Context-Sensitive Conversation Patterns for Agents in Wireless Environments

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Abstract. We outline an approach for adapting software agent conversations between a mobile client and a service provider. The adaptation takes advantage of the context information characterizing the client's current situation. The service provider takes this context information into account when selecting / creating a suitable interaction protocol for communicating with the client. Both the context information and the interaction protocol descriptions are based on ontologies, which are assumed to be known by the conversating agents.

1 Introduction

In ubiquitous environments, services can be accessed in various contexts. Context information is anything that can be used to characterize the situation of an entity. An entity, in turn, can be a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves [1]. Also details of the device used to access the service, and characteristics of the network over which the services are accessed, are contextual information. In this paper, we focus especially on wireless networks, and how they can be utilized when customizing agent-based services for users. Particularly, network Quality of Service (QoS) is investigated.

When performing a handshake between a client and the service provider, context information is taken into account before the actual interaction. Context information can have influence on what services are provided to the client, or how a specific service is tailored to best facilitate the interaction between the client and the service provider. More specifically, context information may have impact on the chosen interaction protocol according to which the service is accessed. Interaction protocols set the rules that govern the interaction [2] and are often used to steer software agent conversations. They typically consist of ordered sets of messages, as well as restrictions on which participant can send a message, of what type, to whom, and in what state of the protocol.

In [3], the authors discuss a bilateral negotiation protocol. Conversating agents can utilize it for adapting to the quality of the network they are using. In contrast to their approach, we make a distinction between the client and the service provider, and do not

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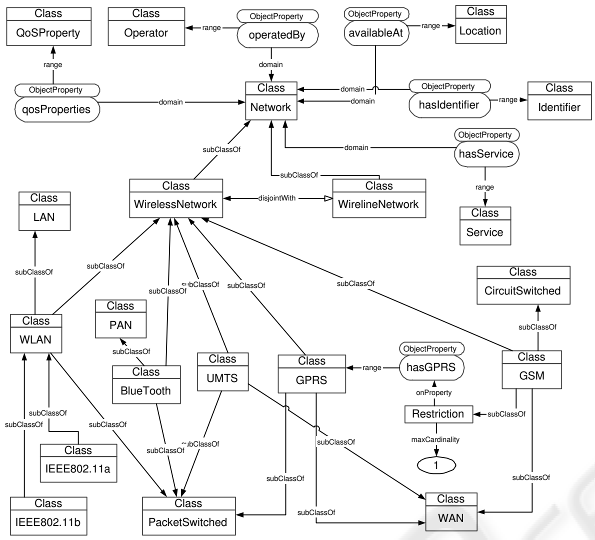

Fig. 1. The core concepts of the network ontology

design a framework where the agents could negotiate as equal peers about how the interaction should take place. Instead, in our approach the service provider is responsible for the selection / creation of the interaction protocol to be used.

We are unaware of any research in ubiquitous environments, which investigates the relationships between context information and the selection / creation of interaction protocols used to access services. We believe, however, that such relationships could be found and explicated. One rule of thumb might be, that the longer round-trip times for messages, the simpler interaction protocol should be. Another one could emphasize the relationship with the device's and operating system's ability for parallel processing and the number of concurrent protocols under execution.

Both context information and interaction protocol descriptions are specified according to ontologies. The ontologies can be utilized for adaptation by both the service provider and the client. The service provider's agent can adapt the service based on the context information received from the client. The client, in turn, can modify its behavior to conform with the interaction protocol description received from the service provider. An example on how the client-side adaptation to interaction protocol descriptions can take place is described in [4].

In the next section, we briefly address the ontologies that are relevant for adapting interaction protocol based services according to network characteristics and network QoS attribute values. We then consider an example of such adaptation. Finally, we present some concluding remarks and future directions.

2 Context Ontologies for Service Adaptation

This section summarizes three ontologies. These are intended for describing networks, network QoS, and interaction protocols, respectively. These ontologies are needed in order to perform the adaptation of services according to the context information characterizing the client. There are other kinds of relevant contextual information that could have impact on the service adaptation. Information about the person accessing the service is one potential candidate. Information which is more permanent in nature, such as gender and nationality, could result in completely different services provided to different people. In addition, dynamic information such as social context and user's current mood, could be taken account when adapting the services. Properties of client device, such as screen size, operating system, and available memory, could also have impact on the adaptation [5]. However, in this but in this paper we focus on the network, especially on its QoS.

Figure 1 concentrates on the wireless branch of the network ontology [6], which is more important in typical ubiquitous scenarios, than the wireline branch. WIRELESSNETWORK has several subclasses such as WLAN and UMTS. The notions of CIRCUITSWITCHED and PACKETSWITCHED can be used to define the data connection mode of the network. Furthermore, each network is available at some LOCATION. In this paper, we do not consider how locations are expressed, but assume that there is some other ontology, which can be used to describe such issues.

Figure 2 depicts a network QoS ontology, which is based on the FIPA Quality of Service Ontology [7]. It is contains for example the following properties. LINERATE is used to express the bandwidth in one direction over a measured component. DELAY is the (nominal) time required for a data segment to be transmitted to a peer entity. RTT, round-trip time, is the time required for a data segment to be transmitted to a peer entity and a corresponding acknowledgment sent back to the originating entity. FRAMEERRORRATE is the probability, that a data segment is not transmitted correctly over a measured component.

Interaction protocol ontology [8] plays a different role in the service adaptation than the previous two ontologies. The network ontology and the network QoS ontology were used to describe the context information, whereas the interaction protocol ontology is used to describe how the services are accessed. The offered interaction protocol is selected / created based on the contextual details.

Figure 3 depicts the concepts forming the core of the interaction protocol ontology. INTERACTIONPROTOCOL concept contains general information about the interaction protocol, such as information about the participating agents. Every protocol has one INITIATOR and one or more PARTICIPANTs.

Every interaction protocol has exactly one PROGRESS component that defines progression of the interaction protocol. PROGRESS consists of STATEs that constitute the flow of the protocol. STATEs can have decision points called CHOICEs that in turn have OPTIONs to choose from. Only one OPTION can be chosen in a given STATE. A MESSAGE can be sent or received as a consequence of choosing an option in a particular state. In the core set of the ontology, the message only contains an identifier and the sender and receiver information. However, it can be extended with concepts that enable

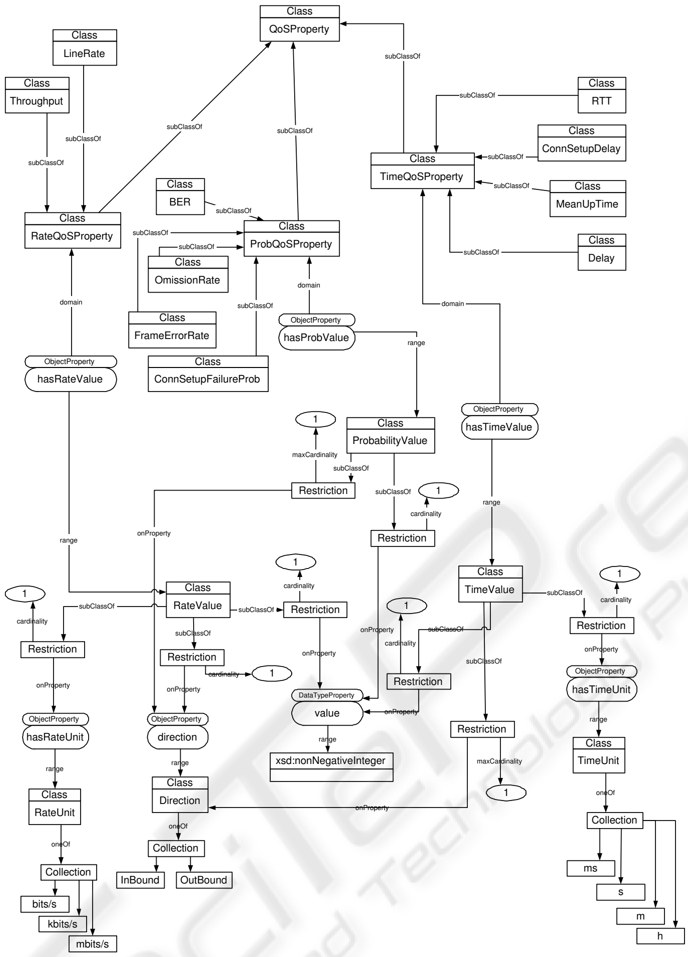

Fig. 2. The network QoS ontology

more detailed descriptions. For example, in [8], we introduced a FIPA extension to the ontology.

3 An Adaptation Example

We now describe one way of adapting a service according to network conditions. Location of a mobile user changes as he moves around. By having location information of the user, the service provider can conclude where the user is heading and how fast. These information may be useful for the service provider when adapting services [9, 10]. Knowledge of the direction, for example, can result in the system providing the user with information related to things that are ahead of user, rather than behind [11].

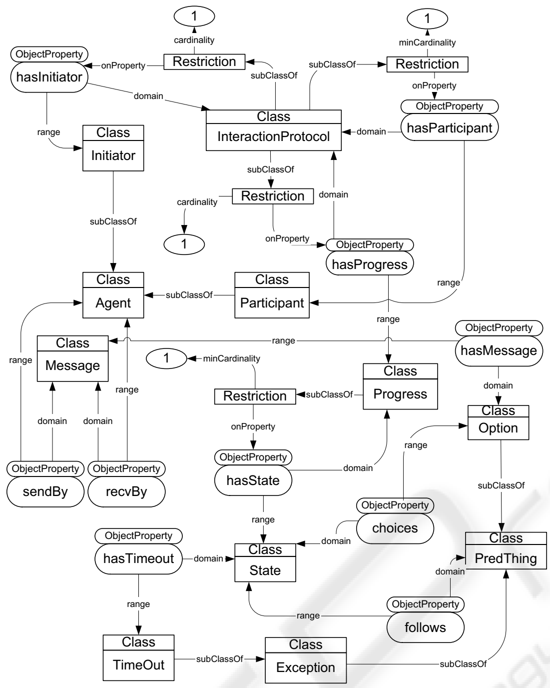

Fig. 3. The core concepts of the interaction protocol ontology

Knowledge of speed and direction of the user can be utilized also when specifying the interaction protocol for accessing the services. The service provider can estimate, for example, how soon the user is expected to be out of network coverage. This estimation can in part determine the chosen interaction protocol. If the service provider estimates that the user is expected to be out of network coverage soon, it tries to provide the user with an interaction protocol description with less roundtrips. Instead, if the user is expected to stay longer within the network coverage area, the service provider can provide him with a more sophisticated version of the interaction protocol. This kind of reasoning could, for example, result in providing different interaction protocols to users on foot than to users on a tram or driving a car.

Should the service provider have the user's current network and QoS information, it can perform further reasoning besides that based on the speed and direction. For example, if the expected round-trip time is short enough, the service provider can decide to go forward with a protocol having more round-trips, even if the user is soon heading out of the network coverage area. With a potential for more round-trips, the service provider can engage a conversation trying to find out the user's preferences and interest of the services it is providing.

Furthermore, should there be multiple networks to choose from, the service provider can select the most suitable one to best facilitate the user. The service provider can also perform handovers, for example from WLAN to GPRS networks and back [12]. While in WLAN coverage area, the service provider and the client can engage a conversation along a more sophisticated interaction protocol, and shift to a more stripped-down version when the user is heading out of the WLAN hotspot. In addition to mere network types, the service provider could also take advantage of the real-time QoS values, as discussed in [13]. For example, should the user enter a crowded WLAN hotspot, continuing the conversation with GPRS connection can prove to be more appropriate.

4 Conclusions and Future Work

We presented ontologies for expressing wireless networks, network QoS, and interaction protocols. Such ontologies can in part enable service adaptation according to context information in ubiquitous environments. We outlined one adaptation example.

Our future work around the area includes considering further properties of networks and how they could have impact on the chosen interaction protocol. In addition, we are going to consider device details and user preferences as context information. In this paper we focused on interaction protocols and did not consider individual messages. Further work could be done on adjusting message contents and sizes based on the context information. Such message level adaptation could also be integrated with the interaction protocol level adaptation.

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