Context and Context-aware Computing

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The notion of context refers generally to all the information that surrounds an activity and additional information about its environment. In their interactions, humans use and take into account their context in an implicit way for better understanding and better behavior change. For example, a person can speak loud in the presence of noise or speak in a low voice in a quiet place. Unfortunately, in a classic human-computer interaction, the computer system has not generally this ability to take full advantage of the context surrounding the interaction. To take advantage of the enormous potential of surrounding information, computer systems should consider the current context to provide adapted and appropriate services. This then requires a good understanding of context for its effective use.

What's Context?

Before presenting the definitions of the context proposed in the field of informatics, we will give the definitions provided by some dictionaries to put it within a general framework. Reference dictionaries include:

- Oxford Dictionary of English: "*The circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood*"
- Cambridge Dictionary: "*the situation within which something exists or happens, and that can help explain it*"
- In Linguistics: "*Context is the part of a text or statement that surrounds a word/passage & determines its meaning*"

According to these definitions, a context is the useful information to interpret something.

The most known definitions of context in the field of informatics are: (Schilit, Adams and Want, 1994) considered that context has three important aspects as answers to the following questions: questions: where you are? who you are with? And resources are nearby? (Brown, Bovey and Chen, 1997) proposed a set of extensible elements to characterize the context whose

basic elements are: localization, all objects which the user needs, time and spatial orientation (direction). (Ryan, Pascoe and Morse, 1997): "The context elements are: user localization, environment, identity and time". (Chen and Kotz, 2000): "A set of environmental states and parameters that determine the behavior of an application or in which an application event occurs that is of interest to the user". A previous study on context in mobile computing by (Chen and Kotz, 2000) showed that the existing definitions of context are general, vague, loose and do not help much to understand this concept in a IT environment. According to (Dey, 2001): "any information that can be used to characterize the situation of a entity. Any entity is a person, or an object that is considered significant to the interaction between the user and the application, including the user and the application themselves". (Henricksen, Indulska and Rakotonirainy, 2002): "the circumstance or situation in which a computer task is taking place ". An analysis by (Brezillon et al., 2004) of the definitions of the context led them to conclude that most definitions are the answers to the following questions:

- Who? identity of the current user and other persons present in the environment;
- What? perceive and interpret the activity of the user;
- Where? localization of the user, or system event;
- When? temporal index of an activity, temporal indexing of an event, elapsed time of the
- presence of a subject at a given point;
- Why? it is a matter of understanding the purpose of the activity;
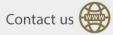- How? the way in which the activity proceeds.

The answers to the questions cited above can lead to a large set of information, much of it are unnecessary. This also requires a greater effort to manage this information. The recent definitions of context were mostly oriented to the adaptation task like the following ones: (Miraoui and Tadj 2007): "Any information that triggers a service or changes the quality (form or mode) of a service if its value changes". (Najar, Saidani et al. 2009): "the context acts as an external element to the computer system that affects its internal variability, and as a parameter guiding the variant and the process of adaptation". (Viana, Miron et al. 2011): "the context is the set of characteristics of the physical or virtual environment that affects the behavior of an application and whose representation and acquisition are essential for the adaptation of information and services".

Despite the large number of existing definitions and their similarities (most of them refers to the localization and the environment), the word context remains always general with loose meaning.

Context Sources

Contextual information could be collected from different sources with different characteristics. These sources are quite numerous because of ubiquity and depend on the field of application. Methods of acquiring contextual information can be classified in categories. According to (Henricksen, Indulska and Rakotonirainy, 2002), there are three methods for acquiring information for localization systems in particular. These three methods are:

1. **Physical sensors** that can be embedded in other devices (resp. appliances) like mobile phones, watches, tablets, laptops, etc. Or standalone sensors. They can capture several types of physical information such as temperature, geographical localization, noise level, light, etc.;
2. **Virtual sensors** that extract contextual information from virtual spaces such as programs, operating systems, network, and so on. (example: localization information can be retrieved from an electronic calendar and a network log);
3. **Logical sensors** that use physical and virtual sensors information to derive additional ones.

Similarly (Mostefaoui, Pasquier-Rocha and Brezillon, 2004) have classified three methods for acquiring context. These methods are:
• the context captured by the physical sensors (temperature, pressure, light, …);
• derived context which can be computed on the fly (time, date);
• explicitly provided context such as user profile, information about a machine in a network, and so on.

Context-aware Computing

The context is taken into account in different computer domains including operating systems, natural language processing, machine learning, human-computer interaction, computer vision, information extraction, mobile and ubiquitous computing. With the emergence of the ubiquity of computer systems in everyday objects of the users, the configuration and management of these equipment require time and an additional effort of the user for their updating which allows them to provide the appropriate services. Such task could prevent users from focusing on their main tasks. Context-awareness is a possible key to decrease such deficit.

In a general sense, context-aware systems are those able to adapt their operations to the current context without explicit user intervention. To be aware of something mean to be conscious or having knowledge of it and awareness is the state/quality of being aware of something. Many researchers have studied this topic and built several context-aware applications which are capable to adapt to the changing context in order to demonstrate the usefulness of this technology. The term context-awareness was first mentioned by Schmidt et al. in 1999 during the development of the PARCTAB project (Schmidt et al., 1999) which is considered to be the first mobile computing system built to explore and exploit the concept of context-awareness. In addition, the authors have introduced the mobile distributed computing system which characterized by a constantly changing execution environment and it concerns mobile people not just mobile computers. thus, context-aware computing is in reality a mobile computing paradigm. context-aware systems were defined as systems that adapt according to the location of use the collection of nearby people, hosts and accessible devices, as well as to changes to such things over time. (Brown, 1995) defined context sensitivity in his work on a tourist guide as any application that takes into account the context of the user. (Dey, 2001) defined it as a system that uses the context to provide information and / or
services relevant to the user. According to him the relevance depends on the task of the user. (Chen and Kotz, 2000) gave two definitions:

- **Active context-awareness:** an application that automatically adapts to the context discovered by changing the behavior of the application;
- **Passive context-awareness:** an application that presents the new or updated context to an interested user or makes the context persistent for later use.

(Dey, 2001), then (Chen and Kotz, 2000) have made context-oriented research surveys, focusing on the applications, the contextual information used, and the way in which it is used. It appears from these two surveys that most computer systems rely mainly on the location of the user as contextual information. In rare cases, a time index is used as well as the location of neighboring objects. Based on a service - oriented approach, Miraoui and Tadj proposed another definition as follows: A system is said to be context-aware if it can automatically change its forms of services or trigger a service as a response to changing the value of an information or a set of information that characterizes the service (Miraoui and Tadj, 2007). This definition better describes a context-aware system since it explains awareness in terms of the system's response to changes in context by triggering a service or changing service forms. As in the interaction between humans, the aim of context-aware computing is to strengthen the adaptability and the support to the decision of the computer systems. As said by (Dey, 2001): "By improving access to the computer context, we increase the richness of the communication in the human-computer interaction and enable the production of more useful computing services".

Since the first definition of context-aware computing by (Schmidt et al., 1999), researchers have adopted the term of context-awareness and defined it in similar, extended, and more nuanced ways compared to Schilit and Theimer. However, how to effectively use contextual information is still a challenging problem for context-aware application developers. Nowadays context-awareness is mostly applied mainly in pervasive and ubiquitous computing, smart spaces and IoT (internet of things) with the aim to make computing devices provide more appropriate services to users according to the current context.

References:

- Schilit, B. N., and M. M. Theimer. 1994. « Disseminating Active Map Information to Mobile Hosts ». IEEE Network, 8(5), (September/October 1994), p. 22-32.
- Brown, P. J., J. D. Bovey et X. Chen. 1997. « Context-aware applications: from the laboratory to the marketplace ». IEEE Personal Communications, vol. 4, no 5 (October 1997), p. 58-64.
- Ryan, N., J. Pascoe et D. Morse. 1997. « Enhanced Reality Fieldwork: The Contextaware Archaeological Assistant ». In Computer Applications in Archaeology. Oxford, UK.
- G. Chen and D. Kotz. 2000 « A survey of context-aware mobile computing research », Technical Report TR2000-381, Dept. of Computer Science, Dartmouth College, p.1–16.
- Dey, A. K. 2001. « Understanding and using context ». Personal and ubiquitous computing, vol. 5, p. 4-7.
- Henricksen, K., J. Indulska and A. Rakotonirainy (2002). Modeling context information in pervasive computing systems. Pervasive Computing, Springer: 167-180.
- Brezillon, P., M. R. Borges, J.A. Pino and Pomerol J.-Ch. 2004. « Context-Awareness in Group Work: Three Case Studies ». In 2004 IFIP Int. Conf. on Decision Support Systems (DSS 2004) (Juillet, 2004). Prato, Italie.
- Miraoui M., Tadj C. (2007), A service Oriented Definition of Context for Pervasive Computing, in Proceedings of the 16th International Conference on Computing, Mexico city, Mexico
- Najar, S., O. Saidani, M. Kirsch-Pinheiro, C. Souveyet and S. Nurcan (2009). Semantic representation of context models: a framework for analyzing and understanding. Proceedings of the 1st Workshop on Context, Information and Ontologies, ACM.
- Viana, W., A. D. Miron, B. Moisuc, J. Gensel, M. Villanova-Oliver and H. Martin (2011). "Towards the semantic and context-aware management of mobile multimedia." Multimedia Tools and Applications 53(2): 391-429.
- Mostefaoui, K. G., J. Pasquier-Rocha et P. Brezillon. 2004. « Context-Aware Computing: A Guide for the Pervasive Computing Community ». In the Proceedings of the 2004 ACS/IEEE International Conference on Pervasive Services (ICPS'2004) (19-23 July). p. 39-48. Beirut, Lebanon.
- Schmidt, A., Beigl, M. and Gellersen, H.W., 1999. « There is more to context than location ». Computers & Graphics, vol.23, n°6, p.893-901
- Brown, P. J. 1995. « The stick-e document: a framework for creating context-aware applications ». Electronic Publishing Origination, Dissemination and Design, vol. 8, no 2 (JUNE & SEPTEMBER 1995), p. 259-272