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Interoperability of Personal Health Records

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Abstract—**Personal Health Records (PHR's) and related services are emerging rapidly. Currently, most PHR's are isolated and do not communicate with other systems. Standards for interoperability exist, but they are oriented towards clinical applications. However, a substantial part of a typical PHR consists of non-clinical information such as a health diary. The present paper highlights the requirements related to exchanging non-clinical PHR information between services and shows how this information exchange can be accomplished. The approach utilizes a SOAP message for carrying the actual PHR content in a structure referred as Health Diary Entry (HDE) document. The HDE document provides mechanisms to bind the contents to external vocabularies and ontologies to achieve semantic interoperability. The approach was successfully tested in the context of an occupational health pilot, in which data contents from several health and wellness applications were merged into a common database.**

I. Introduction

RAPIDLY rising healthcare costs are forcing healthcare payers to deploy new strategies in providing health for citizens. The focus is being shifted from reactive care of patients into proactive health care and wellness maintenance. Personal Health Records (PHRs) are key drivers of this paradigm shift in enabling individuals to take more responsibility of maintaining their own health. It has become evident that most benefits can be achieved by interoperable PHR architectures [1]. Interoperability is a prerequisite for PHR ecosystems in which free competition between services is allowed and services can be provided in cooperation of several organizations.

Interoperability between PHR services and other related services can be achieved by using common message sets, data structures and health information semantics. Although, relevant standards and open specifications for PHR's are already existing [2], their support for the exchange of semantic PHR information is still limited. Currently, two main standards are used for describing PHR content: Continuity of Care Record (CCR) [3] and Continuity of Care Document (CCD) [2]. The standards include mechanisms for referencing external code systems, such as SNOMED CT and MeSH providing the basis for semantic interoperability. However, the content standards and code systems referred above are primarily targeted for clinical information. Their support for non-clinical information, such as diary entries on exercising, is limited, although such information typically constitutes an important part of the PHR content.

The main contribution of this paper is to highlight the requirements related to exchanging non-clinical PHR information and to show how this information exchange can be accomplished. The technical approach includes a semantic representation for non-clinical health information content and a definition for sending the content within a SOAP message. This approach is analogous to using HL7 CDA documents and HL7 messaging in the clinical domain. The paper also presents an implementation of the technical solution for an occupational health pilot setting.

The paper is organized as follows. Section II describes the approach for exchanging information over the interface between the PHR service and a trusted service (iPHR) in a PHR ecosystem. Section III proposes a new information structure, Health Diary Entry (HDE), for describing non-clinical health diary entries. Section IV shows how ontologies and vocabularies can be linked to the diary entries to provide semantic interoperability. Section V demonstrates usage of HDE for aggregating information from several wellness services into a common PHR database. Sections VI and VII provide discussion and conclusions.

II. Information Exchange in PHR Ecosystem

Service oriented architectures, and in particular the Web Services (WS) architectures, are attractive for PHR ecosystems due their inherent support for loose coupling of services across organizational boundaries. The present paper focuses on the interface referred as iPHR in Fig. 1. It resides between a PHR service and an external service, which can be another PHR service or some other trusted service.

The iPHR interface actually forms the basis for the PHR ecosystem by allowing the services to communicate with each other. The open interface enables one PHR service to retrieve information from other services, thereby providing an integrated view to personal information. Furthermore, the interface allows the user to freely move the entire PHR contents to another PHR service, which opens fair competition between PHR service providers. From service provider's point of view the iPHR interface enables innovative services to be composed of components provided by a network of service providers.

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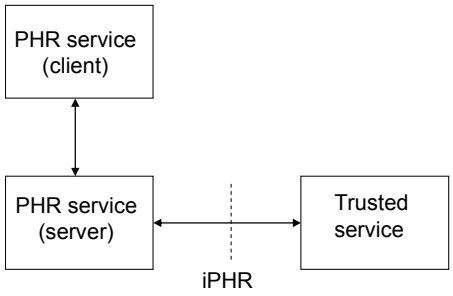

Fig. 1. PHR service interface.

The iPHR interface is bidirectional, which means that both parties can act in both the provider and the consumer roles in the WS architecture. Information is exchanged over the iPHR interface as request-response message pairs using the SOAP protocol. Fig. 2 illustrates the generic structure of an iPHR message. The SOAP header includes information for optional content encryption and electronic signatures according to the WS-security specifications [4]. The actual message is incorporated in the SOAP body together with the PHR content.

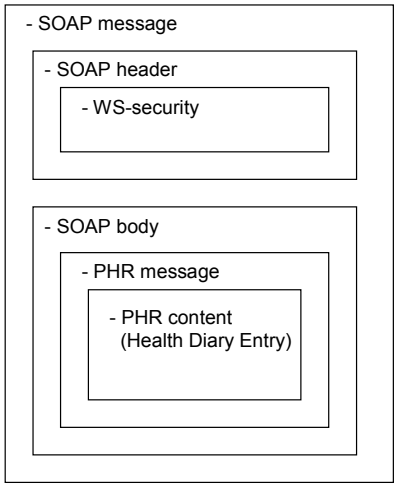

Fig. 2. Generic SOAP message structure for iPHR interface.

The PHR message structure can be formed according to the HL7 v3 messaging standard, but also a more simple xml-structure would be sufficient for most applications. The most common messaging needs for information exchange can be fulfilled by a message set covering retrieval, sending and enumerating data. However, the detailed definition of the message set is beyond the scope of this paper. The following section addresses the PHR content description as the message payload.

III. Health Diary Entry

The non-clinical PHR content is typically composed of information originating from the user or a measurement device controlled by the user. A Health Diary Entry document for such content is proposed in Fig. 3.

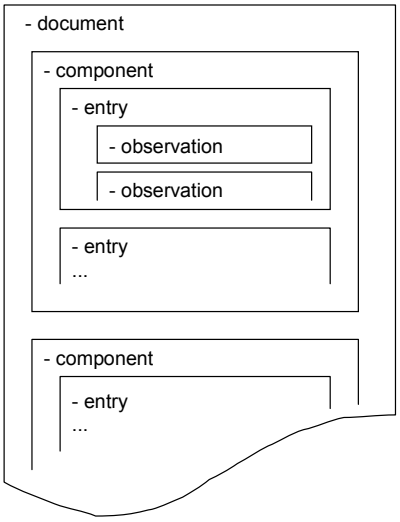

Fig. 3. HDE document structure.

The HDE document is a collection of health diary entries representing one of the following types:

- occurred event
- goal
- background entry

Occurred event indicates that the given entry is referring to an event which has taken place. Typical examples of such events are exercising sessions or enjoyed meals. *Goal* refers to a target, which has been set for the individual. This could be, for example, the targeted amount of exercising per week. *Background entry* indicates that the entry contains PHR owner's constant or infrequently changing data, such as identity, contact or demographics information. Each entry may be accompanied by one or more observations characterizing the entry. An observation may be a subjective note or measurement value provided by a measurement device.

Several entries can be grouped into a component based on a specific context. For example, information related to different subjects may be transferred in different components of one document.

The structure described above defines semantics at generic level, i.e. allowing the receiving party to understand that a diary entry concerning a certain subject and a certain time period has been transferred. The exact definition of the diary entry is indicated by links to external information sources as described in the next section.

IV. Semantic Interoperability

Each entry of the HDE document is tagged with an entry identifier, archival date and coding information defining the classification of the entry. Also observations are tagged with coding information defining the type of observation. The coding information can be used for referring to external ontologies and vocabularies.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<HedDocument>
  <id root="1.2.246.10.2446794.10.1.10.6773.11.2007" ext="1234"/>
  <component>
    <subjectID root="1.2.246.21" extension="010144-123X"/>
    <contextID root="1.2.246.10.2446794.10.1.10.6773"/>
    <entry code="D016138" codeSystemName="MeSH" displayName="Walking">
      <entryID root="" value="993421230"/>
      <effectiveTime value="20071009145547"/>
      <observation code="p2382" codeSystemName="YSO" displayName="Energy consumption"">
        <value deviceCode="1.2.246.10.2446794.10.1.6773.13.2007.4.4" deviceName="Suunto T6" type="long" unit="kcal" value="600"/>
      </observation>
      <observation code="2.1" codeSystem="1.2.246.10.2446794.10.1.10.6773.5.2007.4" codeSystemName="NUADU/Source" displayName="Duration">
        <value type="double" unit="s" value="3600"/>
      </observation>
    </entry>
  </component>
</HedDocument>
```

Fig. 4. Health Diary Entry (HDE) example.

The optional coding information includes:

- *code*: code within the used coding system
- *codeSystem*: reference to the used coding system
- *codeSystemName*: literal reference to the used coding system
- *displayName*: literal name of the entry or observation

The *code*, *codeSystem* and *codeSystemName* attributes are assumed to uniquely identify the related entry or observation class. The identification may be based on an OID (Object Identifier), URI (Uniform Resource Identifier) or a system-specific code. The *displayName* attribute provides a literal representation of the entry or observation class according to the referred vocabulary.

Fig. 4 shows an HDE document example describing a set of diary entries, with a number of external references. The document root and context id's are based on the OID code assigned to the NUADU project by the project owner (VTT) providing an unambiguous link to the source of the information [5]. The entry describes a walking event which is defined by referring to the corresponding item in the MeSH vocabulary. The General Finnish Ontology [6] is referred to define that a measurement on energy consumption has been made. The used measurement device has been Suunto T6 type wrist computer which has been coded with a project specific OID in the *source ontology* of the NUADU ontology collection [7]. Another observation related to the walking event is duration, which is also bound to the *source ontology*.

V. Use case: occupational health pilot

The technological approach described above is being tested in the pilot study of the NUADU project. The objective of the pilot is to study the role of different ICT based wellness applications in achieving changes towards healthy lifestyles and maintaining good health [5]. Several ICT applications from different vendors are being used in the pilot. Nokia Wellness Diary (WD) is a mobile application allowing the user to enter and manage information on physical activities. Wellness Diary Connected (WDC) is the corresponding service accessed by web browser. Tuulia Hyperfit is a platform for recording and analyzing information on nutrition. Firstbeat Mobile Coach is a mobile application for maintaining personal exercising programs and analyzing exercises. Relaxline's SelfRelax is a mobile application for personal stress management.

As illustrated in Fig. 5 the NUADU architecture supports transferring of information contents from the different applications into one PHR database, from which the data can be exploited for results analysis as shown in Fig. 5. The server applications create HDE documents and send them to the centralized reasoning engine within SOAP messages. Information from mobile applications is manually downloaded in the end of the pilot. In this case a specific adapter component is used to create the HDE document and to wrap it in a SOAP message. The reasoning engine matches the incoming information into the PHR database schema by using the NUADU ontology collection (NOC). The NOC is a set of ontologies (activity, weight, nutrition, sleep, stress, context, event, risk, device, personal), which together cover the required terminology for the pilot purposes [7]. For example, the *source ontology* contains information on the used wellness applications and devices acting as information sources. The ontologies include synonym information, thereby supporting merging of information from different vendors using different vocabularies. Besides terminology specifically entered for the project purposes, the NOC reuses vocabulary on activities based on the Compendium of Physical Activities [8] and on nutrition based on IST/PIPS project [9].

VI. Discussion

The spectrum of different PHR services and their respective information contents is wide. Currently, the services are isolated from each other, but increasing need for the exchange of structured information between services is foreseen. This paper presents a technical approach for semantic interoperability of PHR services. Instead of trying to define one common vocabulary the approach relies on a common data structure, HDE document, which includes a mechanism for binding with external ontologies and vocabularies, which is similar to the approach adopted by clinical document standards.

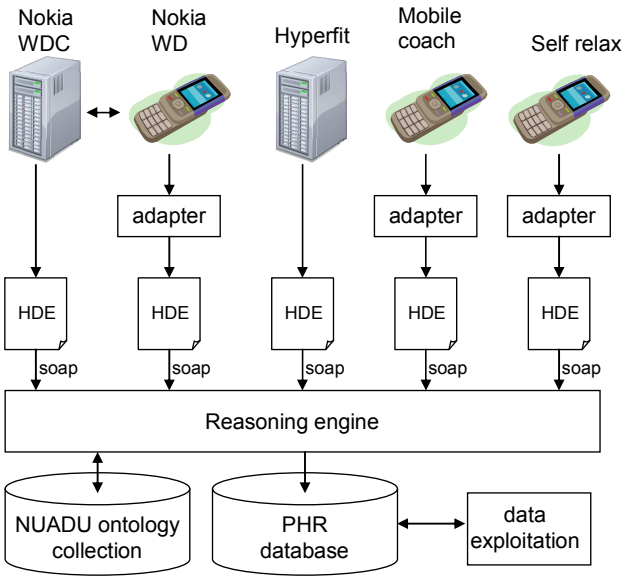

Fig. 5. Architecture for collecting PHR information from various services piloted in the NUADU project.

In the clinical domain, there are well-established infrastructures for developing, maintaining and distributing vocabularies. These infrastructures are almost completely missing in the non-clinical domain. Vocabularies are developed on "project basis" and there are neither responsible organizations nor funding to take care of them in the long run. Moreover, there is lack of platforms - such as code servers in the clinical domain - providing a programmatic interface to vocabularies for applications and services. It seems clear, that the infrastructure consisting of non-clinical vocabularies, ontologies and related distribution platforms needs to be set up before an interoperable PHR ecosystem can be achieved. Generic ontology platforms are an interesting opportunity [10]. They provide a cost effective solution by integrating several ontologies representing different domains, ontology development tools and ontology access interfaces on one platform. Utilization of such platforms could lower the step for the providers of wellness services and devices to expose their vocabularies and ontologies for public use.

VII. Conclusions

This paper highlights the need for an interoperable ecosystem of PHR services and the shortcomings of the current standards in supporting it. As a technical solution we propose a new data structure, Health Diary Entry document, which complements the existing standards in supporting transfer of non-clinical information. The data structure includes a mechanism for binding with external vocabularies and ontologies to achieve semantic interoperability. The technical solution is being used in an occupational health pilot setting. The experiences have shown the suitability of the approach when information needs to be collected from different services into a common PHR database.

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