Enhancing Location-Based Social Media Network Services with Semantic Technologies: A Review

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Abstract— Today's location-based social media services have gone beyond mere sharing users' real-time locations via internet, they now serve as the bridge between the real world and the online world. Location-based social media application can now recommend point of interest to users based on geographical information and user's profile gathered on social media networks. Semantic web technology provides tools, platforms and techniques to extract meaning, process and integrate structure data from the social web and other sources. The rapid increase in number of social media networks, the enormous amount of geographical and social data flow across mobile and web platforms, have not only provided rich data source for web applications but also help developers to facilitate location-based social media services. However, unprecedented amount of noise and unstructured data exist on these networks, making knowledge representation, point of interest recommendation and precision of search engine results cumbersome processes. In this paper, we present a review of various semantic technologies that could be deployed to enhance location-based social media services with emphasis on architectures, tools, supporting technologies and the pros and cons of each of these technologies.

Keywords— Ontology, Semantic Web, Social media networks, Point of Interest, Data Mining

1 Introduction

The growing popularity of powerful and ubiquitous wireless devices using various triangulation mechanisms, global positioning system (GPS) and cellular identification technologies, initiated the emergence of Location-based services(LBSs). LBSs are popular information services provided to mobile and web users based on the knowledge of their geographic location. LBSs are services that depend on positional or geographic information of mobile users. They extend spatial and temporary processing capabilities to end users through the internet (Dhar and Varshney, 2011). These services have enjoyed considerable attraction from numerous users due to their potential for a range of highly personalized and context-aware services.

The upcoming generation of these services will involve proactive LBSs that can persistently keep track of users' locations in an automated, unobtrusive manner and proactively notify them about potential useful information in their vicinity (Uzun, Salem and Kupper, 2013). According to Uzun, Salem and Kupper, (2014), the delivery of personalized proactive location based services is based on two main helms: (i) the continuous background tracking of locations (ii) Smart analysis of the retrieved positions or locations with respect to point of interest of a given user. Apparently, a number of position tracking technologies suchas GPS, Wi-Fi positioning and Cellular ID already exit. This solved the first challenge of continuous tracking of locations, leaving us with the challenges of autonomous processing and smart analysis of the retrieved point of interests.

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Semantic technologies play an important role in today's web, redefining knowledge representation and problem solving techniques through use of common vocabularies, link data and other related techniques. Semantic technologies involve application of techniques that support and exploit semantics of information to enhance existing information systems (Polikoff and Allemang, 2003). The inclusion of these techniques into the current web architecture created a knowledge layer just above the usual web layers, which allow the meaning of information to be precisely described such that it is well understood by computers and users (Shruiti and Arora, 2014).

To enable machines to understand and exchange information on the web, LBS providers can use semantic web technologies to develop semantics-enabled LBSs (Ku et al, 2013). Semantic web technology also provides remedies to various challenges associated with centralized social networking services by allowing standardization and reusability of data. Data can now be processed, stored and exported in specified format, which facilitates web data linking. The impact of semantic techniques is being greatly felt in various domains such as media, health, geography, transportation and tourism, especially when developing domain-specific applications that can capture knowledge and enable reasoning (Marko et al., 2009).

The extensive use of social media and real-time geographical mapping through various mobile applications have been greatly exploited indata mining and location based service, and these have had considerable influence on human lives and their interaction with their geo-environment. Mobile and web applications provide huge amount of data, which conveys information about persons, events, locations and user's point of interest (POI). Semantic web technologies allow developers to present these data in unified, standardized format that is understood by machines, thereby minimizing the challenges of noise and low precision associated with today's web and LBSs. LBSs main attraction is that users do not have to input location or POI information manually, rather, the services automatically track relevant data and pinpoint such information to users' locations based on their interest. Semantic web technologies bring such attribute as this into rendering social media location based services (Ilarri et al, 2012).

This paper presents how semantic technologies could be deployed to enhance location-based social media and web services. The focus here is to emphasize the impact of these technologies on existing location-based social media and web applications and also prescribe potential methods through which these technologies can be further harnessed to improve the preciseness of location-based applications. This will also help improve the accuracy of predicting user's POI and recommending locations based on user socio-geographical information on both mobile and web platforms. The objective is not only to stress the applicability of the semantic web technologies as tools or techniques that could be employed to improve applications that use unstructured data, but also to present them as frameworks, which provide knowledge based search that could beused in solving challenges related to geographical location finding and recommendation. User's taste profiling, social media information and also the big influence of location-based service on human socio-geographical interaction are the key ingredients used to facilitate these objectives.

The rest of the paper is arranged as follows: Section 2 presents the overall background and related research works on location based social media applications and semantic web. In Section 3, key semantic web technologies that could be exploited in enhancing location-based social media services are presented. Conclusion and recommendations for future works are presented in the final section.

2 RELATED WORKS

The increase in number of social media users and millions of GPS enabled mobile device connected to the internet have made information sharing easier and create a big network ofstructured and unstructured data. Hundreds of thousands of tweets and Facebook post carries real-time opinion of tens of thousands of social media users about their POIs, events, tourism and other vital information about some locations. Studies indicates that about 80% of an organisation's information is available on the web in the form of documents such as emails, memos, customer correspondence, reports and so on (Wu, Shenghua and Ling, 2013). Although, the bulk of this information can be considered unstructured with a lot of noise, giving a certain degree of trust to them gave birth to various social media services enjoyed by users today.

Many applications have exploited big data flow on social media network to facilitate different services, such as games, location-dependent advertising, tracking, and digital travel assistant. Users now have access to global and valuable services based on their location, context-awareness and social interest. The driver for optimizing location-dependent and context-aware services does not only lies in their economic values but also in their social values (Ilarri et al, 2012). However, challenges such as low precision and recall rate and the capacity to efficiently process location-dependent queries with responses that depend on objects' or events location persist in these areas (Shruiti and Arora, 2014). This is a leading motivation for research in these areas.

Several researchers have exploited the capabilities of semantic web technologies to develop domain-specific applications and ontologies that could capture knowledge and enable reasoning (Marko et al, 2009). An example of such application in location-based domain is presented by Balduini et al. (2013), where an augmented reality application that offers personalised and localised recommendation of POIs based on temporally weighted opinions of the social media community is presented. The authors utilize the potentialities of semantic and web technologies such as inductive and deductive stream reasoning to recommend POI to users and continuously analyse social media stream. These gave them not only an automated POI location recommendation framework but also an understanding of collective users' perception about the POIs of a given location.

Another related work was presented by Ku et al. (2013), where a framework for supporting semantic-enabled location-based service was developed. The framework utilized resource description framework (RDF) data vocabularies to model spatial features and used spatially aware-mapping instead of dictionary mapping to encode uniform resource identifiers (URIs) and literals for preserving spatial locality. The system evaluates spatial queries on RDF triples stores to provide semantics-enabled LBSs. Uzun, Salem and Kupper, (2014), also exploited location semantics to achieve a proactive LBSs by extending an existing LBS with a semantically modelled user-specific location profile and context data cloud.

Shruiti and Arora (2014) and Niemann et al (2009) developed an automated search engine that search, recommends and rate hotels in a given POI location. The authors employed the potentialities of semantic web technologies to enhance precision and recall rates of the search engines. A semantic driven location-based service oriented application is also presented by Gongolidis et al. (2012). The application is able to extract DBpedia data relevant to user's preferences and geographic position. It used Google latitude technology to locate users and exploited RDF standard to presents its data graph and SPARQLAPI capabilities to query DBpedia data set.

However, despite the wide usage of social media networks services, various challenges related to data reusability, database interoperability, low precision and recall rate and the capacity to efficiently process location-dependent queries with responses that depend on objects' or events location still persist. Section 3 presents an overview of semantic web technology and how various semantic web techniques could be used to solve the challenges discussed in this section.

3 SEMANTIC (WEB) TECHNOLOGY

Semantic web technology comprises of set of technologies, tools and standards, which form the basic building blocks of systems that could support the vision of a web imbued with meaning. These technologies emerged out of the desire to improve the World Wide Web such that interoperability and integration of multi-thematic, multi-authored and multi-perspective information and services could be achieved in real-time (Jain et al, 2013).

The term semantic technology is used in this context to describe the application of techniques that support, utilize and exploit semantics of information to complement existing information system. In more practical terms, semantic web technology involves the use of standards and techniques such as RDF, RDF schema, reasoning, data analysis, web ontology language (OWL) and so on. The application of these techniques enable data extraction and preparation of interoperable web information system that could bring knowledge and reasoning into any domain-specific application. Semantic web could generally be considered in three different perspectives, namely the technology, program and vision (Mattews, 2005).

This paper focus on the technology aspect that could be used to improve various social media and location based applications. Semantic web technology supports and makes information creation, retrieval, reuse and integration possible. These values added by semantic web technology is not only suitable for the web but are also picked up to enhance solutions in application areas that have similar challenges such as intelligence and big data analysis, information reusability and integration of data. These solutions provided by semantic technology made it a key ingredient in enhancing location based social media services. Figure 1 shows a typical layered architecture of semantic web, with each layer representing certain technology or tool used to form the embodiment of semantic web technology. Although, each layer (with its associated technology) has it specific purpose, Section 4 describes the layers that are most relevant to the data processing, analytics and managing semantics in location-based services.

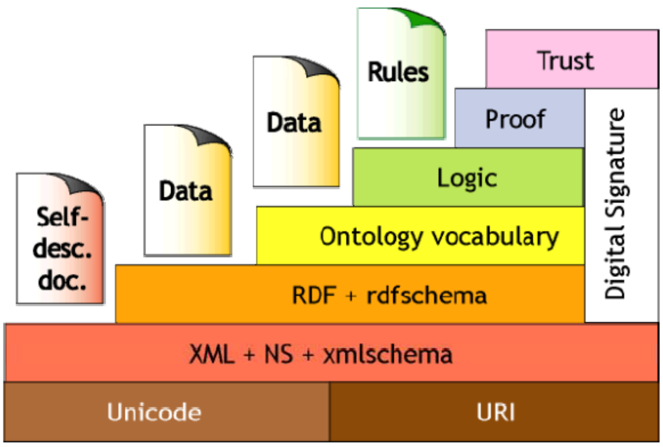

Fig. 1. Semantic Web layered architecture (Berners-Lee et al 2001)

4 LINKING LBSS WITH SEMANTIC (WEB) TECHNOLOGY

Advances in semantic web technologies encouraged the development of domain-specific systems, which allow machines to understand and respond to human queries or requests based on their meaning. These advances can also have interesting applications aimed at location-based service enhancement. For example, the emergence of the linked open data (i.e. web of data, which is a result of semantic web), allows us to transform unstructured and heterogonous data into semantically annotated structured data that is more machine readable, processable and understandable. Thus, in this section, we consider semantic technologies that can enable LBS applications process information automatically and more accurately such that POI recommendation precision and recall rate are enhanced. The technologies would also add values such as reusability of data, interoperability and standardisation to exiting LBSs.

4.1 Ontologies

This is the fundamental ingredient for meaning-centered reconfiguration of syntactic structure, which is one key aspect of semantic technology. It's a richer language for providing more complex constraints on the types of resources and their properties. According to Gruber (1999), ontologies are formal, explicit specification of a shared conceptualization. It involves encoding knowledge using web ontology language (OWL). Ontologies can provide LBSs with knowledge about context, leading to applications that can reason and provide intelligent services (which may be restricted by human).

4.2 RDF (Resource Description Framework)

RDF is a formal language for describing structured information, enabling applications to exchange data on web and preserving the meaning. In contrast with usual HTML and XML, RDF's primary aim is not to display documents correctly but rather to allow further processing and integration of the exiting information with others data sets. RDF is a World Wide Web Consortium (W3C) standard, which uses URIs for describing and distinguishing web resources from each other. It uses graph model for describing relationships between resources. Thus, is regarded as the primary layer of semantic web proper (Mattews, 2005). RDF can facilitate interoperability among LBSs and providers, and also allows easy integration of similar services in different geographical areas, thereby making data or information sharing among different location-based services possible.

4.3 RDF Schema

The RDF schema defines the terms, what restrictions apply and what extra relationships are there in resources and classes. It is a simple type of modelling language used for describing classes of resources and properties between in a basic resource description model. RDF schema provides a less complex reasoning framework for inferring kinds or types of resources.

4.4 Logic and Proof

An autonomous reasoning system provided on top of the ontology structure to make new inferences. Hence, using such a system, an intelligent agent (software agent) can make deductions as to whether a particular resource satisfies its requirements or not. All these semantic web techniques are use with various semantic technologies to enhance social media location based service and applications. Thus, semantic technology enables applications to automatically process information, search more accurately and even make recommendation based on some variables or POI of the user. Services rendered by the semantic-based location applications automatically track relevant data needed to facilitate specified operations. Apart from this, in information services such as LBSs, various semantic technologies enable natural interpretation of information available for user's information needs. This is one of the key attractions of semantic technology.

4.5 Ontology Modelling of Location-Based Service System.

Ontology is one of the key ingredients of semantic web technology and it is extensively deployed in the modelling stage of location based application to populate the system schema with knowledge by extracting and integrating knowledge from multiple data sources. To capture knowledge distribution and properties of historical ties, a language model is utilized to model check-in behavior; human interaction with geographical environment and other social event features that characterize locations and user's interest about the given POI. Ontology defines a common vocabulary for people who need to share such information in a domain. It includes machine-interpretable definitions of basic concepts in the domain and relations among them (Hendler, 2001).

Some other reasons for developing ontology for any location-based service or any information system are: (i) To enable sharing of common understanding of structure of information among people or software agents (ii) Enabling reuse of domain knowledge (iii) Making domain assumptions explicit (iv) Analyzing domain knowledge and separating them from operational knowledge. Ontology modelling in location-based service system involves encoding knowledge representation using OWL Ontologies can provide social media location based services with explicit knowledge about context. Systems developed based on this technique have reasoning capabilities to initiate intelligent services (Noy and McGuinness, 2001).

5 SEMANTICS-ENABLED LOCATION-BASED SERVICES

Location-based social media applications can deploy several semantic technologies such as concepts of ontological and semantic web reasoning, flexible querying techniques, linked data techniques to improve their backend operations. For example, Celino et al, (2012), built their system's reasoning engine on a large knowledge collider platform (LarKC), a service-oriented architecture for building applications with semantics (Assel et al, 2011). The description of various semantic techniques and how they are utilized in various existing location-based applications are described as follows:

5.1 LBSs Data Mining

Location based social network applications are built on two major types of data, the static description of POIs and dynamic context-aware social media streams. Static descriptions of POIs data type are collected either by manual effort from a location data repository or from various related POI websites. The result is used in forming a manually curated high-quality data, geo-referenced knowledge-based in which each point and location are described using various attributes such as name, images, position, address, ambiance, specialties and so on. Online data mining applies in many contexts. Social Media streams are gathered from the mobile and web platform and converted into RDF streams using various techniques and semantic querying tools. Linked open data (LOD) is used to describe the combination of data originated from open source, to such data no license terms apply and it is easy to link different data sets to each other. Supporting LBS with the extensive pool of interconnected data in LOD cloud will improve the LBS experience and allow the development of proactive LBS applications (Uzun, Salem and Kupper, 2014). SPARQL Interface is one of the most powerful open source tools used in semantic web for querying web of data for data sets. It can translate relational data, XML, spreadsheets and other formats to RDF (Gongolidis et al, 2012). Several developers have proposed other proprietary tools. Woensel et al. (2013) developed a framework called SCOUT that provide various techniques for detecting nearby physical entities and extracting their associated online semantic information. Bozzon et al. (2011) also proposed a framework called Search Computing (SeCo), which used a semantic based query language SeCoQL for context-aware service data queries. SeCoQL is aimed at producing top ranked results of context-aware information search.

5.2 Location-Based Social Network Data Analysis

Current researches on location prediction and recommendation focus on predicting user's static home location and user's location at any time by using the user's trajectory information while the user is in motion. The distinct geographical properties and social network information presents various challenges for location-based social network data analysis. The complexities of these networks (such as user-user network, content-content network, user-content or user-location network) indicate the need for deploying efficient data analysis techniques specifically designed for LBSs. Unlike traditional online social network data, location-based social networks provide data consisting of both geographical information and social networks data; the data have unique and distinct properties in various aspects (Gao et al, 2014). These properties include, geographical property, unique and accurate description of geo-spatial locations, explicit social friendship (as in Friend of a friend FOAF), large-scale mobile data and data sparseness.

The geographical property is one of the most significant and distinguishing properties of location-based social network services. With this property, users on the network can check in at a place and share their experiences with friends and other users. This check in attribute indicates the current geographical status of every user. Analyzing the data retrieved provides interesting answers to questions related to location and POI recommendations. Researchers have introduced various data analysis techniques to provide answers to these questions. The techniques are used base on the nature of the social platform, the characteristics of user behavior and the pattern of the data produced by the social network platform. User activity pattern and mobile pattern on large-scale data are two major patterns discussed by researchers as drivers, which dictate the methods of location-based social network analysis.

Li et al., (2009) presented large-scale analyses method that considers different user types and activities on a real world commercial location-based social network. The authors analysed different users' profiles and observed that a large number of users of specific status were willing to participate on social media and share data of some similar feature. The users are said to be more mobile and active. The method classifies users into five groups (normal, active, inactive, mobile and trial users) based on their number of updates, uniquely visited places, user point of interest etc. The majority of the users are categorized as trial users. Vasconcelos et al. (2012) used different type of characteristics to categorise users. They focused on the number of tipped venues, percentage of tips with links and considered lists of to-do and done activities. The authors reported that the largest group was the group of about 86% of users that tip a larger number of locations and get more dons and to-do lists in return. They noted that spam users and unrelated content could be detected by this method. Both Vasconcelos et al. (2012) and Cheng et al. (2011) also considered mobile pattern as another crucial feature used during social media data analysis. The authors grouped users based on their mobility pattern derived from user's updates and movement paths. They categorized users into four distinct groups based on this method, namely home users, home-vacation users, homework users, and other users. Each group presented different mobility pattern.

Content-based approach is another method of providing data service in LBS. The approach examines the richness of location information involved in users'social media posts and proposed a location prediction and recommendation framework based on the correlation between specific terms in tweets and their corresponding locations (Gao et al, 2014). Other methods used for analyzing social media content are qualitative content analysis, linguistic analysis, network analysis and inductive content analysis (Chen, Vorvoreanu &Madhavan, 2014). An example of this system is BOTTARI system, which exploited the availability of highly dense structured and related data on social media stream and also the curated date sets for POI description (Celino et al, 2012). The social media streams are collected from the web of posts and converted to an interoperable format (RDF) using data mining tool. The data on POI description were static with various attributes such as location, range, review, contact etc. These are information regarding a specific place and expressed in RDF format with thousands of triples.

5.3 Linked data techniques

Linked data technique involve employing RDF and hypertext transfer protocol (HTTP) to publish structure data on the web and connecting data between different data sources and efficiently enabling interconnection data of different source (Bizer et al, 2008). Traditionally, data published on web or social media networks are of different format without a specific structure or semantics. Linked data technique is deployed when publishing and connecting structured data on the web. This technique is normally used to facilitate data space connection from various domains or social network platform to enable knowledge sharing. Linked data depends on data in RDF format and is driven by two technologies that are fundamental to the web. These are Uniform Resource Identifiers (URIs) and the Hypertext Transfer Protocol (HTTP). URIs that use http:// scheme identifies /entities; these entities can be looked up simply by dereferencing the URI over the HTTP protocol. HTTP provides a universal mechanism for retrieving resources and descriptions of entities related to a domain, which cannot be sent across the networks themselves (Bizer et al, 2008). This technique was extensively used in the development of BOTTARI-LBS framework. The two main data source used for the application (curated dataset about a specific area and data set gathered from social media) were efficiently linked to other knowledge bases.

5.4 Semantic Reasoning forLBSs.

In order to make sense from different tweets, posts, and stream of feeds, which are continuously published on the social media networks, there is a need for rich background knowledge to fulfil significant reasoning task beyond the normal stream processing capabilities. Deploying reasoning methods to support ever-changing knowledge is one of the key challenges for LBSs. However, various methods exist to tackle this challenge. The two major semantic reasoning methods frequently deployed by developers are inductive stream reasoning and deductive stream reasoning. In authors (Barbieri et al,2010) approach, RDF streams with an enhanced version of SPARQL for continuous queries were deployedto interconnect data streams. The combination of deductive and inductive stream reasoning was used to extend the notion of pure stream reasoning, which involves reasoning in real-time on big and noisy data streams to support many concurrent decision processes.

Many Location based projects and research works pursued stream-reasoning conceptualization within LarKC (Large knowledge collider) framework (Fensel et al, 2008). The LarKC platform has a pluggable architecture to exploit techniques and heuristics from diverse areas such as databases, semantic web and machine learning (Barbieri et al,2010a). The platform was adopted in order to achieve a deductive and inductive reasoning capability on large-scale heterogeneous data collected from the data sources such as social media (Fensel et al, 2008). Since RDF is the primary data interchange format used, it is regarded as one of the key attributes to the success of System's reasoning technique. BOTTARI employ both a deductive and an inductive reasoning technique, which are based on Continuous SPARQL (C-SPARQL) (Celino et al, 2012) and Statistical Unit node set (SUNs) respectively. The Continuous SPARQL is an enhanced version of SPARQL that continuously processes RDF streams observed through a set of windows (Barbieri et al,2010b), while the SUNs is a scalable machine learning approach for detecting large data pattern and predicting unknowns but potentially true statements (Huang et al, 2011) (Barbieri et al,2010b). It exploits regularities in structured and large dataset and also deals with highly sparse related data. The combination of these two approaches was used to produce reliable ranking and recommendation.

6 CONCLUSION AND FUTURE WORKS

In this paper, we have discussed how semantic technologies can be used to enhance the services of location based social network applications. We examined semantic web technology approaches that can be exploited to support location-based applications. This aspect of information processing remains a fast growing area with a lot of potentials. There is no doubt that the deployment of semantic technology will go along way in redefining how the user-driven geographical and eventful information provided by the networks are used to bridge the gap between the real-world and online social media. The use of context-aware information and personalization in Location based Service would lead to highly effective customized services and high level of customer satisfaction. Various applications such as mobile marketing, traffic planning, tourist guide and disaster prediction applications will exploit these available technologies to enhance their performance. By utilizing the different approaches described in this paper, it will be possible to analyse social media information and human mobility patterns to show how human interaction and geo-location information affects human interaction and POI recommendations. Semantic web technology can influence the performance and effectiveness of location-based social network services, enabling the extraction of sense and knowledge out of real-time information analysis and sharing.

Emerging technologies such as Semantic Web, Context-aware service composition and integration of new functionalities in hand-held and wearable communication devices will impact the future of location-based services. In addition, security and privacy issues related to users' context-aware information and exposure of user's location by LBSs need to be improved. Further research work can be done in this area.

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