Enhancing Social Media with Pervasive Features

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Abstract. During the last decade, social media have enjoyed meteoric success in bringing people together online. On the other hand, pervasive computing assists users in their everyday tasks, in a seamless unobtrusive manner exploiting the resources available in the user's environments focusing on the needs of individuals. The time is ripe for the two paradigms to converge. This paper presents research work undertaken to integrate pervasive computing with various social computing systems, including enterprise social media, aiming to contribute to the emergence of the next generation of social media systems.

Keywords: social networking, pervasive computing, pervasive communities, enterprise social media.

1 Introduction

Web and mobile technologies and devices have rapidly evolved and have known extensive market penetration to the majority of potential users. This fact, along with the inherent need of humans to communicate, socialise and share, have been the driving forces behind the rise of social media [1] and their meteoric success in enabling them to virtually socialise, interact and network, to share multimedia (user generated) content, to generate collective knowledge, etc. A wide variety of existing applications and services have already been integrated with social media and have evolved based on them, while new attractive applications have been enabled via social networking means, very often exploiting the vast wealth of information and content made available by social media facilities [2]. However, the wide spectrum of services provided via social networking systems (SNSs) do not integrate well or not at all with the variety of services, devices and resources in general that the users have access to locally or remotely.

On the other hand, there is ambient intelligence and pervasive computing [3] that aim to unobtrusively assist users in their everyday lives, by transparently and ubiquitously embedding numerous computing, communication and sensing resources in their surrounding environment and mobile devices. Up to this point,

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Smart Spaces and pervasive computing systems in general have been built so that they primarily serve the requirements and desires of individual users. Compared to the success of social media, the products and services enriched with pervasive features or designed specifically to support the establishment of smart environments have known limited penetration in the wide market.

The SOCIETIES project (`http://www.ict-societies.eu`) investigates approaches to enable the convergence of social computing and pervasive computing. Integrating current pervasive computing systems with social networking services allows users to communicate and socialise, while it facilitates their everyday activities by supporting their interaction with other users that have similar interests, preferences and expectations, and in general, the same or similar context. The most popular SNSs do not exploit such information explicitly, but rather rely on the users' actions and intentions on describing their situation, their relationships with the other users, their preferences, etc. Nevertheless, lately there have been observed some social networking services that gradually exploit location information. But this is a very limited usage of a single type of context information and is still very far from the establishment of actual pervasive social media.

This is more intense for the Enterprise Social Media [4], where no such attempts to exploit pervasive information or enable pervasive computing facilities have taken place. However, there are numerous reports that enterprise social media will re-shape corporate culture forming the new paradigm that leverage the knowledge of employees, customers, and partners [5]. Social media enhance the exposure of enterprises reducing at the same time their overall marketing expenses. In addition, social technology may substitute companies' traditional intranets allowing employees to efficiently collaborate via innovative means. Mobile service provision and intelligent behaviour of services are two crucial aspects of pervasive computing that need to integrate with emerging enterprise social media technologies. Exchanging ideas, managing resources and locating people are only few of the aspects that will be improved. On the other hand, as emerging social media technologies should be highly interoperable, the need for standardisation is raising.

The framework proposed in this paper aims to contribute to enriching social networking systems, including enterprise social media, with pervasive computing features. This is accomplished via the notion of the Cooperating Smart Space (CSS) [6] that extends pervasive systems beyond the individual to dynamic pervasive communities of users. A Pervasive Community, modelled as a Community Interaction Space (CIS), is a group of, two or more, individuals who have agreed to share some, but not necessarily all, of their pervasive resources with other members of that community [6].

The remainder of this paper is structured as follows. In Sect. 2, a state-of-the-art review is presented with regards to pervasive features provided by social computing systems in general and in enterprise social media in particular. In Sect. 3, the implemented architecture is described focusing on the integration of our platform with existing social networking systems. Subsequently, Sect. 4

elaborates on the manner that social media data are modelled to be treated as pervasive information (context data in particular) so that they can further enhance the perceived experience of SNS users. Section 5 provides information on the enterprise user trials that have already taken place and have enabled validation of our system by enterprise users. Finally, in Sect. 6, the paper conclusions are drawn.

2 State of the Art on Pervasive Social Media

Social Networks have evolved dramatically during the last decade and pervasive computing is becoming part of today's Social Networks. Such an approach, of pervasive social networks is presented by the WhozThat system [7]. In this system, the users are interconnected based on their location proximity and their personal interests, while initially the user is notified for the identities of their proximal users and if they share some common interest, social communities are formed on the fly, exploiting information gathered from popular social media (e.g. Facebook) automatically.

Another effort of using pervasiveness in SNSs is presented in [8], where a friend recommendation approach for mobile Social Network Sites is proposed. The authors integrate community discovery with context-awareness and ontology modelling technologies. Although the system recognises the variety of context information around users, it mainly sets the user location, the social network and the personal information as the basis for supporting dynamic recommendation in mobile communities.

An effort to retrieve users' behaviour from location habits has been presented in [9]. The authors use Foursquare, a Location-based Social Network, to derive user behaviours and specifically the activity duration. The activity duration, is approximately calculated using a method based on statistics from real users' activity. The system avoids the use of external location-purpose devices like GPSs in order to reduce the power consumption of smartphones.

Another important factor in pervasive computing is the use of sensors. In this respect, the authors in [10] try to recognise emotions of the user by collecting and analysing user-generated data from different types of sensors on the smartphone. To evaluate the proposed approach, they developed a social network service client for Android smartphones classifying seven types of emotions: happiness, surprise, anger, disgust, sadness, fear, and neutral.

Recently, in addition to being part of users' personal lives, social networks have also been adopted for business purposes. In particular, social networks are being used in order to build someone's professional profile, such as in LinkedIn [11] and Xing [12]. Leaving aside the use of social networks by individuals, many recent studies indicate the benefits that can be accomplished by the use of social networks inside modern enterprises. Some of the most know Enterprise Social Networks are IBM Social Business [13], Jive [14], Coyo [15] and Yammer [16].

The use of Enterprise Social Networks is valuable irrespectively of the company size, as both small/medium-sized and international enterprises may benefit.

In [17], the authors analyse specific decisions and approaches regarding the social media adoption in enterprises. In this process, they also consider the high cultural diversity and independence of the local entities.

Similarly, the authors in [18], examine the adoption, usage and benefits of social media in Small and Medium-sized Enterprises (SMEs), as well as, potential concerns that may prevent a wider adoption of social media in SMEs. According to their research, SMEs started to use internal social media (e.g. wikis, blogs) in order to support collaboration among employees and to improve knowledge management.

Though there are many studies proposing social network approaches in the business sector, to the best of our knowledge, there has been no effort to combine Enterprise Social Networks with Pervasive Computing.

3 Architectural Approach

This section initially provides an overview of the functional architecture of the SOCIETIES platform and, subsequently, elaborates on the integration of the platform with existing social network services.

3.1 High-level Architecture View

The overall system architecture encompasses the SOCIETIES platform services, third party (3P) services that utilise the platform, as well as, software and hardware elements, such as, sensors, devices, web interfaces and social networks. Figure 1 depicts a functional viewpoint of the implemented architecture, where platform services are grouped in different layers according to the logical deployment they support [19]. These layers are outlined hereafter.

Multi CSS/CIS Layer: Services contained in this layer support federated search, identity, and domain administration functions, and store public information referring to multiple CSS or CISs. Each administrative domain maintains one instance of these services that may be utilised by other federated domains.

CIS Layer: Services contained in this layer support the members of a community and the respective CIS. Every CIS maintains at least one instance of these services, and an instance of these services can be used by multiple CISs.

CSS Layer: Services contained in this layer support an individual participant and the respective CSS. The word "participant" is used to refer to a single user or organisation. There is at least one instance of these services per participant, and an instance of these services can be used by multiple participants. This layer also maintains the necessary components that allow the integration of existing social networking systems (SNSs), enabling the extraction of public information available in SNSs, as well as, access/update of non-public information for the CSS owner. This functionality is provided by the *Social Network Connectors* component depicted in Fig. 1, which will be described in the following subsection.

Node Layer: Services contained in this layer are characterised as core services and are available per node. A CSS node is a logical node/device/cloud instance

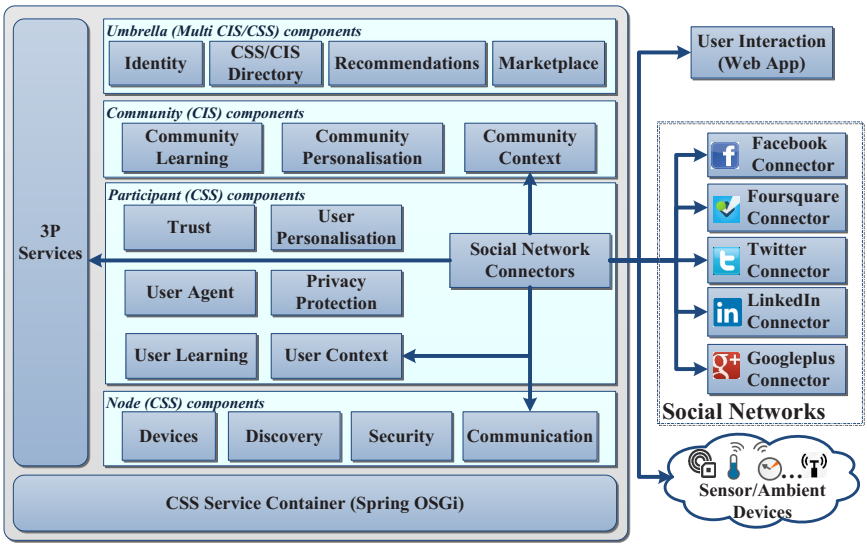

Fig. 1. High-level functional architecture

running CSS software that coordinates with other CSS nodes to form a participant's CSS. There is an instance of these services per CSS node.

3.2 Integration with Social Media

An important aspect of the pervasive community vision is to seamlessly capture and facilitate Social Web interactions. SOCIETIES is not providing another Social Network in its common definition, but a bridging scheme between the Social Web and pervasive communities. Our first step is to link the profiles and activities of users in our pervasive communities with those in their online social networks (e.g., Facebook, LinkedIn, Google+, Twitter, Diaspora, etc.). Interoperability with Social Web initiatives needs to be taken into account, with regards both to standards work on federation, as well as, to non-standardised approaches given their popularity. Towards this approach, common representation of people, profiles, and activities is necessary. Another key step is to facilitate the exchange of information between both systems, for example, details such as the name of the pervasive community, the participants' identities and the activities of individual participants.

The *Social Network Connectors* component provides a proxy between the SOCIETIES Platform and the user's social network communities. Using this subsystem, the platform is able to connect to one or more social networks and fetch most of the user's profile information, plus his/her behaviour on the social network. It also provides an API to push data through one or more social channels. The component hides the details of each social network API and provides

a common model to describe and store the social data in order to make them available to other modules of the platform. Social networks can also be accessed via their proprietary APIs (for example, FaceBook's Graph API). This allows the extraction of information out of existing (non-federated) social networks.

Each Social Network that the user is member of, is linked with the SOCIETIES platform through a *SN Connector*. Its goal is not to translate or further process the fetched data, but to aggregate or use the specific API to provide a full JSON [20] string as a result of the described method. The SN Connector requires an *Access Token* to secure access to the Social Network. Such a token identifies a User, App or Page session and provides information about granted permissions. It also includes information about when the token will expire and which app generated the token. Most of the API calls need to be signed with this access token, which is generated with OAuth 1.0/2.0 authentication and authorisation procedures. The generated SN Connectors are persisted, meaning that every time the client is restarted all the connections can be restored. The Social Network Connectors component provides API methods that support: SN authentication; query functionality, such as, access to public profile information of other users or their own SN profile; retrieval of SN contacts; retrieval of groups the user belongs to/follows/likes; retrieval of activities performed within SNs; and publishing of content on the SN (e.g., posting a textual message on the SN, performing a check-in or posting an event).

The most valuable piece of functionality exposed by this component is data abstraction. Each active SN connector is periodically called, and the extracted raw data are passed to a converter. In order to support interoperability among the different information items originating from each source, the converter translates the specific social network language into a common object according to the OpenSocial specification [21] which has been introduced by Google. OpenSocial is an open set of programming interfaces for building web-based social network applications. It encompasses several aspects of Social Networking Applications including Profiles, Relationships, Activities, Shared applications, Authentication and Authorisation. The following three OpenSocial data objects are of particular interest: (i) *Person* (OpenSocial defines many common attributes associated with a person and is aligned with the Portable Contacts specification), (ii) *ActivityEntry* (consists of an actor, a verb, an object, and a target; it can, thus, describe a person performing an action *on* or *with* an object), and (iii) *Group* (OpenSocial Groups are owned by people, and are used to tag or categorise people and their relationships).

The mapping between the information retrieved and the OpenSocial object is not always complete, as it relies on what the user has provided on their profile, as well as, the type of social network that the data are coming from. The strength of this approach is that an application, which needs to consume such data, is not required to understand different languages or dialects for the same information type, but just one, and is, thus, able to handle them in a uniform fashion. This allows for incorporating social media data from heterogeneous sources into the CSS Context Management system which serves a twofold purpose: on the one

hand, to enrich the SOCIETIES user profile information, while on the other, to make these data available to other components of the platform or interested 3P services.

4 Modelling of Social Media Data as Context Information

A dominant feature of pervasive computing is the provision of mechanisms that support proactive and intelligent platform behaviour. User/community personalisation, context management and learning are some of the facilities offered by the SOCIETIES architecture, as illustrated in Fig. 1. Such facilities rely on a variety of data that need to be derived from heterogeneous sources (e.g. hardware sensors, social networks, user feedback) in order to provide an enhanced user experience for both individuals and entire user communities establishing proactive smart space behaviour [22].

It is, therefore, necessary to integrate all this information, including data originating from social media, into a common data model. This was one of the core design principles for the SOCIETIES Context Model (SCM) [23]. The SCM data model comprises the following core classes: `CtxEntity`, `CtxAttribute`, `CtxAssociation`, `CtxHistoryAttribute`, `CommunityMemberCtxEntity`, `IndividualCtxEntity`, `CommunityCtxEntity` and `CtxBond`. The first four of these classes serve as the basis for the representation of context data pertaining to individuals. As it is obvious, an entity–attribute–value model is adopted, where an entity is assigned with various attribute types and respective values detailing the properties of the entity. Relations among entities are expressed by the `CtxAssociation` class that has a crucial role in modelling Social Network data. An association may entail a parent `CtxEntity` and various child entities and hence, it is characterised as directed or may relate two or more peer entities forming an undirected association. A predefined but extendable taxonomy semantically describes the types of entities, attributes and associations. SCM supports the modelling of information referring to communities of individuals, communities that consist of other sub-communities forming community hierarchies and even complex structures, where community members are a mixture of both individuals and subcommunities. The `CommunityMemberCtxEntity`, `IndividualCtxEntity`, `CommunityCtxEntity` and `CtxBond` classes tackle the added complexity imposed by the representation requirements of community context [23].

In Fig. 2, an example data object diagram is presented. A person is modelled as an `IndividualCtxEntity` that is assigned with various attributes describing the current situation of the user (e.g., user status, location, etc.). Each social network account that the person maintains is modelled as a distinct `CtxEntity`, where the type of the social network service is stored as a `CtxAttribute` value. Additional data derived from the social network (e.g., "interests", "books", "movies") are represented as extra `CtxAttributes` of the respective type. Complicated Social Network data structures that cannot be mapped to simple attribute–value objects, are modelled as `CtxEntities` assigned to a `CtxAssociation`. For example, each SN connection (Facebook friend or Twitter follower) is represented as

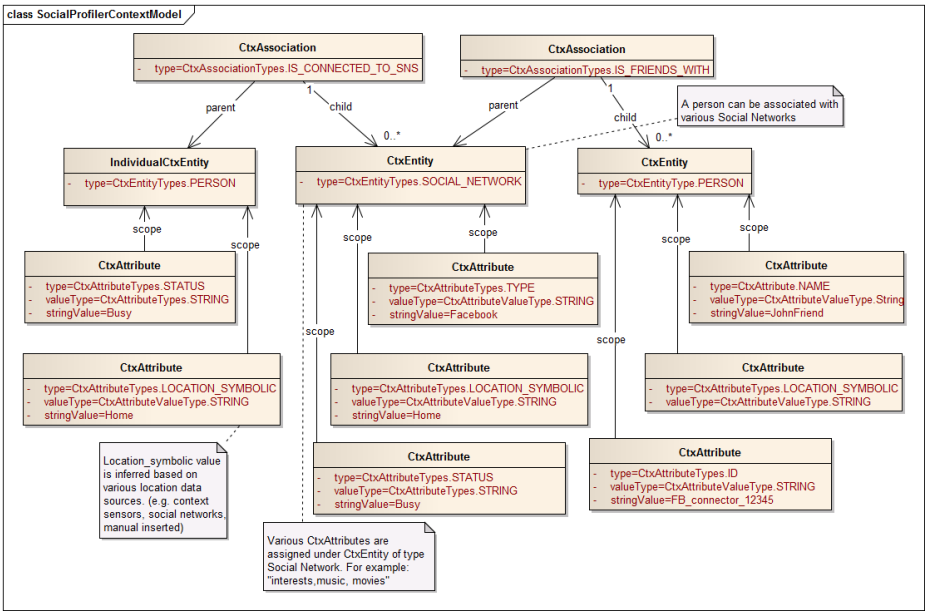

Fig. 2. The social profile context model

a distinct `CtxEntity` escorted by a number of `CtxAttributes` that correspond to the profile information being shared (e.g., name, location, social network user ID).

5 Enterprise User Trial

The SOCIETIES platform is intended to be used by both individuals and entire communities. It is, thus, imperative that the design is user-centred and, wherever possible, user-driven. The SOCIETIES methodology [24] is based on the inclusion of three different user communities, which have engaged continually in the design and development process from initial user requirements gathering and early concept creation, through to scenario refinements and feature revisions via early prototype evaluations. These are an Enterprise community, a Student community, and a Disaster Management community. Early user requirements were elicited via ethnographic techniques, involving close observation of each community in their real-world environment, combined with questionnaires and participatory discussions.

The remainder of this section focuses on the Enterprise users for whom the above methodology indicated a profound interest in pervasive community services, which could enhance the workflow of their daily lives, with additional features for more selective relevant communications. Enterprise communities play an important role in bringing together people, goods and services within global

markets, local ecosystems or large organisations. These busy executives, in several cases, reported being over-loaded with communications and information, and the automatic filtering of both, without missing opportunities for useful connections, would be attractive to them.

5.1 Trial Outline

The SOCIETIES prototype Enterprise user trial took place in the Intel Campus in Leixlip, Ireland, during April 2013. The trial participants were Intel employees who elected to partake in the trial following a SOCIETIES Innovations presentation. Participants were given a mobile device with the prototype applications installed. The trial activities included a participatory demo and playful context discovery games, followed by role–playing conference scenarios and open discussion sessions. All of these trial participants were technology literate men, who work in technology research and development, and therefore did not have unrealistic expectations about the maturity of trial prototypes. In addition, all participants as frequent conference organisers, and/or attendees, were familiar with the conference settings for the trial scenarios, and each one brought his particular knowledge, expectations, experience and preferences about such events to the trial.

5.2 The Conference Scenario

Early in the project lifecycle, SOCIETIES chose to focus on conference scenarios in order to investigate novel social and pervasive concepts and services for the Enterprise community. These enterprise scenarios aim at supporting the formation of relevant context-aware communities in a conference environment, and as such, assume a large number of users, who are willing to share information, to access a wide range of integrated dynamic context and community aware services, including the following: pre-conference planning, personalised agendas, ad-hoc meetings, post-conference reviews, and tailored peripheral services, such as, organising menus and taxi sharing.

At the time of the prototype trial, two of the five conference services in development were selected for inclusion, along with the main SOCIETIES application:

- *Networking Zones:* The service provides backend and client components that enable users to detect a virtual networking zone, based on their location, which informs them with details on a 'topic of interest' for each zone, other users (and relevant details) who have agreed to share these details in the zone, and existing social network connections between users in the various zones.
- *Context-Aware Wall:* The service allows users to post messages in the area (zone) they are in. The message stays in the zone—or on the wall for a while, is visible to others who walk in to the same zone, and are in the intended group/community for which the posting user selected.

– *SOCIETIES Application:* Provides end users with web and mobile interfaces to the platform and services. It enables users to: join communities, control which information to share, access context-aware services and review their interactions with the system through an activity feed.

5.3 Role–Play

Role–play was adopted as an evaluation tool for the trial. This is a powerful and flexible tool as described in [25], which has been employed in several HCI studies from early design to evaluation. Role–play allows for complex socio technical experiences to be modelled. This facilitated giving trial participants access to particularly interesting aspects of SOCIETIES innovations, whilst protecting them from having to share personal information. The functioning and benefits of the system required existing social network connections, which could be better managed through preloaded personas and pre-configured social media identities. Inviting participants to act out characters with such personas allowed them to get a condensed complex view inside a situated staging of the system in a conference setting, at no personal risk.

Another objective that role–playing fulfilled, was to direct trial activities to interesting and innovative aspects of the projects' enterprise applications. The restricted number of trial participants enabled detailed character development into new personas and improvised ideas which evolved into outline scripts. Pre-existing relationships and links from private and professional social networks were assigned to each character in the script and set up explicitly in actual social media accounts. The scripts were devised to motivate participants to engage with the trial system, thus allowing them to experience creating groups, making friends, and organising meetings, and to understand the unique innovations of the SOCIETIES system with regards to: personalisation, social network integration, context-awareness, and discovery of relevant friends and communities. Finally, a System Usability Survey was conducted and a post role–play discussion was facilitated.

5.4 Findings

Despite some software bugs and the controlled environment of the trial scenario, participants were clearly willing and inspired to imagine the potential for the types of services made feasible by a system such as SOCIETIES. They were intelligent about the possible risks and the assurances they would require with regard to the management of their data, but enthusiastic about the reach of services which link social networks, relevant contacts and communities with pervasive features. Discovering relevant connections, while still protecting one's identity or detail of organisation from others was considered very useful. There are potential drawbacks in including both SOCIETIES researchers, and trial participants in a set of participatory exercises. More specifically, the participants could be reluctant to criticise the proposed technologies for fear of offending developers; or they might vocalise their own presumptions of confusion or frustration even

before attempting to perform a task, so perceived flaws may gain greater significance than they otherwise would. The emotional responses and instincts of participants are understood in a more meaningful way by direct observation and engagement. Also as everyone in the participatory discussions understood that these are prototype trials and there is scope for improvement, it allowed for a more honest discussion. Finally, it should be emphasised that the findings that emerged, have led to design and development refinements for the final prototype.

6 Conclusions

This paper elaborated on the SOCIETIES vision and concepts that allow the integration of social media with full-scale pervasive functionality. Social media have already penetrated a wide spectrum of applications and are expected to revamp corporate culture by leveraging the knowledge of employees, customers, and partners. In this respect, services and products enriched with pervasive features need to amalgamate with these emerging enterprise social media technologies. The framework presented in this paper, provides innovative mechanisms that are able to support the incorporation of social media data into the intelligent facilities of the SOCIETIES platform. The implemented architecture has been evaluated through a series of user trials from different domains in realistic environments. The evaluation results from the Enterprise trial verify the potential for the types of services made feasible by a system such as SOCIETIES, which links social networks, relevant contacts and communities with pervasive services.

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