Context-Awareness for Ubiquitous Computing System

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Abstract

In this paper, we propose a level of contexts such as low level and high level contexts, and its criteria of categorization are the existence of interaction and composite process done by the inference mechanism. When there is no matching high level service for the associated high level context, this context is described as meaningless. If the services cannot be provided with the entities by the system, this situational information is of little consequence. To provide services with the entities, we propose "community computing" architectural concept which provide the high level service to a group of agents in a community, and can be managed by the service scenario

Keywords:

Ubiquitous Computing; Context-Awareness; Community Computing

Introduction

With the advent of ubiquitous networking infrastructures such as wireless broadband network and intelligent portable communication devices, our daily lifetime comes close to convenient and human-centric computing environments. In ubiquitous computing technology, one of the difficult intrinsic attributes can be assigned to context-awareness.

A variety of literatures have attempted to define the context-awareness. However, there remains a distinct lack of agreement concerning 'context' and the considerable controversies surround what it means, what it includes, and what role it plays in the interactive systems [1-2]. Recently, in AI (Artificial Intelligence) researchers have tried to describe context in term of knowledge content [3-4]. Moreover the semantic web technology has spurred the knowledge representations and inferences. Each context type corresponds to a class in the ontology which is written in OWL. The ontology can be utilized to check predicates' validity and it confines the knowledge inference domains. In spite of these endeavors, context is difficult to acquire and vagueness still remains [5]. A.K Dey defined the *context* as any information that can be used to characterize the situation of an entity. He specified that the *entity* implies a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves [6]. And he defined the context aware as follows: A system is *context aware* if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task. We took the notion of services into account and assigned the existence of associated services as the characteristic criterion of context. If the services do not support to the context information, this context is not beneficial from the viewpoint of system.

Our Approach for Context-Aware Computing

Since location is the important component of context, much research has been focused on the location sensing and the location based services [7-12]. And the identification of the entities that make the dynamic behaviors is also studied such as the human authentication [13], the physical device discovery, and the software service discovery [14], etc. To extract the relevant context from the situational information researchers have adopted 5W (Who, Where, When, What and Why) for the context representation [15]. We propose the hierarchical approach by categorizing the two levels of contexts, such as *low level contexts* and *high level contexts* to establish the context aware computing system as shown in figure 1. The low level contexts can be acquired by the explicit data acquisitions and are characterized as "Who", "Where" and "When". The low level contexts are acquired by the measurements and data acquisitions. We define the "Who", "Where", and "When" as the *elemental contexts* since these contexts are explicitly objective and play a basic role in describing situational information. In contrast, the

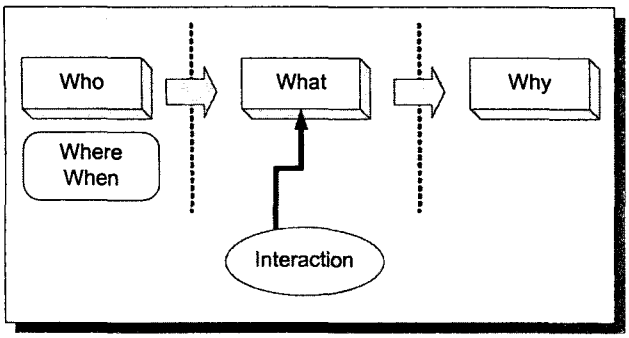

Figure 1. Level of Contexts

high level contexts are compositions of the low level contexts. The high level contexts are involved in the interactions and inferences. The high level context can be described as the triple type statements (subject – predicate - object). The predicates represent the situational states and behaviors. And much research has been enthusiastically studied the predicates for knowledge representation using the semantic web technology [16-18]. The high level contexts can be divided into two categories such as "What" and "Why". The "What" corresponds to the explicit context, and can be described by current interactions. We define the high level context, "What" as the *interaction context* since the entities (humans, machines, and environments) are associated with one another by the interaction to describe that "What" is going on. Meanwhile, the "Why" corresponds to the implicit context, and should be inferred by the histories of situational information to describe the intention of interactions. So we define the "Why" as the *intention context*.

Low level contexts

The low level contexts are described as Table1. The "When" is easy to obtain in comparison with other contexts since the usual machines can have access to the current time. And time in itself is not associated with people, machine and environment. However, "Who" and "Where" are coupled with each other in the viewpoint of specifying the location of entities. Since the behaviors of entities are accompanied by the interactions among entities, we will consider the behavior of entities on next section of the high level contexts.

The location can be specified after assuming the existence of some entities. In this point of view, whether the existences of entities correspond to the interaction category or not, can lead to a semantic problem for extracting contexts from the situational information. In our consideration, the interactions between entities should be accompanied by the changes of states which the associated entities possess. Hence, when some entities do not affect the other entities, we consider this case as no interaction exists between entities. However, when even the existence of one entity affects the other entities, we will consider this case as the interaction exists between entities.

Table.1 Components of low level contexts

Low level Contexts	Description
"Who"	Human or machine (The active object which can influence on another objects or environments)
"Where"	Location information
"When"	Time information

In our description as Table.1, the "Who" corresponds to the active entity which can behave independently. For example, the printer machine can be considered as "Who", in contrast the paper is not. The paper cannot behave of itself, and is passive entity. This specification of active entities is convenient to simplify the situations because we can focus only the active entities. The passive entities are considered as the objects which are affected by the active entities.

High level contexts

The high level contexts can be described as the triple type statements. Our contribution of this paper is that we propose this triple type (subject – predicate – object) statement as the "What" context and "predicate" as the representations of interactions between entities. The "What" context needs computation of machines because the interactions are involved between entities. The machine-related interactions between entities are divided into three categories, such as H-M, M-M, and M-E (H; Human, M; Machine, E: Environment). In this description, the environment represents the temperature, luminance, noisy level etc. And machines represent the hardware or software of systems.

Many researchers have adopted the triple type statement of context for context infrastructure implementations since the well-defined standards like RDF (Resource Description Framework) offer the united approach to the knowledge management and information processing.

The "Why" context is implicit and can be subjective since the intention is difficult to detect. Moreover, the intentions of entities should be inferred by considering the current and past histories of the active entities. If the inference of "Why" context is plausible, the proactive services can be inferred beforehand to support human the ideally comfortable services.

Table.2 Components of high level contexts

High level Contexts	Description
"What"	Triple type description (subject – predicate – object)
"Why"	Intention of active entities (inferences are based on the situational history)

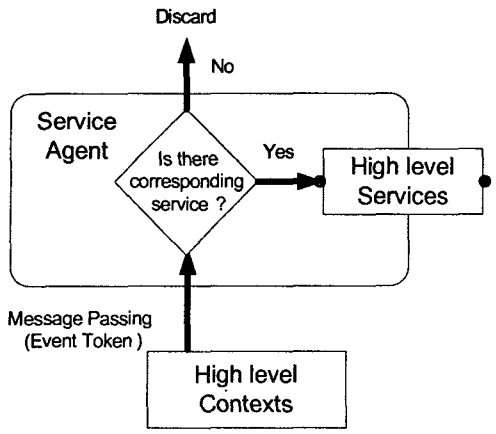

Figure 2. Service Agent

Services

In the previous section, we described the 5W which are composed of contexts. However, sometimes some interactions can be made in the ad hoc manners by the entities, and even irrelevant of the current situations. In this case, 5W cannot characterize the situational information, and this information should be discarded on account of the semantically meaninglessness.

To overcome the problem of meaningless interaction, we consider the contexts in the viewpoint of services. When services can be provided in response of corresponding requests, these requests can be mapped onto the associated contexts by service agent in one-to-one correspondence manners. The service agent checks the one-to-one correspondence between high level context and high level service as shown in figure 2. "High level service' is service mode which depends upon the pre-defined scenarios.

Community Computing

The service agent maps the high level context onto the high level service. And this high level service can be interpreted into the goal of service by the community manager. This architectural concept of community is proposed by the ubiquitous frontier office [19]. We developed this novel concept into the application conceptual model for the context aware computing system. The community computing concept will provide the foundation to integrate hardware and software for supporting the ubiquitous system. The community can be described as the aggregation of components which have the same goal. And community is composed of members of which relations are established by the given goal or objective of services.

The communities are created to accomplish the specific goals which are specified by the high level services commands. As shown in figure 3, the communities can be a member of another community and can collaborate with another community to achieve the specific goals. The

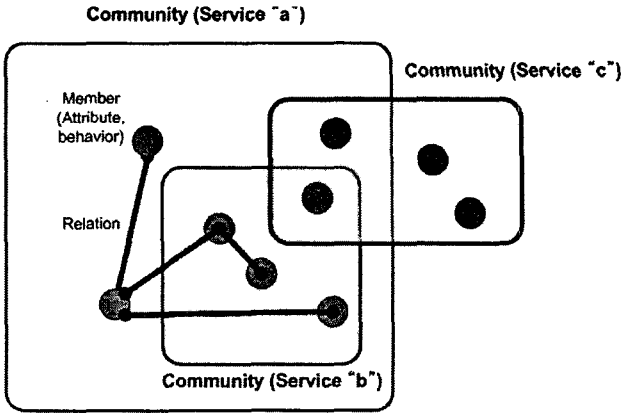

Figure 3. Model of the Community Computing

relation between members can be represented by RDF. If RDF representations are adopted, the predicates can describe the relation between members.

Overall architecture for context aware computing

The community architecture is created by the high level service message, and managed temporarily by the community manager. The main function of the community manager is to instantiate the communities, establish the relation of the communities and manage the communities. The member of the community can be device agent software and user agent software. This agent software generates the action list for commanding the low level services to devices. The overall system architecture is described as shown in figure 4. The message flow is feedback loop which starts from the environment, human, devices and terminates at the device. Human can interact with system by the exposure to the sensing mechanism (i.e. vision, voice, touch) and device manipulations. The device control point can be manipulated by manual or automatic. When device control point is developed by following the UPnP (Universal Plug and Play) Architecture (www.upnp.org), the message protocol should be the XML web service standard protocol, SOAP (Simple Object Access Protocol). And the event token is published as GENA (General Event Notification Architecture) to process the context changes.

Conclusion

We have described a level of contexts in relation to the interactions. And context is selected by the existence of corresponding services which are provided by the system. The services can be grouped by the concept of community computing. Although there remains work to be undertaken for examining this system architecture, the conceptual model to develop the overall ubiquitous computing system should be considered beforehand.

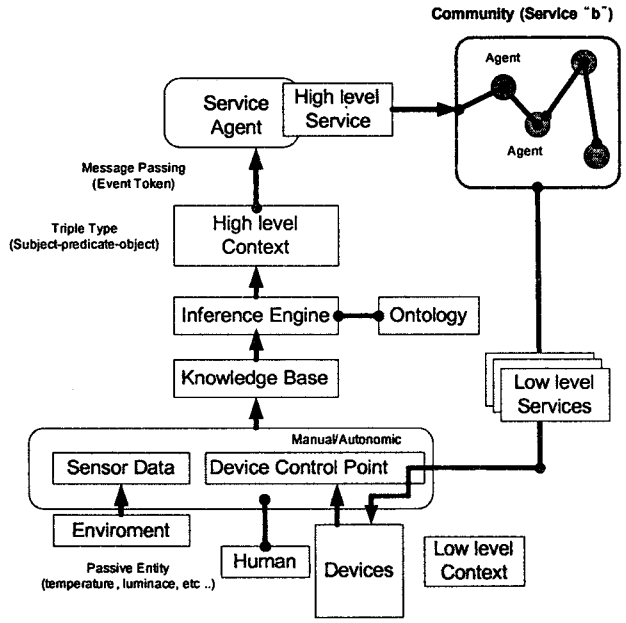

Figure 4. Overall System Architecture for Context Aware Computing

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