Development of Smart City Model: Smart Bus System

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Abstract— **Our purpose is contributing to the smart city model which is highly demanded by many organizations myriad number of organizations for developed cities in the world to significantly amplify and ameliorate the quality of life of the occupants, improve the utilization of city resources and reduce the operational prize. This model is used in urban places and it helps us to do the things which take our time and in this way it alleviates our job. Including different kinds of heterogeneous technologies such as Cyber-Physical Systems (CPS), Internet of Things (IoT), Wireless Sensor Networks (WSNs), Cloud Computing, and Unmanned Aerial Vehicles (UAVs). However, to reach these important objectives, efficient networking and communication protocols are needed to provide the necessary coordination and control of the various system components, this model can produce various benefits. In this paper, we give some information about the model and present some new ideas to develop the smart city.**

Keywords—Smart city, smart governance, smart transportation, Smart Bus system *(key words)*

I. INTRODUCTION

"Smart city" is the term that was realized late in the 20th century. Main purpose of the term is developing the future of our lives.[1] Its meaning expands year by year. It never gets old and out of date. As it needs to be developed to improve information and communication technologies for urban areas. A smart city is an urban area that uses different types of electronic Internet of Things (IoT), sensors in order to collect data and then use these data to manage assets and resources efficiently.[2][3] This includes data collected from citizens, devices and assets that is processed and analyzed to monitor and manage traffic and transportation systems, water supply networks, waste management, power plants, information system, libraries, hospitals, schools, crime detection and other community services.[4] Smart cities are progressive, forward-looking and resource-efficient while providing at the same time a high quality of life. They promote social and technological innovations and link existing infrastructures. They incorporate new energy, traffic and transport concepts that go easy on the surroundings. They concentrate on new forms of governance and public participation. Intelligent decisions should be taken at the strategic level if cities want to become smart. It takes more than individual projects but careful selections on long-term implementations. Considering cities as entire systems can help them attain their ultimate ambition of becoming smart. Smart cities forcefully tackle the current global challenges, such as climate change and scarcity of resources.[5] Their demand is also to secure their economic competitiveness and high quality of life for urban populations continuously on the rise.

Urbanization. More than half the world's population already occupied urban areas. Estimates reckon that number to obtain two thirds by 2050. This dramatic development is ultimately hence the many opportunities people are awarded to design their own lives in cities. Rising urbanization, however, also means greater challenges: as cities grow people's needs and demands must be met in ways that go easy on the environment.

Scarce resources. Resources such as fossil energy, clean water and disposable land are limited as most of us are aware of. We also know that cities consume the lion share of all energy produced all over the world. Mobility, housing, food and waste removal require raw materials and energy. To maintain a high standard of living for the long term cities need to decrease their ecological footprint and seek for alternatives to scarce fossil resources.

Climate change. Climate change is one of the most pressing issues that we are nowadays faced with. CO2 emissions must be reduced in the decades to come while measures need to be taken to reign in global warming, floods and extended heat waves. Cities are responsible for about three-quarters of greenhouse gases worldwide. Being major polluters they are also called upon to provide solutions.

Globalization. Worldwide networking of labour forces, institutions and information has its repercussions on cities, too. Economic and social structures are changing and urban politics need to adjust their strategies to these new circumstances. It means positioning cities internationally between competition and cooperation. The measures taken must be not serve the sole purpose of appearances but must focus on internal social, economics, spatial and structural aspects as well.

Some people doubt that it is good to get everything smart. Concepts and ways towards becoming a smart city are as different as cities themselves. Some approaches are technology-oriented, while others have put the social aspect in the fore. Measures cover the full range in between but they all have in common their aim to constantly add substance to the concept of smart cities. A smart city encourages people to walk, meet, talk, and congregate on streets, in shops and in public spaces. It is a place of random informal interactions, serendipitous meetings, and spontaneous relationships.[6]

New technologies must be assessed as to their benefit for the public interest and the preservation of creative freedom in

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public places. Smart ideas, to be implemented, require active public participations. Skills need to be acquired to handle the new tools with care, especially with regards to data management and data security. Ultimately synergies must be progressed across systems so that objectives and solutions can be found for smart cities to become forward looking, use resources with caution and provide an environment worth living in for everyone.

II. SMART CITY DEVELOPMENT

The first step towards becoming a smart city is taken at strategic level. Main fields of action in this context are the environment, energy, mobility, society, the economy, administration, politics and quality of life. Some of the above are intertwined and increasingly networked with the support of Information Technology (IT). Technical, economic and social innovations supply the foundation for such activities. Smart cities build on suitability but also on resilience in the sense that cities as systems made more resistant and adaptable to influences from inside and out.

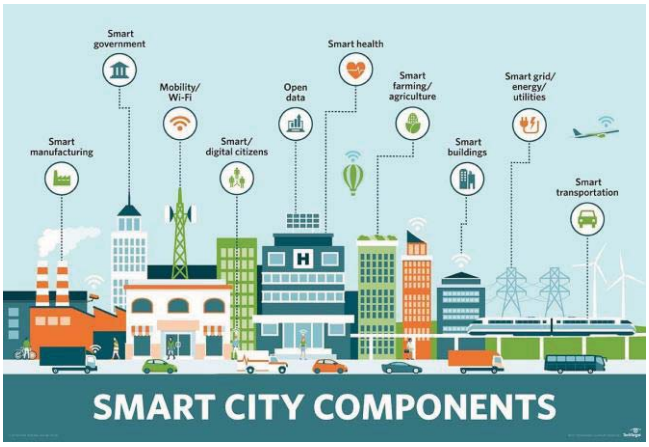

Figure 1[7]. Smart city components.

A. Energy and the Environment

Reducing energy and raw material consumption and forward-looking resource management are among a city's major concerns. Smart supply and disposal systems are just as important as process-driven changes, technological developments and networks for energy, mobility, infrastructures and buildings. Smart grids, for that matter, are a step towards smart energy consumption: intelligent networks and monitoring systems are put in charge of energy generation, storage and consumption. Smart meters are installed to make actual energy consumption more transparent. [8]

B. Governance

Smart governance is about the future of the public services, it is about greater efficiency, community leadership, mobile working and continuous improvement through innovation. Smart governance uses technology to facilitate and support better planning and decision making. It is about improving democratic processes and transforming the ways that public services are delivered. It includes e-government, the efficiency agenda and mobile working.

C. Economy

Smart economies actively support education, qualification, research and entrepreneurial spirit, innovation, productivity and flexibility.[9] Continuous knowledge acquisition and transfer, as well as local and global networks are the main ingredients for creative output. Enterprises offering Information Technology (IT), environmental and energy services in particular are considered the driving force for smart economies.

D. Mobility

Smart mobility means innovative traffic and transport infrastructure that saves resources and builds on new technologies for maximum effectivity. Accessibility, affordability and safety of transport systems, as well as compact urban development are essential factors in this context. New user-friendly facilities will make it easier for people to switch to integrated transport systems concentrated on environmentally friendly transport model. Joint utilization, i.e. "car sharing", instead of private ownership is what counts these days when using motor vehicles. [10]

E. Society

Increasing people's quality of life requires more than technical innovations. Also and above all it is the social dimension that needs to be taken into account. Civil society should be actively involved in making smart cities become reality. Main focus must be on education, lifelong learning, culture, safety of individuals, health, social cohesion and plurality of society. Urban everyday life provides sufficient leeway to promote people's creativity and competences. Networking and self-management are major pillars of society without which smart cities would be doomed to fail.[11]

III. SMART TRANSPORTATION

Traditional transportation systems or facilities such as the railway network, road transport, airline transport and water transport have existed for a long time. In traditional transport each of these operates independently even in a specific type of transport system, making global usage complicated. Smart transportation also known as the Intelligent Transport Systems (ITS) involves different types of communication and navigation systems in vehicles, between vehicles (e.g. car-to-car), and between vehicles and fixed locations (e.g. car-to-infrastructure).[12] ITS also covers the water, rail and air transport systems, and even their interactions. A broad illustration of the smart transportation is presented in Fig.1. The smart transportation system has made it possible to construct global airway hubs, intercity railway networks, intelligent road networks, protected cycle routes, protected pedestrian paths, and integrated public transport for safe, rapid, cost effective, and reliable transportation. The use of ICT and real-time data processing has made the smart transportation system manageable.[13] The smart transportation system maximizes the utilization of the vehicles used in the system, for example, the number of aircraft that an airline has or the number of trains a railway network has. The smart transportation system allows passengers to easily select different transportation options for low-cost, shortest distance, or fastest routes.[14]

[15]

Figure 2. Illustration of Smart Transportation.

Specific examples of smart transportation technology including sensors in vehicles for collision avoidance and anti-skidding to increase the safety of the system. A radio frequency identification (RFID) based toll collection is an example of smart transport technology. In the RFID toll collection drivers need not stop at a physical toll booth which typically takes time, blocks the traffic flow, as well as requires manpower for toll collection.[16] Automatic passport control at airports is an emerging technology deployed in smart transportation. In automatic passport control, the passengers can use RFID based passports or electronic passports for fast and reliable entry without the need for manual passport check. Another example of smart transportation is the use of smart apps in mobile phones to hire taxis and even tracking the exact location of the taxi and driver information in the same smart app.[17]

IV. PROPOSED SMART BUS SYSTEM

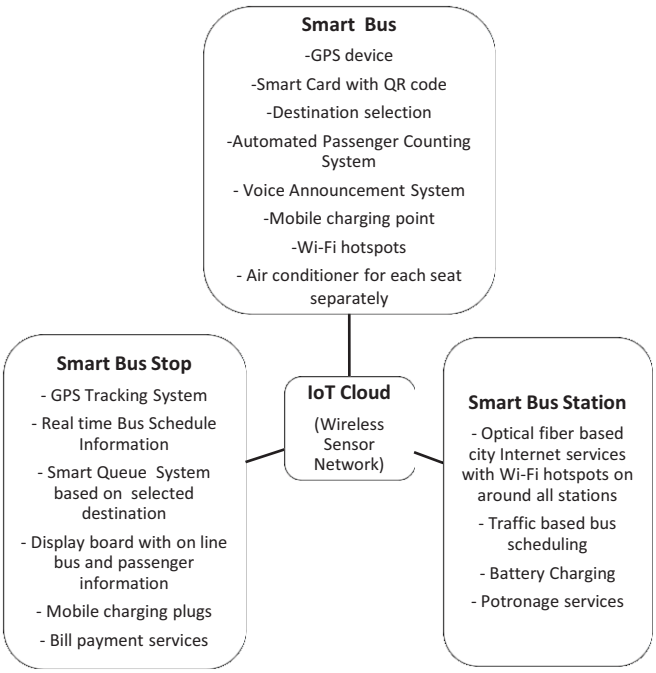

Figure 3. Proposed SBS

Our proposed Smart Bus System (SBS) will consist of three basic components namely Smart Bus Stations, Smart Bus Stops and Smart Buses. Each of these components will be connected through fiber-optic to high bandwidth Internet service. Again each of the components will consist of many numbers of heterogeneous wireless and embedded sensors. These sensor networks will be connected to city internet backbone through Wi-Fi hotspots in the bus stops, stations and inside buses. Every component will contain intelligent autonomous devices attached to or embedded into the system that will sense the user requirements and interact with them, share information among each other as well as take decisions without any human intervention.[18] In the next subsections we will discuss each of the components of SBS in detail (Figure 3).

V. SMART BUS

Smart Buses are the non-stationary components of the SBS. Normal buses can be converted into smart buses with the incorporation of intelligent sensors and IoT devices. Smart buses will be battery powered, so called e-Bus with zero carbon emission for the greener environment. Smart bus will have Wi-Fi hotspot to provide internet connectivity to the embedded sensors as well as to the commuters. All buses will have Global Positioning Systems (GPS) attached to it, so that its location can be tracked at real time. Air pressure sensors will be attached to the wheels will send data to control center as well as to the drivers control panel. It will be able to recognize obstacles and pedestrians on the road, comes to a precise halt at bus stops, opens and closes its doors, moves off automatically and communicates with traffic light systems. Throughout the journey the driver does not need to operate the accelerator or brake at all, and only needs to take the wheel in accordance with traffic regulations when there is oncoming traffic. However, the driver is able to intervene at any time and immediately take control if required.[19]

Passengers show their card which includes QR code, and it will be scanned by bus. If card is not empty, then bus stops and takes passenger. If the card is empty then it does not stop. When all seats are busy, bus automatically stops scanning QR codes. In case of smart card, which will have value recharge facility can be used to pay the fare. Complete route of the bus with each bus stop will be displayed on a touch enabled display panel inside the bus. Commuters will have the facility to choose the destination by touching the bus stand after smart card or use may get down wherever they wish by swapping their smart card to open the exit gate. In both the cases bus fare will be automatically calculated and deducted from smart card. For school students special smart card will be provided by the transport department after verification of identity.[20]

Furthermore, smart buses will be facilitated with android system which counts amount of passengers automatically. Any passengers who will board, it will be shown in the display monitor installed in front of the bus. No manual counting would be needed. If there is no passenger on seat, it will show a blank seat. But when a passenger will be seated on the bus, it will show occupied on the display screen. Display will change the color for each seat occupied. The display database updates in every 30 sec. There will be

some checkers for every stoppage. When the bus reaches any stoppage, checker will enter into the bus. He will access into the display database by giving his login credentials and send the updated data to server. So that, from every starting point to destination, the actual number of passengers will be automatic counted and it will reduce the window of corruption. In this system, it has a pressure pad beneath every seat and the pressure pad acts like an open circuit connected to Arduino microcontroller and variable resistors. When passengers are sitting on the seat, pressure pad becomes closed circuit and passes the voltage into the circuit. The voltage goes to Arduino IDE and the Arduino converts the voltage into a digital signal like 0, 1. It means when a passenger is sitting on the seat, it passes the value as 1. Also, when there is no passenger, it passes the value as 0.

Another display-only screen placed just behind the driver's seat will show the live location of the bus on a map as well as estimated time to reach. In order to create comfort, another emphasis is given to Voice Announcement System, similar to the announcement systems in railways. The reason for modifying is that it helps the illiterate people and the visually challenged people efficiently with announcing the upcoming destinations in multiple languages. There will be USB charging ports beside every seat. In this bus there is an air conditioner which balances the weather and the climate of the bus. It would be much better if the bus includes automatic drink snack vending machine. In this way the bus can earn more money. Drivers cabin will have a display panel where live monitoring of passengers inside the bus as well as live communication with control office (Smart Bus Station). Driver gets live update about traffic condition, emergency alerts, number of passengers going to get down at next stop, even estimated number of passengers waiting at next bus stop for that bus.

VI. SMART BUS STOP

All IoT devices in a Smart Bus stop are connected to city internet backbone through fiber-optic network. Wi-Fi hotspot and USB charging facilities may be provided at the bus stops. These bus stops will be solar powered with rooftop panels. Smart buses will stop at the smart bus stops present throughout the route. More than one different route can pass through a bus stop. Different display boards for each of the routes through a bus stop are placed in prominent places. Each of the display screens will show live smart bus position in a map with whole route marked in another color. All the buses that are on the road will be shown in the map with their current location. As added feature commuters at smart bus stop can view details of the dynamically scheduled buses that are ready to depart from smart bus depots. Also how much seat is vacant in a particular bus can also be queried online.[21] Smart queue facility will be presented in these bus stops where as soon as a commuter arrives to a bus stop, he can use his smart card (provided by city transport department) with RFID, NFC technology to register his presence on a touch screen based system where he has to select the destination as well as route if multiple route connects these two bus stops. Automatically smart queue will be generated for each route. These waiting commuter list will also reach to drivers control display, as well as smart bus depots control center in real time.

Moreover, Smart Bus Stops can be customized with a range of facilities, for instance, emergency call boxes, defibrillators, fire extinguishers, parcel delivery, bill payment and mobile top-up services, as well as direct phone links to taxi companies. They also feature traffic monitoring systems to improve scheduling and devices for measuring pollen count and noise levels. By improving the public transport experience for passengers, these new bus stops could lay the foundations for smarter, more environmentally friendly cities.

VII. SMART BUS STATION

This will be the central facility to manage the whole city bus services. It is the operating base station of a city's transportation system. It provides parking accommodation, servicing and maintenance facilities along with an administrative control facility to monitor and control the fleet. Smart bus depots will have battery charging facilities (refueling) for the smart buses (e-buses). These stations will have the main servers (all IoT devices will send data to this server) and terminals with technical support.[22] Operators at the control center will get real time information from the Smart Buses about their location, number of passengers on-board, and from the smart bus stops waiting queue for each route, average waiting time at each bus stop etc. They can also schedule bus timings (dynamic demand based time lag between two consecutive buses in same route) as per the waiting passenger list. Smart Bus depots robotic automatic bus maintenance system will take care most of the normal schedule maintenance. Air pressure data from smart buses will automatically select buses that need air pumping or any other maintenance facilities. There will be many other electrical, mechanical sensors attached to the smart buses (such as break shoe condition monitoring, Battery charge level indicator, engine cooling water level/temperature indicator etc.) that will send data to the control facility based on which other maintenance schedule will be generated.[23] Preventive maintenance rather than breakdown maintenance is always much less costly.

VIII. CONCLUSION

In this article, the term «Smart city», specifically Information about Development of smart city, smart infrastructure and building, smart transportation is clarified. There are many systems of smart city, but in this paper, the main focus was on city bus services than can be used to build smart cities. Proposed Smart Bus System (SBS) models a city wise bus transport system with the services and utilities that matches smart city requirements. Different components of the SBS have been discussed and the interconnectedness of them, interfacing with other systems, web portals for citizen access has been discussed. Next logical step in implementing this idea will be to design a framework to integrate the heterogeneous sensor data with modules for the software facilities provided at the bus stops, to the cabin and to the central facility operators at the bus

stations. Also interfacing smart card and checking devices using RFID, NFC technologies to the central server and proper database needs to be considered. As the proposed system consists of numbers of modules, integrating them properly is a big challenge. Therefore, before the implementation at city level a number of case studies could be conducted. Once the feedback from the commuters are collected and other problems are identified the system could be upgraded for better performance and implemented at the city level.

As it is the century of information technologies, this idea supports the century and contributes to the development of smart city.

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