INFORMATION SHARING IN ONESOCIALWEB USING A MULTIPLE PROFILE MANAGER TO BETTER INFORMED MEDICAL DECISION MAKING PROCESSES

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Extensible Markup Language

Abstract

The study shows an alternative solution to existing efforts at solving the problem of how to centrally manage and synchronise users' Multiple Profiles (MP) across multiple discrete social networks. Most social network users hold more than one social network account and utilise them in different ways depending on the digital context (Iannella, 2009a). They may, for example, enjoy friendly chat on Facebook[1], professional discussion on LinkedIn[2], and health information exchange on PatientsLikeMe[3]. Therefore many web users need to manage disparate profiles across many distributed online sources. Maintaining these profiles is cumbersome, time-consuming, inefficient, and may lead to lost opportunity.

In this thesis the researcher proposes a framework for the management of a user's multiple online social network profiles. A demonstrator, called Multiple Profile Manager (MPM), will be showcased to illustrate how effective the framework will be. The MPM will achieve the required profile management and synchronisation using a free, open, decentralized social networking platform (OSW) that was proposed by the Vodafone Group in 2010. The proposed MPM will enable a user to create and manage an integrated profile (IP) and share/synchronise this profile with all their social networks. The necessary protocols to support the prototype are also proposed by the researcher. The MPM protocol specification defines an Extensible Messaging and Presence Protocol (XMPP) extension for sharing vCard and social network accounts information between the MPM Server, MPM Client, and social network sites (SNSs).

The writer of this thesis adopted a research approach and a number of use cases for the implementation of the project. The use cases were created to capture the functional requirements of the MPM and to describe the interactions between users and the MPM. In the research a development process was followed in establishing the prototype and related protocols. The use cases were subsequently used to illustrate the prototype via the screenshots taken of the MPM client interfaces. The use cases also played a role in evaluating the outcomes of the research such as the framework, prototype, and the related protocols.

[1] www.facebook.com
[2] www.linkedin.com
[3] www.patientslikeme.com

An innovative application of this project is in the area of public health informatics. The researcher utilised the prototype to examine how the framework might benefit patients and physicians. The framework can greatly enhance health information management for patients and more importantly offer a more comprehensive personal health overview of patients to physicians. This will give a more complete picture of the patient's background than is currently available and will prove helpful in providing the right treatment.

The MPM prototype and related protocols have a high application value as they can be integrated into the real OSW platform and so serve users in the modern digital world. They also provide online users with a real platform for centrally storing their complete profile data, efficiently managing their personal information, and moreover, synchronising the overall complete profile with each of their discrete profiles stored in their different social network sites.

Table of Contents

List of Figures

List of Examples

List of Abbreviations

EHR	Electronic Healthcare Records
IP	Integrated Profile
JAP	Java Persistence API
MPM	Multiple Profile Manager
MP	Multiple Profiles
MPA	Multiple Profile Account
MPAs	Multiple Profile Accounts
MPAL	Multiple Profile Account List
OSW	Onesocialweb
SNDs	Social Network Domains
SNS	Social Network Site
SNSs	Social Network Sites
XML	Extensible Markup Language
XMPP	Extensible Messaging and Presence Protocol

Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature: _____

Date: _____

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Publications

This publication is based on Chapter 5.

Liang, J., Iannella, R., Sahama, T. (2011). Synchronised Integrated Online eHealth Profiles. *Proceedings of the HIC 2011*. (Appendix D for abstract)

Chapter 1: Introduction

Web-based social networking services have become increasingly important in recent years. The services are widely applied in fields such as education, business, and health. Web-based social services allow individuals to communicate or interact with others, promote business, share health information with other patients or physicians. However, to date there is no central controlled integrator for users to manage their social network accounts and distributed profiles. This thesis focuses on designing a platform named Multiple Profile Manager (MPM) that enables users to create and control their own single profile, and more importantly share partial aspects of the profile with various social networks in the Onesocialweb (OSW) federation.

1.1 BACKGROUND

One of the most visible trends on the Web is the emergence of SNSs such as Facebook, LinkedIn or Google Health[4] which provide online services or platforms that help users build social networks or social relations with others. An SNS allows its members to share information such as knowledge, interests, life or work experience, activities, and events within its domain. The social network services provided by an SNS are comprised of a user profile, social links, and a series of additional services. A user profile is a document describing an entity with details such as name, gender, avatar picture, but also things like favourite food, interests, or other attributes about one's education, work, or health.

The user profile plays a vital role in the use of online social networking. In order to attract more customers, social network service providers can provide members with personality services by collecting users' personal information as much as they can. Also, web users can store and share their various kinds of personal information by creating multiple profiles in various kinds of SNSs. For example one young engineer, Bob, may have a Facebook profile for sharing events and interests with his friends and families, a LinkedIn profile to expand his business network, and a Google Health account to manage and store his digitised health records.

[4] http://www.google.com/health

Consequently, what is really needed is the ability for Bob to centrally manage and share his multiple profiles. Once he has this ability, Bob can gain centralised control of his personal profile in Facebook, work profile in LinkedIn, and health profile in Google Health (see Figure 1).

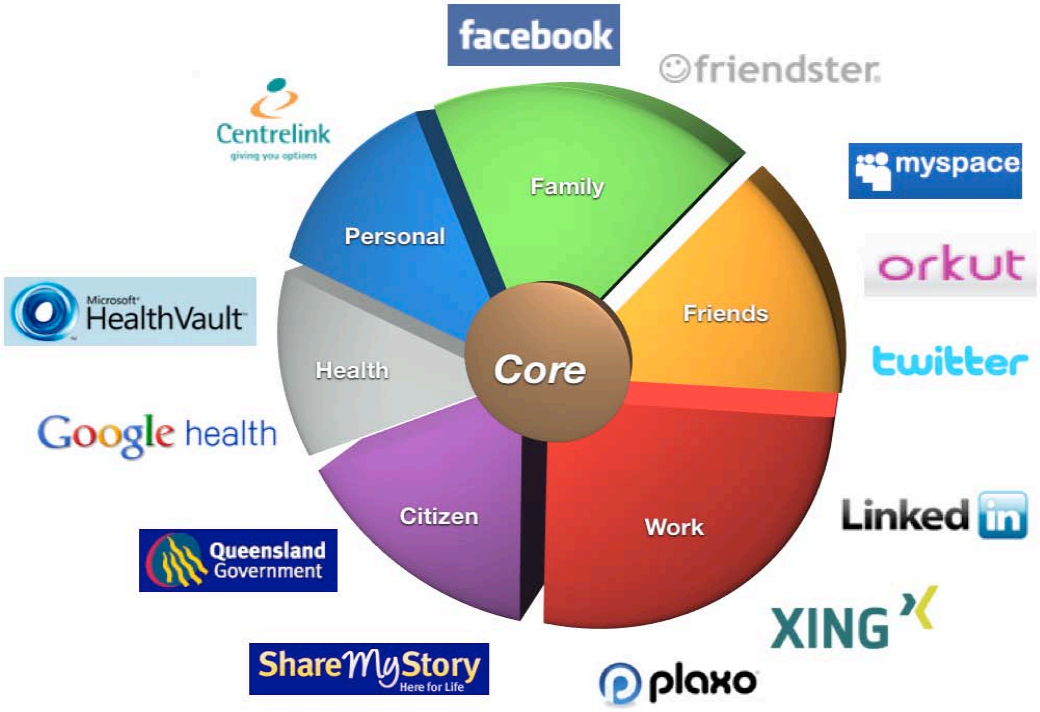


Figure 1. Social Web Profiles (source: Iannella, 2009a, p. 2)

Most SNSs are isolated from one another. This leads to limitations and inconvenience for users when they try to share and manage data across different SNSs. For this reason, Eschenauer and Weisscher (2010) proposed a new platform named Onesocialweb (OSW) that aims to "connect all SNSs in this platform by defining the language to bridge these SNSs, and make it easy for social network sites to join". The OSW allows users to connect with friends across different SNSs and platforms. This provides the writer with the basic platform for achieving multiple profile-sharing between the different SNSs and platforms.

1.2 STATEMENT OF RESEARCH PROBLEM

How to share/synchronise and centrally manage users' profiles across multiple discrete social networks is the specific problem which is considered in this research. While progress is being made in the technologies associated with social network interoperability and profile aggregation, issues related to the development of a secure

platform and communication protocols for multiple profile management using widely used technology such as semantic web, Extensible Messaging and Presence Protocol (XMPP), and vCard still need to be investigated.

1.3 PURPOSES

The aim of the MPM platform the writer proposes is to overcome the existing limitation in social networks by taking advantage of the new proposed OSW technology (Eschenauer, 2010) and the widely used technologies mentioned above. Briefly, the MPM platform will offer the full benefits of centrally managing and sharing users' multiple profiles residing in distributed sources. It should allow a web user to create and control a single profile in the MPM platform, to gain access to specific partial profiles from social networks, and to synchronise changes between them over time. Additionally, to demonstrate the advantage and feasibility of the MPM platform, an MPM prototype will be implemented to evaluate the platform, and it should realise the following four main functions: read/publish profile; synchronise profile; disable/enable synchronisation; and cancel social network accounts. Finally, the MPM will be applied to the area of public health informatics. To do so, the following research objectives will be addressed:

- To research the related semantic technologies for reading and publishing the multiple profiles such as distributed profile data extraction, representation, and integration, and the profile structure interpretation (Vcard4).
- To analyse the OSW and vCard specifications.
- To explore protocols by which the system can update and synchronise the changes of profiles over time.
- To develop and propose extension specifications to the OSW specifications and vCard specification for sharing multiple profiles between the MPM and external SNSs.
- To study the literature regarding the application of online social networks to public health informatics.

1.4 CONTRIBUTION TO KNOWLEDGE

This research gives one possible solution for integrating and managing users' distributed profiles (user profiles residing in discrete social networking sites) including social, professional, and healthcare profiles. While there are numerous studies on the interoperability, representation, and application of one's distributed profiles, few pay close attention to the sphere of centralised storage and control of users' distributed profiles.

Moreover, the MPM will be an extension of the OSW specification which means that this MPM is able to be integrated into the OSW platform to contribute to the development of social networks in the real world. In addition, this study can be used as the basis for further research in terms of integrating distributed profiles, profile interoperability, and the application of online social networking.

Finally, the MPM is able to integrate a patient's medical profile into their complete private profile, facilitate the collection of personal healthcare data, and simplify the management of their medical profiles. Thus, patients and physicians can both benefit from the application of an MPM to online social networks. The MPM allows medical staff to obtain a more complete picture of patients' backgrounds so that doctors can provide better health care to patients.

1.5 SCOPE AND LIMITATIONS OF STUDY

The scope of this study is to focus on proposing a prototype which is based on the Onesocialweb (OSW) platform to achieve both centralised management and sharing of profiles across multiple discrete social network sites.

This research was severely limited by the amount of time available. Thus, there are three aspects of the project which will not be given determinative weight in this study – security issues, synchronisation conflicts, and privacy support. Due to time constraints, the researcher will not develop any new method for MPM security in terms of users' account validation, profile data integrity and profile synchronisation authenticity; rather, the security solution from OSW will be employed. The OSW has excellent web security performance. All traffic is routed through the server and the identity of that server can be validated with signatures issued by Certified Authorities. Apart from that, synchronisation conflicts in this study will not be considered. In addition, further research needs to be undertaken to establish support for privacy in

the MPM platform. Once this is in place, users can decide on which Social Network Sites can access their personal details stored in MPM by exposing one (or more) Partial Profiles to that site.

Another limitation to this research arises from the OSW platform which is still in early testing. Some core protocols and specifications remain under development and testing.

1.6 THESIS OUTLINE

This thesis consists of six chapters. Following this introductory chapter is the review of literature in Chapter 2 which provides a summary of related work in the field of Social Networks, distributed profiles, semantic web, Onesocialweb technologies, information security, and health informatics.

Chapter 3 discusses the methodology and a proposed research approach that enables the implementation of the research. It depicts the research plan; introduces the research scenario and a framework for multiple profile management; discusses use cases that aim to capture the functional requirements of the MPM platform; and clarifies the outcomes to be achieved.

The framework includes four parts: the Social Network Domains (SND); Multiple Profiles (MP); Multiple Profile Manager (MPM) storing the Integrated profile (IP); and the Users. It shows the communication architecture for managing and sharing of users' MP residing in the SND. The MPM prototype is used to demonstrate the feasibility and advance of the MPM platform.

Chapter 4 gives details of the implementation of the project which include a vCard Format Extension, the MPM prototype, and related protocols. The vCard Format Extension is used to define the properties and their format for the Integrated Profile in the MPM platform. The researcher describes the MPM prototype by using the screenshots of the MPM Client and following the use cases mentioned in section 3.5. The MPM protocols here are to support the prototype for the communication between the SND, MPM and the user client. The protocols are illustrated using several protocol examples and also by following the use cases.

Chapter 5, covering the application of the MPM platform in public health informatics, examines the contribution of the MPM to the development of the web-

based healthcare social networks. The MPM prototypes are used to show that the MPM can facilitate the collection of patients' personal information and simplify the management of their profiles. Moreover, the MPM allows health professionals to obtain a more complete picture of the patients' backgrounds, so that they can provide better health care.

Finally, Chapter 6, the concluding chapter, summarises the research findings, gives a further discussion of the research implementation and indicates future work.

1.7 SUMMARY

In this chapter the background knowledge to the project was discussed and the research purpose and problems were indicated. The problem definition will be used together with evidence from the literature review to build proof for the existence of a research gap. Also the contribution to the body of knowledge in the area was summarised, and the limitations and scope of the study were clarified. Finally, the whole of the thesis was outlined. .

Chapter 2: Literature Review

Most people who use the Internet know the buzzword ‘social network’. Social network technologies have demonstrated their utility in facilitating human contact and connectedness, even when individuals are geographically distant from each other. Also, almost every social network site gives users the opportunity to include a profile by which Internet services are able to deliver personalised content to their clients. Users can collect, store, and share their personal information. However, there are “walled-gardens” between social network sites which block information sharing and communication between them. As a result, web users’ profiles are stored in distributed sources (i.e. social network sites), and maintaining those online profiles is cumbersome and time-consuming for typical web users. While there are numerous studies on the interoperability, representation, and application of one’s distributed profiles, few pay close attention to the sphere of integration and centralised control of users’ distributed profiles. Many researchers have explored social networking technologies in health in efforts to provide an assistive environment for patients. But to date, not one has investigated how online user profiles can benefit the healthcare industry. To address these two gaps in the literature, this study will propose a platform called Multiple Profile Manager (MPM) which enables users to create and manage integrated profiles that can be shared across numerous social network sites. Moreover, the MPM is able to facilitate the collection of personal healthcare data, which contributes to the development of public health informatics.

This literature review will firstly present the background of online social network sites including definitions, history, development, types, as well as problems. The second section reviews the major technologies used for achieving profile interoperability, profile representation and profile aggregation which can help the researcher address technical issues in relation to profile management. Onesocialweb (Eschenauer & Weisscher, 2010) and its protocols (Eschenauer, 2010) are discussed in detail in the third section, as the MPM is based on this platform. The fourth section, “Healthcare social networks”, discusses how to utilise social networks for improving public healthcare. The last section examines the privacy and security studies relevant to social network services and online profiles.

2.1 ONLINE SOCIAL NETWORKS

"I read somewhere that everybody on this planet is separated by only six other people. Six degrees of separation between us and everyone else on this planet… I am bound – you are bound – to everyone on this planet by a trail of six people." – Guare (as cited in Breslin & Decker, 2007, p. 86)

2.1.1 DEFINITION

Recently, Internet users have come to know the words "social networks", and with the development of the Internet there are an increasing number of websites that provide social network services for millions of users. Boyd and Ellison (2008, p. 2) defined social network sites as "web-based services that allow individuals to:

- Construct a public or semi-public profile within a bounded system;
- Articulate a list of other users with whom they share a connection;
- View and traverse their list of connections and those made by others within the system".

However, normally, there are two key terms used to describe this phenomenon; one is "social networking" and the other one is the "social network". The "social networking" stresses relationship initiation, often between strangers, whereas "social network" does not involve individuals meeting strangers, but rather enables "users to articulate and make visible their social networks" (Boyd & Ellison, 2008, p. 2). For this research, we use "social network". Additionally, Zengestrom (2005, p. 1) not only had a similar discussion about the meaning of the "social network", but also raised another notation – "object-centred sociality". This will be analysed in the subsequent sections.

2.1.2 THE HISTORY OF SOCIAL NETWORK WEBSITES

It is essential to have a clear understanding of the history of social network sites (SNSs) before trying to utilise them. According to Breslin and Decker's research (2007), the Internet was not only used to connect machines, but also as a medium for connecting people. In fact, before the emergence of the notion of "social network websites/services", some online functionalities or services had defined social networks and allowed people to connect and form online social networks typically around specific topics. These took the form of mailing lists, Usenet, and bulletin boards. "Although these groups didn't explicitly define social networks, the ways people acted and reacted did so implicitly" (Breslin & Decker, 2007, p. 86). The SixDegrees (SixDegrees.com), launched in 1997, was recognised as the first social network website that allowed users to create profiles and contact their friends (Boyd & Ellison, 2008, p. 3). From then on a number of community tools began to support social network services, and more and more new SNSs were launched, such as Friendster and LinkedIn. "These sites have brought a different notion of online communities by explicitly facilitating connections based on information gathered and stored in user profiles" (Breslin & Decker, 2007, p. 86). Boyd and Ellison proposed a timeline to illustrate the development of the social network sites and their features (see Figure 2).

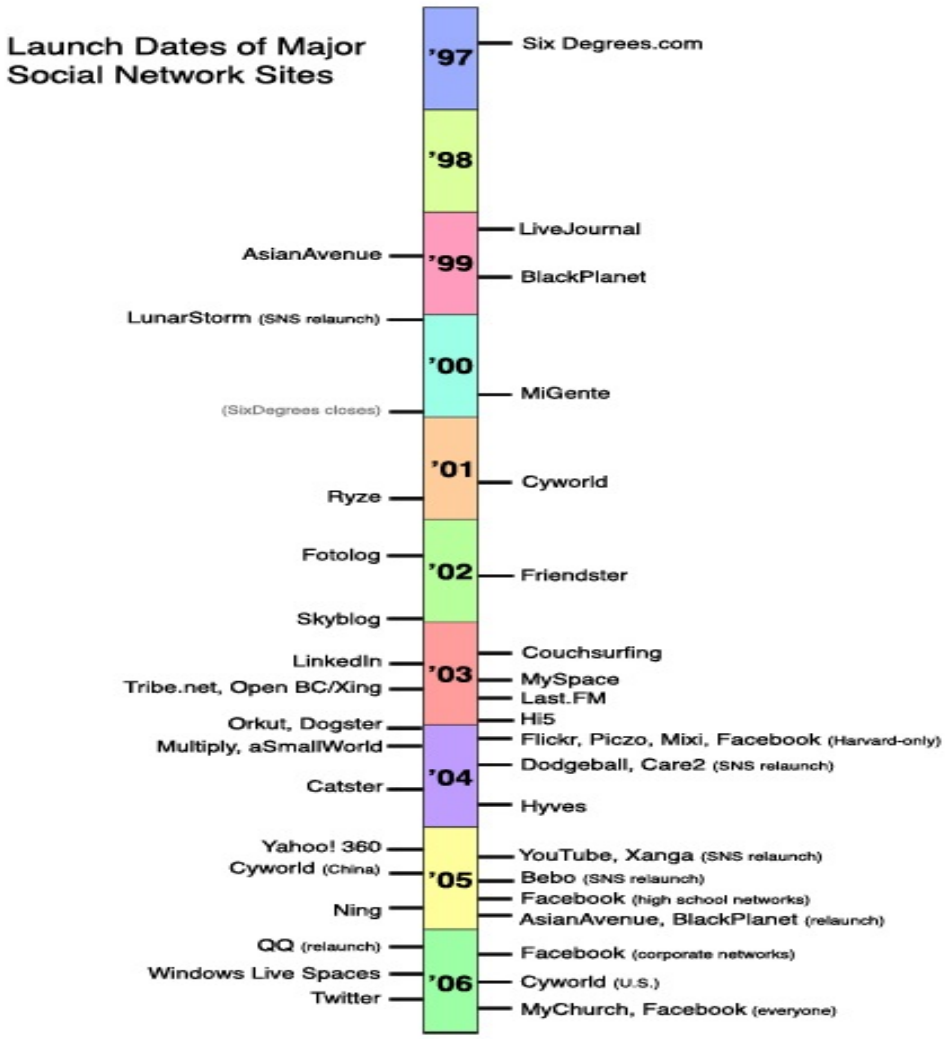


Figure 2. Timeline of the launch dates of many major SNSs and dates when community sites re-launched with SNS features (source: Boyd & Ellison, 2008, p. 5)

2.1.3 SOCIAL NETWORK TYPES

From 2003 onwards, social network sites not only placed their emphasis on profiles, friends, comments, and private messaging, but also on a variety of features and user bases that lead to various types of social networks (Boyd & Ellison, 2008, p. 6). Specifically-focussed social network sites identified by Boyd and Ellison include:

- Socially-organised SNSs such as Facebook and MySpace solicit broad audiences (labelled as General Social Networks in this thesis)
- Professional sites such as LinkedIn and Xing focus on business people (Professional Social Networks)
- "Passion-centric" SNSs like Dogster (http://www.dogster.com/) which is a dog-themed social networking and forums-based website

- Media sharing SNSs such as YouTube and Flickr
- Activity-centred sites like Couchsurfing
- Identity-driven sites like BlackPlanet
- Affiliation-focused sites like myChurch

However, Boyd and Ellison failed to identify another crucial area of social networking development, which is the medical/healthcare industry (Healthcare Social Networks). Healthcare social networks can be divided into two groups: physician-oriented and patient-oriented (Domingo, 2010). Physician and Patient social networks have grown in popularity, complexity, and capability since 2009.

Additionally, electronic health record (EHR) networks play a vital role in the area of online social network development. Kukaflka et al. (2007) redesigned EHR systems to support public health, and "Google and Microsoft recently extended their public services by introducing internet-based personal healthcare information platforms – Google Health and Microsoft HealthVault" (A Sunyaev, Kaletsch, & Krcmar, 2010, p. 195). They are two of the largest and most popular EHR networks of recent days.

This thesis focuses on three social network domains: General Social Networks, Professional Social Networks, and the Healthcare Social Networks. The latter will be discussed in the "Healthcare Social Networks" section in detail.

2.1.4 OBJECT-CENTRED SOCIAL NETWORKS

"The term 'social networking' makes little sense if we leave out the objects that mediate the ties between people" (Zengestrom, 2005, p. 1). "'Social networks' are not just made up of people, but they consist of people who are connected by a shared object" (Zengestrom, 2005, p. 1). However, in fact, "social network theory is good at representing links between people, but it doesn't explain what connects those particular people and not others" (Knorr-Cetina as cited in Breslin & Decker, 2007, p. 87). Breslin and Decker argued that users often connect to others for no other reason than to boost the number of friends they have in their profile. Thus, there are a number of social networking sites becoming increasingly boring and meaningless. To solve this problem, they proposed the concept of object-centred social networks

which is “the degree to which people are connecting via items of interest related to their jobs, workplaces, hobbies, and so on” (Breslin & Decker, 2007, p. 87).

“On the social web, people are related through user-generated content.” (Bojars, Breslin, Peristeras, Tummarello, & Decker, 2008, p. 34). Figure 3 is a demonstration of the object-centred social networks:

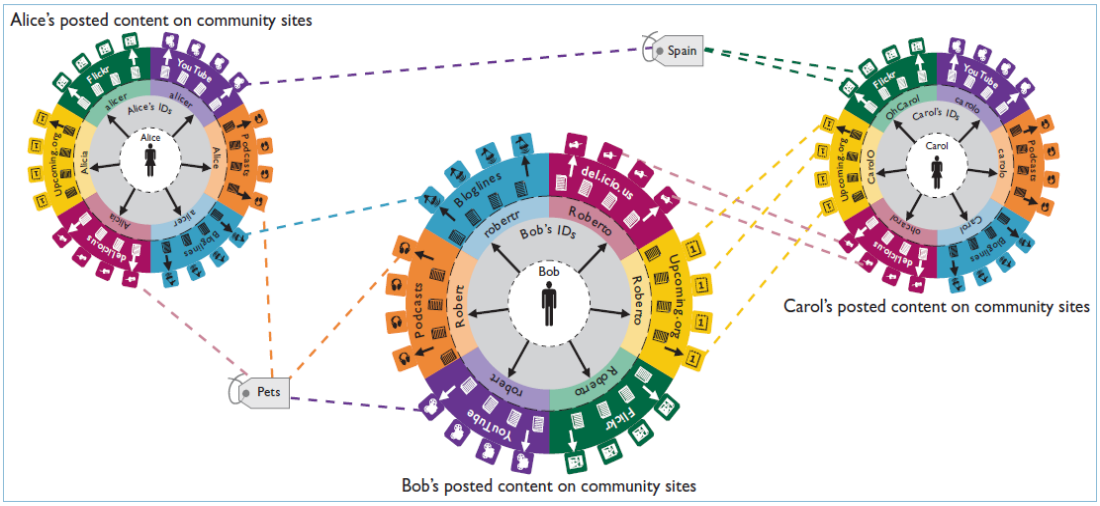


Figure 3. Object-centred social network. Users form social networks (using their possibly multiple online accounts) around the content items they act on – here, on the Web 2.0 (source: Breslin & Decker, 2007, p. 87)

Bob and Carol are connected by events that both have participated in, and URLs of their favourite Websites. Alice and Caro like similar types of images or videos.

Figure 3 demonstrates that many web users have more than one social networking account. This means a user may hold multiple profiles which are stored in different SNSs. For example, Bob maintains six profiles which is cumbersome and time-consuming (Iannella, 2009a, p. 2; Leonardi et al., 2009, p. 19). Iannella further adds that the necessity for users to maintain numerous profiles is “an impediment for new social networks to attract new members simply because of the effort involved in creating and maintaining ‘yet-another-profile’, and re-establishing different aspects of [one’s] profile under a new context” (Iannella, 2009a, p. 1). Thereby, the core concept of the topic ‘Multiple Profile Manager’ not only provides users with the notion of “centralised control” (Iannella, 2009a, p. 2), but also enables network service providers to attract more users.

2.2 USER PROFILE

2.2.1 DEFINITION

Almost every online social network site contains user profiles which consist of personal data. A user profile which is explicit digital representation of a user's identity can be used to store the description of the characteristics of a person, where the basic entities in this description are pairs of attributes and values. After joining a social network site, a user is asked to provide his or her demographic details, such as age, name, contacts and interests. In most SNSs, "users are also encouraged to upload a profile photo as well as customise the look and feel of their profiles using code they find online" (Liu, 2008, p. 254) (see Figure 4).

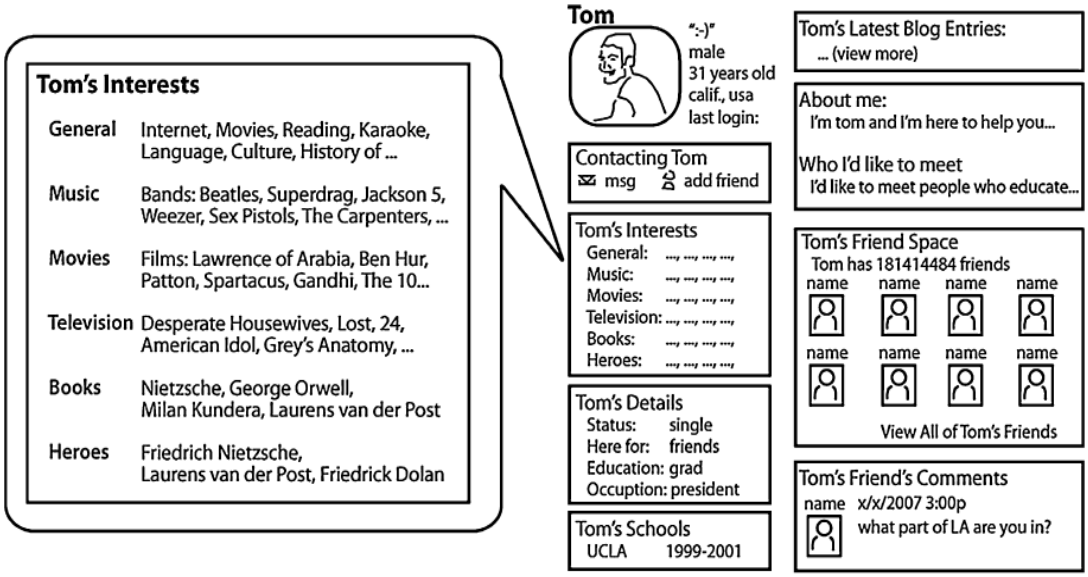


Figure 4. The typical layout of a MySpace profile, filled in with details from MySpace founder Tom Anderson's profile (source: Liu, 2008, p. 254)

Moreover, with the evolution of SNSs, the "personalisation of services, content and user interactions are considered as key to a superior customer experience. This requires service providers to build and maintain accurate models of a customer's preferences (e.g. a description of a user interacting with a social network service), interests, background, etc. i.e. a user profile" (Ghosh & Dekhil, 2008, p. 1229). The better framework manages a user's profile, and better and more personalised services can be delivered to users (Agostini, Bettini, Cesa-Bianchi, Maggiorini, & Riboni, 2003, p. 2; Houben et al., 2005, p. 9) (see Figure 5).

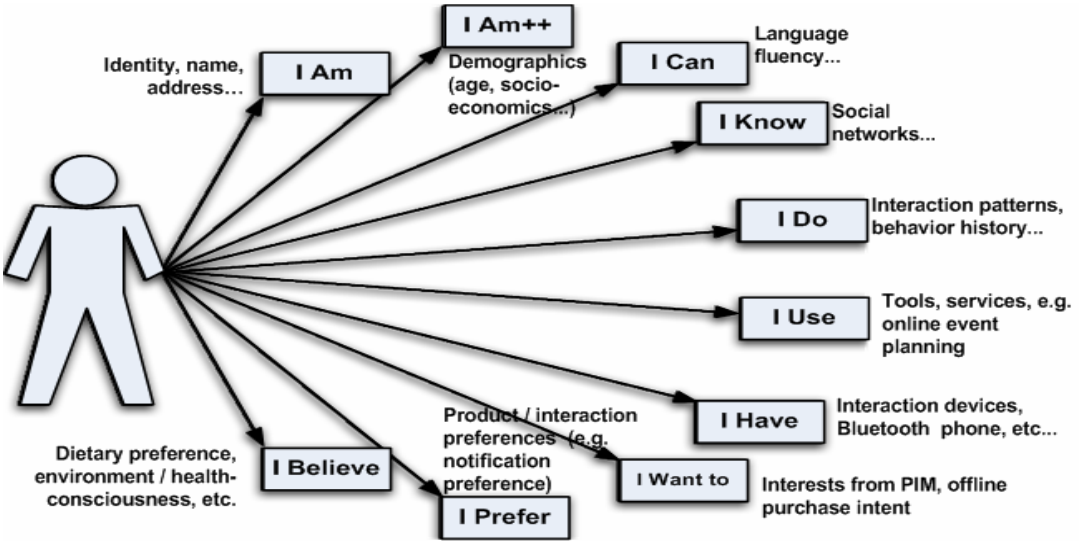


Figure 5. Types of profile information captured (source: Ghosh & Dekhil, 2008, p. 1229)

Agostini et al. (2003, p. 2) also argued that besides user personal data and preferences, a profile should also include "information on the device [being used by the networker], its current status, the network infrastructure, the current context and the content involved in the service request".

2.2.2 DISTRIBUTED USER PROFILES

According to the above definition of user profiles, a user's complete information is owned by various entities (e.g. different SNSs and devices) located in different logical and physical places (Agostini, et al., 2003). This is what makes user's profiles distributed. Integrated user profile data should include all information that can help social network sites (SNSs) offer "better" services to their members (Ghosh & Dekhil, 2008). Therefore, Ghosh and Dekhil conclude that the social network service providers just looking at SNS history and interactions with the customers is insufficient; they also need to study the user's preferences and interactions with other websites or services providers. This leads to a series of technical issues such as distributed profile interoperability, representation, and data retrieval. "[T]he range of technical issues for distributed profiles is immense and growing; from different architectures and representation formats that all provide interoperability challenges for the future" (Iannella, 2009a, p. 3)

2.2.3 PROFILE INTEROPERABILITY

Although object-centred sociality can address the problem of social network sites becoming boring, the remaining issue is how to implement interoperability

among different social network sites (SNSs) (Breslin & Decker, 2007). Breslin and Decker argued that the semantic technologies are able to provide an opportunity to achieve this goal. The knowledge in relation to the semantic technology and "semantic web" (Bojars, et al., 2008) will be discussed in the "Semantic Web" section.

The interoperability of user profiles plays a vital role in achieving the interoperability of the whole SNSs. For example, Google Health utilises the open standards SOAP (Simple Object Access Protocol) for the web-services interoperability (A Sunyaev, et al., 2010).

After reviewing works regarding profile and semantic interoperability, the researcher found that there are three main methods of addressing user profile interoperability:

(1) The shared format approach

As the name suggests, the shared format approach needs "a common language for a unified user profile" (Leonardi, et al., 2009, p. 20). For example, Heckmann et al. (2005) proposed The General User Model Ontology (GUMO) for the uniform interpretation of distributed user models in intelligent semantic web enriched environments. Ontology language OWL (Houben, et al., 2005, p. 54) was used to represent user model terms and their interrelationships.

Another example is a framework proposed by Agostini et al (2003) that offers tools to integrate distributed profile data located in different sources (see Figure 6).

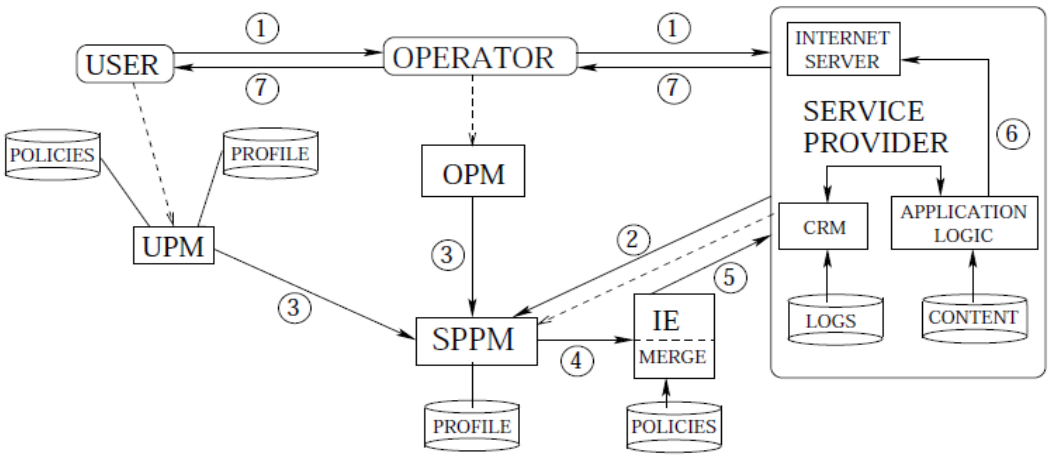


Figure 6. Information Flow upon User Request (source: Agostini, et al., 2003, p. 3)

For implementing an integrated profile, Agostini et al. (2003, p. 3) identified three main entities that are the user, network operator, and service provider, and three corresponding user profile manager modules to manage their profile data. As seen in Figure 6, these three manager modules are the UPM (User Profile Manager), OPM (Operator Profile Manager), and SPPM (Service Provider Manager) respectively. This framework and Agostini et al.'s research provide very clear and useful methods for integrating distributed user profiles and also representing these profiles, which have different formats and features.

The shared format approach is easily exchangeable and interpretable because "it does not need to consider any issue of syntactic and semantic heterogeneity, however, this approach is not suitable for the open and dynamic environments" (Leonardi, et al., 2009, p. 20).

(2) The conversion approach

The core technique of this approach is to "convert a user profile in one application to another one" (Leonardi, et al., 2009, p. 21). Also, Leonardi et al. stated that this approach is suitable for the open and dynamic environments; nevertheless, it has many drawbacks. For example, the conversion may cause information loss. Consequently, they proposed the third approach, "mashup approach" (Leonardi, et al., 2009, p. 19).

(3) Mashup approach

"Morpho" (Leonardi, et al., 2009, p. 22) is a framework to elicit, enhance and transform a user profile from one application to another in a mashup environment (see Figure 7).

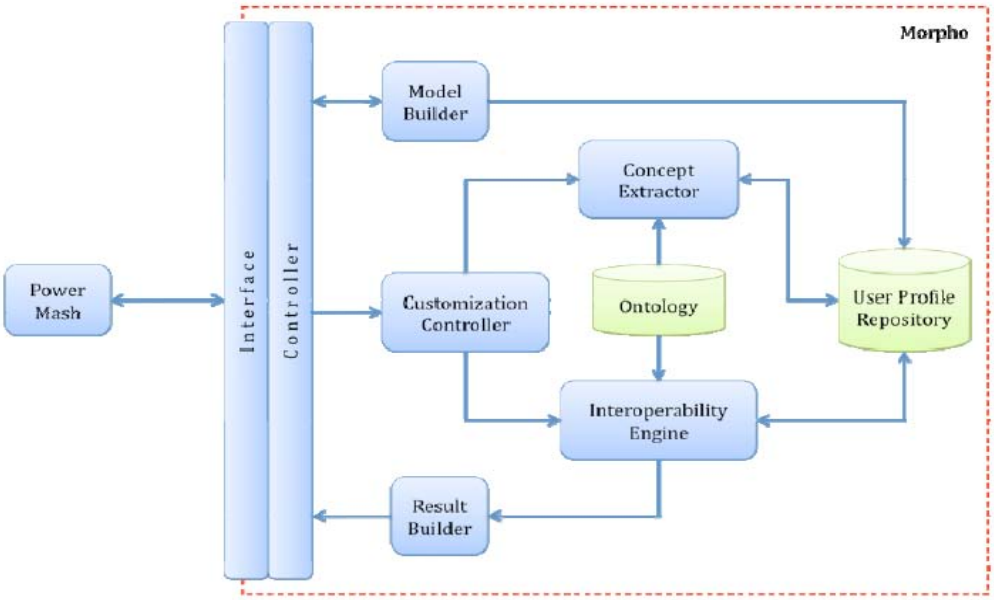


Figure 7. The Architecture of Morpho (source: Leonardi, et al., 2009, p. 23)

Furthermore, to address the problems of integrating user profiles residing in distributed sources, sharing profile data between social network sites (SNSs), and semantic interoperability, Ghost and Delhi (2008, p. 1230) presented a framework called the "Semantic User Profile Management Framework" (SUPER). It uses ontology language OWL to define the semantics of a user profile. Figure 8 shows a prototype of the SUPER framework.

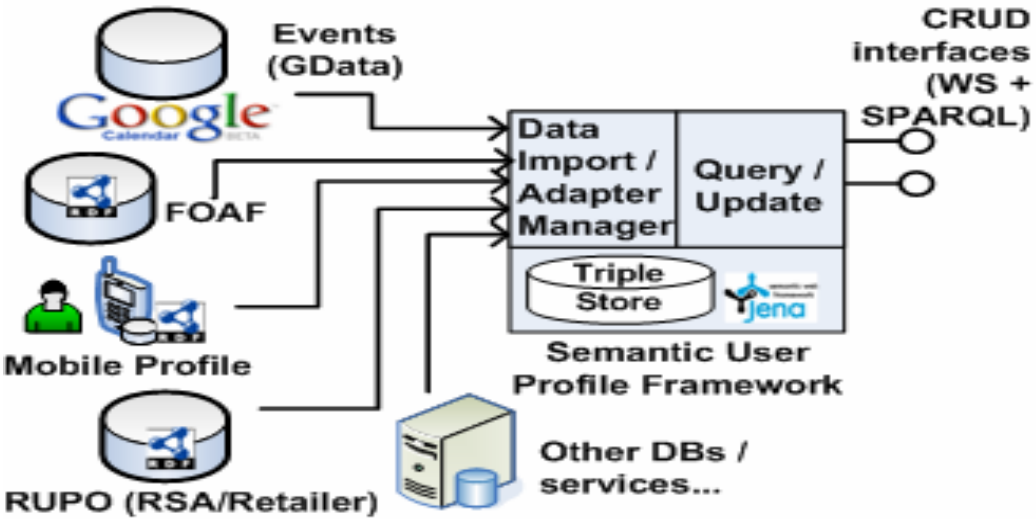


Figure 8. Overview of the SUPER framework (source: Ghosh & Dekhil, 2008, p. 1230)

This prototype is used to illustrate how SUPER can facilitate the creation and management of a user's extensible and distributed profiles which may include the Google user's calendar data, interests, preferences, social networks from FOAF sources, profile information from their mobile phone, and simple shopping list

information from their RUPO document (e.g. Amazon wish-list) (Ghosh & Dekhil, 2008).

In summary, profile interoperability is a challenge for managing and utilising a user's distributed profile (data located in different social network sites or devices). The frameworks, prototypes or approaches discussed above will greatly contribute to the research in terms of profile integration, representation and synchronisation.

2.2.4 PROFILE REPRESENTATION

This section discusses many popular methods used for representing user profile data along with their associated storage and representation formats. In order to achieve profile interoperability between a user's profiles across different social network sites (SNSs) or devices, "the scheme or format used for representing user profile data should be machine-interpretable" (Houben, et al., 2005, p. 54), which allows an SNS to map a user's profile that is used in a certain domain (e.g. Facebook site) to another profile in another domain (e.g. LinkedIn site).

Houben et al. argued that ontology (a formal representation of knowledge as a set of concepts within a domain, and the relationships between those concepts) can be a good way to help represent user profiles. They analysed five main ontology languages – XML (eXtensible Markup Language), RDF (Resource Description Framework), SHOE (Simple HTML ontology Extensions), OWL (Web Ontology Language), and KIF (Knowledge Interchange Format) – that can be used to express user profiles. Then, they presented the advantages, drawbacks and features of these ontology languages.

Besides the SUPER framework (see Figure 8), Ghosh and Dekhil (2008, p. 1230) also proposed an OWL ontology called the Retail User Profile Ontology (RUPO), to present the semantics of a user profile (see Figure 9).

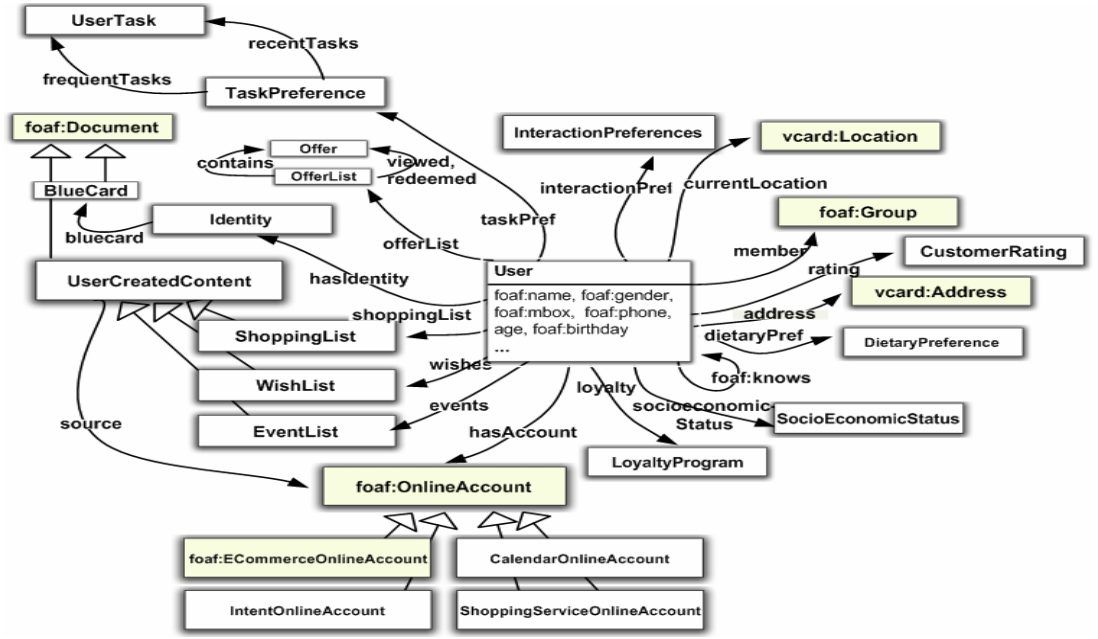


Figure 9. Partial Snapshot of Retail User Profile Ontology (source: Ghosh & Dekhil, 2008, p. 1230)

RUPO is very useful to this research in terms of multiple profile representation, as "it utilises shared concepts from some existing ontologies like vCard and FOAF" (Ghosh & Dekhil, 2008, p. 1230). In this research, vCard was chosen as the format for multiple profiles and the shared concepts from other existing ontologies might be used in the future.

Agostini et al. (2003, p. 7) used the Composite Capabilities/Preference Profiles (CC/PP) structure and vocabularies to represent the profiles in their research (see Figure 6). Also, Google Health and Microsoft HealthVault use XML format conventions to send medical information via data messages containing all the necessary information and to share users' profiles (A Sunyaev, et al., 2010).

In conclusion, "ontologies are a significant part of the Semantic Web and profile representation. All structures or languages mentioned above utilise the semantic technologies" (Word Wide Web Consortium, 2001).

2.3 SEMANTIC WEB

As stated above, the Semantic Web (Berners-Lee, Hendler, & Lassila, 2001) provides us with an opportunity to achieve social network sites' interoperability and represent the distributed profile data. The Semantic Web is "an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation" (Berners-Lee, et al., 2001, p. 3).

The number of researchers that pay attention to the "Social Semantic Web" (Bojars, et al., 2008) has increased significantly. Bojars et al. (2008, p. 29) defined the Social Semantic Web as "applying Semantic Web frameworks to the Social Web" (see Figure 10). They raised and analysed two of the major Semantic Web frameworks – SIOC (Semantically Interlinked Online Communities) and FOAF (Friend-of-a-Friend), and illustrated how these frameworks can be used to create a network along with interlinked semantic knowledge.

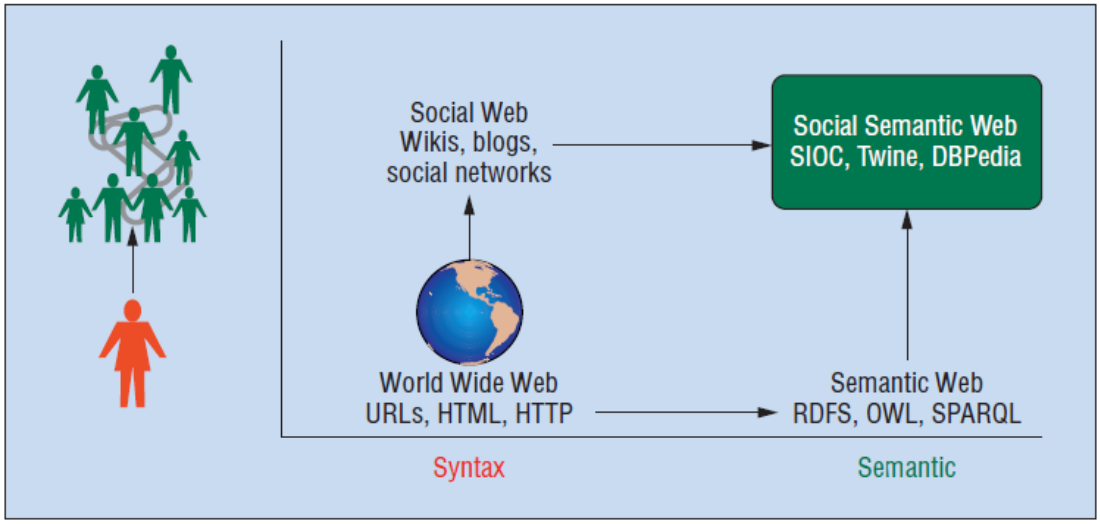


Figure 10. The Social Semantic Web. Applying Semantic Web technology to the Social Web could bring the Social Web to its full potential (source: Bojars, et al., 2008, p. 30)

Additionally, Iannella (2009a, p. 3) proposed the notion of 'Semantic profile', which means "a user's profile can be created or updated depending on his/her interaction with the services of the social network sites". In this research, the Multiple Profile Manager should use the knowledge from the Semantic Web to achieve the "dynamic properties [that] capture the evolving changes of a person's context" (Iannella, 2009a, p. 3).

2.4 ONESOCIALWEB (OSW)

Social network sites (SNSs) do play a vital role in people's daily communication these days. However, when one SNS is isolated from others, it hinders users in making friends and sharing messages or information across the SNSs. Thus, the Vodafone group proposed a platform OSW (Eschenauer & Weisscher, 2010) that aims to bridge the gaps between different SNSs, allowing users to connect with friends across these SNSs and different platforms. The OSW enables free, open, decentralized social applications on the web.

The protocol of the OSW proposed by Eschenauer (2010) is based on open standards:

- **XMPP** (Extensible Messaging and Presence Protocol): Identity, discovery & communication (Basic engine)
- **Activitystreams**: Data model for social objects
- **Vcard**: Data model for profile
- **XFN** (XHTML Friends Network): Data model for relationships

In addition, based on XMPP architecture, Eschenauer defined one draft XMPP protocol extension for each of the above protocols (Eschenauer, 2010). Within these protocol extensions, Vcard4 is very useful to this research as it is a protocol for user profile management and representation. The Vcard4 defines an XMPP protocol extension for sharing profile data between users. Eschenauer presented several key features such as "Vcard4 support a fine grained privacy extension which means users can assign access control rules on a field per field basis, [and when using Vcard4] users delegate their write access rights to elements of their Vcard to other entities" (Eschenauer, 2010, p. 1). Most importantly, this protocol offers a flexible platform for user profile management in a decentralised social network. Thus, the proposed protocols in this thesis will be an extension of Vcard4 to achieve the distributed profile management. The OSW protocol can be used to turn any XMPP server into a fully-fledged social network, participating in the OSW federation.

The OSW also enhances social web security. All traffic is routed through the server and the identity of that server can be validated with signatures issued by Certified Authorities. Consequently, it enables users to establish secure communication without having to use complex things like signatures.

2.5 HEALTHCARE SOCIAL NETWORKS

As the Multiple Profile Manager will be applied to the area of healthcare, it is vital to analyse the knowledge about healthcare social networks. "Surveys show an increased reliance on physician and patient social networks, which promise to transform healthcare management" Domingo (2010, p. 20). Domingo (2010) argued that "healthcare social networks provide an active platform for sharing ideas, discussing symptoms, and debating treatment options – tasks that together promise to

improve patient care and can be either physician or patient oriented" (Domingo, 2010, p. 20). Furthermore, she proposed several popular physician networks such as: Serrmo (www.sermo.com), the largest online physician community; Ozmosis (www.ozmosis.com); and DoctorNetworking (www.doctornetworking.com). She also advocated patient networks like: PatientsLikeMe (www.patientlikeme.com); CureTogether (www.curetogether.com); and Disaboom (www.disaboom.com).

Besides that, with the Internet's increasing popularity, a great number of researchers have focused their attention on the EHR networks that bridge the social network services and the medical/healthcare industry. Shachak and Jadad (2010, pp. 452-453) presented the following seven components, based on resources and knowledge that exist today, for consideration during the development of the EHR network:

- "Tools to Promote Health, Not Only to Treat Diseases,
- Fully Integrated and Interoperable Components,
- Incorporation of Multimedia,
- Support for Virtual Interactions,
- Integration of Social Networking Tools,
- Promotion of Optimal Health Outcomes, Resource Utilisation, and Policy Development,
- Open and Collaborative Systems, Free of Unnecessary Concerns about Privacy."

"These components may contribute to current efforts to provide the public with access to tools that meet the public's needs and expectations" (Shachak & Jadad, 2010, p. 453).

Google Health and Microsoft HealthVault are EHR frameworks built to provide an easy way for users to store their personal health records online (Google, 2010; Microsoft, 2009). Frameworks for EHR are an opportunity for gaining a strong market position. They encourage third parties to develop a variety of services to attract more and more patients. "Patients can choose their favoured [services] out of a wide array of available services and add them into their personal profiles" (A Sunyaev, et al., 2010, p. 195). "EHR platforms are very valuable tools for future

health service providers as well as other online social webs" (A. Sunyaev, Chornyi, Mauro, & Kremar, 2010, p. 1).

2.6 PRIVACY AND SECURITY

2.6.1 PRIVACY

Privacy is still one of the major issues with online profiles managed by social networks. Google protects its users' information privacy through giving them complete control, which means that users decide which parts of their profiles can be exposed to which groups of friends (A Sunyaev, et al., 2010). Similarly, for an integrated profile that consists of partial profiles located in different social network sites, "the users [are] in direct ... control of access and usage permissions to their Partial Profiles; users decide on which service providers can access their personal details by exposing one or more Partial Profiles to that Provider" (Iannella, 2009a, p. 3). The Multiple Profile Manager will adopt this privacy policy. Furthermore, Iannella argued that "developers need new "policy-oriented web" architecture to support trusted rule-based services in the longer term" (Iannella, 2009b, p. 3).

2.6.2 SECURITY

OAuth is an open protocol to allow secure API authorisation in a simple and standard method from desktop and web applications. There are two main benefits to using OAuth:

1. "Clients are able to access server resources on behalf of a resource owner (such as a different client or an end-user).
2. End-users can authorise third-party access to their server resources without sharing their credentials (e.g. a username and password pair)" (Hammer-Lahav, 2010, p. 1).

Google Health uses the open protocol OAuth to create a connection between a developer's site and Google Health (Hammer-Lahav, 2010). As the Multiple Profile Manager is a central profile control system, building an efficient and secure connection between itself and external social network sites is very important. Thus, OAuth will be utilised to address the authorisation issues in this research.

2.7 SUMMARY

Since 1997 when the first SNS was launched, the number and variety of social network services has been growing dramatically. In order to provide users with more and better services, SNSs need to obtain customers' preferences, interests, and background information, that is, a user profile (Ghosh & Dekhil, 2008). On the other hand, most people hold more than one SNS account, which means they have to manage more than one profile (multiple profiles). Consequently, the Multiple Profile Manager platform used to centralise control of a user's distributed profile, becomes particularly significant.

This literature review discussed the background of online social network sites including definitions, history, development, types, as well as problems, and then reviewed the approaches used for achieving profile interoperability. There are three main approaches: the shared format approach, the conversion approach, and the mashup approach. These three approaches can address the issues of distributed profile representation and integration. In addition, Onesocialweb platform and related protocols which aim at removing the "walled-gardens" between SNSs were discussed in detail. The MPM prototype will be implemented based on the Onesocialweb platform. Additionally, the researcher discussed the application of online social networks to the area of health informatics. Finally, privacy and security studies relevant to social network services and online profiles were examined. Privacy and security issues of MPM will not be given determinative weight in this study due to the time constraints. The discussion about these issues in this chapter will be a support for the future research.

Chapter 3: Research Design

In Chapter 2, the writer reviewed the literature regarding online social networking, user profile aggregation and management, health informatics, and security issues. This literature indicated that at this time, very limited work has been done on integrating and centrally managing users' multiple profiles and few researchers have investigated the application of online user profiles on public health informatics. Additionally the framework and protocols of the Onesocialweb (OSW), which is a basic platform of this project, were studied.

This chapter describes the design adopted by this research to achieve the aims and objectives stated in Chapter 1. Section 3.1 discusses the methodology to be used in the study and describes a research approach that enables the implementation of the research. Section 3.2 outlines the research plan which indicates the four stages needed to complete the project. Section 3.3 consists of the research scenario that is considered in this research. Section 3.4 builds a framework for multiple profile management. Section 3.5 creates use cases which are depicted by the UML Use Case Diagram and detailed below. These use cases are proposed based on the research scenario and framework, and it is essentially the core of the project. The project is implemented by fulfilling each use case. Finally, section 3.6 gives the outcomes that the project wants to achieve.

3.1 METHODOLOGY

The research will start by reviewing recent research materials such as journals, white papers and other relevant publications such as case studies related to the social network, semantic technology, profile management, and in particular OSW technology that were based on the Extensible Messaging and Presence Protocol (XMPP). These research materials provide an overview of earlier and current information in implementation of data transmission, management and interpreting technologies between different social networks.

In this research, a framework for achieving multiple profile management will be proposed. To validate the framework, a prototype profile manager will be implemented and this will be followed by an illustration of its protocol specifications.

This prototype is going to establish five simulated social network sites that imitate social applications: Facebook; a professional site, LinkedIn; and three healthcare social sites: Google Health, PatientsLikeMe, and Disaboom respectively. In order to achieve the implementation of the prototype, a research approach will be used.

Research Approach

This approach is based on the Iterative and Incremental Development Process (IIDP) proposed by Cockburn (2008). It consists of six main steps (see Figure 11).

- To propose an **Objective**.
- **Requirements Analysis:** Propose and analyse main activities (tasks) for this objective.
- **Literature Review:** Research existing related technologies, frameworks or specifications.
- **Development:** Develop the new framework and protocols to achieve this objective.
- **Evaluation, Testing, and Improvement:** Implement the corresponding prototype for this objective to validate this task and improve it by the feedbacks from supervisors and Onesocialweb Group[5].
- **Integration:** Integrate the prototype and knowledge implemented by this iteration with the preview work.

[5] http://groups.google.com/group/Onesocialweb

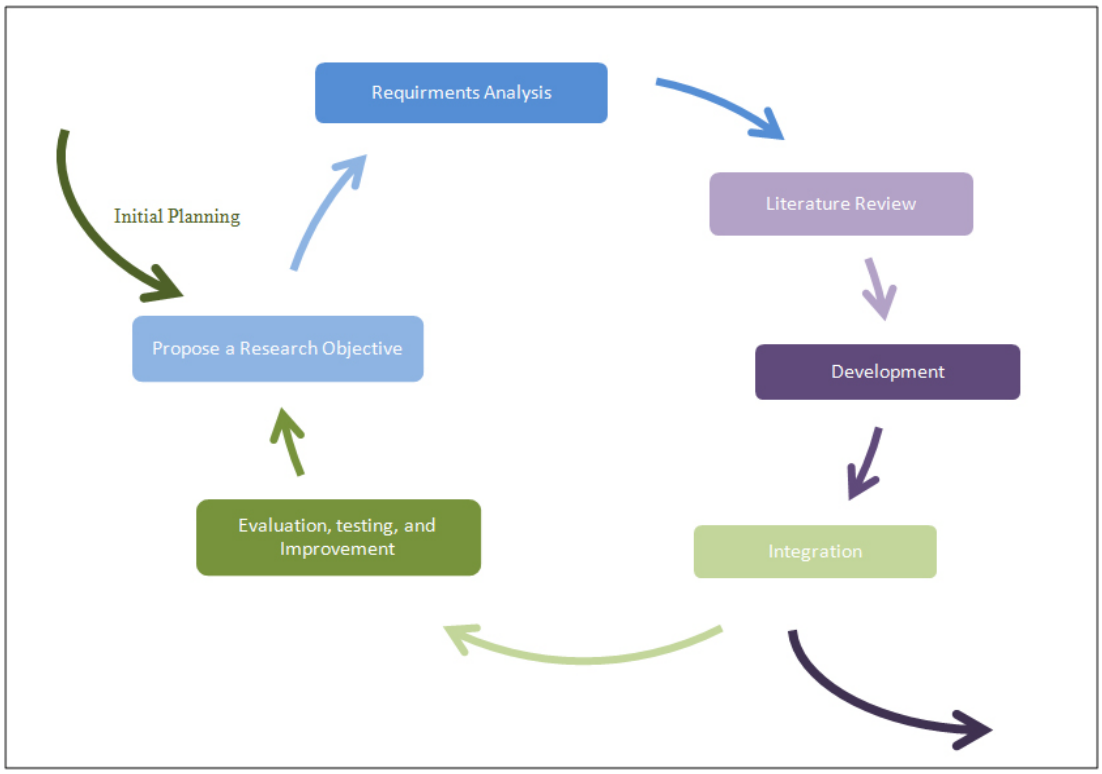


Figure 11. Iterative and Incremental Development Process Overview

As shown in Figure 11, the research approach starts with an initial planning and ends with the integration. The cyclic interactions are in between. Every circle is considered to be a loop, and each loop is based on the proposed research objective. Given the initial planning, the research objective is firstly proposed according to the initial planning, and then the analysis of the main tasks of the objective are carried out. Following this, a comprehensive literature review covering the existing technologies and frameworks is conducted. Next the development of the new framework and the integration with the system will be achieved. Through extensive evaluation and testing, the corresponding prototype for the objective in this loop will be validated along with possible improvements. The improvements will then be considered and put into the next circle. The research can be divided into several research plans, and each of them can be further accomplished by repeating this interactive and incremental development process.

3.2 RESEARCH PLAN

The main aim of this research is the design and implementation of the platform MPM which is able to create and modify a user's Multiple Profiles (MP), and synchronise changes over time. The outcomes of the research will support the Onesocialweb (OSW) platform by proposing a framework for the platform, a prototype to illustrate the advantage and feasibility of the platform, and related protocols used to support the prototype. The implementation of the project will be composed of the following four major stages (see Figure 12):

Stage 1: Research Planning and Design **1st June 2010 – 31st August 2010**

The first stage of this research is the development of the research plan, which includes the following steps: 1) initial definition of the research problem; 2) preliminary literature review, followed by further refinement of the research problem; and 3) production of a research plan.

The literature review has the following three main benefits:

- Allows the researcher to gain a stronger understanding of management of online distributed profile and the application of online social networks,
- Shows the background of the social networks and the requirement of these service providers as well as their users,
- Helps the researcher address the technique issues in regard to profile management.

Stage 2: Build Framework and Use Cases **1st September 2010 – 30th September 2010**

This stage will consist of five main tasks:

- To design research scenario,
- To build a framework for multiple profile management,
- To investigate the structures, protocols, and attributes of profiles in different social network sites – Online User Profile Attributes Report (see Appendix A),
- To list all attributes that should be used in the prototype to be developed – Integrated Profile Properties List (see Appendix B),

- To capture the functional requirements of the Multiple Profile Manager system and describe the interactions between the users and the system itself – Use Cases.

Stage 3: Implementation and Evaluation **1st October 2010 – 14th February 2011**

This stage will consist of five main tasks:

- To define the properties and their format for Integrated Profile (IP) in the MPM – vCard Format Extension (see Appendix C),
- To define MPM protocol specification which is based on the vCard Format Extension,
- To implement the MPM prototype and evaluate the prototype using the researcher's use cases,
- To discuss the application of the prototype in the health informatics area.

After clarifying the research problems and completing the investigation around current literature, the research will enter the core stage. The method used to approach the problem is based on the Iterative and Incremental Development Process (IIDP), which starts with an initial planning and ends with integration with the cyclic interactions in between (see section 3.1). Here the use cases are employed as the initial planning and each case can be considered as a loop. In each loop, the research objective is proposed according to requirements of this case, and is followed by the analysis of the main tasks of the objective. In addition to the requirement analysis, a systematic literature review is needed to study the related technologies, techniques and frameworks. And following through, the process reaches the stage of the development of the MPM and the integration of the system. Extensive evaluations and testing are required to test the implemented partial MPM prototype. And then improve and optimise the implementation according to the feedback from supervisors. This will conclude the loop for one case, and each successive case can follow this same interactive and incremental development process until all use cases have been solved and successfully implemented.

Among the five steps of the IIDP, the most important part is at the stage of development. In this stage, the MPM prototype and related protocols are proposed

and established. The MPM prototype and protocols enable users to publish and read the integrated profile, synchronise it with all profiles residing in Onesocialweb-supported social networks, and control the Multiple Profile Accounts (MPAs) (that is add/remove, enable/disable accounts) in the MPM. Ideally, it should cover all the use cases proposed.

The MPM prototype is based on the Onesocialweb (OSW) platform to share Multiple Profiles (MP) between the MPM Server and OSW-supported social networks. It includes two main parts, one is the MPM Server, and the other one is the MPM Web Client. The MPM Server is mainly responsible for information (that is profile data and MPA information) management and storage. The MPM Web Client is used to display the form of a user's Integrated Profile (IP), and more importantly provides individuals with a user-friendly interface to control the MPM system. The implemented MPM prototype is used to demonstrate the feasibility and functionality of the project.

The MPM protocols can be seen as an extension of the Onesocialweb (OSW) protocol (Eschenauer, 2010), while OSW protocol is an extension of Extensible Messaging and Presence Protocol (XMPP). The purpose of the OSW protocol is to enable free, open, and decentralised social applications on the web. In particular, this protocol can be used to turn any server into a fully-fledged social network, participating in the OSW federation. Thus, the MPM protocols can realise the sharing of MP between any network sites in the OSW federation.

Stage 4: Final Thesis Submission **15th February 2011 – 31st May 2011**

The objective of the final stage of the master programme is to submit a completed thesis. The steps involved in this stage include: 1) completing the thesis document by interpreting the research implementation, drawing conclusions and providing suggestions for further research and submitting the draft thesis for review by supervisors and relevant external reviewers; 2) preparing and delivering the final seminar presentation; and 3) finalising and submitting the thesis for the purpose of graduating from the programme.

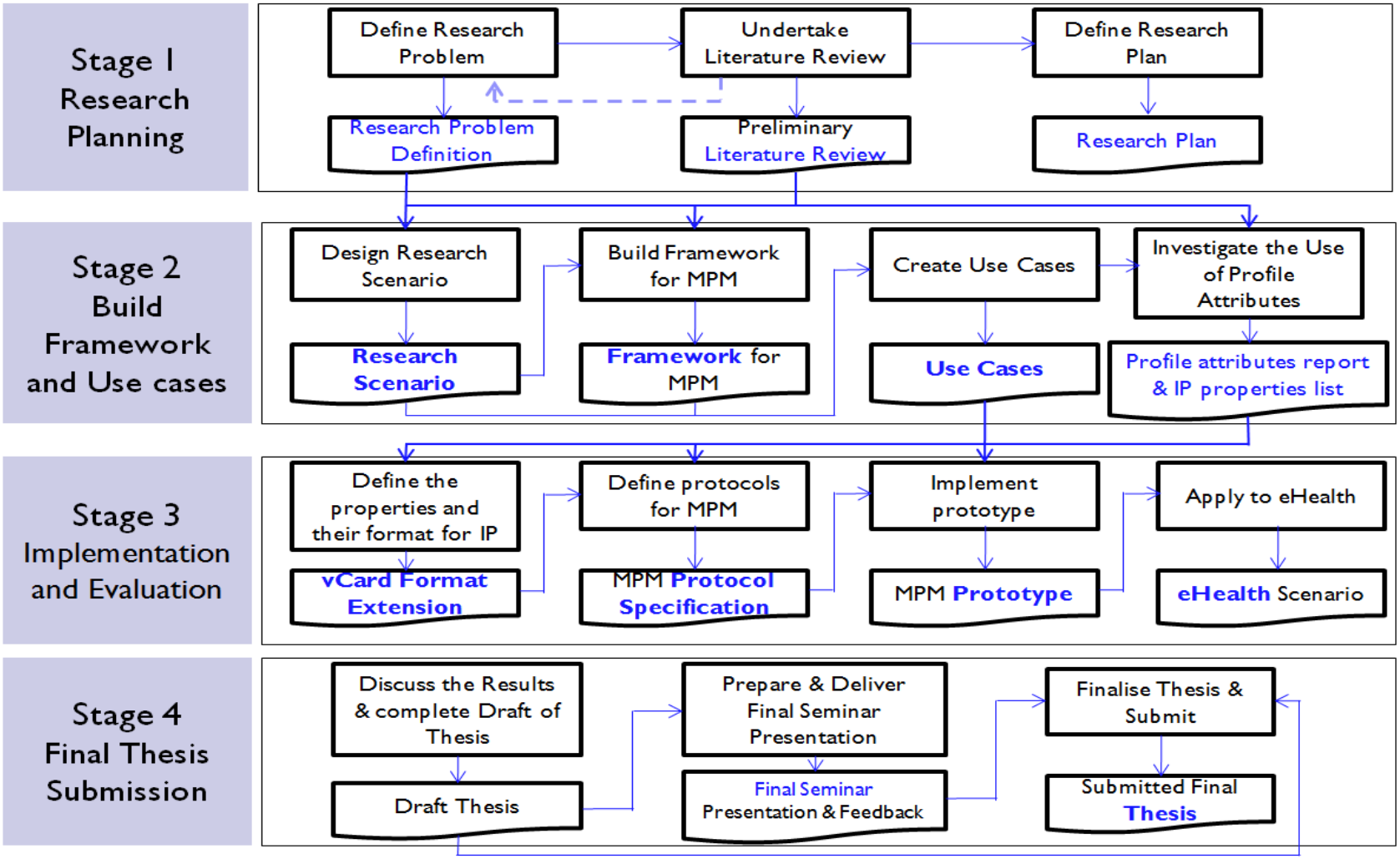


Figure 12. Research Plan

3.3 SCENARIO

Consider Bob, a steam turbine engineer who was exposed to loud occupational noise for at least six months per year. Bob already has a Facebook account, and he uses Facebook to communicate with his friends and share pictures and words with his family. In the Facebook profile, in addition to his basic information, such as his name, email address, telephone number, and home address, he also has specified his social information like interests, favourite food, and best dance moves.

Now, Bob wants to create several new social network accounts and utilise them in different ways depending on the digital context. First, Bob intends to expand his professional network and look for more business opportunities through LinkedIn. LinkedIn is a business-oriented social network site which is being used by more and more business professionals to build relationships, meet new contacts, and market themselves. The LinkedIn profile is able to store Bob's professional information such as his working environment, working time, previous employment, areas of expertise, working pressures and risks. Then, Bob would like to register a Google Health account to store and maintain his health and fitness information. As well, he wants to create PatientsLikeMe and Disaboom accounts to share treatment and symptom information with other people online. By doing this, his private doctor can monitor the progress of Bob's medical situation.

Bob decided to change his email address, and he wanted to update the email address in all the social network sites that he has registered in. Not only this, but Bob's health information has also changed. His weight has changed from "80kg" to "75kg"; his conditions from "Tension Headache" to "Tension Headache, Chronic Heart Disease"; and his allergies from "Erythromycin Base" to "Erythromycin Base, Nut & Peanut". As a result, he needs to update the changes to his Google Health, PatientsLikeMe, and Disaboom profiles respectively.

Bob is a person with chronic heart disease, and whenever he goes to see his private doctor, he will be asked to provide personal information about his daily life, work conditions, interests, and dietary habits, in as much detail as he can. The doctor requires this comprehensive knowledge to suggest the right treatment.

Current Approach

Under the current platform, Bob has to type his personal information into the LinkedIn profile, Google Health, PatientsLikeMe, and Disaboom profiles repeatedly. The profile data in these SNSs can never be shared and the information is not interoperable. Another limitation of the current social network framework is that updating profiles stored in two or more social network sites is cumbersome. As recent SNSs are isolated from others, the connection between different social networks is mostly lost. This causes Bob to have to repeat the operation of profile creation and updates.

When Bob's private doctor wants to access Bob's Google Health account to monitor his health condition, s/he is limited to viewing Bob's healthcare records rather than a complete set of information including his habits, hobbies, diet, and working environment. Some of these elements are related to Bob's health condition, and it is important for Bob's doctor to know about them. However, there is not yet a service available that enables users to print or export an integrated profile report. The report should include Bob's personal information in as much detail as possible.

3.4 THE FRAMEWORK FOR MULTIPLE PROFILE MANAGEMENT

In line with the above research scenario, this researcher proposes a framework for overcoming the existing limitations in the management of the MP. The framework is based on developing a conceptual structure to enable social network users to have centralised management and sharing of multiple profiles which reside in different SNSs. As shown in Figure 13, the framework includes four parts: the Social Network Domains (SND), Multiple Profiles (MP), Multiple Profile Manager (MPM), and Social Network Users.

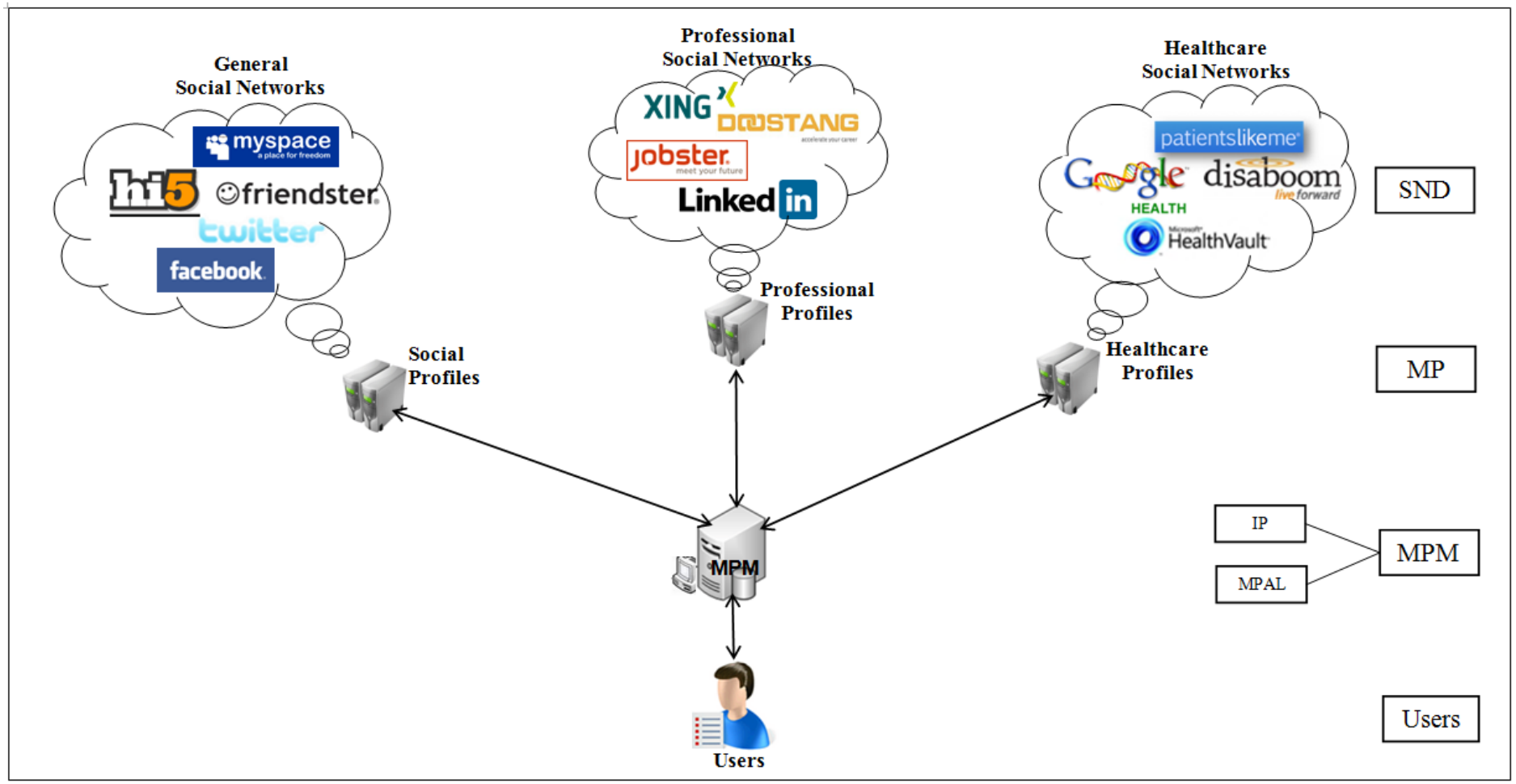


Figure 13. A Framework for Multiple Profile Management

3.4.1 SOCIAL NETWORK DOMAINS

This study proposes an expanded concept of social networks which include three domains:

- **General social networks** (Facebook etc.)
- **Professional social networks** (LinkedIn etc.)
- **Healthcare social networks** (Google Health, Disaboom, PatientsLikeMe[6], etc.)

General social networks are websites that provide users with online services to communicate with friends and families, as well as to share pictures and words with them. Professional social networks are business-oriented sites that are mainly used for professional networking. Healthcare social networks are sites that enable users to store and maintain their health and fitness information, as well as to share treatment and symptom information.

3.4.2 THE MULTIPLE PROFILES

The three social network domains mentioned above categorise the Multiple Profiles (MP) into three corresponding categories – Social Profiles, Professional Profiles, and Healthcare Profiles. These three kinds of user profiles are stored in the three corresponding social network domains and maintain the different categories of user information (see Figure 14).

- **Social Profiles:** The social profiles stores users' social information including interests, likes, friends, and beliefs. These are only available for general social networks.
- **Professional Profiles:** The professional profile plays the role of storing work-related information such as previous employment roles, areas of expertise, working conditions. These details are only provided for professional social networks.
- **Healthcare Profile:** The healthcare profile keeps users' personal health information such as health conditions, medications, and allergies. These are only for healthcare social networks.

[6] http://www.patientslikeme.com

Thus, individuals' MP include their social profiles created and maintained in the general social network sites, professional profiles in the professional social network sites, and healthcare profiles in the healthcare social network sites.

3.4.3 THE MULTIPLE PROFILE MANGER (MPM)

The MPM is the platform to be discussed and implemented in this project. It should be a trusted online server or application that provides services for multiple profile management. It includes two major parts: one is the Integrated Profile (IP) which stores users' complete personal information; the other one is the Multiple Profile Account List (MPAL) which is used to save the information of the Multiple Profile Accounts (MPAs).

Integrated Profile

The Integrated Profile (IP) is created and maintained by the proposed MPM platform. It stores users' complete personal information such as identity information, contact details, and other specific information covering social, professional, and health domains. The IP is composed of four Partial Profiles (Iannella, 2009a) the Basic, Social, Professional, and Healthcare Partial Profile (see Figure 14). The Basic Partial Profile stores users' basic personal information such as avatar, names, gender, home address, and telephone number. It is usually captured by all social network sites in the three domains. The combination of the partial profiles can be mapped to the MP. For example, in Figure 14, the LinkedIn profile, which is a Professional Profile, can be mapped to the combination of the Professional Partial Profile and the Basic Partial Profile in the IP in the MPM platform. Additionally, the properties which are described in the IP will depend greatly on the needs of the individual user and his/her MP (context of the SNSs).

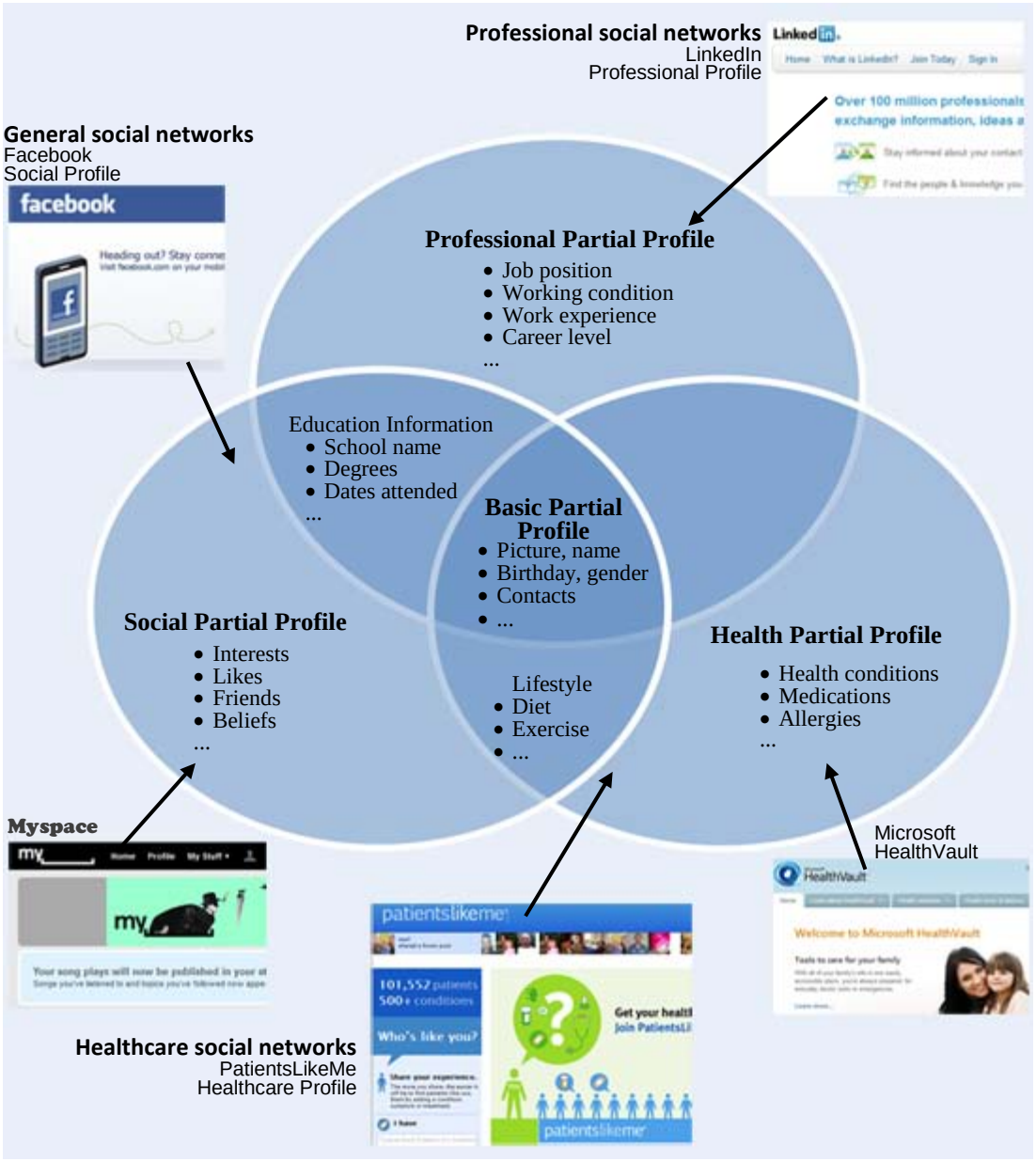


Figure 14. Multiple Profiles (MP) and Integrated Profile (IP)

Multiple Profile Account List

The Multiple Profile Account List (MPAL) in the MPM is to record all Multiple Profile Account (MPA) information for the MPM users. The MPA information is composed of the MPA address, type, and status. The MPA address is the user ID for access to the SNSs in which the MP is stored. As each MPA will be mapped to one partial profile, four MPA types are proposed: “Basic”, “Social”, “Professional” and “Health” according to the type of partial profiles (see Figure 14). The account status indicates whether the profile synchronisation is “Enabled” or “Disabled” for the MPA. By default, the status is “Enabled”.

3.5 MPM USE CASES – MPM APPROACH

Now, imagine Bob's case in light of the MPM, a large online platform that stores users' complete information including social, working, and health information. The MPM use cases are based on following five main scenarios whose actors are the MPM users, and three secondary scenarios whose actors are the MPM Server.

Main Scenarios (Actor: MPM Users)

- Bob creates a LinkedIn account.
- Bob updates his weight, conditions, and allergy information in his Google Health profile.
- Bob exports or prints his Integrated Profile (IP).
- Bob disables profile synchronisation for his LinkedIn social profile.
- Bob wants to cancel his LinkedIn account.

Secondary scenarios (Actor: MPM Server)

- The MPM authenticates and authorises Bob's account.
- The MPM Server synchronises Bob's new profile to his Facebook, LinkedIn, Google Health, PatientsLikeMe, and Disaboom sites.
- The MPM Server manages Bob's Multiple Profile Accounts (MPAs), including adding, deleting and enabling/disabling MPAs.

According to the scenarios, the present writer can easily draw the following UML Use Cases diagram (see Figure 15) which represents the actors involved into the MPM system. There are two actors, the MPM users and the MPM Server. MPM users utilise the MPM to control their MPAs; to centrally store and manage their Multiple Profiles (MP); and more importantly, to synchronise the profile changes over time.

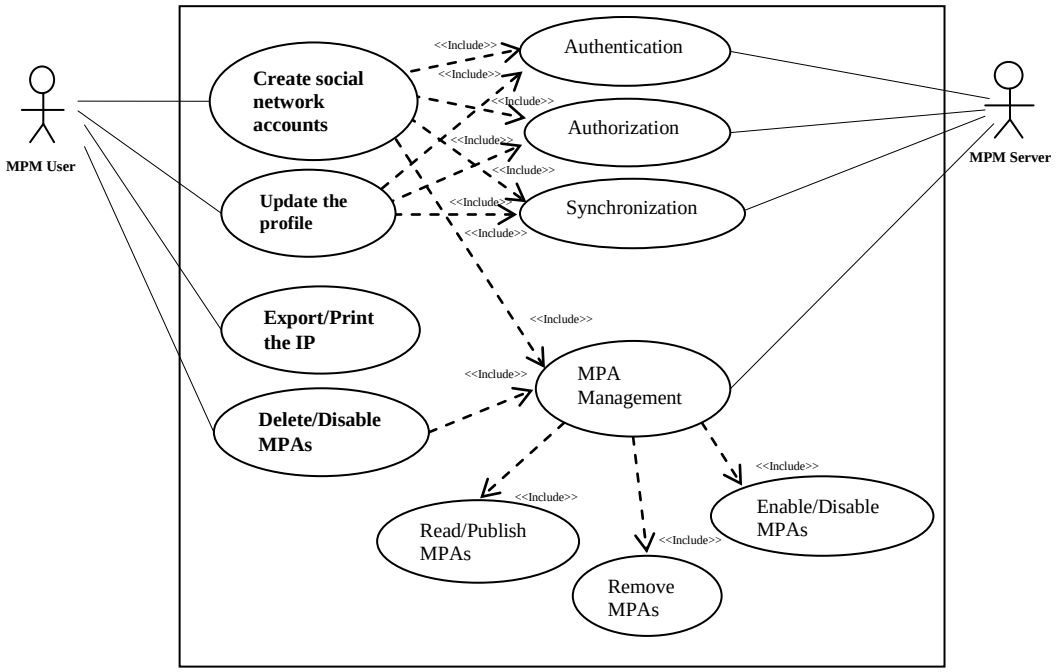


Figure 15. Use Cases Diagram

3.5.1 CREATE SOCIAL NETWORK ACCOUNTS

General Description

After creating a new social network account, LinkedIn, Bob decides to use the services provided by the MPM to fill in the LinkedIn profile form. First, the LinkedIn profile manager establishes a connection between the MPM Server and LinkedIn server after doing the authentication. Second, it requests the basic and professional profile values from the MPM Server. The use case text shown below is used to illustrate this process.

Use Case Text

Goal Level: Basic Level

Main Success Scenario:

1. After Bob creates a new LinkedIn account, the LinkedIn connects to the MPM Server.
2. The MPM authenticates the user password and username.
3. The MPM passes an authorisation token to the LinkedIn server.
4. The LinkedIn server sucks the basic and professional profile from the MPM Server (Read Vcard).
5. The MPM saves the LinkedIn MPAs (that is, “bob@linkedin.com Basic Enabled” and “bob@linkedin.com Professional Enabled”) into the database.

6. Close the session.

Extensions:

1a: User does not want to use the MPM to fill in the LinkedIn profile.
.1: User fills in the LinkedIn profile manually.

3.5.2 UPDATE THE PROFILE

The profile update, which is the most significant functionality of the MPM, is used to modify a user's profile values and synchronise the changes to his/her all social network sites (SNSs). There are two ways to update Bob's health information. The first way is to directly modify the Google Health profile. The second way is to update the Health Partial Profile in the MPM Server. Here, the profile update process using the first way is shown. After Bob modifies his health information in Google Health, the changes will be sent to the MPM Server to update the healthcare profile in Bob's IP. After that, the MPM will be responsible for the healthcare profile synchronisation to his PatientsLikeMe, and Disaboom profiles.

Use Case Text

Goal Level: Basic Level

Main Success Scenario:

7. Bob updates his health information in the Google Health profile (weight from "80kg" to "75kg"; conditions from "Tension Headache" to "Tension Headache, Chronic Heart Disease"; allergies from "Erythromycin Base" to "Erythromycin Base, Nut & Peanut").
8. The Google Health updates the healthcare profile in the MPM. **IP Update**
9. The MPM synchronises Bob's healthcare profile to PatientsLikeMe and Disaboom. **MP Synchronisation**

Integrated Profile (IP) Update

Goal Level: Second Level

Main Success Scenario:

10. Google Health creates a session which connects the MPM Server and does the authorisation.
11. The Google Health profile manager sends the modified part of the profile to the MPM.

12. The MPM interprets the profile properties.
13. The MPM modifies the values in the database.
14. The MPM closes the session.

Multiple Profiles (MP) Synchronisation

Goal Level: Second Level

Main Success Scenario:

15. The MPM retrieves Bob's healthcare profile values from its database.
16. The MPM scans the MPAL and selects those MPA addressees with the "Enabled" status – "bob@googlehealth.com and bob@disaboom.com". The health partial profile of PatientsLikeMe has been disabled.
17. The MPM sets up connections between it and these two healthcare social networks (two sessions), and then passes two authorisation tokens to them.
18. The MPM sends out its healthcare profile to update the profile in these two sites.
19. The MPM closes the session.

3.5.3 EXPORT/PRINT THE IP

Bob is able to export his Integrated Profile (IP) including the basic, social, working, and health information data into a file in XML, Excel, or Word formats. Bob is also then able to print out an IP report which offers doctors a better picture of his background.

3.5.4 DELETE/DISABLE MPAS

The MPM platform enables Bob to manage his MPAs including to enable/disable and delete accounts. To disable an MPA will hinder the IP update and MP Synchronisation between the MPM and the corresponding SNSs. In addition, as MPM is a central control platform for users to manage their MP, Bob should also have the ability to delete his MPAs. Here the deletion means the MPM Server will send out a request which makes the SNSs cancel users' accounts and remove all user information.

Disable the LinkedIn Professional Account

USE CASE TEXT

Goal Level: Basic Level

Main Success Scenario:

20. Bob disables the LinkedIn professional account in the MPM.
21. The MPM modifies the status of LinkedIn professional account to be “disabled” in the database (“bob@linkedin.com Professional Disabled”).

Delete the LinkedIn Account

USE CASE TEXT

Goal Level: Basic Level

Main Success Scenario:

22. Bob “cancels” the LinkedIn account in the MPM.
23. The MPM authenticates Bob’s MPM ID (username and password).
24. The MPM asks for Bob’s LinkedIn ID.
25. The MPM gains the authorisation from the LinkedIn server using Bob’s LinkedIn ID.
26. The MPM sends the request for the account cancellation in the LinkedIn server.
27. The MPM deletes Bob’s LinkedIn MPAs (i.e. “bob@linkedin.com Basic Enabled” and “bob@linkedin.com Professional Disabled”) in the database.
28. The MPM closes the session.

Extensions:

1a: Bob’ LinkedIn account cannot be verified.

.1: End

The purpose of this Use Case is to capture the functional requirements of the MPM system. Use cases work by describing the typical interactions between the MPM users and the MPM Server, and providing a narrative of how the MPM is used. The development of the project will follow the use cases, and more importantly, the use cases also play the role of evaluating the MPM prototype and related protocols.

3.6 ANTICIPATED OUTCOMES

According to the purpose of the research mentioned in Chapter 1, there are five major outcomes to be achieved. The first outcome is a framework which enables online users to centrally manage and share their Multiple Profiles (MP). The second one is the vCard Format Extension defining the properties and related formats for the integrated profile in the Multiple Profile Manager (MPM) platform. Thirdly, a protocol specification, which is an XMPP protocol extension, will be proposed to provide a flexible platform for profile management in decentralised social networks. The fourth outcome is a prototype to validate the proposed framework and related protocols. Also, the contribution of the MPM platform to public health informatics, particularly to the informed medical decision making process will be examined.

3.7 SUMMARY

In this chapter, the researcher discussed the methodology and proposed a research approach which is based on the IIDP to attain the research objectives. Also, the research stages to be followed to implement the project were outlined. In addition, the researcher indicated the research scenario, proposed a framework for multiple profile management, and described the use cases according to the framework. The scenario shows a general picture of social network users' demands for a centralised platform to manage and synchronise their MP. The use cases which are based on the scenario and framework discuss the functionality of the MPM platform in detail. Finally, the researcher listed the anticipated project outcomes including the MPM prototype, related protocols, and vCard extension specification.

By using the proposed framework and use cases, the researcher shows the research implementation in the next chapter. The implementation of this project includes the MPM prototype which is based on OSW and demonstrates the feasibility of the study, the vCard Extension Specification, and the protocols needed to support the prototype for controlling and sharing MP between the MPM and the OSW-supported SNSs.

Chapter 4: Research Implementation

In Chapter 3, the design of the research including the methodology, research approach, a framework for multiple profile management, research scenario, use cases, implementation steps and anticipated outcomes were discussed. The approach combined the Incremental Development Process (IIDP), the research scenario, and use cases. It described a research strategy for achieving the research objectives such as the Multiple Profile Manager (MPM) prototype and related protocols. Also the researcher illustrated five major stages for the implementation of the project and the anticipated outcomes.

In this chapter, first the MPM prototype is illustrated by using a series of screenshots of the MPM Web Client (web-based interfaces). The prototype is used to demonstrate the framework which is a conceptual structure enabling the multiple profile management (see section 3.4). It was established on the Onesocialweb (OSW) platform and employed recent popular technologies such as Extensible Messaging and Presence Protocol (XMPP), vCard, Java Persistence API (JPA), and the semantic web. The MPM prototype covered all functional requirements described in the use cases. The writer also proposed a vCard Format Extension to specify the Integrated Profile (IP) properties and their data format in MPM. Next, the protocols needed to support the prototype for the multiple profile management were explained in detail. The protocols enable the communication between the MPM and SNSs by defining the processes and transmission format that must be followed by these entities.

4.1 VCARD FORMAT EXTENSION

The purpose of the research is to propose a solution enabling a user to centrally control their complete personal information that is, IP, which consists of the Basic, Social, Professional, and the Health Partial Profile (see Figure 14). The capture and exchange of the structured IP information plays a vital role in this research. The vCard XML[7] is utilised as the data model for representing and exchanging a variety of information about individuals. The existing vCard specification (Howes & Dawson, 1998) has already defined the properties for the Basic Partial Profile in the

[7] The latest draft being available at < http://tools.ietf.org/html/draft-ietf-vcarddav-vcardxml-11>

MPM. For the other Partial Profiles, a vCard Format Extension is proposed (see Appendix C) which specifies the properties and the data format for representing and exchanging the social, professional, and health information.

The specification is divided into three groups: the social properties which are INTEREST, FOODBEVERAGE, and PHILOSOPHY; the professional properties: EDUCATION and WORK; and the health properties including the WELLNESS, PROBLEM, MEDICATION, IMMUNISATION, ALLERGY, and INSURANCE. Each group is given a vCard XML example to show the structure of the partial profiles in our MPM.

4.2 MULTIPLE PROFILE MANAGER PROTOTYPE

4.2.1 PROTOTYPE ARCHITECTURE

To demonstrate the MPM platform, besides a Multiple Profile Manager Site (MPMS), five simulated social network sites (SNSs): FaceLook (facelook.com), LinkedMe (linkedme.com), HoogleHealth (hooglehealth.com), Disabom (disabom.com), and PatientsLikeU (patientlikeu.com) were established to replicate the five real SNSs: Facebook, LinkedIn, Google Health, Disaboom, and PatientsLikeMe respectively. These five simulated sites are able to cover the three social network domains (SND): General Social Networks, Professional Social Networks, and Healthcare Social Networks, proposed in section 3.4.1. The architecture of the MPMS (mpm.com) and the five simulated sites are depicted in Figure 16, and detailed below.

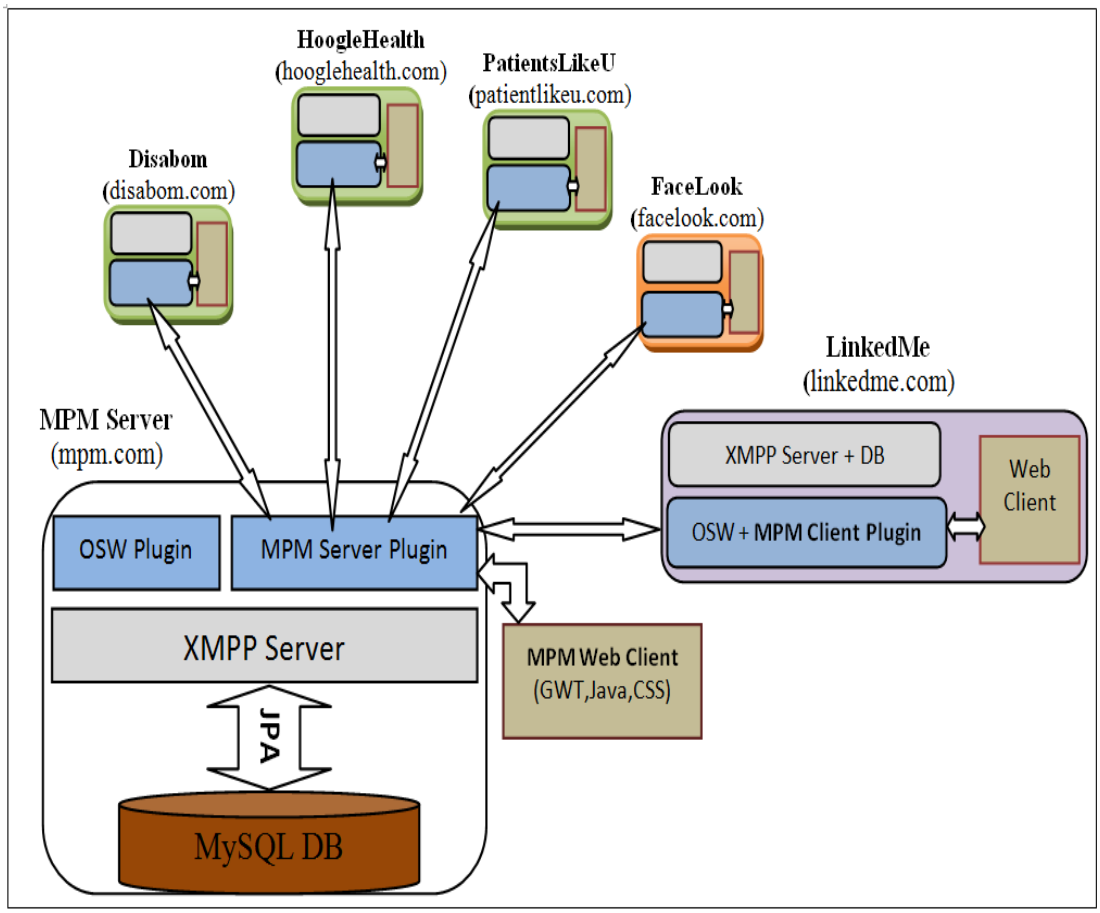


Figure 16. Multiple Profile Manager (MPM) Prototype Architecture

The MPMS consist of two parts, the MPM Server for profile data storage and management; and the MPM Web Client for information request and display. The structure of the MPM Server is composed of three main parts: the Database, XMPP Server, and Server Plugin. First, the bottom layer is the database which plays the role of data storage. MySQL is employed to establish and manage the MPM database, and utilise the Java Persistence API (JPA) to achieve the process of mapping Java Objects to database tables and vice versa (called "Object-relational mapping"). With JPA the researcher can map, store, update and retrieve data from the MPM database to Java Objects of the XMPP Server and vice versa.

Second, in the middle layer, the MPM Server is based on the Extensible Message and Presence Protocol (XMPP) architecture (Onesocialweb employs the XMPP). The XMPP is an open and XML[8]-based protocol aimed at near-real-time, extensible instant messaging (IM) and presence information. It has been expanded

[8] Extensible Markup Language (XML), http://www.w3.org/TR/PR-xml-971208

into the broader realm of message-oriented middleware. Here the Openfire[9], which is an XMPP server written in Java and dual-licensed under the Apache License 2.0 is used to serve as a solid foundation for the MPM Server.

At the top layer the Server Plugin is made up of the Onesocialweb (OSW) plugin enabling the OSW services on the MPM Server and the MPM Server Plugin which adds the MPM protocol support to the Server. The other significant component of the MPMS is an http-based console interface for users, the MPM Web Client. It is coded in a browser-supported language JavaScript combining with the browser-rendered markup language HTML, and built with Google Web Toolkit[10] (GWT).

As shown in Figure 16, a very similar architecture is employed to construct the five simulated SNSs. The only difference between the MPMS and these five simulated SNSs is the Plugins (see Figure 16). The simulated SNSs utilise the MPM Client Plugin rather than the MPM Server Plugin. This is designed to form the server/client architecture between the MPMS and the simulated SNSs. The MPM Client Plugin adds the MPM protocol support for the external SNSs to make service requests from the MPMS.

4.2.2 MPM PROTOTYPE FUNCTIONALITY

The described framework in section 3.4 and use cases in section 3.5 show how to constitute a platform on which the MPM capabilities are built. The underlying functionality is illustrated in Figure 17, and detailed below.

[9] http://www.igniterealtime.org/projects/openfire/
[10] http://code.google.com/webtoolkit/

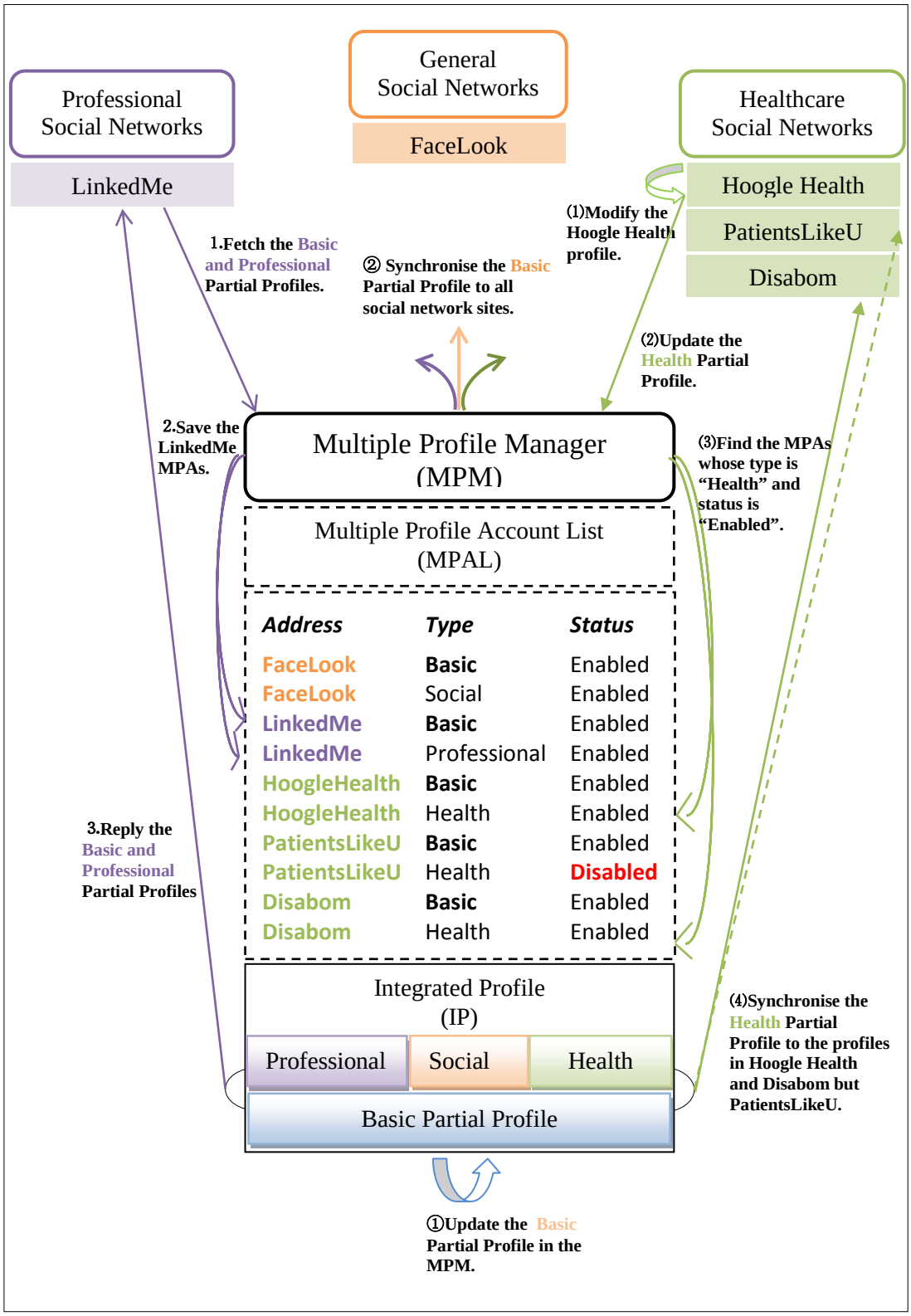


Figure 17. Multiple Profile Manager (MPM) Prototype Overview

The MPM prototype consists of two main parts – the Integrated Profile (IP) and the Multiple Profile Accounts List (MPAL). An IP collects a user's information and groups the information into the following four types: Basic, Social, Professional, and Health (see section 3.4). The MPAL is used to record the information of the Multiple Profiles (MP) held by a user, including the account address, type, and status. An account address is a user's Jabber ID (JID) which is structured like an e-mail address with a username and a domain name for the server where that user resides, separated by an "at" sign (@), for example, "bob@linkedme.com". The account type indicates the profile type of the MPA, for example, "Basic" and "Social". The MPA status determines whether the MPA was activated to participate in the profile synchronisation, for example, "Enabled".

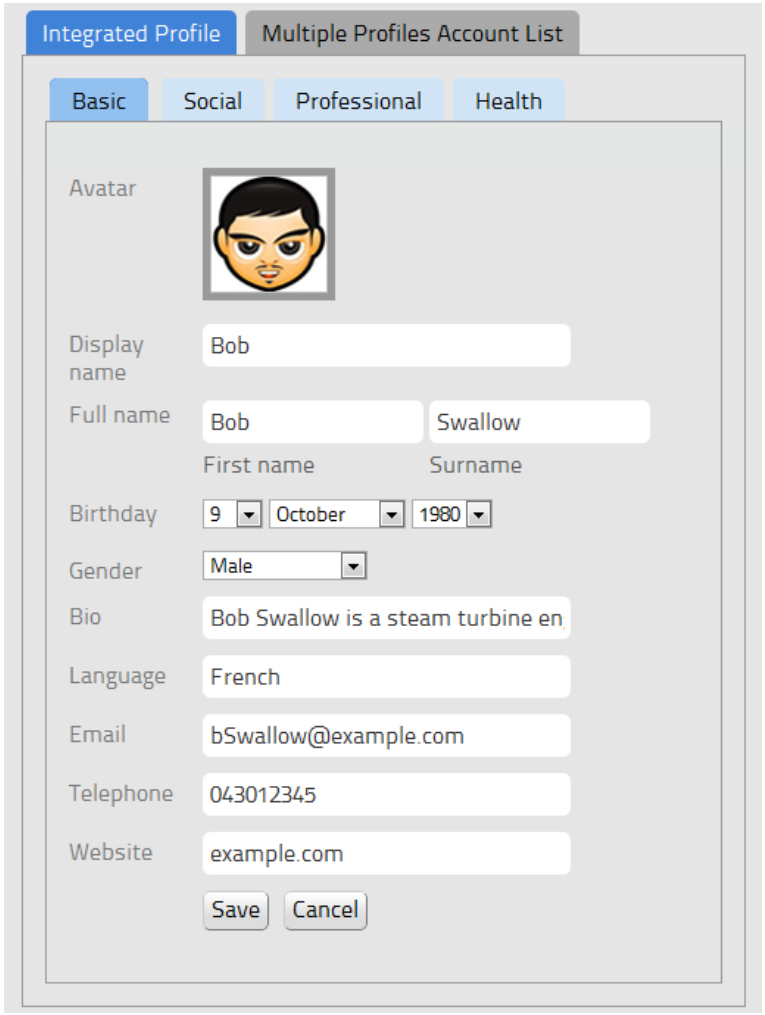
The MPM prototype realises the centralised management of one's distributed profiles by fetching and synchronising profiles, as well as providing PMA management. First, it allows users to create a new SNS account without having to manually input the profile data by transferring the appropriate information to the new site (see processes 1 and 3 in Figure 17). In the meantime, the MPA address "bob@linkedme.com" and types "Basic" and "Professional" will be lodged into the MPAL in preparation of future profile synchronisation (see process 2 in Figure 17). Second, the MPM enables the information synchronisation for MP distributed in different SNSs. No matter when a user's profile is changed, all profiles within the enabled social networks belonging to that person will be updated accordingly. For example, after Bob's profile value in HoogleHealth was modified, the Health Partial Profile in MPM will first be updated (process ⑵ in Figure 17), after which the health information in his Disabom account will be synchronised (process ⑷ in Figure 17). However, Bob's profile in PatientsLikeU will not be synchronised due to the Health Partial Profile of the PatientsLikeU account having been disabled in the MPAL (process ⑶ in Figure 17). The MPM allows the users to temporarily disable some of their MPAs. Processes ① and ② in the figure show the other way to update users' MP. Bob can modify his email address directly in the MPM (Basic Partial Profile) and then the MPM Server will undertake to synchronise the new Basic Partial Profile to all profiles in Bob's SNSs.

4.2.3 MPM PROTOTYPE WEB CLIENT OVERVIEW

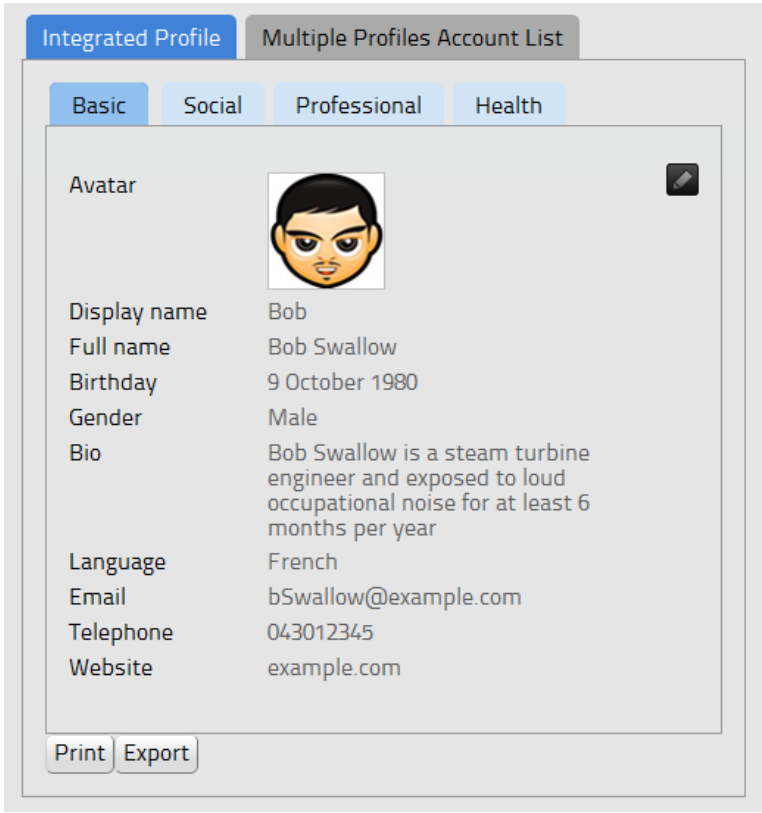
The screenshots in this section (see Figure 18) present Bob's complete MPM Web Client. The MPM Web Client is a web-based application that enables users to execute the commands on the MPM Server. It allows users to create, edit, and save their IP in the MPM Server, as well as activate, deactivate, and delete the MPAs. It doesn't require installation – all its features are accessible online after logging in.

The MPM window can be divided into three sections: the **Menu** (top); the **Main section** (centre) and the **Command section** (bottom), as shown in Figure 18. Naturally, the **Main section** view depends on the tab selected in the **Menu** on the top. The **Command section** contains all control buttons – **Save**, **Cancel**, **Print**, and **Export**. The **Menu** is the control panel of the program. The tabs in the **Menu** are used to switch between the MPM interface pages, which are shown in the centre. Thus, the possible views of the **Main section** are **Integrated Profile** and **Multiple Profile Accounts List**.

Basic Partial Profile Edit Interface

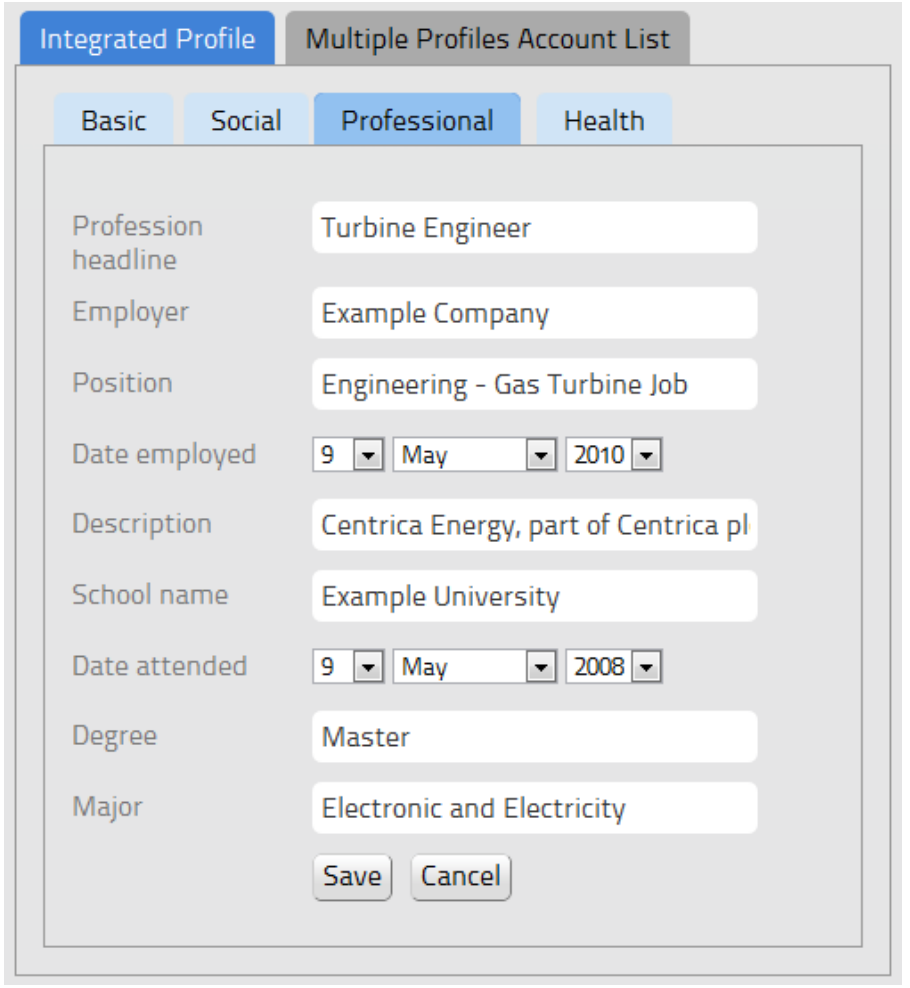


Basic Partial Profile View Interface



Social Partial Profile

Professional Partial Profile



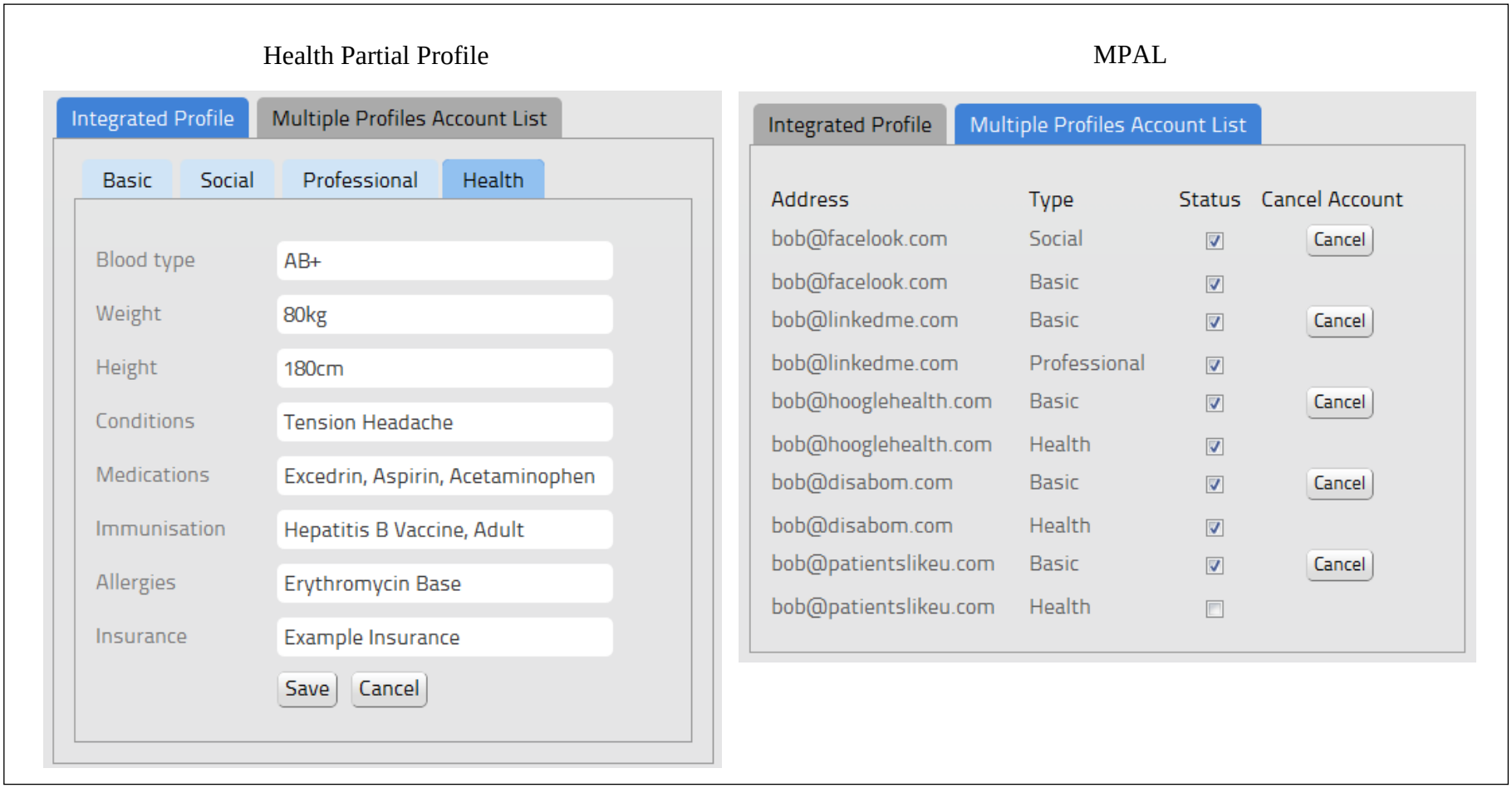


Figure 18. Integrated Profile (IP) Interfaces

Integrated Profile (IP)

Every time a user logs into MPM, the Integrated Profile page appears and it shows four panels. The panels contain the Basic, Social, Professional, and Health Partial Profiles respectively and share the space of the **Main section**. The Basic Partial Profile is a collection of Bob's general information like identity information and contact details, and all properties in it have already been defined in the vCard specification by Howes and Dawson (1998). The Social, Professional, and Health Partial Profiles are the three new concepts proposed and store Bob's social, working, and health information (see more details in section 3.4.3). All properties used in these three partial profiles have been specified in the vCard Format Extension proposed in this study (see section 4.1). Each partial profile panel has two types of interfaces: the **Edit Interface** by which users edit the profile and the **View Interface** which is the profile display page. Users can click the  button to edit the profile or click the "Cancel" button to view the profile form. The "Save" button is used to save the profile into the database and trigger the profile synchronisation event. The functions of the "Export" and "Print" buttons will be discussed in the next section.

Multiple Profile Account List (MPAL)

The MPAL lists all Multiple Profile Accounts (MPAs) which have been mapped to the IP and provides a control interface for users to manage the MPAs. The researcher will discuss the MPAL panel in detail in the next section.

4.2.4 USE CASES

The illustration of the MPM prototype will follow the use cases stated in section 3.5 including the "Create Social Network Accounts", "Update the Profile", "Export/print the IP", and "Delete/disable MPAs". Each case was demonstrated by a series of screenshots of the MPM Web Client and the simulated SNSs' Web Clients. The corresponding background protocols used by each case will be discussed in the next section.

4.2.4.1 Create Social Network Accounts

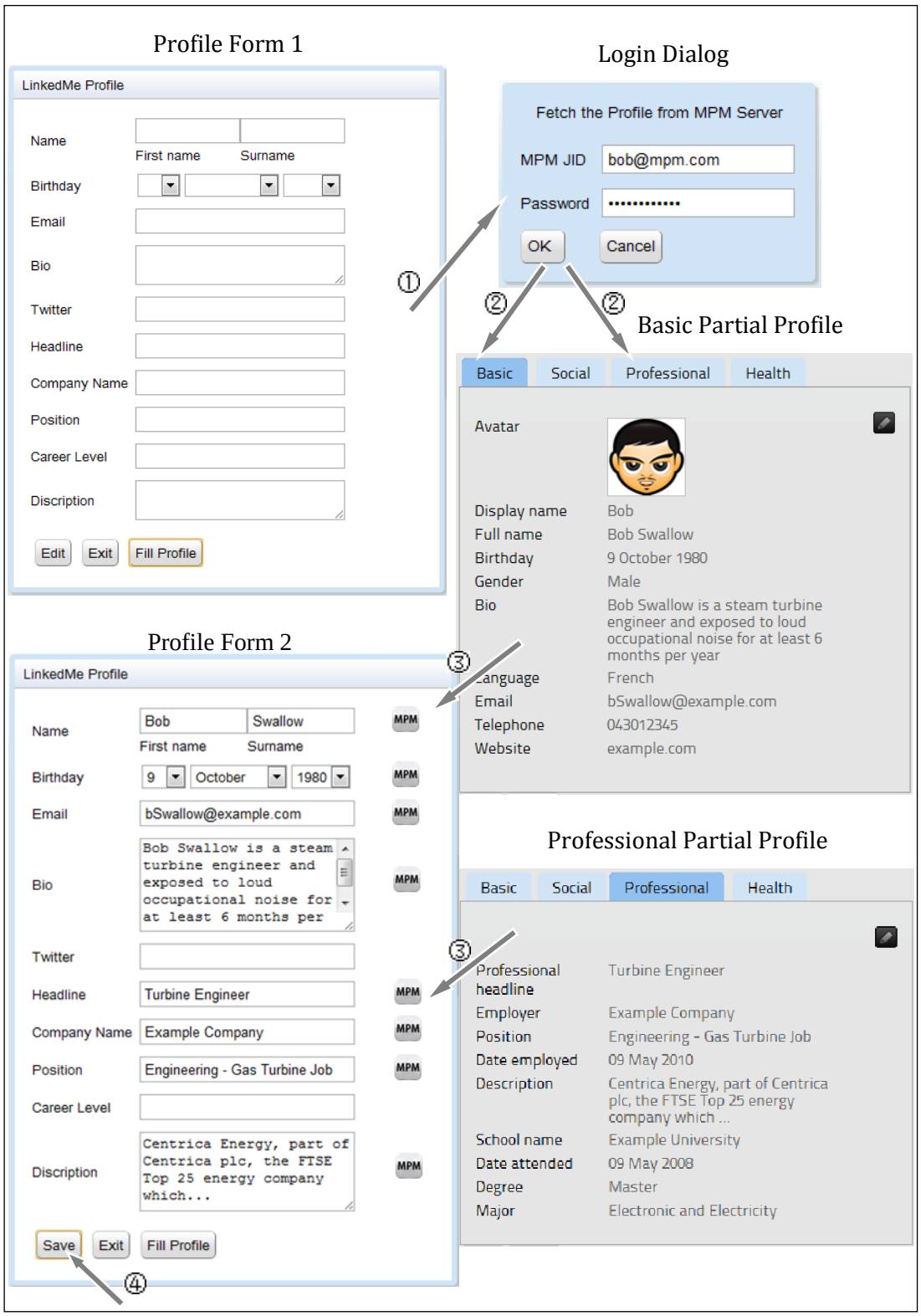


Figure 19. Profile Creation

The “Profile Form 1” in Figure 19 is the profile form that needs to be filled out after Bob created a LinkedMe account. As seen from the figure, a LinkedMe profile consists of two components: one is the basic information section including birthday, email, bio, and twitter, and the other is the working information section which is composed of the professional headline, employer, job position, career level, and job description. Thus, to fill in the ‘Profile Form 1’, the LinkedMe site needs to fetch the Basic and Professional Partial Profile data from the MPM Server by doing the following:

① After clicking the “Fill Profile” button in the “Profile Form 1”, Bob is required to enter the security information (username and password) in the “Login Dialog” (a new window pop-up after the click) for the MPM authentication.

② Bob clicks the “OK” button in the “Login Dialog”. If the verification is successful, an authorisation token will be given to the LinkedMe Server for the access to the IP in MPM. And then the LinkedMe profile manager will send the request of Basic and Professional Partial Profiles extraction to the MPM Server.

③ The MPM Server replies with the Basic and Professional vCards (see Appendix C) containing Bob’s general and working information, and then save the LinkedMe Multiple Profile Accounts (MPAs) in the database (see Figure 20). After receiving the vCards from the MPM, the LinkedMe site will fill out the form automatically by matching the names of the properties in the LinkedMe profile to the property names in the vCards (see ‘Profile Form 2’ in Figure 19).

Note that the ‘Property Names’ here means the names of properties specified in the vCard specification or vCard Format Extension, rather than the ‘Element Names’ shown on the profile form. The element name of an item in the profile can be different with its property name; for example, “Company Name” is an element name in the LinkedMe profile but its corresponding vCard property name is the “employer”.

④ Bob clicks the “Save” button in the “Profile Form 2” to save the LinkedMe profile.

The “Profile Form 2” shows the result of the profile extraction. The icon MPM appears on the rightmost part of an item to indicate a successful mapping of the profile item between the LinkedMe and the MPM profile. This means that the items with the icons will be synchronised to the IP in the MPM.

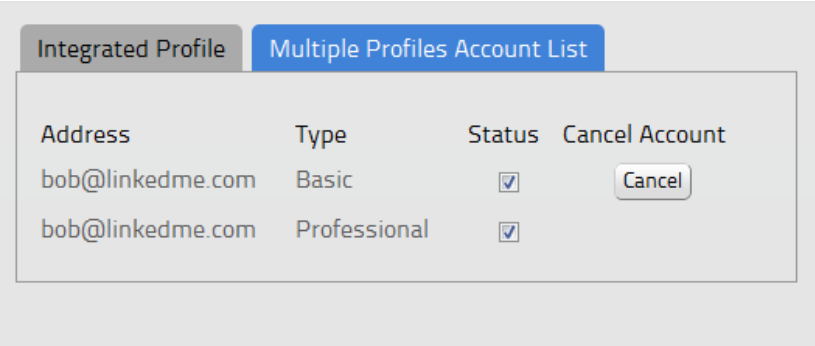


Figure 20. Multiple Profile Account List (MPAL)

Bob can create other social accounts (FaceLook, Hoogle Health, PatientsLikeU, and Disabom) following similar steps. The MPM enables users to create new social accounts more conveniently and efficiently than previously if they had to manually enter and re-enter the same details.

4.2.4.2 Update the Profile

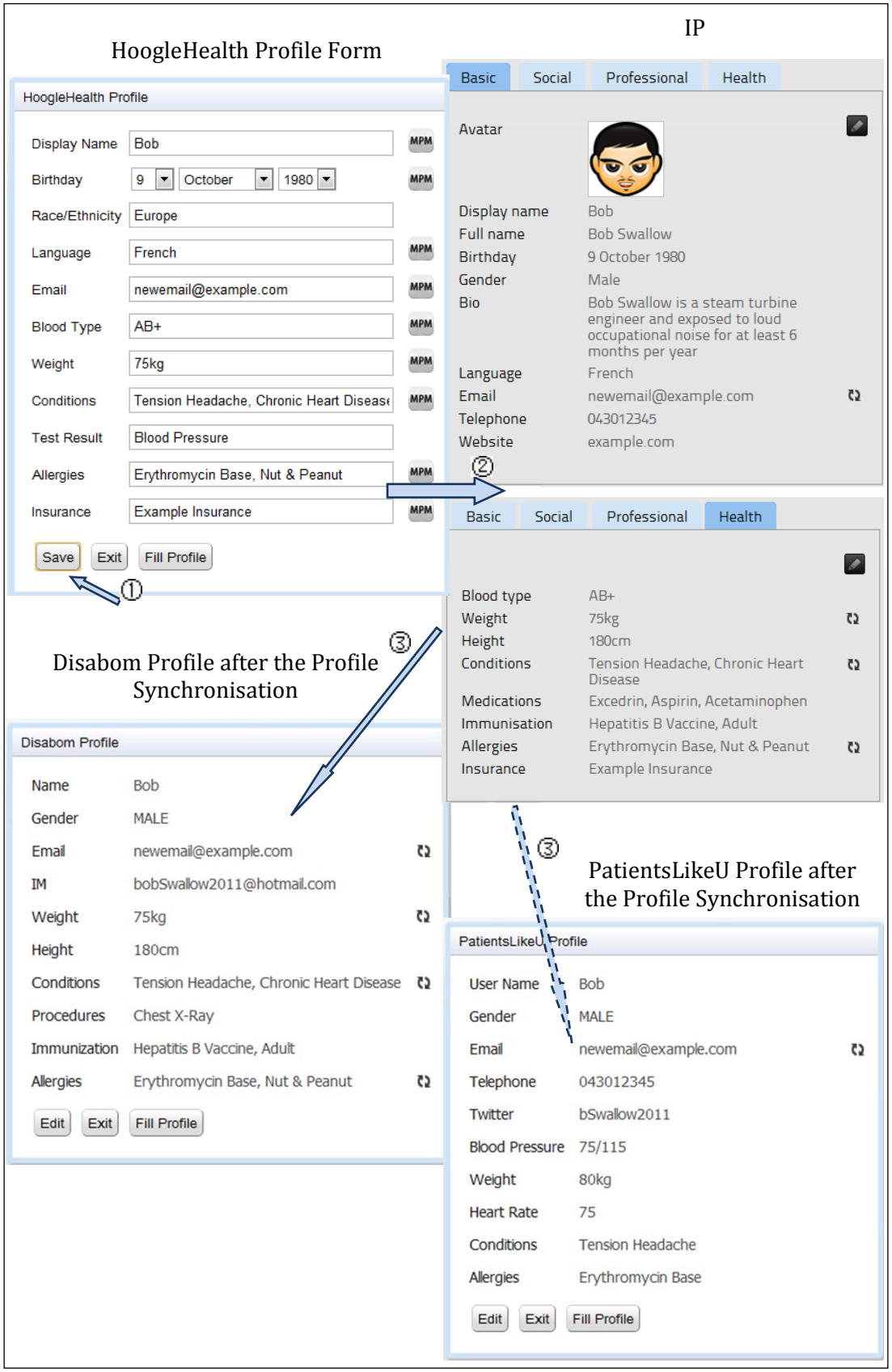


Figure 21. Profile Update

Figure 21 shows the whole process of updating Bob's Healthcare Profiles using the MPM:

① Bob modifies the values of four items in the "HoogleHealth Profile Form": email changed from "bSwallow@example.com" to newemail@example.com; weight changed from "80kg" to "75kg"; conditions changed from "Tension Headache" to "Tension Headache, Chronic Heart Disease"; allergies changed from "Erythromycin Base" to "Erythromycin Base, Nut & Peanut" and then clicks the "Save" button.

② The HoogleHealth Server saves the changes into the local database and at the same time updates the four mapped items in Bob's Basic and Health Partial Profiles in the MPM Server – **IP Update** (see section 3.5.2).

③ The MPM Server synchronises the Basic and Health Partial Profiles to the Disabom and PatientsLikeU sites – **MP Synchronisation** (see section 3.5.2).

Note that the health information in Bob's PatientsLikeU will not be synchronised as the healthcare profile account of PatientsLikeU has been disabled in the MPAL (see Figure 17). The icon 🗘 indicates the items which have already been updated or synchronised by the MPM Server.

As a result, from Figure 21, it is concluded that the MPM facilitates the management of a user's profile residing in multiple discrete social networks. It has the ability to store and organise the profiles in a centralised location and more importantly, keep these profiles updated.

4.2.4.3 Export/Print the IP

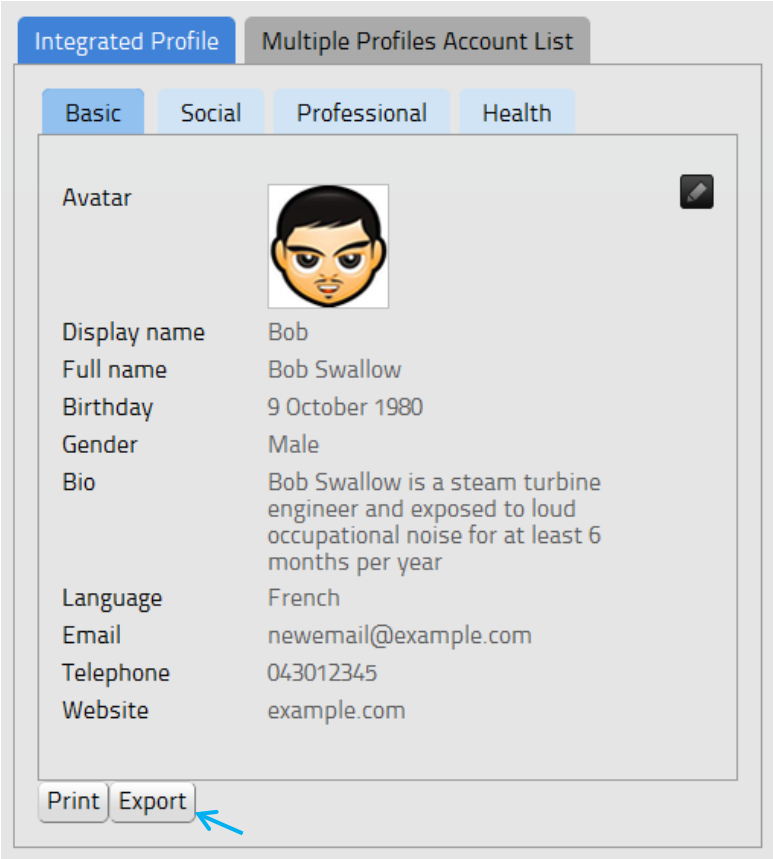


Figure 22. Export and Print IP

Now, Bob is able to show an integrated profile report which includes the basic, social, professional, and health information to his private doctor or families just by clicking the “Print” or “Export” button in the MPM Web Client (see Figure 22). The integrated profile report makes it easier for Bob and his doctors to gain a better picture of his health condition. Thus, the MPM enables health professionals to provide better care for patients.

4.2.4.4 Delete/Disable MPAs

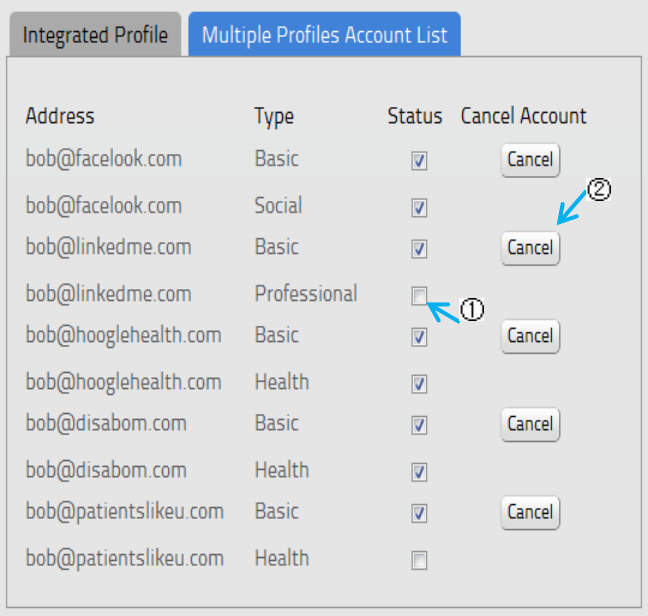


Figure 23. Delete and Disable MPA

One of the MPM functions is to store and control users' MPAs which consists of the account address, type, and status.

① Users can enable or disable the profile synchronisation for their MPAs through checking or unchecking the **Checkbox** of the "Status" column. For example, as seen from Figure 23, the "Multiple Profile Account List" tab panel exhibits all MPAs belonging to Bob. Bob deactivates the synchronisation between the Professional Partial Profile in MPM and the profile in LinkedMe.

② The MPM also provides a remote control of the social network account for MPM users. For example, Bob can delete his account on LinkedMe by clicking the "Cancel" button beside the LinkedMe MPA. After the successful deletion, the MPM Server will remove the MPAs of LinkedMe from the MPAL (see Figure 24).

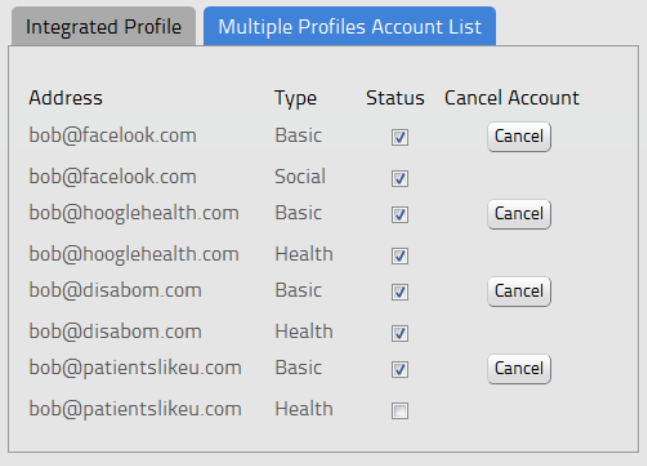


Figure 24. After Delete MPA

4.3 PROTOCOL SPECIFICATION

4.3.1 INRODUCTION

This specification defines an XMPP protocol extension for synchronising vCard between different Onesocialweb-supported Social Network Sites (SNSs), as well as managing the Integrated Profile (IP) and the Multiple Profile Accounts (MPAs). Due to the Multiple Profile Manger (MPM) prototype being based on the Onesocialweb (OSW) open source platform, the protocols proposed are also partial extensions of one of the OSW specifications – VCard4 over XMPP (Eschenauer, 2010). The protocols enable a user to manipulate (update/read/publish) the vcards in the MPM Server (an XMPP server), synchronise their Multiple Profiles (MP) between the SNSs and the MPM Server, and control (disable / enable / publish / query / delete) the MPAs. This is done by sending an <iq /> of type "set" (storage) or "get" (retrieval) to the MPM Server containing an **entity** scoped by the **namespace**, with the XML elements containing the user information.

Table 1. vCard Overview

Entity	Namespace	Comments
vcard	urn:ietf:params:xml:ns:vcard-4.0	The vCard entity contains the details such as name, address, avatar picture. And it has been defined in the vCard specification (Howes & Dawson, 1998).
social	http://example.com/profile/social	The social, professional, and health entities are hypothetical and simply used for the MPM demonstration. These entities have been defined in the vCard Format Extension (see section 4.1).
professional	http://example.com/profile/professional	
health	http://example.com/profile/health	

4.3.2 DATA MODEL

The data model used is the vCard XML model. The vCard properties used in the protocols have been defined in either the vCard Format Extension or the vCard Formation Specification.

4.3.3 USE CASES

The purpose of this section is to demonstrate the protocols which enable the communication between the MPM Server, MPM Web Client, and the five simulated

SNSs (see section 4.2.1). The demonstration of the protocols will also follow the use cases stated in section 3.5, and each case is accompanied by the protocol examples.

4.3.3.1 Create Social Network Accounts

According to the statements in the use cases, Bob wants to create a new LinkedMe account with the help of the MPM. Thus, the LinkedMe profile manager will read the Basic and Professional Partial Profiles from the MPM Server (see Figure 19), and after that, the MPM Server will save the LinkedMe MPAs into the database (see Figure 20).

READ VCARD

Here only an example of reading the Professional Partial Profile from the MPM Server is shown. One entity can fetch the professional information in the MPM by sending an IQ-get to the bare JID of the MPM containing a <query /> element with an empty <professional /> child. The MPM Server replies to this request with a vCard containing all the professional fields. The vCard syntax should conform to the data model (see section 4.3.2).

In the following example, <bob@linkedme.com> fetches the Professional Partial Profile stored in Bob's MPM account. The LinkedMe Server queries for the vCard with the following request:

Example 1. Read Professional vCard

```
<iq    type='get'
       from='bob@linkedme.com'
       to='bob@mpm.com'
       id='mpm_1'>
   <query    xmlns="http://Onesocialweb.org/spec/1.0/vcard4#query" >
      <professional    xmlns="http://example.com/profile/professional"    />
   </query>
</iq>
```

To which the MPM Server replies with a professional vCard containing all working information:

Example 2. Return Professional vCard

```
<iq    type='result'
       from='bob@mpm.com'
       to='bob@linkedme.com'>
   <query    xmlns="http://Onesocialweb.org/spec/1.0/vcard4#query">
      <professional    xmlns="http://example.com/profile/professional">
         <education>
            <parameters>
               <pref>1</pref>
               <type>University</type>
            </parameters>
            <school><text>Example University</text></school>
            <attendday>
               <date-time>2008-05-09T00:00:00.000Z</date-time>
            </attendday>
            <degree><text>Master</text></degree>
            <majors><text>Electronic and Electricity</text></majors>
         </education>
         <work>
            <parameters><pref>1</pref></parameters>
            <headline><text>Turbine Engineer</text></headline>
            <employer><text>Example Company</text></employer>
            <position><text>Engineering – Gas Turbine Job</text></position>
            <startday>
              <date-time>2010-05-09T00:00:00.000Z</date-time>
            </startday>
            <description>
                  <text>Centrica Energy, part of Centrica plc, the FTSE Top 25 energy
                  company which…</text>
            </description>
            <homepage><uri>http://www.example.com</uri></homepage>
         </work>
      </professional>
   </query>
</iq>
```

PUBLISH MPA

In the MPM platform there is an MPA management function (see Figure 15) which is responsible for querying, publishing and updating the information of the MPAs. After LinkedMe successfully reads the Basic and Professional Partial Profiles from the MPM Server (see Example 1), the MPM Server will save the LinkedMe profile account information (that is, "bob@linkedme.com Basic Enabled" and "bob@linkedme.com Professional Enabled") in the database for future use of profile synchronisation (see Figure 20).

4.3.3.2 Update the profile

Bob wants to update his email address and health information in his MP. Here only the example of the health profile update is given. As mentioned at the outset there are two ways to update Bob's health information. The first way is that Bob modifies the profile in his Hoogle Health account (see Figure 21); the Hoogle Health profile manager updates the Health Partial Profile in Bob's MPM Server (**IP Update**); the MPM Server checks the MPAL; finally, the MPM Server synchronises the Health Partial Profile with his Disabom account (**MP Synchronisation**). The second way to update Bob's health information is to update the Health Partial Profile in the MPM Server (**Publish Health vCard**) and then do the **MP Synchronisation**.

IP UPDATE

Firstly, the Hoogle Health updates the Health Partial Profile in the MPM Server by sending an IQ-set to the bare JID of the MPM containing a <update/> element with a <health /> child. The health vCard only includes the changes in the Hoogle Health profile.

Example 3. Update Health vCard

```
<iq    type='set'
       from='bob@hooglehealth.com'
       to='bob@mpm.com'
       id='mpm_2'>
   <update    xmlns="http://Onesocialweb.org/spec/1.0/vcard4#update">
      <health    xmlns="http://example.com/profile/health">
         <wellness>
            <weight><text>75kg</text></weight>
         </wellness>
         <problem>
            <parameters><pref>1</pref></parameters>
            <text>Tension Headache, Chronic Heart Disease</text>
         </problem>
         <allergy>
            <parameters><pref>1</pref></parameters>
            <text>Erythromycin Base, Nut & Peanut</text>
         </allergy>
      </health>
   </update>
</iq>
```

CHECK MPAS

Secondly, the MPM Server will check if Hoogle Health was entitled to do the profile synchronisation. After finding that the Hoogle Health MPA ("bob@hooglehealth.com health Enabled") is activated the Server starts to select all enabled health MPAs for the next step – **MP Synchronisation**.

MP SYNCHRONISATION

Thirdly, the MPM Server triggers the profile synchronisation which will update the health vCard in the Disabom profile. This happens by sending an IQ-set to the bare JID of the target entities containing a <synch /> element with a <health /> child. The following example shows the Health Partial Profile synchronisation protocol to <bob@disabom.com>:

Example 4. Synchronise Health vCard

```
<iq    type='set'
       from='bob@mpm.com'
       to='bob@disabom.com'
       id='mpm_2'>
   <synch    xmlns="http://Onesocialweb.org/spec/1.0/vcard4#synch">
      <health   xmlns="http://example.com/profile/health">
         <wellness>
            <bloodtype><text>AB+</text></bloodtype>
            <weight><text>75kg</text></weight>
            <height><text>180cm</text></height>
         </wellness>
         <problem>
            <parameters><pref>1</pref></parameters>
            <text>Tension Headache, Chronic Heart Disease</text>
         </problem>
         <medication>
            <parameters><pref>1</pref></parameters>
            <text>Excedrin</text>
         </medication>
         <medication>
            <parameters><pref>2</pref></parameters>
            <text>Aspirin, Acetaminophen</text>
         </medication>
         <immunisation>
            <parameters><pref>1</pref></parameters>
            <text>Hepatitis B Vaccine</text>
         </immunisation>
         <immunisation>
            <parameters><pref>2</pref></parameters>
            <text>Adult</text>
         </immunisation>
         <allergy>
            <parameters><pref>1</pref></parameters>
            <text>Erythromycin Base, Nut & Peanut</text>
         </allergy>
         <insurance>
            <text>Example Insurance</text>
         </insurance>
      </health>
   </synch>
</iq>
```

PUBLISH HEALTH VCARD

An entity can publish its profile (and thus overwrite any previously published profile) by sending an IQ-set to the bare domain containing a <publish /> element with a <professional /> child. For example, Bob publishes his new health information into the Health Partial Profile:

Example 5. Publish Health vCard

```
<iq    type='set'
       from='bob@mpm.com/client'
       to='mpm.com'
       id='mpm_3'>
   <publish    xmlns="http://Onesocialweb.org/spec/1.0/vcard4#publish">
      <health   xmlns="http://example.com/profile/health">
         <wellness>
            <bloodtype><text>AB+</text></bloodtype>
            <weight><text>75kg</text></weight>
            <height><text>180cm</text></height>
         </wellness>
         <problem>
            <parameters><pref>1</pref></parameters>
            <text>Tension Headache, Chronic Heart Disease</text>
         </problem>
         <medication>
            <parameters><pref>1</pref></parameters>
            <text>Excedrin</text>
         </medication>
         <medication>
            <parameters><pref>2</pref></parameters>
            <text>Aspirin, Acetaminophen</text>
         </medication>
         <immunisation>
            <parameters><pref>1</pref></parameters>
            <text>Hepatitis B Vaccine</text>
         </immunisation>
         <immunisation>
            <parameters><pref>2</pref></parameters>
            <text>Adult</text>
         </immunisation>
         <allergy>
            <parameters><pref>1</pref></parameters>
            <text>Erythromycin Base, Nut & Peanut</text>
         </allergy>
         <insurance>
            <text>Example Insurance</text>
         </insurance>
      </health>
   </publish>
</iq>
```

After publishing the profile, the MPM Server will begin the **MP synchronisation** which updates Bob's Disabom profile (Same as Example 4).

Delete /Disable MPAs

This section defines the protocols to be used by the MPM Web Client to read the MPAs (including the account address, type, and status) from the MPM Server, update the account status ("Enabled/Disabled"), and even delete the account from the corresponding SNS.

READ MPAS

The MPM Web Client queries the MPA information stored in the MPM Server by sending an IQ-get to the server containing a <query /> element with an empty <accounts /> child. The server replies to this request with a list of MPAs. In the following example, Bob wants to check his MPAs. He opens his MPM Web Client <bob@mpm.com/client> and clicks the "Multiple Profile Account List" tab (see Figure 23). The client queries for the accounts with the following request:

Example 6. Read MPAs

```
<iq    type='get'
       from='bob@mpm.com/client'
       to='mpm.com'
       id='mpm_4'>
   <query    xmlns="http://example.com/protocol/query">
      <accounts    xmlns="http://example.com/spec/accounts" />
   </query>
</iq>
```

To which the MPM Server replies with a list containing all social network accounts owned by Bob.

Example 7. Server Reply to MPAs Query

```
<iq    type='result'
       from='mpm.com'
       to='bob@mpm.com/client'>
  <query    xmlns="http://example.com/protocol/query">
     <accounts    xmlns="http://example.com/spec/accounts">
       <account    xmlns="http://example.com/spec/account">
          <jid>bob@facelook.com</jid>
          <type>http://example.com/spec/account/type/basic<type>
           <status>http://example.com/spec/accounts/status/enabled</status>
       </account>
       <account    xmlns="http://example.com/spec/account">
          <jid>bob@facelook.com</jid>
          <type>http://example.com/spec/account/type/social<type>
           <status>http://example.com/spec/account/status/enabled</status>
       </account>
       <account    xmlns="http://example.com/spec/account">
          <jid>bob@linkedme.com</jid>
          <type>http://example.com/spec/account/type/basic<type>
           <status>http://example.com/spec/accounts/status/enabled</status>
       </account>
       <account    xmlns="http://example.com/spec/account">
          <jid>bob@linkedme.com</jid>
          <type>http://example.com/spec/account/type/professional<type>
           <status>http://example.com/spec/accounts/status/enabled</status>
       </account>
       <account    xmlns="http://example.com/spec/account">
          <jid>bob@hooglehealth.com</jid>
          <type>http://example.com/spec/account/type/basic<type>
           <status>http://example.com/spec/accounts/status/enabled</status>
       </account>
       <account    xmlns="http://example.com/spec/account">
          <jid>bob@hooglehealth.com</jid>
          <type>http://example.com/spec/account/type/health<type>
           <status>http://example.com/spec/accounts/status/enabled</status>
       </account>
       <account    xmlns="http://example.com/spec/account">
          <jid>bob@disabom.com</jid>
          <type>http://example.com/spec/account/type/basic<type>
           <status>http://example.com/spec/accounts/status/enabled</status>
       </account>
       <account    xmlns="http://example.com/spec/account">
          <jid>bob@disabom.com</jid>
          <type>http://example.com/spec/account/type/health<type>
           <status> http://example.com/spec/accounts/status/enabled</status>
       </account>
       <account    xmlns="http://example.com/spec/account">
          <jid>bob@patientslikeu.com</jid>
          <type>http://example.com/spec/account/type/basic<type>
           <status>http://example.com/spec/accounts/status/enabled</status>
       </account>
       <account    xmlns="http://example.com/spec/account">
          <jid>bob@patientslikeu.com</jid>
          <type>http://example.com/spec/account/type/health<type>
           <status>http://example.com/spec/accounts/status/disabled</status>
```

```
        </account>
      </accounts>
   </query>
</iq>
```

UPDATE MPAS STATUS

Bob can update the account status by publishing the new value of the account to overwrite the previous one. The MPM Web Client publishes the MPA by sending an IQ-set to the server containing a <publish /> element with an <account /> child. In the following example, Bob wants to disable the professional profile account at LinkedMe. He uses the MPM Web Client and publishes the following:

Example 8. Update MPA Status

```
<iq    type='set'
       from='bob@mpm.com/client'
       to='mpm.com'
       id='mpm_5'>
   <publish    xmlns="http://example.com/protocol/publish">
      <account    xmlns="http://example.com/spec/account">
         <jid>bob@linkedme.com</jid>
         <type>http://example.com/spec/accounts/type/professional</type>
          <status>http://example.com/spec/accounts/status/disabled</status>
      </account>
   </publish>
</iq>
```

DELETE MPA

Bob can delete his social network account by sending an IQ-set to the MPM Server containing a <delete /> element with an <account /> child. Bob opens the “Multiple Profile Account List” interface and clicks on the “Cancel” button which is beside “bob@linkedme.com” (see Figure 23). The Web Client sends the request to the Server as following:

Example 9. Delete MPA

```
<iq    type='set'
       from='bob@mpm.com/client'
       to='bob@linkedme.com'
       id='mpm_6'>
   <delete   xmlns=" http://example.com/protocol/delete">
      <account    xmlns="http://example.com/spec/account" />
   </delete>
</iq>
```

Bob's MPM Server intercepts the request, validates it, deletes the account "bob@linkedme.com" in the MPAL, and sends a notification to the LinkedMe server to remove Bob's account:

Example 10. Server Notifies the Remote SNSs of the Deletion

```
<iq    type='set'
       from='bob@mpm.com'
       to='bob@linkedme.com'
       id='mpm_6'>
   <delete   xmlns=" http://example.com/protocol/delete">
      <account    xmlns="http://example.com/spec/account">
   </delete>
</iq>
```

4.4 SUMMARY

In this chapter the MPM prototype and related protocols which enable a user to create and manage an IP and share it with all OSW-supported SNSs were demonstrated. The MPM prototype is an online site which contains two parts: the MPM Server and the MPM Web Client. The MPM Server which is based on Openfire (an XMPP server) consists of the database, OSW Plugin, and the MPM Server Plugin. The MPM Web Client is an http-based console interface and is built with Google Web Toolkit (GWT). In order to demonstrate the prototype, the researcher also established five simulated SNSs which employed similar architecture to the MPM site. The five simulated SNSs can cover the three Social Network Domains (Social, Professional, and Healthcare) mentioned in section 3.4.

This thesis discussed the functionality of the MPM by demonstrating the communication between the five simulated sites and the MPM site. There are two major functions in the prototype: the IP and MPA management and profile synchronisation. The IP and MPAs are two essential components that form the MPM. Users can use the MPA to save the MP address (a JID), type ("Basic, "Social", "Professional", or "Health"), and status ("Enabled" or "Disabled"). And they use the IP to store their complete personal information including basic, social, professional, and health information and share it with the MP in their SNSs. This researcher took the vCard specification to represent and exchange the basic information, and proposed a vCard Format Extension for the other information.

The protocol specification described in detail the essential protocols needed to support the prototype for multiple profile management and sharing. The protocols enabled the communication between the MPM Server, the OSW-supported SNSs, and the MPM Web Client. It defines the processes and transmission format that must be followed when these entities want to request data from, respond to, and communicate with each other. The basic functionality is for a user to store and retrieve an XML representation of his or her vCard or MPAs. This is done by sending an <iq /> of type “set” (storage) or “get” (retrieval) to the MPM Server containing an entity scoped by the corresponding namespace, with the XML elements containing the vCard-XML elements as defined by the vCard Format Extension. As the MPM protocol is an extension of the OSW protocol, the MPM services can be integrated into any OSW server by adding the MPM Server Plugin (to be the server) or the MPM Client Plugin (to be the client) (see Figure 16).

The MPM platform/framework is able to contribute significantly to improving public health informatics. In the next chapter, an application of the MPM platform in the eHealth domain will be discussed and the potential benefits presented.

Chapter 5: EHealth Scenario

In Chapter 4, the researcher described the Multiple Profile Manager (MPM) prototype, and related protocols. The prototype is an online site offering multiple profile management services. It was divided into two parts, the MPM Server (mpm.com) and the MPM Web Client (an http-based console interface for users). It enables a user to create and manage an integrated profile (IP) that can be shared across numerous Onesocialweb-supported social network sites (SNSs). The prototype is used to demonstrate the feasibility and advantage of the MPM platform/framework proposed. The protocol specification, which is an Extensible Messaging and Presence Protocol (XMPP) extension, plays the role of managing and synchronising profile data (vCard) between the MPM Server, MPM Web Client, and the SNSs. The introduction of the MPM prototype and related protocols follows the way of use cases proposed in Chapter 3.

In this Chapter, the application of the MPM platform/framework in the sphere of public health informatics will be discussed. Here this researcher wants to prove how patients and physicians can benefit from applying the MPM in online social networks. The MPM is not only able to facilitate the collection of personal healthcare data, but simplify the management of patients' profiles and allow health professionals to obtain a more complete picture of the patients' backgrounds. Thus, doctors can provide better health care to patients. To do so, the MPM prototype proposed in Chapter 3 will be employed.

5.1 OVERVIEW

Recently, the social-networking revolution came to the healthcare industry via online social networks that enable information sharing, collaboration and communication in the area of personal healthcare data (Domingo, 2010). However, most of the physician or patient social networks only pay attention to the user's healthcare profile which is stored in healthcare social networks (see section 3.4.1). The healthcare profile stores users' health information like specific wellness, conditions, medicines, and allergies. However, factors, such as lifestyle, interests, exercise, interpersonal support, work environment, and job risk, could also be used to

give a better understanding of a user's health background (Walker, Sechrist, & Pender, 1987). These factors are stored in the social profile of general social networks like Facebook and Hi5[11], and the professional profile of professional social networks such as LinkedIn and Jobster[12] (see section 3.4.1). Consequently, health professionals may not be able to gain a total view of a person's health background because they do not have access to their patients' LinkedIn or Jobster sites.

Only an IP (see Figure 14), which contains basic, professional, and health partial profiles together, could meet current online health informatics demands. For example, it is well known that high fat food may pose a serious threat of heart disease (Lupton & Chapman, 1995), but loud noises in the workplace doubles an individual's risk for heart disease (Gan, Davies, & Demers, 2010). Thus, for a patient with a chronic cardiac disease (e.g. Bob), an IP which includes complete personal information such as favourite foods, working conditions, life styles, health problems, and medications is able to provide a more comprehensive personal health overview for doctors than a single healthcare profile.

[11] http://www.hi5.com
[12] http://www.jobster.com

5.2 PROTOTYPE DEMONSTRATION

Figure 25 shows how a user can benefit more from public healthcare through applying the MPM in the area of online health informatics than not doing so. As stated in Chapter 4, Hoogle Health and Disabom are two simulative healthcare SNSs that here empower Bob to record his health information and share it with others. The basic and health partial profiles in Bob's MPM are shared by Hoogle Health and Disabom, which make it possible for the Multiple Profiles (MP) to be updated on a timely basis. The arrows in Figure 25 indicate the mapping of profile properties. The profile properties, such as "Display name", "Birthday", and "Race" in HoogleHealth, map to three corresponding properties in the MPM Basic Partial Profile and the other four properties – "Blood type", "Weight", "Conditions", and "Medications" – can be found in the MPM Health Partial Profile. The two-way arrows signify that the pair of properties will be synchronised and the synchronisation event can be triggered by either side. Beyond that, it is easy to detect that the MPM Health Partial Profile contains all properties in both Hoogle Health and Disabom profiles. The MPM profile not only collects users' health information, but also social and professional information. Consequently, through the MPM, the user can have a comprehensive view of their healthcare report.

Additionally, it is more convenient for a patient who wants to seek another health opinion, to have all the information displayed in a single health profile. The patient does not need to repeat their medical history every time they change or move between health professionals. Moreover, it is more convenient for doctors to make a right or better medical decision. For example, a doctor's new patient may be allergic to some specific food; misdiagnosis could be avoided if the doctor looks at the patient's comprehensive health profile.

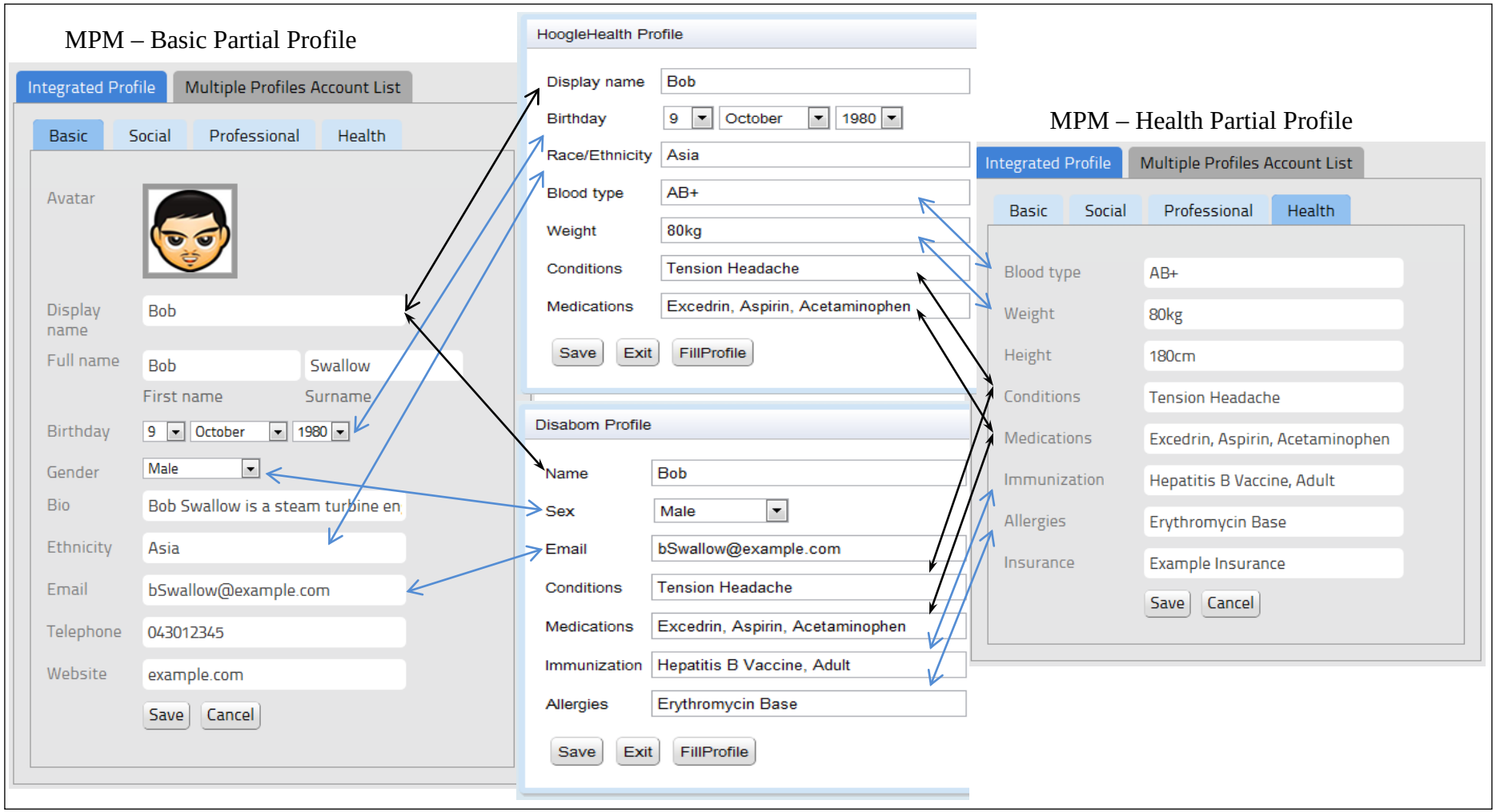


Figure 25. The Application of MPM in Healthcare Informatics

5.3 SUMMARY

In this chapter, the MPM prototype was used to illustrate the potential contributions of the MPM platform/framework to the sphere of public health informatics. Recently, there has been an increased reliance on healthcare social networks which provide an active platform for storing personal healthcare data, sharing ideas, and debating treatment options. The MPM can be applied in this healthcare social network platform to improve patient care. The MPM promised to simplify the management of patients' profiles, and more importantly allow health professionals to obtain a more complete picture of patients' backgrounds so that they can make better medical decisions.

Chapter 6: Discussion & Conclusions

6.1 DISCUSSION

This section discusses and summarises the research implementation in the following four parts. With respect to profile security, the process of updating the profile was subdivided into two sub stages (see section 4.2.4.2) – the Integrated Profile (IP) Update and the Multiple Profiles (MP) Synchronisation, and each has different protocols (see Example 3 and Example 4). The IP Update is the process whereby the external Social Network Sites (SNSs) transmit the changes of the profile to the Multiple Profile Manager (MPM); however, the MP Synchronisation means the MPM delivers a complete partial profile (basic, social, professional, or health) to the external SNSs. The IP Update has been distinguished from the profile synchronisation. This is because the MPM plays the role of the information provider in the framework (see section 3.4). The profile synchronisation must be a one-way operation from the MPM to the SNSs.

The researcher believes that Onesocialweb (OSW), an open source platform, can serve as a solid foundation for the MPM prototype. OSW aims to work as a network and platform allowing users to connect with friends across different social networks and different platforms. It allows users to connect all their networks in a truly interactive way. It is an example of true interactive networking; not just streaming RSS feeds and cross posting status updates. For example, if Bob is on Facebook and Lisa is on Myspace then they can connect, without changing networks. Thus it provides an alternative solution for breaking down the "walled-gardens" between different SNSs. The main advantages of OSW are based on decentralisation, its open standards, security and flexibility. The decentralisation allows anyone to run their own XMPP server without the need of a central master server. OSW tackles security and privacy issues that are not straight forward to solve in the web world (see section 2.4). The MPM prototype can be seen as an extension of the OSW that extended the functionality to achieve the centralised management and sharing of MP.

Through the simulation (see section 4.2), it can be concluded that the MPM can fit the actual requirements and be very valuable. The MPM facilitates the creation of new social network accounts by sharing profiles between these social networks, and

simplifies the process of MP updates for users by profile synchronisation. The MPM has the ability to accelerate the development of web-based social networks.

The current applications in the healthcare sphere can support health information management, but to date there is no patient-controlled integrator. The Multiple Profile Manger (MPM) propose in this research can be used as the integrator. As seen from the Figure 14, the IP integrates a patient's medical profile (healthcare profile) into their complete private profile to provide a more comprehensive personal health overview for doctors. Poor patient data and incomplete personal information can impact on treatment and could possibly lead to a fatality. Using the new technology such as the OSW, semantic web, and XMPP to address the challenges of integrating multiple profiles is vital for the next generation of health informatics.

6.2 CONCLUSION AND FUTURE WORK

This research suggests an alternative solution to the problem of how to manage and synchronise/share profiles across multiple discrete social networks. A framework is proposed to achieve this purpose. In order to demonstrate the feasibility and advantage of the framework, the researcher has established a prototype, MPM and the related protocols, by taking advantage of the OSW and related technologies such as semantic web, vCard, Java Persistence API (JPA), and Extensible Messaging and Presence Protocol (XMPP). The prototype and protocols enable a user to create and manage an integrated profile that can be shared across numerous OSW-supported social networks. The framework, prototype, and protocols make the management of user profiles able to overcome weaknesses in previous proposals. Previous research in this field was concerned with aggregating the distributed profiles but they cannot truly achieve the centralised storing, managing, and synchronising of users' distributed profiles. Additionally, it is easy to ensure privacy control as the researcher has developed the complete platform. Beyond that, the MPM has many advantages. It is an Open-source, privacy-aware, and extensible platform and can be applied in various fields in the Internet.

As a contribution of practical or immediate significance, the MPM prototype and related protocols can be integrated into the OSW platform to serve the current digital world. The MPM services can be integrated into any OSW-supported site

through adding the MPM plugins (Server Plugin or Client Plugin) into the site's server. Users are able to manage their MP stored in the OSW-supported SNSs more effectively and efficiently, and more importantly keep their social network profiles updated.

Future work for the researcher is outlined here and can be divided into the following three major aspects: first, a focus on security and privacy which are still major issues with online profiles; second, individuals may hold more than one name, contact address, phone number, and so needs the ability to control what partial aspects of the profile they will expose to different SNSs; finally, "Semantic Profiles" (Iannella, 2009a) which capture the evolving changes of a person's social context, could be established. For example, the healthcare profile properties may capture health conditions and health risks based on a user's actual discussion group and blog interactions on healthcare social networks such as Disaboom and PatientsLikeMe. The semantic profiles are explicitly able to make a great contribution to development of web-based social networks.

Appendices

APPENDIX A: ONLINE USER PROFILE ATTRIBUTES REPORT

The online user profile attributes report which is in the form of a matrix is used to analyse the use of the social network profile attribute. This study proposes an expanded concept of social networks which include three domains: General, Professional, and Healthcare Social Networks. We select three typical web sites (Facebook, Myspace, and Hi5) from the General Social Networks, three sites (LinkedIn, Xing, and Jobster) from the Professional Social Networks, and four sites (Google Health, Inspire, Cure Together, and PatientsLikeMe) from the Healthcare Social Networks to explore the use of the profile attribute. As seen from the matrix, the tick (√) mark indicates which **attribute** has been included in that **profile**. The degree of importance and their usability are presented in the "Rate" column. In addition, we use the "vCard" column to show the attributes that have been defined in the vCard specification (Howes & Dawson, 1998). This report provides a basis for the vCard Format Extension we proposed in section 4.1.

Profiles / Attributes	General Social Networks			Professional Social Networks			Rate	vCard
	Facebook	Myspace	Hi5	LinkedIn	Xing	Jobster		
Basic information								
Photo	√	√	√	√	√	√	**6**	√
First, Last Name	√	√	√	√	√	√	**6**	√
Former/Maiden Name				√	√		**2**	√
Display Name		√		√			**2**	√
Gender	√	√	√		√		**4**	√
Birthday	√	√	√	√	√		**5**	√
Hometown	√	√	√				**3**	
Current Location	√						**1**	√
Ethnicity		√	√				**2**	
Language			√				**1**	√
Headline		√					**1**	
Contacts								
Emails	√		√	√	√	√	**5**	√
Website	√			√	√	√	**4**	√
Twitter				√			**1**	
IM	√		√	√	√		**4**	√
(Mobile)	√		√	√	√		**4**	√

Phone								
Fax					√		1	√
Time Zone					√		1	√
Address, City, State, Country	√	√	√				3	√
Zip	√	√					2	√
Neighbourhood	√						1	
Interests								
Interests	√	√	√	√	√		5	
Video						√	1	
Music	√	√	√				3	
TV/Television	√	√	√				3	
Books	√	√	√				3	
Activities	√						1	
Heroes		√					1	
Movies/Films	√	√	√				3	
Personal Information								
Political Views	√						1	
Religious Views	√	√					2	
Bio	√						1	
Favourite Quotations	√		√				2	
About me		√	√				2	√
Who I'd like to meet		√					1	
Sexual Orientation		√					1	
Height		√					1	
Body Type		√					1	
Smoker		√					1	
Drinker		√					1	
Children		√					1	
Education		√					1	
Occupation		√					1	
Income		√					1	
Honours and Awards				√	√		2	
Profession Headline				√		√	2	√
Industry				√		√	2	
Groups and Associations				√			1	√
Academic title, degree					√		1	
Wants					√		1	
Haves					√		1	
Organisations					√		1	
Document upload					√		1	
Availability						√	1	
Resume						√	1	
Skill tags						√	1	√
Education								

School Name	√	√		√	√	√	**5**	
Dates Attended	√	√		√	√	√	**5**	
Year Graduated		√					**1**	
Student Status		√					**1**	
Degree	√	√		√	√	√	**5**	
Major	√	√		√	√		**4**	
Minor		√					**1**	
Attend for	√						**1**	
City, State, Country		√		√			**2**	
Clubs Organisations		√					**1**	
Activity and Societies				√			**1**	
Additional notes				√			**1**	
Specialised subjects					√		**1**	
Qualification					√		**1**	
Language					√		**1**	
Describe school time						√	**1**	
Skill tags						√	**1**	
Work								
Employer (Company name)	√	√		√	√	√	**5**	√
Position (Title)	√	√		√	√	√	**5**	√
Division		√					**1**	
Dates Employed	√	√		√	√	√	**5**	
City, State, County		√					**1**	
Description	√			√	√	√	**4**	
Industry					√		**1**	
Status					√		**1**	
Career level					√		**1**	
Company size					√		**1**	
Company homepage					√		**1**	√
Type of Organisation					√		**1**	
Additional Industries					√		**1**	
Skill tags						√	**1**	
Others								
Recommended by				√	√	√	**3**	
What your biggest achievement?						√	**1**	
What's your personal elevator pitch?						√	**1**	

Profile / Attributes	Healthcare Social Network				Rating	vCard
	Google Health	Inspire	Cure Together	PatientsLikeMe		
Basic Information						
Photos		√		√	2	√
Screen name		√	√	√	3	√
Date of birth	√	√	√	√	4	√
Sex	√	√	√	√	4	√
Race/Ethnicity	√				1	
Email	√	√	√	√	4	√
Relationship status		√			1	√
Post Code		√	√	√	3	√
Country		√	√	√	3	√
Favourite link		√			1	
Bio				√	1	
Health information						
Blood type	√		√		2	
Weight	√		√	√	3	
Height	√		√		2	
Conditions	√	√	√	√	4	
Medications	√				1	
Allergies	√				1	
Procedures	√				1	
Test results	√			√	2	
Immunisation	√				1	
Insurance	√				1	
Files and images	√				1	√

APPENDIX B: INTEGRATED PROFILE PROPERTIES LIST

<table>
<tr><th colspan="3">General Information</th></tr>
<tr><td colspan="3">Basic Partial Profile</td></tr>
<tr><td colspan="3">Photo (PHOTO); First, Last, Maiden, Name (N); Display Name (NICKNAME); Gender (SEX); Birthday (DDAY); Bio (NOTE); Language (LANG); Email (EMAIL); Mobile, Fax, Phone (TEL); Website (URL)</td></tr>
<tr><th colspan="3">Specific Information</th></tr>
<tr><th>Social Partial Profile</th><th>Professional Partial Profile</th><th>Health Partial Profile</th></tr>
<tr><td rowspan="2">Interests
Movies/Films
Sports
Games (PC, Online)
Favourite Food & Beverage
Religious Views</td><td>Education</td><td rowspan="2">Blood type
Weight
Height
Conditions
Medications
Test results
Immunisation
Allergies
Insurance</td></tr>
<tr><td>School Name
Dates Attended
Year Graduated
Degree
Major
Work
Headline
Employer
Position
Date Employed
Description
Company homepage</td></tr>
</table>

The above table lists all attributes within an integrated profile in the Multiple Profile Manager prototype. All Basic Partial Profile attributes have been defined in the vCard specification (Howes & Dawson, 1998) and their corresponding vCard properties are shown in the parenthesis. The attributes in the Social, Professional, and Health Partial Profiles will be defined in the vCard Format Extension we proposed in section 4.1.

APPENDIX C: VCARD FORMAT EXTENSION

Introduction

This extension is to define the properties and their data format for the capture and exchange of the Integrated Profile (IP) data in the Multiple Profile Manager (MPM). These properties are related to sharing social network information including general, professional, and healthcare information. The basis for these properties came from the “Integrated Profile Properties List” we proposed (see Appendix B).

Terminology Used

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119] (Bradner, 1997).

Social Properties

1. INTEREST

Namespace: http://example.com/profile/social

Purpose: Lists the vCard owner's interests (social, recreational, technical, etc.). This allows users to identify others with common interests.

Value type: A string value consisting of one or more text values separated by a COMMA character (ASCII decimal 44).

Cardinality: (0, n)

Property parameters: TYPE, PREF

Description: This property MAY include the parameter "TYPE" to indicate the type of interest, and the parameter “PREF” to rank the importance of the vCard owner’s interests.

Format definition:

INTEREST-param = type-param / pref-param / any-param

INTEREST-value = text

type-param-interest = “text” / “movies” / “sports” / “games”/ x-name; type-param-interest MUST NOT be used with a property other than INTEREST.

Example:

INTEREST:Mountain Climbing

INTEREST; PREF=1;type=movies:God Father

INTEREST;PREF=2;type=sports:Basketball

INTEREST;type=games:World of Warcraft

2. FOODBEVERAGE

Namespace: http://example.com/profile/social

Purpose: Lists the vCard owner's favourite food and beverage.

Value type: A string value consisting of one or more text values separated by a COMMA character (ASCII decimal 44).

Cardinality: (0, n)

Property parameters: TYPE, PREF

Description: This property MAY include the parameter "TYPE" to point out the category of the food and beverage (coffee, wine, seafood etc.), and the parameter “PREF” to indicate the preferred food and beverage when more than one is specified.

Format definition:

FOODBEVERAGE-param = type-param / pref-param / any-param

FOODBEVERAGE-value = text

type-param-foodbeverage = “text” / “wine” / “coffee” / “seafood”/ x-name; type-param-foodbeverage MUST NOT be used with a property other than FOODBEVERAGE.

Example:

FOODBEVERAGE;PREF=1:Burgers & Coca

FOODBEVERAGE;type=wine: Tequila

3. PHILOSOPHY

Namespace: http://example.com/profile/social

Purpose: Lists the vCard owner's religion, political views, and so on.

Value type: A string value consisting of one or more text values separated by a COMMA character (ASCII decimal 44).

Cardinality: (0, 1)

Property parameters: TYPE

Description: This property MAY include the parameter "TYPE" to indicate the philosophy type. The TYPE parameter values can include: “religion” and “political views” to indicate the vCard owner’s religion and political views.

Format definition:

PHILOSOPHY-param = type-param / any-param

PHILOSOPHY-value = text

type-param-interest = “text” / “religious” / “political” / x-name; type-param-philosophy MUST NOT be used with a property other than PHILOSOPHY.

Example:

PHILOSOPHY;type=religious:Buddhism

4. Social vCard XML EXAMPLE

The extension proposed above is a data format for representing and exchanging social information about individuals and other entities. It is a text-based format (as opposed to a binary format). This section shows the Bob’s social profile (using XML format) as an example.

```
<social   xmlns="http://example.com/profile/social">
      <interest>
         <parameters>
            <pref>1</pref>
            <type>Movies</type>
         </parameters>
         <text>God fathers</text>
      </interest>
         <interest>
               <text>Mountain Climbing</text>
      </interest>
      <foodbeverage>
            <parameters>
                  <pref>1</pref>
            </parameters>
            <text>Burgers & Coca</text>
      </foodbeverage>
      <philosophy>
            <parameters>
               <type>Religious</type>
            </parameters>
            <text>Buddhism</text>
      </philosophy>
</social>
```

Professional Properties

1. EDUCATION

Namespace: http://example.com/profile/professional

Purpose: To specify the education information of the object the vCard represents.

Value type: A single structured text value. Each component can have multiple values.

Cardinality: (0, n)

Property parameters: TYPE, PREF

Description: This property MAY include the parameter "TYPE" to indicate the education levels (secondary school, university, etc.), and the parameter “PREF” to indicate the importance level of the education.

Special note: The structured property value corresponds, in sequence, to the School Name, Attend Day, Graduate Day, Degree, and Major. The text components are separated by the SEMI-COLON character (ASCII decimal 59). Individual text

components can include multiple text values separated by the COMMA character (ASCII decimal 44).

Format definition:

EDUCATION-param = type-param / pref-param / any-param

EDUCATION-value = list-component 5 (";" list-component)

type-param-education = "secondary" / "university" / x-name; type-param-education MUST NOT be used with a property other than EDUCATION.

Example:

EDUCATION;PREF=1;type=university:Example University; 20080509; 20100509; Master; Electronic and Electricity

EDUCATION;PREF=2;type=university:ABC University; 20040509; 20080509; Bachelor; Engineering

2. WORK

Namespace: http://example.com/profile/professional

Purpose: To specify the working information of the object the vCard represents.

Value type: A single structured text value. Each component can have multiple values.

Cardinality: (0, n)

Property parameters: PREF

Description: This property MAY include the parameter "PREF" to indicate the importance of the work.

Special note: The structured property value corresponds, in sequence, to the Professional Headline, Employer, Job Position, Start Date, End Date, Job Description, and Home Page. The text components are separated by the SEMI-COLON character (ASCII decimal 59). Individual text components can include multiple text values separated by the COMMA character (ASCII decimal 44).

Format definition:

WORK-param = pref-param / any-param

WORK-value = list-component 7 (";" list-component)

Example:

WORK;PREF=1:Turbine Engineer; Example Company; Engineering – Gas Turbine Job; 20040509; 20080509; Centrica Energy, part of Centrica plc, the FTSE Top 25 energy company; www.example.com

3. Professional vCard XML Example

The extension proposed above is a data format for representing and exchanging professional information about individuals and other entities. It is a text-based format (as opposed to a binary format). This section shows the Bob's professional profile (using XML format) as an example.

```
<professional   xmlns="http://example.com/profile/professional">
      <education>
            <parameters>
                  <pref>1</pref>
                  <type>University</type>
            </parameters>
            <school><text>Example University</text></school>
            <attendday>
                  <date-time>2008-05-09T00:00:00.000Z</date-time>
            </attendday>
            <graduateday>
                  <date-time>2010-05-09T00:00:00.000Z</date-time>
            </graduateday>
            <degree><text>Master</text></degree>
            <majors><text>Electronic and Electricity</text></majors>
      </education>
      <work>
            <parameters><pref>1</pref></parameters>
            <headline><text>Turbine Engineer</text></headline>
            <employer><text>Example Company</text></employer>
            <position><text>Engineering – Gas Turbine Job</text></position>
            <startday><date-time>2004-05-09T00:00:00.000Z</date-time></startday>
            <endday><date-time>2008-05-09T00:00:00.000Z</date-time></endday>
            <description>
                  <text>
                  Centrica Energy, part of Centrica plc, the FTSE Top 25 energy
                  company which…
                  </text>
            </description>
            <homepage><uri>http://www.example.com</uri></homepage>
      </work>
</professional>
```

6.2.1.1 Health Properties

1. WELLNESS

Namespace: http://example.com/profile/health

Purpose: To specify the health information like weight, blood type, height, and more.

Value type: A single structured text value. Each component can have multiple values.

Cardinality: (0, 1)

Special note: The structured property value corresponds, in sequence, to the Blood Type, Weight, and Height. The text components are separated by the SEMI-COLON character (ASCII decimal 59). Individual text components can include multiple text values separated by the COMMA character (ASCII decimal 44).

Format definition:

WELLNESS-value = list-component 3 (";" list-component)

Example:

WELLNESS:AB+; 80kg; 180cm

2. PROBLEM

Namespace: http://example.com/profile/health

Purpose: To specify the vCard owner's health problem.

Value type: A string value consisting of one or more text values separated by a COMMA character (ASCII decimal 44).

Cardinality: (0, n)

Property parameters: PREF

Special note: This property MAY include the parameter "PREF" to indicate the importance level of the condition.

Format definition:

PROBLEM-param = pref-param / any-param

PROBLEM-value = text

Example:

PROBLEM; PREF=1:Tension Headache

3. MEDICATION

Namespace: http://example.com/profile/health

Purpose: To specify the medication the vCard owners has used.

Cardinality: (0, n)

Value type: A string value consisting of one or more text values separated by a COMMA character (ASCII decimal 44).

Property parameters: PREF

Special note: This property MAY include the parameter "PREF" to indicate the importance level of the medication.

Format definition:

MEDICATION-param = pref-param / any-param

MEDICATION-value = text

Example:

MEDICATION; PREF=1:Excedrin

MEDICATION; PREF=2: Aspirin, Acetaminophen

4. IMMUNISATION

Namespace: http://example.com/profile/health

Purpose: Note any shot (inoculation), liquid vaccine, or nasal spray vaccine, whether routine or travel-related.

Value type: A string value consisting of one or more text values separated by a COMMA character (ASCII decimal 44).

Cardinality: (0, n)

Property parameters: PREF

Special note: This property MAY include the parameter "PREF" to indicate the importance level of the immunisation.

Format definition:

IMMUNISATION-param = pref-param / any-param

IMMUNISATION-value = text

Example:

IMMUNISATION; PREF=1:Hepatitis B Vaccine

IMMUNISATION; PREF=2:Adult

5. ALLERGY

Namespace: http://example.com/profile/health

Purpose: To indicate the causes of vCard owner's allergies so doctors are informed in an emergency.

Value type: A string value consisting of one or more text values separated by a COMMA character (ASCII decimal 44).

Cardinality: (0, n)

Property parameters: PREF

Special note: This property MAY include the parameter "PREF" to indicate the importance level of the allergy.

Format definition:

ALLERGY-param = pref-param / any-param

ALLERGY-value = text

Example:

ALLERGY; PREF=1:Erythromycin Base

6. ***INSURANCE***

Namespace: http://example.com/profile/health

Purpose: To indicate the vCard owner's insurance including policy numbers, coverage dates, and contact information so he/she can easily find the information when he/she need it.

Value type: A string value. It can also be reset to uri value. The uri value can be used to specify a value outside of this entity.

Cardinality: (0, n)

Property parameters: PREF

Special note: This property MAY include the parameter "PREF" to indicate the importance level of the insurance.

Format definition:

INSURANCE-param = pref-param / refer-param

INSURANCE-value = text / refer-value

refer-param = "VALUE=uri"

refer-value = uri

Example:

INSURANCE; PREF=1:Example Insurance

INSURANCE;PREF=2;VALUE=uri:http://www.abc.com/insurance/example.pdf

7. Health vCard XML Example

The extension proposed above is a data format for representing and exchanging health information about individuals and other entities. It is a text-based format (as opposed to a binary format). This section shows Bob's healthcare profile (using XML format) as an example.

```
<health   xmlns="http://example.com/profile/health">
      <wellness>
            <bloodtype><text>AB+</text></bloodtype>
            <weight><text>80kg</text></weight>
            <height><text>180cm</text></height>
      </wellness>
      <problem>
            <parameters><pref>1</pref></parameters>
            <text>Tension Headache</text>
      </problem>
      <medication>
            <parameters><pref>1</pref></parameters>
            <text>Excedrin</text>
      </medication>
      <medication>
            <parameters><pref>2</pref></parameters>
            <text>Aspirin, Acetaminophen</text>
      </medication>
      <immunisation>
            <parameters><pref>1</pref></parameters>
            <text>Hepatitis B Vaccine</text>
      </immunisation>
      <immunisation>
            <parameters><pref>2</pref></parameters>
            <text>Adult</text>
      </immunisation>
      <allergy>
            <parameters><pref>1</pref></parameters>
            <text>Erythromycin Base</text>
      </allergy>
      <insurance>
            <parameters><pref>1</pref></parameters>
            <text>Example Insurance </text>
      </insurance>
      <insurance>
            <parameters><pref>2</pref></parameters>
            <uri>http://www.abc.com/insurance/example.pdf</uri>
      </insurance>
</health>
```

APPENDIX D: PUBLICATION ABSTRACTS

HIC 2011: Proceedings; 19th Annual Health Informatics Conference: the Transformative Power of Innovation, 1-4 august 2011, Brisbane Convention and Exhibition Centre

Synchronised integrated online e-health profiles

Jian Liang[1], Renato Iannella[1, 2] and Tony Sahama[1]

Abstract: Web-based social networking applications have become increasingly important in recent years. The current applications in the healthcare sphere can support the health management, but to date there is no patient-controlled integrator. This paper proposes a platform called Multiple Profile Manager (MPM) that enables a user to create and manage an integrated profile that can be shared across numerous social network sites. Moreover, it is able to facilitate the collection of personal healthcare data, which makes a contribution to the development of public health informatics. Here we want to illustrate how patients and physicians can be benefited from enabling the platform for online social network sites. The MPM simplifies the management of patients' profiles and allows health professionals to obtain a more complete picture of the patients' background so that they can provide better health care. To do so, we demonstrate a prototype of the platform and describe its protocol specification, which is an XMPP (Extensible Messaging and Presence Protocol) [1] extension, for sharing and synchronising profile data (vCard) between different social networks.

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