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CityMii - An integration and interoperable middleware to manage a Smart City

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Abstract

Modern cities are supported by multiple heterogeneous IT systems deployed and managed by distinct agents. In general, those systems use old, dependent and non-standardized technologies, which make them legacy and incompatible systems. As smart cities are moving toward a fully centralized management approach, the lack of integration among systems raises several problems. Since they are independent, it is not easy to correlate information from different systems and put it together to work in order to achieve application goals.
The collaboration among different systems enables an agent to offer new functionalities (services or just information about the city) that cannot be provided by any of these systems working as individual entities. The goal of this paper is to propose an integration middleware to support the management of Smart Cities in a dynamic, transparent and scalable way. The proposed middleware intends to support interoperability among different systems operating in a city.

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Keywords: Smart Cities, Middleware, Integration, Interoperability;

1. Introduction

Nowadays, cities rely on multiple systems (e.g. smart grid, efficient buildings, healthcare, garbage, water) which make it smarter. However, typically those systems are from different providers and are managed by distinct agents, using their own computational infrastructure, and work in isolation. In addition, those systems are often incompatible since in general they use old, dependent and non-standardized technologies. This results in an

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environment in which there is no interoperability among the systems, debilitating the goal of fully addressing the urban development challenges.

An intelligent city need tools able to contribute to an efficient management and orchestration of the existing different services. It is important to design and implement solutions for urban management based on the knowledge of the state of the city (in each instance – real time or near it) allowing to share information with third-party services thus promoting quality of life within the city.

The information of the city (sensed data) is collected through sensors distributed over urban space, which communicate using wired or wireless networks. These sensors may be owned by cities, but may also be owned by different stakeholders that supply services on the city infrastructure. Typically, the data is collected and handled by different management systems, owned and managed by each stakeholder and do not integrate with others.

The goal of this paper is to propose a framework that allows city authorities to efficiently manage the city by centralizing all relevant data in a single point while enabling to gather knowledge from correlated data. This will allow to process data collected by different systems, presenting it in a structured way that enables extracting new insights from this data in order to facilitate the decision-making process. This framework aims at supporting interoperability among the different systems of the city by providing a set of services and tools to have direct control over the environment, allowing a real-time update of the different devices distributed in the urban space. Once developed, the proposed solution will enable developers and city authorities to provide richer and more interesting applications to help them solving problems detected on the city ultimately providing better services to citizens.

2. Related work

Smart cities and IoT applications have received a considerable attention from researchers in recent years. Smart cities can provide a new generation of real-time and time-critical, location, social, and context-aware services to their digital citizens, such as for emergency and health-care [1], surveillance [2], entertainment, and social good [3, 4]. Recent research activity related with smart cities, focuses on event forecasting [5], multi-sensor information fusion [6], business model and profit maximization [7], ontologies [8], service models [9] and quality of experience [10]. Researchers have also developed a multitude of application-specific solutions for areas such as diagnostics [11,12], environmental monitoring [14, 15], social interest [16], traffic management [17], etc. However, these application-specific solutions are not integrated.

The lack of integration raises some problems, for example, how distinct, heterogeneous, fully decentralized and independent systems can closely collaborate with each other to achieve innovative application and to manage a city from a single point.

In the literature, there is a set of works proposing middleware approaches [18, 19, 20, 21, 22] which provide abstractions to develop Smart City applications. Nevertheless, in general, they do not fully address the interoperability needed to manage a real city. For instance, some of them are focused on IoT environments and in other abstractions for Smart City [18, 19, 20]. Other middleware approaches focuses on the integration of public and private cloud platforms for smart cities environments [21, 22] rather than interoperability. In contrast, OverStar [23] does have a strong focus on interoperability but its generality fails to address Smart City scenarios and requirements. There are other works more oriented to the interoperability context that can be used in Smart City scenarios. These works are related with System-of-Systems (SoS) approaches that support different heterogeneous, stand-alone and largely independent constituent systems [24, 25, 26, 27, 28]. While there has been significant research into SoS middleware, these works have not addressed the needs, and complexities of smart cities.

3. CityMii Middleware for Smart Cities

A city becomes truly smart only if it is an autonomous city where the heterogeneous utility systems and sub-systems within the Smart City are able to communicate with each other to operate in an integrated manner. In this context, to achieve a truly Smart City, a common middleware platform is essential.

The CityMii middleware is a centralized hub where the utility systems communicate to their own producers, data collection units, sensors and with each-others (required systems) for synchronized operations. CityMii allows the Smart City authorities to have a centralized control over the data that flows through the various utilities and subsystems. The authorities are able to view the data acquired and handled by these systems. Also, based on defined