Internet of Things for Smart Cities - Smart India

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Abstract- **Internet of Things (IoT) also today most commonly known as Internet of Everything (IOE) shall be able to incorporate transparently and seamlessly a large number of different and heterogeneous end systems. Evolving an existing city in India into a "smart city" is a henceforth a very challenging task and IOT has its own role to play into successful transformation of a city into its smarter version. Here in this paper we focus specifically on urban IoT systems that, which happens to be a very vast area and has various applications based on the type of domain IoT is used. This paper hence provides a comprehensive survey of the enabling technologies, protocols and architecture for an urban IoT.**

Key-Words- Smart Cities, Sensor System Integration, Network Architecture, Service Functions and Management, smart grids..

I. INTRODUCTION

Need for Smart City in India- Smart Cities India is all set to become the most populous country in the world by 2030, making it the home to the biggest and the most under-penetrated market for global manufacturers and service providers. Unlike its preceding generations, this growing population is also shifting to top tier cities of the country giving rise to new megacities estimated to generate 80% of economic growth, with potential to apply modern technologies and infrastructure, promoting better use of scarce resources.

II. ROLE OF INTERNET OF THINGS IN SMART CITY DEVELOPMENT

A. Internet of Things involves three distinct stages:

- The sensors which collect data (including identification and addressing the sensor/device),
- An application which collects and analysis this data for further consolidation and,
- Decision making and the transmission of data to the decision-making server.

Analytical engines, actuators and Big data may be used for the decision making process.

B. Definition

IoT is a seamless connected network system of embedded objects/ devices, with identifiers, in which communication without any human intervention is possible using standard and interoperable communication protocols.

C. Vision

To develop connected, secure and smart IoT based system for our country's Economy, Society, Environment and global needs.

III. AREAS TO FOCUS ON BUILDING IOT ENABLED SYSTEMS

A. The M2M + IoT Sectors Contribution towards Smart Cities

1) M2M: Underpinning much of the discourse about 'smart cities' is the tremendous growth and innovation in the electronics and IT. IT has two of the prominent terms associated with the co-evolution of these sectors are M2M and IoT. M2M stands for **Machine-to-Machine Communication** and describes the automatic exchange of information between machines and devices.

2) *IoT-* ***Internet of Everything*****: IOT** takes things to the next level by offering advanced interaction between devices actuation and automation systems and services. Beyond machines and users, IoT allows devices to share and receive information with software and applications using a variety of telecommunication technologies and protocols.

B. Role of m2m + IoT in smart cities: The IoT powered smart cities is improving the quality of life of citizens through a slew of technological solutions. Among other things this involves improving Eco efficiency, facilitating sustainable environments, offering optimized transportation, good governance, enabling high-quality healthcare, improving security and streamlining crisis management responses. The section below touches upon a few areas in which smart technologies can offer significant improvements in the quality, reliability and costs of services in cities, particularly in the Indian context.

1) *GIS based urban planning*: GIS systems allow spatial data management for cities with mapping of utilities, services and resources below the ground as well as infrastructure and land-use above the ground. Using modelling technologies, software and satellite data systems allow integration of databases that capture three dimensional information. This leads to better quality urban planning that incorporates wider concerns [5]. Linking GIS data with other land-use information (ownership, type of property, legal status, tax etc.)

allows online delivery of targeted public services as municipal authorities are better equipped to identify shortfalls in services, monitor revenue collection and stay abreast with changes in a property or plot's attributes . GIS also makes the process of building and managing cities more inclusive as it facilitates better communication of plans and activities for citizens. The figure below gives an illustrative example of one approach to using GIS for smart city development (given by Rolta) [4].

Fig. 1 A plan by Rolta Systems

2) *Water Management:* An area where creating a GIS layer for a city can improve the quality of urbanization is water. The International Telecommunications Union (United Nations) in its Technology Watch report identifies the combination of sensor networks, internet communications and GIS tools as having an important role in water management in the future [7]. The report states these technologies can be very beneficial to government authorities in efficiently managing the water distribution network and water quality while reducing water consumption and wastage in sectors such as agriculture and landscaping. Indeed this has been put into practice in cities such as Singapore where water is managed through a full controlled network in a manner analogous to the electric grid – leakages are detected quickly and from remote locations, different streams of water are collected, treated and added to the supply accordingly [1]. The proof of concept has led to the increasing use of terms such as 'Water Grid' and 'Smart Water Management' by companies providing IT enabled solutions. Singapore in particular has augmented its water supply through integrating water into urban planning and design while leveraging sensors, SCADA and water quality measurements to augment supply by cutting wastage. The figure below depicts one example of smart water distribution control (by Hitachi) [6].

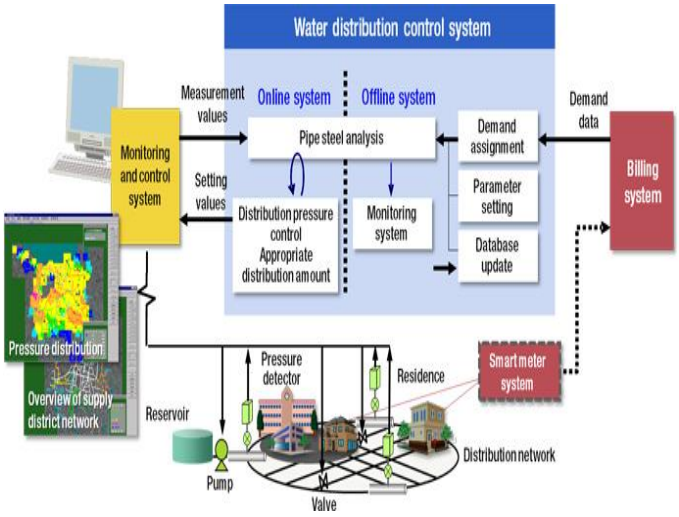

Fig. 2: Hitachi

3) *Transportation:* An area in which IoT has achieved considerable integration is transportation. Telemetry and satellite data have transformed traffic management, not only on the road, but also in the air and underground. Applications include real-time tracking for traffic management; services like radio-cabs, online maps to find the most efficient routes, smart parking – displaying available spaces, time signalling on traffic lights and scheduling information of trains [5].

A popular example is automatic smart card ticketing systems such as the London Oyster card – now increasingly linked to contactless payment credit and debit cards, rather than dedicated cards [2]. This is a large scale application of IoT in transportation that offers savings in terms of time and money by reducing the number of ticket booths and waiting time. It also provides enormously valuable information about people's travel habits – allowing much better management and planning.

Another interesting example of combining telematics with eco-mobility comes from the Indian company **Mahindra** that has created India's first smartphone controlled car. Using an app, it allows users to track the general performance of the electric car while controlling features like Air Conditioning. The app also sends timely alerts to customers about damaged parts [7]. The basic design of the electric vehicle, reduces the number of mechanical parts, and allows issues to handled and solved via OTA (over the air) firmware and parameter updates. This has created a new service model for Mahindra Reva that collaborated with Vodafone for M2M Connectivity4

4) *Energy Management:* Cities consume 75 per cent of the total energy consumption in the world and are responsible for 50 to 60 per cent of the world's total greenhouse gas emissions - a figure that goes up to 80 per cent if we consider emissions due to urban inhabitants. In this respect, the IoT has played a central role in the development of solutions for improving energy management. Rapid growth in digital technology, concomitant with transformations in the way energy is generated and consumed has led authors to coin terms such as Energy 3.0 and the Energy Cloud. These are

terms generally used to represent IoT driven innovations such as smart grids, electrification of demand, demand visualization and flexible generation that can help achieve desired outcomes from energy infrastructure in cities [4].

An initiative in India was announced by **IBM** in 2013. The IT Company has been selected by **Tata Power** Delhi Distribution to conceptualize, design and deliver an advanced smart grid solution to better manage energy output and further reduce outages. IBM will also collect and analyse real-time information from smart meters and data from ICT infrastructure. With technologies such as smart meters comprising less than one per cent of the 200 million energy meters in India, there is a tremendous opportunity for pilot projects to exhibit the value smart energy management [6].

5) *Buildings:* Another equally significant area is solutions for building low energy resident and commercial developments in our cities. It is estimated, that the buildings sector in India is responsible for 40 per cent of energy use, 30 per cent of the raw material use, 20 per cent of water use, and 20 per cent of land use in cities. Therefore, solutions that can help realize the objectives of policies such as the Energy Conservation Building Codes are much needed. The ICT sector has the expertise to facilitate delivery of sustainable buildings through solutions for simulation, modelling, analysis, monitoring and visualisation - all vitally needed for a whole building approach to designing and operate buildings. With India's microclimate drastically different from Western economies there is a need for combining technologies with indigenous expertise [4].

6) *Healthcare:* Among the broad areas under 'smart city' concepts, the use of 'connected technologies' in healthcare has been one of the most advanced. Today there are several applications, apps and technologies targeting common citizens, patients as well as healthcare professionals offering a variety of services for health, fitness, lifestyle education, monitoring and management of key parameters (heart rate, perspiration, blood oxygen etc.), ambient assisted living, and continuing professional education tools public health surveillance. This is reinforced by Gartner's observation that in February 2010 there were over 4000 apps focused on health and patient-end functionality on the Apple App Store [1].

A widely cited example of a 'smart healthcare' initiative is the SPHERE project in the city of Bristol. A part of the wider 'Connect Bristol' smart city initiative it is introducing M2M technologies in the home to enable remote monitoring of lifestyles and patient parameters. The technologies include 3D cameras and autonomous wearable sensors. Relying on well-developed Small Area Networks or Home Area Networks, Wide Area Networks and Wireless Control the project is aimed at fusing big-data and pattern recognition to provide low-cost and low-energy healthcare.

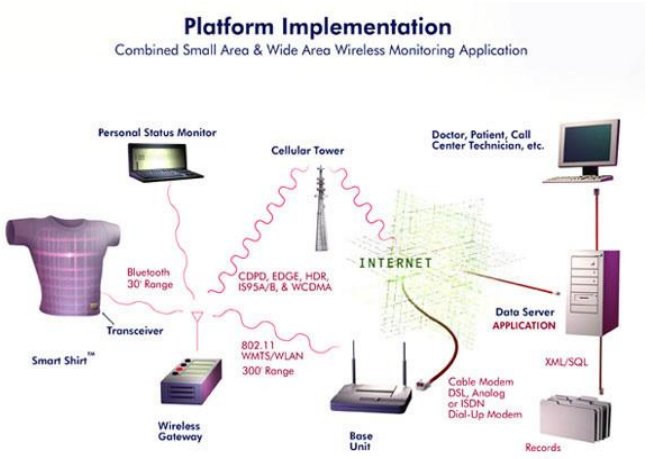

Fig. 3: Park, J. for Stanford University, Original source Sensatex

The figure above presents a conceptual schematic of a 'smart shirt' - embedded with sensors to measure vital parameters - along with IoT and M2M technologies to deliver remote and efficient healthcare [2].

With monitoring systems and interactive patient data communication methods estimated to reduce face-to-face visits by 40 per cent the economic benefits of smart healthcare in a smart city extend to reduction in travel, time savings (for healthcare professionals and patients) and reduced risks such as exposure to hospital infections etc. This makes smart healthcare highly desirable in Indian cities that witness high prevalence of infectious diseases and growing lifestyle related ailments such as diabetes.

7) *Security:* A straightforward application of infrastructure for collecting and transmitting real-time data is public security through a surveillance system. The figure below (from sensity) gives some examples of ways in which smart city technologies such as digital communication, CCTVs, sensors, controllers and analytics can improve public safety and security.

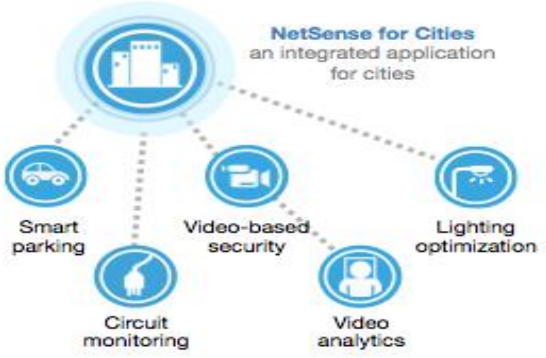

Fig. 4: NetSense for cities.

C. *Envisioning smart cities of the future*

To present a better understanding of the applications of IoT driven technologies in a smart city the following section attempts to envision life in a smart city. Imagine yourself asleep, a few hours before your alarm goes off in the morning. Your temperature, heart-rate, blood pressure and respiration

are constantly monitored to regulate the thermal parameters in your room to optimise your comfort - like the SPHERE (**S**ensor **P**latform for **He**althcare in a **R**esidential **E**nvironment) service currently being developed in the city of Bristol. The real-time data is monitored remotely by healthcare professionals that are given instantaneous updates in the case of an emergency or undesirable trends. The figure below shows an example of a similar smart healthcare solution envisioned by Samsung [7].

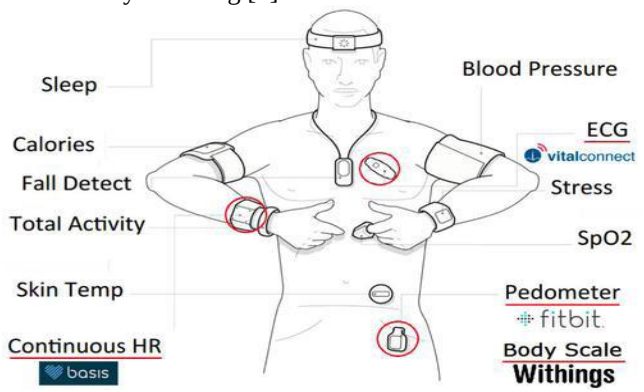

Fig 5: Smart human monitoring system

The above figure shows the concept for SAMI (Samsung Architecture Multimodal Interaction) by Samsung)

As you wake up air quality data crowd-sourced from your neighbourhood using air quality sensors attached to smart phones of people traversing on your preferred routes helps you decide whether you want to walk to work, drive or use public transport. The figure below shows an example of such a sensor provided by a venture called Air Quality Egg.

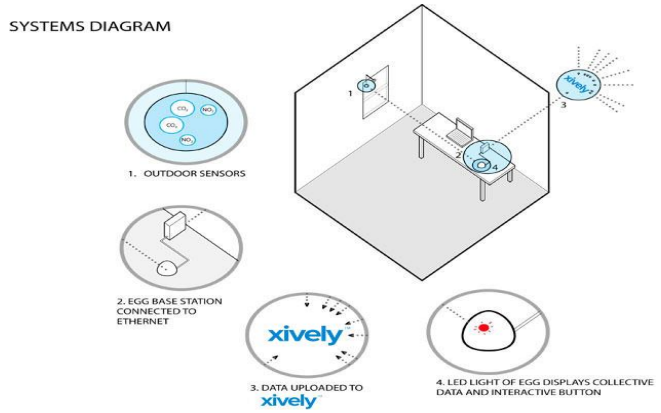

Fig.6: Air Quality Egg

In case you want to go on a quiet jog before your day begins you can view mediated maps of peaceful routes in your city on Noise Tube - an application that transforms smartphones into an acoustic detector to measure noise pollution and aggregates crowd-sourced data [2]. Let us suppose that you decide to take the bus to work. In a smart city, your bus stop will most likely be connected to the city's fibre optic network with displays for real time bus timetables, tourist information and digital advertising along with USB charging sockets for mobile devices such as smartphones and tablets, and free WiFi hotspots - just like bus stops in Barcelona [3].

The figure below shows Barcelona's Informative Solar Bus Stop (PSI) - a solar powered bus stop that shows arrival times for buses along with seat availability.

Fig. 7: Ecofriend43

As you enter the bus going to your destination, virtual traffic managers will coordinate between priorities and requirements of different modes of transport and authorities (traffic police, highway authorities, municipal government etc.) to avoid congestion on the streets - as seen in Amsterdam. Assuming your destination is a business district you will enter an area with buildings committed to improving energy efficiency and powered by smart-grids in an urban area with a healthy mix of green spaces. While you work in your office you can use smart phone applications like NEST to operate devices at home - move them to power saving modes or run the washing machine during off-peak hours [6].

D. Sectors with a significant role in the 'smart cities' agenda

To keep the contents of this paper relevant to the scope of the IoT + M2M Forum 2015 the following discussion will present a brief overview of three key sectors.

1) Information Technology and IT enabled services: India's preeminent position in IT services and a growing start up ecosystem will make IT among the most important sectors in realizing the smart cities vision. With its size and scale, India's IT sector can also 'indigenize' efforts to build smart cities by creating services, products, and apps tailored to the Indian market. A few examples of IT sector driven smart city solutions in India include

- *Smart Water Services Platform by Cap Gemini* - An off the- shelf software-as-a-service (SaaS) solution that will allow utilities to deploy radio water meters and networks elements. Meter manufacturer agnostic, with open architecture allows integration with any radio data collection solution, meter data management system, or ERP system including SAP and Oracle.

- *Nano Ganesh*- allows farmers to use mobile phones to remotely monitor and switch on irrigation pumps in remote locations.

2) *Telecom*: While the onus for software platforms, web-enabled services, and big data analysis rests with the IT sector the telecom will provide the highways (physical or wireless)

for connected devices, user interfaces and in the case of smart phones – both a sensory and control device. The telecom sector is also crucial for accelerating the uptake of e-governance and smart governance. While future projections are promising, current growth has also been impressive.

3) *Electronics:* This includes electronic components, sensors, communication and broadcasting equipment, telecom products, and other hardware that goes into making the M in M2M technologies.

One example of an attempt to use automated metering infrastructure in the Indian context is a pilot project by Uttar Haryana Bijli Vitran Nigam's (UHBVN, Haryana) that covers 31,914 consumers and 531 distribution transformers - approximately 131.8 MU input energy consumption. Covered under the Restructured Accelerated Power Development and Reform Programme (RAPDRP) Scheme for IT implementation and system strengthening, the project is introducing the functionality of peak load management by implementing automated metering infrastructure (AMI) for residential and industrial consumers [4].

IV. CONCLUSION

In this paper we have focused on tremendous potential in India to build an effective ecosystem to enable our burgeoning urban areas to become smart by using digital technology. This in turn will create employment opportunities and contribute to economic growth through innovation. Our cities are fast becoming the defining units of human habitation. How smartly we build, manage and operate our cities will be the single biggest determinant of our people's future.

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