DESIGNING ONTOLOGY FOR PERSONAL HEALTH RECORD CHALLENGES AFFECTING THE ADOPTION OF PERSONAL HEALTH RECORD (PHR)

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Abstract- The Personal Health Record (PHR) has been part of healthcare by decades but its adoption is very slow due to the various challenges affecting it. This paper presents the methodology used to build ontology for personal health record that gathers all the terms needed by the researchers to produce knowledge that can help to find out the challenges in the adoption of PHR and provide an ideal PHR to the patients.

Keywords- PHR, Personal Health Record, PHR Challenges, PHR Ontology.

I. INTRODUCTION

The Personal Health Record (PHR) has been part of healthcare and utilized by patients for decades. Nowadays with the power of innovation and the rapid growth of technology especially in the healthcare sector, the concept of PHR has been replaced with an Electronic PHR as a new opportunity for better healthcare (Kupchunas, 2007). It allows patients to keep track of their health information, monitor and manage their illness especially in cases of chronic diseases, (Tenforde, et al., 2011),"increase efficiencies in appointment scheduling, medication refills",(Bonander & Gates, 2010) and improve the communication with healthcare providers for better quality of care. It defined according to the National Coordinator of Health Information Technology (NCHIT) as "an individual's electronic record of health related information that conforms to the national recognized interoperability standards where various source data; clinical, financial and other information are integrated into a single record." (Kahn et al., 2009, p.369)

In fact there are two approaches of it, one linked to the organization's Electronic Medical Record (EMR) as an organization PHR to insure patient access to his/her data and the other approach is through online websites as a commercial PHR that allow patients to record his/her health behaviors similar to WeMED website (Bates & Wells, 2012; Bonander & Gates, 2010; Gaskin, Longhurst, Slayton & Das, 2011).

III. LITERATURE REVIEW

The establishment of an ideal PHR as defined earlier by National Coordinator of Health Information Technology (NCHIT) may face various challenges such as interoperability, policy barriers, concerns about patients' confidentiality and privacy, lack of awareness, the dislike or lack of time to use computers and internet and limited internet literacy (Hamlaka et al., 2008) (Dalencia et al., 2013) (Britto et al., 2009) (Tang et al., 2006) (Khan et al., 2009) (Lober et al., 2006).

According to Tang et al., (2006) interoperability standards dictate that the ability of a PHR to exchange data among multiple healthcare systems requires supporting of "communication, messaging and content coding standards" (Tang et al., 2006, p.124). Hence, implementing the concept of Health Information Exchange (HIE) in the development phase of PHR must be emphasized and such exchange has been introduced by the use of ontology based framework as a concept of semantic web (Demurjian et al,). Semantic web is a kind of technology helps to store data in web that can be read by machine. On the other hand ontology is "a formal explicit description of concepts in a domain of discourse,properties of each concept describing various features and attributes of the concept(slots) and restrictions on slots" (Noy & McGuinness, 2001). Indeed it can be defined as common terms needed by researchers for a specific concept with a relation between these terms that result an effective knowledge.

Policy plays an important role in strengthening the ideal PHR. The law governing the dispersion of information is dictated by policy regarding electronic transaction among healthcare organizations (Kahn et al., 2009). The information must be standardized in order to be able to integrate EHR with PHR to improve efficiency within the system. Thus, there is a need to fund PHR research, and incentives must be given to establish national PHR. A patient may not only be restricted to specific organization as he/she may move from one healthcare organization to another healthcare organization and there are synergies to be exploited with further development of the technology.

The implementation must also be constantly monitored to attain the ideal. The issues of patient confidentiality protection, privacy issues, and PHR

security must all be addressed satisfactorily. As reflected on by Hamlaka et al, (2008) authentication access for patients' minors' access to PHR; and the secure messaging between patients and physicians must be effectively set up. Effective steps such as building PHR awareness through education must be taken to ensure the reduction of opposition to change which were seen in the UK –through low PHR adoption rates (Khan et al., 2009, p.374) and in South Africa also highlighted in the study conducted by Dalencia et al., (2013). Concerns about PHR use regarding; privacy, the time spent capturing data, and aversion to computers and the internet contribute to slowing the adoption of PHR unless effectively managed from the start.

Since Ministry of Health (MOH) is in the preparation phase to implement the national PHR, the perceived barriers and challenges are still unknown although expected as outlined in the literature especially in case of the interoperability as the data will be exchange between the various EMRs implemented in several healthcare organizations. Hence, as a new concept of semantic web called ontology that has been recently used as illustrated earlier by Demurjian et al, as a solution to address the issue of HIE; and a way to achieve the semantic interoperability (Puustjärvi, & Puustjärvi 2011). This paper presents the ontology designed to find out the challenges that may affect the adoption of PHR and build an ideal PHR according to patients' needs.

IV. METHODOLOGY

The method used to design the ontology required for this study is based on the following common steps for designing ontology according to (Noy, et al., 2002) which are:

1. Identifying the domain of the ontology which is in this case is about Personal Health Record (PHR) to find out the different types of challenges that may affect the adoption of PHR and build an ideal PHR by answering the following questions :

   a. What are the challenges/barriers (personal related to patient concerns or technical as mentioned in the literature) that affect the adoption of PHRs whether organization's PHR or commercial PHR?
   b. What are the challenges of PHR that can be consider as personal challenges?
   c. How can measure patients' level of interest for PHR?
   d. What are the components requested by the patients who are older than 40 years?

2. For this step where its prefer to find out similar existing ontology and use it , indeed according to the research process to find out articles that could support the idea of designing ontology about PHR challenges there were only ontology designed to address the interoperability issue of the HIE as illustrated earlier. In addition there were other searches done on swoogle search engine to find out similar ontologies but there were no specific ontology designed for this purpose. Therefore, the purpose of this paper is to represent a new ontology about PHR challenges
3. Determining the common terms that will be used on this ontology which are :
   a. PHR
   b. PHR components
   c. Age
   d. Education Level
   e. Health Status
   f. Challenges
   g. Gender
   h. PHR Type
   i. Challenges Type
   j. Patients
   k. PHR Interest
   l. PHR Component Type

Hence, through the use of one of the semantic web application used to build ontology is a tool called protégé. However, protégé version 4.3.0 has been used to develop OWL (Web Ontology Language), indeed the sublanguage of OWL which is OWL DL. OWL is an ontology language used to provide the syntax required to be read by the machine. It builds on RDF and RDFS. RDFS (Resource Description Framework Schema).is a simple ontology language used to provides a method for describing specific domains. Thus, the development in such a tool according to the common steps was by:

4. Determining the classes (super classes) with their hierarchy which called sub classes that inherits all the prosperities from the super class. However, according to the mentioned terms in step 3 there will be no hierarchy and the classes are as follow:
   a. PHR
   b. Patients
   c. Challenges
   d. PHR components

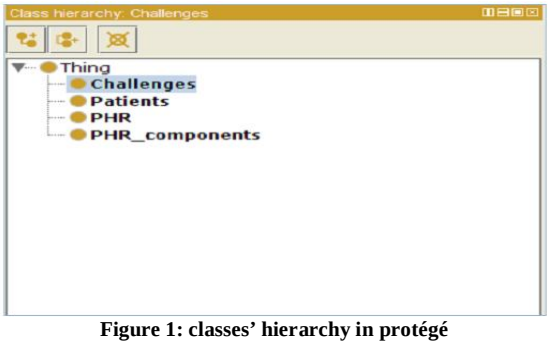


Figure 1: classes' hierarchy in protégé

5. Identifying the properties of the classes that called data property as an attribute /slots and object property as a relationship between the classes, which will help to provide more knowledge about the classes according to the following table :

Classes	Data Property	Object property
PHR	PHR Type	Has challenges
		Has components
Patients	PHR Interest	Request component
	Gender	
	Education Level	
	Health Status	
	Age	
Challenges	Challenges Type	Challenges of
PHR Components	PHR Component Type	Component of Requested by

With regard to the object property according to the above table it can be defined, as below:

- The first object property (Has challenges) links the PHR class with the challenges class.
- The second object property (Has component) links the PHR class with the PHR component class.
- The third object property (Request component) links the patient class with the PHR component class.
- The forth object property (challenges of) links the challenges class with PHR class and it is reverse of the object property (Has challenges) (see figure 2)
- The fifth, object property (component of) links the PHR component class with PHR class and it is reverse of the object property (Has component)
- Finally, object property (Requested by) links the PHR component class with patient class and it is reverse of the object property (Request component).

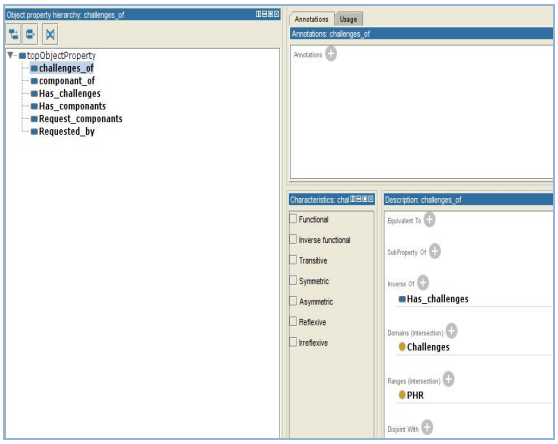


Figure 2: object property (challenges of) in protégé

6. Determining the constrains (facets) of the slots/attribute that considered as a type and cardinality according to the following table as an extension of the previous table mentioned in step 5 :

Classes	Data Property	Type	Cardinality
PHR	PHR Type	String	Exactly 1
Patients	PHR Interest	String	Exactly 1
	Gender	String	Exactly 1
	Education Level	String	Exactly 1
	Health Status	String	Exactly 1
	Age	Nonnegativeinteger	Between (20 and 60)
Challenges	Challenges Type	String	Exactly 1
PHR Components	PHR Component Type	String	Exactly 1

According to the above table the constraints of the values in the data property in protégé can be done in several ways for example in case of the data property (PHR Type) as the value of PHR type cannot be commercial PHR and organization PHR at the same time. Hence, such a constraint can be done by either checking the functional characteristic under the characteristic section in the data property as follow in figure 3:

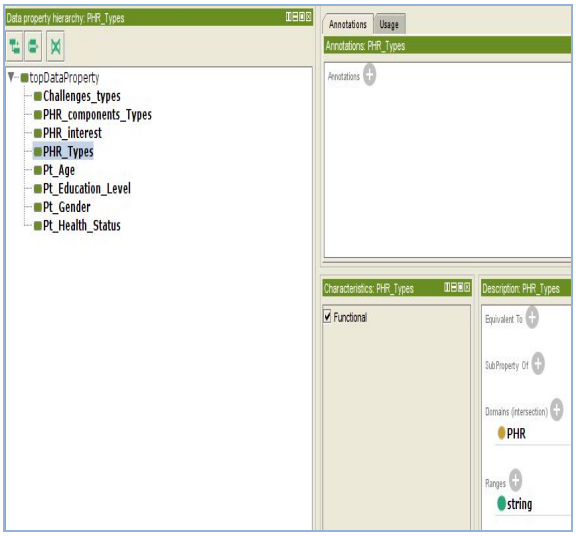


Figure 3: restrictions on data property (PHR Types) in protégé

Or on the other hand by using the restrictions capability under the PHR class that done through the selection of the specific data property which is according to the mentioned example is PHR Type and the restriction type is exactly of 1 see figure 4

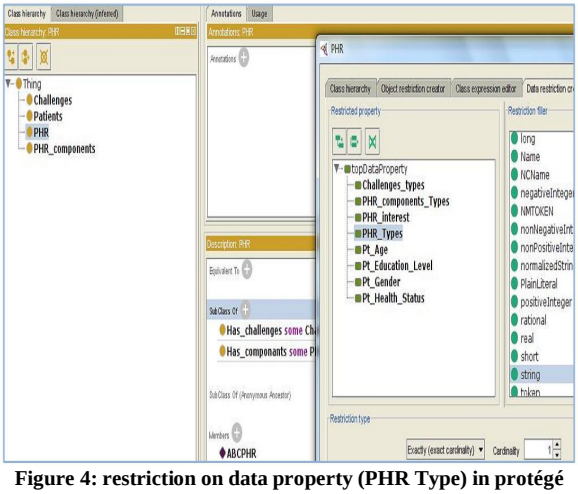


Figure 4: restriction on data property (PHR Type) in protégé

Other example about the constraints in data property is under the patient class which is in the data property (Age) first, it should be non negative integer as its type and functional data property because the age of any person should include only one value (see Figure 5). In addition, other restriction on the value that it should be from 20 years old to 60 years old as a part of the requirements added in this ontology (see Figure 6).

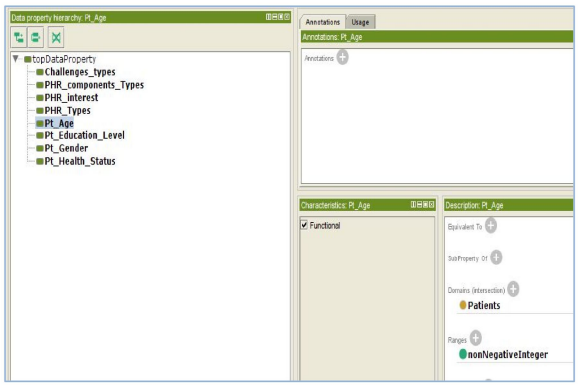


Figure 5: restriction on data property (Age) in protégé

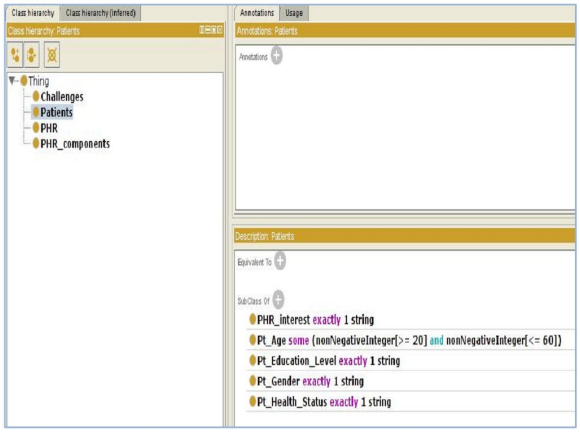
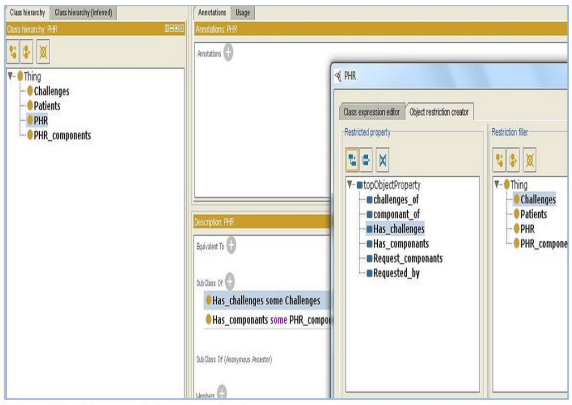


Figure 6: restriction on data property (Age) in protégé

7. In addition to the data property's constraints as mentioned in step 6 there are constraints for the object property as included in the following example (see figure 7).



(Has Challenges) in protégé.

Figure7: restriction on object property (Has Challenges) in protégé.

According to figure 7 the restriction (some) made on the object property Has challenges indicates that any PHR has at least one challenge.

8. The final step is about creating individual instances for the classes by defining the specific class for each individual, then filling each individual's data property with a specific value according to the mentioned constraints as

included in step 6. Hence, as an example of the individuals, present in the following figure(8):

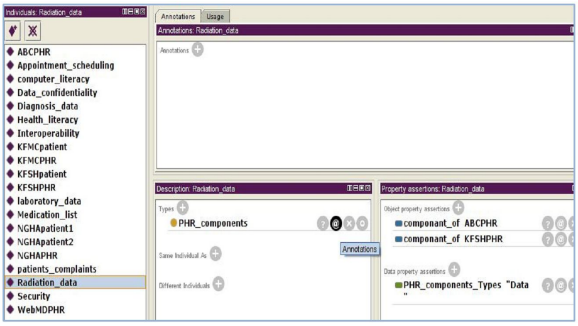


Figure 8: an individual (Radiation data) in PHR component class with its properties in protégé.

According to figure 8 Radiation data was filled as an individual for PHR component class with its data property that considered as a data not as a service like patient compliant or appointment scheduling. In addition to its relation with PHR class (ABCPHR and KFSHPHR) as a component of them.

Hence, from the overall steps mentioned, in order to check the consistency of this ontology, reasoner FaCT++ has been used and it indicated the consistency of this ontology.

IV. RESULT

As a result of the previous questions mentioned earlier regarding this ontology and after filling the classes' individuals with its properties the following Sparql queries has been used to answer these questions.

a. SELECT *
WHERE {
?PHR aj:Has_challenges ?Challenges}
See figure 9

b. SELECT *
WHERE {
?Challenges aj:Challenges_types ?Challenges_types.
FILTER (str(?Challenges_types) = "personal challenges").}
See figure 10

c. SELECT *
WHERE {
?Patients aj:PHR_interest ?PHR_interest.
}
See figure 11

d. SELECT ?componants
WHERE {
?Patient aj:Pt_Age ?Pt_Age.
FILTER (str(?Pt_Age) > "40").
?Patient aj:Request_componants ?componants
} GROUP BY ?componants
See figure 12

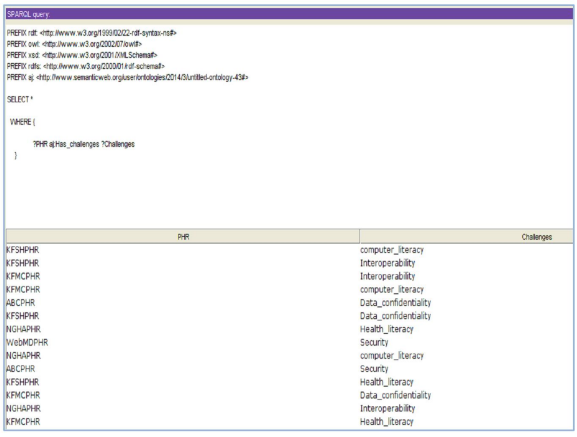


Figure 9: challenges' result of the PHR whether commercial PHR or organization PHR.

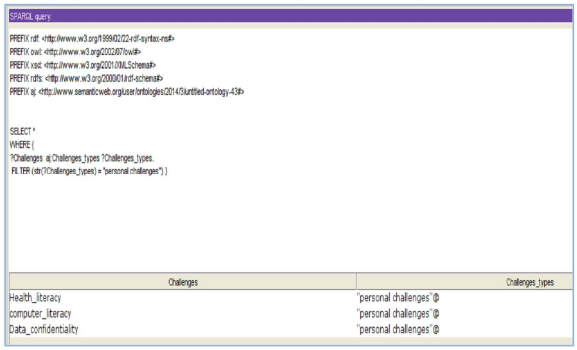


Figure 10: personal challenges of PHR.

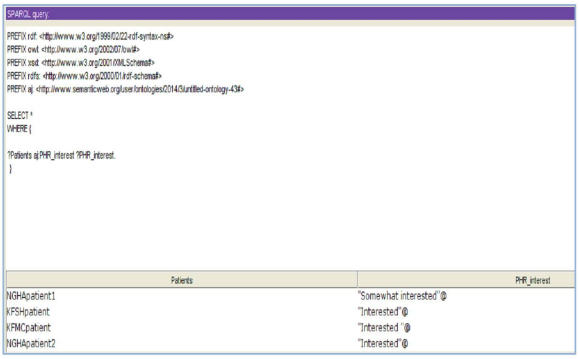


Figure 11: patients' level of interest about PHR

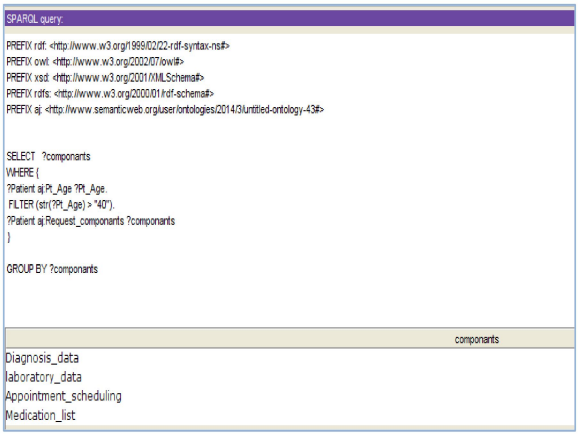


Figure 12: PHR components requested by patients older than 40 years.

V. DISCUSSION

According to the results it's clear that the different types of PHR have challenges specially the interoperability as a challenge for all organizations' PHR. in addition to the data confidentiality as a challenge for both organization PHR and commercial PHR. Moreover, data confidentiality, computer literacy and health literacy are considered as personal challenges.

However, patients are interested to the PHR and the components requested by those who are older than 40 years are diagnosis data, laboratory data, medication lists and appointments scheduling

CONCLUSION

The adoption of PHR has various challenges, therefore, this paper presented the concept of semantic web by designing ontology that include all the terms needed by the researchers via a tool called protégé through defining classes, properties and the relations between these classes then using Sparql queries to extract knowledge from this ontology that confirm interoperability, data confidentiality and others as challenges of PHR, in addition to other knowledge needed to have an ideal PHR for the patients.

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