Role of User Profile in Cloud-based Collaboration Services for Innovation

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***Abstract*—Enterprises are evolving their businesses from silo-based knowledge to collaborative-based knowledge by promoting open innovation through collaboration in to their technology infrastructure. Despite of being a prevailing trend, enterprises are not quite willing to embrace the collaboration into their working environment. This unwillingness is due to number of technical obstacles including user profiling, balancing of open and close collaboration and trust establishment. Therefore, the paper tries to address these impediments by contemplating collaborative enterprise computing approach that creates the network of enterprises for enabling the active, automated and trusted inter-enterprise collaboration. We propose a privacy-enhanced innovation framework that eases off the innovation process in an open and control manner. The framework does not only allow enterprise employees to create a user profile but also encourage them to initiate innovation activity by registering their novel ideas, which later can be realized in the form of business opportunity. We select an "innovation stock exchange" case study in order to apply the proposed approach. Furthermore, we intend to implement the framework in the form of cloud services that are interoperable with any enterprise collaboration platform.**

***Keywords*-Cloud Computing, Collaboration, Enterprise, Innovation, Privacy, Social Computing, Trust, User Profile**

I. INTRODUCTION

While open innovation is a prevailing trend that could spur new business opportunities, but enterprises are reluctant to adopt and invest in open innovation initiatives due to the risk factors associated with it. Most of the enterprises consider such initiatives as potential channel of loss of knowledge, control and core competencies, which in turns could negatively impact the enterprise long term innovation life cycle. However, success of consumer based social computing compels the enterprises to tend towards collaborative knowledge environment where the inter-enterprise boundary line is becoming indistinct by braking the silos. Today, collaboration is invertible for an enterprise in order to meet the rapid and dynamic demands of the businesses. Recently, HP Labs started the initiative to conduct open innovation by establishing the Innovative Research Program (IRP) between universities, enterprises and governments [1]. This fosters the collaboration among different participants in the form of sharing new ideas, enabling people to work across enterprise boundaries. It creates opportunities for capturing relevant knowledge, expertise so that innovative products and services could be introduced to the market. Initial indicators from HP Labs show that active collaboration helps in augmenting and accelerating knowledge creation and technology transfer, and the result of IRP is 179 papers and 34 HP patent disclosures in just three years [1].

Bringing innovation through collaboration is relied on enabling tool sets that allow enterprises to collaborate beyond their perimeter in a trusted open environment. Mostly, enterprises use email as an enabling tool for collaboration, where the new idea owner invites others through email to provide feedback and collaborate on its innovative idea that could be realized to a business opportunity by involving some external partners. This approach limits the collaboration space to the personal contacts of the idea owner within and outside of the enterprise. It is highly probable that the most suitable partners will be missed since they are not in direct contact of the idea owner.

In order to foster an active collaborative environment, enterprises can benefit from social computing platforms because these platforms promote sharing and openness within communities. These platforms offer different functionalities such as sharing of knowledge and idea, displaying recent activities of people, showing contacts and skills of people, and providing a list of colleagues and friends from social network sites. Enterprises are also considering social computing platforms to communicate with their customers and inform them about new services and releases. This does not only bring value and uptake for their business in the form of enhanced productivity and revenue, but also provides customers with the benefits of receiving services that are pertinent to their preferences. A survey report from McKinsey Global indicates that enterprises have gained high-business benefits by integrating social computing platforms in their working environment [2]. A range of studies [3][4][5] pointed out the significant of social computing, but only few [6][7] addressed the challenges and opportunities of social computing in an enterprise environment. Though enterprises can possess significant benefits from consumer based social computing platforms such as Facebook, but stringent security and privacy requirement of an enterprise does not foster use of such platform for collaboration. This amplifies the need of equipping innovation platform with corporate social computing platforms so that stringent enterprise security and privacy requirements can be enforced. Current state-of-art collaborative platforms, such as Microsoft's SharePoint and IBM's Lotus, only support

intra-enterprise collaboration and deficit in providing collaboration beyond the enterprise perimeter. However, extending collaboration space beyond the enterprise perimeter brings some new research challenges, which needs to be addressed. First one is the user profiling, which is the foundation of the multitude of functionalities within any collaborative platform. User profile is the core for automated collaboration for any enterprise. It allows to perform different numbers of interesting scenarios, including people search based on their expertise, target content push towards users to accelerate the knowledge sharing. User profiles are essential for an enterprise, containing information about the people working in an organization and helping to obtain appropriate information about people's skills, education, and contacts. As user profiles are not linked, it is not possible to reuse existing user profile on any other site. Even state-of-art social computing platforms do not facilitate any mechanism for linking user profiles to objects such as people, device, data and sensors. Second one is balancing of open and close collaboration for innovation in a user-centric way by specifying collaboration criterion. We envisage that the future lies in an innovation process that are under perceived control of each innovation initiative owner. In many cases, enterprises do not willing to share knowledge with certain competitors in order to serve the increasing demands of shorter innovation life cycle, and create successful products faster than their competitors to protect their business. This leads to third challenge of establishing trust and forming trusted virtual enterprise, connecting a number of autonomous enterprises that collaborate to achieve either a common business goal or to form a virtual market place.

In this paper, we propose a privacy-enhanced collaborative framework for an enterprise that operates in an open-controlled environment. The proposed approach aims at easy and automated collaborative process within and beyond enterprises perimeter for bringing innovation by sharing knowledge and technology transfer. The idea is to form an innovation cloud by leveraging the cloud computing that facilitate and speed up the innovation life cycle. This provides an entry point especially to SMEs and making them active part of the innovation process. The proposed framework comprises of three-components: Access Manager (AM), Collaboration Ensembler (CE) and Collaboration Criterion Manager (CCM). The framework supports user profile management and enables enterprises employees to register their profiles. It further allows them to initiate any novel idea or business opportunity. The user profiles and ideas are backed up with profile and idea database whose schema is structured though semantic enhanced models which are specified in the form of user profile ontology, trust ontology and idea ontology.

The rest of the paper is structured as follows. Section *II* discusses related work. Section *III* outlines the collaboration enterprise computing approach. Section *IV* provides details of the case study where proposed approach is employed. Section *V* discusses how automated collaboration can be enabled in an enterprise environment. Section *VI* presents the details of proposed framework. Section *VII* provides the road map to realized proposed framework in the form of cloud services and integrate those services with existing enterprise collaboration platforms. We conclude the paper in Section *VIII*.

II. Related Work

This section presents the overview of prior work in the area of user profiling, and cloud-based collaboration computing.

A. User Profiling

Social Network sites such as Facebook, Orkut, and MySpace allow people to share their interests, social information and contents among their friends or group of friends. It had been seen in the very beginning that the information which is stored on social network sites are not under the user control. All the information is owned or controlled by database owner. The profiles which contains user's personal information and attributes are typically cannot be exported in machine processable formats. The lack of machine understandability is a big hindrance in data portability and transformation between systems.The aforementioned drawbacks can be resolved with the advent of semantic technologies [8], more specifically the Friend of a Friend (FOAF) project [9] which was initiated by Dan Brickley and Libby Miller in 2000. Friend of a Friend (FOAF) contains RDF vocabulary for expressing user personal information (i.e., homepage, interest, friends, etc.) to create FOAF profiles which are shared among people in a distributed manner. FOAF profiles are posted on personal web site of the user and linked from the user's homepage. FOAF profiles are static in nature and contains only one term "knows" for describing social relationships. FOAF profiles also contain only one term "interest" for describing user's interest in a specific topic. FOAF profiles does not provide any vocabulary for capturing user's context. Hence, FOAF profiles are only for describing and linking people and things but not best suited to address user profile for personalized and context-aware service delivery.

Gosh et. al. present technique of creation and discovery of user profile [10]. The discovery of appropriate user profile for specific service is addressed by considering the user sparse information and context-awareness impact while accessing services.Dynamically construction of user profile is done by Profile Mediator and Constructor that receives desired user profile information for requesting services. The user profile ontology is defined in OWL by reusing FOAF vocabulary. Thus, it inherits the same aforementioned FOAF limitations.

The 3rd Generation Partnership Project (3GPP) is a major standardization body dealing with future 3G networks and services. The Generic User Profile (GUP) spcecification [11] is one of the 3GPP initiative to provide personalized services delivery within the operators domain. The GUP aggregates user related information such as user description, user services, and user devices to provide personalized service delivery in a standardized manner. GUP defines a global schema of the user profile in XML. Though, GUP is a well-known specification for user profiling but it lacks the enrichment of user profile and since it is based on XML so it cannot provide any intended

meaning to associated data and only constrain the structure of GUP profile.

Stann et. al. presents user profile ontology [14] which is inspired by the SPICE project [15]. A dynamic, situation aware user profile ontology is represented which enables real time situation awareness of the user and to express the social network related preferences in situational sub-profiles.The preferences are only limited to how a person's friend or category of friend can reach him in a specific situation and how Services (vibrate, ring, voice message) can inform or notify him from a mobile phone.

The General User Model Ontology (GUMO) [12] is a notorious user profile ontology, represented using OWL. The GUMO inherits the UserML [13] approach where user profile is divided into triples. It contains some basic and useful information about user's characteristics, emotional state and some facts about user's personality. However, GUMO is quasi-static model where applications can retrieve and add information into the profile.

B. Collaboration and Cloud Computing

Rapid adoption of social computing not only brings a new collaborative and innovation business opportunity for enterprises but also leads to the issue of corporate privacy when the collaboration is formed within the trusted network. Mostly, studies shed light on the collaboration within the enterprise boundary by isolating their employees from the rest of the world. Some works have identified the significance of collaboration not only in the enterprise environment but also across the enterprise. In [16], authors analyze and compare the existing vocabularies as a promising source for expert finding framework. To make the finding simple and structure, they highlight several factors such as common machine readable formats, reusable vocabularies and support of enabling technologies for practical use cases. In [17], authors raise the advantage of using linked data as an evidence source of expertise by analyzing the traditional information retrieval approaches. They also described some disadvantages of the linked data on the basis of the results of their hypothesis. Marian Lopez proposed a PeopleCloud platform [18] that enables experts to collaborate from inside and outside organization. The platform helps organizations in completing their tasks more efficiently and also leverage the expert networks for future activities. They illustrated the platform capabilities by discussing knowledge acquisition in IT inventory Management and IT support domain. Their comparison shows that the knowledge acquisition either explicitly or implicitly has significance to enterprises working environment. In [19], authors propose a propagation-based approach in order to find an expert in social network. They consider people local information as well as their relationship between people for their experiment. Their results show that the relationship is a useful factor for precision in expert finding. Capuano. N presents the enterprise framework by using semantic web technologies, assisting enterprises for collaboration [20]. Their framework comprises several layers and, each layer performs their own task. For instance, data representation handles modeling of data and data storage layer collects all the data from the data representation layer. In [21], authors propose the secure collaboration platform for enterprises by pointing out the security requirements for the cloud environments. They employ web service policy framework for their platform as a service (PaaS) infrastructure in order to mitigate the security threats. The aforementioned studies are insufficient in dealing privacy challenges in collaborative enterprises environment. In this paper, our objective is to propose a framework that will address the privacy issue in collaborative enterprise environment. Furthermore, the framework is not only capable of managing semantic-enhanced user profiles but also provide open innovation mechanism, which assists enterprises in collaborating new idea and finding relevant partners having right expertise.

III. Collaborative Enterprise Computing Approach

Enterprises is growing and expanding their businesses globally where different people from different geographical locations connect, communicate and collaborate for achieving their business goals. In this scenario, enterprises require reduction in the cost of IT infrastructures without compromising their business values. Cloud computing assists enterprises on-demand resources provisioning where enterprises can exploit different cloud computing models such as Platform as a Services (PaaS), Infrastructure as a Services (IaaS) and Software as a Service (SaaS) according to their conditions for reducing the IT costs and increasing the productivity. Microsoft, IBM and Google are notorious cloud computing providers not only providing data and network infrastructure to the enterprises but also providing software and applications for ease of business work. For instance, word processing, document management, content management and spreadsheets are delivered to enterprises on-demand without buying and installing into their enterprise environment. Indicators show that enterprises are considering the adoption of cloud computing in their environment and its market is growing with estimate of approximately $60 billion by 2012 [22].

Cloud providers have already appraised value of collaboration by incorporating social computing into their services and application, which opens a new horizon of innovation. Such collaborative environment facilitate enterprises in two ways: 1) It allows people to share their knowledge and information between partners and co-workers 2) It captures feedback from customers about products and services. In this way, enterprises can make their business processes efficient by involving skillful and competence people in the right place at right time and improving the quality of products and services rapidly by getting the response from customers. Hence, the overall impact will be increased efficiency and agility in the enterprises working environment that could lead to the introduction of new services and products to the market.

With the globalization of businesses, enterprises are producing large volume of disparate data with a different format, which are located on different geographical locations. In the

larger interest of enterprises, such data require to be exposed to different trusted partners and co-workers. The exposure can be done on the basis of the relationship between enterprises and/or people. The semantic web technologies can be used as the glue that helps in providing meaning and linking to enterprise data, services and user profiles. With such semantic enhance descriptions it is possible to employ vertical search on a predefined topic to get relevant and precise search results. The in-built reasoning capabilities of semantic web enables the system to deduce new facts from the existing facts. Today, many enterprises are adopting semantic web technologies into their software development life cycle to bring intelligence and smartness in the decision-making process. The semantic web technologies are being implied in many areas such as enterprise information integration, content management, life sciences and e-government. According to the gartner, the user of semantic web technologies in corporate, called as corporate semantic web, will reduce costs and improve the quality of content management, information access, system interoperability, database integration and data quality [23].

In our vision, we amalgamate cloud computing, social computing and semantic web technologies to expand the collaborative environment across enterprises boundaries and we commonly referred to Collaborative Enterprise Computing (CEC) as depicted in Figure 1. This fusion benefits enterprises

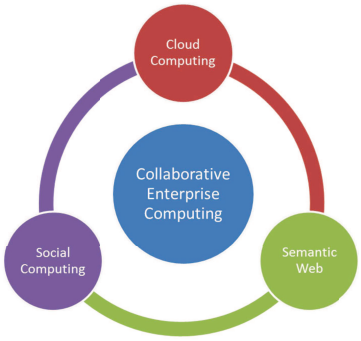

Figure 1: Collaborative Enterprise Computing

in many ways but low IT costs, correlate data of different enterprises and providing communication mediums (Blogs, Wikis, Social Network sites) are the most significant. The main rationale behind the CEC is to bring innovation through collaboration. Moreover, CEC ease the process of innovation by finding the trustworthy partners across enterprise boundaries who can be involved in the innovation process. These trustworthy partners are discovered/find according to their competences and experiences on the basis of criteria which can be given by enterprise.

IV. Case Study - Innovation Stock Exchange

The objective of developing the innovation framework is to create a trusted network for collaboration in an open-controlled environment. Collaboration allows enterprises, governments, entrepreneurs, academia, and other business entities to come together from a closed environment to an open environment and create new ideas as depicted in Figure 2.

Figure 2: Innovation through collaboration

This innovation ecosystem fosters the innovation process and introduces new products and services to the market. Such members of the innovation ecosystem could have the opportunity to register their ideas and openly collaborate with people of their trusted network. This could also lead towards the innovation stock exchange as depicted in Figure 3 where investors could invest on highly ranked ideas for increasing the business opportunities. By leveraging the collaboration into

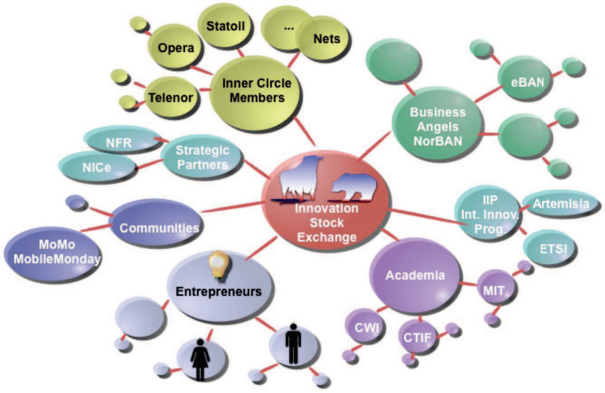

Figure 3: Innovation stock exchange a case study under consideration

the innovation ecosystem, enterprises will be able to develop innovative products and reduce their operational costs. For instance, Norwegian oil Industry reduced operational costs from 30-50% and enhanced productivity from 5-15% by integrating several operations together into their system [24]. Moreover, Procter&Gambler and Orange both has taken the initiative of collaboration by inviting people to present their ideas on a specific problem, and the most prominent idea was selected for the transformation into product [25]. Thus, significant revenue and customer satisfaction were acquired by both companies with innovation through collaboration. Current approaches are based on selected people from different organizations working together for a common goal. Our privacy-enhanced innovation framework will allow members of the innovation ecosystem to register an idea, assign scores from experts and find out trustworthy partners who can help in fostering the innovation

process so that the results can be achieved in the minimum time.

Assume Bob has an innovative idea, which he registers it in the system so that he could get right partners who could collaborate to transform the idea into realization. Idea will be reviewed for acceptance by the experts that belong to different enterprises. The idea will be published categorically according to the nature of its topic. The system will find experts in that topic by employing idea owner polices and criteria. The system will send notification to experts via email or sms and consider them to assign scores. The system facilitates Bob in finding trustworthy partners with whom he could collaborate for the realization of the idea regardless enterprise premises. Furthermore, the high-score idea will be published in the innovation stock exchange where members could open a vital investment opportunity. Thus, the system not only helping Bob in finding the right partner for his idea but also providing him implicit technical review, scientific value and the importance of his idea.

V. Enterprise Collaboration Enablement

This section outlines how an automated and trusted collaboration can be enabled in an enterprise.

A. User Profiling

User profile plays an important role for enabling automated collaboration beyond enterprise perimeter. User profiling generally involves profile setup, manipulation, and synchronization. In profile setup a basic user profile is created with explicit user feedback. The profile setup procedure can get user social network sites membership information from user basic profile, allowing profile setup mechanism to retrieve more information about user's preferences, groups and friends. In turns, this leads to implicit user feedback, where user information is collected without any intervention of user. The profile manipulation consists of create, read, update, and delete functions. The profile synchronization keeps update of all distributed profiles. ETSI [26] , 3GPP GUP [11] and MAGNET Project [27] among others are first initiatives towards standardization of user profile structure. However, these aforementioned research initiatives do not aim for collaboration. They mostly focus on personalized services. Whereas, in this outlook we specifically focus on user profile in the context of enterprise collaboration. We extend the user profile ontology proposed in [35], which classify the profile into different categories. Each profile contains relevant information according to its category and comprises authorization policy to restrict its access to third parties. For instance, corporate profile contains person's professional skills and expertise in a specific topic. This profile can only be accessed by third parties (i.e., colleagues, friend from trusted-virtual company etc.) to whom the permission has been granted. In this manner, a person can explicitly choose what to share and with whom to share his profile. Currently, we have defined one core concept Profile, which contains subclasses: (i) personal Profile, (ii) social profile, (iii) corporate profile, (iv) public profile and (v) private profile of it. A simplified snapshot of the user profile ontology is depicted in Figure 4.

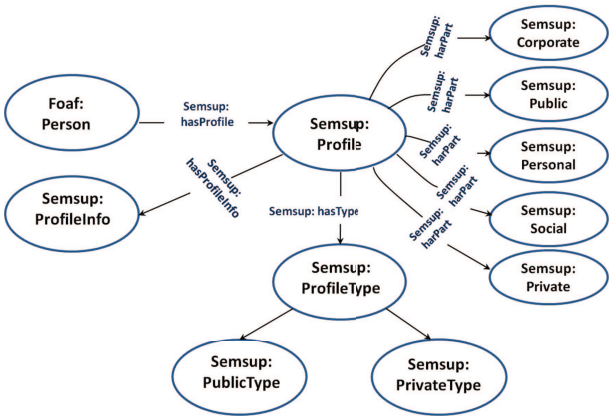

Figure 4: User Profile ontology

B. Trust Modeling

While Trust is relative term, which is defined differently in literature according to the nature of the work. In [28], author defines "Trust in a passionate entity is the belief that it will behave without malicious intent". In [29], authors consider context as an important factor for establishing trust by defining, "Trust is the firm belief in the competence of an entity to act securely, dependably and reliably within a specific context". In this paper, enterprise establish trust between their partners and co-workers to collaborate with each other for improving the quality of work and minimizing the risk factors. Thus, we define trust in such a way where the trusting agent has belief on trusted agent capabilities (see Figure 5) on the basis of relationship with the trusted agent for collaboration in order to realize a specific business opportunity.

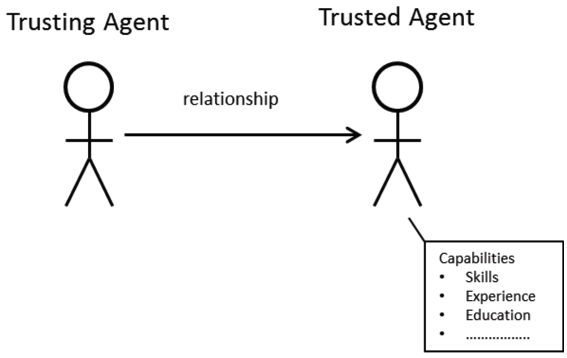

Figure 5: Definition of trust

We consider four factors context, time period, relationship and trust value that influence enterprises to obtain trusted partners for collaboration. The context is the situation or scenario for enterprises such as writing a research proposal, sharing new idea, discussing recent activity. Time period is a time at which one person interact with the other person and afterwards assign a trust value to it. For instance, one can

establish trust for the context ”writing a research proposal” in the time period 2009-2010. Relationship plays a pivotal role in the trust establishment, which associates the trusting agent with the trusted agent. The strength of the relationship is determined with the trust value which is assigned by trusting agent for a given context and time. Employees of an enterprise establishes a relationship with others by doing direct interaction and thus assign trust values to them. For instance, Bob meets Alice in a conference and becomes friend, Bob has a colleague and Bob meets Charlie on random meetings. Employees also receive recommendations about others from trusted friends, and trusted partners, which increase enterprises contacts not only within enterprise boundaries but also outside enterprise boundaries. For instance, Bob has a direct relationship with Alice, and Alice has a direct relationship with Charlie. Neither Bob nor Charlie has a direct relationship. Alice recommends Bob about Charlie and since Bob believes on Alice recommendation he can treat Charlie as a trusted partner. Trust relationship is depicted in Figure 6.

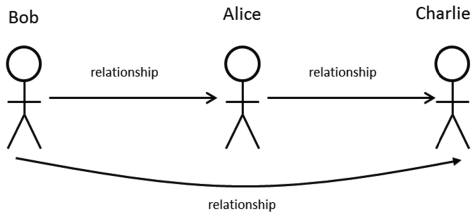

Figure 6: Trust relationship

To contrive social graph of trusted partners, Friend-of-a-Friend (FOAF) vocabulary helps for establishing friendship relation with foaf:knows property but it does not specify what is the value of friendship between two friends? FOAFRealm Onotology Specification [30] leverages the foaf:knows property by assigning the friendship value to the relationship. However, the ontology lacks in associating the value with given context and time period that are pivotal factors for enterprises. Thus, we propose to reuse FOAFRealm Ontology in conjunction of our Trust Ontology that allows employees to define their list of partners and assign trust values to them in a given context and a time period. The values can be given in the range of 0% (very distant) 100% (very close). The

Relationship	Trusting Agent	Trusted Agent	Time Period	Context	Trust Value
R1	Bob	Alice	2009-2010	Writing Research Proposal	90%
R2	Alice	Charlie	2003-2011	Working on project	95%

above table presents the two relationships R1 and R2 where Bob has 90% trust on Alice in the context of ”Writing research proposal” for the time period 2009-2010. This shows that Bob only trusts Alice in writing research proposal context and he does not trust her in other contexts. It can also be possible for Bob to assign trust values to Alice in different context for different time.

The trust Ontology is designed in [36] by considering the key elements (i.e., Trust direction, Trust Value, and Trust Type) to define the concept of Trust. Person can assign numerical trust values to other person with respect to their relationship. Furthermore, person can also assign multiple trust values to same person on multiple contexts. All this information is stored in Trust Ontology, which later can be used as a security attributes for assigning authorization policies to the user profiles. Moreover, we defined the concept of the TrustedParties as a union of ServiceProviders and Friends class and then subsume it to TrustedParties. A simplified snapshot of Trust ontology is depicted in Figure 7.

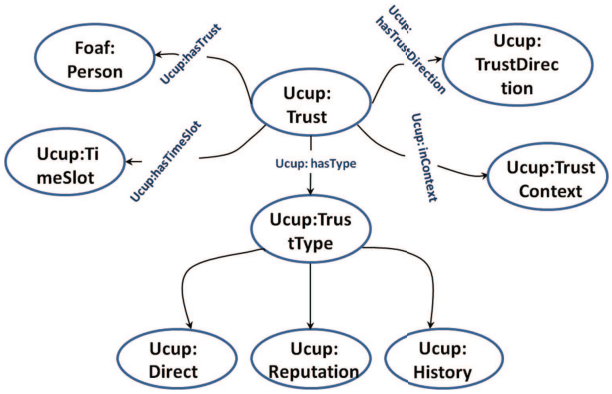

Figure 7: Overview of the trust ontology

C. Collaboration Criterion

As we discussed before that user-centric is one of the most demanding and prevailing feature of any collaboration platform, where innovation process is under perceived control specific innovation activity initiator. This can be achieved by defining collaboration criterion, where initiators can specify their conflict of interest, policy for establishing trust and some other requirements for automated collaboration. This paper proposes Semantic Web Rule Language (SWRL) [31], which is a combination of RuleML and OWL-DL [32]. In SWRL, rules are expressed in terms of OWL concepts i.e., classes, properties, individuals and literals. Rules are written in the form of Horn clauses antecedent (body) and consequent (head) where implication combines both the antecedent and consequent together. SWRL expressivity can be expanded with built-ins that provide traditional operations for comparison, mathematical transformation and URI construction. SRWL also enhances the expressivity by taking OWL expression (i.e., restrictions) in the antecedent or consequent of a rule but at the cost of undecidability. However, the undecidability issue can be resolved with DL-Safe rules [33]. The DL-Safe rule binds only known instances in ontology to rule variables. This restriction is sufficient to make SWRL rules decidable.

D. Business Idea Ontology

The Business Idea Ontology provides a mechanism to describe an idea which can be created by person,

reviewed by executive members of an organization and made it available for others in order to assign a score. The ontology is combined with existing ontologies, such as SKOS and FOAF, to achieve the modularity approach. We choose a hierarchical model that links our main classes id:Idea, org:ExecutiveMembers, skos:Concept, id:Score and foaf:Person to the super class owl:Thing. An Idea class (id:idea) contains the ideas by including abstracts, dates, keywords and title to it. ExecutiveMembers class contains the list of members who are responsible for providing review and assign scores. These scores reside in the subclasses of Score class (id: Score), which describes the assigned values in three terms such as ”Excellent”, ”Good” and ”Fair”. Furthermore, score class is created as a value partition class that included the subclasses ”Excellent”, ”Good” and ”Fair” as shown in the class definition.

$$Score \equiv Excellent \cup Good \cup Fair$$

We make these subclasses disjoint so that an individual cannot be a member of more than one class. In this manner, an idea can be classified on the basis of assigned score. We also defined properties (object and data) that allow us to describe the relationship between individual and literal values to these classes.

- id:hasTopic is an object property that links idea to the skos:Concept, describing the topic of an idea, e.g., Security, and Mobile Development.
- id:isCreatedBy is an object property that links the idea to a foaf:Person who is the creator of the idea.
- id:hasAssign is an object property point to the score class, containing score values that assigned by executive members.

The Figure 8 represents the complete overview of the Business Idea Ontology.

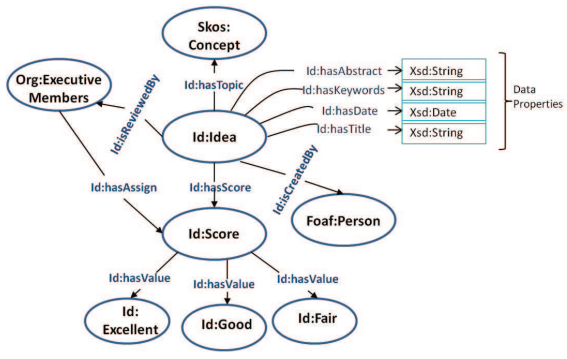

Figure 8: Overview of the business idea ontology

VI. Innovation Framework

The innovation framework is designed with the following components: Access Manager, Collaborate Ensembler and Collaboration Criterion Manger as depicted in the Figure 9. A framework first registers a person through Access Manager and allows him to create his user profile. After registration, the person interacts with Idea manager for the creation of a new Idea.

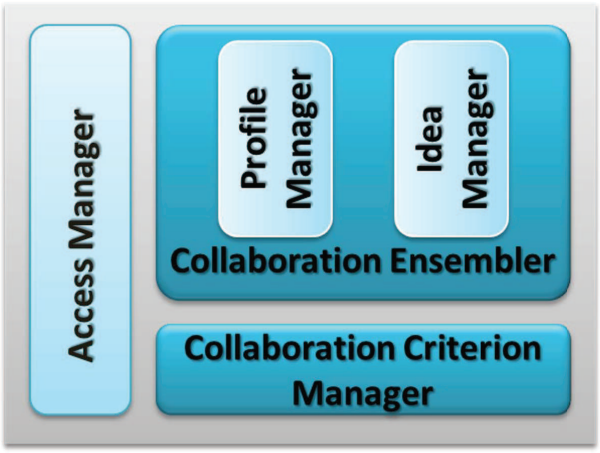

Figure 9: Innovation framework functional architecture

Idea manager notifies the members of an organization about the new idea so that they can review it and score it. After scores, the idea manager makes it available to different members or trusted-virtual communities according to their access rights that are accorded by the idea creator. Later, Collaboration ensembler reads the relevant information from the user profile and the idea along with the criteria from collaboration Criterion Manager by discovering the relevant partners. Apart from that, user profile manager also links the distributed user profiles by enabling linked data repository. This empowers a person to separate his corporate profile from his social or public profile and accord access according to their relationship. In this manner, person can expose his data in a controlled fashion where everything is under perceived control.

A. Profile Creation Phase

During the user profile creation phase, access manager receives a profile creation request from a user. First, access manager validates the user identity and after successfully validating the user, a profile creation page will be displayed where the user supply his information, needed by the profile manager. After completing the profile, access manager sends the CreateProfileRequest to Profile Manager, which stores the user profile information in the profile Knowledge Base (KB). Once the access manager receives the acknowledgment from the profile manager, it sends the ProfileCreatedResponse to the user as depicted in Figure 10. The user can also be asked to present the URI of his distributed profiles so that the user profiles can be integrated from multiple sources. These linked user profiles are stored in the linked data repository and later, co-workers or other third parties can access accordingly.

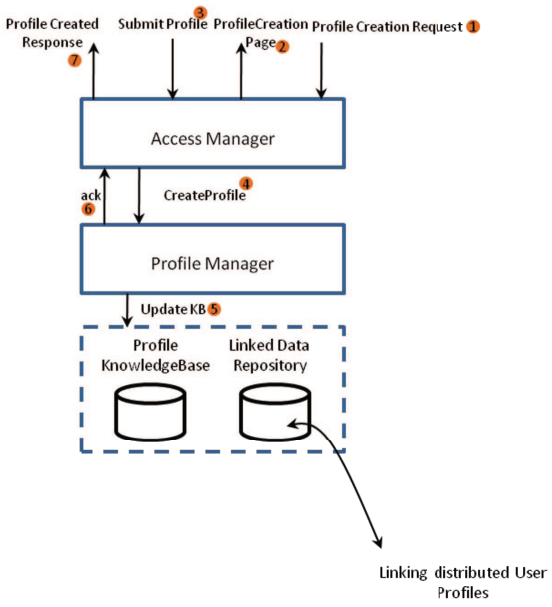

Figure 10: Profile creation phase

B. Idea Registration Phase

The idea manager is responsible for managing the idea requested by the Access Manager. Idea manager is also responsible by providing the mechanism of assigning scores. Initially, the person requests Access Manager for the registration of a new idea. After successfully validating the identity of the person, access manager precedes him to the IdeaRegistrationPage where idea can be written by providing its Title, Abstract and Date. Idea manager stores the idea in to the Idea Knowledge Base (KB) upon receiving RegisterIdea request from the Access Manager by getting SubmitIdea request from the person as depicted in Figure 11. Once the idea is registered

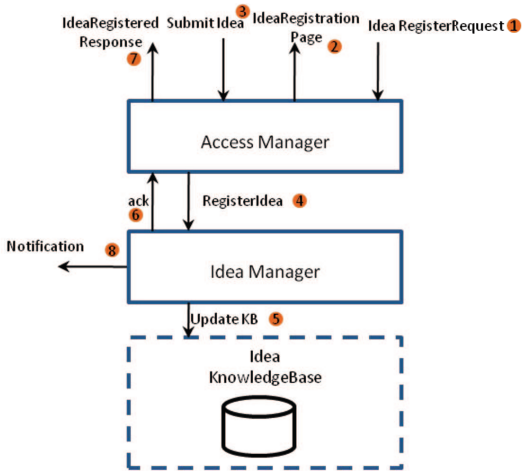

Figure 11: Idea registration phase

and stored in the knowledge base, Idea Manager sends the notification through SMS or email to executive members of the organization so that they can make the innovation process effective by involving themselves as soon as possible.

C. Score Phase

After receiving the new idea registration notification, the executive members can review the idea. To initiate the review process the executive members provides their credentials and idea name to access manger, which in response return the newly register idea review page after validating the credentials. The executive member can submit their score after reviewing the idea. Once all the executive members submit their score the IdeaManager calculate the overall score and set the status of the Idea based on the score. If the idea achieved status of open for collaboration then the CEE exploits description logic [34] based reasoning capabilities over user profile KB and the approved idea by incorporating collaboration criteria associated with the idea. The end result of this reasoning process is a trusted-virtual company, containing a list of relevant partners that are suitable for the approved idea. The score phase in depicted in Figure 12.

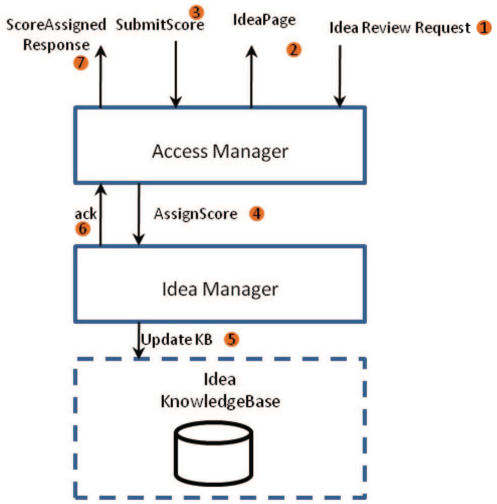

Figure 12: Score phase

VII. Implementation Road Map

Having described the innovation framework architecture, this section outlines the road map for implementation of cloud based services using the state-of-the-art technology enablers.

We propose to implement innovation framework in the form of APIs as they are becoming mainstream. The essence of this approach is better integration with existing apps, enablement of custom apps development and augmentation of existing apps with new functionalities. Additionally, we favor an open API strategy instead of an internal-first API strategy where APIs are developed internally first and then shared with close partners and in the last phase made them open to the world.

This outlook aims to bring all stakeholder from all areas of collaborative ecosystem, including industry and academia, to enhance and ease off innovation process. Such inter-organization collaboration demands a common/shared place to publish and share novel and innovative ideas without

delving into technology infrastructure. We anticipate that cloud computing platform is the most appropriate for such inter-organization collaboration because it allows to focus more on delivering services rather than on managing technology infrastructure. We use cloud platform as a service endpoint provider and data storage. In this regard, we select the windows azure platform [37], which comprises of: (1) Windows Azure - an operating system as a service that facilitate on-demand compute, storage and mange web application on the internet, (2) SQL Azure - a relational data storage service in the cloud that foster reuse of familiar relational models, tools and utilities, (3) Windows Azure AppFabric - a cloud-based infrastructure services for applications running in the cloud or on enterprise premises.

The prototype implementation of innovative stock exchange case study can be realized in the form of windows azure services. For this purpose, we propose to develop UserProfileService, IdeaRegistrationService, IdeaRatingService, and IncubationService by using the innovation framework APIs. Each service is backed by a DB storage such as ProfileDB, IdeaDB, and ScoreDB. Despite the fact that windows azure platform provides a wide range of storage options but it still lacks the support of semantic enhance storage (i.e., triplet storage). This limitation can be fixed by having a mapping mechanism for proposed ontologies that is capable of incorporating ontology level changes into relational storage. Such mechanism can maintain semantic related stuff into separate tables for each service DB storage, which works as an overlay for the each service DB storage. These windows azure services can be integrated with other apps regardless of the technology since windows azure supports different standards, protocols and languages including REST, SOAP, JAVA, PHP and Ruby. However, we will focus only on SharePoint Server 2010 [38] (i.e., Microsoft based enterprise collaboration and social computing platform). The integration of windows azure services with SharePoint 2010 requires the development of Silverlight enabled Web Parts. In this case, each Web Part is associated with some Windows Azure service and SharePoint acts as service consumer. The overall integration strategy is depicted in Figure 13.

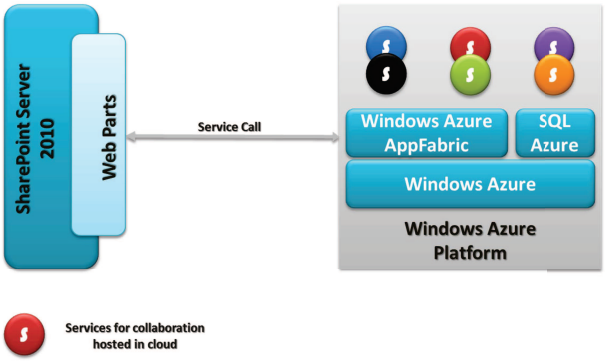

Figure 13: Integrating collaboration services with SharePoint server 2010 using SharePoint Web Parts

VIII. Conclusion and Future Work

In this paper, we proposed the collaborative enterprise computing (CEC) approach, helping in the creation of the network of enterprises for enabling active, automated and trusted inter-enterprise collaboration. This is achieved by considering the challenges of user profiling, balancing of open and close collaboration and trust establishment. The CEC approach is quite significant for discovering trusted relevant partners who could involve in the innovation life cycle process.

The proposed framework comprises three core components such as Access Manager (AM), Collaboration Ensembler (CE) and Collaboration Criterion Manager (CCM). As the framework is designed by considering the standard semantic web tools it inherits some built-in features such as interoperability, integrating of data from multiple sources, and reasoning for deriving the entailment facts from the knowledge base. We also designed semantically enriched user profile ontology, trust ontology and business idea ontology by considering the modular approach. Moreover, the paper provides the road map for the implementation of the innovation framework in the form of APIs. The API oriented approach is suited for better integration with other apps. We proposed to develop cloud based services such as UserProfileService, IdeaRegistrationService, and IdeaRatingService using proposed APIs. Our exploration shows that capturing enterprise employee expertise, and ideas in a structured and machine understandable way are highly eminent for an automated inter and intra- enterprise collaboration.

Our ongoing and future work includes evaluating the framework by describing the sophisticated criteria for discovering relevant partners. We are also considering enhancing the framework by providing a Trust Management component, which can ease the trust assigning and evaluation process. Moreover, we will evaluate the framework in a real environment.

Acknowledgment

This work is supported by the Norwegian Research Council.

References

[1] P. Banerjee, R. Friedrich. L. Morell, ”Open innovation at HP Labs”, IEEE Computer Society, Nov. 2010, pp. 88-90, doi:10.1109/MC.2010.322.

[2] J. Bughin, M. Chui, and A. MillerHow, ”Companies are benefiting from Web 2.0: McKinsey Global Survey Results”, http://www.mckinseyquarterly.com/Business_Technology/BT_Strategy/How_companies_are_benefiting_from_Web_20_McKinsey_Global_Survey_Results_2432 [accessed on 31 January 2011]

[3] Oracle, ”The Social Enterprise: Using Social Enterprise Applications to Enable the Next Wave of Knowledge Worker Productivity”, http://whitepapers.techrepublic.com.com/abstract.aspx?docid=391431 [accessed on 31 January 2011]

[4] A. Fu, C. Finn, D. W. Rasmus, R. Salkowitz, ”Social Computing in the Enterprise Microsoft vision for Business Leaders”, Microsoft White Paper, 2009

[5] K. Efta, ”Enterprise Social Computing”, http://www.allyis.com/thinking/Pages/Enterprise-Social-Computing.aspx [accessed on 31 January 2011]

[6] A. P. McAfee, ”Enterprise 2.0: The Dawn of Emergent Collaboration”, http://sloanreview.mit.edu/the-magazine/articles/2006/spring/47306/enterprise-the-dawn-of-emergent-collaboration/3/ [accessed on 31 January 2011]

[7] D. Hinchcliffe, "Top Ten issues in adopting Enterprise Social Computing", http://www.zdnet.com/blog/hinchcliffe/ten-top-issues-in-adopting-enterprise-social-computing/581 [accessed on 31 January 2011]

[8] G. Antoniou, F. Van Harmelan, "A Semantic Web Primer", MIT Press 2008.

[9] FOAF Project, "http://www.foaf-project.org/", [accessed on 31 January 2011]

[10] R. Gosh, M. Dekhil, "Discovering User Profiles", Proceedings of the 18th international conference on World wide web, 2009.

[11] 3GPP TS 29.240, "3GPP Generic User Profile, Stage 3, Release 6", http://www.3gpp.org/ftp/Specs/html-info/29240.htm [accessed on 31 January 2011]

[12] D. Heckmann, E. Schwarzkopf, J. Mori, D. Dengler,A. Kroner, "The user model and context ontology GUMO revisited for future Web 2.0 Extensions", Contexts and Ontologies: Representation and Reasoning, pp.37-46

[13] D. Heckmann, A. Krueger, "A user modeling markup language (UserML) for ubiquitous computing", User Modeling 2003 In User Modeling 2003 (2003), pp. 148-148

[14] J. Stan, E. Egyed-Zsigmond, A. Joly, P. Maret, "A user profile ontology for situation-aware social networking" , 3rd Workshop on Artificial Intelligence Techniques for Ambient Intelligence (AITAmI2008)

[15] IST FP6 Spice project,"http://www.ist-spice.org/" [accessed on 31 January 2011]

[16] B. Aleman-meza , U. Bojars , H. Boley , J.G. Breslin, M. Mochol , L. Jb Nixon , A. Polleres , A. V. Zhdanova, "Combining RDF Vocabularies for Expert Finding", in proceedings of the 4th European Semantic Web: Research and Applications , 2007

[17] M. Stankovic, C. Wagner, J. Jovanovic, P. Laublet, "Looking for Experts? What can Linked data do for you", in proceedings of the Workshop on Linked Data on the Web, April 27, 2010

[18] M.Lopez, M. Vukovic, J. Lardeo, "People Cloud Service for Enterprise Crowdsourcing", in proceeding of IEEE Service Computing, 2010

[19] J. Zhang, J. Tang, J. Li , "Expert Finding in a Social Network", in proc. of Advances in Databases: Concepts, Systems and Applications In Advances in Databases: Concepts, Systems and Applications, Vol. 4443 (2010), pp. 1066-1069-1069.

[20] N. Capuano, M. Gaeta, F. Orciuoli, P. Ritrovato, "Semantic Web Fostering Enterprise 2.0" in Proceeding of Intelligent and Software Intensive Systems, International Conference, Los Alamitos, CA, USA, 2010.

[21] S. Bertram, M. Boniface, M. Surridge, N. Briscombe, M. Hall-May, "On-Demand Dynamic Security for Risk-based Secure Collaboration in Clouds", in Proceeding of IEEE 3rd international conference on Cloud Computing, Miami, August 2010.

[22] Cisco White Paper, "Transforming Enterprise IT Services with a Secure, Compliant Private Cloud Environment", http://www.cisco.com/en/US/services/ps2961/ps10364/ps10370/ps11104/services_cloud_enablement_white_paper_enterprise.pdf [accessed on 15 January 2011]

[23] Gartner Press Release, "Gartner's 2006 Emerging Technologies Hype Cycle Highlights Key Technology Themes", http://www.gartner.com/it/page.jsp?id=495475 [accessed on 5 January 2011]

[24] R. A. Fjellheim, R. B. Bratvold, M. C. Herbert, "CODIO - Collaborative Decision making in Integrated Operations", in proc. of Intelligent Energy Conference and Exhibition, Society of Petroleum Engineers, 2008.

[25] NESTA, "Open innovation from marginal to mainstream", http://www.nesta.org.uk/library/documents/Open-Innovation-v10.pdf [accessed on 5 January 2011]

[26] ETSI User Profile Management, http://portal.etsi.org/stfs/STF_HomePages/STF265/STF265.asp [accessed on 15 January 2010]

[27] MAGNET Project, http://www.telecom.ece.ntua.gr/magnet/index.html [accessed on 15 January 2011]

[28] A. Jsang, "The right type of trust for distributed systems," in Proc. of the 1996 workshop on New security paradigms (NSPW '96). ACM, pp. 119-131, doi:10.1145/304851.304877, http://doi.acm.org/10.1145/304851.304877.

[29] T. Grandison, M. Sloman, "A Survey of Trust in Internet Applications," in proc. of the Communication Surveys and Tutorials, IEEE, Volume 3 Issue 4, pp. 2-16, 2000, doi:10.1109/COMST.2000.5340804.

[30] FoaFRealm Ontology Specification, http://www.foafrealm.org/xfoaf/0.1/index.html}accessed on 15 January 2011]

[31] Semantic Web Rule Language, http://www.w3.org/Submission/SWRL/ [accessed on 15 January 2011]

[32] Ontology Web Language, http://www.w3.org/TR/owl-guide/ [accessed on 15 January 2011]

[33] B. Motika, U. Sattlerb, R. Studera, Query Answering for OWL-DL with Rules, in Web Semantics: Science, Services and Agents on the World Wide Web journal. Volume 3, Issue 1, July 2005, Pages 41-60.

[34] Franz Baader, Diego Calvanese, Deborah L. McGuinness, Daniele Nardi, and Peter F. Patel-Schneider "The Description Logic Handbook: Theory, Implementation and Application", Cambridge University Press, 2002.

[35] Zahid Iqbal, Josef Noll, Sarfraz Alam, Mohammad M. R. Chowdhury, "SemSUP: Design and Implementation of Semantic Enhance Social-Aware User Profile", in proc. of IEEE DEST, 12-15 April 2010, Dubai.

[36] Zahid Iqbal, Josef Noll, Sarfraz Alam, Mohammad M. R. Chowdhury, "Toward User-centric Privacy-aware User Profile Ontology for Future Services", in proceedings of IEEE third International Conference on Communication Theory, Reliability, and Quality of Service (CTRQ 2010), 13-19 June 2010, Athens, Greece, pp. 249 - 254.

[37] Windows Azure - Microsoft's Cloud Services Platform, http://www.microsoft.com/windowsazure/ [accessed on 15 January 2011]

[38] Microsoft SharePoint Server 2010, http://sharepoint.microsoft.com/en-us/Pages/default.aspx [accessed on 15 January 2011]