Who, Where, What, and When: Towards Characterizing Contexts in Pervasive Environments

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Introduction. A key challenge in pervasive systems is that of identifying and developing appropriate formal approaches for understanding and reasoning about contexts. This is a difficult task since there is no common agreement on what constitutes a context and what its properties are. Although the literature contains a rich variety of context models [1, 2], most of the resulting implementations are domain-dependent and lack powerful reasoning capacities. Preliminary work on logic-based reasoning about contexts has been proposed in [3, 4], using bridge rules and argumentation theory. However, application-wise there are still open questions on how to model context-related pieces of knowledge in general domains, so that appropriate reasoning techniques can be applied. In order to put the basis for a comprehensive theory of contexts one should take into account the general structure of knowledge needed to represent contexts, in particular, what is intended as a context in pervasive environments and which components/properties should be identified and described. System properties that are of interest for the specification of contexts should be also considered. Motivated by application challenges, this short paper highlights observations that can be used to address these issues.

Generalization of Context in Pervasive Environments. Previous investigations of context models in pervasive environments revealed that within contexts certain entities are more important than others in practice. These are *location*, *identity*, *activity* and *time* [5, 6]. In pervasive environments, the more intuitively relevant aspects of the context in which a person acts are who she is, which resources/entities are related to her, where she is and when. The representation of knowledge about contexts is very similar to the structure of a sentence in natural language, where actors are the subjects and the objects, verbs are relations and sensor data are the adjectives in that they assign a value to attributes of the actors. As an example, in a home monitoring scenario, a generalization of actors may correspond to the following entities: *Person* to be monitored, *Room* and *Area* for localization and *Object* for resources. If attributes correspond to sensor data, relations that we consider interesting depend on the task we want to solve (localization of a person, reaction from the system, identification of an action, etc.). The fact that a relation holds or not should be the result of reasoning (commonsense, default, temporal) on the knowledge we want to characterize.

To enhance generality and modularity of the representation, we suggest to represent entities at a primary level while all the other pieces of sensed information are at a second level and can be indexed as attributes of the entities at primary level. As for the relations between subjects, objects, and places in pervasive environments the basic interesting relations that should be formalized are *spatial* (being close/far, being in/out), *temporal* (occurring before/after) and *causal* (occurring because of something).

Properties. In a given context, attributes and relations need to be associated to a time stamp. In this way, the reasoning system can take into account their dynamic evolution to characterize aspects such as commonsense, temporal reasoning, belief revision and update. In general the temporal evolution of a context is one of the most important aspect to be correctly and formally characterized. Additional properties may be needed to determine what is true in a given context where certain objects, attributes and entities have been defined. These properties should make it possible to express belief merging and belief revision/update in contexts.

Conclusions. We believe reasoning about contexts became harder and harder because of the proliferation of very personal representations of context knowledge in terms of admissible relations, their arity and their properties, which have been developed ad-hoc for very diverse specific applications. Our attempt is that of providing a more general and modular representation of context knowledge. The intuition is that in this way multi-context reasoning could be supported by the verification of formal properties at a knowledge representation level, in the same way as human deduction is based on roles of the grammatical components of a sentence.

References

1. Baldauf, M., Dustdar, S., Rosenberg, F.: A survey on context-aware systems. International Journal of Ad Hoc and Ubiquitous Computing (2007) 263–277
2. Strang, T., Linnhoff-Popien, C.: A context modeling survey. In: Proc. of the Workshop on Advanced Context Modelling, Reasoning and Management. (2004)
3. Brewka, G., Eiter, T.: Equilibria in heterogeneous nonmonotonic multi-context systems. In: Proc. of the 22nd AAAI Conference on Artificial Intelligence, July 22-26, 2007, Vancouver, British Columbia, Canada, AAAI Press (2007) 385–390
4. Brewka, G., Eiter, T.: Argumentation context systems: A framework for abstract group argumentation. In: Proc. of LPNMR09, Springer-Verlag, In press (2007)
5. Ryan, N.S., Pascoe, J., Morse, D.R.: Enhanced reality fieldwork: the context-aware archaeological assistant. In Gaffney, V., van Leusen, M., Exxon, S., eds.: Computer Applications in Archaeology 1997. British Archaeological Reports, Tempus Reparatum (1998)
6. Schilit, B., Adams, N., Want, R.: Context-aware computing applications. In: Proc. of the Workshop on Mobile Computing Systems and Applications, IEEE Computer Society (1994) 85–90