A Two-Leveled Semantic Web Service Description of the Pervasive Information System

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Abstract. To begin with, the semantic web service adaptation is based on the addition of contextual information to this web service description. So the technique of adapting the web service allows the user to establish reusable, interoperable, flexible and context-aware applications. The basic feature of the pervasive applications is the context-awareness. What is more, the pervasive systems are based on the NNN paradigm (aNywhere, aNytime, with aNything). Therefore, these systems must be used in different contexts depending on the user environment, his profile and the used terminal. Indeed, this type of system is dynamically adapted. Furthermore, we seek to offer a dynamic description of the web services. This objective, however, can be achieved by adding contextual information structures to the web service description. In the literature, more research works strive to combine the contextual description with the web service description by using the OWL-S structure. In fact, the main objective of this paper is to propose structures with two levels for the contextual description of the pervasive system. The first level is used to select the adapted web service to respond to the users needs, while the second level is aimed to offer the user the adapted description to respond to these needs.

Keywords: Pervasive, Information system, Ontology, OWL, OWL-S, Design, Model.

1 Introduction

In the last decade, new technologies witnessed a rapid evolution. This evolution stepped up the complexity of the users mobile environment and pervasive computing becomes a reality. As a result, a large number of pervasive computing projects around the world try to prove the viability and usefulness of this vision in a variety of domains. Unfortunately, along with the new and existing possibilities, difficult challenges come into being. As pervasive applications are highly distributed and mobile in nature, pervasive system developers have to transcend all the challenges found in the fields of distributed systems, mobile computing, as well as the new set of challenges that did not exist in either the distributed systems or mobile computing alone.

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In this, adaptability is deemed to be a key aspect in the pervasive computing systems. Therefore, the system needs to adapt its functionality and behavior depending on the context of the user and the resources that are available at any instant. Although many research works highlight the idea of implementing and establishing adaptation in pervasive systems, none of them is interested in the design of adaptation in pervasive systems. We attempt, in this work, to suggest a system that can be conceptually adapted to the pervasive system. This system is based on semantic web services. Therefore, we have proposed a classification of contextual information for pervasive systems and used the OWL-S structure to integrate such information into the web services. In fact, the OWL ontology is a solution to support greater automation in the service selection and invocation and the automated translation of the message content between the heterogeneous inter-operating services and the service composition.

This paper is organized as follows. First, we study some concepts related to our research domain such as the pervasive system, the semantic web services and the existing OWL-S extension to describe the semantic web services. Then, we present the architecture to adapt the pervasive system functionalities. Finally, we present our purpose that concerns the proposal of contextual description of the pervasive system.

2 State of the Art

2.1 The Semantic Web Service

To realize the vision of Semantic Web services, several research works create a semantic markup of Web services that makes them understood by the machine. They are also developing the agent technology that exploits this semantic markup to support the automated Web service composition and interoperability. The convergence of the semantic web with the service oriented computing is manifested by the semantic web services technology. In fact, it addresses the major challenge of automated, interoperable and meaningful coordination of web services to be carried out by intelligent software agents. Additionally, each semantic service description framework can be characterized with respect to (1) what kind of service semantics are described, (2) in what language or formalism, (3) allowing for what kind of reasoning upon the abstract service descriptions. The Semantic Web services can use the OWL-S process model and grounding in order to manage their interactions with other web services.

2.2 The OWL-S Ontology Presentation

OWL-S is a Web Services ontology that specifies a conceptual framework to describe the semantic web services. OWL-S is also a language based on the DARPA work of its DAML program and takes the result of DAML-S (DARPA Agent Markup Language Service). It was incorporated into W3C in 2004, within the interest group of semantic web services at the OWL recommendation [3].

The original purpose of OWL-S is to implement semantic web services. OWL-S is based on OWL to define the abstract categories of entities, events in terms of classes and properties. OWL-S uses this ontology language description to define a particular ontology for the web services. This ontology is used to describe the web service properties as well as its services available to the public. The OWL-S structure regroups a set of ontology. Each one provides a functionality to describe the web service semantically. The ontology main classes described by OWL-S [4] are defined by the following figure (see Figure 1). The necessity to use the OWL-S ontology is justified by the creation of a semantic web service that has a dynamic description. This dynamic is provided by the addition of contextual descriptions to the OWL-S structure. The description depends on the use of the context of a pervasive system.

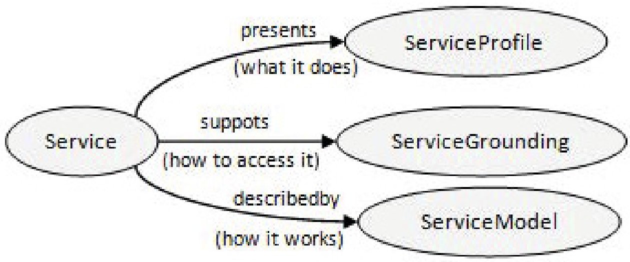

Fig. 1. The principal OWL-S classes

2.3 The Existed OWL-S Extension

Several research works take the advantage of the existing OWL-S structure to describe the different contexts. In this paper, we present two research works of of Qiu et al., [5], [6] and Ben Mokhtar [7]. Qiu et al., research works propose an adaptation system based on the service composition approach. To do this, the authors offer three context categories [5]: the user context, the web service context and the environmental context. The user context ("U-Context") specifies the context information about the user. In this context, the authors defined two types of contextual information: the user static context (profile, interest, and preferences) and the user dynamic context (location, current activity and task trying to achieve). The web service context ("W-Context") includes the not-functional contextual information (price, execution time, confidence degree). The environmental context ("E-Context"): this category collects the context information about the user's environment (time, date, etc.). Each context category is represented by the OWL ontology and is integrated in the existing OWL-S extension ontology to introduce the OWL-SC (OWL-S for context) [6]. The latter is intended to describe a general contextual information (see Figure 2) based on the users description. The proposed structure focuses only on the user context

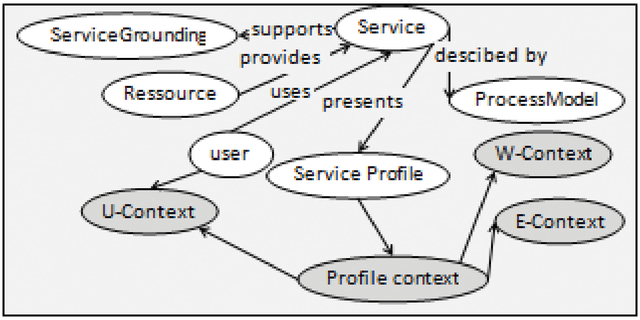

Fig. 2. The OWL-SC Ontology [6]

description. However, it presents a vision for the integration or the addition of more information to the OWL-S structure.

Ben Mokhtar et al., research works propose a system to adapt the web services to a pervasive environment [7]. The context definition includes the description of four types of contextual information: the context sensors, services, devices and users. In addition, the contextual adaptation in this work is based on the service representation and the user task representation. In the service representation, the authors describe the services using OWL-S extended with context information. This information is decomposed into a high level context attributes, preconditions and contextual effects. However via the user task representation, the user task representation is performed while extending the OWL-S service model ontology. To do this, the authors propose to integrate the quality conditions service descriptions and the context conditions required by the user task in the OWL-S structure. The context information description is performed by means of an OWL extension ontology, the adaptation is carried out by applying a finite-state automaton (see Figure 3). Ben Mokhtar et al., their proposal concerns the contextual information integrated in the OWL-S structure, but this information is

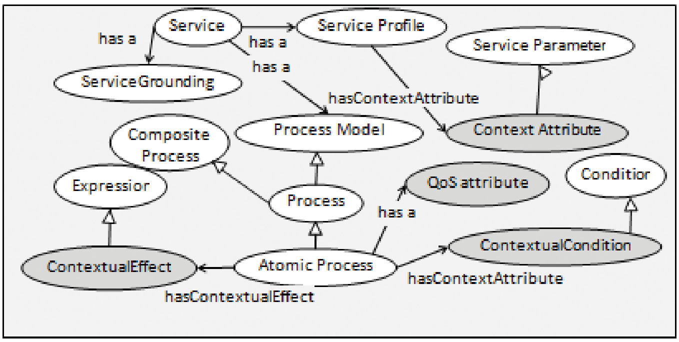

Fig. 3. The OWL-S ontology extension for the pervasive system [7]

not related to the pervasive system description. We focus on, via this work, the integration of pervasive contextual information in the OWL-S structure.

2.4 The Pervasive Systems

Weiser [1] believed that the exponential evolution of data, software, hardware and connectivity would generate new environments rich of computing elements that lack proper interaction. As a result, he presented a paradigm where the computing elements would disappear from the users consciousness while functioning homogeneously in the background of his environment. The final objective is to provide the user with omnipresent and seamless services available whenever and wherever they are needed [2].

When the digital services kept increasing, many applications appeared. These applications can sometimes replace human beings. Thus, technology becomes a principal factor that could affect and improve life quality and business productivity by ensuring higher interoperability between the different business partners and the surrounding dynamic environments. With all these dynamic elements, a growing demand for easier, mobile, transparent and seamless interaction is sought in order to adapt it to the users situations, abilities and needs.

2.5 The General Model Used to Describe the Pervasive System

The pervasive system description is based on a general model [9]. The latter is a UML class diagram representing the intersection result of four existing models to describe the pervasive systems: SOUPA, Activity, and CSCP COMANTO. The classes defined in this diagram (see Figure 3) are described below:

- **Agent:** this class is used for the presentation of different actors in a pervasive system. It assembles the human actor and device actor.
- **Person:** presents all human actors.
- **Device:** presents the peripheral devices in a pervasive system.
- **Service:** presents the services offered by each device.
- **Network:** regroups the characteristics of different types of network.
- **Location coordinate:** represents the spatial relation between the different locations in a pervasive system.
- **Preference:** presents the information profile of a person who realizes the activity in a pervasive system.
- **Activity:** presents the characteristics of the activity requested by the user.
- **Rules:** regroups the different rules of activity, person and network interacting in a pervasive system.
- **Time:** presents the characteristics of a temporal thing and the relation of different things in a pervasive system.
- **Location:** represents the characteristics of localizations of human and mobile devices in a pervasive system.
- **Role:** represents the role of the users in the pervasive system.

The class descriptions are classified into six contextual information categories: the user context, the device context, the network context, the location context, the service context, and the application context. We consider a semantic web service to adapt the pervasive application to each category of contextual information.

3 The Purposed Architecture to Adapt the Pervasive System

The proposed architecture to adapt the functionality of the pervasive system to the users needs regrouped two description levels and an adapter. The adapter is used to apply an adaptation rules to the destined web service description. In this paper, we are interested in the description levels (see Figure4). The goal of the generic web service creation is to communicate with the different contexts by selecting the specific web service to respond to the users needs. We used the web service discovery technique to ensure this level functionality. The web service discovery is the process of finding a suitable web service for a given task. The specific web services are created to select the adapted description to respond to the users need. The fulfillment of a specified web service is provided by the generic web service. The next section is devoted to the presentation of the contextual description used for each level.

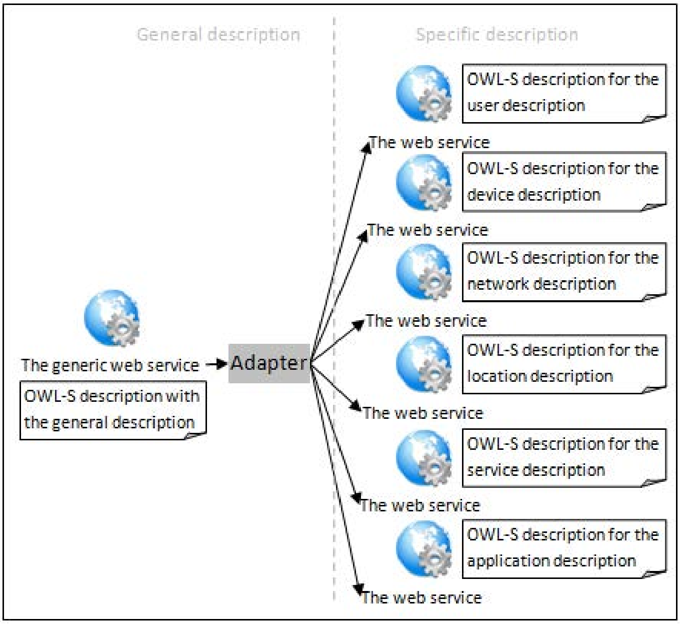

Fig. 4. The purposed adaptation architecture

4 The First Level of the Web Service Description

The first level is represented by a semantic web service that generally describes the pervasive environment. It has all the necessary information about each web service context shown in the second level. This information is described in an extended OWL-S ontology (see Figure 5). The extended OWL-S ontology includes the basic information examining a pervasive system.

The pervasive context is presented by the "PervasiveContext" OWL class. The activities in a pervasive system are presented by the "A-Context" OWL class. They exist in a device. The latter is symbolized by the "D-Context" OWL class. Each "D-Context device offers services in a pervasive system. The services are presented by the "S-Context" OWL class. The latter regroups the characteristics of the services provided by the pervasive system. All the devices existing in a pervasive system are interconnected via multiple networks. These networks are modeled through the "N-Context" OWL class. The two classes "D-Context" and "U-Context" represent the entire agent that exists in a pervasive system. For this reason, we placed the two classes as a sub-class of the "Agent" OWL class.

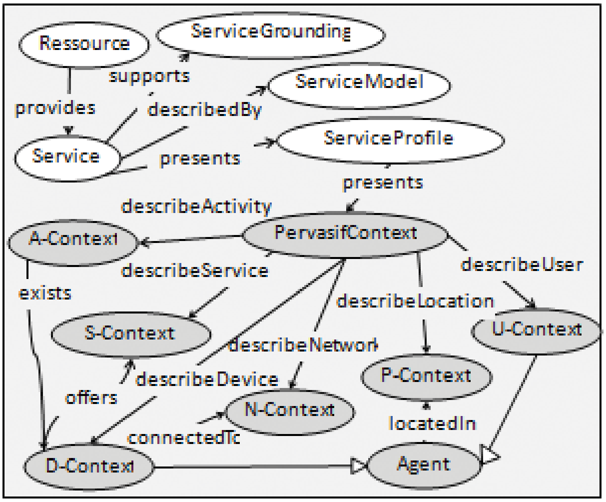

Fig. 5. Proposed structure for the first level of description

Each of the classes presented in the proposed OWL-S structure will be transformed in ontology. The latter regroups the classes and the attributes shown by the OWL semantic relation "owl:onProperty". The ontological structures are used to detail the contexts defined in the pervasive system.

5 The Second Level of the Web Service Description

The second level is the most detailed contextual description. It is at this level that we discover the low-level description of the pervasive system (see Figure ??). To define each context, we have to get a set of extended OWL-S structures corresponding to the number of contexts described in a pervasive system.

5.1 The OWL-S Extension to Describe the Physical Context (OWL-SPHC)

The suggested OWL-S extension of the physical Context is an ontology that describes the user physical context as well as the set of devices and persons existent in a pervasive system. The physical context includes the contextual information related to the location and the location coordinates of an agent in a pervasive system. The idea here is to add the physical context description to the existing OWL-S ontological structure. The OWL-S extension structure is suggested in figure 6. The adaptation of the user to the physical context is mainly manifested by the constraints expressed by the rules related to the execution of the applications in a pervasive system. These constraints can be summarized by the example in which an application is running in a location such as train station (where there is huge noise) or in a location such as a house (where there is silence). The time constraints occur when an application is executed in the same location but at different times. For instance, the execution constraints of an application during a work break are not the same as when it is running.

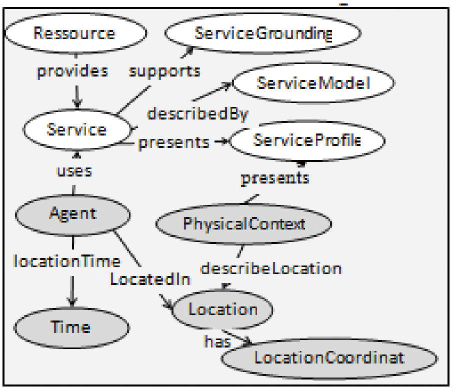

Fig. 6. The structure OWL-SPHC

5.2 The OWL-S Extension to Describe the Application Context (OWL-SAC)

The OWL-S structure is designed to describe the application context is an ontology structure that defines the activity context executed in the pervasive system.

The activity context includes both the contextual information related to the activity and the application that uses the rules in a pervasive system. The idea here is to add the activity context description to a standard OWL-S ontology. We present the suggested structure of the OWL-S extension in the following figure (see Figure 7).

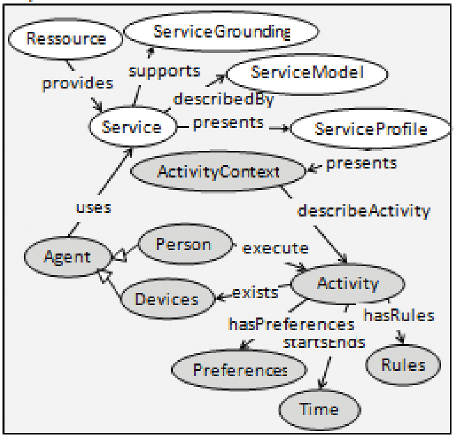

Fig. 7. The structure OWL-SAC

The adaptation of an activity in a pervasive system manifests itself in the activity characteristics and the rules implementing this activity. The devices characteristics may affect the activity performance. The activity execution begins and ends at a given moment in time. A computer activity can be executed in a specific platform may not be executed in another environment. In other words, audio or multimedia activity can be executed only in multimedia environments.

5.3 The OWL-S Extension to Describe the User Context (OWL-SUC)

In fact, the user is the focal point of any information system. In the pervasive system, the user is defined by two information characteristics: the static characteristics (name, age, sex, etc.) and the dynamic characteristics. The dynamic characteristics are defined by the preferences and the users environment (location, time, etc.). To describe the user context, we consider the OWL-S extension structure presented in figure 8 which combines the two types of characteristics of the user context.

The adaptation of the applications to the users characteristics manifests itself essentially during the interaction between the human-machine interfaces and the method of executing an activity. An activity can be executed according to the users preferences. In addition, the users static characteristics can impact on the methods of using a pervasive system since this type of system is adaptable to any user.

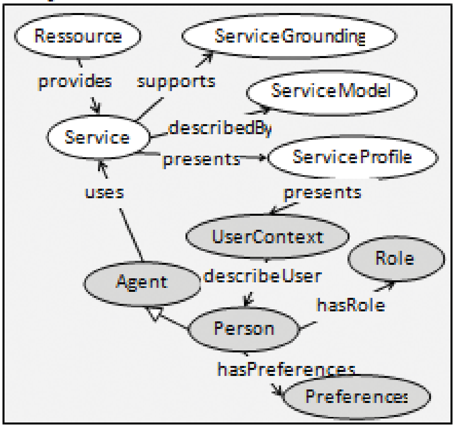

Fig. 8. The structure OWL-SUC

5.4 The OWL-S Extension to Describe the Service Context (OWL-SSC)

The OWL-S structure used to describe the service context as an ontology which contains information about the services provided by the pervasive system. Each service in the pervasive system has a set of rules. Since we have an intelligent system, this system must provide services according to the users desires and preferences such as the physical features, the available networks, etc. The OWL-S ontology is proposed as follows (see Figure 9).

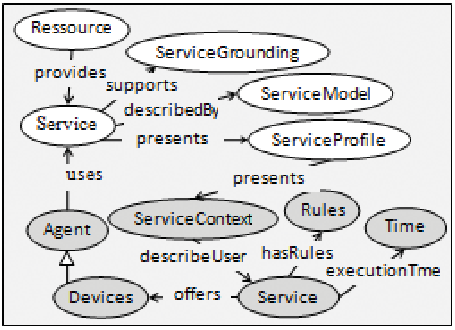

Fig. 9. The structure OWL-SSC

This ontology is meant to describe the services provided by the pervasive system and to adapt an application to the user's desires and preferences. In other words, a single system must interact with any type of users, networks, devices, etc.

5.5 The OWL-S Extension to Describe the Device Context (OWL-SDC)

The OWL-S structure is created to describe the device context and the activity profiles in the pervasive information system. Each device has a configuration, rules and preferences. In the mobile system, a new communication method has emerged to satisfy the users needs. Such a method paves the way for the propagation of intelligent systems through the invention of smart phones such as the Blackberrys, the iPhone... and touch pads such as the iPad. In order to ensure the adaptation, the pervasive system must capture a material list to ensure the answer to the query in accordance with the hardware configuration (see Figure 10).

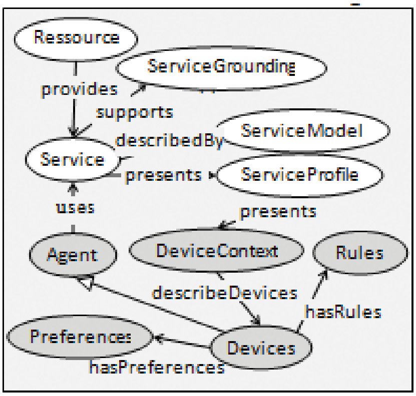

Fig. 10. The structure OWL-SDC

The material side is very important since the pervasive system is accessible anywhere, anyhow and to anything. Indeed, such a system can be executed according to the existing hardware.

5.6 The OWL-S Extension to Describe the Network Context (OWL-SNC)

The proposed OWL-S structure regroups the network context description and combines the characteristics of all the available networks in the pervasive information system. In this type of information system, there are several types of wireless networks (3G, WiFi, GSM, UMTS ...). Actually, each type of network has its own characteristics, access rules and preferences. To describe the network context, we propose the following OWL-S structure extension (see Figure 12).

The network selection or adaptation in the pervasive system is provided by the proposed ontology (see Figure 11) since the web service will use this structure to describe its services semantically. We can give real examples to describe

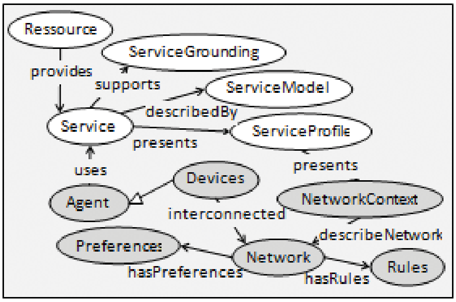

Fig. 11. The structure OWL-SNC

the network in a pervasive system: the traveler can check and send his documents according to the characteristics of the wireless networks available in the airport, the patient can make an appointment through his PDA, the manager can supervise the workers remotely, etc.

6 An Example of Using the Proposed OWL-S Extensions

In this paper, we present an OWL-S extension for each context. In this section, we present a scenario to give an idea about the description related to the pervasive system. The presented scenario (see Figure 13) is obtained after applying the representation of the rules exemplified in the figure below. In other words, the rules are defined by a set of conditions. The latter resulted from the users request values by means of logic operators ("AND" or "OR"). The value used in this presentation is manipulated by the two operations "getValue()" and "setService()". The result may be one service or several services according to the logic operator (see Figure 12).

6.1 The Scenario Definition

A user in an airport waiting for a flight. He has a large multimedia file. He wants to send it to the wireless network in a transmission time that does not exceed 30 minutes.

6.2 The Scenario Result

In this scenario, three types of context are defined; the physical context, the activity context and the network context. Among the classes of the physical context Physical Context, we have the class location that has the attribute Location Name. In the existing structure, we note the existence of three possible values: airport, work and home. In this situation, the sensor detects that the user is at the airport. This value is returned by the method getUserLocation(). Across the context of activityActivityContext, we can extract the type and the execution time of the activity. The type activity is returned by the attribute ActivityType of the class Activity in this situation which includes three possible values: play online, chat on facebook and send multimedia documents. The potential value in this case is expressed by the method getActivityType(). The activity execution time is returned by the attribute ExecutionTime of the class Time which includes, in this situation, the values: 15 minutes, 30 minutes and 45 minutes. The potential value in this case is expressed by the method getExecutionTime(). The final context is the network context NetworkContext. It allows returning the network to be used in this scenario. The class Network has an attribute Bandwidth which includes the bandwidths value of all networks stored in this structure. This value is perceptible by means of virtual sensors.

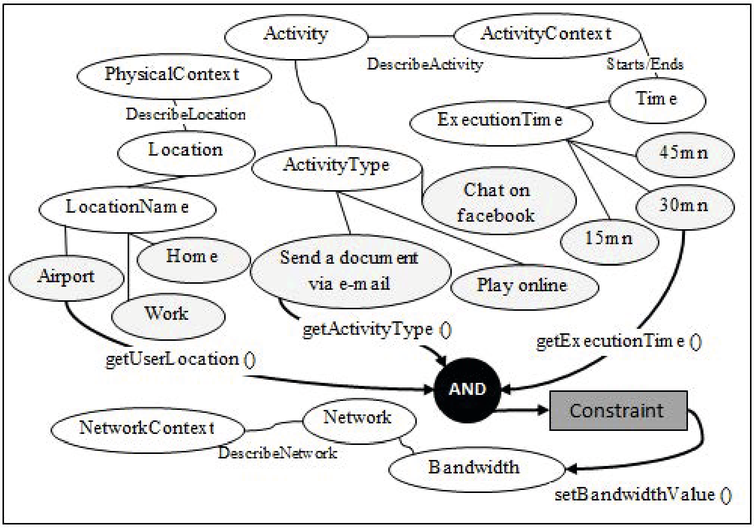

Fig. 12. The scenario description

7 Conclusion

This paper, indeed, is aimed present the two leveled description of the pervasive system based on the contextual information derived from a generic model. Hence, we suggest a classification of this information. The result of this classification is six ontology; the user context ontology, the physical context ontology, the network context ontology, the activity context ontology, the device context ontology, and the service context ontology. These ontology are implemented in the semantic web services to give the pervasive system developers an adapted description. This set of ontology is integrated into an existing OWL-S structure to create the semantic web services and to determine the second level of description. Also, we propose a generic description for the first level. We kept the model of generic structure to ensure communication between the different contextual information In future work, we intend to suggest a set of generic rules that can be applied to this ontology to adapt the functionality of the pervasive system.

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