

Chapter IV

Context Aware Mobility Management

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ABSTRACT

Context is any information that can enhance a computing system's relevance, timeliness, and usefulness to the user. Recent research has been devoted to the use of context in a mobile environment, particularly in handling the mobility itself. This chapter will start with defining what context is, how it is represented, and present a generalized system architecture. The authors then look at the problem of mobility in general and discuss existing solutions. Next they show how context can be leveraged to achieve more intelligent mobility management decisions. The authors highlight some of the research issues particular to context-aware mobility management and survey existing solutions. Last, they argue that these solutions have not truly addressed these issues and present their own architecture for handling mobility.

INTRODUCTION

In this section we attempt to define what context is and discuss some ways of modelling it. We also discuss the generalized framework for context-aware systems.

What is Context?

The term context has been defined in many ways and in many forms, but up to the time of this writing no

single definition of context has been put forth that sufficiently captures all the various aspects of this term. Perhaps this reflects the existing “paradox” in context-aware computing. Understanding the concept of context is in itself one of the fundamental research challenges in this field (Schmidt, 2002).

The most widely accepted definition is by Dey (2001), defining context as “any information that can be used to characterize the situation of an entity” (p. 5). This very general definition of context by Dey has

been formally extended by Zimmerman, et al (2007) to include a description of context using five fundamental categories, namely individuality, activity, location, time, and relations. In an attempt to better understand context, Henricksen, et al (2002) described it using the following characteristics:

- Context information can be static or dynamic. This implies that context exhibit temporal characteristics, as frequently we are not just interested of present context values but past and future (predicted) context as well.
- Context is imperfect – it can present contradicting, incomplete or even incorrect information. This imperfection stems from a number of reasons, such as sensors becoming faulty or information getting quickly out of date.
- Context can be represented in many ways. A significant gap exists between data captured from sensor outputs and the level of context needed by applications. A context model must be flexible enough to handle the different levels of granularity demanded by various applications.
- Relationships exist between context information. This relationship can be as simple as ownership, and can be exploited to infer that presence of a device mean presence of a person. A person's location also pinpoints his activity, if he is at a gym he is most probably engaging in some sort of exercise.

Context Models

A number of models have been proposed for representing context information. Strang & Linhoff-Popien (2004) categorized the most relevant context modelling approaches based on their representation of data for information exchange and we describe some of the more relevant ones here.

The *key-value model* assigns values to a key and uses a searching algorithm to look-up matching values. An example is the Context Toolkit (Dey, et al, 2001), the first system to define a software abstraction for context-aware applications. Although simple and easy to implement, it is difficult to share data among different entities using this model. An attempt to address this issue is the *mark-up scheme model*, which employs a hierarchical data structure consisting of tags and content. A number of these models are extensions of the Composite Capabilities / Preferences

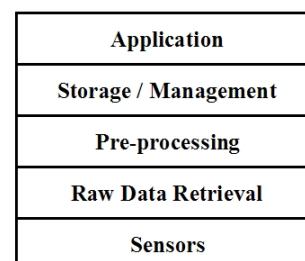
Profile (CC/PP) standard (Klyne, et al, 2004), such as the one proposed by Indulska, et al (2003). This is the right step forward but by itself is insufficient to address more complex needs such as overriding and merging mechanisms. A totally different approach is the use of graphical models, which relies heavily on visual representation to ease development and understanding by designers. The context extension to Object-Role Modeling (ORM) by Henricksen, et al (2005) is an excellent example of this.

The most promising approach at present is the use of *ontology-based models*. They are the most expressive, extensible, flexible, and can easily support validation (Strang & Linhoff-Popien, 2004). Additionally, the World Wide Web consortium has put forth standards for the semantic web such as the Resource Description Framework (RDF) and the Web Ontology Language (OWL) which can easily be used for modelling context. Ontology-based context management systems have already been proposed, such as the Context Broker Architecture (Chen, et al, 2003), Context Management Framework (Floreen, et al, 2005) and Service-Oriented Context-Aware Middleware (Gu, et al, 2004). These architectures rely on one or more centralized components to manage the context information on behalf of the resource-deprived devices. Our proposed architecture minimizes this dependence on central servers by delegating most of the functions to the mobile nodes themselves.

Generalized Architecture of Context-Aware Systems

Baldauf, et al (2007) presented a general layered conceptual framework for context-aware systems, shown in Figure 1. This common architecture is identifiable to most context-aware management systems, though

Figure 1. General layered conceptual framework for context-aware systems (Baldauf et al, 2007)



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