RING: A Context Ontology for Communication Channel Rule-based Recommender System

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Abstract. Since a few years there has been an explosion of communication possibilities. The wide number of communication channels available nowadays brings, with no question, enormous benefits for the users, however it brings new challenges as well. The choice of the best communication channel not only depends on the characteristics related to the channel itself (QoS, rates, etc.); the user context (location, personal agenda, etc.) affects the decision as well. The combination of all the factors generates a list of variables impossible to handle by the human being. The information available about channels, together with the information that smart devices are able to extract from the user context, make possible to introduce a computing system to help the user in selecting the most appropriate communication channel.

In this paper we present RING, a context-aware ruled-based recommender system for the automatic Redirection of incomING communications based on Semantic Web, that allows users to receive any kind of communication through the best channel available depending on his context and personal preferences.

Keywords: Communication Channels, Semantic Web, Context Ontology, Rule-based Recommender.

1 Introduction

Within the telecommunications, telephony is one of the technological development fields with an ever-growing demand for services in recent years. Today, the fact of being able to establish different communications anywhere at any time is a request from users. This is the reason why, to ensure they have access to the communications channels they require, they used to be subscribed to several communication services.

Voice services currently offered by the telecommunications operators consist on fixed telephony, mobile telephony and voice over IP (VoIP). The variety of voice services, along with the infinite possibilities regarding companies, devices, etc., promotes the increment of multi-connected users; users that have multiple active connections through single or multiple voice services. As might be the case of a user with more than one SIM card, multiple telephone lines (in the same or different location) and multiple registrations to operate with VoIP. This situation makes the user to become a “communication center” and the need for new technologies to handle the single user - multi-channel communication paradigm arises.

On the other hand, the consumer behavior has dramatically changed during last years on the way they are carrying out the communication. Twitter, Facebook, SMS, WhatsApp, BBM (BlackBerry Messenger) and many others have pushed the typical synchronous voice communication into the background. These new tools or technologies offer the possibility of an asynchronous multi-channel communication. The user will decide to use or to be addressed at one of these services depending on his/her current location, as on economic and social factors, this is the user’s information context.

The goal of the recommendation system proposed in this paper is to provide the best outbound communication channel, in order to reach the end-user based on the current user’s context. Therefore, it could make possible the integration of all the services of a given user in a unique endpoint. This can be used, for instance, for redirecting incoming calls to the service which better fulfills the requirements of the destination user at a given time. The system would offer a "virtual integration" of voice services, providing flexibility and adaptability when routing voice traffic, deciding the service which will carry out the communication in order to fit the user necessities.

Ontologies describing the user’s context can be employed to support processes focused on user features, situation and preferences, as for instance rerouting calls systems. User profiling is commonly used to support customization and flexibility [1]. RING ontology aims at creating a user’s context model for describing the current situation of a user with reliable information to be used for outbound communication channel recommendation.

The smart phones, social networks and, in general, the Information Technologies allow extracting reliable information of the user’s context, so-called Context Awareness. It deals with the fact that smart phones typically include apps (i.e. contacts or agenda related apps), multiple sensors and features that can be used to define the user’s current situation in a very accurate manner at any time. Also the social networking services make possible to improve and verify this information. In consequence, information as location, current activity, relationships, social status, camera input, etc., can be used to establish the user’s context [2].

As the user’s context information is extracted from independent and heterogeneous systems, like smart phone GPS, Outlook agenda, social networks, etc. Several agents are dealing with the context information recording and semantic annotation.

Ontologies have been proved to be an effective mean for representing knowledge related to user context. Ontologies depict concepts and relationships at a high level of abstraction, which allows human beings to understand the model representation. Well designed ontologies enable machines to use the knowledge-base and apply reasoning techniques to obtain results [1].

The remainder of this paper is organized as follows. Section 2 provides a thorough related work as a starting point. In Section 3 a motivation example is presented to introduce the problem faced in multi-channel communication. Section 4 explains and defines the RING user’s context ontology. The application of RING ontology to a communication channel rule-based recommendation system is illustrated in section 5. Finally, section 6 shows the conclusions and future work.

2 Related Work

The term Semantic Web has recently been coined to designate the next-generation Web, where content, which has semantic information, are independent of the presentation to the user, and can be processed automatically without human intervention. This creates an environment where software agents can perform tasks efficiently [3].

The Semantic Web requires a formal structure to represent the knowledge associated with the data, which is the role that ontologies are playing [4]. The two-pronged use of ontologies has the dual functions of allowing humans to grasp the meaning of any element having a well-defined vocabulary and, secondly, having formal semantics to support reasoning. In our approach, using semantic technologies as the key technology enables the data management of data generated due to the use of smart mobile phone devices (aka. Smartphones). This technology has already been used to represent knowledge in a variety of domains, such as clinical [5,6], organizational memory [7,8], knowledge management [9], bioinformatics [10] and even e-learning [11]. Ontologies allow the knowledge they contain can be reused and shared, so that their use greatly reduces the effort needed to implement expert systems. Ontologies are a key technology for the Semantic Web [12].

In this work we focus on context ontologies, they are used in context-aware systems, such as the one we propose, which exploit contextual information in order to generate recommendations or provide relevant information to the users [13]. A number of context ontologies have been developed for a variety of fields [14,15,16], there have been some efforts, as well, in the development context ontologies for mobile environments [17,18], it is worthwhile to mention the ontology in [19], where the authors present a context ontology in the mobile environment with the objective of representing the knowledge about the user regarding his interaction with mobile devices. This approach is similar to the one we present whilst this manuscript, however, our focus is not just on mobile devices, we consider all the possible communication channels that a person can use, and the contextual information that can be extracted from them.

By leveraging the Semantic Web technologies, recommendation agents enhance their understanding of users and their needs. The recommender systems can offer specific recommendations for a given user by means of personalization techniques [20]. Among them, rule-based techniques are well established and broadly used [21]. Regarding rule-based systems, a number of efforts have discussed automated extraction of rules as input to an expert system [22]. A large number of rule-based systems are also applied to very different fields such as process controlling [23], different process types optimizations [24] and treatment recommendation [25] among others. Further efforts explain the benefits of the application of such systems ([26] and [27]), from a theoretical perspective.

Finally, there are context-aware applications in the same field of this paper, such as [28] for call forwarding, [29] for reminders, [30] for social events, etc. Nevertheless, to the best of our knowledge, there is no previous work that has developed a complete ontology for all the possible communication channels to use it in a context-aware rule-based recommender system.

3 Motivating Example: Where the hell is Matt?

"Where the hell is Matt?" refers to a viral video series, where the protagonist, Matt, a young American traveler, from Westport, Connecticut, was dancing around the world with local people in front of famous landmarks and sightseeing spots.

We live in a dynamic world where people, like Matt, change their location and context in a short interval of time. Thus, the telecommunication operators have been driven to increase the amount of communication services in order to fulfill the ever-growing user's requirements. Due to the effort carried out by the telecommunication sector, very likely, Matt was able to communicate with his relatives from almost all the places where he was dancing in a multi-channel communication approach.

These services or communication channels differ from each other in their quality of the service (QoS), rates, security, networks and protocols, type of communication (synchronous or asynchronous), etc. In Matt's case, we can consider that during his trips he had to deal with communication problems, such as different time zones, high voice call rates, lack of 3G connection, etc. Therefore, probably Matt would have loved to specify the best communication channel for every situation, depending on the features offered by the different services and based on his context.

Although his friends and relatives were aware of his location due to the pictures and videos that Matt was uploading to his personal blog, it is quite sure that Matt, as any other young people, was making use of multi-channel communication, by means of different technologies and tools besides his blog, as social networks (i.e. Twitter or Facebook), instant messages programs (i.e. gChat, Microsoft Messenger or Whatsapp) VoIP services (i.e. Skype or VoipBuster), landlines in hotels and hostels, mobile phone, etc. Nevertheless, Matt went to remote places, where he was not reachable by any communication mean, due to lack of network coverage, unavailable services due to location, impossibility of accessing any endpoint, etc. In consequence, the communication was, sometimes, hard or even unfeasible. That situation caused family and relatives trying to connect through all the possible communication channels, as they did not know where, when, and how he was going to be available. In this situation, the recommender ensures that if there is at least one communication channel available, it will choose it automatically. It means that a single communication attempt, which does not succeed, is enough to be sure that Matt is not available at all.

For instance, when the network coverage was too low to maintain a regular conference over mobile phones due to several interruptions in the communication channel, Matt would have rather use SMS communication or chatting application on his smart phone or laptop. Or, when the availability of high speed internet access allowed him to use VoIP services, he would rather choose that than a costly international voice call over the landline. We can even imagine that he was in extreme situations where the only communication channel available was the phone of the chief of an African tribe; a rule in the recommender to forward all the communication to that phone would have been a great help for Matt.

In a nutshell, we face two different problems in the scenario presented here. The first one refers to the fact of managing different telephone numbers and usernames for a single user in order to be able to set up a communication, this is, know all the communication channels endpoints. And the second problem is about choosing the service that better covers the communication requirements for the user based on destination user's context.

The overall situation could have caused communication problems among his friends and relatives to reach Matt over a communication channel. The aforementioned problem can be solved by means of a recommendation system which tells the user who establishes the communication, the best communication channel to reach the destination user at a given moment.

This recommendation system should be able to know Matt's context (location, preferences, communication channels and their characteristics, etc.). To define the context, a semantic approach, by means of an ontology, as RING ontology presented in this paper, can be used for semantic reasoning, inferring logical consequences from a set of rules to be able to make recommendations of the best outbound channel to establish the communication.

4 RING Ontology

The RING ontology captures the model of the callers' information along with necessary context, such as location, preferences, communication channels, planned events or trips. The data stored within the system (modeled after the RING ontology) is used as an input to the recommendation system that is driving the process of communication channel selection. Its main task is to ensure that the communication is successfully established with the other party, which may be a phone call, a message or a VoIP videoconference.

Figure 1 shows the overview of the process of establishing voice connection supported by the RING system. The knowledge for making necessary decision consist of 3 main parts: (i) the data model represented as lightweight ontology (providing definition of concepts, relationships and taxonomies of classes), (ii) rulebase capturing the behavior of recommendation system and (iii) profiles data set.

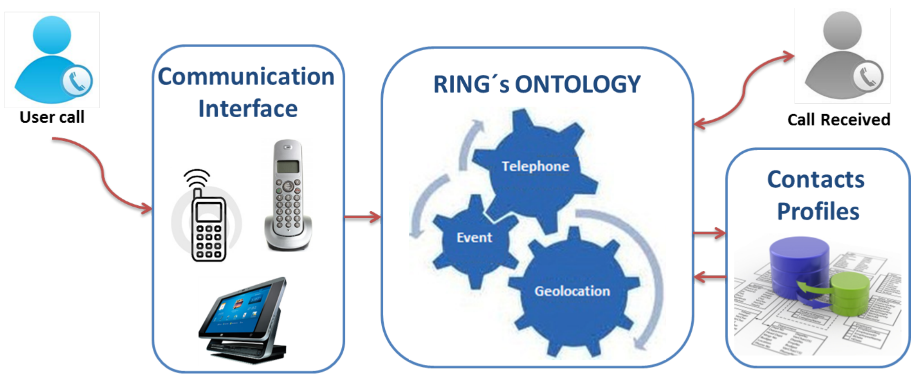

Figure 1: Functionality of RING´s Ontology.

The high-level overview of the data model is presented on Figure 2. It consist of 5 main pillars:

- Geolocation data – a history of user locations (including the most recent one) for building the location profile. It is later related with communicators used in certain places (such as using fix line at home, skype at work, etc.).
- Event schedule – user-planned events (e.g. 2-week travel to Egypt in first half of June). The schedule has priority when directing the message to the recipient, as only a subset of available message channels can be available abroad.
- Contact – list of user's contacts with their numbers (or account identifiers, depending on the communicator).
- Communicators – account list of communicators used by the user.
- Preferred communication channels – list of preferred communication channels (e.g. voice, video, message).

While description of the whole ontology is beyond the scope of the paper, we only explain part of it, to give the reader a gist of the motivation that leaded us to use a context ontology in the RING system.

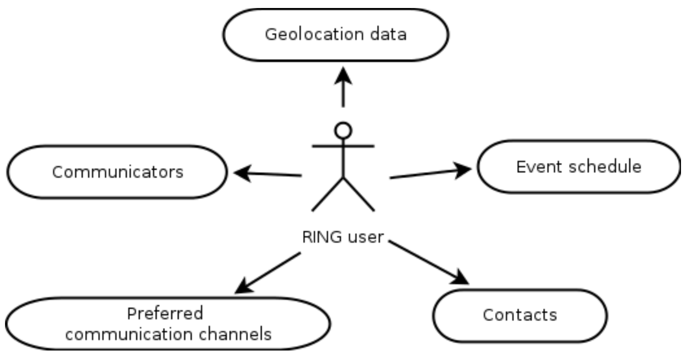

Figure 2: High-level ontology model.

Figure 3 shows a fragment of the RING ontology, which contains the event schedule part. The specific event is an instance of class event, i.e. travelWilliam that contains details of the travel (such as date, destination, etc). It is connected to the concrete user through the relation `participatesInEvent(User, Event)`. Each Event class provides additional characteristics that improve the decision process, such as additional communication means. This can be, for instance, availability of work phone during the working hours (for `Work` event type).

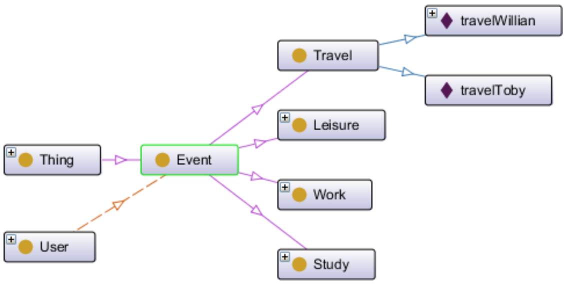

Figure 3: Example of the Event Schedule ontology fragment.

While the five RING pillars describe several aspects of the user's profile, actually they are connected through a much higher number of relationships. Those relationships represent not only facts gathered by the system (ubiquitous geolocation snapshot of user activity, call history, custom habits) or future plans (planned events), but most of the additional knowledge inferred from all the previous facts by applying the forward chaining rulebase system (based on Drools[1] rules).

5 Rule-based Recommendation System: reasoning over the RING knowledgebase

The rule-based recommendation system is being driven by general rules and user preferences. In this way, the recommendation system is using a semantic reasoning engine to be able to infer logical consequences from RING context-aware ontology. The materialized factbase is later augmented with custom, domain-specific knowledgebase in a form of if-then rules (production rule system). Inferred facts (in a form of new data relations) are crucial for communication channel recommendation. The knowledge-based systems with large structures of concepts and rules are being used extensively in a wide variety of applications.

The goal of the recommendation system is to integrate all the communication services of a given user in a unique endpoint and to provide the channel which better fulfills the requirements of the user, based on user's context, at a given time to carry out the communication. The purpose of the integration of the services is to provide to the users with a unique access point to establish communication. Thus it allows other users to contact each other in a straightforward manner and in consequence simplifying the system and increasing the probability to communicate with the end-user. In other words, tie the communication to a user instead to a device, by generating precise recommendations. Therefore the system offers a "virtual integration" of a set of communication channels, providing the service, which will carry out the communication in order to fit the user necessities.

[1] See: http://www.jboss.org/drools/

As explained before, the call is redirected depending on the user's context (location, agenda, etc.) modeled in RING ontology. With this aim, a set of agents deals with external information systems in order to extract all the relevant information to populate the RING ontology. Agents are heterogeneous and independent from each other; they obtain information from different sources, such as smartphones, social networks, and the like. The information collected by the agents is used in the annotation tool to instantiate the knowledge base, which contains the instances of the reference ontology.

The user preferences are a set of rules determined by the user for driving the rule-based recommendation system. These preferences establish a policy in the system. These preferences, used in a later stage to generate the rules, refer to schedules, priorities, costs, location, etc.

6 Conclusions and Future Work

In this paper, we have presented RING, a context ontology for communication channel rule-based recommender system. The representation of user's context data in a semantic modeling in conjunction with the rule-based reasoning are the core parts of the system proposed, which aims to provide recommendation on the best channel to carry out the desired communication.

We truly believe that RING can be integrated in any platforms for rerouting communication requests over several outbound communication channels, to provide recommendations depending on the current situation of the recipient user. Generating an added value to the platform by offering flexibility and adaptability for establishing communications.

Future research lines in the context of RING will analyze qualitative and quantitative aspects for a complete evaluation of the system, a real use case from the project GECALLIA (A Geolocation System for Call Routing based on Artificial Intelligence and Semantic Web) will be used for that purpose.

We will consider as well using a Private Branch Exchange (PBX) or a similar system to carry out call rerouting based on user's context.

Some changes in the proposed system to study the performance of the recommender will be investigated, the use of neural networks instead of rule-based recommender is an appealing option. Another option would be to introduce parameters related to the behavior of the user in different situations, in this way the system would be able to learn with the actions of the user in order to provide more adaptability and flexibility for each user of the system

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