mouth mechanism, where the truster exploits the collective knowledge of his trustee friends and their friends (collective opinion). Local trust models are those which exploit individual opinions as they are available, and collective opinions otherwise [1], [4], [2].

Our objective in this paper is to show that collective opinions can be fruitful and efficient to improve the trust based recommender system's performance even in the presence of individual opinions. We show this by comparing two trust based recommender systems: the first relies on a classical local trust model, and the second uses permanently collective opinions. Both of them are based on the subjective logic (SL) [5], which is an extension of probabilistic logic, based on the belief theory [6], [7]. SL provides a flexible framework form modelling trust.

The object of our comparison is the dataset stackoverflow [8]. It is a social website based on a question answering platform to assist users to find answers to their questions in diverse domains (programming, mathematics, English language, cooking, etc.). We assume that proposing an answer is a proof of willingness to assist the person asking. Therefore, our objective is to find the user capable to provide the most relevant answer.

The paper is organized as follows: in Section II, we present the general framework, starting by presenting social trust and computational trust. In II-B, we introduce subjective logic and some of its operators. In Section III, we describe both individual and collective trust models that we propose. In Section IV, we describe the used dataset, and present our evaluation method. In Section V, we discuss our results. Finally in Section VI, we present our conclusions and future work.

II. GENERAL FRAMEWORK

The objective of trust is to find the appropriate person to cooperate with in order to achieve a given task or context. Truster's decision about to cooperate or not is influenced by many factors such as: the context, the completeness his opinion about the trustee, the emergency of the task for him and many more. In the following section, we present a real life example about trust in order to explain this phenomena, and some factors that can influence the cooperation decision.

Suppose that Alice wants to paint her house. She publishes this information and receives three offers from three professional candidates (Eric, Fred and George) *willing* to do the job

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for her. She already knows Eric because he painted her clinic sometime ago. Alice does not know neither Fred nor George. If Alice is satisfied by the job of Eric in her clinic, she might hire him for the house directly, and ignore the offers of Fred and George. Nevertheless, if Alice is perfectionist, she will investigate about them. Alice can ask her friends (Bob and Caroline) about Fred and George.

Suppose that Bob says that Fred is a good professional. Caroline says that she recently hired George to paint her house and she is not satisfied about his work, whereas her sister Diana has hired Fred and was satisfied. Note that even though Alice trusts Bob and Caroline, she will not ask any of them to paint her house, because she thinks that they *lack competence*. Even so, they are still capable to play an important role as advisers or recommenders.

After the suggestions of Bob and Caroline, Alice will eliminate George and choose between Eric and Fred.

In this scenario, Alice asked her friends only about the candidates that she herself does not know. The scenario could have been changed if she asked them also about Eric. Bob could say for example that Eric is good for concrete walls used in Alice's clinic, but he is not very competent for wooden walls like those of Alice's house. This information can be sufficient to convince Alice to hire Fred instead of Eric.

This example shows the limit of direct interactions manner, and that the word of mouth may be useful to enrich the knowledge of the truster about the trustee. It can lead to sharpen his decision even when he thinks that his own acquired knowledge is sufficient to take a decision.

Furthermore, this scenario allow us to distinguish four types of trust relationships; these types are also discussed in [4]:

1) Direct trust: trust is the result of interactions between exclusively the truster and trustee, such as the relations "Alice Bob" and "Alice Eric".
2) Indirect trust: the two persons do not know each other. Trust is established due to trustee intermediate persons, such as the relation "Alice Fred".
3) Functional trust: the expectation of the truster is that the trustee accomplishes the task himself, such as the relation "Alice Eric", "Alice Fred" and "Alice George".
4) Referential trust: the expectation of the truster is that the trustee will recommend someone to accomplish the task, such as the relation "Alice Bob" and "Alice Caroline". Note that the recommendation of Caroline is also based on her referential trust in her sister Diana. In other words, no obligation for the trustee in referential trust to base his recommendation on a functional trust relation. Normally a series of referential trust relations must end with one functional trust relation [9].

Fig. 1 illustrates the trust network used by Alice to make her decision.

In the next section, we discuss the formalization of social trust for the social web, and compare the different models that exist.

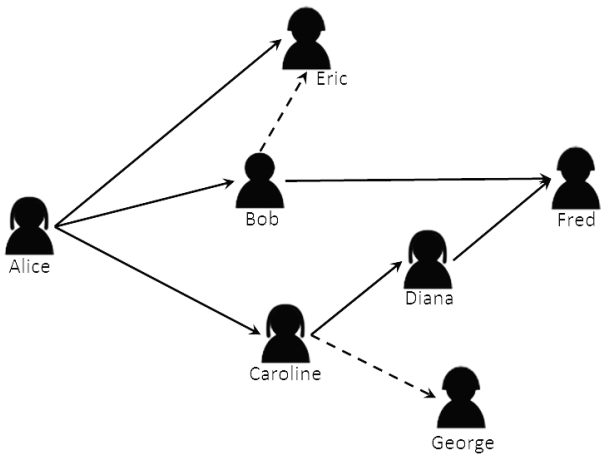

Fig. 1: Trust network

A. Computational trust

Computational trust raised in the last decade to ensure trust awareness in intelligent systems. It usually consists of a formalization of social trust adjusted to specific context and application. Basically, computational trust has three axes [10]:

- Quantitative, also called global-trust or reputation: the system computes a score for each user, this score represents his global trustworthiness. This score is considered when any other user needs to interact with this user [11].
- Qualitative, also called local-trust or relationship: it takes into account the personal bias. It is represented as user to user relationship. It is the trustworthiness of a user Y from the point of view of one single user X [11].
- Process driven (system): it represents the trust of the users in the system [10].

This work focuses on the qualitative axes. Most local trust models [1], [12], [13], [14] tend to formulate local trust problem in the form of a trust network. A trust network is a directed weighted graph where vertices represent users and edges represent trust relationships. Models differ by their notation of edges, and their strategies in traversing the network to compute trust between two unconnected users. This operation is called Trust propagation. It is fundamental in local trust models, as it allows to estimate how much a user A (called source node) should trust a user B (called destination node).

Computational trust is applied to many fields in artificial intelligence, recommender systems, file sharing, Spam detection, networks security, etc. Most computational models are fitted to their application fields and context. Basically, we identify two categories. Models dealing only with trust relationships, and models dealing with trust and distrust relationships.

The first category contains numerous models such as[15], [16], [17], [18], [19], [20]. The main disadvantage of this category is that models do not distinguish between distrusted and unknown persons. Social systems have to give chances to

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new and unknown users to prove their trustworthiness, whereas it must be more severe in blocking distrusted and malicious users [21]. Unknown users are often new users, a system unable to distinguish them from distrusted users risk to be very severe with them, so discourage the evolution of the trust network, or to be so tolerant even with distrusted users, so less efficient.

Models in the second category distinguish between unknown and distrusted people. Models in [22], [23], [24], [4], [25], identify three possible cases: trust, distrust and ignorance. Authors in [25] classify these models into two groups; gradual models [22], [23], [25] and probabilistic models [24], [4]. Gradual representation of trust is more similar to the human way in expressing trust, whereas probabilistic representation is more meaningful mathematically.

We use subjective logic [4], [5] (SL) in our models. Our choice is motivated by many factors. SL considers trust ignorance and distrust relationships, which is compatible with our need to distinguish between unknown and distrusted people. Most other trust models consider the creation and the evolution of trust links as an external issue, they describe and deal with existing links. SL is more transparent about this issue, trust relationships in SL are based on the accumulation of interactions between a couple of users. It proposes many operators that allow to integrate many aspects and factors of trust, which make it one of the most generic and flexible trust models.

It is based on the belief theory [6], [7] which offers the capacity to aggregate many beliefs coming from many sources (even contradictory ones), which corresponds to the case when a user has to aggregate the opinions of many friends of him about a given problem.

The following section II-B is dedicated to explain the structure and some operators of subjective logic.

B. Subjective logic

Subjective logic (SL) [5] is an extension of probabilistic logic, which associates each probability with a degree of uncertainty. Subjective logic allows to build models that treat with situations of incomplete evidences.

Belief theory [6], [7] is a special case of probability theory dedicated to treat incomplete knowledge. The sum of probabilities of possible cases can be less than 1. Subjective logic [26] offers a belief calculus using a belief metrics called opinion. The opinion of an individual U about a statement x is denoted by:

$$\omega_x^U = (b, d, u, a)$$

where: $b, d, u \in [0, 1]$ are respectively the belief, disbelief and uncertainty of U about x. The sum of the three values equals to one (i.e $b + d + u = 1$). Base rate $a \in [0, 1]$ is the prior probability. Basically, base rate is a statistical measure applied in cases of evidences' absence. For example, when we know that the percentage of a disease x in a given population is 1%, then the base rate of x's infection is 1%. When we meet a new individual who did not make a test for the disease, a priori we assume that the probability that he is infected is 1%. In social trust cases, while no a priori statistics are present, we consider that unknown person has a half chance to be trustworthy. So we use a base rate $a = 0.5$. In subjective logic, the base rate steers the contribution of the uncertainty in the computation of the probability expectation value according to 1:

$$E(\omega_x^U) = b + a \times u \tag{1}$$

The opinion in subjective logic is based on the accumulation of successful and failed experiences. After each experience, U updates his opinion about x consistently with experience's outcome. According to this description, opinion can be represented as a binary random variable. Beta distribution is normally used to model the behaviour of this kind of variables. By consequence, the opinion corresponds to the probability density function (PDF) of beta distribution. PDF is denoted by two evidence parameters α and β that can be written as functions of the number of successful and failed experiences respectively.

$$\begin{aligned} \alpha &= r + W \times a \\ \beta &= s + W \times (1 - a) \end{aligned} \tag{2}$$

where r is the number of successful experiences (evidences). s is the number of failed experiences. W is the non-informative prior weight which ensures that the prior (i.e., when r = s = 0) Beta PDF with default base rate a = 0.5 is a uniform PDF (normally $W = 2$).

The expectation value of beta PDF is:

$$E(Beta(p|\alpha, \beta)) = \frac{\alpha}{\alpha + \beta} = \frac{r + Wa}{r + s + W} \tag{3}$$

In subjective logic, the mapping between the opinion parameters and the beta PDF parameters is given as follows:

$$b = \frac{r}{(r + s + W)} \tag{4}$$

$$d = \frac{s}{(r + s + W)} \tag{5}$$

$$u = \frac{W}{(r + s + W)} \tag{6}$$

Table I shows an example of the evolution of an opinion with successive interactions.

TABLE I: Opinion evolution with successive interactions

No	state	r	s	belief	disbelief	uncertainty
0	no interaction	0	0	0	0	1
1	successful interaction	1	0	1/3	0	2/3
2	failed interaction	1	1	1/4	1/4	2/4
3	successful interaction	2	1	2/5	1/5	2/5

In the first line of Table I, we see the case of absence of evidences (experiences). The opinion is completely uncertain $(u = 1)$. In this case, according to 1, the expectation value equals to the base rate value. The arrival of new experiences, will make the uncertainty decreases, regardless if these experiences are successful or failed. Successful experiences will

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augment the belief, whereas failed experiences will augment the disbelief.

Subjective logic opinions can be illustrated in the interior of an equilateral triangle. The three vertices of the triangle are called belief, disbelief, and uncertainty. The uncertainty axis links the uncertainty vertex with the opposite edge (the belief-disbelief edge), the uncertainty value of the opinion is plotted on this axis considering that its contact with the edge belief-disbelief represents the value 0, whereas the contact with the uncertainty vertex represents the value 1. In the same way we describe the belief and the disbelief axis.

The opinion is represented by the intersection point of the three projections on the three axis (belief, disbelief and certainty) as shown in the example in Fig. 2. The bottom of the triangle is the probability axis, the probability expectation value is the projection of the opinion point on the probability axis with respect to the line linking the uncertainty vertex with the base rate point on the probability axis. Fig. 2 illustrates an example of opinion mapping in subjective logic. The opinion is represented by a point inside the triangle. The point is the intersection of the projection of the three values b, d, and u on the axis of belief disbelief and uncertainty respectively. the probability expectation value $E(x)$ is the projection of ω_x on the probability axis directed by the axis linking a_x with the uncertainty edge.

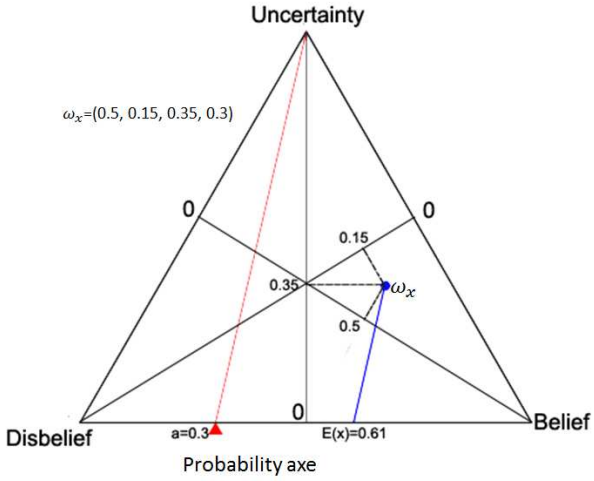

Fig. 2: Subjective logic Opinion

Note that changing the value of base rate can make people more reckless or more cautious.

After defining the structure of the opinion in subjective logic, we need to explain some of subjective logic operators that are useful for building trust network. Local trust networks are usually represented by a direct graph, where vertices represent users, and edges represent trust relations. Consequently, computing trust value between two users is reduced to finding a path or more connecting them to each other.

1) Trust transitivity: If an individual A trusts another individual B, and B trusts C, trust transitivity operator is used to derive the relation between A and C.

Subjective logic proposes the uncertainty favouring transitivity. This operator enable the user A to receive the opinion of a friend C of his trustee friend B, or to ignore the opinion of B in case of A distrust B. Formally the operator is given by 7

$$\omega_B^A = b_B^A, d_B^A, u_B^A, a_B^A$$
$$\omega_C^B = b_C^B, d_C^B, u_C^B, a_C^B$$

$$\omega_B^A \otimes \omega_C^B = \begin{cases} b_C^{A:B} = b_B^A.b_C^B \\ d_C^{A:B} = b_B^A.d_C^B \\ u_C^{A:B} = d_B^A + u_B^A + b_B^A.u_C^B \\ a_C^{A:B} = a_C^B \end{cases} \quad (7)$$

2) Opinion fusion: Suppose in the previous example that A has another trustee friend D who also trusts C. A has two separate sources of information about C.

Subjective logic proposes two main types to fuse B's and D's opinions about C:

$$\omega_B^C \underline{\oplus} \omega_D^C = \begin{cases} b_{B\diamond D}^C = \frac{b_B^C.u_D^C + b_D^C.u_B^C}{u_B^C + u_D^C - u_B^C.u_D^C} \\ d_{B\diamond D}^C = \frac{b_B^C.u_D^C + b_D^C.u_B^C}{u_B^C + u_D^C - u_B^C.u_D^C} \\ u_{B\diamond D}^C = \frac{u_B^C + u_D^C}{u_B^C + u_D^C - u_B^C.u_D^C} \end{cases} \quad (8)$$

This operator allows the user to aggregate the opinions of his trustee friends, regardless if their opinions were contradictory or not.

III. Proposed Models

The aim of our models is to predict the most relevant answer to a given question within a list of answers. Basically, trust models consider that the question owner will trust more the answers written by trustworthy people, so they try to retrieve these users. We have developed two trust aware models. Both of them use subjective logic. We refer to them as individual trust model (ITSL), and collective trust model (CTSL). ITSL is a classical local trust model, so it exploits only individual opinions when they are available, otherwise it exploits collective opinions. CTSL exploits collective opinions all the time.

A. Individual trust subjective logic (LTSL)

This model is basically based on the model proposed in [4]. It consists of building a local trust network between users. The edges of this network are SL opinions of users about each other. Formally, we represent the trust network as a graph $G = (V, E)$ where V represents the set of vertices (users), and E represents the set of edges (direct trust relationships). Suppose that a user a asks a question q, a set of users $\mathcal{R}$ will propose many answers to him. The aim of the trust model is to compute a score for each user $r \in \mathcal{R}$ using the trust network. The trust model estimates that a will accept the answer proposed by the highest score member of $\mathcal{R}$. Local trust computes the score according to 9:

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$$score(r) = \begin{cases} e(a,r) & if\ e(a,r) \in E \\ \sum\limits_{j} \underline{\oplus}[e(a,f_j) \otimes e(f_j,r)] & elsewhere \end{cases} \quad (9)$$

where: $e(a,r)$ is the direct opinion (edge) of a in r.
f_j is a member of F, the set of the direct friends of a, formally: $f_j \in F : \Longleftrightarrow\ e(a,f_j) \in E$.
$\Sigma_{0 \leq j \leq N} \underline{\oplus}$ is the aggregation of multiple (exactly N) opinions. Note that $e(f_j,r)$ itself can be composed of the opinions of the friends of f_j.

In stackoverflow, when a user A asks a question, he receives a list of answers from many users. A can accept only one answer. Unaccepted answers are not necessarily bad ones. They might be simply not good enough compared to the accepted one. They even might be better but arrived too late and A has already accepted another satisfactory answer. Basically, while we do not have an explicit reaction from A towards the unaccepted answers, we suppose four hypotheses to treat them:

1) rigorous hypothesis: unaccepted answers are considered as failed interactions.
2) ignoring hypothesis: unaccepted answers are not considered at all.
3) independent subjective hypothesis: in both previous methods, the interaction value is either +1 (successful), or -1 (failed). In this method, we introduce relatively successful/failed interactions. We use the rates of community towards the answer to estimate a subjective successful/failure of the interaction. In fact, the thumb-up represents a successful interaction with an unknown user, same thing for the thumb-down with a failed interaction. The global reaction of the community towards the answer is subjective opinion resulting from members' interactions with the answer. We consider the expectation value of the community's opinion as the value of the partially successful/failure of the interaction between the person asking and the replier.
4) dependent subjective hypothesis: regarding to the fact that a user can give a thumb-up for an answer because it is better/worse than others, the attribution of thumb-up and thumb-down can be relative too. The reason why we propose another subjective method where our certainty is influenced by the global number of thumb-up and thumb-down attributed to all answers of the same question. In this case, the opinion about an answer is dependent on the the other opinions about the other answers.

$$Certainty_j = \frac{\sum_j th}{2 + \sum_{i=an_0}^{an_n} \sum_i th}$$

where th is an absolute value of thumb (up or down).
j is the current answer.
n is the number of answers of the current question.
The default non-informative prior weight W is normally defined as W = 2 because it produces a uniform Beta PDF in case of default base rate a = 1/2.

```
1: procedure INDIVIDUALTRUST(A, B)
2:     if (e(A,B) ∈ E) then
3:         return e(A,B)
4:     else
5:         e(A,B) ← e(0,0,1)                ▷ a neutral opinion
6:         for all f ∈ A.friends do
7:             e(A,B) ← e(A,B) ⊕ [e(A,B) ⊗ e(f,B)]
8:         end for
9:         return e(A,B)
10:    end if
11: end procedure
```

Fig. 3: Individual trust function

The three components of the opinion are:

$$belief_j = uncertainty_j \times \frac{\sum_j th_{up}}{\sum_j th}$$

where $\sum_j th_{up}$ is the number of thumbs up attributed to the answer.

$$disbelief_j = uncertainty_j \times \frac{\sum_j th_{down}}{\sum_j th}$$

where $\sum_j th_{down}$ is the number of thumbs down attributed to the answer.

$$uncertainty_j = 1 - certainty_j$$

Finally we compute the expectation value of the resulting opinion and consider it as the value of the relative success/failure interaction.

To predict the accepted answer of a given question q asked by the user A, we identify $\mathcal{R}$ the set of users who contributed answers to the current question. Then, we traverse the graph (trust network) to compute the local trust between the owner of the question and each of them. We assume that A will accept the answer of the most trustee user within $\mathcal{R}$. According to this model, A consults his friends only about members of $\mathcal{R}$ with whom he has no direct interactions, otherwise considers only his own opinion. Consulted friends repeat the same strategy in consulting their friends. The drawback of this model is when A has only one interaction with a member r of $\mathcal{R}$, this might be not enough to evaluate him. A may have a friend B who has had many interactions with r so more apt to evaluate r. According to this model A will not ask B about his opinion in r.

The aim of A is to rank $\mathcal{R}$ by the trustworthiness of its members. Whenever he has no information about a member r of $\mathcal{R}$, A will ask his friends about their opinions in this very member. So the task of friends is to evaluate r without any farther information. The pseudo code 3 shows how this model works in demanding friends' opinions.

B. Collective trust

This model is based on collective opinions instead of personal opinions. In the previous model, collective opinions were used only in the case of absence of personal opinions. In this model, collective opinions are used in all cases. This

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```
1: procedure COLLECTIVETRUST((A, R))
2:     Declare scores[R]
3:     for all score ∈ scores do score = e(0, 0, 1)        ▷ neutral opinion
4:     end for
5:     for all (r ∈ R do
6:         if opinion(A, r) ∈ E then
7:             scores[r] = e(A, r) ⊗ scores(r)
8:         end if
9:     end for
10:    for all f ∈ A.friends do
11:        fscore = collectiveTrust(f, R)
12:        for all r ∈ R do
13:            scores[r] = scores[r] ⊕ fscore[r]
14:        end for
15:    end for
16:    return scores
17: end procedure
```

Fig. 4: Collective trust function

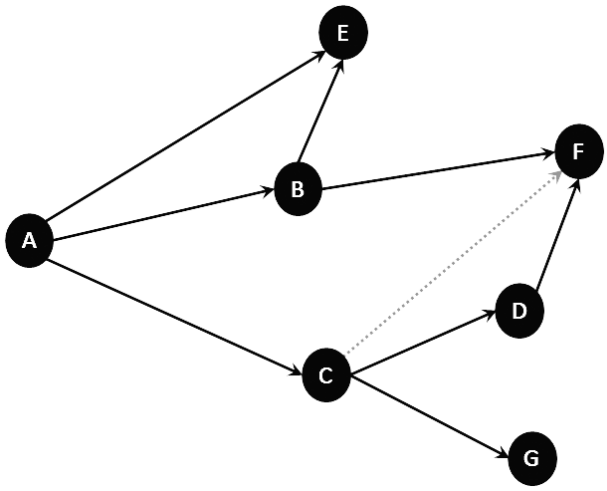

Fig. 5: Trust graph

semantically means that A will ask his friends about all the members of R, so even those who he already knows. Formally:

$$score(r) = \begin{cases} (a,r) \underline{\oplus} \sum\limits_j \underline{\oplus}[e(a,f_j) \otimes e(f_j,r)] \\ \qquad if\ e(a,r) \in E \\ \sum\limits_j \underline{\oplus}[e(a,f_j) \otimes e(f_j,r)] \\ \qquad elsewhere \end{cases} \tag{10}$$

This model assumes that direct interactions are frequently unable to assure sufficient information about users. In the previous model, user could supply a personal opinion about another user once he has at least one interaction with him. We think that this affects the quality of the opinion, because of the lack of experience. In the current model, user aggregate his opinion with the his friends' opinions, each friend's opinion is conditioned by the trust given to him by the active user.

Example:

Back to the same example in Section II. Fig. 5 illustrates trust network extracted from the described relations in the example. So when A asks a question to which she get replies from E, F and G, then $\mathcal{R} = E, F, G$. A needs to rank the members of $\mathcal{R}$ to identify the most trustworthy member.

For the individual trust model, scores are computed as follows:

score(E)= e(A,E)

score(F)= [e(A,B) $\otimes e(B,F)]\underline{\oplus}[e(A,C) \otimes e(C,D) \otimes e(D,F)]$

score(G)= e(A,C) $\otimes e(C,G)$

As for the collective trust model, the scores of F and G do not change, but the score of E becomes as follows:

score(E)= e(A,E) $\underline{\oplus}$ [e(A,B) $\otimes e(B,E)]$

Now let us add a link between C and F, and see the effect of such a link:

In individual trust model:

score(F)= [e(A,B) $\otimes e(B,F)]\underline{\oplus}[e(A,C) \otimes e(C,F)]$

In collective trust model:

score(F)= [e(A,B) $\otimes e(B,F)]\underline{\oplus}[[e(A,C) \otimes e(C,F)]\underline{\oplus}[e(A,C) \otimes e(C,D) \otimes e(D,F)]]$

Once again, we see that in individual trust model, when A asks C about his opinion in F, as C has a direct link with F, he his response to A is based only on this direct link. Whereas in collective trust model, for the same case, C asks D about this last's opinion about F, and return to A the aggregation of the opinion D conditioned by the trust between C and D, and C's own opinion.

IV. EXPERIMENTAL WORK

We use the dataset of the website stackoverflow. The website offers a question answering forum for multiple domains, mainly but not limited to computer science. The available data contains 30 domains. Users subscribe to the website by domain, so one user can have multiple accounts, according to the number of domains in which he participates. The total number of accounts is 374,008 for about 153,000 users.

The user asks a question in a given domain, and associates a set of keywords to his question, then he receives many answers. He chooses the most relevant answer to him and attributes an "accepted answer" label to it. Nevertheless, users can keep proposing new answers. Subsequent users who have the same problem as the person asking can take advantage of the answers and rate them on their usefulness by attributing thumb-up or thumb-down. In the available dataset, we have access to only the total number of thumbs-up and the total number of thumbs-down an answer has, but no information about suppliers' identities. The website, offers the possibility to order answers by relevance, where the accepted answer is put in the top of the list, followed by the other answers ordered

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by the difference between thumbs-up count and thumbs-down count. Our work aims to use trust based models to predict the accepted answer over the set of available answers. Total number of questions in current dataset equals to 371,594, for a total number of answers 816,487. We divide the questions of each domain in five equivalent sets. Then, we apply a crossing test in five iterations, in each iteration we use four sets for learning and building the trust network and the fifth for testing the prediction quality.

Evaluation Metrics

We consider the problem of finding the accepted answer as a list ranking problem with one relevant item. Mean reciprocal rank (MRR) is a quality metrics used to evaluate systems that have to give out a ranked list with only one relevant item. Reciprocal rank (RR) of question is $1/r$ where r is the rank given by the evaluated algorithm to the accepted answer. Mean reciprocal rank is the mean value of RR's to all questions. The value of this metrics varies between 0 and 1, where 1 is the best precision score.

MRR is a good indicator to the performance of prediction algorithms for ranked lists. Nevertheless, we think that it is not perfectly adapted to our case. MRR is usually used for systems that have to predict a list of items within which a relevant item exists. We are trying to find the accepted answer by re-ranking an existing list of answers. Remark the case when the algorithm ranks the relevant item in the last position of the list, the algorithm is recompensed for at least having chosen the item within the list. In our case, the list is predefined, so the algorithm should not be recompensed for ranking the relevant item at the end of the list. The range of RR values is $[1/r, 1]$, we propose a modified version where the value varies between 1 if the relevant item is in the top of the list, and 0 if it is at the end of the list. We call this metrics mean predefined lists rank (MPLR), where predefined lists rank PLR is given by the formula:

$$PLR = \frac{N - r}{N - 1}$$

where: N is the size of the list.

MPLR is the average of PLRs for all questions. We employ a modified competition ranking strategy, so the ranking gap is left before the *ex aequo* items. For example if two items on the top of the list have the same score, they are considered both second, and no item is put at the top of the list.

V. Results and discussions

Only questions with accepted answer and more than one proposed answer are appropriate for our test. The corpus contains 118,778 appropriate questions out of the 371,594 questions of the corpus.

Table II illustrates the MRR scores of both models, and table III illustrates MPLR scores. MPLR scores are, of course, lower than those of MRR. Nevertheless both tables lead to the same conclusions.

It is obvious that the collective trust has a considerably better performance than individual trust on this dataset. This is because of collective opinions that rely on more complete evidences than individual ones. Trustee friends enrich collective opinions by more knowledge that leads them to be more reliable and accurate than individual ones. These results show the limit of individual opinions and local relationships, because direct interactions can be poorly informative, and relying only on them can lead to inaccurate decisions. An individual in a social environment needs always to integrate and interact within communities to be more informed, and more capable to adjust his decisions.

TABLE II: MRR results

method	Individual trust SL	Collective trust SL
Rigorous	0.57	0.88
Ignoring	0.58	0.75
Dependent probabilistic	0.62	0.87
Independent probabilistic	0.617	0.86

TABLE III: MPLR results

method	Individual trust SL	Collective trust SL
Rigorous	0.37	0.85
Ignoring	0.36	0.69
Dependent probabilistic	0.442	0.84
Independent probabilistic	0.438	0.83

In real life, regret can assist to re-establish trust. The structure of local trust systems does not possess any mechanism to reconsider relationship after a bad integration with a destination user (which can be occasional), collective opinions allow the reconsideration of the relation with this user if he was trustee by intermediate friends of source user.

Regarding the four hypotheses about treating unaccepted answers in individual trust, we find that probabilistic methods are slightly better than both rigorous and ignoring hypotheses. In the collective trust model, the three hypotheses that try to infer from unaccepted answers surpass the performance of the forth that neglects these information (ignoring hypothesis). We conclude that unaccepted answers can be profitable, and then should not be neglected. Extracting information from these answers is possible thanks to the flexibility of subjective logic. This framework proves again its capability to deal with incomplete evidence cases.

On the other hand, in global trust, all users contribute in evaluating the trustworthiness of each user. A unique score is attributed to each user. The score is based on all his interactions (as trustee), so a source user can access more information about the destination user (compared to collective trust). The disadvantage of global trust is its weakness against malicious group attack. If a group of malicious users cooperate to highly rate each other they can improve their reputation score and disturb the system [27].

Collective trust model can provide source users with more information about destination users compared to local trust, and it controls who can participate in computing the score of destination user. Theoretically, collective trust model is more resistant to group attack compared to global trust model. In addition, collective trust is user biased, this means that a destination user has not the same score every time, and that the score is dependent to the source user too.

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VI. Conclusion and future works

We showed in this paper the superiority of collective opinions over individual ones in a trust model. They are usually more complete, reliable and informative. So, depending on them, it leads the user to take more robust decisions.

The model proposed lies between local and global trust. Collective trust supplies its users with more complete information than classical local trust. Besides, it relies, theoretically, on more trustworthy information than global trust.

The first argument was proven experimentally on real dataset in this work. Our future work will focus on comparing the performance of a collective trust model and global trust model, when injecting malicious group attacks in the dataset.

References

[1] P. Massa and B. Bhattacharjee, "Using trust in recommender systems: an experimental analysis," *Trust Management*, p. 221235, 2004. [Online]. Available: http://www.springerlink.com/index/TFCG7W34VF58YAWL.pdf

[2] J. A. Golbeck, "Computing and applying trust in web-based social networks," Ph.D. dissertation, University of Maryland at College Park, College Park, MD, USA, 2005, AAI3178583.

[3] S. D. Kamvar, M. T. Schlosser, and H. Garcia-Molina, "The eigentrust algorithm for reputation management in P2P networks," in *Proceedings of the 12th international conference on World Wide Web*, ser. WWW '03. New York, NY, USA: ACM, 2003, p. 640651. [Online]. Available: http://doi.acm.org/10.1145/775152.775242

[4] A. Josang, R. Hayward, and S. Pope, "Trust network analysis with subjective logic," in *Proceedings of the 29th Australasian Computer Science Conference-Volume 48*, 2006, p. 8594. [Online]. Available: http://dl.acm.org/citation.cfm?id=1151710

[5] A. Josang. (2013, Sep.) Subjective logic. [Online]. Available: http://folk.uio.no/josang/papers/subjective_logic.pdf

[6] A. Dempster, "The DempsterShafer calculus for statisticians," *International Journal of Approximate Reasoning*, vol. 48, no. 2, pp. 365–377, 2008.

[7] R. R. Yager, J. Kacprzyk, and M. Fedrizzi, Eds., *Advances in the Dempster-Shafer theory of evidence*. New York, NY, USA: John Wiley & Sons, Inc., 1994.

[8] (2013, Sep.) Stack overflow website (data collected in sep 2011). [Online]. Available: http://stackexchange.com/

[9] A. Josang and S. Pope, "Semantic constraints for trust transitivity," in *Proceedings of the 2nd Asia-Pacific conference on Conceptual modelling-Volume 43*, 2005, p. 5968. [Online]. Available: http://dl.acm.org/citation.cfm?id=1082284

[10] M. Kwan and D. Ramachandran, "Trust and online reputation systems," in *Computing with Social Trust*, ser. HumanComputer Interaction Series, J. Golbeck, Ed. Springer London, Jan. 2009, pp. 287–311. [Online]. Available: http://link.springer.com/chapter/10.1007/978-1-84800-356-9_11

[11] C. N. Ziegler and G. Lausen, "Spreading activation models for trust propagation," in *e-Technology, e-Commerce and e-Service, 2004. EEE'04. 2004 IEEE International Conference on*, 2004, p. 8397.

[12] A. Abdul-Rahman and S. Hailes, "Supporting trust in virtual communities," in *Proceedings of the 33rd Annual Hawaii International Conference on System Sciences, 2000*, Jan. 2000, p. 9 pp. vol.1.

[13] K. Krukow, *Towards a Theory of Trust for the Global Ubiquitous Computer: A Dissertation Presented to the Faculty of Science of the University of Aarhus in Partial Fulfilment of the Requirements for the PhD Degree*. Department of Computer Science, University of Aarhus, 2006.

[14] L. Mui, *Computational Models of Trust and Reputation: Agents, Evolutionary Games, and Social Networks*. PhD Thesis, Massachusetts Institute of Technology, 2002. [Online]. Available: http://www.cdm.lcs.mit.edu/ftp/lmui/computational%20models%20of%20trust%20and%20reputation.pdf

[15] W. Tang, Y.-X. Ma, and Z. Chen, "Managing trust in peer-to-peer networks," *Journal of Digital Information Management*, vol. 3, no. 2, p. 58, Jun. 2005. [Online]. Available: http://www.questia.com/library/1G1-186470835/managing-trust-in-peer-to-peer-networks

[16] M. Richardson, R. Agrawal, and P. Domingos, "Trust management for the semantic web," in *In proceedings of the second international semantic web conference*, 2003, p. 351368.

[17] I. Zaihrayeu, P. P. D. Silva, D. L. Mcguinness, I. Zaihrayeu, P. Pinheiro, S. Deborah, and L. Mcguinness, "IWTrust: improving user trust in answers from the web," in *Proceedings of 3rd International Conference on Trust Management (iTrust2005*. Springer, 2005, p. 384392.

[18] R. Falcone, G. Pezzulo, and C. Castelfranchi, "A fuzzy approach to a belief-based trust computation," in *Lecture Notes on Artificial Intelligence*. Springer-Verlag, 2003, p. 7386.

[19] F. Almenrez, A. Marn, C. Campo, and C. G. R, "PTM: a pervasive trust management model for dynamic open environments," in *First workshop on pervasive security, privacy and trust PST04 in conjuntion with mobiquitous*, 2004.

[20] J. O'Donovan and B. Smyth, "Trust in recommender systems," in *Proceedings of the 10th international conference on Intelligent user interfaces*, 2005, p. 167174. [Online]. Available: http://dl.acm.org/citation.cfm?id=1040870

[21] R. Burke, B. Mobasher, R. Zabicki, and R. Bhaumik, "Identifying attack models for secure recommendation," in *Beyond Personalization: A Workshop on the Next Generation of Recommender Systems*, 2005. [Online]. Available: http://maya.cs.depaul.edu/mobasher/papers/sp-iui05.pdf

[22] M. De Cock and P. P. da Silva, "A many valued representation and propagation of trust and distrust," in *Proceedings of the 6th international conference on Fuzzy Logic and Applications*, ser. WILF'05. Berlin, Heidelberg: Springer-Verlag, 2006, p. 114120. [Online]. Available: http://dx.doi.org/10.1007/11676935_14

[23] R. Guha, R. Kumar, P. Raghavan, and A. Tomkins, "Propagation of trust and distrust," in *Proceedings of the 13th international conference on World Wide Web*, 2004, p. 403412. [Online]. Available: http://dl.acm.org/citation.cfm?id=988727

[24] U. Kuter and J. Golbeck, "Using probabilistic confidence models for trust inference in web-based social networks," *ACM Trans. Internet Technol.*, vol. 10, no. 2, p. 8:18:23, 2010. [Online]. Available: http://doi.acm.org/10.1145/1754393.1754397

[25] P. Victor, C. Cornelis, M. D. Cock, and P. P. D. S. B, "Gradual trust and distrust in recommender systems. fuzzy sets and systems," in *In press*, 2009.

[26] A. Josang, "A logic for uncertain probabilities," *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, vol. 9, no. 03, p. 279311, 2001. [Online]. Available: http://www.worldscientific.com/doi/abs/10.1142/S0218488501000831

[27] B. Mobasher, R. Burk, R. Bhaumik, and C. Williams, "Toward trustworthy recommender systems an analysis of attack models and algorithm robustness.pdf," vol. 7, no. 4, 2007. [Online]. Available: http://doi.acm.org/10.1145/1278366.1278372

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