Using Semantic Web Ontologies for better inter-operability on social network sites

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Abstract- Nowadays, social web has been emerged to help people create and collect knowledge through online social network sites. Since these sites usually isolated from each other, semantic web tools are needed to inter-link social network sites. Ontologies and their classes/properties as semantic tools have been used to provide inter-operability among social network sites. Although many efforts have been gone on semantic web and use of ontologies, an exhaustive and applicable framework which aggregate ontologies is still scarce. In this study, we aim to provide a base-line for researchers creating such a framework by using FOAF, SIOC, SKOS, and DC. In addition, we present ontologies and their relationships to express semantic web in the realm of social network sites and concepts of inter-operability and user-generated content management.

Keywords- Ontology, semantic web, social network.

I. Introduction

The social-networking sites have been exploited since recent decades and considered as one of the most well-known places on the internet. There are some features, which provided on social network's sites such as the ability to share basic information through posting profile, ability to invite friends and also connect their profiles through the system. The social-network sites also present tools to enable user browsing for common friends, discovering new potential friends, and finding friends thought to be lost by referring to shared interests [13]. Despite facilities provided by each system alone, integration and inter-operability among different social-networking sites are still an issue. Having this fact, the Semantic Web has been introduced as a series of technologies, which proposed by W3C as the next-generation web, on the other hand, it is considered as an existing web accompanies by much meaningful information and better collaboration among people and computers. The Semantic Web will facilitate data accessibility in Web by means of semantic constructors, such as ontology [11].

The study [16] proposed a method to develop presentation of social networks by ontology based knowledge representation, which applied combination of three offered semantic web vocabularies involving FOAF, DC and SIOC. The literature [10] also posited that the SIOC ontology can combine terms from existed vocabularies with new terms needed to describe the inter-connectivity between concepts through online social communities.

In addition, social network analysis is known as a process to address and assess inter-relationships and data flows between people, communities, organizations, computers, and other knowledge-based entities [15]. In recent decades, there are many efforts have been done to introduce a holistic system to exploit data interchange and inter-operation. Thus, the Semantic Web technology was introduced, which provides both metadata creation and inter-connected vocabularies. These efforts by Semantic Web strive to make social web sites more connected. To gain such a connectivity and inter-operability Semantic Web offers frameworks such as SIOC (Semantically Interlinked Online Communities) and FOAF (Friend of-a-Friend) which facilitates the creation of network interlinks and semantics as whole [22].

Moreover, since many users have multiple social network accounts, hence, data inconsistency exists and inter-operability is difficult to implement. Thus, there are many semantic web practices that can improve data inter-operability. Reusing existing ontologies and vocabularies is considered as one of these best efforts. The SIOC ontology reuses the FOAF vocabulary to explore persons' attributes and the Dublin Core (DC) vocabulary to illustrate SIOC content properties [22]. Although this framework has applied FOAF, DC and SIOC to certify inter-operability between diverse social networks, it has not introduced a comprehensive system to bring other ontologies together to discover more relationships among a user- generated content. In addition, the study [25] posited a service to act as a tool for social network inter-operability. However, this framework has been built on sole perspective by using FOAF ontology and related classes and properties. Besides, Many other studies have been conducted on the semantic web, but how extract relationships and integrate social networks is still a challenge. In another word, there exists lacks of integration to extract many meaningful relationships among diverse ontologies. There still need to combine other ontologies and test different classes' integration to explore whether new frameworks are eligible to be replaced by existing ones. The main purpose of this study is to describe the most dominant and practical ontologies and their combination to help building an exhaustive framework for social network websites. We constructed our paper as follows: first, we provide background by studying over literatures in Literature review section; In the next step, we

introduce ontologies' classes/ properties and how they can have relationships with each other, and finally, we come up with our conclusion accompanying with our research significance and limitation.

II. Literature review

There are literatures related to social network and semantic network has been reviewed, to provide basic implication and background for this study. Basically, this section is grounding to find answers for study questions and fulfil the research objectives. We divide our review of literatures into three faces which the first one is the concept of social network; second face introduces semantic network and third one deal with social network analysis and tools to extract relationships among social networks.

A. Social Networks

To be more clear about social networks, it can be defined as a social structure which exists among people or organizations. It also defines either a relationship or couple of affiliations among both casual and familiar social parties [15]. In addition, it was introduced as collections of links, which classify actors, including individual or groups and organization in a democratic manner seeking common objectives [17]. Since we focus on an online area, literature "Analysis on Community Characteristics of Online Social Network" defined online social network as an online network which indicates connections between actors in social activities [24].

B. Semantic network

Before we are able to analyze social networks and extract relationships between social network sites, it is imperative to understand the concepts of Semantics network. In one definition, semantic network is a group of entities, which are connected through their relationships. Semantic networks offer valuable information, for instance, individuals' trustworthiness and extraction of people's relation [14]. In other words, the Semantic Web considered as using new technologies and standards, which allows data interpretation and information processing on World Wide Web [18].

Meanwhile, many studies have been conducted on data acquisition from social networks by using of semantic web [1]. Thus, there are findings about how Semantic Web can provide inclusive data presentation by employ technologies such as RDF and OWL, which offer richer semantics among social networks [5]. However, acquiring most related data in social network sites has been challenging in order to an intense amount of data and its ongoing growth on the web. One of the main reasons of this challenge is that data spread widely on the web and there is no systematic approach to organize the data in a way that can be used and processed by machines to eliminate mankind's contribution [16]. Automatic user profile extraction, for instance, can be one way out from this challenge and it can reduce inconsistency and deficiency of user profile [9]. The study [16] stated that advent of semantic web and its respective technologies such as ontologies and vocabularies introduces methods for better data presentation and allow machines to automatically originate data from web.

C. Social network analysis and tools

To delve into a social network and extract relationships, we need to understand the social network analysis which basically provides tools to find a pattern of relationships among individuals and social network actors. Web, especially social network's sites are known as social network. Thus, analysis of social network sites seems essential these days. Ontology is known as a tool to analyze and extract relationships among web sites. The literature [11] stated ontology as a logical theory to describe the meaning of a formal vocabulary, to identify knowledge within a vocabulary, and extract semantics from interconnections on the web. The ontology can be employed in Semantic Web Services, which comprise of documents or files and delineate relationships between their embedded terms. Ontology can also improve the Web functionality by discovering and categorizing relationships that exist. Moreover, ontologies include classes and properties which each of them reveal specific meaning when we use semantic web languages such as RDF and OWL [12]. These classes and properties formed ontologies and can be found in Resource Description Framework (RDF) documents where consists of resources (nodes), properties, and values to describe resources. Referring to RDF documents and employ ontologies semantics can be discovered among them [8]. Four top ontologies and vocabularies which are intensively employed on the web were listed as follows:

1) Dublin Core (DC): Dublin Core is a combination of fifteen elements, which known as a system to describe resources. These sets of elements assist the well-organized search and information retrieval by capturing basic descriptive categories on the web.

In addition, there are some characteristics, which provide the ability to compile metadata and build more complicated description for data resources. The Dublin Core characteristics are: Simplicity (of creation and maintenance), Inter-operability (among collections and indexing systems), International applicability, Extensibility, and Modularity. Referring to these abilities the

semantics of Dublin Core have been initiated by a group of professionals from different community and background [4].

2) Friend of a friend (FOAF): the FOAF ontology has been developed on RDF based schema to semantically express individuals and their social network. There are many places where FOAF can be used such as wikis, Forums, and social network sites [19].

3) Semantically-Interlinked Online Communities (SIOC): the SIOC is known as a Semantic Web technology. There exist methods in SIOC, which enable interconnection between Blogs, forums, and other community websites. The SIOC ontology is an open-standard machine readable format to extract metadata for more semantic browsing, content management, and more social web facilities [20].

4) Simple Knowledge Organization System (SKOS): SKOS is a set of characteristics which projects standard control over RDF documents' vocabularies [21]. SKOS is also considered as a data model to interlink organization knowledge and facilitate knowledge sharing through the web. The SKOS captures organizational knowledge, which is provided in RDF documents and extract similarities and enable technology and information sharing among organization systems [2].

D. Ontology classes and properties

There are classes and properties related to each ontology which can use to extract relationships among diverse social network websites. We listed some of them as following:

i. The SKOS vocabulary [3]**:**

Table 1. SKOS Classes and Properties

Table 1. SKOS Vocabulary	
URI	Definition
skos:Concept	A SKOS concept can be viewed as an idea or notion; a unit of thought.
skos:ConceptScheme	A SKOS concept scheme can be viewed as an aggregation of one or more SKOS concepts. The notion of a concept scheme is useful when dealing with data from an unknown source, and when dealing with data that describes two or more different knowledge organization systems.
skos:inScheme	
skos:hasTopConcept	
skos:topConceptOf	
skos:altLabel	A lexical label is a string of UNICODE characters, such as "romantic love" or "れんあい", in a given natural language, such as English or Japanese (written here in hiragana). The Simple Knowledge Organization System provides some basic vocabulary for associating lexical labels with resources of any type. In particular, SKOS enables a distinction to be made between the preferred, alternative and "hidden" lexical labels for any given resource.
skos:hiddenLabel	
skos:prefLabel	
skos:notation	A notation is a string of characters such as "T58.5" or "303.4833" used to uniquely identify a concept within the scope of a given concept scheme.
skos:changeNote	Notes are used to provide information relating to SKOS concepts. There is no restriction on the nature of this information, e.g., it could be plain text, hypertext, or an image; it could be a definition, information about the scope of a concept, editorial information, or any other type of information.
skos:definition	
skos:editorialNote	
skos:example	
skos:historyNote	
skos:note	
skos:scopeNote	
skos:broader	SKOS semantic relations are links between SKOS concepts, where the link is inherent in the meaning of the linked concepts. The Simple Knowledge Organization System distinguishes between two basic categories of semantic relation: hierarchical and associative. A hierarchical link between two concepts indicates that one is in some way more general ("broader") than the other ("narrower"). An associative link between two concepts indicates that the two are inherently "related", but that one is not in any way more general than the other.
skos:broaderTransitive	
skos:narrower	
skos:narrowerTransitive	
skos:related	
skos:semanticRelation	
skos:Collection	SKOS concept collections are labeled and/or ordered groups of SKOS concepts. Collections are useful where a group of concepts shares something in common, and it is convenient to group them under a common label, or where some concepts can be placed in a meaningful order.
skos:OrderedCollection	
skos:member	
skos:memberList	
skos:broadMatch	The SKOS mapping properties are skos:closeMatch, skos:exactMatch, skos:broadMatch, skos:narrowMatch and skos:relatedMatch. These properties are used to state mapping (alignment) links between SKOS concepts in different concept schemes, where the links are inherent in the meaning of the linked concepts. The properties skos:broadMatch and skos:narrowMatch are used to state a hierarchical mapping link between two concepts. The property skos:relatedMatch is used to state an associative mapping link between two concepts. The property skos:closeMatch is used to link two concepts that are sufficiently similar that they can be used interchangeably in some information retrieval applications. In order to avoid the possibility of "compound errors" when combining mappings across more than two concept schemes, skos:closeMatch is not declared to be a transitive property. The property skos:exactMatch is used to link two concepts, indicating a high degree of confidence that the concepts can be used interchangeably across a wide range of information retrieval applications. skos:exactMatch is a transitive property, and is a sub-property of skos:closeMatch.
skos:closeMatch	
skos:exactMatch	
skos:mappingRelation	
skos:narrowMatch	
skos:relatedMatch	

ii. FOAF [6]**:**

Table 2. FOAF Classes and Properties

Class	Properties
foaf:Agent	Weblog, icqChatID, msnChatID, account, age, mbox, yahooChatID, tipjar, jabbered, status, opened, gender, interest, holdsAccount, topic_interest, aimChatID, birthday, made, skypeID, mbox_sha1sum
foaf:Group	member
foaf:Organization	**Subclass Of** Agent **Disjoint With:** Person Document
foaf:Person	myersBriggs, familyName, publications, lastName, family_name, firstName, currentProject, surname, knows, workInfoHomepage, pastProject, geekcode, schoolHomepage, workplaceHomepage, img plan
foaf:Document	Topic, sha1, primaryTopic
foaf:Image	Thumbnail, depicts
foaf:OnlineAccount	accountServiceHomepage, accountName
foaf:PersonalProfileDocument	**Status:** testing **Subclass Of** Document
foaf:Project	**Status:** testing **Disjoint With:** Person Document
foaf:LabelProperty	**Status:** unstable
foaf:OnlineChatAccount	**Status:** unstable **Subclass Of** Online Account
foaf:OnlineEcommerceAccount	**Status:** unstable **Subclass Of** Online Account
foaf:OnlineGamingAccount	**Status:** unstable **Subclass Of** Online Account

iii. SIOC [23]**:**

Table 3. SIOC Classes and Properties

Class	Properties
sioc:Community	Community is a high-level concept that defines an online community and what it consists of. A Community is different from a Site: a Site describes a single community site whilst a Community can consist of a number of Sites and other resources described in SIOC or other ontologies (e.g., FOAF). Community is linked to its constituent parts using the property dcterms:hasPart.
sioc:Container	**in-range-of:** sioc:has_container, sioc:has_parent, sioc:parent_of, sioc:subscriber_of **in-domain-of:** sioc:container_of, sioc:has_parent, sioc:has_subscriber, sioc:last_item_date, sioc:num_items, sioc:parent_of
sioc:Forum	**sub-class-of:** sioc:Container **in-range-of:** sioc:host_of, sioc:moderator_of **in-domain-of:** sioc:has_host, sioc:has_moderator, sioc:num_threads
sioc:Item	**in-range-of:** sioc:container_of sioc:earlier_version sioc:has_reply sioc:later_version sioc:latest_version sioc:modifier_of sioc:next_by_date sioc:next_version sioc:previous_by_date sioc:previous_version sioc:reply_of sioc:sibling **in-domain-of:** sioc:about sioc:addressed_to sioc:attachment sioc:content sioc:earlier_version sioc:embeds_knowledge sioc:has_container sioc:has_discussion sioc:has_modifier sioc:has_reply sioc:ip_address sioc:later_version sioc:latest_version sioc:next_by_date sioc:next_version sioc:previous_by_date sioc:previous_version sioc:reply_of sioc:sibling
sioc:Post	**sub-class-of:** sioc:Item foaf:Document
sioc:Role	**in-range-of:** sioc:has_function sioc:scope_of **in-domain-of:** sioc:function_of sioc:has_scope
sioc:Site	**sub-class-of:** sioc:Space **in-range-of:** sioc:administrator_of sioc:has_host **in-domain-of:** sioc:has_administrator sioc:host_of
sioc:Space	**in-range-of:** sioc:has_space sioc:usergroup_of **in-domain-of:** sioc:has_usergroup sioc:space_of
sioc:Thread	**sub-class-of:** sioc:Container
sioc:UserAccount	**sub-class-of:** foaf:OnlineAccount **in-range-of:** sioc:follows sioc:has_administrator sioc:has_creator sioc:has_member sioc:has_moderator sioc:has_modifier sioc:has_owner sioc:has_subscriber **in-domain-of:** sioc:account_of sioc:administrator_of sioc:avatar sioc:creator_of sioc:email sioc:email_sha1 sioc:follows sioc:member_of sioc:moderator_of sioc:modifier_of sioc:owner_of sioc:subscriber_of
sioc:Usergroup	**in-range-of:** sioc:has_usergroup sioc:member_of **in-domain-of:** sioc:has_member sioc:usergroup_of

iv. Dublin Core Elements which describe properties of SIOC content items [7]**.**

Table 4. Dublin Core Elements

Elements	Definition
Contributor	An entity responsible for making contributions to the resource.
Coverage	The spatial or temporal topic of the resource, the spatial applicability of the resource, or the jurisdiction under which the resource is relevant.
Creator	An entity primarily responsible for making the resource.
Date	A point or period of time associated with an event in the lifecycle of the resource.
Description	An account of the resource.
Format	The file format, physical medium, or dimensions of the resource.
Identifier	An unambiguous reference to the resource within a given context.
Language	A language of the resource.
Publisher	An entity responsible for making the resource available.
Relation	A related resource.
Rights	Information about rights held in and over the resource.
Source	A related resource from which the described resource is derived.
Subject	The topic of the resource.
Title	A name given to the resource.
Type	The nature or genre of the resource.

Based on Bio-zen and SISC study the SIOC, FOAF, and DC was utilized along with other ontologies such as Creative and Science Commons, Open Biomedical Ontologies, and Health Care and Life Sciences. They applied SIOC as their basic ontology to signify scientific discussion in both publications and Web. Refer to one of the creators Matthias Samwald, SIOC was chosen as a basic ontology in order to its ability to explain scientific discourse in a practical, Web-centric manner [22]. We believe that SIOC, FOAF, and DC and their classes and properties still can be combined with other ontologies such as SKOS to mine more relationships and move toward a more semantic web.

III. Overview on classes/properties' relationships

In this section, we present important ontologies' properties/ classes and their relationships, which can provide insights building an exhaustive framework for social network sites.

The SIOC ontology comprises of two main parts: first, it contains classes and properties that describe discussion forums and posts in online community sites. Second, it includes mappings that relate SIOC to existing vocabularies such as FOAF and RSS. Regarding to literature main concepts in online communities are Site, Forum, Post, Event, Group and User, which are shown in Figure 1. In addition, relationships, sub-classes and properties depicted in Figure 1 provide unique ability for SIOC were not previously possible [10].

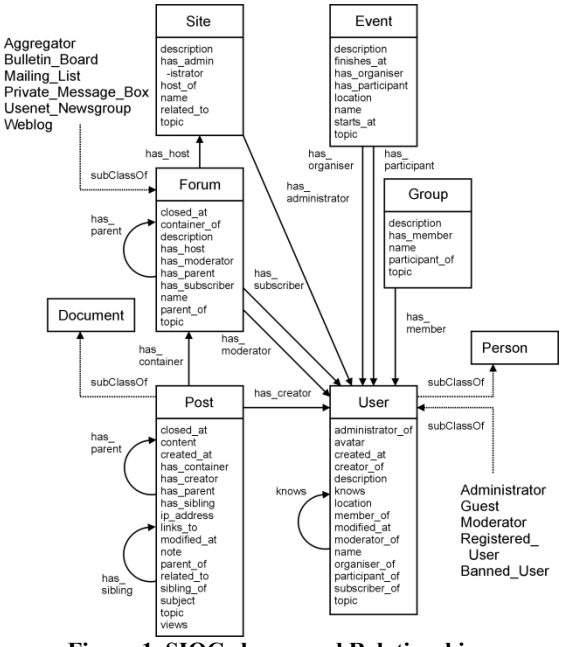

Figure 1. SIOC classes and Relationships

The FOAF documents basically describe personal profiles on weblogs, websites and social network sites. The FOAF vocabulary may be used to describe things but in here we focus on its usage in describing personal information. Based on literature, which explored FOAF on both blog and non-blog websites, the most important properties to better describe person information are listed as below [12]:

Table 5. Most famous classes in FOAF

from non-blog	from liveJournal.com
foaf:name	dc:title
foaf:knows	foaf:interest
foaf:homepage	foaf:nick
foaf:mbox_sha1sum	foaf:weblog
rdfs:seeAlso	rdfs:seeAlso
dc:title	foaf:knows
foaf:nick	foaf:page
foaf:weblog	dc:description
foaf:mbox	foaf:mbox_sha1sum
daml:equivalentTo	foaf:dateOfBirth

As presented in table 5, there exist Dublin Core (DC) elements to help FOAF to describe person information more deliberately.

To understand the relationships between four ontologies, the literature proposed a picture to show relationships between them, which depicts in figure 2 as follows:

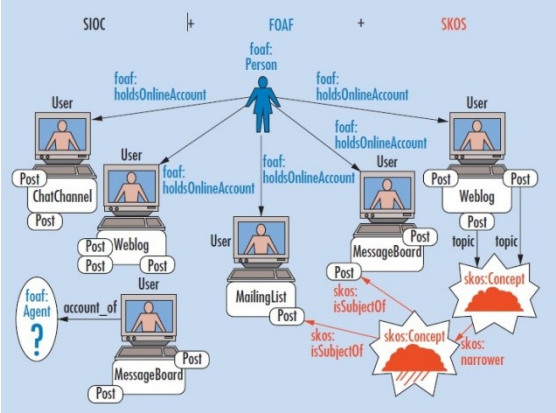

Figure 2. Relationships between Ontologies

Figure 2 depicts relationships between SIOC and other vocabularies such as FOAF and SKOS. The property foaf:Person describes a person who usually owns different online accounts. The sioc:User defines that person on diverse online community sites. The person who has different accounts, can create content by using sioc:Item or sioc:Post through posting. The class sioc:User is a subclass of foaf:OnlineAccount, and the foaf:holdsOnlineAccount property links a person to his or her online accounts. SIOC content items which are shown as Posts in Figure 3 are described using properties from SIOC, FOAF, and DC.

Although topics in social web are defined as categories allot to content item in SIOC (appears in sioc:topic property), SIOC doesn't need the sioc:topic value to be a particular ontology. Thus, SIOC let information system architects to choose the most appropriate ontology to represent topics in each case. One approach, illustrated in Figure 3, uses the Simple Knowledge Organization System (SKOS) schema to represent topic hierarchies and their relationships [22].

IV. Conclusion

In this paper, we attempt to present an overview on semantic web ontologies, and their related classes/properties to provide a guideline for researchers to build a holistic framework which can better describe user-generated content in social network sites and connect them appropriately. We first described social network, second we delved into semantic web concepts and then social network analysis and tools were introduced accompanying with ontologies and related classes and properties. Accordingly, we reviewed over important classes and properties and then relationships between ontologies have been described. As a result, to be able to integrate users' content across the social web and create an applicable framework for a better content management system and facilitate inter-operability between diverse social network sites, first we need to use FOAF to define multiple accounts in social sites, which registered to each person and articulate user- content by using SIOC on these sites. In addition, by using SKOS, information system architects can define the most related ontology to each user- content and tag it appropriately.

V. Significance and limitation of Research

This study contributes to help finding a framework of ontologies' combination through exploring classes and properties within RDF documents and to extract relationships among these RDF files on social network sites. There some researches have been gone through the ontologies and semantic web, but little concentration has been dedicated on how ontologies can be combined and which properties and classes are the best use for more relation and semantics catching. The benefits of this research include better understanding of ontologies and their respective classes and properties, aid introducing a new framework to extract more relevant information from social network sites, and provide a foundation for software developers to build application for social network sites. In addition, as this study has been done on the theoretical basis, there still need to further work to build an exhaustive framework and empirically test it on social network sites to achieve more connectivity and better user content management system.

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