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Implicit Social Networking: Discovery of Hidden Relationships, Roles and Communities among Consumers

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Abstract

This paper proposes the implicit social networking as an innovative methodology for approaching consumers who possess information-rich user profiles based on a plethora of online services they use. An implicit social network is not explicitly built by consumers themselves, but implicitly calculated by third parties based on a level of a common interest between consumers (i.e., profile matchmaking). The analysis of a consumer social network created in such a manner enables discovery of hidden roles, relationships and communities among consumers and represents a basis for provisioning of innovative services (e.g., personalized and/or context-aware services such as recommender systems). The implicit social networking methodology is evaluated through two pilot cases: (i) implicit social networking based on the SmartSocial platform; and (ii) implicit social networking of IPTV users. The generalizability of the implicit social networking is demonstrated through additional example aimed not at external company stakeholders (e.g., company consumers), but at internal stakeholders (i.e., company employees) through the implicit corporate social networking pilot case.

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Keywords: user profiles; consumers; employees; matchmaking; social networking; social computing; social network analysis

1. Introduction

Today, more than a billion of users world-wide employ various social networking services on a daily basis for both personal and businesses uses, interacting with their "friends" in quest of web pages they liked, places they visited or movies they watched. In the same time, service provisioning paradigm is shifting from the CRM (*Customer Relationship Management*) to the CMR (*Customer-Managed Relationship*)[1], where companies use a methodology, software and Internet capabilities to encourage its consumers to manage information pertaining to them (i.e., their user profiles). This shift enables companies to collect even more extensive knowledge about their consumers and the following research question arises: *is there a way for companies to improve existing or introduce new services based on innovative reasoning upon rich consumer profiles they now possess?*

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We argue that an *implicit social networking* is a possible methodology which builds upon rich user profiles characteristic to the CMR era and enables discovery of hidden roles, relationships and communities among company consumers. While *explicit social networking* implies that company consumers connect intentionally (e.g., if they want to connect on the most popular social network Facebook, they need to perform two actions – (i) a connection initiator has to send a "friend request"; and (ii) the invited user has to confirm the request), implicit social networking approach enables automatic connection of users (i.e., they do not need to perform any action). This not only creates competitive advantage for companies which use a novel implicit social networking methodology but provides them with a new knowledge about their consumers what enables provisioning of innovative personalized and/or context-aware services.

The research on how "big data" can enhance CRM is an intensive multidisciplinary field of research where engineers, economists and psychologists try to create new ways for vast amounts of user-generated data in Web 2.0 era to be combined with latest data science technologies in order to create added value both for companies and consumers across industries[2]. The scientific contribution of this paper is a proposal of a new methodology, called the *implicit social networking*, which enables companies to improve existing or introduce new services based on innovative reasoning upon big data describing their consumers. Namely, our approach facilitates automatic creation of consumer social networks through consumer profile matchmaking, what further allows discovery of hidden relationships, roles and communities among company consumers.

The remainder of the paper is organized as follows. Section 2 discusses related work. Section 3 presents the idea of social networking and explains the central role of user profiles. In Section 4 the main idea behind the implicit social networking is described and compared to traditional explicit social networking approach. The methodology for implicit social networking is presented in Section 5. Section 6 evaluates implicit social networking methodology through several pilot cases. Section 6 concludes the paper and discusses the future work.

2. Related work

Some of proposed approaches within a telecommunication industry include subscriber classification[3] or rethinking network architecture[4] through applying big data technologies, as well as designing recommender service based on social information extracted from telecommunication networks[5]. It should be noted that user profiles are explored for recommendation purposes from the early beginning of on-line social network services[6].

There are several interesting studies on both categories of social networks – implicit and explicit – and their relationships. A framework for evaluating topology and flows in explicit and associated implicit social networks by using measurement matrix is proposed in[7]. Another approach to convergence of implicit and explicit social networks is elaborated in[8] where interest-based implicit networks are combined with explicit networks in order to allow users to identify and build connections to other users that can provide certain interesting information.

Extraction of implicit social networks from communications services data using different approaches is performed for various purposes. Characteristic examples are related to phone communications[9-13], Short Message Service (SMS)[14] and e-mails[15-19] in public and private networks, as well as gaming[20].

Although all these, as well as a number of similar approaches, combine ideas of social networking and big data, our approach is different in a way that proposes a novel process of social network creation based on connecting users *implicitly* and therefore presents a platform for creation of innovative personalized and/or context-aware services such as recommender systems.

3. Social networks and user profiles

The two basic building elements of every social network (SN) are *users* (i.e., nodes/vertices/entities in a graph representing a social network) and *relationships* among these users (i.e., edges/connections/ties in a graph representing a social network). In this paper we focus on a specific type of users – company consumers. There is no single definition of a social network, which is probably due to the fact that the study of social networks is one of the most interdisciplinary areas of science – for a comprehensive understanding of social networks one requires knowledge of sociology, psychology, mathematics (specifically, graph theory), economics, computer science, statistical physics and other[21]. However, almost all social network definitions have one idea in common – a notion of

common interest, which connects users involved in a certain social network[22,23]. In this paper the notion of common interest is manifested through the fact that users are existing or potential consumers of a certain company.

All social networks services as well share a common foundation – (semi-)public *user profiles* which have a threefold role in a social networking model:

- *Representation role*: a user profile contains information about the user, such as interests and activities;
- *Connection role*: a user profile contains links to other members of social network with whom the user is connected. The relationship of connection between users is usually called the *"friendship"*. If a user profile provides only links to "direct friends", then the *"reachability"* within the social network is limited to one step. If a *user A* enables his/her friend, *user B*, access to a profile of his/her friend, *user C* (while *user B* and *user C* are not friends), then reachability is limited to two steps (*Facebook*) and *user B* and *user C* are in the *"Friend-of-a-Friend"* relationship. Some social networking services (SNSs) enable even greater reachability, such as *LinkedIn* which enables a three step reachability;
- *Affiliation role*: a user profile contains information about affiliation of the user to various interest groups.

In the context of this paper, from the perspective of representation role a user profile contains information about company consumers; from the perspective of connection role a user profile contains links to other *similar* consumers; and from perspective of affiliation role a user profile contains information about membership in various consumer clusters.

Generally, user profile is a user virtual representation enriched with his/her *ego social network* (EN). User ego social network consists of a set of nodes with direct ties to a focal node (called "ego") and a set of corresponding ties. Consequently, a user profile enables other users to attain a certain impression about the profile owner. User profiles on popular social networking sites can be used for finding long lost or searching for new friends (*Facebook*, *Google+*), discussing concisely about specific topics (*Twitter*), seeking for a new job (*LinkedIn*), communicating through mobile photo-sharing (*Instagram*), looking for a romantic partner (*Friendster*), receiving and making recommendations (*tribe.net*), presentations or critics of various artistic activities (*deviantART*, *Flickr*, *Fotoblog*), enjoying the music (*Last.fm*), reestablishment of broken family bonds (*MyHeritage*, *MyLife*, *Geni.com*), discovering nearby friends (*Foursquare, Gowalla*) and various other activities.

4. Explicit vs. implicit social networking

Social networks can be constructed in two different ways – *explicitly* and *implicitly*[24], as presented in Table 1.

Table 1. A comparison between explicit and implicit social networks.

	Explicit social network	**Implicit social network**
User representation	Profile	Profile
Formation principle	Aggregation of ego networks	Calculation of a level of common interest between users (i.e., user profile matchmaking)
Relationships	Public	Hidden
Roles	Public	Hidden
Communities	Public	Hidden

In an *explicit social network* all connections between users are direct result of intentional action of those users, i.e., every social network user must initiate a connection with another user for them two to become "friends". Each user of a social network, therefore, consciously "connects", grounding explicit social networks on the notion of *public relationships*, *public roles* and *public communities*. From the perspective of companies, information of public relationships, roles and communities represents additional knowledge about their consumers. However, it does not represent competitive advantage over their competitors because the same public information about consumers is available to competitors as well.

Social relationships established by todays SNSs are all based on ego social networks – every user builds his/her own social network by explicitly defining connections with other people. Let us assume that an ego social network of a user u_i is denoted as $\mathcal{EN}_i$. Ego social networks of all users (i.e., users from the set $\mathcal{U}$) interlock to form a social network $\mathcal{SN}$:

$$\mathcal{SN} = \sum_{a=1}^{|\mathcal{U}|} \mathcal{EN}_a \tag{1}$$

On the other hand, in an *implicit social network* all connections between users are result of a "third party" reasoning over user profiles. Moreover, users even do not necessarily have to be aware of other users they are "connected" to. Mechanisms employed by the "third party" for the construction of a social network can be diverse, but must be based on the calculation of a level of common interest between users, i.e., user profile matchmaking. Matchmaking is the process of comparing two objects represented through profiles, resulting with a number within a certain interval (i.e., a number between 0 and 1, where the larger number reflects a higher level of a common interest between users).

Generally, the formation principle of implicit social networks is grounded on a threefold view on users – users can be observed through three different layers of abstraction: *physical layer*, *knowledge layer* and *social layer*[6]. Firstly, *physical layer* observes users as persons physically situated in the *Internet* environment and using computing devices connected to the Internet via *physical links*. Furthermore, *knowledge layer* observes users through their user profiles represented with *domain knowledge*. Finally, *social layer* observes users through an implicit social network.

The knowledge layer is used for mapping users from physical domain represented with physical layer into social domain represented with social layer. Consequently, operations with user profiles in the knowledge domain define resulting social network materialized through the social layer. For example, user profiles could initially be filtered according to a certain criterion (e.g., location, age, sex, etc…). Afterwards, profiles of filtered users are compared (i.e., matchmaking between all possible pairs of filtered users is performed) and users are connected via *logical links* (i.e., discovery of *hidden relationships*). Moreover, social subnets (i.e., *hidden communities*) and *important users* (i.e., *hidden roles*) could be identified.

5. Building an implicit social network

From the perspective of companies, information of hidden relationships, roles and communities represents not just additional knowledge about their consumers but competitive advantage over their competitors as well because their competitors usually do not have mechanisms for implicit social networking of consumers due to fact this is an innovative CMR methodology. Our approach, presented in this section, proposes a novel process of social network creation based on connecting users implicitly and therefore presents a platform for creation of innovative personalized and/or context-aware services such as recommender systems.

We propose to create virtual representatives, *User Agents*, which autonomously represent consumers in interactions with virtual representatives of other consumers, or with a virtual representative of a company, the *Company Agent*, in the e-market. A User Agent creates and manages a consumer profile and thus possesses knowledge about devices, interests, preferences and context of its owner. A User Agent shares this knowledge with the Company Agent, to enable provisioning of personalized and context-aware services to its owner. The Company Agent (i.e., the "third party") utilizes the knowledge about its consumers for the creation of a consumer social network, which is built by means of the implicit approach based on the level of common interest between consumers, with no explicit involvement of consumers.

A lifecycle of such an implicit social network is presented in Figure 1. It is based on two computing paradigms. Firstly, the *social computing* paradigm is used for: i) matchmaking of user profiles representing consumers, and, ii) creation of implicit social network. Afterwards, the *economic computing* paradigm is used for an analysis of user and/or structural properties of created implicit social network – results of this analysis represent a basis for provisioning of innovative *personalized* and *context-aware* services in an Internet economy, such as recommender systems.

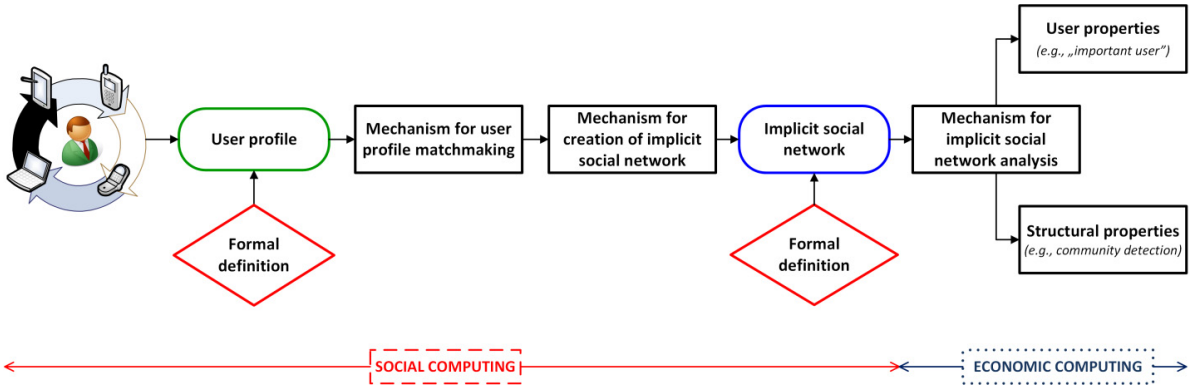

Fig. 1. An implicit social network lifecycle.

5.1. Social computing (phase 1): a mechanism for user profile matchmaking

The mechanism for matchmaking of user profiles is defined as:

$$compare\left(\mathcal{p}_{u_i}, \mathcal{p}_{u_j}\right) : \mathcal{P} \times \mathcal{P} \rightarrow [0,1] \tag{2}$$

where $\mathcal{P}$ denotes the set of all user profiles, while $\mathcal{p}_{u_i}$ and $\mathcal{p}_{u_j}$ being two elements of that set (profile $\mathcal{p}_{u_i}$ describes characteristics of user u_i, which is represented by agent a_{u_i}). The matchmaking resulting in the $compare\left(\mathcal{p}_{u_i}, \mathcal{p}_{u_j}\right) = 0$ means that $\mathcal{p}_{u_i}$ and $\mathcal{p}_{u_j}$ do not have any common interest. A higher matchmaking result means that $\mathcal{p}_{u_i}$ and $\mathcal{p}_{u_j}$ have more mutual interests, while the maximal result $compare\left(\mathcal{p}_{u_i}, \mathcal{p}_{u_j}\right) = 1$ means that $\mathcal{p}_{u_i}$ and $\mathcal{p}_{u_j}$ have identical interests.

5.2. Social computing (phase 2): a mechanism for creation of an implicit social network

The mechanism for building a user social network is formally defined as a function that takes the matrix of mutual common interest of all users as an argument. The output from the function is a graph $\mathcal{G}_{isn}$:

$$transform\left(mat_{compare_{\mathcal{p}_{u_{|\mathcal{U}|}}}}\right) : \begin{bmatrix} compare(\mathcal{p}_{u_1}, \mathcal{p}_{u_1}) & \cdots & compare\left(\mathcal{p}_{u_1}, \mathcal{p}_{u_{|\mathcal{U}|}}\right) \\ \vdots & \ddots & \vdots \\ compare\left(\mathcal{p}_{u_{|\mathcal{U}|}}, \mathcal{p}_{u_1}\right) & \cdots & compare\left(\mathcal{p}_{u_{|\mathcal{U}|}}, \mathcal{p}_{u_{|\mathcal{U}|}}\right) \end{bmatrix} \rightarrow \mathcal{G}_{isn} \tag{3}$$

The graph $\mathcal{G}_{isn}$ (formally defined as the *adjacency matrix*) represents consumer social network and is defined as follows:

$$\mathcal{G}_{isn} = (\mathcal{U}, \mathcal{E}) \tag{4}$$

what means that graph has $|\mathcal{U}|$ vertices (one vertex for every consumer) and vertices are connected with edges (a set of all edges is denoted with $\mathcal{E}$). The edge weight denotes the connection strength between consumers this edge is linking in a created social network.

5.3. Economic computing: a mechanism for an implicit social network analysis

Once an implicit social network is created (i.e., *discovery of hidden relationships* is accomplished), a social network analysis needs to be applied in order to analyse individual user properties (e.g., identification of most important users within the network – *discovery of hidden roles*) or network structural properties (e.g., detection of communities within the network – *discovery of hidden communities*). This step is referred to as "economic computing" because it produces added value for companies and therefore presents the basis for improving existing or introducing new services based on innovative reasoning upon rich user profiles.

6. Implicit social networking pilot cases

We implemented a multi-agent system, composed of *User Agents* and the *Company Agent*, modelling an information and communication service market in a new generation network. Furthermore, we implemented two innovative pilots where implicit social networking was validated in a real world environment: i) *context-aware social networking platform for mobile users*; and ii) *video on demand recommender service*. While the same implicit social networking methodology is applied in these pilots, different implementations are used across pilots. Reasons for that are the following: i) differences in user profile structures and technologies used for computational representation of user profiles (e.g., semantic profiles based on ontologies *vs* unstructured profiles based on NoSQL databases), and/or ii) differences in range of available data for building user profiles.

It is important to note that a special attention in pilot cases is given to preserving user privacy. This means that we are profiling users based on data for which we received explicit user consent, where applicable we analyze quantity of items without going into content (e.g., counting number of Facebook inbox messages between two users without analyzing content of a message) or use aggregated/anonymized data when quantity analysis is not sufficient (e.g., distance between users can be calculated from anonymized user locations).

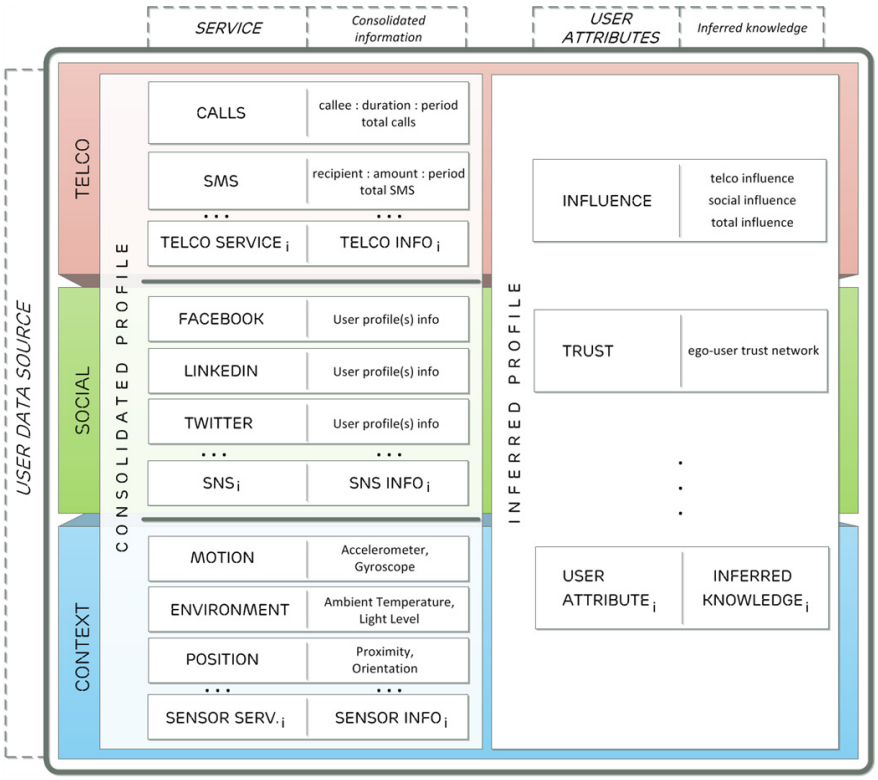

Fig. 2. The SmartSocial platform user profile.

6.1. SmartSocial platform

SmartSocial Platform (SSP) is used for context-aware social networking of mobile consumers and as such requires information-rich user profiles for providing personalization through new innovative services and applications[25]. The SSP profile (Figure 2) is a profile of information and communication technology user (ICT user) who generates data on a daily basis through different online accounts and plethora of online services and is comprised of three parts aligned with available user data sources: *telco*, *social* and *context data*. *Consolidated Profile* (i.e., *user profile* from Figure 1) holds information that has been acquired, aggregated and consolidated from available user data sources, such as *calls* (telco service), *Facebook profile* (social networking service) or *motion* (smartphone accelerometer). *Inferred Profile* holds knowledge about users which is extracted from a created implicit social network, such as *influence* of specific user in a social network or *trust* between two (directly or indirectly connected) users in a social network.

In this pilot case, *Company Agent* represents the SSP while *User Agents* represent mobile consumers. User Agents have information only about specific parts of Consolidated Profile of the consumer they represent (in the best case they have information about the full Consolidated Profile). On the other hand, Company Agent has knowledge about full SSP profiles of all consumers whose User Agents have joined the SSP platform, including knowledge of hidden relationships, roles and communities among consumers.

The SSP pilot case was validated on 500 users whose SSP profiles were created based on consumer data gathered through a specialized Android application.

6.2. *Implicit social networking of IPTV users*

In this real world pilot case a combination of explicit and implicit social networking is used for recommending Video on Demand (VoD) based on Internet Protocol Television (IPTV)[26]. IPTV is a multimedia service which is used to deliver television, video, audio and other interactive content over IP-based networks and VoD is one of the most popular IPTV services. A profitable VoD service needs to offer innovative features to attract new consumers as well as retain existing ones. To achieve this goal, a possible solution is to employ VoD recommendation engines to offer personalized lists of VoD items that are potentially interesting to a consumer from a large amount of available titles. A good recommendation engine does not offer just popular and well-known titles (Figure 3: (a)), but is also able to identify interesting among less popular items which would otherwise be hard to find (Figure 3: (b)).

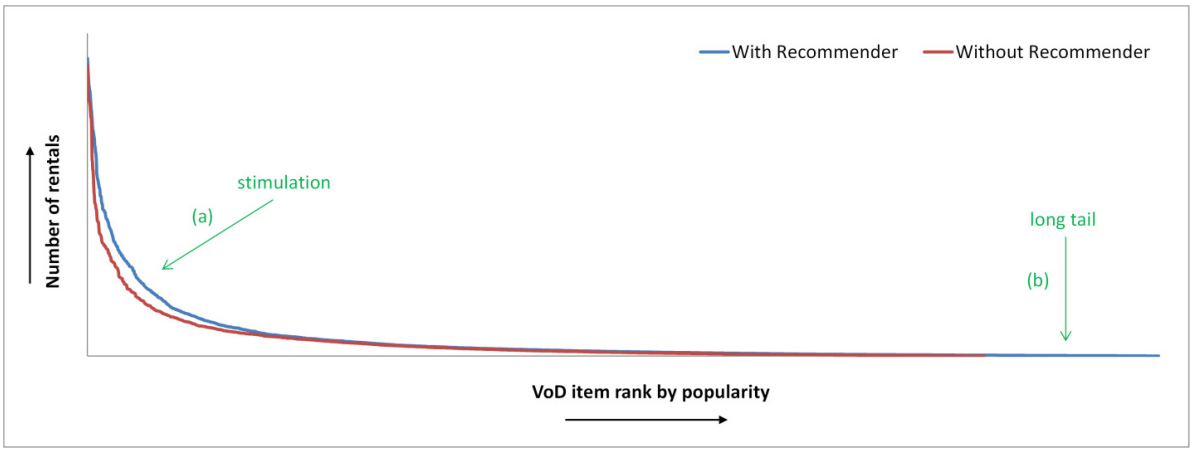

Fig. 3. Recommendation system based on implicit social networking does not just stimulate consumers to watch popular and well-known titles (a), but is also able to identify interesting items in the long tail of less popular items (b).

In this pilot case, *Company Agent* represents IPTV provider while *User Agents* represent IPTV subscribers. A combination of explicit and implicit social networking methodology is used to identify "potentially interesting" items among VoD titles already watched by ego consumer "friends", according to the following steps:

1. explicit social networking is used for determining a set of "friends" in a consumer social network (i.e., identification of consumer profiles, a set $\mathcal{P}$, based on explicit IPTV subscription and Facebook membership);
2. implicit social networking is used to calculate relations among users in the social network (i.e., calculation of network edge weights according to formulas (2) and (3));
3. implicit social network analysis is used for generation of recommendations based on discovery of hidden relationships among IPTV consumers.

The pilot case on implicit social networking of IPTV users was validated as the part of recommender engine for IPTV service provider with more than 250 thousands users.

6.3. Implicit corporate social networking

The generalizability of our proposed innovative methodology – the implicit social networking – is demonstrated through additional example aimed not at external company stakeholders (e.g., company consumers), but at internal stakeholders (i.e., company employees) through the implicit corporate social networking pilot case.

In this real world pilot case implicit social networking is used for analysis of dynamics among company employees. Contrary to the widespread opinion, which assumes that social networks are interesting only for personal users, they can produce added value within companies as well. While explicit corporate social networking can reduce internal communication costs and foster innovation[27] or have positive results on employee productivity[28], implicit corporate social networking can go one step further and create competitive advantage through discovery of hidden relationships, roles and communities among company employees[29]. This information can be used by company management in both day-to-day as well as strategic decision making, such as composition of coherent teams or identification of key employees (Figure 4).

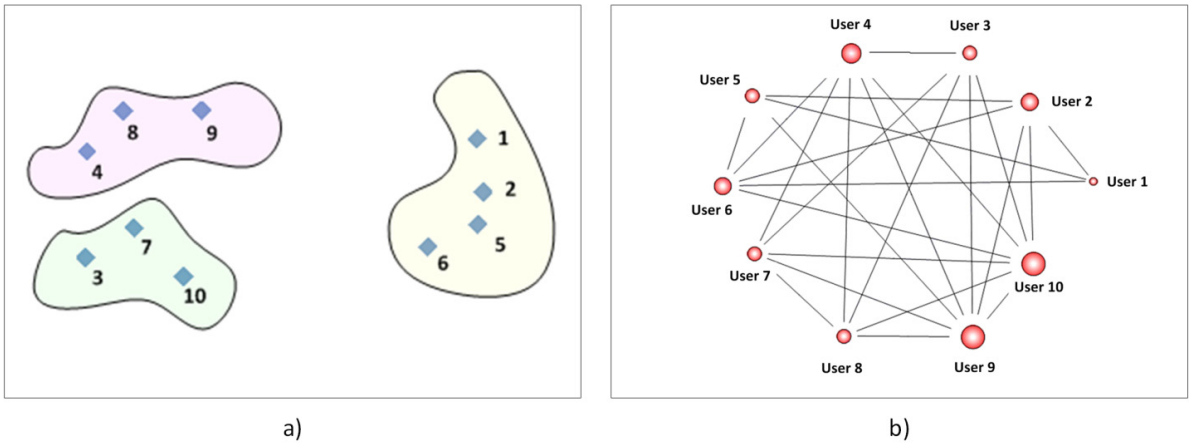

Fig. 4. Discovery of hidden relationships, roles and communities among 10 selected company employees: company management can use information about hidden communities for composition of coherent teams during day-to-day decision making (a), company management can use information about hidden roles for identification of key employees during strategic decision making (b).

In this pilot case, *Company Agent* represents company management while *User Agents* represent company employees. Based on communication patterns extracted from four different communication channels (*e-mail*, *file transfer*, *telephone calls* and *instant messaging*) between selected company employees, the company social network graph was built and analyzed according to the following steps:

1. creation of user profiles, a set $\mathcal{P}$, based on affiliation to a specific division of the analyzed multinational company;
2. implicit social networking was used to calculate relations among users (i.e., employees) in the social network (i.e., calculation of network edge weights according to formulas (2) and (3));
3. implicit social network analysis was used to identify "special employees" based on discovery of hidden roles as well as "special employee groups" based on discovery of hidden communities.

The interesting outcome of implicit corporate social networking analysis was the fact that results did not always correspond to a company hierarchy. We have also found that the most central employees in the corporate social network were not the most senior in the company hierarchy. The pilot case on implicit corporate social networking was validated on a corporate social network of a multinational company division with 125 employees.

7. Conclusion and future work

Recent advances in computing devices and communication networks changed the way people use ICT systems and services, making almost all software and devices innately social-aware. On the other hand, a proliferation of autonomous computing paradigms, such as agent technology, opens new horizons in modelling business-to-consumer economic interactions on the e-market across industry sectors.

In this paper, we presented how a synergy of social and economic computing can improve provisioning of innovative services. Namely, we showed how building an implicit social network produces added value for both consumers and companies. From the consumer point of view, implicit social networking enables them to use personalized and context-aware services. At the same time, companies can exploit extensive knowledge about their consumers by discovering hidden relationships, roles and communities among their consumers and, consequently, by enriching service offerings through improving existing or introducing new services.

For the future work we will continue to improve the SmartSocial Platform user profiles by extending user data sources, in order to further enhance the quality of implicit social networking based on SmartSocial profiles. Furthermore, we will design and test new innovative services that will be built upon results of implicit social network analysis.

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