Transforming Social Networking from a Service to a Platform: a Case Study of Ad-hoc Social Networking

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ABSTRACT
In this paper we discuss how a synergy of fundamental concepts standing behind the Facebook (i.e., social networking) and the iPhone (i.e., mobile and pervasive platform) can generate a sustainable business model for the ICT industry. Namely, we will show that a transformation of social networking from a service to a mobile and pervasive platform can produce multiple benefits for both social network service providers as well communication operators/smartphone manufacturers, while provisioning end-users an added value. Additionally, we will demonstrate our proposal through a case study presenting ad-hoc social networking, a platform for managing ad-hoc social relationships (i.e., set up by (mobile) users located in a limited geographical area during a certain period in time).

Categories and Subject Descriptors
C.2.0 [**Computer-communication Networks**]: General, H.3.4. [**Information Storage and Retrieval**]: Systems and Software, H.4.3. [**Information Systems Applications**]: Communications Applications, K.4.4 [**Computers and Society**]: Electronic Commerce, J.4 [**Computer Applications**]: Social and Behavioural Sciences.

General Terms
Economics, Human Factors.

Keywords
ICT Evolution, Social Networking, Application Store, Impulse Purchase, Ad-hoc Connections, User Collaboration.

1. INTRODUCTION
"For connecting more than half a billion people and mapping the social relations among them, for creating a new system of exchanging information and for changing how we live our lives", Mark Zuckerberg, Facebook's co-founder and CEO, was named TIME's 2010 Person of the Year [57]. And just seven years ago, Zuckerberg's Facebook did not even exist. In the same year, Steve Jobs, Apple's CEO, was named FT's 2010 Person of the Year [58] – "Buoyed by the iPod, iPhone and iPad, Jobs's Apple finally surpassed Microsoft in 2010 to make it the world's most valuable technology concern".

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Facebook, based on concept of *social networking*, is a web service which needed only seven years to utterly change the way people use Internet. Albeit shorter period of time was sufficient for iPhone, an innovative Apple's mobile gadget based on concept of *mobile and pervasive platform*, to revolutionize the way people use communication devices. As both Facebook and iPhone climb towards its S-curve plateau – a mythical place on market that every technology wants to reach fast and leave never – the following question arises: how can they preserve the role of ICT (*Information and Communication Technology*) industry main drivers? In this paper we argue that a synergy of fundamental concepts standing behind the Facebook and the iPhone is a possible solution.

The past few years, surely the most dynamic period in the history of ICT industry, were irretrievably labelled by Zuckerberg's and Jobs's immense innovativeness and impudent fortitude to change the way people use Internet and communication devices. Zuckerberg has set a requirement that all successful ICT systems should be inherently *social-aware*. However, ICT-enabled social networking still lacks a sustainable business model because personalized advertising cannot be only long-term revenue stream. Hopefully for Zuckerberg, Jobs has found a viable business model for ICT industry – Apple developed a multi-device platform which innately contains only a basic set of end-user applications but encourages users for serendipitous *impulse purchase*[1] of low priced, instant access applications that can be bought through an online application store.

This paper will: i) propose how impulse purchase business model can be applied to social networking domain, and ii) demonstrate our proposal through a case study presenting ad-hoc social networking. Firstly, Section 2 gives a preview of related work on ad-hoc social networking. Then, Section 3 explains how evolution of ICT systems on the one side and proliferation of social networking phenomenon on the other side led to an advent of social-aware ICT systems. Afterwards, Section 4 presents the transformation of social networking from a service to a platform as a business model for enabling sustainable social-aware ICT systems. In Section 5, a proof-of-concept service for social networking platform – ad-hoc social networking – is demonstrated. Finally, Section 6 concludes the paper and announces our future work.

[1] An *impulse purchase* is a process that occurs when the consumer experiences a sudden urge to purchase an item that he/she cannot resist (an opposite of a *planned purchase*) [42].

2. RELATED WORK ON AD-HOC SOCIAL NETWORKING

Various combinations of user i) location in a particular period of time, ii) knowledge/skill/experience/interests, and iii) social relationships are recognized by social networking services (SNSs) on the Internet as one of the major pillars for their future business models, as well as by academia as a hot research topic. Here we present a brief overview.

Facebook introduced *Facebook Places*[2], a supplementary service which enables Facebook users to:

- "Easily share where they are, what are they doing and the friends they are with right from their mobile";
- "Never miss another chance to connect when their happen to be in the same place at the same time as one of their friends", and;
- "Find local deals by checking in to get individual discounts, sharing savings with friends or earning rewards for repeat visits".

Furthermore, *Foursquare*[3] and *Gowalla*[4], SNSs devoted exclusively to mobile users, have been in public use since 2009 and already has reached 7.5 and 1 million users, respectively [69][70]. During registration procedure a new Foursquare/Gowalla user has an option of importing his/her friends from other SNSs (such as *Facebook* and *Twitter*). Foursquare/Gowalla users publish their current location (automatic "checking-in" based on current GPS-location) and post location-related comments. They are encouraged to do that because not only they can easily connect with friends nearby but also they get rewards in form of a certain "badge" (e.g., Foursquare user will be the *Major* of a place if most times reported in this area). Other examples of popular location-based SNSs are *Brighkite*[5] and *MocoSpace*[6].

Additionally, in mid-2010, Apple released a new privacy policy for *iTunes* pertaining to the capture and collection of users' real-time location information.

Finally, there is a number or related research projects – some of them are focused on theoretical settings and others on design and implementation issues. In [41], authors present a graph analysis based approach to study social networks with geographic information and new metrics to characterize how geographic distance affects social structure. Furthermore, in [25] authors analyse challenges and present an innovative solution for providing SNS in a vehicular context. The Stanford's Mobile and Social Computing Research Group developed Junction [61], an infrastructure designed to support *partyware* (class of social software that assists users in their real-world social encounters). In [1] authors propose a flexible middleware for development and deployment of location/context-aware services for heterogeneous data access in the Internet, while in [20] the MobiSoc middleware, which provides a common platform for capturing social state of physical communities by learning patterns from the geo-social data and incorporating this new knowledge with the social state, is presented. The Social Serendipity project [15] applies Bluetooth technology for detecting other nearby users (by calculating similarity score between user profiles and behavioural data) and uses it to cue informal interactions between nearby users who do not know each other. Another project, the SAMOA framework [10], integrates a set of common management facilities for personalizing location-dependent social networks and for propagating social network visibility up to the application level. Finally, the Whereabouts Diary [5] is a middleware service that supports location-aware activities of a mobile user through logging the places visited by the user and labelling them in an automatic manner, with descriptive semantic information.

[2] *http://www.facebook.com/places*

[3] *http://foursquare.com*

[4] *http://gowalla.com*

[5] *http://brightkite.com*

[6] *http://www.mocospace.com*

3. SOCIAL-AWARENESS IN ICT SYSTEMS

We are entering a period of time when almost all software and devices are not just network-aware [26] but social-aware as well [52]. All this is a result of (Figure 1): i) substantial advances in the ICT industry over the past 60 years, and ii) global proliferation of social networking phenomenon during past 50 years.

3.1 An Evolution of ICT Systems

The ICT industry, as we see it today, was shaped through interweaving three different technologies: i) computers, ii) the Internet, and, iii) mobile networks.

Computers, the Internet and mobile networks merged into a unified, extremely prominent and globally ubiquitous intelligent network [34]. This intelligent network, characterized with ambient intelligence where devices embedded in the environment provide seamless connectivity and services all the time, enables the transformation of physical spaces into computationally active and intelligent environments [47]. This is aimed at improving the human experience and quality of life without explicit awareness of the underlying communication and computing technologies. Tremendous developments in wireless technologies and mobile telecommunication systems, as well as rapid proliferation of various types of smartphones, have significantly amended computing lifestyle, thus advancing the vision of ubiquitous computing toward technical and economic viability [27].

3.1.1 Computers

Computers have come a long way, from the titanic machines of the early 1950s to the today's micro-scale smartphones [16].

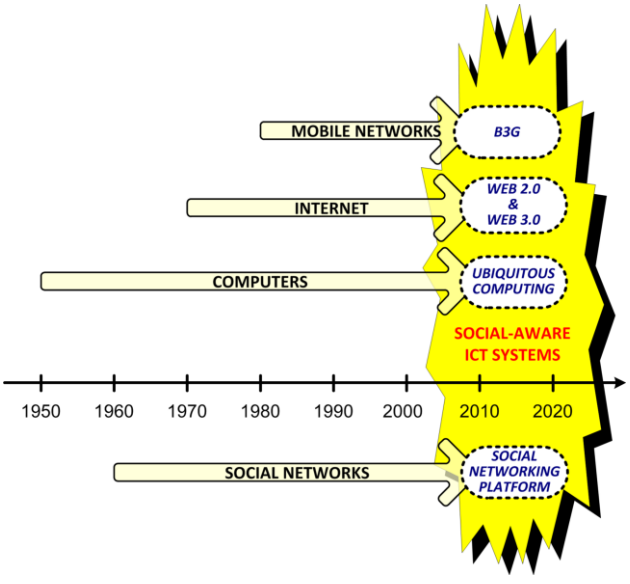

Figure 1. An advent of social-aware ICT systems

Throughout the history of computing, three main eras can be identified [49]. The first era was the era of *mainframe computing*, when large and powerful computers were shared by many people. The second era was the era of *personal computing*, when there was one computer per person. We are currently in third era, where we interact no longer with one computer at a time, but rather with a dynamic set of small networked computers, often invisible and embodied in everyday objects in the environment [47]. This third era is the era of *ubiquitous computing* (also called pervasive computing) [49], with smartphones being predominate computing devices.

The modern smartphone, regularly equipped with a rich set of sensors [27][32][23][4][24][53] is not used only as a phone anymore, but it is a gaming device, media player or a social networking tool as well. Every now and then, you might see it also used as an email client, clock, calendar, dictionary, camera, audio recorder, GPS device, map, compass, remote control, file locker, instant messengers, to-do list and even a torch light.

3.1.2 The Internet

The Internet emerged in the early 1970s, as a small network interconnecting just a few computers. As the Internet grew through the 1970s and 1980s, many people started to realize its potential. Nevertheless, the Internet did not experience real proliferation until the invention of the World Wide Web (WWW or simply Web 1.0), a service provisioned through the Internet infrastructure [2]. Web 1.0, as an information medium enabling users to read and write via computers connected to the Internet, became the bearer of the digital revolution in the 1990s and critical global service that touches almost all aspects of modern life. Consequently, all further Internet evolution after the invention of Web 1.0, is characterized as Web X.0, in spite of the fact that the WWW is just one of many Internet services. Web 2.0, also called "the Social Web", become no longer simply about connecting information, but also about connecting people to collaborate in ad-hoc groups that can be created and dismantled with minimal overhead [37]. Web 3.0, also called "the Semantic Web", is the next stage in the evolution of the Internet in which it will become a platform for connecting knowledge. Web 3.0 is an evolutionary path for the Internet which will enable people and machines to connect, evolve, share, and use knowledge on an unprecedented scale and in many new ways make our experience of the Internet better [60]. One of the most promising Web 3.0 technologies, besides the Semantic Web [3], are intelligent software agents [10][14] which can utilize semantically annotated information and reason in a quasi-human fashion.

3.1.3 Mobile Networks

Mobile network evolution started in the 1980s when the network was designed merely to provide voice communication. The first and second generations (1G and 2G) of mobile networks have enabled circuit-switched voice services to go wireless. As the Internet grew, it became necessary to ensure mobile Internet access. The 2G GSM (*Global System for Mobile communications*) system was enhanced to 2.5G by introducing data communication and packet-switched services into the GSM network. The technologies of 2.5G, GPRS (*General Packet Radio Service*) and EDGE (*Enhanced Data Rate for GSM Evolution*) were the first step towards creating a mobile Internet. The third generation (3G) system, known as UMTS (*Universal Mobile Telecommunications System*), has introduced higher data rates which enable multimedia communications. This has made mobile Internet access available to users, including a wide spectrum of Internet-based data services, better coverage and multiple services in a terminal. The development of mobile networks has continued in both access and core networks. The UMTS access network has been improved by HSPA (*High Speed Packet Access*) technology which enables very high bit rates and throughput focusing on streaming and interactive services. The core network incorporates IMS (*IP Multimedia Subsystem*) which integrates mobile communications and the Internet, enabling the convergence of existing networks with the Internet in mobile broadband networks. Long Term Evolution (LTE) is working on the evolution of mobile communication systems beyond GSM-UMTS-HSPA systems (B3G) which introduce higher levels of capacity, bit rates and performance, and support new services and features.

3.2 A Proliferation of Social Networking

Social networks (SNs) are well-developed area of study in social sciences, with a history longer than 50 years. Everything has begun in 1960s with the Brown's identification of "a need for understanding complexities of collective human behaviour at a level that is more objective and more scientific than the approach of psychology and sociology to the same problem [13] and the Milgram's "small world experiment" which demonstrated the idea of "six degrees of separation" [28][44]. A solid theoretical foundation in the field of SN research was made in 1970s [19][17][50][18], while the next two decades were mainly dedicated to practical studies that applied theoretical knowledge from the field to real-world situations, such as investigation about the interconnections of supervisory boards of various companies [29], analysis of the human social structure [45] or discussion about spreading of new ideas within a community [38]. Furthermore, a research of social scientists confirmed the importance of the SNs in provisioning of social support among community members [52], in structuring unrests and other political conflicts [43], in analysis of the immigration processes [40], as well as in studying internal processes within companies [30].

However, in the beginning of 2000s SNs experienced a proliferation grounded on an advent of ICT-enabled SNSs. This was a huge shift for both scientists, who now got an unprecedented source of data on human behaviour [21], and people in general, who now became able to interconnect at a global scale in just few second and with just few mouse-clicks. Implementation of SNs based on ICT infrastructure not only allows people to map their social relationships from the real world to a virtual one, but also to build virtual communities with other people that share the same interests/activities. This is achieved through creating (semi-)public user profiles and defining a list of other user profiles (i.e. people) with whom they are associated. Although the SNSs [54][8] less a decade ago represented only a drop in the sea of web pages with different themes and purposes, today they are truly global phenomenon which greatly affects the modern way of life.

In period between 2002 and 2006 a myriad of SNSs appeared on the scene, some of which have grown in the most popular SNs supported by ICT infrastructure – first started *Friendster*[7], then *MySpace*[8] and *LinkedIn*[9], and at the end *Facebook*[10] [46], *Bebo*[11]

[7] *http://www.friendster.com*

[8] *http://www.myspace.com*

[9] *http://www.linkedin.com*

[10] *http://www.facebook.com*

[11] *http://www.bebo.com*

and *Twitter*[12] [56]. Today, hundreds of millions of users world-wide employ various SNSs on a daily basis for both personal and businesses uses – the list of major SNSs has around 200 names (more than 50 million registered users, apart from those already mentioned, have *Bebo*, *Flixster*, *Habbo*, *hi5*, *MyLife*, *Netlog*, *Orkut*, *Qzone*, *Tagged*, *vkontakte* and *Windows Live Spaces*). By far the most popular SNS is the Zuckerberg's Facebook with over 650 million registered users (almost half of that number are mobile users) [62][63].

In 2010, social networking consumed up twice as much of our online time as any other activity [68]. According to statistical data, sites like Facebook and Twitter accounted for 22.7% of time spent on the web, while the next closest activity was online gaming, which made up 10.2%. The data also shows the degree to which social networking displaced other forms of communication, with e-mail as a percentage of online time dropping from 11.5% to 8.3% from mid-2009 to mid-2010. Instant messaging also saw a significant plunge in share, with a 15% decline from mid-2009 to mid-2010.

4. SOCIAL NETWORKING AS A PLATFORM

Today, the growth rate of smartphone usage is higher than 30% per a year and the mobile web adoption proceeds at a rate that is eight times faster than the equivalent point ten years ago for the desktop [64]. Moreover, Cisco predicts that world mobile data traffic will explode by factor of 26 by 2015 [59]. The other major ICT players on the market recognized this as well. Firstly, in 2010 Google announced that company's focus has moved from desktops on smartphones (i.e., "Mobile First Strategy" based on Google's *Android* operating system) [64]. Afterwards, in the beginning of 2011 Microsoft used its *Windows Phone 7* operating system to enter into partnership with Nokia [65].

Table 1. Smartphone market data vs. smartphone application market data

Company	Operating system (OS)	*Market share [%]*	Application store (AS)	*Market share [%]*	*Share ratio (AS/OS)*
Apple	iOS	*16.0*	App Store	*82.7*	***5.17***
Google	Android	*32.9*	Android Market	*4.7*	***0.14***
BlackBerry	RIM	*14.4*	App World	*7.7*	***0.53***
Nokia[13]	Symbian	*30.6*	Ovi Store	*4.9*	***0.16***
others		*6.1*		*0.0*	

Table 1 presents a data about global smartphone sales, as well as global smartphone application sales. The global smartphone market data reveals that *Google's Android* is the world's leading smartphone operating system with 33.3 million devices (i.e., 32.9%) sold in Q4 2010 [66]. *Nokia* and *Apple* follow with 30.6% and 16.0% of market share, respectively. The list is closed by *BlackBerry* with 14.4%. On the other hand, the global smartphone application market data for 2010 reveals that *Apple* took in $1.78 billion (82.7%) in worldwide sales from its *App Store*, a leap of 132% from $769 million in 2009 [67]. *BlackBerry* and *Nokia* follow with 7.7% and 4.9% of market share, respectively. The list is closed by *Google* with 4.7%. However, the last column – denoting ratio between smartphone application market share and smartphone sales market share – reveals that *Apple*, although behind *Google* and *Nokia* according to smartphone sales market share, has by far the best business model for smartphone application distribution (i.e., *Apple's ratio* is more than 32 times better than *Nokia's* and almost 37 times better than *Google's*) .

4.1 The Apple's Business Model

Apple's flagship triad of end-user devices appeared during last ten years. Firstly, there was an *iPod*, portable media player launched in 2001. Afterwards, in 2007 Jobs' company launched multimedia-enabled smartphone named *iPhone*. Finally, Apple's triad was rounded with an *iPad*, multi-touch display tablet, in 2010. By the end of 2010, Apple sold 280 million iPods, 75 million iPhones and almost 15 million iPads. Although these numbers are astonishing, from Table 1 we can learn they are not the real reason why Jobs' innovativeness had a decisive influence on how people today use smartphones and Internet – it was *iTunes*.

iTunes, Apple's application used for playing and organizing digital music and video files, was launched together with an iPod in 2001. However, when in 2003 iTunes were upgraded with the *iTunes Store* end-users were enabled to purchase and download music, music videos, television shows, iPod games, audiobooks, movies, etc. Today, iTunes Store is used to download applications from the *App Store* for the iPhone and iPad as well.

Although the concept of online application store was already probed by a number of telecom operators, iTunes was first successful attempt of the ICT industry which enabled that costly, low volume software is replaced with high volume, low priced, instant access applications that can be bought through an online store. The following question naturally arises: why Jobs succeeded in something that all telecom operators failed for years? The answer is that he firstly created multi-device platform (i.e., installed on iPod, iPhone and iPad) which innately contains only an essential set of end-user applications but boosts users for continuous spontaneous impulse purchase of various additional applications via App Store.

4.2 Mapping of Apple's Business Model to a Social Networking Domain

A transformation of social networking from a *web-service* to a *mobile and pervasive platform* enables mapping of Apple's business model to a social networking domain. From the architectural perspective, a platform for social networking consists of following components (Figure 2):

- Client platform – *social networking platform (SNP)*;
- Server with basic and supplementary services – *SNP server*;
- Social network database – *SNP database*, and;
- Client application distribution entity – *SNP application distribution store*.

Users interested in using SNP services firstly have to download and install the *SNP* on their communication device (e.g., smartphone, laptop, etc.) While registering to the SNP users SN-members can import their profiles from existing SNSs (e.g., *Facebook*, *Twitter*, etc.) or create new profiles. When registered to certain SNP, users can utilize its basic and supplementary services via mobile network.

[12] *http://www.twitter.com*

[13] Nokia shifted from *Symbian* operating system to *Windows Phone 7* in 2011.

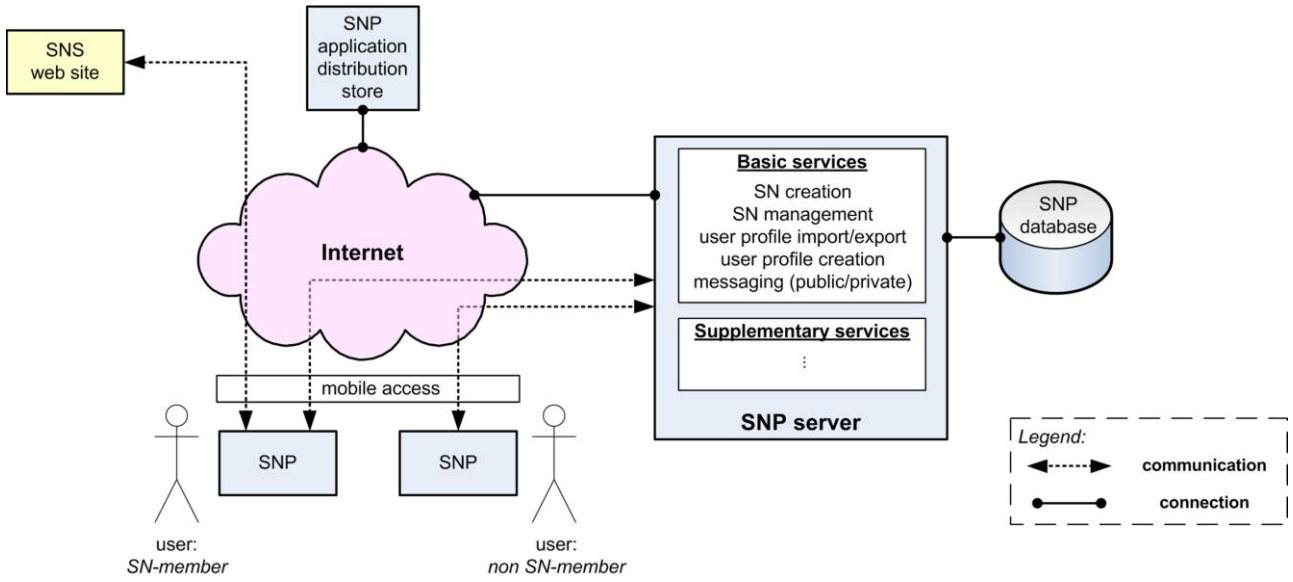

Figure 2. A social networking platform

The list of basic SNP services is as follows:

- Creation and membership management for an SNP;
- Transfer of user profiles and other user-related information between existing SNSs and an SNP, and;
- Interaction among social network members via mobile network (public/private messaging).

After they have installed SNP with basic set of services, users can purchase supplementary services from the *SNP application distribution store* (i.e., something like Apple's App Store but for SNP users). In such a way users upgrade SNP with functionalities they need.

One can argue that we described existing Facebook business model. However, this is not true as Facebook's business model is much more alike Google's Android Market – Google provides an open platform and encourages developers for implementing free applications which should earn money through in-app advertising. Although Google, same as Facebook, has a greatest user base, Apple's business model generates much higher profitability.

Mapping of Apple's business model to a social networking domain results in multiple benefits for both social network service providers as well communication operators/smartphone manufacturers, while provisioning end-users an added value (Figure 3):

- "Uplifting" a social networking S-curve by creating new revenue stream (i.e., "Application Store");
- "Stretching" a social networking S-curve by continuously introducing new services through an "Application Store";
- Moving from fixed to mobile users, from desktops to smartphones, and;
- Personalizing SNP by upgrading it only with services that implement specific functionalities the respective user needs.

5. AD-HOC SOCIAL NETWORKING

SNSs on the Internet support more or less permanent social relationships, where user interaction takes place via fixed or mobile access to the Internet. However, in many situations social relationships are ad-hoc (i.e., set up by (mobile) users located in a limited geographical area during a certain period in time). Such an appearance of a mobile user in a specified location during a specified period in time is often associated with a certain social event (e.g., business/academic event such as a meeting/conference, everyday event such as a football match, or disaster event such as a road accident). To effectively support this kind of social relationships, we propose an extension of basic SNP services with the application implementing *ad-hoc social network*

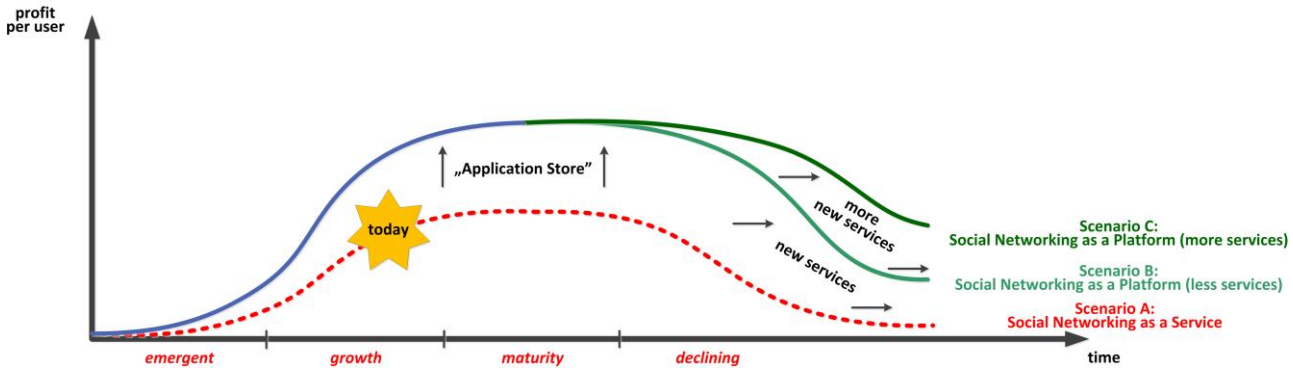

Figure 3. Social networking on an S-curve

service (ahSNS) [36]. Users should have option of purchasing ahSNS application as a supplementary service from the SNP application distribution store.

5.1 Building a Social Network from Multiple Ego Social Networks

Social relationships established by SNSs are based on ego social networks[14] – every user is building his/her own social network by defining connections with other people.

Let us assume that an ego social network of a user u_i is presented with the graph in the Figure 4.a) and an ego-network of a user u_j is presented with the graph in the Figure 4.b).

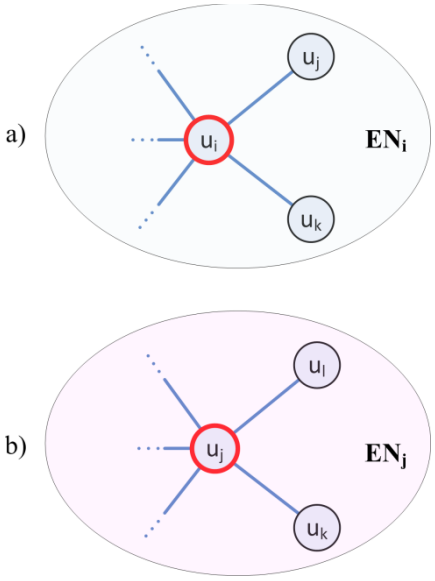

Figure 4. An ego-network of:
a) a user u_i,
b) a user u_j

From the Figure 4 it can be noted that we consider only *undirected* relations between users, meaning that one user cannot be related to a second without the second being related to the first. This presumption is generally true for many social relationships (such as partnerships, friendships, alliances and acquaintances) [22].

We can formally define an ego social network $\mathcal{ESN}_i$ of a user u_i as:

$$\mathcal{ESN}_i = (u_i, \mathcal{F}_i), \tag{1}$$

where a set $\mathcal{F}_i$ includes all users who are in a social relationship with the ego-user:

$$\mathcal{F}_i = (\dots, u_j, u_k, \dots). \tag{2}$$

[14] Note that the structure we refer to as an *ego social network* differs from a structure known in literature as an *ego network* [9]. While the ego social network consists from the set of nodes with direct ties to a focal node (called "ego") and only the set of corresponding ties, the ego network additionally contains the set of ties among non-ego members.

Analogously, we can define an ego social network $\mathcal{ESN}_j$ of a user u_j as:

$$\mathcal{ESN}_j = (u_j, \mathcal{F}_j), \tag{3}$$

where:

$$\mathcal{F}_j = (\dots, u_k, u_l, \dots). \tag{4}$$

Ego social networks of all users (i.e., users from the set $\mathcal{U}$) interlock to form a social network $\mathcal{SN}$:

$$\mathcal{SN} = \sum_{a=1}^{|\mathcal{U}|} \mathcal{ESN}_a. \tag{5}$$

The result of equation (5), having in mind definitions of ego social networks $\mathcal{ESN}_i$ and $\mathcal{ESN}_j$ from equations (1)-(4), is presented with the graph in Figure 5.

We can formally define a social network $\mathcal{SN}$ as:

$$\mathcal{SN} = (\mathcal{U}, rel), \tag{6}$$

where

$$rel = \begin{bmatrix} 0 & \cdots & rel_{1|\mathcal{U}|} \\ \vdots & \ddots & \vdots \\ rel_{|\mathcal{U}|1} & \cdots & 0 \end{bmatrix} \tag{7}$$

represents a $|\mathcal{U}| \times |\mathcal{U}|$ matrix, in which rel_{ab} $(a, b \in \{1, \dots, |\mathcal{U}|\})$ denotes the relation between users u_a and u_b. This matrix is often referred as the *adjacency matrix*, as it lists which users are linked to each other – or in other words – which users are adjacent to one another. The matrix rel is a binary matrix, meaning that the value of its element rel_{ab} can either be:

- zero (0) – if there is no immediate relationships between users u_a and u_b, or
- one (1) – if there exists immediate relationship between users u_a and u_b.

Specifically, one can note from equation (7) that the value of diagonal elements of the matrix rel is always zero (i.e., $rel_{aa} = 0, \forall a \in \{1, \dots, |\mathcal{U}|\}$) – this is corollary of the fact that a user within a social network cannot be connected with (him/her)-self. Furthermore, the matrix rel is a symmetric matrix. This is corollary of the presumption about undirected relations between users (i.e., $rel_{ab} = rel_{ba}, \forall (a, b) \in \{1, \dots, |\mathcal{U}|\}$).

Social relationships in the social network $\mathcal{SN}$ from Figure 5 are the following:

- users u_i and u_j (as well as users u_i and u_k and users u_j and u_k) are *directly connected* (because there exists immediate social relationship between users, i.e., $rel_{ij} = rel_{ik} = rel_{jk} = 1$) with *geodetic distance* $d_{ij} = d_{ik} = d_{jk} = 1$,
- users u_i and u_l (as well as users u_k and u_l) are *indirectly connected* (because there is no immediate social relationship between users, i.e., $rel_{il} = rel_{kl} = 0$) with $d_{il} = d_{kl} = 2$,
- users u_i and u_x (as well as users u_j and u_x, users u_k and u_x, and users u_l and u_x) are *indirectly connected* (if there exists a path between observed pair of users) or *unconnected* (if there does not exist a path between observed pair of users) with $d_{ix}, d_{jx}, d_{kx}, d_{lx} > 2$.

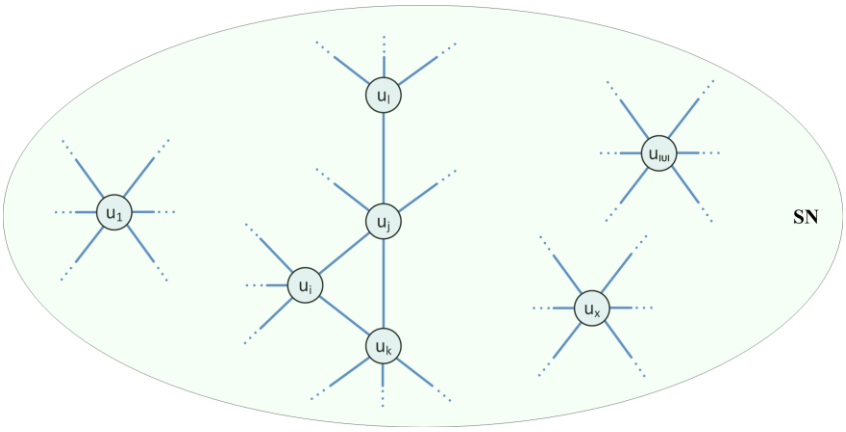

Figure 5. A social network of users $\mathcal{U}$

5.2 Building an Ad-hoc Social Network

An ahSNS can be created as a *closed* or an *open* SN. A *closed ahSN* includes following two features:

- definition of an ahSN initiator (e.g., a user u_i from the SN defined with the Figure 5 initiates creation of an ad-hoc social network $a\hbar\mathcal{SN}_i$), and;
- automatic invitation, by the initiating user u_i, of certain SN-members (e.g., users u_j, u_k, u_l and u_x from the SN defined with the Figure 5) for joining the $a\hbar\mathcal{SN}_i$, their registration to the $a\hbar\mathcal{SN}_i$ and, finally, direct interconnection of all users in the $a\hbar\mathcal{SN}_i$.

An *open ahSN* includes one additional feature:

- registration of non SN-members (e.g., user u_y) to the $a\hbar\mathcal{SN}_i$ and direct interconnection with all users in the ahSN. A registration of non SN-members must be approved by the initiating user u_i.

It can be noted that the initiating user u_i manages the $a\hbar\mathcal{SN}_i$'s membership, regardless of the fact whether the $a\hbar\mathcal{SN}_i$ is a closed or an open ahSN.

Let us assume that the $a\hbar\mathcal{SN}_i$, created as an open ahSN, is presented with the graph in the Figure 6. One can note that this graph is a *complete graph* (a simple graph in which every pair of distinct users are connected) and that geodetic distance between all pairs of users in the $a\hbar\mathcal{SN}_i$ is equal to one (1) – both facts are consequences of direct interconnection of all users in the ahSN. This is also the reason why adjacency matrix of every ahSN is identical – with all non-diagonal elements equal to one (1) and all diagonal elements equal to zero (0). All that simplifies a formal

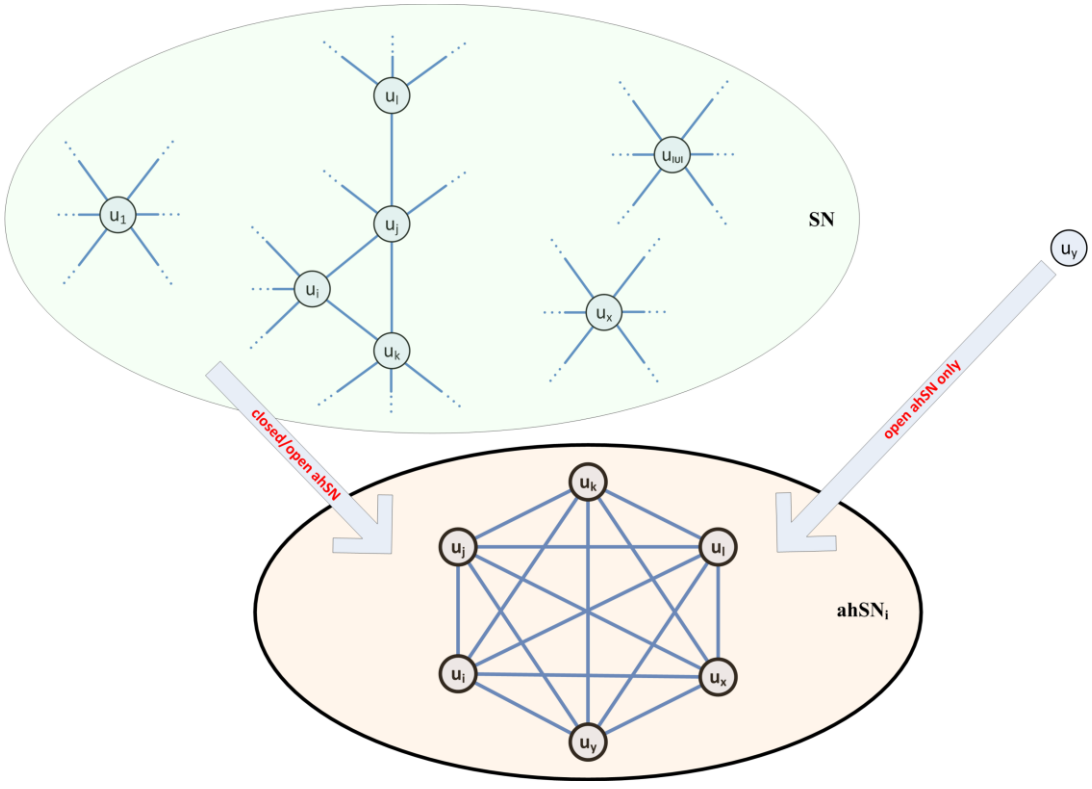

Figure 6. Creation of an ad-hoc social network $a\hbar\mathcal{SN}_i$

definition of an ahSN and we can define ad-hoc social network $a\hbar\mathcal{SN}_i$ as:

$$a\hbar\mathcal{SN}_i = (u_i, u_j, u_k, u_l, u_x, u_y). \quad (8)$$

A user is represented within an ahSN with a profile, according to the following rule:

- *SN-members of an ahSN* – ahSN-profile is imported from a user's SN-profile (under the control of the user), and;
- *non SN-members of an ahSN* – user creates an ahSN-profile from the scratch.

A member of an ahSN should be able to export his/her ahSN-profile to a certain permanent SN, such as *Facebook*.

5.3 Benefits of Ad-hoc Social Networking

User interaction within an ahSN should have i) *better availability*, ii) *lower costs*, and iii) *greater energy efficiency* than those offered by "ordinary" SNs. For all three reasons, it is rational to locate the ahSN server closer to users and make it almost immediately available for the mobile network that geographically covers the location relevant for the ahSN.

Service availability is critical for situations such as (natural) disasters, when the global connectivity required for the SNSs, as well as communication in general, is difficult or impossible to achieve. Consequently, ahSNSs can serve as support for the disaster management processes.

Service costs are reduced because users need to connect to the SNS web-site only while creating an ahSN (i.e., during invitation and registration of new ahSN-members, including the import of users' SN-profiles).

Through a reduction of the number of communication and server systems mediating the service, achieved through replacing a remote service provisioning paradigm with a local service provisioning, ahSNSs become *green services* characterized with lower energy consumption than "ordinary" SNSs. Additionally, energy efficiency of ahSNSs can be additionally increased by using short-range communication technologies (e.g., Bluetooth) for communication among ahSN-members.

Furthermore, user activities within an ahSN are enhanced by SNP supplementary services. Let us assume that the reason for ahSN creation is performing a certain electronic commerce transaction. Now, users can use ahSN either in a transaction preparation phase or in a transaction execution phase. Examples of supplementary services for transaction preparation are the following:

- *social search* – search for new members fulfilling some knowledge/skill/experience criteria or sharing some common interest, and;
- *meeting and group facilitation* – scheduling of activities, temporal and spatial arrangement of the group according to specific knowledge/skill/experience.

On the other hand, examples of supplementary services for transaction execution are the following:

- *buyer coalition formation* – grouping members in order to reduce price or take advantage of volume discounts, and;
- *collaborative download* – piecewise download of a specific document by group members and mutual exchange of pieces in order to merge them into a full document.

5.4 Proof-of-Concept Supplementary Services provisioned through Ad-hoc Social Network Application

We already used JADE agent platform to implement a number of ahSN functionalities. Firstly, we utilized the *LocalNote* service [11], a location-triggered instant messaging service that provides a mechanism for sending text messages whereby the sender can specify the area in which the recipient must reside in order to receive the message, to enable agent-based session mobility in next-generation network (NGN) [31].

Furthermore, we implemented a JADE multi-agent system for group-oriented service provisioning in NGN [35]. Specialized agents were in charge of: i) user profile creation, ii) user profile semantic comparison, iii) user SN creation and analysis (i.e. user clustering/classification). As a proof-of-concept we implemented a group-oriented service RESPIRIS (*Recommendation-based Superdistribution of Digital Goods within Implicit Social Networks*) [33].

Finally, we implemented a multi-agent system enabling a proof-of-concept *Collaborative Urban Computing* (CUC) service, which we named the *Collaborative Downloading* [6]. The CUC paradigm [7] supports serendipitous cooperation among a set of users located in an urban environment and all sharing a common goal.

6. CONCLUSIONS AND FUTURE WORK

Recent technical innovations and improvements in computing devices and communication networks changed the way people use Information and Communication Technology (ICT) systems, making almost all software and devices innately social-aware. One of the most obvious examples is rapid proliferation of social networking services (SNSs) during the last decade. However, ICT-enabled social networking still lacks a sustainable business model because personalized advertising cannot be only long-term revenue stream.

In this paper, we explained why and how a synergy of main concepts standing behind the Facebook (i.e., social networking) and the iPhone (i.e., mobile and pervasive platform) can generate a sustainable business model for the ICT industry. Namely, we showed how a transformation of social networking from a service to a platform can produce multiple benefits for both SNS providers as well communication operators/smartphone manufacturers, while provisioning end-users an added value. Afterwards, we demonstrated our proposal through a case study presenting an ad-hoc social networking, a service for supporting serendipitous cooperation between a set of users physically located in a limited geographical area during a certain period in time and all sharing a common goal. The ad-hoc social networking represents a supplement to existing myriad of SNSs, which all support more or less permanent social relationships.

For future work, we plan to implement a social networking platform (SNP), as well as an application for ad-hoc social networking. Moreover, we will even extend a list of supplementary services which ad-hoc social networking application provides for SNP users.

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