IDEA GROUP PUBLISHING
701 E. Chocolate Avenue, Suite 200, Hershey PA 17033-1240, USA
Tel: 717/533-8845; Fax 717/533-8661; URL-http://www.idea-group.com

ITB12832

This paper appears in the book, *Emerging Trends and Challenges in Information Technology Management, Volume 1 and Volume 2* edited by Mehdi Khosrow-Pour © 2006, Idea Group Inc.

Applications Utilising the PHOAF Prototype for Integrated ENUM and FOAF Queries

Kurt Reichinger, Vienna University of Technology, Computer Science Department, Institute of Information Systems, Database and Artificial Intelligence (DBAI) Group, A-1040 Vienna, Austria, Phone: +43 (1) 58801 18403, Fax: +43 (1) 58891 18492, http://www.dbai.tuwien.ac.at/, reiching@dbai.tuwien.ac.at

Gerd Reichinger, Vienna University of Technology, Computer Science Department, Institute of Information Systems, Database and Artificial Intelligence (DBAI) Group, A-1040 Vienna, Austria, Phone: +43 (1) 58801 18403, Fax: +43 (1) 58891 18492, http://www.dbai.tuwien.ac.at/, gerd.reichinger@brz.gv.at

Robert Baumgartner, Vienna University of Technology, Computer Science Department, Institute of Information Systems, Database and Artificial Intelligence (DBAI) Group, A-1040 Vienna, Austria, Phone: +43 (1) 58801 18403, Fax: +43 (1) 58891 18492, http://www.dbai.tuwien.ac.at/, baumgart@dbai.tuwien.ac.at

ABSTRACT

Linking Electronic Number Mapping (ENUM) with the Semantic Web proposed by the authors in previous work necessitated a prototype for proofing the concept and application examples for further analysis. ENUM is a protocol for mapping a telephone number to a Uniform Resource Identifier (URI) giving access to a wide range of a person's (communication) identifiers. Friend-of-a-friend (FOAF) is a project for machine-readable modelling of social networks based on the Resource Description Framework (RDF). In this paper a JAVA-based prototype called PHOAF is introduced, enabling ENUM query, ENUM data retrieval, FOAF RDF file lookup and FOAF RDF file parsing. Application examples utilising that PHOAF capabilities are used to evaluate the concept. The examples range from VoIP add-ons to a semantic phonebook directory and increasing trust for FOAF data.

INTRODUCTION AND MOTIVATION

As outlined in earlier papers regarding introducing ENUM to the Semantic Web by the authors [10, 11] a prototype implementation as well as application examples are needed for a proof-of-concept and to identify critical issues to be examined further.

Therefore a prototype was designed and implemented in Java [12]. The prototype is designated for looking up the ENUM DNS database for a given telephone number, retrieving the ENUM data, detecting the location of FOAF RDF data using different methods and parsing a FOAF file for relevant data. The prototype's name PHOAF indicates the combination of *PHO*NE numbers and the FO*AF* model.

The first example application presented in this paper is enriching the result of a standard ENUM query with information from FOAF. This is especially useful when setting up a VoIP call and a full set of information on the called party can be presented to the calling party on the screen of the VoIP device.

A second example application models the internal structure of a company with departments, working groups, employees and their relations and uses this taxonomy with ENUM for automatically redirecting incoming connections.

Another example application spices up an ordinary personal phonebook (directory) typically used in mobile phones or personal digital assistants. With the combination of personal phonebook entries and publicly available information from ENUM and FOAF it becomes possible to discover relations between contacts, detect previously unknown contacts and model a semantic phonebook contact network.

A fourth example introduces a trust rating for FOAF data. As ENUM data and FOAF data is stored in logically and physically different databases it becomes a possibility to set a higher trust level for those URIs found to be matching in respective queries.

ENUM AND FOAF

ENUM is the acronym for Electronic Number Mapping and describes a protocol specified by the Internet Engineering Task Force (IETF) [6], which defines the mapping of a Telephone Number in the international format as specified by the International Telecommunications Union (ITU) [8] to an Internet Domain Name, which can subsequently be used for supporting a wide range of (communication) services. The introduction of ENUM brings the opportunity to use an ordinary E.164 telephone number as a single, unique identifier for pointing to other (communication) identifiers and services related to the holder (owner) of that telephone number.

ENUM utilizes the Internet Domain Name System (DNS) with the Naming Authority Pointer (NAPTR) DNS Resource Records (RR) holding the information on URIs and services associated with a telephone number. That information can be retrieved by means of a qualified DNS query. The range of URIs and related services, which can be made available via the NAPTR RRs, is broad. The services proposed for ENUM implementations are explained in a technical report by the European Telecommunications Standardization Institute (ETSI) [5]. Each of these so-called "ENUMservices" indicates how an associated URI should be interpreted by the application initiating the ENUM DNS query and therefore adds meaning to a URI.

FOAF is the acronym for Friend-of-a-friend and describes a Semantic Web project for machine-readable modelling of social networks [4, 9]. FOAF is based on the Resource Description Framework (RDF) with a specification defining terms that can be used in statements that can be made about someone, such as name, gender and various online attributes. Additionally, FOAF enables linking to ones friends resulting in a social network of FOAF-connected persons.

FOAF is organised in a highly decentralised way with FOAF data being distributed over the Web. The owner of a FOAF RDF file has to administer the data and to publish the file to be publicly accessible on

the Web. Agents capable of spidering the Web and harvesting FOAF data can retrieve the information for further processing.

PHOAF – A PROTOTYPE FOR ENUM AND FOAF QUERIES

The authors' theoretic concept of integrating ENUM and the Semantic Web's FOAF needed a prototype to better evaluate proposed applications. Therefore a JAVA prototype named PHOAF was developed. The main functionalities of PHOAF are looking up the ENUM DNS database, retrieving the ENUM NAPTR data, detecting the location of FOAF RDF data (i.e. a foaf.rdf file) using different methods and finally parsing a FOAF file for data requested by the respective application. The PHOAF architecture's focus is on simplicity. PHOAF utilises the Java 2 Standard Edition 1.4 (JDK) namely using the javax.naming directory (for DNS query) and the Java Swing library's HTML parser (for FOAF link tag detection). Additionally, the SAX parser is used for the XML parsing of FOAF files. PHOAF is implemented as Web frontend in Java Server Pages (JSP) directly calling static methods of the utility classes.

PHOAF allows three different input parameters to start a query (figure 1):

- Start ENUM DNS NAPTR query with given phone number – the result is a list of URIs and services of the queried phone number's owner
- Start FOAF RDF file lookup with given web URL – the result is the exact location of a foaf.rdf file
- Start FOAF RDF file parsing with given location of foaf.rdf file – the result is data available from the foaf.rdf file

Appropriate results of any of these three operations can be used to start any further query. Should an ENUM query result contain another phone number, that phone number again can be used as input for another ENUM DNS NAPTR query. The same applies to FOAF data results, with e.g. a phone number used for an ENUM DNS NAPTR query or a website URL for a FOAF RDF file lookup.

The results of these queries can be manifold. In the case of an ENUM DNS NAPTR query using a given phone number a typical result is shown in the left-hand screenshot from figure 2. The query result page indicates a successful query with two e-mail addresses and one web URL returned. As it is not clear in the first instance whether the web:http URI is just a simple website or the location of a foaf.rdf file, both "Visit website" and "Lookup FOAF RDF file" are listed as options for further action.

Choosing the "Visit website" option opens the website described by the URL retrieved in a browser window, while choosing "Lookup FOAF RDF file" starts another PHOAF operation looking to find a valid FOAF RDF file (named foaf.rdf) at the retrieved location.

Looking for a FOAF RDF file can be done in different ways, as there are different ways the existence of such a file can be annotated. PHOAF is designed to work with two options:

Figure 1. Flowchart of JAVA prototype operations

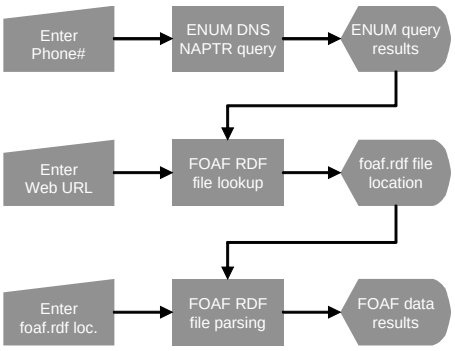
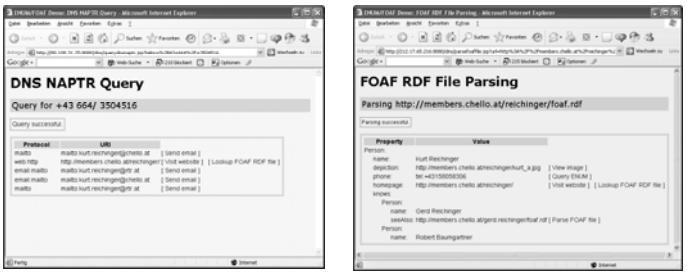


Figure 2. Screenshot of DNS NAPTR query result (left) and FOAF RDF file parsing result (right)



Explicit annotation of FOAF RDF file using the HTML link tag: This method works in a similar way bloggers are pointing to their RSS feeds. A link is placed in the <head> section of an HTML file and looks like the following: <link rel="meta" type="application/rdf+xml" title="FOAF" href="foaf.rdf" />

No explicit annotation of FOAF RDF file: In this case, a given URL (e.g. found by doing an ENUM DNS NAPTR query) can be used for an "educated guess" regarding the location of a FOAF RDF file.

As there are various ways of specifying a URL (e.g. www.example.com without the HTTP referrer, http://www.example.com with HTTP, http://www.example.com/ with a slash at the end or http://www.example.com/index.html including the name of a HTML file), guessing the right location for insertion of the foaf.rdf string (e.g. http://www.example.com/foaf.rdf) is not trivial. PHOAF's FOAF RDF file guessing algorithm takes such distinctions into account.

Should a FOAF RDF file lookup have been successful, PHOAF offers to "Parse FOAF file", i.e. to subsequently retrieve information available from the foaf.rdf file. The PHOAF parsing algorithm is based on a simple XML parser, screening an XML/RDF file for the FOAF RDF properties needed by the applications proposed in this paper. However, it is an option to utilise RDF Query Languages [1] in future PHOAF versions. The right-hand screenshot from figure 2 shows a typical result of such a FOAF RDF file parsing, namely the person's full name, a phone number, a homepage and a link to a depiction as well as the names of two other known persons. One of these two persons (Gerd Reichinger) was found to be described having an own FOAF RDF file which again can be parsed using PHOAF.

USAGE SCENARIOS

In this chapter several application examples combining ENUM and the Semantic Web are presented. All examples take advantage of the PHOAF prototype's basic capabilities introduced in chapter 3. However, the previously separate PHOAF operations are now used in a combined and integrated way.

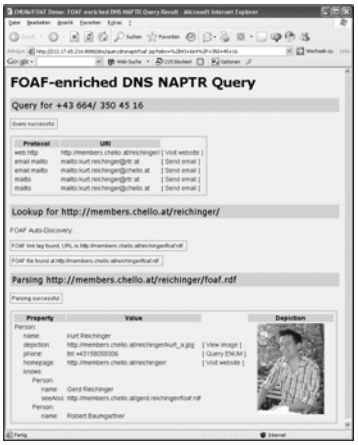
VoIP Called Party Information Presentation

The first application example combining ENUM and the Semantic Web by utilising PHOAF is enriching the result of a standard ENUM query. It uses a telephone number entered by the user (or an agent) to search for relevant data in ENUM and FOAF, and to present that information in aggregated form to the user.

The application works with a telephone number in the international format as input either manually or by an agent importing the telephone number from a VoIP client, for instance. The application shows (in the example screenshot from figure 3) the called party's full name, a depiction, a private homepage URL, two e-mail addresses and a further phone number. In addition, the application indicates two other persons to be known by the called party (foaf:knows property) with one of them (Gerd Reichinger) being described by an own FOAF RDF file.

In this type of application, PHOAF can either be used as a stand-alone client on the user's device or server-sided with the VoIP provider

Figure 3. Application utilising PHOAF for presentation of additional information on a contacted person or company



transmitting the data found (or ordered by the calling party) to the customer (push service). Further options are the integration in Semantic Web Portals [13] or to use a telephone number as unique key to semantic personalisation information in order to give a user optimal support in accessing, retrieving and storing information [2].

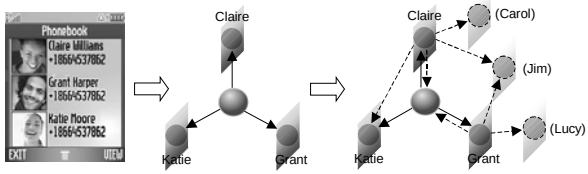
VoIP Call Forwarding on Called Party Availability Information

A second example application is modelling the internal structure of a company with departments, working groups, employees and their relations and using this taxonomy with ENUM for automatically redirecting incoming connections to a person (or service) defined to be related with the person (or service) contacted initially. The degree of relationship between a company's employees can be mapped onto the ENUM data. The Semantic Web's reasoning capabilities add extra value by enabling the establishment of well-founded redirect options or rules. This could be used in the form of a Computer Telephony Integration System typically installed in call centre environments for Customer Relationship Management. A practical implementation of this example is planned to be presented in detail in a future paper.

Phonebook Contact Network

Another example examined is spicing up an ordinary personal phonebook (directory) typically found in mobile phones or personal digital assistants by means of additionally available ENUM and FOAF RDF information. Using the data available, in most cases at least a contact's name and phone number, PHOAF will first perform an ENUM DNS NAPTR query for each and every single phone number found in the phonebook. The data found in ENUM already is a valuable enhancement to a user's phonebook as URIs like e.g. e-mail address, SIP AoR, website URL or fax number could be added to the phonebook. However, it is the FOAF RDF file lookup and the FOAF RDF file parsing that adds even greater extra value. Using the information available from FOAF, it becomes possible to discover relations between contacts as well as previously unknown contacts. The data retrieved can be used for modelling a network of primary (already known) and secondary (previously unknown) contacts. Such a network can be built with contacts modelled as nodes and their corresponding relations modelled as directed arcs. A relation of two persons is annotated as a triple, with the arc pointing from the person that has stated to know another person (by means of a FOAF-knows relation) to that other person. As triples are one of the building blocks of RDF, the resulting phonebook contact relations can be easily annotated by e.g. a new FOAF RDF file forming a network of persons, their relations and individual descriptions.

Figure 4. Weaving a contact's network out of a simple mobile phonebook



In the example from figure 4 the sequence of actions necessary is shown. First, a simple network is created out of data directly available from the personal phonebook with the phonebook owner as central node and the contacts as adjacent nodes. In a second step, PHOAF performs ENUM and FOAF queries searching for further details of the contacts.

In the example from figure 4, Claire has stated in her FOAF file to know Katie and three other persons (Carol, Jim and the phonebook owner) annotated as light grey (secondary) nodes connected with dashed arcs. Two of them (Jim and the phonebook owner) are found to be also known by Grant. It has to be noted that Carol, Jim and Lucy have not been known to the phonebook owner prior to the first run of PHOAF. It is up to the phonebook owner to add those new contacts (as well as their relations) to the personal phonebook.

Introduction of Trust on Corresponding Data in ENUM and FOAF

A last option presented in this paper is to introduce a trust rating for corresponding data available both in ENUM and the Semantic Web's FOAF [5].

In the case of a comparison of URI's from ENUM and FOAF resulting in a match (e.g. an identical e-mail address is found in ENUM and FOAF), this gives an indication of a higher probability that the respective URI (e.g. the e-mail address) is correct. This is due to two facts. First, ENUM is used for all-day communication purposes and therefore a rather high probability of the NAPTR RRs containing correct and up-to-date information can be expected. Otherwise ENUM-based services would not work properly, which is contradictory to the interest of the party maintaining the ENUM data (i.e. the called party). Second, ENUM offers the opportunity to have the NAPTR RRs updated in rather short intervals depending on the respective application. So, the person (or an agent) responsible for the NAPTR RRs can alter the preferences within ENUM according to specific situations (e.g. no voice service URI at all from 9:00 to 10:30, voice URI from corporate extension from 10:30 to 12:30, voice URI from mobile phone number during lunch time, e-mail URI on weekends, and so on). Again, this means ENUM data must be correct and up-to-date for the associated applications to work. In conclusion, it becomes possible to introduce a trust level for FOAF data, if corresponding ENUM data results in a match. Therefore it is proposed to add a "thumbs up" indicator to FOAF data after a positive ENUM-type verification. A practical implementation is planned for future work.

CONCLUSIONS AND FUTURE WORK

The paper introduces the PHOAF prototype performing ENUM query, ENUM data retrieval, FOAF RDF file lookup and FOAF RDF file parsing. PHOAF supports the design of applications integrating the concepts of ENUM and FOAF. Accordingly, application examples utilizing the PHOAF capabilities are presented, fostering the author's proposal of moving Telecommunications (ENUM) and Semantic Web (FOAF) closer together for the benefit of both areas. As work in this area progresses, it is planned to implement further application examples utilising the PHOAF prototype and to evaluate the applications in real-world environments.

ACKNOWLEDGEMENT

This research has been partially supported by REWERSE, a research "Network of Excellence" (NoE) on "Reasoning on the Web" (http://rewerse.net) within the 6th European Framework Program of the European Commission.

REFERENCES

1. Bailey, J., Bry, F., Furche, T., and Schaffert, S.: Web and Semantic Web Query Languages: A Survey. In: Reasoning Web, First International Summer School 2005, Malta, July 2005.
2. Baldoni, M., Baroglio, C., Henze, H.: Personalization for the Semantic Web. Reasoning Web, First International Summer School, LNCS, 2005.
3. Berners-Lee, T., Fielding, R., and Masinter, L.: "Uniform Resource Identifiers (URI): Generic Syntax," RFC 2396, August 1998.
4. Brickley D., Miller L.: FOAF Vocabulary Specification, http://xmlns.com/foaf/0.1/, July 2005.
5. European Telecommunications Standardization Institute: Minimum Requirements for Interoperability of ENUM implementations, TS 102 172 V1.2.1, ETSI, May 2005.
6. Faltstrom, P., Mealling, M.: The E.164 to Uniform Resource Identifiers (URI) Dynamic Delegation Discovery System (DDDS) Application (ENUM), IETF RFC 3761, 2004.
7. Golbeck J., Hendler J., Parsia B.: Trust Networks on the Semantic Web, World Wide Web Conf. WWW2003, May 2003.
8. International Telecommunications Union, ITU-T Recommendation E.164, The International Public Telecommunication Numbering Plan, approved May 1997 incl. Supplements 1 – 4
9. Mika, P.: Social Networks and the Semantic Web. Proc. of the Int'l Conf. on Web Intelligence (WI2004), IEEE Computer Society Press, 2004.
10. Reichinger, K., Baumgartner, R.: SEMNUM RDF Vocabulary Specification v.01, DBAI Technical Report, http://www.dbai.tuwien.ac.at/local/reports/semnum.pdf, December 2004.
11. Reichinger, K., Baumgartner, R.: Introducing ENUM to the Semantic Web, Proceedings of the IASTED Int'l Conf. on Web Technologies, Applications and Services WTAS2005, July 2005.
12. Reichinger, K., Reichinger, G., Baumgartner, R.: A Prototype for Integrated ENUM and FOAF Queries, Demo Presentation, Int'l Semantic Web Conf. ISWC2005, November 2005.
13. Stollberg, M., Lausen, H., Lara, R., Ding, Y., Han, S., Fensel, D.: Towards Semantic Web Portals, Proceedings of the WWW2004, May 2004.