Analyzing the Acquisition and Management of Context

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ABSTRACT

Mobile users want mobile services tailored to their current context and needs. These context-aware services have primarily focused on position information; using other types of user information would enhance the development of smarter services. There is a range of frameworks that manage and distribute user context; however, when several information sources and inference techniques are available, these context frameworks face the need to make appropriate decisions to facilitate the most suitable context information to applications. This article describes strategies to solve a context acquisition problem, namely the choice of the information channel, given available user information and context obtaining services. The proposed context acquisition strategy, based on Bayesian decision theory, improves the frameworks’ decision making and enables integrating and encapsulating a wide set of context inference and reasoning algorithms and data sources, in a well-documented, transparent, and principled way.

KEYWORDS

Context, Context Inference, Context-Aware Services, Decision Making, Decision Networks, Ontology-Based Modelling, Pervasive Computing, Smart Mobile Services

INTRODUCTION

The development of smartphones and communication technologies has had tremendous impact on our daily habits. Two decades ago, mobile phones were primarily used for making calls; nowadays, they are the means for myriads of activities. Specific-purpose applications allow mobile users to do almost anything, from booking a hotel room for the weekend, e-mailing their colleagues, to checking the weather forecast. Not only have mobile applications arisen to help conduct these daily activities, but more user-related information sources are available. It is possible to obtain information about user position, gender and hobbies, among others, and use this information to provide users with tailored services that further facilitate the carrying out of certain tasks. These applications are so-called context-aware applications (Rivero-Rodriguez, Pileggi, & Nykänen, 2016). In practice, most context-aware applications are based on spatial user information, constituting the so-called Location-Based Services (LBS) (Rao & Minakakis, 2003). The success of LBS is due to the relevance of positioning information for user daily activity, its standardization and ease of usage. Using other information,

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e.g. from sensors or social networks (Rivero-Rodriguez, Pileggi, & Nykänen, 2016), would benefit the further development of context-aware applications. Information can be extracted or it can be inferred, such as in the case of user needs, habits, gender or hobbies. Nevertheless, the management of this information raises several difficulties, particularly when mobile applications developers need to create applications that obtain such information without user assistance.

Consider a mobile application that provides specific information or service to the user based on the gender. If the application had access to the user web browsing history, it could analyze this information to determine the user gender. Typically, the app developer should find the means, e.g. some inference techniques or available services, to obtain the missing information based on the available user information. Such services are available; however, the developer may be unfamiliar with suitable tools and would need to spend a significant amount of time finding the most suitable ones. An intuitive solution for developers is to delegate this context management task to context management frameworks. The rest of the paper will use a concrete use case of Tom using such a mobile app. The Context Management framework would need to provide the application with the information of Tom’s gender, given some information about him. The ideas explored in this research work would assist mobile apps to obtain certain information. For instance, it allows to provide users with better information and mobile apps that are tailored to them.

This paper discusses how context management frameworks can solve the problem of choosing the optimal information channel to obtain a specific contextual attribute, based on available services and user information. For ontology-based context-aware systems, the previously proposed approaches to this problem have considered only the accuracy of the information for decision making. This work describes how other relevant parameters for selecting the appropriate channel, such as monetary cost or time of response, can be included in the decision. The optimal channel selection is a trade-off between information accuracy, monetary cost and time of response.

BACKGROUND

Context Manager

Research on context aware systems (CAS) began in earnest in the early 1990’s (Abowd et al., 1999). According to Baldauf et al., context “can refer to any information that can be used to characterize the situation of an entity, where an entity can be a person, place, or physical or computational object” (Baldauf, Dustdar, & Rosenberg, 2007). In a nutshell, the context-aware system may get user-related information from logical or virtual sensors and from different information sources. The context-aware system is responsible for dealing with, reasoning with and distributing context to context-consuming applications (Nykänen & Rivero Rodriguez, 2014).

CASs encapsulate a range of techniques to process information for different purposes such as: i) to obtain user context based on raw sensor data, e.g. using activity recognition methods (inference) to infer user motion status from accelerometer data (Su, Tong & Gi, 2014); ii) to infer user information based on other user-related information, e.g. inferring user profile attributes based on his/her social network structure (Rivero-Rodriguez, Pileggi, & Nykänen, 2015) and iii) to solve data conflicts for integration of two or more sources of information (Al-Shargabi & Siewe, 2013).

The representation of contextual information plays a major role in context-aware systems, since different modeling strategies offer different properties. Several approaches have been proposed for context modelling using key-value models, object-oriented models or ontology-based models, among others. According to Strang and Linnhoff-Popien, ontology-based models offer the most desirable properties such as information alignment, dealing with incomplete or partially understood information, domain-independent modeling, and formally working with context model of varying level of detail (Strang & Linnhoff-Popien, 2004). Our focus lies, therefore, on ontology-based
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