Smart City Management based on IoT

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Abstract:
The smart city concept is now a target for the development of urban areas. The urban challenges (pollution, overpopulation, resources etc.) are pressuring on urban governance and the municipalities have to find solutions for all these issues as well as a new way to develop the city. Technological progress in ICT as well as the facile access to these technologies could be a good reason to open the city for the smart city approach. Internet of things could be a technological solution in terms of finding the optimum way in making the decision on urban life. A smart city management based on IoT could solve the problem of collecting information from the urban area, processing information and making the right/optimum decision for city management.

Keywords: smart city, IoT, smart city management, smart city architecture, assisted decision

1. Introduction

The movement of people from rural areas to the cities generated new challenges for urban areas and a new approach is needed to face it. This new approach could be defined as a smart and brained approach and the concept is called *smart city*. This new concept needs more technological support in terms of covering all components of the smart city model: smart people, smart mobility, smart economy, smart living, smart governance and smart environment ("European Smart Cities," n.d.). This paper is focused on smart governance based on new technology, called Internet of Things (IoT) which could be a solution for real time decision making process as well as for a better connection between the urban components and city management. The speed of societal modifications and economical dynamic request proper management tools for shorter decision making process. The city management system has to be connected with the city and to be able to face new challenges. The competitive profile of the city was increased by the application of ICT technologies in urban area and the trend shows us a bigger impact of ICT in future (Caragliu, Bo, & Nijkamp, 2011; Kumar, 2014).

The participation of citizens in the city management process is also a "must" and the inclusion of them is important to validate the management decision. This inclusion could be done directly or could be facilitated by new technologies (one example is social media and the impact of social media in the society – the social media need a strong support system in terms to define the roles and the main objectives).

Internet of Things is a way to connect the physical components of the city in an intelligent manner and to ensure a real time connection between the city management and urban support systems (systems installed in the field – ex. water management system).

Another important challenge is the need for new managerial skills based on new technologies and new concepts, as smart city is.

The concept of smart city requested new models for cities as well as new architectures for all support systems or smart components of the city (F. Nemtanu, Schlingensiepen, Buretea, & Iordache, 2016; J. Schlingensiepen, Mehmood, & Nemtanu, 2015; Joern Schlingensiepen, Nemtanu, & Mehmood, 2016). These models have to be used to understand new behaviour of the city's components and the relations between all these components.

The innovation is the main key element of a smart city and the implementation of novelty in terms of technologies, procedures, methods, contracts, etc. could be considered and the risk of smart city could be re-managed (new threats and opportunities are revealed in this new context) (Nam & Pardo, 2011).

2. Decision Making Process in Smart City

City management includes all tasks of setting the strategy of a city and steering the efforts of all people involved to accomplish its objectives through the using of available resources (human, material and financial). If the objectives and the ways to accomplish them are smart, we can define this style of management or governance as smart governance (one of the smart city's components).

The most important process of city management, as well as of the management, is decision making process. This process is important because is the main influencer of other management processes (i.e. control and monitoring).

Definition of the decision making process could be defined using the seven layers' model (Dartmouth, n.d.). Based on this model, the following components are defined:

- STEP 1 - *Identify the decision* – the manager identified the need for a decision and the context of this decision is defined as well as the nature of the decision.
- STEP 2 - *Gather information* – the collection of information and the definition of information's types as well as the sources of information.
- STEP 3 - *Identify alternatives* – during the collection of information the identification of alternative ways of the action could be done.
- STEP 4 - *Weigh the evidence* – every alternative could be weight and a priority could be allocated for each alternative.
- STEP 5 - *Choose among the alternatives* – the best alternative or a combination of alternatives will be selected.
- STEP 6 - *Take action* – the most important step is to implement the alternative or the combination of alternatives.

- STEP 7 - *Review the effects of the decision* – the effects of the decision are analysed and if the result of implementation of the decision met the need identified at first step, the decision was correct selected, if not, the process will be start again and other alternatives will be selected and applied.

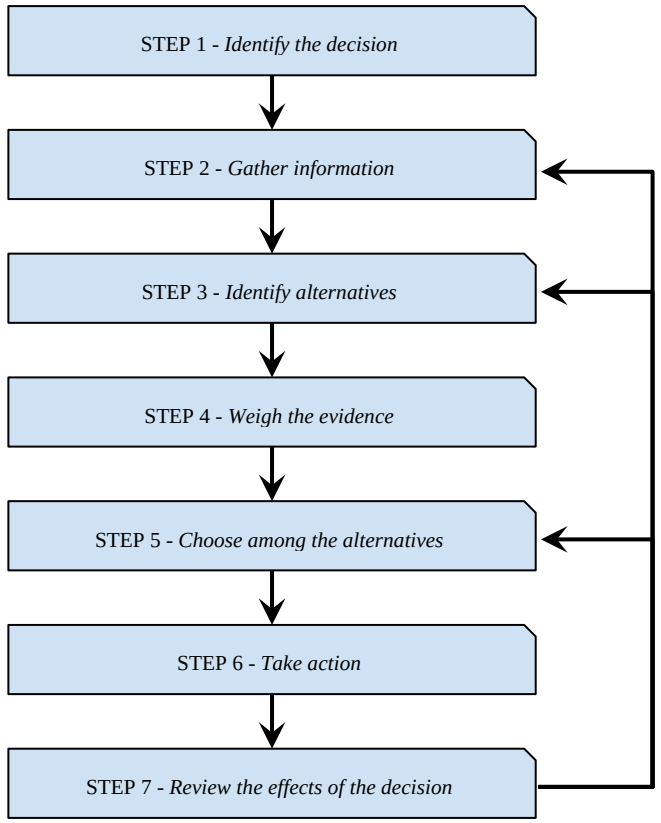

Fig. 1 Multi-step model of decision making process (Dartmouth, n.d.)

The role and integration of ICT support systems in decision making process and in the previous model could be defined based on five levels:

- Level 0 – no involvement of ICT – the decision is made without any support from ICT systems;
- Level 1 – the decision maker is using ICT tools in decision making process - the lowest level of machine intervention;
- Level 2 – the decision maker is assisted by ICT systems - the decision makers have ICT tools;
- Level 3 – the decision is made by support system and the manager validates the decision;

- Level 4 – the decision is under the responsibility of support system – automated or autonomic systems - the machine is the decision maker and the direction and the strategy is set up by city manager or experts.

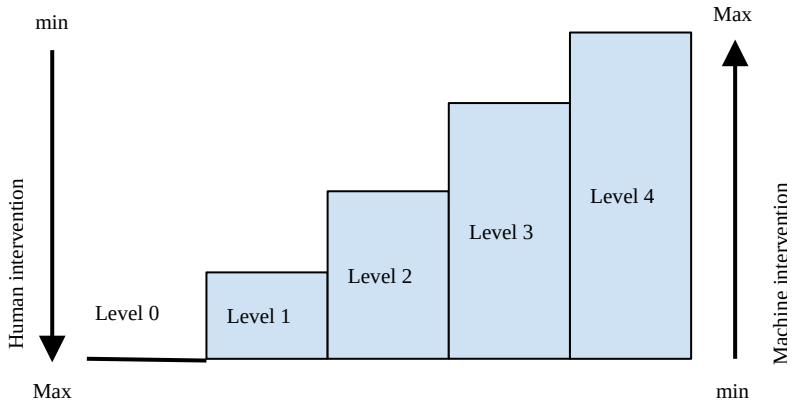

Fig. 2 The role of ICT support systems in decision making process

The ICT support systems has the main advantages of reducing the time of collecting data, which is needed to make the decision, and increasing the accuracy of the decision without any additional resources (only the initial investment in the system - this initial investment is same times already done and only the development of new functions are needed).

3. IoT and the Architecture

The Internet of things (IoT) is the internetworking of physical devices which are designed and built to collect, process and exchange data with other similar objects based on electronics, sensors, software and network technologies. The IoT World Forum has already set up a framework for IoT and the framework is starting with things and sensors from bottom to applications (on top of the figure).

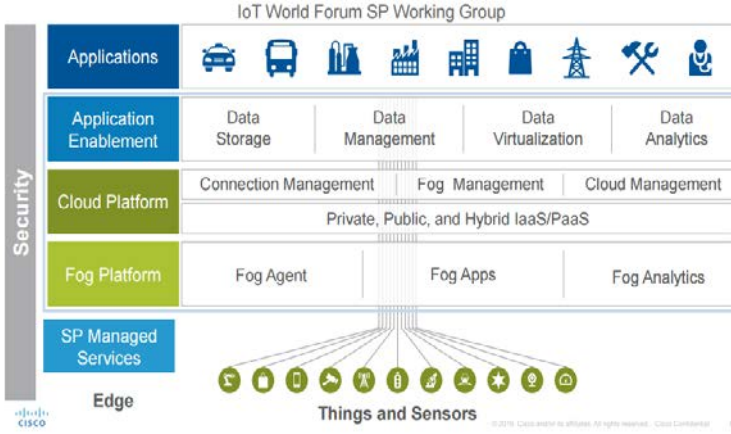

Fig.3 IoT Reference architecture (Nivaggioli, 2016)

Every hardware component of the city will be able to communicate each other and it will be part of the network. The main advantage of this approach is the high speed of data collection, processing and sending the information as well as the decision. It is a huge step to automation of the city and the result will be the increasing of the adaptability of the city to new context and environment. At this moment, a modification of a city procedure or process could take years and after the implementation of this concept this task will be done in hours or days and it depends on the level of human intervention.

The architecture of IoT based system could be started based on the architecture defined in FRAME project (F. C. Nemtanu & Minea, 2005; Nemţanu, Minea, & Bureţea, 2004) as well as based on SOA (Graham, 2008; Krafzig, Banke, & Slama, 2005) or any other software and ICT architecture tools and methods. The advantage of using FRAME as reference is that the architecture has been defined based on multiple components: functional, physical, communicational, organisational, security. This approach is focused on the integration of humans and organisations in the technical systems to extend the frontiers of that systems.

The architecture proposed by the author is shown in Fig.4 and it is the starting point of a new model for the IoT applied in urban areas to support the development of smart city.

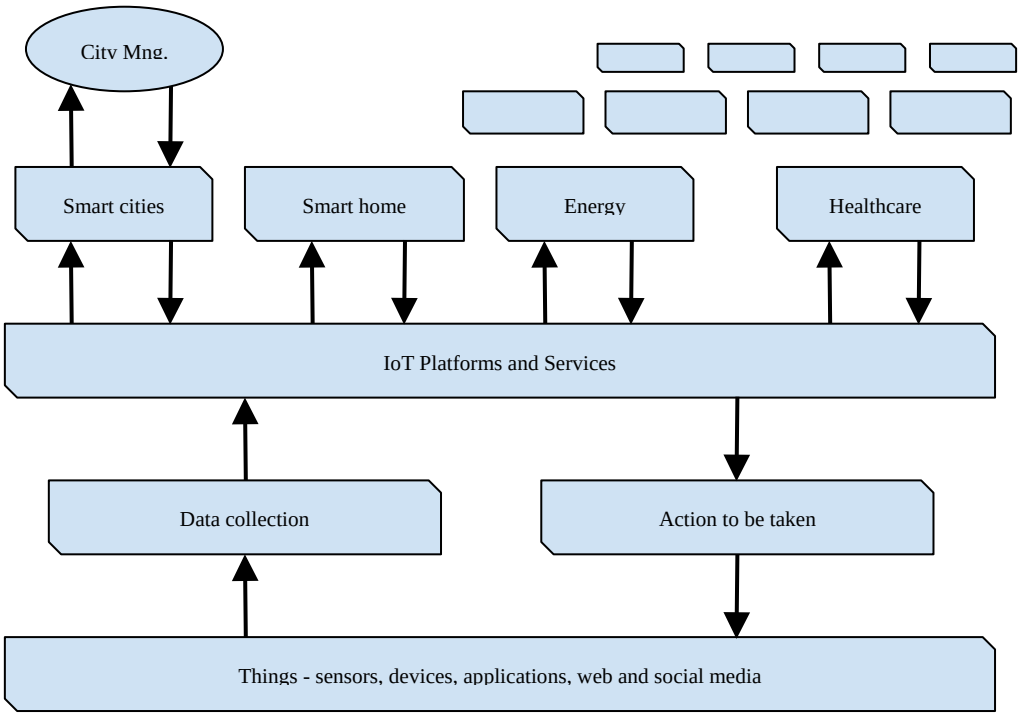

Fig. 4 IoT architecture in the context of smart city

The authors considered both categories of things: hard things (devices, buildings, sensors, vehicles etc.) and soft things (applications, social media, virtual profiles etc.).

One of the most important stage of the development of new technologies is the design stage and the ICT support systems have to be designed in an open manner to permit the development of future applications and services. The ICT support systems based on IoT technologies has this ability to be opened for new configurations as well as new applications of the system.

The data is collected from various things and will be transmitted to IoT Platforms and Services. The decision could be defined as: local (at the level of things), at fog level, at cloud level and central level. Every decision, at every level, will be done after the information of the city management and the level of automation is setting up by the city management (a very simple example is the electronic voting system which is able to collect all votes from citizens, to process all collected data and to generate reports and inform citizens about the result. This vote could be expressed directly by citizens or could be done automatically by a virtual profile/avatar).

4. Conclusions

The smart city concept is based on a mixture of various components (6 components, as the European project established ("European Smart Cities," n.d.)) and on the application of ICT technologies in all these components. This is the technical approach of the concept, based on IoT and ICT support systems, and this technical approach has to be linked with social, economic, political and environmental approaches in terms of finding the best solution for the development of the city.

The IoT is a support system which are not be able to replace the subsystems of the city. This system is able to help decision makers to take the right and the optimum decision in terms of the governance of the city.

The IoT infrastructure is able to provide services for many applications not only for city governance and the main challenge is to design a multi-purposes support system in terms of providing services for many other applications.

The automation of the decision could be defined at various level and the city manager is in charge with setting this level as well as with human implication in this process. The decision is also related to the collected data as well as to the credibility of data sources. This is the reason to use IoT infrastructure to collect data automatically and to take the action based on machine decision. The human machine interaction could be analysed and the effects of using machine in the decision making process could be also analysed.

The multilevel decision model (local, fog, cloud and central) has the advantage of adapt the system to the strategy of city management and to the IoT infrastructure which is already installed in the city.

The urban things have to be classified into two groups: hard things (vehicles, buildings, houses etc.) and soft things (software, applications, social media etc.) in terms of using all available resources in urban area. An application on a smart sensor could be part of IoT infrastructure and could provide data as well as support for taken the action.

The next step of this research is to develop the model of smart city based on IoT using the specific technologies for IoT and the integration of this support system with other installed systems or future systems. Another important aspect is to develop a smart city architecture based on this new paradigm (IoT) and without interferences from the existing technologies (to be open for new technologies and new approaches).

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