Chapter 2.16
Context-Aware Services for Ambient Environments

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ABSTRACT

This article presents the iTransIT framework for building context-aware pervasive services in large-scale ambient environments. The iTransIT framework provides an architecture for conceptually integrating the independent systems underlying an ambient environment and a data model for capturing the contextual information generated by these systems. The data model is based on a hybrid approach to context-modelling that incorporates the management and communication benefits of traditional object-based context modelling with the semantic and inference advantages of ontology-based context modelling. The iTransIT framework furthermore supports a programming model designed to provide a standardised way to access and correlate information from systems and their devices based on context and ultimately, to build context-aware ambient services. The framework has been assessed based on a prototypical realisation of an architecture for integrating diverse intelligent transportation systems in Dublin and by building context-aware ambient transportation services for urban journey planning and for visualising traffic congestion.

INTRODUCTION

Ambient environments describe smart spaces where networked systems and devices interact to support the everyday life activities of their inhabitants. Such intelligent environments are based on the vision of ubiquitous computing where everyday objects communicate and collaborate to provide information and services to users. Ambient environments may support people in spaces ranging from smart offices, to smart cars, to smart homes, to large geographical areas, for example, outlined by a shopping mall, by a road, or by a town. Ambient environments are inherently heterogeneous, as they likely will consist of a multitude of sensors, devices, networks, and ultimately systems, especially, with increasing scale of the space. People moving in such intelligent environments may use integrated devices, such as on-board computers in a vehicle, or handheld devices, such as mobile phones and Personal Digital Assistants (PDAs), to interact with the environments and to use the services they provide. These devices will provide access to the contextual information and the context-aware services available in an ambient environment, ranging from personal and professional information services, to environmental monitoring and control, to social services, to city-wide information systems (Cheverst, Davies, Mitchell, Friday, & Efstratiou, 2000), to traveller assistance (Kjeldskov et al., 2003).

Transportation is one obvious domain for large-scale ambient environments since services can be built to exploit the very many heterogeneous sensor-rich systems that have already been deployed in towns and cities and along national road networks to support urban traffic control and highway management. Such an ambient environment might enable people to access information ranging from places of interest, to prevailing road and weather conditions, to expected journey times, to up-to-date public transport information. It might also enable suitably privileged users to interact with the infrastructure, for example, to request a change to a traffic light or to reserve a parking space.

This article presents a framework for building context-aware services in large-scale ambient environments. The basis for the provision of such context-aware ambient services to users is the integration of the individual systems associated with intelligent environments into comprehensive platforms. The iTransIT framework (Meier, Harrington, & Cahill, 2005, 2006) proposes an architecture for the conceptual integration of the individual systems and their information deployed in an ambient environment. This enables information integration and sharing across independent systems and context-aware ambient services. The framework also proposes an extensible and layered data model to facilitate data exchange between systems and services with diverse data sets and quality of service requirements. Data layers are defined within a common context model along the primary context dimensions of space, time, quality and identity, and may be distributed across multiple systems. The data model is based on a hybrid approach to context modelling that combines the management and communication benefits of traditional object-based context modelling with the semantic and inference advantages of ontology-based context modelling. The Primary-Context Model and Primary-Context Ontology (Lee & Meier, 2007) have been designed with a strong emphasis on primary context, which is used to access other system context and to correlate context from independent systems, making them particularly suitable for large-scale ambient computing environments. And finally, the framework proposes a spatial programming model designed to provide a standardised way for ambient services to access context information that is provided by independent systems by exploiting the overlapping primary context attributes of the information maintained by these systems. This enables services to use and act upon information from a variety of deployed (and novel) systems as well as to share information between them. The spatial programming model hides the complexity and diversity of the underlying systems and their data sources and provides services with a common view on the available information and its context. For example, a service might use the spatial programming model to retrieve public transport information, which might be provided by an underlying system, and then access relevant weather information provided by another system using the temporal and spatial primary context of this information.