A REVIEW ON CONTEXT MODELLING TECHNIQUES IN CONTEXT AWARE COMPUTING

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Abstract--A system is context-aware if it uses context to provide relevant information or services to the user, where relevancy depends on the user’s task. Context-awareness is offering services to users with reactively to user environment and service conditions. The main goal of context-aware system is to track and identify the users. There exist many approaches for modeling contextinformation and each model brings along some reasoning techniques. Many researchers are concentrated the context aware computing and pervasive computing and has developed different context modeling and reasoning techniques. This paper mainly addresses key performance issues, challenges and different modeling techniques for Context aware computing and summarizes them.

Keywords: Context, Context aware computing, Modeling Techniques

I. Introduction

The term “Context” is some information which can be used to describe the situation of the entity”. An entity is a person, place or object that is considered relevant to the user or an application [16]. In a real time scenario, Context are might be location, time, temperature, noise and bandwidth of communication etc. A context-aware system is described as a system which uses context to provide adequate and proper information and/or services to the user, where relevancy depends on the user’s task [17]. As Schilit, Adams, & Want [18] definition, “A Context aware computing is a software that examines and reacts to an individual’s changing context”. The objective of most current research is to develop uniform context models, representation and query languages as well as reasoning algorithms that facilitate context sharing and interoperability of applications. In this paper we want to make a survey of the most relevant current approaches for modeling context for context aware computing.

We start in section 2 with some specific requirements arising from context modeling techniques. Section 3 summarizes various context modeling techniques in context aware computing. Section 4 discusses various contexts frameworks which are used various context modeling technique. Section 5 presents with conclusion and discussion on context modeling techniques.

II. Requirements of Context Modeling Approaches

It is important for any modeling of context information closely with several requirements. In this section, will give a short overview to the requirements defined by Strang and Linnhoff-Popien [19]:

1. Distributed composition: Strang and Linnhoff-Popien define ubiquitous or pervasive computing is a specialized area of distributed and mobile computing. Any context modeling approach for pervasive computing has a lack of a central instance. It is responsible for creation, deployment and maintenance of data and services.

2. Partial validation: Context modeling techniques has the ability to partially validate the contextual knowledge on structure as well as on instance level against context model. This very important requirements because of the complexity of contextual interrelationships.

3. Richness and quality of information: The quality of information delivered by sensors varies over time, as well as the richness of information provided by different sensors. So the context modeling techniques has this requirement.

4. Incompleteness and ambiguity: These existing context information at any time is usually incomplete and/or implicit. Therefore a context modeling approach should be capable with this possibility.
5. Level of formality: Sharing of contextual facts needs the realization of an adequate specification of the contextual information. This requirement describes the ability of a context modeling technique.

6. Applicability to existing environments: Every context modeling approach should be realizable. Every modeling approach should be implemented and realized within the existing infrastructure.

The above mentioned requirements are important for any context modeling approach which has to be realized in a pervasive computing environment [19].

### III. Modeling Approaches

This section will survey the most used context modeling techniques. These techniques are classified by the schema of data structures which are used to exchange contextual information in the system.

#### A. Key Value Models

The model of key-value pairs is the most simple and frequently used data structure for modeling contextual information. Already Schilit et al. [20] used key-value pairs to model the context by providing the value of context information in the context-aware computing. This model lists the attributes as key-value manner.

#### B. Markup Scheme Models

All markup scheme modeling approaches is a hierarchical data structure consisting of markup tags with attributes and content. Representatives of this kind of markup scheme approach are profiles. Typical examples for such profiles are the Composite Capabilities/Preference Profile (CC/PP) (W3C, 2004a) and User Agent Profile (UAProf) (Wapforum, 2001), which are encoded in RDF/S.

#### C. Graphical Models

A very well-known general-purpose modeling instrument is the Unified Modeling Language (UML) which has a strong graphical component (UML diagrams). Due to its generic structure, UML is also appropriate to model the context. Another example is the nicely designed graphics oriented extension to the Object-Role Modeling (ORM) approach context model.

#### D. Object Oriented Models

Object-oriented context modeling approaches is the intention to employ the main benefits of objects-oriented approach. This is namely encapsulation and reusability to cover parts of the problems arising from the dynamics of the context in context-aware environments. All details of the objects are encapsulated within the active objects and hidden to other components of the system.

#### E. Logic Based Models

The context is defined with facts, predictions or roles; a goal is to form new expressions or facts from previous ones. A logic defines the conditions which are a concluding expression or fact may be derived. First logic based context modeling approaches has been published by McCarthy and his group at Stanford [21, 22]. McCarthy introduced contexts as abstract mathematical entities in artificial intelligence.

#### F. Ontology Based Models

This model represents a concept group in a given domain and the relationship between the different concepts; depicts a domain with a graph of concepts; contextual relationships may be hierarchical or semantic. Most context modeling approaches are realized for a special application scenario and on that account many context information models are limited from the view of interoperability. Ontology-based approaches represents knowledge, concepts and relationships about a domain and describes specific situations in a domain. For example, given two atomic classes Person and Female, the class Male can be defined as: Male = Person ¬Female

#### G. Spatial context model

Space is an most important context in many context-aware applications. Context is defined as — Where you are, who you are with and what resources are nearby. Some of the context modeling approaches gives space and location. Most spatial context models are fact-based models. This model organizes their context information by physical location.

### IV. Literature review and related works

Matthias Baldauf [1] proposed a review of common architecture principles of context-aware systems, context modeling techniques and derive a layered conceptual design framework to explain the different elements common to most context-aware architectures. It is the survey paper about existing context aware system focusing on context aware middleware and frameworks which is used to develop the context aware applications based on various modeling techniques. The author summarized the main aspects such as Sensing, Context model, context processing, Resource discovery, historical context data and security and privacy policies of the various context aware architectures which is used various context modeling techniques. The goal of this discussed architecture is to separate of concerns between the context acquisition and the user components.
Muhammad Ashad Kabir[2] proposed a model, manage and reason about social contexts to aid the development of socially-aware applications. The author investigates the existing context modeling and reasoning techniques of socially aware applications. This development of socially aware application manages for the middleware platform. The author defines the social context as a representation of user’s relationship. It further categorizes into interaction-oriented relationships and connection-oriented relationships. And also discusses about the challenges of social context poses.

Johnson Fong[3], gives a semi-automatic and forward engineering context modeling tool which is used to provide design support for developing context models designed using the CML (Context Modeling Language). This tool uses the existing context information and automatically generates code for mapping context models. The proposed context modeling tool is to support Software Engineering of context applications and to check the typical errors including omitting constraints.

Hatim Guermah[4], presents an architecture for the development of context aware services based on ontologies and also discusses about context meta data model and about reasoning process for e-health systems. The author discusses the reasons about why ontology based model is suitable for representing and reasoning on context information. The author highlights the challenges of context awareness. Existing ontology based context aware application is discussed in this paper. As a future work the author plans to provide an applicable layer for context management and reasoning and evaluate more reasoning mechanisms.

Karen Henricksen[5], investigates the reasons about the shortfall, to evaluate the uses of ontology languages and tools in context aware systems. The author integrating the two modeling techniques to form a hybrid solution that combines interoperability support and ontology based reasoning. These context model is based on Object Role Modelling (ORM). The author briefly review the previously developed approach to context modeling and three types of reasoning like Reasoning about context, Reasoning for model checking, Reasoning about interoperability.

Dejene Ejigu[6], aimed at to develop a collaborative context aware service platform based on hybrid context management model. Context Data is organized into a hybrid context management model (HCoM) which is a combination of ontology and relational approach. The main advantage of the HCoM is, it has a heuristic component which has the problem solving techniques. The author presents an enhanced CoCA (collaborative context aware model), which is based on hybrid and collaborative context aware service platform. The proposed hybrid model is to separate the context data management and context knowledge management, process these two separately and given the results together for better reasoning and decision support in a context aware environment. As a future work, the author will concentrate on the security and privacy issues.

Bo Hu[7], proposed the context model framework based on ontology, dividing the model into Meta Ontology level and Domain-specific Ontology level according to the abstraction hierarchy. The author designed an algorithm to convert the context model to the knowledge described in OWL (Web Ontology Language) and used the reasoning tool to complete the context reasoning. The author reviewed the related works done for context models and classified the existing models into three categories as Application based method, Model based method and ontology based method. By using this proposed context model, when application domain has been changed need to change the Domain-Specific ontology not to change the reasoning method itself. The author mainly focuses on how to raise the model reusability and reason automatization.

Samyr Vale[8], proposed Model Driven Development (MDA) in ubiquitous computing to promote reuse, adaptability and interoperability in context-aware applications development and context metamodel proposition based on ontology concept and the parameterized transformation technique applied to context-aware development. The author discusses about the state of the art in context-aware applications development and gives a brief discussion of related works. Most important concepts in MDA are mapping and transformation techniques. The author identifies important benefits of MDA as concerns separation, reuse of models and interoperability and also proposes for context information definition ontologies concepts represented by RDF and RDFSchemas.

Imad Afyouni[9], proposed a survey of spatial models for context awareness indoor navigation systems. The author discussed not only the properties of those spatial models, and also to which degree the notion of context can be taken into account when delivering services in indoor environments. Spatial model requirements are also discussed in this paper and have been classified into two categories as service-oriented and efficiency-related requirements. The strengths and weaknesses of both symbolic and geometric spatial models are assessed by describing and evaluating different spatial representations. A hybrid spatial model is a combination of a hierarchical, set-based representation of space and a geometric representation of places, sensor ranges, and object of interest. This hybrid model achieves a good trade-off between geometrical and symbolic approaches by combining the benefits from both sides.

Jianchao Luo[10], proposed an ontology-based framework for developing NFC-based context-aware applications. This ontology based framework can perceive user context and offer appropriate context-aware...
services to the user by combining the NFC technology with context-aware technology. NFC-based context-aware applications are using this ontology based framework. The author presents the framework's design, implementation, and a real use case scenario that shows the validation of the approach. Related work for context-aware architectures and the framework have also been discussed in this paper. With the proposed framework, development overheads of acquiring, aggregating, inferring and storing context information are greatly reduced. The author provides security service for ensuring data integrity of the NFC context.

Hayashi et al. [11] introduced context-aware scalable authentication using multiple passive factors by modulating active factors to authenticate users. To select active authentication factors, the author proposed a generic probabilistic framework. This framework gives a set of passive authentication factors. The author developed a prototypes and investigated the feasibility and effectiveness of their proposed framework.

Hu and Weaver [12] proposed a dynamic and context-aware security infrastructure for healthcare applications. They developed a prototype and investigated the feasibility and effectiveness of their proposed framework.

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Badram et al. [13] presented context-aware user authentication, supporting proximity-based login in pervasive computing environment which uses a JavaCard for identification and cryptographic calculation, context awareness system for verifying user’s location and implements security fall back strategy. The authors introduced a concept of proximity-based user authentication in a pervasive computing environment. The author designed and implemented a proof of concept of a proximity based user authentication mechanism by combine the context aware subsystem with a personal smart card.

Maw et al. [14], designed and developed an adaptive access control model for medical data in body and wireless area network. The author evaluated the framework using medical scenario in which they included a user behavior trust module along with the access control module. The author concluded with the overriding policy which is useful to handle unanticipated situations and showed that by incorporating user behavior into access control model, one can make better security decisions.

Feng et al. [15] incorporated contextual application information to improve user authentication by presenting a touch based identity protection service. The author proposed the system and evaluate with real time data which is collected from 23 phone owners and deployed it to 13 of them with 100 guest users. The proposed system can achieve 90% of accuracy in real life naturalistic conditions. In touch screen data feature, the author considers two new sets behavioral and contextual features. The proposed system has 90% accuracy for both security and usability concerns. Real time data can be used in the proposed system.

V. Conclusion and discussion

In this paper we described the context modeling which supports gathering, evaluation and dissemination of context information in pervasive computing. Existing approaches to context information modeling differ in the expressive power of the context information models. In the paper we presented a set of requirements that context modeling techniques should meet and the list of context modeling techniques. Most of the people used smart phones, personal assistant devices to access the services through the internet. So need to model the context which is accessed by the internet and sensors. Many frameworks have been proposed and discussed about Context modeling techniques. In this paper, context modeling techniques in context aware computing has been considered and discussed a possible architecture, as well as some research issues to be investigated. We concluded our survey with most of the context aware frame work are used ontology based and hybrid based context modeling techniques.

REFERENCES


