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Smart City Concept, Applications and Services

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Abstract

The purpose of this article is to summarize the current state of understanding the smart city concept and to present a proposed communication platform for the development of city services. The first part of the article is an introduction and definition of a smart city concept. This introduction gives an overview of various aspects - city services, smart infrastructure and facilities, using information and communication technologies, interconnection, feedback, and electronic and digital applications. The next part addresses individual challenges for the planning, development, and operation of cities. New solutions allow for use of different data on cities and meet the request for better city services. An overview of smart cities applications and services is given in the next section of the article. The deployment, implementation and approval of innovative internet based services and applications have to be made in order to permit facing the challenges of advanced cities. An overview of some aspects related to the technological solution of services is discussed in the summary section.

Keywords: Smart service; Control platform; Infrastructure; Wireless network

Introduction

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 analyzed by the use of software systems, server substructure, network infrastructure, and client devices.
- Implements solutions, with the support of instrumentation and interconnection of sensors, actuators, and mobile devices.
- 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.

The city may be considered as a service organization with citizens as the customers - it provides services to its citizens. 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. Urban development and improvement of the city has been turning towards technology. Smart cities use different information and communication technologies (ICT). Solutions characteristically includes various aspects of a city ecosystem such as smart infrastructure, smart operation, smart service and smart industry, smart education systems, or smart security systems. The concept of a smart city integrates the dimensions of the physical, institutional and digital spaces of an agglomeration. This approach introduces aspects such as interconnection, feedback, self-organization, and adaptation in order to provide understanding of the almost organic growth, operation, and evolution of cities.

Cities are now transforming from digital cities to smart cities, digital or intelligent cities that are more technology oriented equivalents of smart city concepts. A city becomes "smart" when it is instrumented, interconnected, adaptive, autonomous, learning, self-repairing, and robust. Parts of its infrastructure and facilities are digitally connected and optimized by using ICT to deliver services to their citizens and other stakeholders. 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 [2]. Intelligent cities, or intelligent spaces more generally, refer to a wide range of electronic and digital applications related to digital spaces of communities and cities, for example smart grids, smart meters, and other infrastructure for electricity, water supply, and waste management. Digital cities, derived from digital representation of cities, mean a digital metaphor of cities, and intelligent cities, derived from the new intelligence of cities that represent collective and distributed intelligence. Another related label is "cyber city", derived from cybernetics, cyberspace, city governance and control based on information feedback. The term digital city has been used as an equivalent of "intelligent city", "knowledge-based city", "information city", "cyberville", "wired city", and "electronic communities".

Smart city systems and city data

Challenges for the planning, development, and operation of cities are encouraging new thinking in various professions. Professionals across architecture, urban planning, engineering, construction, information technology, systems and environmental science, property development, finance, and municipal government acquire a stronger understanding of stakeholders and receive insights as to how best to engage them. Systems models that are capable of seeing deeply into how cities work, how people use the city, how they feel about it, where the city faces problems, and what kinds of change can be applied could be used for smart city developments [1].

The same infrastructure is used 24 hours a day, seven days a week by various stakeholders - citizens, workers, students, researchers, investors or entrepreneurs. A city can be viewed as a system of stakeholders-wider community and community organizations, business community and entrepreneurs, local people and residents, local authority and

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local governance, civic organizations, academic community and educational institutions-with their competing interests. Smart city solutions must address local requirements within a local circumstance and with local actors. Characteristic players in the smart city include municipal leadership, IT and telecommunications companies, utilities, municipality technical services, and grid-infrastructure service providers. Community interests could be recognized at many institutional levels: households, neighbourhoods, city, industries and services, public or private. Assessing these attitudes will help govern the level of interest and influence of stakeholders in relation to the proposed project, incorporating multiple stakeholders into the smart city planning process and balancing interests. Partnerships and strong collaboration strategies and tactics among key stakeholders are required in order to share research and innovation assets such as emerging ICT tools, methodologies and know-how, experimental technology platforms, and user communities for experimentation on e-service applications and future internet technologies [2].

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. 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. There are various data and information obtained from city management and other stakeholders such as public data on transportation, energy consumption, water conditions, data entered at source by shippers and a range of other information. Knowing what data and what information systems the city has would help with understanding the city systems. But the reality is that "nobody has a comprehensive overall picture of the data and information systems of their city [3]. There are many different data on cities: statistics, publications, simulation models, video recordings, images, maps, geographic information, and 3D models. Viljanen et al. [3] 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 [3]. 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.

Smart city solutions for electronic administration

Municipalities have a commitment for integrated urban services planning in order to provide efficient services to citizens in expectation of improving the quality of life. This requires new thinking about how to meet the request for public and other services and to achieve the improvement of the quality of services through development of the city infrastructure. The message is clear - take the paper out and replace it with electronic data and messages through the use of an e-office. Policymakers and public leaders are increasingly looking for ICT solutions to productively and effectively provide public services in the area of utilities, transportation, education, healthcare, or safety. Many local authorities and city administrations are now seeing the benefit of systems integration and more joined-up thinking. Even businesses benefit from more honest and efficient interaction with the city through more streamlined and transparent procurement policies, as well as registration and taxation processes or online services provision.

This is about creating an advanced network between cities and partners to establish and deliver better e-services to stakeholders and communication provision between the public authority and the recipients of services. For example e-participation could be obtained via direct communications through social media or simple applications. The city should interact with its citizen through instant access, digital interfaces rather than through offices with paper forms and long lines of people that are waiting for a service. All the public services and the digital governance in municipalities are now benefiting from technological advances. A public administration or authorities therefore delivers a set of services and infrastructure, based on ICTs. Communication, information sharing and real-time information are an important requirement for implementation of smart city applications and services. Information sharing describes the data exchange between various organizations, people and technologies-new ICTs have a crucial role for this. Information collection, processing and sharing is related to the data exchange, communication protocols and technological infrastructures. There are enterprise-based approaches to developing these solutions on the service provider's behalf. Cities are leveraging diverse applications to increase, and for the enhancement of, collaboration across departments and interaction with citizens. The electronic governance (e-governance) may offer a new instrument for developing a smart city and can support in helping cities to improve the quality of municipal services and make better decisions in order to become more competitive, as well as engaging with constituents in decision-making processes. The administration of a city or a local community offers online (via its web portal) services that previously was accomplished offline. Web page design, content management, and hosting allow an opportunity to create its own web site for services that municipalities and other service providers deliver to their target groups.

Smart Cities Applications and Services

The provision of real-time information about urban environments is important for running different helpful applications and services. A brief overview of various areas of smart city applications is recapitulated in Figure 2. 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

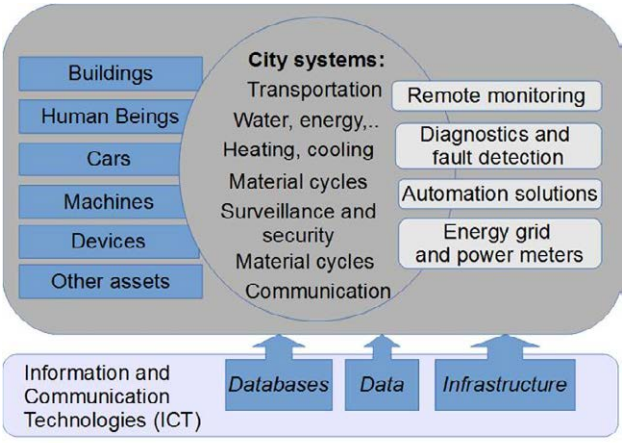

Figure 1: Data, city systems, and their relation to the sensing and control city subsystems.

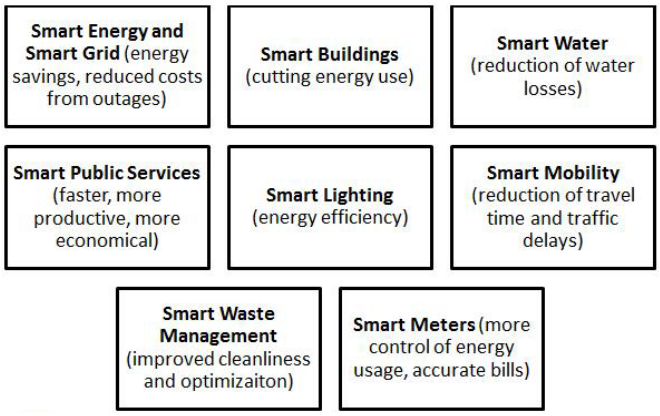

Figure 2: Areas of smart city applications.

a common infrastructure. Smart cities are deploying online services in different sectors of cities.

Cities are structures of services and these services are things through which people interact within the city systems, together with other people. They often consume or transform resources and usually require some form of payment or exchange. Both universal and regional service providers offer to manage and run city applications and services. Many systems integrators and service providers are going beyond the defining, designing, developing and deploying offerings for specific smart city initiatives by integrating multiple initiatives or by proposing to accomplish and run them on behalf of city administrations or other stakeholders. Services delivered by smart cities should be easy to use, efficient, responsive, open and sustainable for the environment. Citizens and other stakeholders expect high quality public services that transform and enhance their daily quality of life. There is a pressure on cities to optimize urban services management, provide better and more efficient infrastructures and services, often for less cost. The general aim is to deliver higher quality services more efficiently, to achieve saving in staff time and costs of delivering services, and provide a safe, convenient, efficient service.

Overview of smart city services

There is a wide range of services and applications (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. Bundles of services range from socially networked services to basic geographical positioning systems and to local market-based services. Firms that are developing and providing e-services in different sectors follow diverse objectives. The general aim is to be more efficient in meeting quality of service targets and to streamline business processes and cover the growing demand for the capabilities needed to build advanced e-enabled city services. The next objective is that e-services provide a potential source of revenue for the service providers. Other objectives include needs to develop and deliver better e-services than competitors and have better statistics for better decision making or help clients optimize all manner of business processes and decisions. 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. Social applications based collaboration and emergent collective intelligence is another way to expand the amount of information available. Social media have offered the technology layer for organizing collective intelligence, with web-collaboration, crowdsourcing platforms, mashups, and other means of participatory problem-solving approaches. Another important application area is decision making, intelligence gathering and forecasting by using data to encourage predictive models enable risk modelling and combined use of available city resources. If the stakeholders are informed fast, thoroughly and reliably and have access to real time information at the level of individual citizen's choices and actions, they are be able to quickly take appropriate action. Those distributed problem solving decisions will make the city function better. It is about giving decision makers consolidated information that helps them to expect rather than just react to the incurred problems. The result is many solutions that lead to increasing the problem solving capability of communities and cities.

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. [4] 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.

Smart city services and applications are focusing on how to shape future Internet based services and applications from a smart city perspective. The deployment, implementation and approval of innovative internet based services and applications have to be made in order to permit facing the challenges of advanced cities. This change and prospect especially involves people who work with knowledge and information. 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 [5].

Application area	Description	Key stakeholders	Examples
General municipal and business services	Creation of networks between cities and partners, and services realization in order to add value to Stake holders	- local authority or governance - local people and residents - local interest groups - business community and enterprises - suppliers and service providers - educational institutions and academic community	- on-line problem solving tools - intelligent shopping - services ordered electronically - helps residents enter the labour market
Intelligent, sustainable buildings and building management (smart building)	Intelligent buildings that contain the advantages that come from integrating communications and building control systems	- local people and residents - local authority or governance - suppliers and service providers - environmental groups and organizations - creditors and owners (shareholders)	- room automation systems - optimized heating, ventilation, and air conditioning - managing municipal facilities
Education, health and social care arena (smart education)	Applications that allow improvement of processes undertaken in this area and with better access to services	- educational institutions and academic community - health and social services providers - local people and residents - local authority or governance - local interest groups - charities and not for profit organisations	- telemedicine monitoring - sharing medical files - tracking systems for elderly people -virtual exhibitions or lectures - provide adherence to rules and regulations
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	- energy suppliers - regulators (health & safety, central government) - business community and enterprises - environmental groups and organizations	- lighting controls - smart grid applications - optimize grid performance - provide adherence to environmental rules and regulations
Gas, electricity and water smart metering (smart grid)	Utility meter that records energy, water or gas usage in real time and maintain continuous two-way communication	- local people and residents - business community and enterprises - suppliers and service providers - creditors and owners (shareholders)	- wireless smart meters -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	- water suppliers and waste management companies and suppliers - local authority or governance - local people and residents - regulators (health & safety, central government) - suppliers and service providers - environmental groups and organizations	- intelligent sewer system - rubbish bins real - time monitoring - pressure management system to leverage water network data - provide adherence to environmental rules and regulations
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	- local people and residents - local authority or governance - local interest groups - business community and enterprises - suppliers and service providers	- cameras around town - IP video surveillance system emergency signalling
Real-time locating services and geographic	Covering of strategic spatial information needs of people or organizations and	- local people and residents - local interest groups - business community and enterprises	- location aware applications - identity related services

Table 1: Overview of smart city services and application areas for remote control of various city subsystems.

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 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. These services improvements have improved operating costs and increased productivity. A citizen may use a lot of city services on-line. The provider may provide services for various user groups, characterized by specific roles and permitted to make diverse activities, depending on their user profile and the associated access policies. Innovation mechanisms that are particularly relevant in future internet services in smart cities as processes that are involving citizens, businesses and public authorities. Services, infrastructures, methodologies and ICT systems for smart cities are put into operation and verified for the use of final users. Confirming cities' level of service provision and refining their robustness means that they have to be increasingly capable in meeting both projected and unpredicted challenges.

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 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

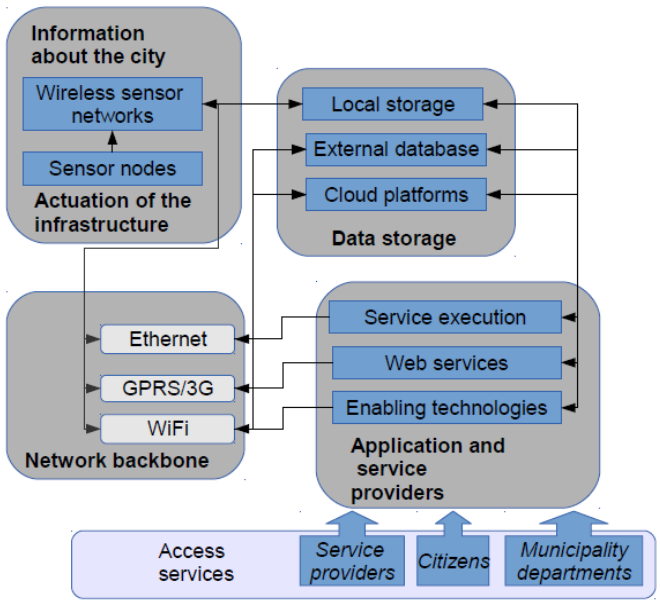

Figure 3: City services and the technological solution of services.

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 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 [6]. The purpose of these networks is monitoring and recording of physical or environmental conditions, such as temperature, sound, pressure, etc., and to cooperatively pass related data through the network to a main location. 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 [7]. 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. Advanced technologies have allowed small-format, battery-powered, sensor-enabled computers, which are able to perform the function of sensor nodes, that could be built at low cost. These sensor nodes could therefore be established from these tiny integrated devices, which serve as a means for sensing, data processing, and communicating, leverage the idea of sensor networks established on a collaborative effort of a large number of nodes. This subsystem includes multiple types of memory, a radio (RF) transceiver for communication with an internal antenna or connection to an external antenna, an electronic circuit for interfacing with the sensors and an on-board battery pack for power.

Much 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 [8].

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.

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-

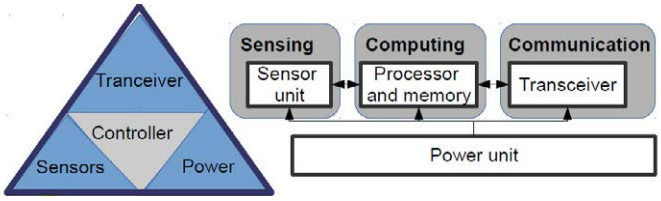

Figure 4: Hardware architecture of sensor node.

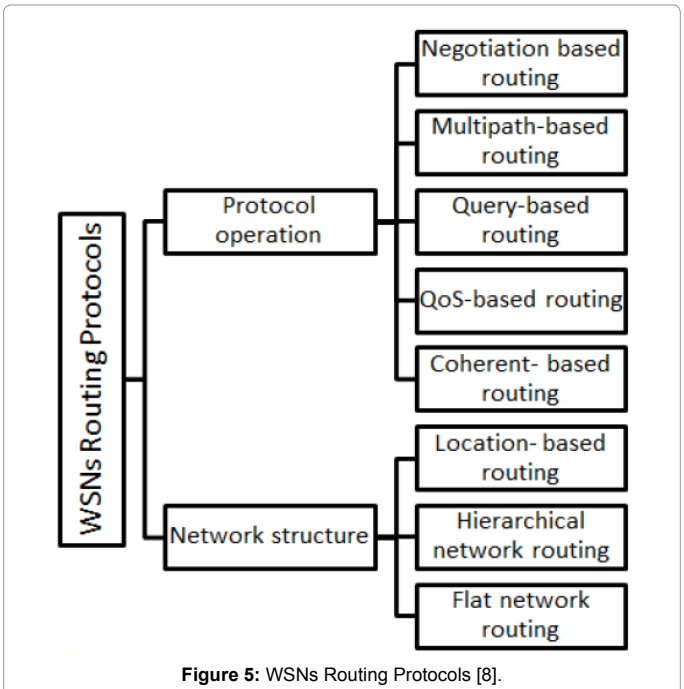

Figure 5: WSNs Routing Protocols [8].

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. Some aspects of this real time data acquisition are summarized in Figure 6. 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 [5].

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.

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 7. 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. 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" [5]. 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. E-government portals permit to better communicate with constituents. For example, collected data are accessed through web based maps that constituents can access. 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. Awareness is closely related to the improvement of methods of monitoring and early warning by exploiting information and communication technology. The application layer could include interactive modules that notify the users of events or alerts and allow them to trigger further actions. Emergency responders share a shared view of the situation and make decisions in light of the actions other agencies are taking.

Conclusions

This paper is a contribution to the understanding of smart city solutions and applications. In the introductory section there is a summary of the definitions and understanding of smart cities. It can be observed that the concept of a smart city is still somewhat unclear, definitions of a "smart city" vary broadly. Cities are becoming "smarter," and "intelligent" as governments, communities, and businesses rely on

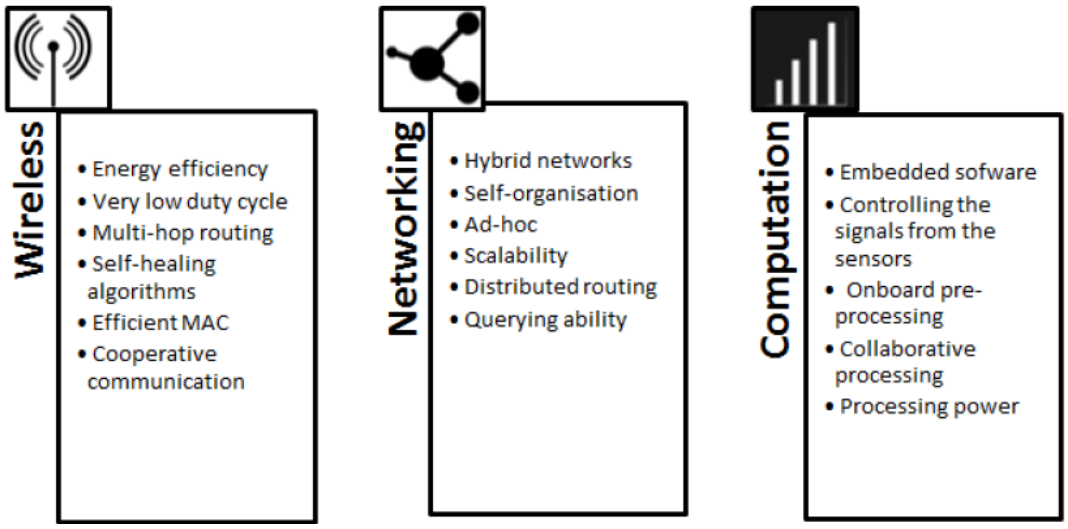

Figure 6: Real time data acquisition.

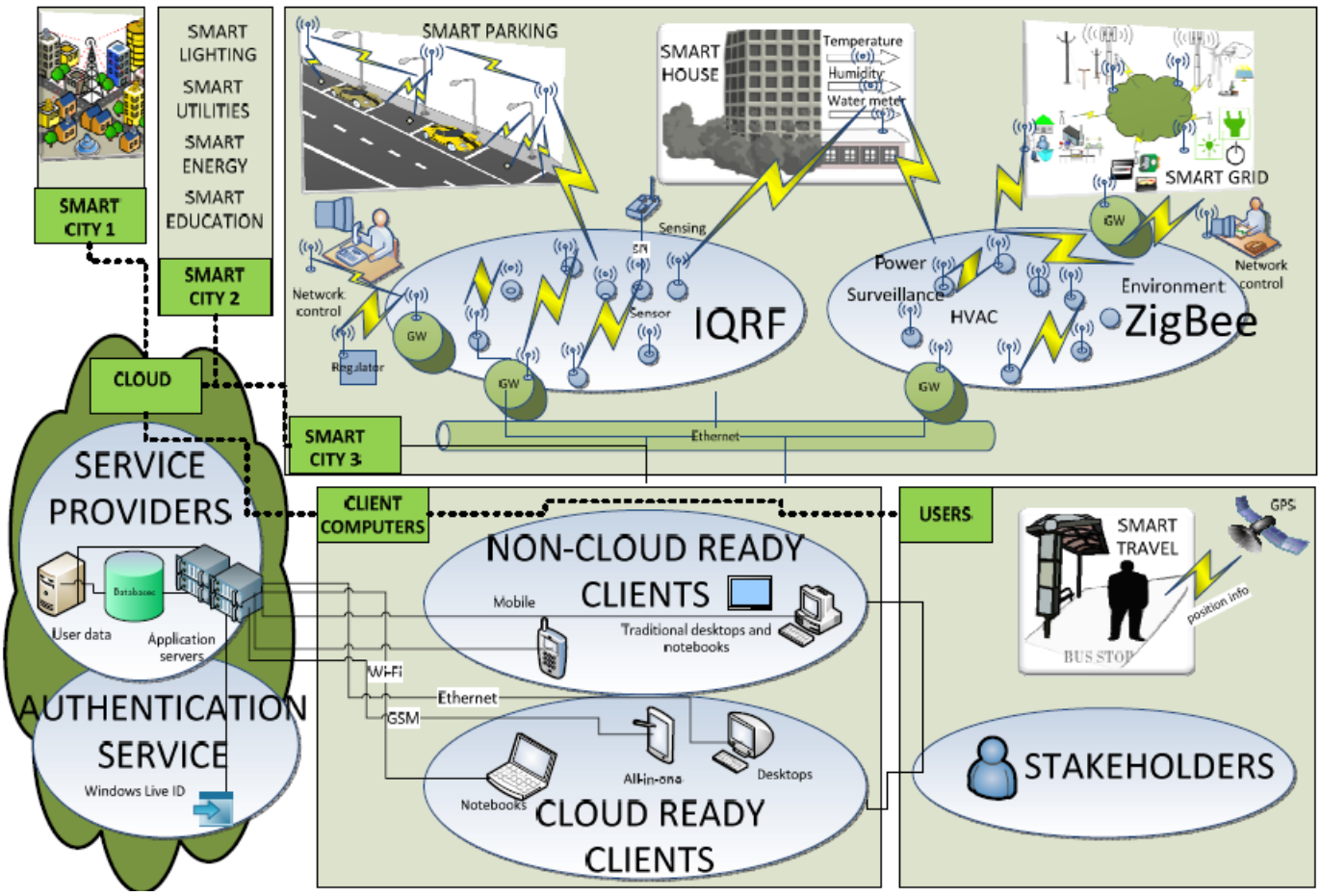

Figure 7: Communication platform for the development of city services and for remote control of varioussystems such as smart parking or smart travel.

technology to achieve goals and overcome changes. Table 1 presented in the article provides an overview of the state of various smart city services that can have a use in an intelligent city. This is a picture of potential services that can have an intelligent city and which may be covered by the proposed communication platform. The smart city is about using new, rich sources of information concerning what is going on in the city and to remotely monitor and to use remote control of various systems.

Because many events related to the city are also arising online, in digital reality, cities and urban areas could be linked to the evolution of information and communication systems. The current state of understanding of the smart city concept and different perspectives were presented as the introduction to the issue of smart cities. The impression of the smart city could be viewed as the next stage in the process of urbanization-the city is a concentration of human activity in a physical location and in digital reality.

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. A city or urban area could be viewed as stocks of resources and assets, accompanied by flows including the movements of information, people, things, and feedback loops. The city ecosystem includes core operational systems related to various aspects such as utilities, mobility, information structures, goods, health, social, education, security, and other various districts of cities - people, trade, transport, communication, water, waste and energy. Each city has therefore three proportions of urban space - physical, digital, and social.

Monitoring, 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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