Smart Cities Based on Web Semantic Technologies

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 Ubicomp/ISWC'16 Adjunct , September 12-16, 2016, Heidelberg, Germany ACM 978-1-4503-4462-3/16/09.
http://dx.doi.org/10.1145/2968219.2968298

Abstract
A good communication and interaction between citizens and the administration is important and crucial, also can greatly help in improving the quality of urban life of citizen. In this paper, we propose a semantic data model for managing and resolving the problems that exist in cities such as water leak, street faults, broken street lights, and potholes. The main idea is to focus on the best practices of linked open data to describe all issues, and then integrate them in the dataset provided by DBpedia. Hence, our approach is based on the standards of the World Wide Web Consortium.

Keywords
Smart cities; Semantic Web; Linked Open Data; DBpedia.

Introduction
Linked Open Data (LOD) has gained significant momentum over the past years as a best practice of promoting the sharing and publication of structured data on the semantic Web 1, 2.

Semantic Web technologies have an extremely high potential and practical impact by providing the ground for new e-services within the ecosystems of cities 3.

Using technologies of Semantic Web, we can develop a set of solutions that might work in parallel with the Internet-of-Things as well as embedded systems. Semantic Web technologies enable to put into practice the Open Government's Data (OGD) principles of transparency, participation and collaboration, in the purpose to integrate citizen within the smart city paradigms 4, 5.

Following that, LOD has the same principle function as OGD, therefore LOD facilitates innovation and knowledge creation from interlinked data; it is an important mechanism for information management and integration. LOD are currently bootstrapping the Web of Data by converting into RDF and publishing existing datasets available to the general public under open licenses. Popular private and public stocks of the semantic web include, among others: DBpedia[1], Geonames[2] and FreeBase[3]. In our context, we chose DBpedia database since it is the most important in the field of the Web of Data.

DBpedia is a project aiming to extract structured content from the information created as part of the Wikipedia[4] project. This structured information is then made available on the World Wide Web by using a package of APIs 6.

The data are automatically extracted from freely available Wikipedia dumps where each single article in Wikipedia is represented by a corresponding resource URI in DBpedia. In this case the URI is considered as unique identifier that makes content addressable on the Internet by uniquely targeting elements. Several RDF statements are generated for each resource by extracting information from various parts of the Wikipedia articles 7.

In 8, RDF (Resource Description Framework) builds on XML to better manage semantic interoperation. RDF is a data model designed to standardize the definition and use of metadata in order to better describe and handle data semantics. Each document written following RDF format is viewed as a set of triples (subject, predicate and object) that can be distributed, stored and treated in scalable triple-stores.

The concept of smart cities is emerged in the international context 9, with the purpose of achieving the objectives established by the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, and by the Kyoto Protocol in 1997.

In 10, Caragliu, defined smart cities as: a city can be defined as 'smart' when investments in human and social capital and traditional (transport) and modern (ICT= Information and Communication Technologies) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.

Using semantic Web technologies, specially LOD, we propose a method that will be used to ensure an efficient management of the smart cities regardless of their nature or size. The main idea behind is to extract

1 http://dbpedia.org

2 http://www.geonames.org/

3 http://www.freebase.com

4 http://wikipedia.org

data from sources that are related to cities, enrich them with tags, and publish them following the LOD paradigm.

The rest of the paper is organized as follows: Section 2 presents the related work. Section 3 and 4 describe the methodologies and tools used for integrating the semantic web in the smart cities. Section 4 ends the paper with conclusions and future directions.

Related Work

In the last few years, several works tried to focus on Semantic Web technologies for extending and integrating smart city data systems 11. In 12, authors present their semantic model to describe the sensor streams, demonstrate an annotation and data distribution framework and evaluate their solutions with a set of sample datasets.

The authors in 13, proposed their approach in building semantic models for consumption in assembling large IT (Information Technologies) solutions in cyber-physical (Smarter Cities) domains. The result, called SCRIBE, is a large-scale semantic model for Smarter Cities based on data gathered from cities worldwide.

The Linked Stream Middleware (LSM) has been developed as a platform that brings both the live real world sensed data and the Semantic Web 14. It provides many functionalities such as: wrappers for real time data collection and publishing; a web interface for data annotation and visualization; and a SPARQL endpoint for querying unified Linked Stream Data and Linked Data.

In 15, 18, authors provides a solution that aims at collecting, enriching, and publishing LOD for the Municipality of Catania in the context of the Italian Smart Cities project PRISMA.

Data Model

In order to illustrate our proposed approach, we have defined an OWL ontology that describes a generic model for an entity.

The main class is called ReportOfFault, which contains the person who can detect and inform the administrator. We define the class Detail for representing the images and photos of fault, and the class Description for including the comment made by any person. The class Status is introduced to determine the status of each fault (started, repairing or finished). Finally, the class Address is defined for representing the address of fault, this class has two sub classes namely, Label (address of fault) and coordinate (Latitude and longitude) (see Figure.1).

Detecting and transforming steps

A good communication and interaction between citizens and the administration is important and crucial, also can greatly aid in improving the quality of urban life of citizen.

Indeed, we propose a semantic data model for managing and resolving the problems that exist in cities as water leak, street faults, broken street lights, and potholes. The main idea is to focus on the principles of LOD to describe all issues, and then integrate them in the dataset provided by DBpedia. Hence, our approach is based on the standards of the W3C (World Wide Web Consortium).

To elaborate this solution, we follow two steps: 1) Detecting the fault by the citizen and reporting it to the public administrator 2) Transforming the information such as photos, e-mail, first name, last name, and phone number into the RDF format, and saving them in the DBpedia database in order to be used later.

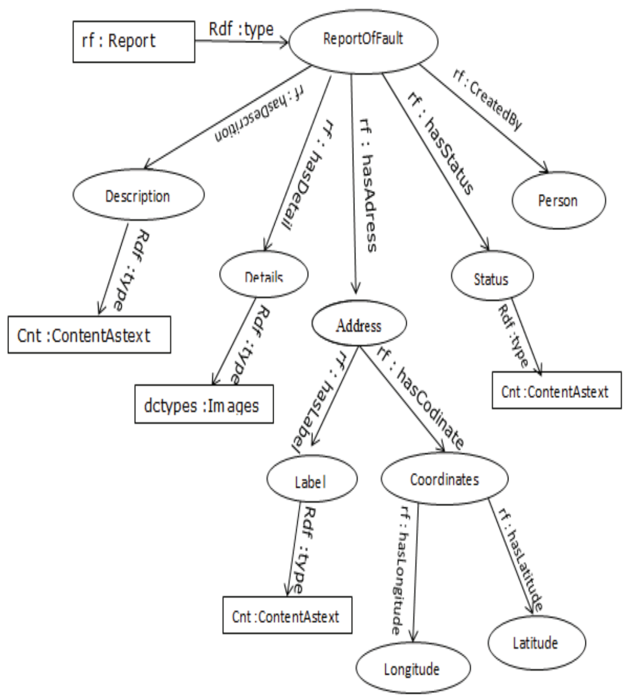

Figure 1: Architecture of the ontology

Detecting the fault

For signaling and detecting any issues in cities, the citizen can begin by introducing some information: e-mail, phone number, date, hour, first name, last name, address associated and geographical localization related to issue (latitude and longitude). The localization is provided automatically by the Geographic Information System (GIS). We used also the mapping service provided by Google, because this service is considered to provide to the end user simplicity, immediacy, accessibility, and responsiveness 17, 16. Following that, the user can select the type of issue like water leak, street faults, broken street lights, and potholes; and may send an e-mail to administrator for signaling any problem in neighborhoods (Figure 2).

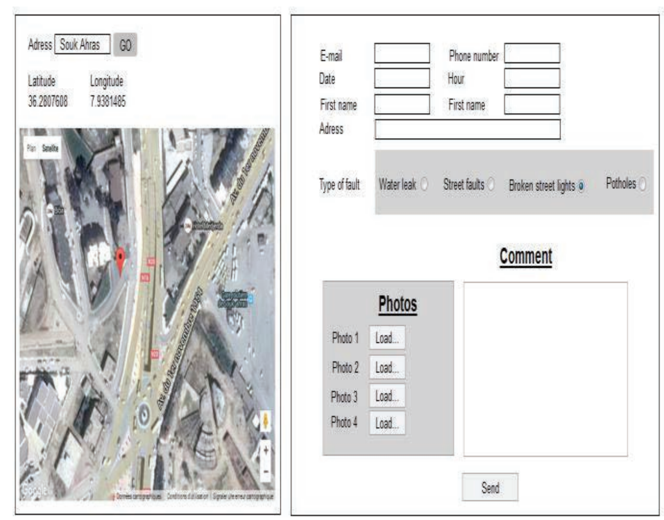

Figure 2: Detect the fault by the citizen

The citizen can also provide some photos to describe the fault. In our case, we limite the number of photo at four due to the size consideration. These information are used to inform in real-time the public administrators about the situation. In addition, the

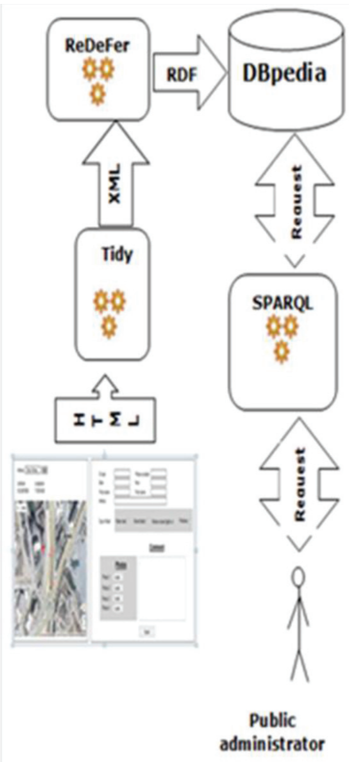

Figure 3: Convert data in RDF and save it in DBpedia

citizen can write a comment to clarify the problem and provide more details to the end of explanation. To avoid spam and false statement, the public administrator must control the current status in which the information can be updated by the citizen. If the information sent by citizen is correct, a report is forwarded to the municipal public relations office, which identifies the office that is responsible to manage and resolve the problem.

Transforming the information into RDF

In this section, we describe methods and tools employed for storing our data in the DBpedia database. Firstly, citizen clicks on the button 'send' to confirm his sending. We can use the utility "tidy" to convert HTML to XML. "tidy" is a small utility, available on many platforms, that allows to easily transform an HTML document into XML document.

We must transform the result code in XML into RDF (Resource Description Language). For doing it, we use a tool for transforming XML data into RDF(ReDeFer[5]), we found more flexible and useful to use a customized conversion script. Finely, the RDF graph is stored in the database DBpedia (Figure 3).

For public administrator, data are accessible by executing SPARQL queries via the Virtuoso[6] triple store. Data are stored in the RDF graphs, and the agent can launch requests using SPARQL to find a new fault in cities.

[5] http://rhizomik.net/html/redefer/

[6] http://dbpedia.org/sparql

Conclusion

In this paper, we have presented several works that focused on Semantic Web technologies for extending and integrating smart city data systems. Therefore, we proposed a semantic data model for helping in the management of the defaults that exist in cities by using the principles of LOD.

Our approach suggests that the citizens can collaborate between the public administrator to improve the state of neighborhoods. In addition, a good communication and interaction between citizens and the administration can greatly aid in improving the quality of urban life of citizen. Two steps are followed to perform this solution: Detecting the fault and Transforming the related data into RDF to be processed in the semantic way. To give more relevance to this work, we are working for implementing all concepts of this purpose. We are also working for testing and integrating other datasets to save our information, namely, Geonames and FreeBase.

As semantic web technology, we used tidy and ReDeFer to transform the HTML into RDF. In the future work, we plan to replace them with RDFa (Resource Description Framework in attribute), which is a W3C recommendation that will allow us to add RDF in HTML attributes of web page. This will help us to analyze our web page by a RDFa parser to extract RDF code.

References

1. BERNERS-LEE, Tim, CHEN, Yuhsin, CHILTON, Lydia, et al. 2006. Tabulator: Exploring and analyzing linked data on the semantic web. *In: Proceedings of the 3rd international semantic web user interaction workshop*. p. 159.

2. BIZER, Christian, HEATH, Tom, et BERNERS-LEE, Tim. 2009. Linked data-the story so far. *Semantic Services, Interoperability and Web Applications: Emerging Concepts*, p. 205-227.
3. BISCHOF, Stefan, KARAPANTELAKIS, Athanasios, NECHIFOR, Cosmin-Septimiu, et al. 2014. Semantic modelling of smart city data.
4. VON LUCKE, Jorn et GEIGER, C. P. Open Government Data–Frei verfugbare Daten des offentlichen Sektors. 2010. Gutachten, Deutsche Telekom Institute for Connected Cities, Zeppelin University, Friedrichshafen.
5. BAUER, Florian et KALTENBOCK, Martin. 2011. Linked open data: The essentials. *Edition mono/monochrom, Vienna.*
6. DI NOIA, Tommaso, MIRIZZI, Roberto, OSTUNI, Vito Claudio, et al. 2012. Exploiting the web of data in model-based recommender systems. *In: Proceedings of the sixth ACM conference on Recommender systems*. ACM. p. 253-256.
7. BIZER, Christian, LEHMANN, Jens, KOBILAROV, Georgi, et al. 2009. DBpedia-A crystallization point for the Web of Data. *Web Semantics: science, services and agents on the World Wide Web*, vol. 7, no 3, p. 154-165.
8. MANOLA, Frank, MILLER, Eric, MCBRIDE, Brian, et al. RDF primer. 2004. W3C recommendation, vol. 10, no 1-107, p. 6.
9. HALL, Peter, et al. Creative cities and economic development. 2000. Urban studies, vol. 37, no 4, p. 639-649.
10. CARAGLIU, Andrea, DEL BO, Chiara, et NIJKAMP, Peter. 2011. Smart cities in Europe. *Journal of urban technology*, vol. 18, no 2, p. 65-82.
11. BISCHOF, Stefan, KARAPANTELAKIS, Athanasios, NECHIFOR, Cosmin-Septimiu, et al. 2014. Semantic modelling of smart city data.
12. BARNAGHI, Payam, WANG, Wei, DONG, Lijun, et al. A linked-data model for semantic sensor streams. 2013. In : Green Computing and Communications (GreenCom), IEEE and Internet of Things (iThings/CPSCom), *IEEE International Conference on and IEEE Cyber, Physical and Social Computing*. IEEE, 2013. p. 468-475.
13. UCEDA-SOSA, Rosario, SRIVASTAVA, Biplav, et SCHLOSS, Robert J. Building a highly consumable semantic model for smarter cities. *In: Proceedings of the AI for an Intelligent Planet*. ACM, 2011. p. 3.
14. LE-PHUOC, Danh, QUOC, Hoan Nguyen Mau, PARREIRA, Josiane Xavier, et al. 2011. The linked sensor middleware–connecting the real world and the semantic web*. Proceedings of the Semantic Web Challenge,* vol. 152.
15. CONSOLI, Sergio, REFORGIATO RECUPERO, Diego, MONGIOVI, Misael, et al. 2015. An urban fault reporting and management platform for smart cities. *In: Proceedings of the 24th International Conference on World Wide Web*. ACM. p. 535-540.
16. KOUA, Etien L., MACEACHREN, Alan, et KRAAK, M.-J. 2006. Evaluating the usability of visualization methods in an exploratory geovisualization environment. *International Journal of Geographical Information Science*, vol. 20, no 4, p. 425-448.
17. KOUA, Etien L. et KRAAK, M.-J. 2004. A usability framework for the design and evaluation of an exploratory geovisualization environment. *In: Information Visualisation, 2004. IV 2004. Proceedings. Eighth International Conference on*. IEEE. p. 153-158.
18. RECUPERO, Diego Reforgiato, CASTRONOVO, Mario, CONSOLI, Sergio, et al. 2016. An innovative, open, interoperable citizen engagement cloud platform for smart government and users' interaction. *Journal of the Knowledge Economy*, vol. 7, no 2, p. 388-412.