Engaging Practitioners to Deliver Government Carbon and Energy Phased Reduction Targets: Toward a Web 3.0 Approach

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***Abstract*—The construction industry is under pressure to increase the sustainability of its practices to meet United Kingdom's commitments to alleviating climate change. This paper, through the use of a mixed method approach, explores the readiness and level of engagement of construction stakeholders in adopting government sustainability agendas. Limited sustainability best practice, regulation awareness, and information provision deficiencies emerged as key themes from the initial survey. Subsequent combined consultations explored stakeholders' knowledge, understanding, attitudes, values and behaviours, and helped identify key barriers to sustainability engagement. This has informed the participative development of a "one-stop-shop" web-based platform that provides integrated access to sustainability resources in the form of interactive, dynamic, and user-oriented services, delivered via discrete "widgets", that exploit web 2.0 concepts, including semantics, user profiling, and professional networking. The innovative dimension of the solution lies in its open, scalable and polymorphic context-based widgets approach that reconfigure and update themselves to respond to changing user context and (sustainability related) queries, while enabling serendipitous information and knowledge discovery. The authors believe that the proposed web portal (a) has the potential to engage further practitioners in delivering sustainable interventions, and (b) contributes to the ongoing debate and shaping of Web 3.0 and beyond.**

Keywords-User engagement; Web 3.0; Knowledge Management; Ontology; Sustainability.

I. INTRODUCTION

Studies indicate that creation and operation of our built environment is responsible for some of the most serious global and local environmental changes [1, 2, 3], accounting for at least 50% of all energy consumption in Europe (European Commission, 2005). In the United-Kingdom (UK), more than 50% of all carbon emissions can be attributed to energy use in buildings [4]. The UK Chancellor of the Exchequer announced in the 2008 budget that the UK government aspires to achieve construction of zero carbon homes from 2016, Public sector buildings from 2018, and all other non-domestic buildings from 2019 [5]. The Welsh government has set aspirations for zero carbon for new buildings earlier than proposed in the rest of the UK [6]. Consequently, the construction industry is under pressure to increase the sustainability of its practices, the implication of which is a requirement on the industry's behalf to understand the demands both from society and its clients, and its sense of corporate responsibility, which, in turn, implies major changes in its working practices [7, 8]. The large scale consultation reported in this paper indicates a clear need for a dedicated resource to enable shared and value-added relevant resources of knowledge and expertise to inform sustainable and energy regulatory compliant design and construction activities. This is the core mission of the Script project, which sets the objective to develop an advanced Web-based "one-stop-shop" platform providing value added sustainable construction experience shared amongst communities of practitioners. Through our initial consultation, it has become apparent that such a "one-stop-shop" platform should address a number of attributes that exceed Web 2.0 capabilities and prompted the authors to explore and contribute to the ongoing debate about the realm of Web 3.0 and beyond. The paper first introduces the methodology that underpins the research and initial consultation results. The authors then discuss perceived features of Web 3.0, interpreted in the context of the "Script" platform. The latter is then further supported by the description of the underpinning system architecture and resulting interface. The paper then illustrates the core aspect of the Script platform, i.e., the sustainable construction ontology and its method of development. The validation of the platform is then discussed, focusing on its fulfillment of an enhanced users' sustainable knowledge experience. The paper concludes with a critical discussion of our Web 3.0 definition and approach, its limitations, and directions for future research.

II. THE "SCRIPT" METHODOLOGY

Requirement capture and elicitation are some of the most critical tasks of any software development project. A socio-technical approach is employed underpinned by the following three research questions (RQ):

- RQ1: What are construction stakeholders' sustainability information needs and government provision deficiencies?
- RQ2: What are construction stakeholders' engagement barriers with governmental carbon and energy reduction targets?

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- RQ3: Can the (above) elicited information needs and engagement barriers inform the development of a reference "one-stop-shop" Web platform for sustainable construction?

These questions were explored via three mixed-method studies. The first study, which addressed RQ1, employed an online Europe-wide survey (February – April 2009) from which 252 responses were received with participants being demographically representative of the total population sampled. Quantitative data were analyzed in SPSS and qualitative data were coded thematically in NVivo. Limited sustainability best practice, regulation awareness and information provision deficiencies emerged as key themes from the consultation and provided the ground to address RQ2. To address this question, the methodology employed a further study focused on industry consultations in Wales. This involved three workshops (c.70 participants in total) and a series of 15 semi-structured interviews with key industry representatives (May – September 2009). The first two workshops explored stakeholders' knowledge, understanding, attitudes, values and behaviors, and helped identify key barriers to sustainability engagement in Wales, which were then debated and confirmed in a third workshop hosted by the Low/Zero Carbon Hub in Wales (Wales LZC Hub). The Wales LZC Hub is a coalition that is supported by the Welsh Government, the building industry, housing, and voluntary sectors, to help meet the policy targets. A number of issues have been captured through our intensive industry consultation and entails a need for construction stakeholders to understand the changing landscape of sustainability and associated legislation, which, in turn, demands easy and timely access to fragmented and multi-faceted information. Moreover, construction stakeholders involved in new or refurbishment projects are faced with: (a) complex legislation related to low carbon buildings, (b) a plethora of overlapping commercial tools supporting the process of delivering low carbon buildings, (c) numerous guidelines and documentation, (d) an increasingly rigorous energy certification process, and (e) lack of clarity on types of financial assistance and eligibility criteria. Also, while a great deal of expertise already exists in detailing and constructing low-energy buildings, much of this expertise is fragmented and exists in various forms, with no real systematic means or mechanisms to assist construction stakeholders in their low carbon decision-making [7]. In this context, it is imperative to make building energy expertise widely available. The findings from these workshops fed forward to a series of interviews where identified barriers were discussed from a variety of socio-technical perspectives. RQ3 formed the focus of our third study, which involved the script platform requirement elicitation from extensive consultations with industry stakeholders including online surveys, semi-structured interviews, collaborative workshops and focus meetings (a mix of one to one and small group consultations). Moreover, 2 workshops and 13 focus meetings (a mix of one-to-one and small group consultations) were organized (February – November 2010). A total of 27 stakeholder organizations took part in the consultations, including: construction companies and practitioners, advisory groups, umbrella professional organizations, consultants, policy makers and education and training bodies.

III. SCRIPT CONCEPT

The Semantic Web and Web Services are transforming the Internet from a network of information to a network of knowledge and services. Using the read-write nature of Web 2.0 applications, new knowledge is inferred based on mashups that occur at the data, rather than at the application level. Web 3.0 in its present manifestation exploits Semantic Web technologies integrated into large-scale Web applications [9]. In fact, the foundations of Web 3.0 services involve Resource Description Framework (RDF) for linking data from multiple distributed databases or Web sites. The SPARQL query language (a SQL-like standard for querying RDF data) enables Web services and applications to use native graph-based RDF stores and extract RDF data from traditional databases. Once the data is in RDF form, the use of Uniform Resource Identifiers (URIs) for merging and mapping data from different resources facilitates development of multiple distributed and fragmented site mashups [9]. RDF Schema (RDFS) and the Web Ontology Language (OWL) provide the ability to infer relationships between data in different applications or in different parts of the same application [10]. The term "linked data" is often used to describe the evolving RDF development space, and "Semantic Web" is increasingly being used to describe coupling linked data with RDFS and OWL. These capabilities are currently being exploited to enable enterprise data integration and related functions [9].

As noted earlier, the Script consultation indicates a need for far greater sophistication than is currently employed in the nearest comparable web resources for knowledge harvesting and sharing. The need to efficiently categorize information coupled with requirements for bi-directional channels for knowledge sharing and enrichment, including professional networking capabilities and access to dynamic information elements aimed at a large constituency, suggested a novel framework employing the concept of 'widgets' (discrete information or service containers). This allows scalability and logical categorization of information, knowledge, and services, augmented with the capability for different users to 'personalize' their Web experience according to their individual needs. As the user is in control of which widgets are visible at any given time, a key benefit of this system is that, rather than having to trawl through a long list of search results for different subject areas in relation to the topic being searched, the system automatically categorizes the results within those widgets of particular interest to that user. Figure 1 illustrates the mock interface used to capture and confirm users' expectations of the modus-operandi of the proposed Web solution. Using the example of a search over "Ground Source Heat Pumps (GSHP)", the system would display widgets that contain information about the search query, including (a) what are

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they, (b) Legislation and regulations, (c) Guidance documents, (d) Manufacturers, suppliers, and installers, (e) projects which have used GSHP, (f) training and skills.

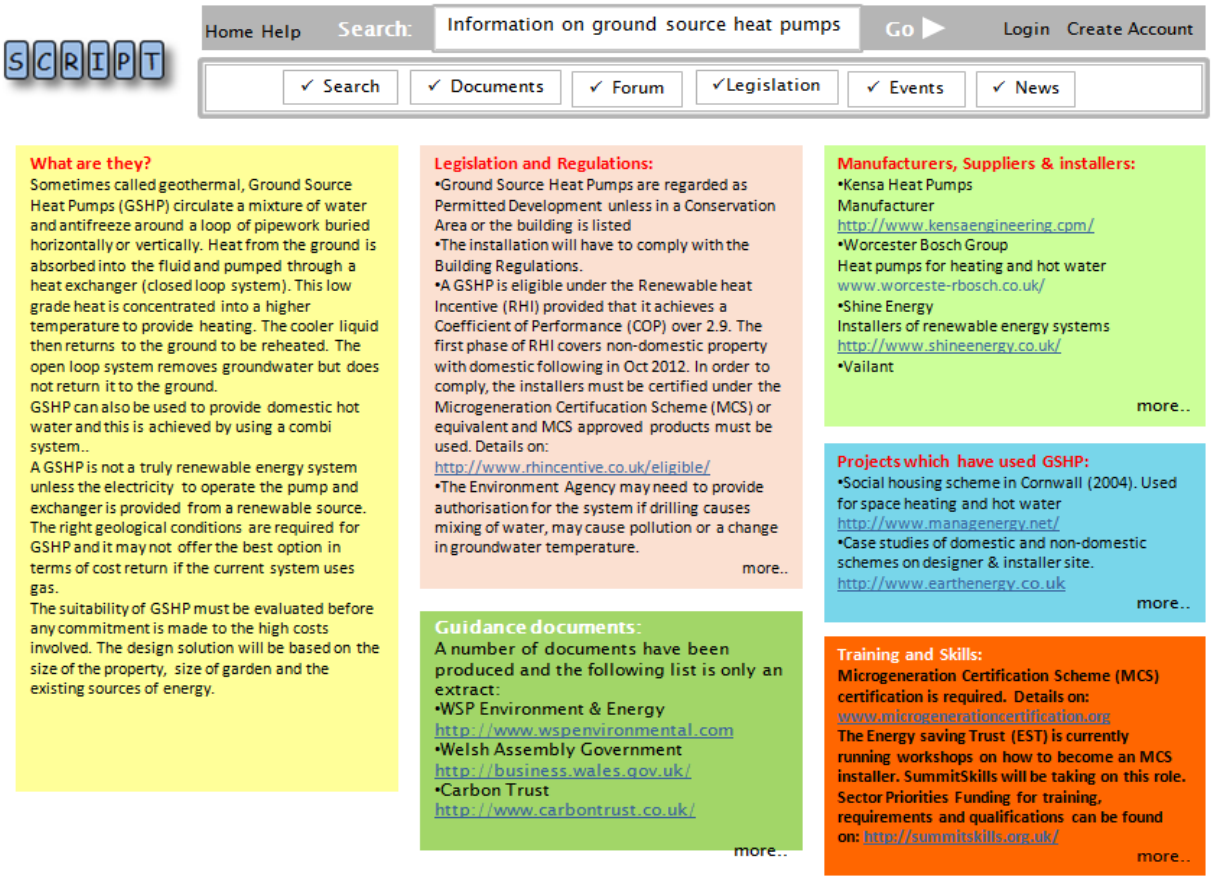

Figure 1. User-centric Concept Elicitation

The proposed Script concept involves features, such as semantics through ontology and user-profiling, widely accepted by the Web 2.0 community. In fact, Web 2.0 is a somewhat overloaded term that can refer either to user-generated and/or managed online content, or the provision of applications via the Web [11, 12]. In an effort to fully understand the changing construction landscape, different actors have built various repositories, organized events, etc., but with little or no coordination or awareness of what one another is doing, and lack of clear guidance and assistance on energy regulatory compliance. A plethora of portals, which operate on an ‘‘information push” basis have been developed [7]. There is little or no attempt to capture the user experience. Also, on viewing these various sites for the first time, in the process of searching for sustainable construction information, there is a feeling of confusion and uncertainty in what constitutes the best and, particularly, the most important information. A key barrier to engagement with sustainability is the fragmented nature of sustainable construction information and knowledge, which is exacerbated by the indiscriminate nature of currently available search engines on the web. Our consultations indicate that a sustainable construction dedicated search facility would greatly alleviate this problem. The way to achieve this is by creating and making available to the system a sustainable construction domain ontology that ‘understands’ a user’s search queries, thereby facilitating disambiguation, while ‘learning’ from a user’s queries. Figure 2 illustrates the current script user interface with its semantic widgets approach. The following section discusses the script underpinning system architecture and services.

The innovative dimension of the Script solution lies in its open, scalable and polymorphic context-based widgets that reconfigure and update themselves to respond to changing user context and (sustainability related) queries, while enabling serendipitous information and knowledge discovery.

IV. THE SCRIPT WEB 3.0 PLATFORM

The Script Platform has been developed using a Service-Oriented Architecture (SOA) and consists of a set of interoperable services, accessed: by a choice of web-based or mobile device-based clients. The architecture of the Script platform is shown in Figure 3. It should be noted that these services can be utilized independently of the platform

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or within the platform brokered by our kernel. In this context, we identify three types of provision that can be implied:

- Direct provision of services, with each service being delivered as a separate discrete service.
- Indirect provision of services occurs within the platform. With this provision mechanism, each service invocation is mediated by the kernel. In this method, the user (client) requests functionality from the kernel and the kernel delegates the execution of this functionality to the appropriate service.
- Inter-service provision. A service can request functionality directly from another service within the system. This occurs frequently for our ontology as other services utilize its functionality.

Figure 2. The Script Web3.0 Concept

Each service has an associated Application Programming Interface (API), which serves as a description for possible access requests. The API defines a set of methods that a service can offer and a set of associated parameters. In the design phase, care was taken to ensure that the API provides maximum flexibility.

Figure 3 also shows how the services within the Script platform interact. All communication within this system is done using Simple Object Access Protocol (SOAP) and, for communications purposes, the system can be divided into four levels:

- The client level contains the client software with which users interact with the system. Currently, Web-based and Android application clients have been implemented.
- The kernel level facilitates the communication between the clients and other levels of the platform. The kernel acts as a broker, delegating requests to other services within the system, and also as a service

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directory allowing services to be added/removed dynamically.

- The services level is the set of services that provides the key functionality of the platform. These services include:

➢ The Knowledge Base Service contains a corpus of related guides, regulations and various existing documentation related to sustainability in construction.

➢ The Search Service performs semantic searching on the platform knowledge base. The submitted query has a set of associated ontological concepts for improving the precision and the recall of the returned results.

➢ The Professional Networking Service enables users to collaborate using social networks, such and LinkedIn and Twitter, while the communication is facilitated with voice-over-IP instruments, such as Skype and Google-Talk.

➢ The Events Calendar Service is notification/reminder of the important events from the engineering community. Users can subscribe and synchronize these events with their personal calendar.

➢ The News Feeds Service provides aggregation of information and updated news relevant to the users' interests and discipline(s).

➢ The Forum Service allows users to interact by sharing data and information within the platform.

➢ The Sustainable Sourcing Service allows users to lookup products (based on their current location) from certified suppliers.

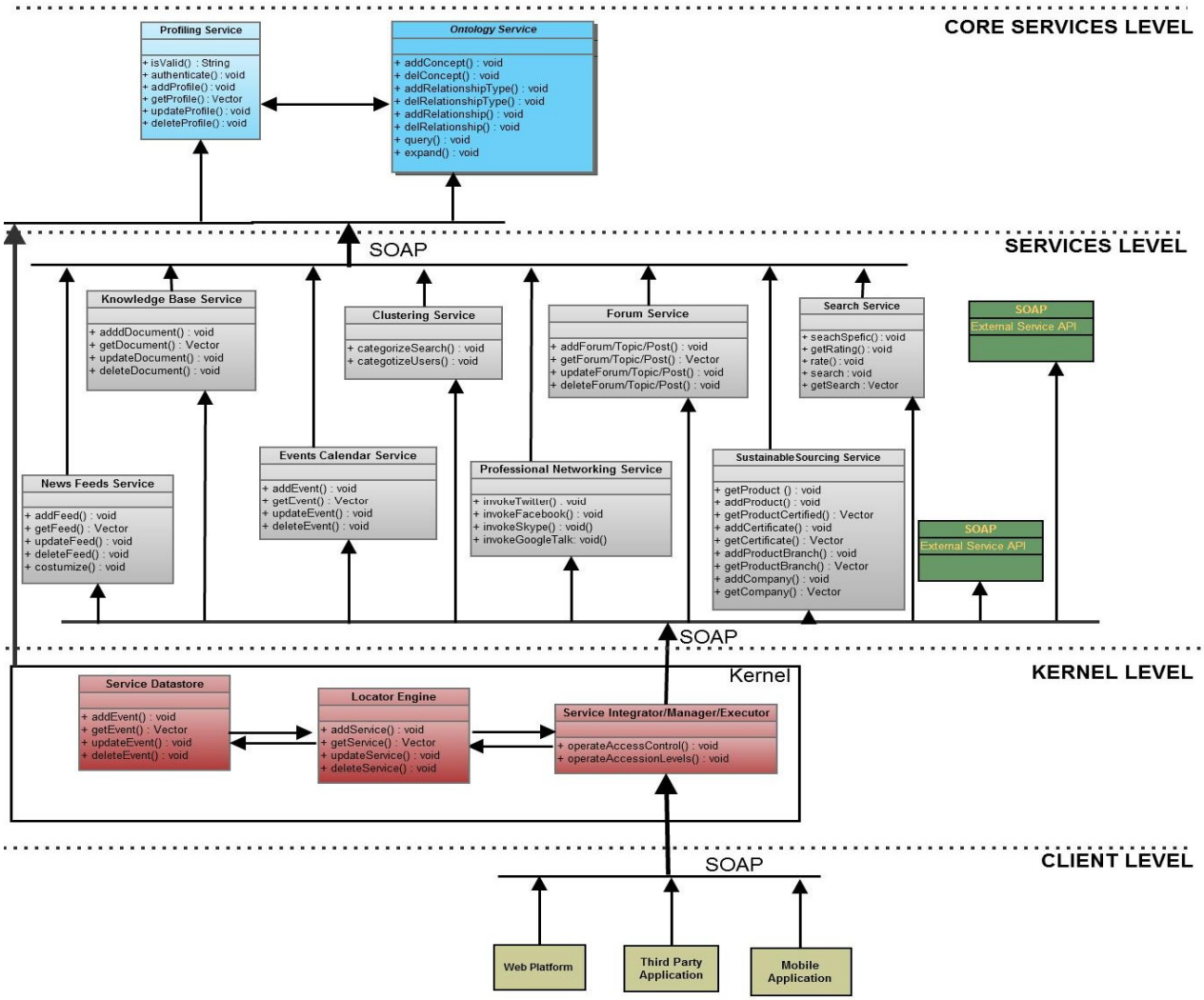

Figure 3. The Script Architecture

- The core services level describes the services that are not only used directly by users, but are also utilized by other services within the system. This is the level in which the ontology service is

integrated alongside the Profiling Service. The latter manages the identities of users and controls the access to the platform. Each user has a set of associated interests and disciplines, which are used as input data for other services, such as searching, professional networking or news feeds.

V. VALIDATION OF SCRIPT PLATFORM AND UNDERPINNING ONTOLOGY

Utilization of automatic or semi-automatic methods for the construction of ontology is not uncommon, and several different examples can be seen in the literature. Rezgui [7] outlines a system where a new ontology for the construction domain is automatically constructed based on a set of existing ontologies for specific related sub-domains and from other semantic resources. Wachter and Schroeder [13] describe a semi-automatic system that enables ontology construction within the Bioinformatics domain based on pdf document collections and the PubMed online database. Wu et al. (2009) describe a methodology utilizing Latent Semantic Analysis [14] to construct an ontology for the semantic web by harvesting concepts from Web Service Description Language (WSDL) files. The authors then apply the process to locate similar Web services based on the similarities between concepts, achieving an average precision of approximately 60%. The authors present promising results, but also state that an important conclusion is that ontology construction can never be fully automated, but well designed semi-automatic systems can provide significant value in assisting domain experts/ontology engineers in their work.

Testing and validation relied on the group of users involved in the initial requirement assessment phase and on an increasingly expanding constituency as the platform was extended to further users. We also monitored user activity by employing Google Analytics. The initial feedback has been positive and encouraging. The analysis of users' comments helped identify some key issues to be addressed in future releases of the platform, as summarized below:

- The ontology needs to be refined and the concepts should be expanded to increase the relevance in searching.
- A new widget is needed reflecting updates taking place within the platform, such as new documents being added, new versions of documents being uploaded, or new events being added.
- Explanation of the different types of documents needs to be available on the platform: due to the nature of the documents available, it is important to support end-users in understanding the exact terminology used to define regulatory (directives, decisions, etc.) and other documents (white papers, project results, etc.)
- A social networking widget is needed, where users can access various social profiles such as LinkedIn, Twitter, Facebook.
- The integration with mobile devices represents an important issue to address. It was identified that many of the visitors prefer mobile devices for retrieving their information.
- The legislation should be extended to UK legislation and possibly to Europe.
- Graphical Interface: The interface should be more intuitive to generally improve the usability of the platform.

To validate the ontology that has been developed, a series of tests have been performed utilizing keyword suggestion functionality. To carry out the validation, users of the sustainable construction platform have been asked to enter a predefined query which has been formulated by a domain expert and were then asked to comment on the relevant terms suggested thus indicating the percentage level of accuracy of the ontology.

To conduct this experiment, ten pre-defined queries were entered. Matching these queries to concepts in the ontology produced a result set of 131 terms with 72% of these terms being deemed accurate matches by the domain expert. Once this initial mapping was produced, the accuracy of the related terms was also examined. To conduct this experiment, each relationship relevant to the queries was analyzed by a domain expert. In total, there were 242 relationships, 73% of which were deemed to be correct.

VI. CONCLUSION AND FUTURE WORK

The Semantic Web, from a Web 3.0 perspective, relates to the development of an environment where data, information and knowledge are inferred, processed, and accessed: in a human friendly manner. The Semantic Web is the symbiosis of Web technologies, knowledge representation artificial intelligence concerned with constructing and maintaining (potentially complex) models of the world. Beyond the potential for maintaining new business models, such as online communities, online market places and advertising supported site, new semantic web paradigm promises to offer facilities for using user profiles (including personal data) with a view of achieving a higher order of knowledge integration and mining enabled by ontology engineering [13]. As noted earlier, the innovative dimension of the Script platform lies in its open, scalable and polymorphic context-based widgets that reconfigure and update themselves to respond to changing user context and (sustainability related) queries, while enabling serendipitous information and knowledge discovery. The authors believe that the proposed web portal (a) has the potential to engage further practitioners in delivering sustainable interventions as inferred through our portal validation work, and (b) contributes to the ongoing debate and shaping of Web 3.0 and beyond. In that respect, key features for a true Web 3.0 environment from our Script portal perspective include:

- Machine processable contents supporting (user) profile-based searching and serendipitous information discovery across the sustainability domain.

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- Sustainability knowledge appraisal, nurturing, validation and feedback through virtual professional communities. For instance, construction products with defects or lack of performance can be quickly made known, while best practice are shared.
- Machine generated ontology for domain conceptualization with potential for evolutionary refinement. The Script ontology has been generated from a large sustainability document corpus while requiring minimal expert input / validation.
- Plug and play capability of third party services that exploit the Script ontology and user profiling. This provides the advantage of widening the scope of users' accessible knowledge while exploiting their profile for filtering information and avoiding information overload.
- Regional and global awareness in terms of sustainability related events, trainings, and continuous professional development.
- Strong sense of professional community belonging with a shared sense of sustainability and social corporate responsibility.
- Management of virtual and physical objects through Radio Frequency Identification (RFID) and Internet of things. For instance, through our Product database, virtual products (such as a building product or equipment) can be purchased, allocated an RFID tag, and then on managed across its lifecycle from delivery, installation, operation, to decommissioning / recycling.

This prompts a discussion on what could form evolutions beyond Web 3.0. The Script platform is currently being enhanced and further developed to embed the capability of transforming buildings and their components / systems into virtual objects with semantics and behavior which can be queried, managed remotely, and operated at optimum performance levels. Moreover, given that Semantic Web technologies are maturing as a means of describing tangible artifacts, we could use their representational power to describe things in the real world. One view is that the physical objects will become Web-accessible in that they will be able to be represented via metadata. Just like applying semantic technologies to problems of interoperability in ubiquitous computing environments, describing physical things will expand our scope beyond the current Web. This forms the focus of the authors' ongoing work and planned enhancements to the Script platform.

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