A Study on Integration of ICT in Smart Cities

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Abstract—*A smart city is a place where people would live with improved quality of life. For a smart city, its subsystems like energy, transport system, hospital, education, water supply, etc. need to be interconnected to make smart use of city assets and resources. Information and communication technology (ICT) enables these subsystems for making interconnections. Various ICT solutions already have been proposed and lot of work is going on to identify new solutions. A study is done with an objective to understand present integration of ICT solutions in smart city and how the ICT technology is enabling the interconnection with the help of real world example. The study also incorporates identification new opportunities of integration of ICT solutions in smart city such that people would get a sustainable and liveable place with reduced environmental and climate footprints.*

1. INTRODUCTION

A city is a system where people live as a component of the system and with other components like energy, transport, healthcare, education, water supply networks, waste management, law enforcement, and other community services. The city is planned for better access of all its components by the people living in. So, a city is designed such that the people living in it must get a quality life. Though each city today is designed with the goal of providing quality life, it is not smart. At present, each city has transport system, hospitals, energy, hotels, education, etc.; however, they are working independently. Although each component somewhere requires input from other component, but since they are not interconnected they show inability to take instant real-time decisions. Each system has their assets and resources and that need to be utilized efficiently for the benefit of human being. For that, integrating multiple information and communication technology (ICT) solutions in the city is required. The ICT solution would provide the necessary interconnection between all the components such that the resources would utilized smartly and preserved for future. Thus, it would help a city to become a smart city that would be sustainable and livable with reduced environmental and climate footprints.

The need of making cities smart arises from the following factors:

1. Rapid urbanization

2. People migration to urban areas

3. Population growth

4. Environmental and climate changes

5. Government policies

All the above points results in highly populated cities, thus, increasing demand for public infrastructure, water supply, sanitation, and energy, as well as for public services (e.g. transportation), health care and education. In order to handle these continuously increasing demands and improve quality of life, there is desperate need Smart Cities.

2. ICT FOR SMART CITY

ITU defines a Smart Sustainable City as "A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects".

In the above definition, the "smartness" of a city directs to its ability on how it brings all of its resources together; and on how much efficiently achieves the goals and fulfils the defined purposes. In other words, the "smartness" of the city depends on how:

• All individual systems are working in an efficient manner; and

• All individual systems collaborate in an integrated way by means of ICT enablement, to enable potential opportunities for individual citizen.

There exist many important areas of standards relating to both of above points. However, the role of Smart City standards is focused on the second, i.e. on collaboration by integration of

ICT standards in order to provide value, both to the city as a whole, and to the individual citizen.

3. REQUIRED KEY FACTORS

In order to facilitate the above to happen, below mention are few important key factors:

- **Data Collection**: the city systems will be equipped with multiple data sources like sensors, GIS, etc. to allow the data collection about daily city happenings and life;

- **Data Processing**: the collected data from different sources in city systems will be aggregated together at any central place to gain application based processing to know current situation in the city;

- **Data Presentation**: the different data access systems e.g. mobile, web, smartphone applications, etc. will present data in respective formats, depending on the framework and the person or technical system needing it, allowing it to be visualized and accessed more easily, thus making it much more useful;

- **Data Availability**: real-time information about the city will therefore be available at every level and at every moment, so that it can be easily accessed by concerned person or technical system would be able to use it to help fulfil their role or achieve their goals, within the framework of the overall effective functioning of the city;

- **Data Analytics**: real time decision making systems will be used (in addition) to generate analytical knowledge to use it effectively, both by city planners, and by the citizen, to support real time decision making and enable effective actions to be identified that will enable future requirements to be met;

- **Autonomous Action**: the city will also be equipped with embedded networks for automated operations such that reliable and efficient city functions to be delivered, without the need of direct human intervention;

- **Infrastructure Sharing**: the city will have collaborative space network created by different service providers, to enable single line for all services and efficient use of environment space; and

- **Integration**: for the benefit of all and a managed city everyone including the physical worlds, the digital worlds, citizens, policy makers and businesses can effectively work together.

For enablement of each of the key factor, ICT has a key role.

4. TECHNOLOGICAL NEEDS IN SMART CITIES

Each of the above key factors for a Smart City needs a wide range of technologies, capable of working together to deliver complex systems and solutions.

- For data collection, large databases storing data from multiple sources like whether, environment, motion, cameras, etc. will be required in order to exploit the use of data from multiple sources, fixed as well as mobile.

- Data collection can be done at central server in communication with sensor networks from all data collection instruments. Further, all the data handling based on the data type and application may get processed.

- Presenting data based on location or making it available on web or on mobile applications.

- For autonomous actions, a robotic or semi-robotic infrastructure with embedded network would be required where the processed data can be sent and necessary actions can takes place.

- To keep the infrastructure simple, infrastructure sharing is important. For that, collaboration between different service providers is required.

5. ICT STANDARDS

Based on the key factors and requirements discussed so far, below presented the ICT standard technologies:

- **Ubiquitous computing** – as the name itself suggests that computing should be "ubiquitous" i.e. computing should be available and done everywhere. Here, each small unit itself own processing power such that it give a processed output for real-time needs.

- **Networking** – for above, networking has a key role. Networking standards like FTTH, 4G LTE, etc. will connect each device with each other.

- **Open Data** – any data that is available for reuse is "Open Data". For example, GPS data, whether information, etc. can be reused again and again. This may be helpful to get insights into the performances of different city systems like transport, energy, health and environment.

- **Big Data** – is a large data set, the collection of all the data for processing to generate meaningful insights. It can be helpful to understand what happened till now and what going to be the trend in near future.

- **GIS (Geographic Information System)** – GIS captures geographical data and processed to provide location based services.

- **Cloud computing** – is all about providing computing as a service to the end user and other systems. In the service, cloud provides all necessary computing resources to the computers using the service.

- **Service-Oriented Architecture (SOA)** – it is a new kind to IT infrastructure where other software compliments the function of a running software in a service. Basic idea

behind it is to create interoperability and use each other's capabilities.

- **E-government** – it is important to allow individual citizen to interact with the government i.e. C2G as well as government with the citizen G2C. It will utilize web-based technologies or mobile technologies for such interactions. This will improve the community, better awareness of government policies and actions.

- **Embedded networks** – electrical and mechanical infrastructure is a keen need of smart cities. This will consist of embedded network of sensors everywhere in order to enable real-time information available to everyone.

- **Internet of Things (IoT)** – bringing machine-to-machine (M2M) communication for better results in an environment where every device is connected to internet. It may lead to intelligent system loop where each input to a device comes from another device.

6. SMART CITY SECTOR AND ICT SOLUTION

As our cities are changing, new cities are emerged. In future scenario, cities will become more complex and interconnected. In order to shape cities efficiently, four core sectors are particularly important. They are as:

- Communication
- Energy
- Safety
- Mobility

With the growing complexity and interconnectedness, the demand on the design of the city increase, not just in the future but already today.

Let us consider mobility sector, it allows for flexible and time efficient travel.

Increase in personal transportation resulted in increased traffic on roads. This is one of the major concerns nowadays modern cities are facing. Even though the traffic flow management systems are provided, there are many times faults occur due to any reasons. The problematic situation arises, e.g. at large road intersection, the traffic light is not functioning and traffic comes to standstill and nothing moves.

Smart city has solution for such situation. It states integration of ICT that means bring the vehicle too in the traffic flow management system by integration sensors in it. The sensors in the vehicles will be in communication with the traffic flow management system of the city. This allows the car to recognize the problem and submit it immediately to the traffic control center of the city. In real time, the information received from the gets processed and transmitted to the approaching vehicles so that they are given advance warning of the traffic jam on the route. At the same time, they are also suggested with an alternative route and traffic jam goes around. In addition, the problem at the intersection bypassed and finally solved.

That is why important resources like energy and time are preserved. The city is complex system and is interconnected from the inside out. Information and the communication solutions are essential for smooth operations.

7. SUSTAINABILITY OF SMART CITY

Sustainability of a Smart City is core requirement. Each ICT solution integrated in the Smart City should be sustainable enough to achieve the objective to provide quality life.

Unsustainable approach: When IT for cities is re-planned for new development or refurbishment today, it is typically done as field-by-field. This creates a mesh of different communication networks very in-kinds with a little or null possibilities for collaborations or over competitions. Applied to single properties or flats, this implies multiple network connections from different service/technology providers, each serving different service for different purposes, sometimes as many as it does in one single apartments. This way of implementing ICT services throughout the city results in many negative effects for the climate and for the environment, as well as the economy and the society. It's clearly an unsustainable approach.

Solution: Shared infrastructure for ICT.

8. CONCLUSION

This study provides a basis for ICT integrations in Smart cities. With this anyone can understand the objective behind the smart city and what are key factors and technical needs for integration of ICT solutions in order to make cities function more efficiently and citizens live more conveniently.

REFERENCES

[1] Technical reports on Smart Cities, http://www.smartcities.info/research.
[2] Technical reports on Smart Cities from ITU.