# Smart City Aspects, Services and Application

A communication platform for smart cities

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***Abstract*—There are plenty of opportunities for new services by interconnecting physical and virtual worlds with a huge amount of wireless nodes distributed in houses, vehicles, streets, buildings and many other public environments. The first objective of this article was to provide an overview of the smart city concept, and the second goal was to propose a technological solution and communication platform for the development of city services in relation to the improvement of urban systems and services. The diagram of proposed communication platform that is presented could be used as a connection between multiple cities. It is applicable for the development of city services and for the integration and use of rendering and actuating technologies. The proposed communication platform can be used for the improvement of specific urban systems and services and as a connection between multiple cities.**

***Keywords - smart, city, survey, connection, communication platform, sensor, network, data, service.***

## I. INTRODUCTION

There is a demand for smarter, effective, efficient and more sustainable cities, pushing the collective intelligence of cities onward, which can improve the ability to forecast and manage urban flows, and integrate the dimensions of the physical, digital and institutional spaces of a regional agglomeration. The expression "smart city" has been used for several years by a number of technology companies and serves as a description for the application of compound systems to integrate the operation of urban infrastructure and services, such as buildings, transportation, electrical and water distribution, and public safety [1]. A smart city can be described as a city that:

• Allows real-world urban data to be collected and analysed by the use of software systems, server substructure, network infrastructure, and client devices [2].

• Implements solutions, with the support of instrumentation and interconnection of sensors, actuators, and mobile devices [3].

• Can combine service production and an intelligent environment, exploits accessible information in its activities and decision making and adopts information flows between the municipality and the urban or business community [4].

The theory of smart cities understood from the perception of technologies and components has some exact properties within the wider cyber, digital, smart, intelligent cities texts [5]. The novelty of this article is summarized in Figure 6 which proposes a connection between multiple cities. The rest of the paper is organized as follows. Section II and III will highlight smart city systems, applications and services, and then in Section IV is presented the role of technology. Section V presents the communication platform that we have proposed. Section VI provides some final conclusions.

## II. SMART CITY SYSTEMS AND CITY DATA

As information systems have become prevalent in urban environments they have formed opportunities to capture information that was never previously accessible. Figure 1 provides an overview of the city systems and relevant aspects.

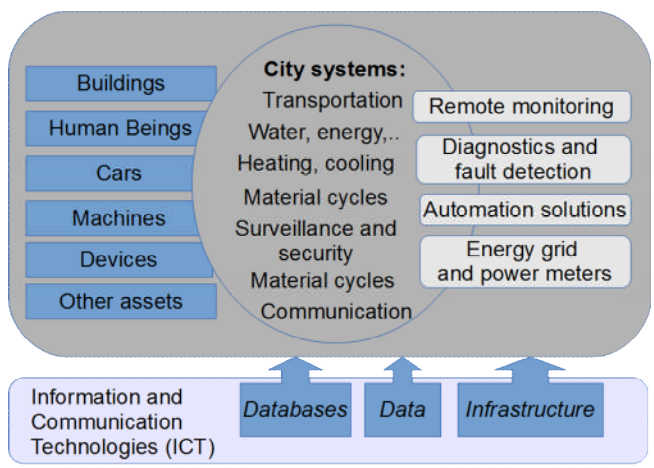


Figure 1. Data and city systems.

This overview is necessary for an understanding of the existing links. Vast amounts of data that describe what happens in the city are available and could be used to create and change intelligent solutions within related areas of e-services application. Knowing what data and what information systems the city has would help with understanding the city systems. But the reality is that

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"nobody has a comprehensive overall picture of the data and information systems of their city [2].“ Viljanen et al recapitulated that "even the City itself does not have a complete overview on all the information systems it has in its dozens of different departments and public service corporations. [2]" The expansion of both computing power and new algorithms allow this information to be analyzed in near “real-time” in order to provide a base for all developed applications.

The same infrastructure is used 24 hours a day, seven days a week by various stakeholders - citizens, workers, students, researchers, investors or entrepreneurs. Characteristic players in the smart city include municipal leadership, IT and telecommunications companies, utilities, municipality technical services, and grid-infrastructure service providers. Partnerships and strong collaboration strategies and tactics among key stakeholders are required in order to share research and innovation assets, such as emerging Information and Communication Technologies (ICT) tools, methodologies and know-how, experimental technology platforms, and user communities for experimentation on e-service applications and future internet technologies [5].

### *A. Smart cities applications and services*

Citizens and other stakeholders expect high quality public services that transform and enhance their daily quality of life. A brief overview of various areas of smart city applications is recapitulated in Figure 2.

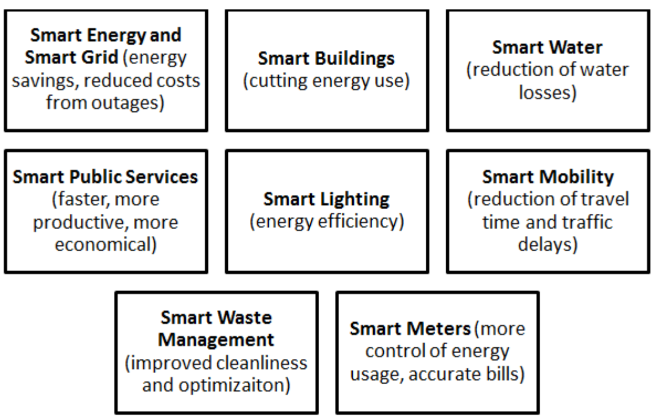


Figure 2. Areas of smart city applications.

It is clear that the spectrum of application areas is very wide. For example, real-time travel information is essential for applications which let people plan trips on public transportation. The user could have real time information about when the next bus or train is coming. Another example is an application, which collects and distributes real time information about where parking is accessible so drivers can promptly find free spaces. Access to suitable data represents an opportunity for developers to create applications. In this way, stakeholders can access wide online services, with portals for basic information, citizen services, business, and tourism, all based on a common infrastructure.

TABLE I. OVERVIEW OF SMART CITY SERVICES

| Application area: | Description: | Examples: |
|---|---|---|
| **General municipal and business services** | Creation of networks between cities and partners, and services realization in order to add value to stakeholders. | - on-line problem solving tools<br>- intelligent shopping<br>- services ordered electronically |
| **Intelligent, sustainable buildings and building management *(smart building)*** | Intelligent buildings that contain the advantages that come from integrating communications and building control systems. | - room automation systems<br>- optimized heating, ventilation, and air conditioning |
| **Education, health and social care arena *(smart education)*** | Applications that allow improvement of processes undertaken in this area and with better access to services. | - telemedicine monitoring<br>- sharing medical files<br>- tracking systems for elderly people |
| **Energy production and energy efficiency *(smart energy, smart lighting)*** | Intelligent electricity system that connects all supply grid (utilities) and demand elements (end users) through an intelligent system. | - lighting controls<br>- smart grid applications<br>- optimize grid performance<br>- provide adherence to environmental rules |
| **Gas, electricity and water smart metering *(smart grid)*** | Utility meter that records energy, water or gas usage in real time. | - wireless smart meters<br>-on-line information about consumption |
| **Smart water and waste management *(smart utility)*** | Intelligent management of water and sewer system and flow management technology with real time awareness and control. | - intelligent sewer system<br>- rubbish bins real-time monitoring<br>- pressure management |
| **Public safety, security and crime prevention** | Anticipate events, respond and preventing them, warn users of dangers, optimize the capacity and response time of emergency services. | - cameras around town<br>- IP video surveillance system<br>emergency signalling |
| **Real-time locating services and geographic information *(smart parking)*** | Covering of strategic spatial information needs of people or organizations and realization of service that helps keep track of things. | - location aware applications<br>- identity related services<br>- keep track of cars |
| **Logistics and supply chain *(smart supply chain)*** | Synchronizing supply with demand, measuring, monitoring and managing transport and inventory movements or supply chain activities across the city supply chains. | - tracking and inventory control<br>- control and visibility of supply chains<br>- provide adherence to rules and regulations |
| **Mobility and transport *(smart transport)*** | Build a real-time and efficient traffic system to optimally use and combine all means of transport (efficiency, delays, and fuel waste and carbon emissions). | - surveillance cameras for transportation<br>- smart parking network<br>- provide adherence to environmental rules and regulations |

## III. OVERVIEW OF SMART CITY SERVICES

There is a wide range of services and applications (See Table 1). These services cover fields, such as transportation (intelligent road networks, connected cars and public transport), public utilities (smart electricity, water and gas distribution), education, health and social care, public safety. Emerging applications and services are extended into diverse fields, such as everyday life of citizens, disaster management, smart buildings, logistics and intelligent procurement.

The applications for this portfolio include implementation for the connected city such as: smart grid, smart home, security, building automation, remote health and wellness monitoring, location aware applications, mobile payments and other machine-to-machine (M2M) applications.

The acronym XaaS (X as a service) refers to any of an increasing number of services provided on-line: everything as a service or anything as a service. The examples of XaaS are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Monitoring as a Service (Maas), Security as a service (SECaaS), Software as a Service (SaaS), and others.

Developed applications are able to supply real-time information and expand the ability to forecast and manage urban flows, and fulfil other functions of the city. Also, they can help to reveal how demands for transportation, water and energy peak in a city and how to take appropriate action and respond. It is important to the city stakeholders that they can collaborate to smooth these peaks and to achieve robustness.

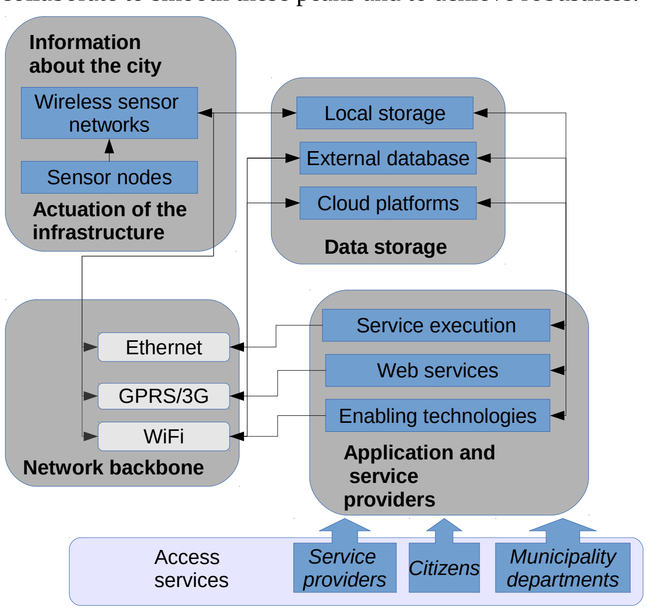


Figure 3. City services and the technological solution.

## IV. THE ROLE OF TECHNOLOGY

Advances in new technology are employed to improve city applications and services. There are communications, analytical and control technologies that permit transforming the way of doing things while influencing better policy and urban management. It is changing the entire way the service can be solved, combining the ICTs with city infrastructure and shifting the city systems solutions. Thanks to these technologies, there is the capability in the provision of services via digital communication, e.g., interactive services or automating the solution of services. Figure 3 presents city services and the technological solution of services. Data are stored and forwarded by using the network backbone in order for use by service providers and in related applications. Cimmino et al [11] highlighted the role of small cell technology in smart cities – there is the prospect of “increased broadband capabilities, improved flexibility and easy deployment of scalable multi-service network architectures.” The article concludes that the integration of broadband personal communications with device-to-device communications and M2M will constitute a significant challenge. The creation of information stuff is not restricted to a particular location, and the resulting products are typically delivered through the network. Smart city services are also available through wireless mobile devices and are enabled by services oriented enterprise architecture including web services, the extensible markup language (XML), and mobilized software applications [15]. Big data to analyze, capture, clean, search, share, store, transfer, and visualize should also be mentioned here.

Smart cities are deploying online services in diverse sectors of cities. An online service, also called Software as a Service (SaaS), is a service delivered by a software application running online and making its facilities accessible to users over the Internet via an interface. The interface could be Hyper Text Markup Language (HTML) obtainable via a standard client, such as web-browser or a web-API (application programming Interface) or by any additional means. It can represent real service that runs on the host (POP, SMTP, HTTP, etc.) or some other kind of metric associated with the host - response to a ping, free disk space, number of logged in users, etc. Eventually, services could be delivered to users through home-based access or mobile access, citywide digital interactive displays, or kiosks. Cloud computing has radically transformed in what way business applications are built and run. Platform as a Service (PaaS) is a way to lease operating systems, storage and network capacity or hardware over the Internet. It is a kind of cloud computing services that deliver a solution stack and a computing platform as a service. Here, online-service users no longer need to own or license the software to run it. Where users need to pay, they are paying for use of the service rather than for owning or licensing the application itself. These innovations have allowed offer more services to more people, to give better access to services with accompanied improvements and innovations.

### *A. Wireless sensor networks and related technological advances*

The aim is to deploy monitoring infrastructure and produce a distributed network of intelligent sensor nodes which can measure many parameters for a more efficient management of the city. Recent advances in wireless sensor networks have been determined by a range of underlying

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technological advances, primarily progress in MEMS (micro-electro-mechanical system) sensor technology, and innovative ways to manage power consumption. These networks responsible for sensing as well as for the first stages of processing are capable of flexible, low-cost monitoring of a range of environmental parameters and phenomena at very fine levels of spatial and temporal detail.

Smart city solutions proposed for event detection based on Wireless Sensor Networks will be generating important growth in this arena. The wireless sensor network (WSN) consists of a group of heterogeneous and spatially dispersed autonomous sensors deployed in large numbers either inside the phenomenon or very close to it. The WSN is constructed from a large number of "nodes" organized into a cooperative network, where each node is connected to one or several sensors.

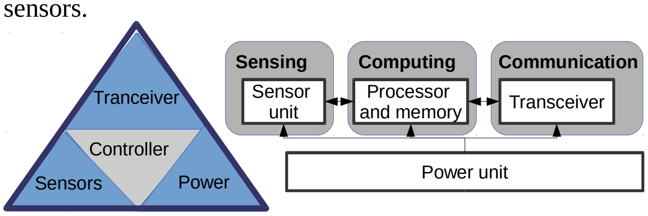


Figure 4. Hardware architecture of a sensor node.

Figure 4 provides a schematic overview of the typical architecture of the sensor node. These sensor nodes have the capability to collect and process data, each node is able to autonomously sense, process, and communicate data about its immediate environment to other nearby nodes and computers. Zheng at al noticed that there are the unique characteristics and constraints for sensor networks: dense node deploymend, battery powered sensor nodes, severe energy, computation, and storage constraints, self-configuration, application specific design requirements, unreliable sensor nodes, frequent topology change, many-to-many traffic pattern, data redundancy, and nonexistence of global addressing scheme [26].

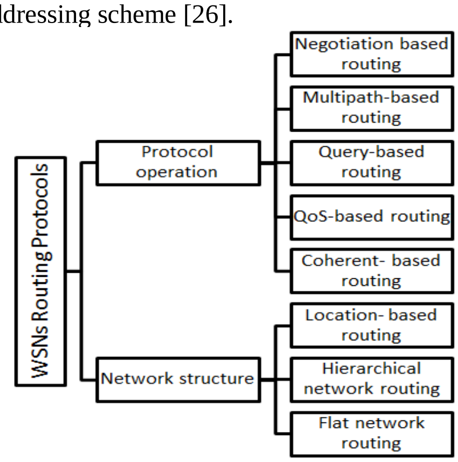


Figure 5. WSNs Routing Protocols [25].

Just as the Internet allows access to digital information anywhere, sensor networks will provide vast arrays of real-time, remote interaction with the physical world (Pinto, 2003). Distributed intelligence from the sensor to the network will become as essential as the Internet - wireless sensor networks give the opportunities for the collation of data which is fit for the purpose supporting the creation of smart cities. Each from a few to several hundreds or even thousands of nodes in the network consists of processing capability given by one or more programmable microcontrollers for controlling node behaviour and processing data.

A lot of research has previously been accompanied into sensor networks, and a comprehensive set of specifications have been completed for the physical layer, link layer, and network layer. The same is true for routing protocols necessary for setting up path or paths from sensor nodes to the data sink. Routing is an important issue and since sensor nodes have limited resources, routing protocols must have a small overhead. As it can be seen in Figure 5 many routing protocols have been developed over the last few years and many innovative routing mechanisms have been proposed [25].

Representative sensor network related communication technologies includes Wireless Fidelity (Wi-Fi), ZigBee, IQRF, Ultra-Wide Band (UWB), and Wireless Hart. Even though it have not been used extensively on a large scale yet, wireless sensor networks (WSNs) offer a substantial technology that helps to cover city conditions monitoring needs. This technology gives the ability to efficiently and quickly detect various spatial events, such as the problems of a region of high pollutant concentration by processing real time data. Air pollution or monitoring of urban environments could be supported by dense WSN of nodes with monitoring capabilities. These advanced real-time systems are wireless, highly distributed, also used in addition to sensors actuators as interfaces deployed across a wide geographic area.

### *B. Sensing of the city and cloud computing*

The intelligence of a sensor network is predominantly reflected in provision of real time information and in the fact that the real-time sensor data might be integrated with environmental modelling and control. The primary concept essential for capability of real-time information distribution and use them in city services lies in establishing the digital infrastructure for processing of both WSN and video surveillance data resulting in a more efficient event detection. The growing penetrations of fixed and wireless networks permit that such sensors and systems to be connected to distributed processing centres. The smart city connects the sensors to sense the city systems, and process the sensing information by cloud computing and so on to integrate cyber space and things of internet [15].

Contemporary wireless sensor networks are principally treated as simply a new data source for integration with other conventional spatial and open data information systems. Examples include sensors connecting buildings, infrastructure, transport, networks and utilities, offers a physical space for experimentation and validation of the Internet of Things (IoT) functions. The data is delivered in real-time through the cloud to the service providers, users, and other stakeholders.

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## V. THE PROPOSED COMMUNICATION PLATFORM

The diagram of proposed communication platform for the development of city services and for the integration and use of rendering and actuating technologies is shown in Figure 6. The help of instrumentation and interconnection of mobile devices and sensors, which collect and analyse real-world data, creates a dynamic environment with numerous groups of users concerned in different city events. We may use smart travel as an example. The provision of real-time information about urban environments could give real-time travel information for passengers, such as current running times of buses or trains. Traffic monitoring can be supported by monitoring of means of transport, weather and traffic condition.

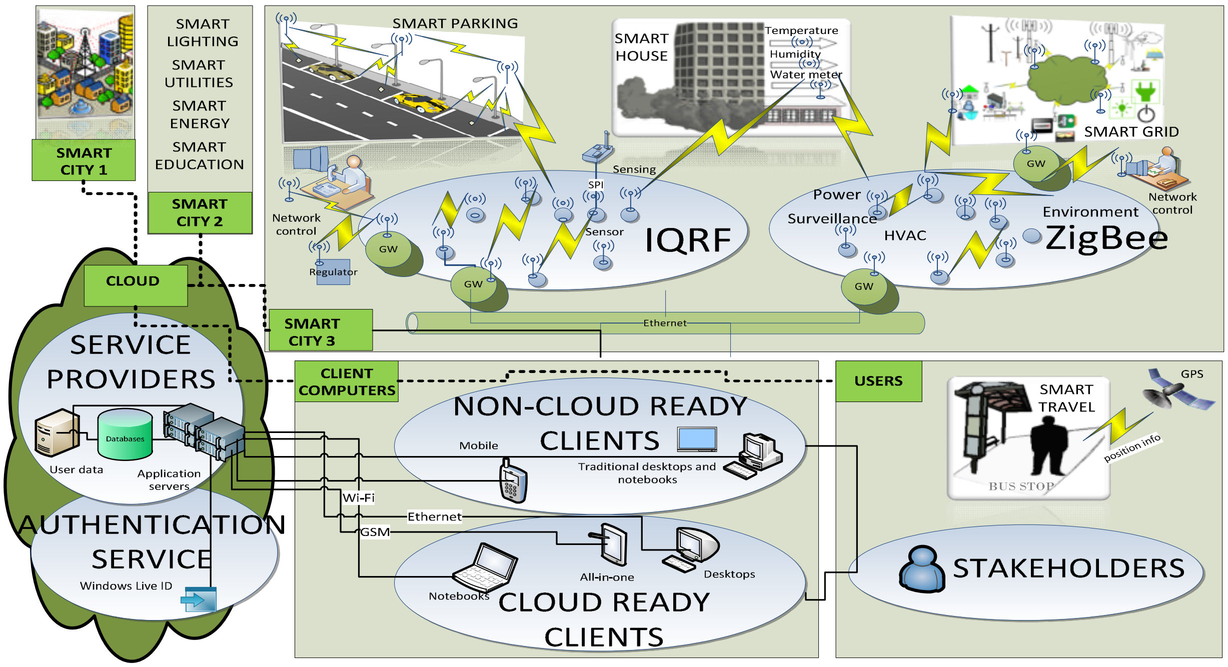


Figure 6. Communication platform for the development of city services and for remote control.

The widespread use of digital sensors and digital control systems for the control and operation of urban infrastructure includes traffic sensors and actuators, building management systems in the smart house solution, digital utility meters in the smart utility area, and so forth. There are plenty of opportunities for new services by interconnecting physical and virtual worlds with a huge amount of wireless nodes distributed in houses, vehicles, streets, buildings and many other public environments. It may be components that will be applied in the fields of vehicle-mounted terminals, wireless meter reading, streetlight (smart lighting), transportation (smart parking), household appliances (smart energy), and industrial cameras (smart house). Ambient spatial intelligence for sustainable cities contains the potential for augmenting such networks with the capabilities to not only capture, but also process, query, and even use spatial data in the network itself.

Thanks to a distributed network of intelligent sensor nodes, a wide collection of parameters can be measured for better management of the city, and data are delivered wirelessly and in real-time to the citizens or the appropriate authorities [1]. By using networks and sensors to measure and control processes, and the cloud for the information sharing, stakeholders can make immediate diagnoses and correct the problem by appropriate action in the event of an accident or another incident. The principle of Smart Earth is that, sensors are embedded everywhere: in the railways, bridges, tunnels, roads, buildings, water systems, dams, commercial equipment and medical equipment, and then physical facilities can be perceived, so information technology extends into the physical world, constructing a "Internet of Things" [15]. A mashup is important to make existing data more useful as a combination of two or more sources to create new services. This can include a wide range of uses from identity and access management to application, web, and portal servers that power stakeholder services and web sites to ensure a view of the citizen and real-time updates of information across city systems. A real time dashboard for monitoring city systems offers solutions to help city authorities manage smart city policies and guarantee the necessary controls and procedures are in place for better governance. The application layer could include interactive modules that notify the users of events or alerts and allow them to trigger further actions.

## VI. CONCLUSIONS

The first objective of this article was to provide an overview of the smart city concept, and the second goal was to propose a technological solution and communication platform for the development of city services in relation to the improvement of urban systems and services. Monitoring,

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measurement and remote control are important areas of a smart city necessary for the full utilization of the opportunities offered by information and communication technologies. Figure 6 included in the previous section gives an overview of the proposed communication platform for the development of city services. This communication platform can be used for the improvement of specific urban systems and services. Directions for our future work include applying the framework for implementation of a proposed communication platform, described in the article in an application for a specific city application.

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