Chapter 4.6
Context-Aware Pervasive Services for Smart Cities

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ABSTRACT

Smart environments support the activities of individuals by enabling context-aware access to pervasive information and services. This article presents the iTransIT framework for building such context-aware pervasive services in Smart Cities. The iTransIT framework provides an architecture for conceptually integrating the independent systems underlying Smart Cities 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 contextual information from systems and ultimately, to build context-aware pervasive services for Smart Cities. 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 pervasive transportation services for urban journey planning and for visualising traffic congestion.

INTRODUCTION

Current advances in information and communication technology, where a variety of networked sensor-based systems and devices are deployed on the scale of towns, cities, and even countries, represent an excellent opportunity to support everyday life activities. Such smart environments are based on the vision of ubiquitous computing where everyday entities communicate and collaborate to provide information and services to users. They will lead to *Smart Cities* that can support the activities of their inhabitants to improve quality

of life and ensure sustainability. Smart Cities will support activities ranging from transportation, to healthcare, to sports and entertainment, to professional and social activities. They will support people in smart workplaces, in smart cars, in smart homes, and in large geographical areas, for example, outlined by a shopping mall, by a road, or by city limits.

Smart Cities are inherently heterogeneous, as they likely will consist of a multitude of sensors, devices, networks, and ultimately systems, especially, with increasing geographical scale. People living and moving in Smart Cities may use integrated devices, such as on-board computers in a vehicle, or handheld devices, such as mobile phones, Personal Digital Assistants (PDAs), and laptop computers to interact with the environments and to use the services they provide. These devices will provide access in a pervasive manner, that is anywhere and at any time, to the contextual information and the context-aware services available in Smart Cities, ranging from personal and professional information services, to environmental monitoring and control, to social services, to city-wide information systems (Abowd et al., 1997; Cheverst, Davies, Mitchell, Friday, & Efstratiou, 2000), to traveller assistance (Kjeldskov et al., 2003; Sivaharan et al., 2004; Wong, Aghvami, & Wolak, 2008), to optimised urban traffic control (Dowling, Cunningham, Harrington, Curran, & Cahill, 2005; Dusparic & Cahill, 2009).

Transportation is one obvious domain for providing the foundation of Smart Cities since services can be built to exploit the very many heterogeneous sensor-rich systems that have already been deployed on metropolitan scale and along national road networks to support urban traffic control and highway management. Such environments 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 pervasive services for Smart Cities. Particularly important for the provision of such context-aware pervasive services is the seamless integration of the individual systems associated with Smart Cities into comprehensive platforms. The iTransIT framework (Meier, Harrington, Beckmann, & Cahill, 2009; Meier, Harrington, & Cahill, 2005, 2006) proposes an architecture for the conceptual integration of the individual systems and their information deployed in a Smart City. This enables information integration and sharing across independent systems and context-aware pervasive 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 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 smart computing environments. And finally, the framework proposes a spatial programming model designed to provide a standardised way for pervasive 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

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