Abstract—A new form of doing business is evolving through collaboration across the enterprise boundary. This paper presents the new paradigm of collaborative enterprise computing that leverages enterprises to collaborate within the trusted-virtual company. We propose a privacy-enhanced innovation framework that has twofold intent (i) managing the innovation process life cycle, and (ii) linking distributed user profiles. The framework contains several functionalities such as registering, reviewing, scoring and realizing the business idea with human resource representations. The framework maintains the semantic representation of the business opportunity and the user profile, which helps in exploiting the framework built-in reasoning capabilities for establishing trusted-virtual communities. In this regards, we develop an business idea ontology using web ontology language. Moreover, the paper outlines the detail of key components of the proposed framework.

Index Terms—Collaboration, enterprise, innovation, privacy, social cloud, semantic web, trust, user profile

I. INTRODUCTION

Social Computing transforms enterprises from silos-based knowledge to collaborate-based knowledge devising a digital ecosystem where boundary line between enterprises and the individual becomes indistinct. Enterprises use different social computing platforms to foster new collaboration working environment both inside the company and in collaboration with others. These platforms offer different functionalities such as sharing knowledge and idea, display recent activities of people, showing contacts and skills of people, List of Colleagues and friends on Social Network sites, etc. Enterprises also consider social computing platforms to communicate with their customers and inform them about new services and releases. This does not only bring value and uptake of business in the form of enhanced productivity and revenue, but also provides customers with the benefit by 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 [1]. A range of white papers [2], [3], [4] pointed out the significant of social computing but only few [5], [6] addressed the challenges and opportunities of social computing in enterprises. Though enterprises possess significant benefits from social computing platforms, but there are some issues which need to be addressed by enterprises. First, Social computing platform possesses user profiles that are essential for an enterprise, containing information about the people working in an organization, and helping to obtain appropriate information about people's skills, their education, their 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. Secondly, social computing platforms do not facilitate employees to communicate and collaborate across organization's firewall. We envisage virtual enterprise as a number of connected enterprises that depends on each other and collaborate across enterprise network to achieve either a common business goal or to form a virtual market place. Thereby, collaboration needs to be handled seamless across enterprises based on their level of trust relationship, which may lead towards a trust based enterprise social computing Thirdly, social computing platforms only aggregates information which is fragmented over an enterprise network and does not provide any mechanism to aggregate information from various sources. Therefore, there is a lack of information interoperability in the current social computing platform sites.

In this paper, we propose privacy-enhanced Innovation framework for enterprise that operates in an open-controlled environment. The proposed framework comprises of three-components: Access Manager (AM), Collaboration Ensemble Engine (CEE) and Collaboration Criterion Manager (CCM). The framework supports user profile management, which has twofold functionalities: (1) User Profile Creation (2) User Profile Interconnection, and Idea management that register new ideas and provide mechanism of scoring. Moreover, the paper describes User profile Ontology, Trust Ontology and Idea Ontology that are written by using Web Ontology Language (OWL).

II. RELATED WORK

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 [7], 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 [8], 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 [9] 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 [10], 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 [11]. 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 etc. In [12], 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. CASE STUDY

The objective for the development of the innovation framework is to create secure social collaboration network in an open-controlled environment. Members should have the opportunity to register their ideas and openly discuss them with people of their trusted network. Enterprises concentrate today on their core business, inviting other for adding their expertise in relevant areas. By leveraging this collaboration into the whole society, enterprises will be able to create innovative products covering several areas. For instance, Norwegian oil Industry reduced operation costs from 30-50% and enhanced productivity from 5-15% by integrating several operations together into their system. Current approaches are based on selected people from various organizations working together in one project. Our privacy-enhanced innovation framework will allow to see which other members of the involved organizations might be interested in the approach, and to invite them to specific aspects of the project.

Bob has an innovative idea, which he registers in the framework so that he can get right partners to formulate the idea in a research proposal. Idea will be reviewed for acceptance by the framework members that belong to different enterprises. The idea will be published in the framework after acceptance in the relevant research area. The framework will find right partners by employing idea owner policies, by notifying all the found partners about this new idea and by asking them to consider and score it. Thus, the framework not only helping Bob in finding right people for his idea but also providing him implicit technical review, scientific value and the importance of his idea.

IV. A PARADIGM OF COLLABORATIVE ENTERPRISE COMPUTING

Cloud computing providers such as Microsoft, IBM, and Google are providing services and application such as word processing, document management, content management and spreadsheets on the web in the form of Software-as-a-Service (SaaS), by allowing enterprises to use such services and application without buying, and installing into their enterprise environment. This enables enterprises to reduce their IT costs and increase their productivity. Recently, cloud providers are incorporating social computing into their service and applications, which opens a new paradigm of collaboration, allowing enterprises to enhance their knowledge and efficient way of doing work by establishing direct relationship with co-workers and customers. For instance, Microsoft SharePoint, IBM Lotus Connection incorporates social computing into their platforms, which provides business collaboration within and across enterprise. However, these platforms provide only basic functionalities for competence match making using horizontal search techniques. Also, they are lacking in linking enterprise data, people and services. The Semantic web [13] can be used as glue that helps in providing meaning and linking to enterprise data, services and user profiles. With such semantic enhance description it is now possible to employ vertical search on a pre-defined topic to get relevant and accurate search results. The vision of semantic web is dreamed by the Sir Tim Berners-Lee, the inventor of World Wide Web. According to his vision, the Web will be evolved by providing meaning to information and services on the Web so that the information can be discovered, linked and accessed in an intelligent manner. He says in the first WWW conference [14].

"To a computer, the Web is a flat, boring world, devoid of meaning. This is a pity, as in fact documents on the Web describe real objects and imaginary concepts, and give particular relationships between them. For example, a document might describe a person. The title document to a house describes a house and also the ownership relation with a person. Adding semantics to the Web involves two things: allowing documents which have information in machine-readable forms, and allowing links to be created with relationship values. Only when we have this extra level of semantics will we be able to use computer power to help us exploit the information to a greater extent than our own
Lot of applications has become smarter with the employment of semantic web technologies (e.g., Hakia, Triplt, clearForest, etc.). Generally speaking, the amalgamation of semantic web technologies, cloud and social computing originates a new paradigm of collaborative enterprise computing as depicted in Fig. 1 that leads enterprises to collaborate in a trusted-virtual company and create an opportunity for open innovation.

Fig. 1. Collaborative enterprise computing

V. KNOWLEDGE REPRESENTATION THROUGH ONTOLOGIES

Enterprises capture and store their business and process information, commonly refer to knowledge representation, by using different approaches. Traditionally, enterprises represent knowledge in relational databases and Extensible Markup Language (XML) but these approaches are seriously facing the challenge of knowledge integration and interoperability. Semantic web leverages the knowledge representation with the introduction of ontology that represents shared knowledge by defining concepts and the relationships for a specific domain.

A. User Profile Ontology

We proposed user profile ontology in [15], which classify the profile into different categories. A simplified snapshot of the user profile ontology is depicted in Fig. 2.

Fig. 2. Overview of user profile ontology

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.

B. Trust Ontology

The trust Ontology is designed in [16] by considering the key elements (i.e, Trust direction, Trust Value, Trust Type etc) to define the concept of Trust. A simplified snapshot of Trust ontology is depicted in Fig. 3.

Fig. 3. Overview of trust ontology

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.

C. 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.

The Fig. 4 represents the complete overview of the Business Idea Ontology. 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 1.

\[
\text{Score} \equiv \text{Excellent} \cup \text{Good} \cup \text{Fair} \quad (1)
\]
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, Mobile Development etc.
- **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.

**VI. INNOVATION FRAMEWORK**

The innovation framework is designed with the following components: Access Manager, Collaborate Ensemble Engine and Collaboration Criterion Manager as depicted in the Fig. 5.

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. 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 ensemble engine 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.

**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 etc. 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.

Once the idea is registered 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. The idea registration phase is presented in Fig. 7.

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 manager, 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 as illustrated in Fig. 8.

If the idea achieved status of open for collaboration then the CEE exploits description logic [17] 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.

VII. CONCLUSION AND FUTURE WORK

In this paper, we irradiated the collaboration involvement in an enterprise environment where new business ideas are generated and shared across the enterprise boundary. This leverages the enterprises to collaborate within the trusted-virtual company that is established after discovering the relevant partners with the right expertise. The current situation does not allow enterprises to collaborate across their boundary; as a result, they encounter difficulty in discovering relevant partners, consume more time in trivial tasks and have less control over the confidential information. This paper proposed the privacy-enhanced innovation framework for managing the business idea based on user profile in the enterprise environment.

The proposed framework comprises three core components such as Access Manager (AM), Collaboration Ensemble Engine (CEE) 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, Trust and Business Idea Ontologies by considering the modular approach.

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 the real environment.

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REFERENCES


