DELIVERING E-GOVERNMENT SERVICES BY USING WIRELESS SENSOR NETWORKS IN THE CLOUD ENVIRONMENT

Konstantin Simić[1], Aleksandar Milić[2], Vladimir Vujin[3], Zorica Bogdanović[4]

Abstract

Digital government, e-government, and e-governance are terms that have become synonymous with the use of information and communication technologies in government agencies. One of the main challenges in developing e-government services is a huge number of users (citizens and enterprises). Thus, a highly scalable infrastructure is required for developing these services. Cloud Computing is one approach for creating a scalable infrastructure. Cloud Computing is a part of computer science and it enables providing Internet services to external customers via very scalable computing capacities. It is abstracted, high-scalable and controlled computer infrastructure which hosts applications for end-users. Data and services are located in shared, dynamic and scalable set of resources based on technologies of virtualization and scalable application environments. For enhancing e-government services, there is a need for deploying virtual servers and storing data in Cloud Computing environment. Data can be acquired from many different sources. Wireless Sensor Networks can be used for collecting these data because they present distributed systems which consists of different sensor nodes. Sensors are spatially distributed and they are used for measuring different values, such as temperature, humidity, sound levels, pressure, environment variables etc. Wireless Sensor Networks are flexible and their configuration and purpose can be easily changed. This paper describes possible applications of Wireless Sensor Networks for providing e-government services more efficiently. The literature review describes some of implemented solutions for integrating Wireless Sensor Networks in e-government. Some of e-government areas which can utilize Wireless Sensor Networks include areas of public transport, issuing personal documents, alerting about natural hazards, etc. Practical part of the paper provides a model of using Wireless Sensor Networks for designing and deploying e-government services. Cloud Computing infrastructure is used for developing this model.

Key words: E-government, wireless networks, cloud computing.

Colloquium for Practitioners

The model developed in this paper can be used in various government institutions at different levels. The example in this paper is focused on the application in the area of natural hazards. However, the model is universal and it can be used in other fields, i.e. smart traffic (collecting the data about traffic congestion), issuing personal documents (monitor congestion in queues) etc. At the national level, the Ministry of Interior can build a central information system for informing citizens and collecting the data from sensors. On the other hand, the local authorities can be responsible for dispersing the sensors in different locations.

1 Introduction

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction (Nist, 2009). Cloud computing services can be provided in three forms:

- Infrastructure as a Service (IaaS) - the consumer is provided with the capability to provision all computing resources and run arbitrary software, including operating systems and applications.
- Platform as a Service (PaaS) - the consumer is provided with the capability to deploy applications, which are produced using programming languages and tools supported by the provider.
- Software as a Service (SaaS) - the consumer is provided with the capability to use the provider's software, usually email, CRM applications or similar.

Application of cloud computing technologies can contribute to improving many aspects of e-government. Through a cloud, government can provide a single access point towards a gateway of interaction with government information, personal information and government representatives, presented through an online desktop or mobile application for all citizens. Numerous applications of cloud computing in e-government can be found in literature:

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1 PhD student at Faculty of organizational sciences, University of Belgrade, Serbia
2 Teaching assistant is a PhD student at Faculty of organizational sciences, University of Belgrade, Serbia
3 Senior system administrator at Faculty of organizational sciences, University of Belgrade, Serbia.
4 Assistant professor at Faculty of organizational sciences, University of Belgrade, Serbia.

- E-voting (D. Zissis, D. Lekkas, 2009);
- Public transportation (Jankovic et al. 2012);
- Healthcare (Vujin et al 2012).

Due to the large number of sensors which are dispersed through the space, it is necessary to create a system capable for acquiring data and data processing. Large amounts of data are collected from sensors and the data are processed afterwards in various control centres. Cloud computing represents a good environment for developing applications which use wireless sensor networks (WSN).

The main aim of this paper is to investigate applications of wireless sensor networks in the area of e-government and propose possibilities for enhancing some aspects of e-government by applying WSNs in the cloud computing environment.

2 Wireless sensor networks

2.1 Technology of wireless sensor networks

Wireless sensor networks (WSNs) present a group of spatially distributed and autonomous sensors wirelessly linked that are used for monitoring and collecting data of physical or environmental conditions such as: temperature, sound, vibration, pressure, movement, pollutants (Huang, Chang, Chen and Kuo, 2011; Akyildiz, Melodia and Chowdhury, 2007). The technology of wireless sensor networks can be very usefull in many application areas such as: environment, medicine, military, agriculture, inventory monitoring, intrusion detection, motion tracking, machine malfunction and many others (Baronti, Pillai, Chook, Chessa, Gotta and Hu, 2007).

For collecting data, WSNs use sensor nodes that as components have a microcontroller, transceiver, external memory, power source and one or more sensors. A microcontroller is often used in many embedded systems such as sensor nodes because of its low cost, flexibility to connect to other devices, ease of programming, and low power consumption. Wireless sensors are equipped with a radio transceiver and a set of transducers through which they acquire information about the surrounding environment. These sensors, in a large sensor field, can automatically organize themselves to communicate with each other and with other sink nodes. A remote user can inject commands into the WSN via the sink to assign data collection, processing and transfer tasks to the sensors, and receiving collected data through the sink (Mezghani, Gatgout, Ellouze, Grati, Bouabidi and Abdellaoui, 2011). For data storing, the commonly used external memories are: user memory for storing application related or personal data, and program memory used for programming the sensor device. Sensors are powered by batteries, usually a couple of standard AA standard batteries that can be replaced upon expiration. Battery size usually determines the size of the sensor, so existing hardware is roughly a few cubic centimetres in size (Baronti, Pillai, Chook, Chessa, Gotta and Hu, 2007). Sensors are hardware devices that produce a measurable response to a change in a physical condition. In order to interact with the sensor hardware, programmers can use different operating systems such as: TinyOs, Contiki, Mantis, Nano-RK, LiteOS (Farooq and Kunz, 2011).

Procedure of the realization of WSN means collecting data from sensors located in the sensor field, local data storage in router, different types of connections, different options of storing and delivering data to the end user. There are three alternatives for exporting data:

- Gateway connected via USB to a computer is an alternative suitable for applications with several nodes in a confined space or for testing when setting up a network;
- GPRS/GSM is an alternative that is used in small networks, when using a single point of data collection, or in combination with two other alternative uses GPRS to send a warning message;
- Router enables distribution of the collected data from nodes. Supports multiple protocols such as: Wireless Internet Protocols (2.4GHz, 5GHz), ZigBee, GPRS, Bluetooth and Ethernet.

Figure 1 shows collecting and storing data on router and options of delivering data. When the router receives data from the sensors, data can be stored: in local file system, local database or external database. Sending data on the Internet can be managed by using Ethernet, WiFi or GPRS. Data can be delivered to the end users by Web or mobile applications.

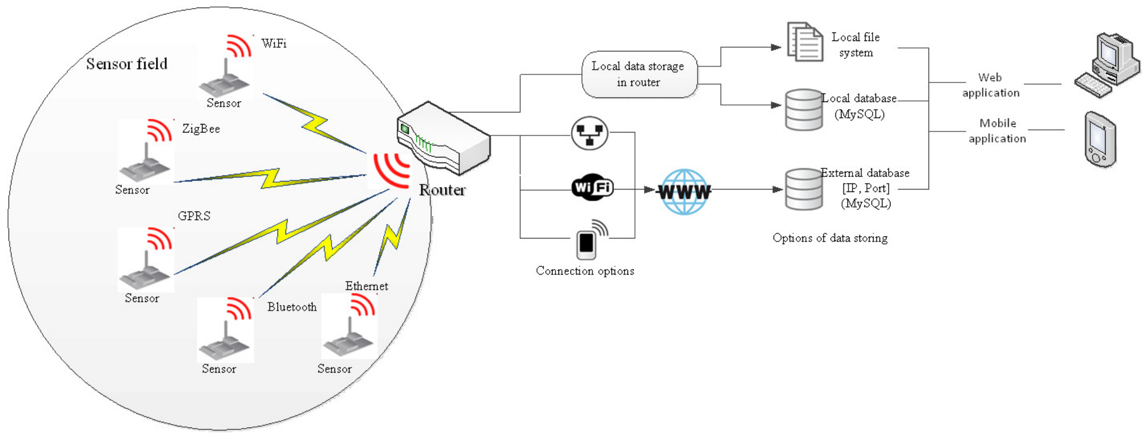


Figure 1. Procedure of the realization of Wireless Sensor Network

Nowadays, the major research challenges are (Familiar, Martínez, Corredor and García-Rubio, 2012):

- Translation of the Service-Oriented Computing (SOC) engineering principles into the world of Wireless Sensor Networks which can contribute to the development of rapid, interoperable and easy for installation entities in Smart Environments based on heterogeneous WSNs scenarios;
- Developing Service-Oriented Architectures (SOAs) based on WSNs. It enhances code reuse, system scalability, parallel service development, unit testing and subsystem integration phases of software architecture (Sollacher, Niedermeier, Vicari and Osipov, 2009).

2.2 Applications of wireless sensor networks

Wireless sensor networks found their application in many areas such as: Smart Cities, Smart Environment, Smart Water, Smart Metering, Security & Emergencies, Retail, Logistics, Industrial Control, Smart Agriculture, Smart Animal Farming, Home Automation and eHealth. Most of them are important for government in sense of collecting relevant data, monitoring and enforcement of corrective actions.

The Smart City can be defined as a developed urban space that enables economic development and high life quality trough six main dimensions: a smart economy, smart mobility, a smart environment, smart people, smart living, and smart governance (Lee, Phaal and Lee, 2013).
Every dimension of the smart city is determined by 31 factors and these factors with 74 indicators. For example, smart economy includes different factors of economy competitiveness such as entrepreneurship, productivity and labor market flexibility and for example, entrepreneurship is determined by the rate of self-employment and number of new featured jobs. Smart city management includes managing different urban areas such as:

- Smart parking - enables monitoring of parking spaces availability in the city;
- Smart lightning - intelligent and weather adaptive lighting in street lights;
- Waste Management - detection of rubbish levels in containers to optimize the trash collection routes;
- Smart Roads - intelligent Highways with warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams;
- Traffic congestion - monitoring of vehicles and pedestrian levels to optimize driving and walking routes;
- Electromagnetic field levels - measurement of the energy radiated by cell stations and and WiFi routers;
- Smartphone detection - detect iPhone and Android devices and in general any device which works with WiFi or Bluetooth interfaces;
- Noise urban maps - sound monitoring in bar areas and centric zones in real time;
- Structural health - monitoring of vibrations and material conditions in buildings, bridges and historical monuments.

Smart environment is a context sensitive system based on ubiquitous computing, in which the environment interacts with its inhabitants through embedded dedicated devices (A Middleware for Smart Environments). The design and construction of a smart environment requires the collaboration among several areas, such as (A Middleware for Smart Environments): intelligent man-machine interfaces, pervasive communications, ambient intelligence, scalable systems and mobile computing. Smart environment includes monitoring of: the forest fire detection, air pollution, snow level, landslide and avalanche prevention and earthquake early detection.

Smart water is a term related to records and wirelessly transmits water consumption data over short time intervals (e.g. second, hour, and day). Wireless data transmission makes information more accessible and replaces the current need for manual meter readings (Blom, Cox and Raczka, 2010). Furthermore, this term is related to detection of water quality, water leakages and river floods.

A smart meter is a digital electric meter that measures and records usage data hourly, or more frequently, and allows for two-way communications between the utility and the customer (IEE Report, 2012). It enables energy consumption monitoring and management trough smart grids; monitoring of water; oil and gas levels in storage tanks and cisterns; monitoring and optimization of performance in solar energy plants; measurement of water pressure in water transportation systems and of measurement emptiness level and weight of the goods.

Smart security and emergencies means access control to restricted areas and detection of people in non-authorized areas, liquid detection in data centers, warehouses and sensitive building grounds to prevent break downs and corrosion, distributed measurement of radiation levels in nuclear power stations and detection of gas levels and leakages in industrial environments, surroundings of chemical factories and inside mines.

Smart agriculture is term related to monitoring climatic conditions of different zones of a large cultivated area and calculates different water or chemical's needs (Rehman, Abbasi, Islam and Shaikh, 2011). Pollution detection systems can also benefit from sensor WSNs where sensors can monitor the current levels of polluting substances in a town or a river and identify the source of anomalous situations (Baronti, Pillai, Chook, Chessa, Gotta and Hu, 2007).

Smart traffic or Intelligent Transportation System (ITS) has been developed and been evolving to support the driving safety and transportation efficiency through the information computing and communications among transportation infrastructures and vehicles (Tacconi, Miorandi, Carreras, Chiti and Fantacci, 2010). The WSN can be integrated into ITS to monitor the road condition for driving safety (e.g., road construction sites or obstacles) and to announce such road condition to vehicles through vehicle-to-vehicle or infrastructure-to-vehicle communications (Wireless Sensor Networking for Intelligent Transportation Systems).

In the medical field, specifically in eHealth WSNs can be used to remotely and unobtrusively monitor physiological parameters of patients such as heartbeat or blood pressure, and report to the hospital when some parameters are altered (Baronti, Pillai, Chook, Chessa, Gotta and Hu, 2007). Sensor networks can be used to detect and locate damages as well as predict remaining life more effectively and economically with respect to traditional monitoring systems.

All these areas can enhance business of local governments on relations G2G, G2B, G2C and G2E. Furthermore, the governments' services can be put on high level and enable better quality of life.

2.3 Smart e-government

Digital government, often called e-government, has been defined as "the use of ICTs, and particularly the Internet, as a tool to achieve better government" (OECD, 2003). One of the reasons why e-government is being adopted, is to strengthen transparency and accountability and to change the passive role that citizens as 'customers/clients' had (Bonsón, Torres, Royo, Flores, 2012). It encompasses the use of ICTs to enable citizens, politicians, government agencies, and other organizations to work with each other and to carry out activities that support civic life (Labus, Bogdanović, Despotović-Zrakić and Vulić, 2012).

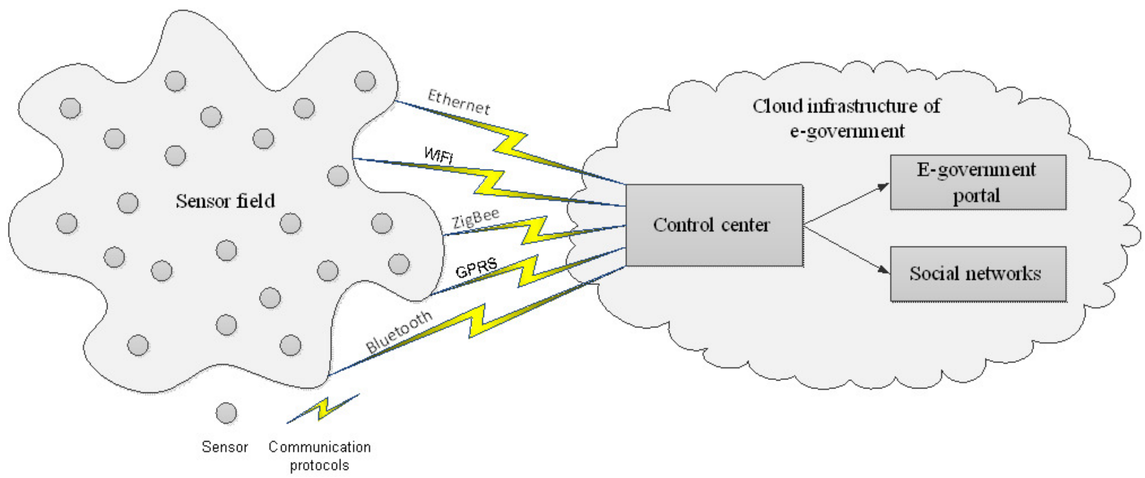
A relatively new terms related to government are: Smart government related to a government that focuses on its strategic roles in society, with an institutional design and a development of managerial capacities that enable it to perform its roles in a highly effective manner (Kliksberg, 2000); and Smart or Ubiquitous e-government related to administration that integrates information, communication and operational tehnologies for planning, managing and business operations in different areas and jurisdiction over which generate sustainable public value.

Ubiquitous government should embrace a broader scope than does e-government because it can be accomplished with or without electronic means. In many ways, e-government facilitates the development of ubiquitous government because it can revolutionize the way how ubiquitous government is established. Establishing ubiquitous government without e-government can be costly in terms of time and resource requirements (Yu and Hu, 2007).

The main aim of smart e-government is focus on structural reforms and fiscal management that would contribute to the following common outcomes: increased employment, improving education, health care systems and reduction of poverty and crime.

3 A model for application of wireless sensor networks in e-government

A model for applications of wireless sensor networks in e-government is shown in Figure 2. The model can be applicable in different government institutions and highlights the use of WSNs for improving some of e-government services. E-government areas where wireless sensor networks can be utilized include public transportation, issuing personal documents, alerting about natural hazards, floods, fires etc.



Fugure 2. A model for application of wireless sensor networks in e-government

One possible example of application of model shown on Figure 2 is in alerting about natural hazards. Sensor fields can be placed in areas of importance such as: woods, buildings, factories, etc. In the sensor field different sensors can be located. For example, for detecting fire, sensors for measuring temperature, humidity, CO2 and strength of the wind would be used. From these sensors relevant data can be collected and sent to control centre. For detecting fires, control centre will be within a fire department. Fire department can have a web application for generating reports for end users. When critical values are detected, the application sends information via SMS or e-mail to the responsible person who can further initiate alarm and post relevant information to be public on the e-government portal. Alerting could be faster is done through social network services, specially Facebook and Twitter.

4 Conclusion

This paper provides a description of application of wireless sensor networks in e-government. Sensors and sensor networks can significantly contribute to improving government services and the quality of life in general. Integration with e-government portal within a cloud computing environment would enable a wider set of users to acquire and use sensor data. The presented model is adapted for application in detecting and alerting in cases of natural hazards. However, the model is universal and can be applicable for wide spectra of government services. Further research will be related to developing and deploying the described model.

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