Smart Cities in India - the role of m2m + iot

india m2m + iot forum

capitalizing connected world

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with inputs from m2mpaper.com

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1. The need for new urbanisation and 'smart' cities in India

1.1 The need for 'smarter' cities

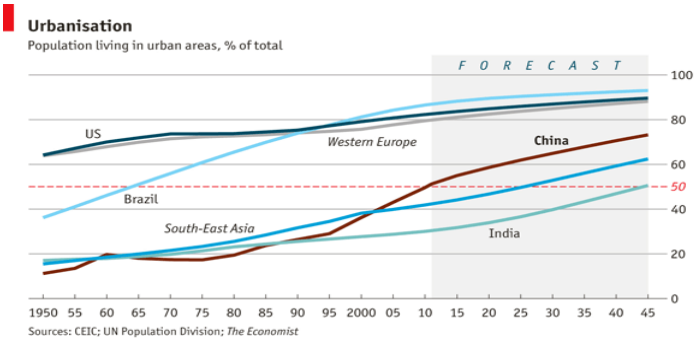
Cities in India contribute over 60 per cent of the country's GDP and 80 per cent of tax revenues. The Government of India envisages new urbanisation and initiatives such as the 100 smart cities project as a means to unshackle the economy from sub 8 per cent growth.

At present, India has 68 cities with a population greater than 1 million. Europe only has 35 such cities. It is estimated that the demand for essential public services namely Water Supply, Sewage, Solid Waste and Transportation is expected to increase by 4.5 to 8 times the existing demand[1]. Despite this impending surge in demand, 25 per cent of India's urban population lives in slums. In the cities of Mumbai, Vishakapatnam, Meerut, Vijaywada and Jabalpur this is above 40 per cent[2].

This backdrop coupled with an expanding middle class has fueled enthusiasm for aspirations of efficient, livable and functioning cities represented by the concept of 'smart cities'. On the other hand the vision for technology driven cities in a country with extreme poverty and sharp income inequality has raised concerns over equity and fairness. The challenge, therefore, is to leverage technology to ensure efficiency and quality in services while in an inclusive manner.

11.1 Impending urbanisation in India

Traditionally, India has been reticent in urbanising. The 2001 census revealed that only 28 per cent of India's population lived in urban areas. It took the country nearly 40 years to reach an urban population of 230 million people. As of 2012, India's urban population was estimated at 380 million.



Source: The Economist[3]

Some might argue that these figures are a misnomer. In recent years, connectivity to an expanding road network, rural electrification and the high penetration of telecom networks in India's villages is challenging the very definition of urbanisation in India[4]. This becomes significant when we consider that the erstwhile Planning Commission (now NITI Aayog) estimated that India will undergo rapid urbanisation in the coming decades with the urban population swelling to 600 million by 2030.

While one can contest the definition of urbanisation in India, it is undisputed that the coming decades will witness tremendous rural to urban migration - through both, the movement of people and spread of urbanisation into the hinterland. Spurred by the quest for economic opportunities, the demand for essential city-level services will expand rapidly.

1.1.2 Quality of existing services

Despite the fact that 380 million people live in urban India, it is estimated that only half of the urban population in India is served by essential urban services that meet current standards[5]. For example, a study of wastewater profiles in 71 Indian cities, conducted by the Centre for Science and Environment (CSE) revealed that less than 30 per cent of the nation's officially recorded sewage is treated as per acceptable standards[6].

In terms of air quality, the World Health Organisation (WHO) claims that 13 out of the 20 most polluted cities in the world are in India. While this claim has been contested by the Government of India, it is hard to deny that air quality in our cities needs to improved.

Furthermore, according to a high-powered committee set up by the Ministry of Urban Development, India will require an investment of INR 7.5 trillion over the next 20 years to improve infrastructure relating to transport, water supply, sewage and sanitation in selected cities. Clearly, the challenge to build a 100 smart cities is immense, yet also timely and urgently required.

The above examples clearly suggest that there is a need for solutions that can expand and improve the quality of public services in existing cities. In addition, there are business opportunities for those companies that can provide new infrastructure and new solutions for environmental and city-level challenges It is crucial to see every existing inefficiency is an opportunity.

1.2 Smart cities in the Indian context

Academic literature is replete with a wide variety of characteristics and indicators that a smart city must have. While the basic indicators are appropriate in most contexts, it is important to adapt these frameworks to the Indian scenario.

1.2.1 Outcomes of preliminary discussions with stakeholders

As per the draft concept note circulated by the Ministry of Urban Development (2014) the smart cities initiative recognizes four pillars on which a city rests. These are Institutional Infrastructure (including Governance), Physical Infrastructure, Social Infrastructure and Economic Infrastructure.

Good quality infrastructure, simple and transparent online business and public services processes that make it easy to establish an enterprise and run it efficiently without any bureaucratic hassles are essential features of an investor-friendly smart city.

The policy position stresses that both economic growth and quality of life need to be understood as two sides of the same

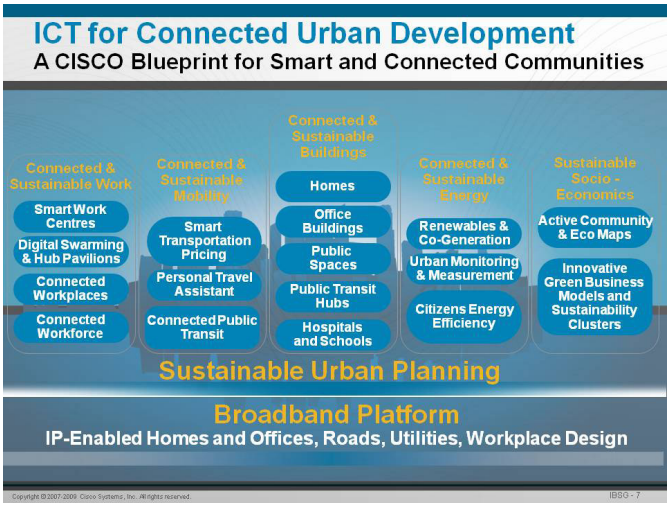
coin in order to achieve truly sustainable scenarios. These cities would therefore need to have smart housing, high level of healthcare, entertainment and quality education. Moreover, safety and security are also viewed as a basic need for residents, migrants and transient population.

1.2.2 What is a smart city in India expected to have?

Some of the key expectations, though not exhaustive, from a smart city in India include

- Clean and reliable water
- Proper sanitation
- Uninterrupted power (from clean sources)
- Zero waste / Effective solid waste management
- Sewage treatment with a waste to wealth approach
- Eco-mobility
- Last mile connectivity
- Effective use of ICT
- Security
- Participatory governance

While the concept of 'smart growth' in the context of urban policies has existed since 1990s, the concept of 'smart cities' has its origins in information system solutions offered by major technologies companies such as CISCO, IBM and SIEMENS that came to the fore around 2005[7].



Source: Connected Urban Development by CISCO[8]

Recognising that the push for embedding ICT in discharging city level functions originates from extensive marketing and advocacy by private companies is extremely important.

It displays the capabilities and willingness of the private sector in introducing efficiency and quality of services into the discourse on governance. At the same time distinguishing between the wide range of products, tools, services and technologies in the market on the basis of quality, cost, efficacy, and usefulness will be a priority going ahead.

At the end of the day it is important to view 'smart cities' *not as an IT solution, rather the alignment of good governance, investments, institutions and time*[9].

2. What does the m2m + IoT sector have to offer to smart cities?

2.1 What is m2m and IoT?

Underpinning much of the discourse about 'smart cities' is the tremendous growth and innovation in the electronics, IT, IT enabled services and allied sectors over the last two to three decades. And two of the prominent terms associated with the co-evolution of these sectors are M2M and IoT.

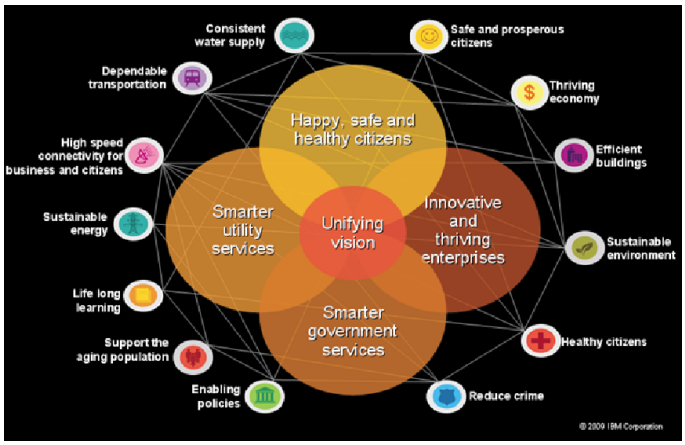
m2m stands for **Machine-to-Machine Communication** and describes the automatic exchange of information between machines and devices[10]. The term originated with machine technologies communicating data using the Internet Protocol[11].

IoT - **internet of everything** - takes things to the next level by offering advanced interaction between devices (such as hand held computers, sensors), actuation and automation systems and services[12]. Beyond machines and users, IoT allows devices to share and receive information with software and applications using a variety of telecommunication technologies and protocols.

Together the two terms encompass the hardware, software and telecommunication options that can make public services or human activities more efficient. Thereby making them central to the discourse on the aspirations from Smart Cities.

2.2 Role of m2m + IoT in smart cities

The raison d'être of 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[13]. The figure below shows IBM's representation of the kind of services available in a smart city.



Source: IBM Corporation

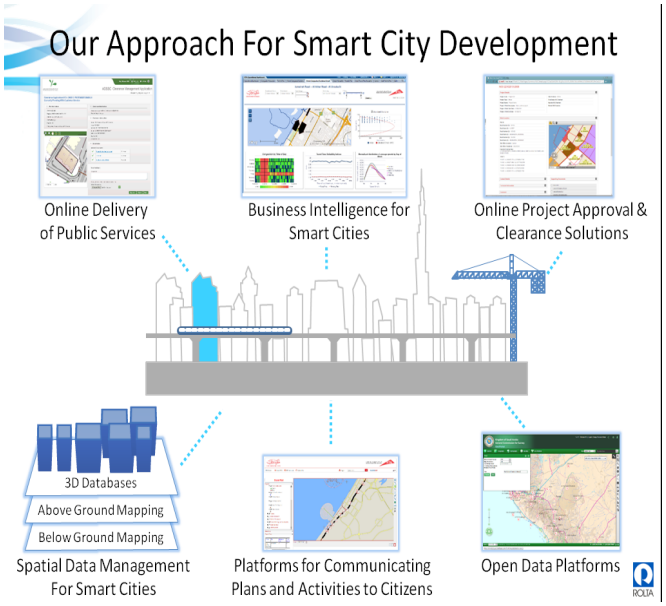
One example of the wider benefits of an IoT driven approach to urbanization comes from the Global e-sustainability initiative's estimate that ICT technologies such as video conferencing and smart building management could potentially cut greenhouse gas (GHG) emissions by 16.5 per cent leading to energy and fuel savings to the tune of 1.9 trillion USD and 9.1 Gigatonnes of CO_2[14].

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.

2.2.1 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 such systems allow integration of databases that capture three dimensional information. This leads to better quality urban planning that incorporates wider concerns.

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).



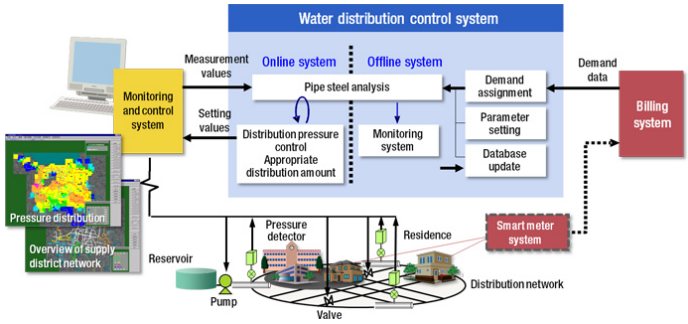
Source: Shafiq Jiwani from Rolta Systems[15]

However, 23 semi-structured interviews conducted by the CIDCO Smart City team at NIUA with heads of department at a prominent city planning and development agency in India - reveal incomplete or insufficient uptake of GIS systems in planning, development and management of cities throughout the country. This implies that few organizations / municipalities tasked with city planning or city development have access to GIS systems and even those that have some exposure to GIS do not use it extensively or effectively. For example, spatial data and land-use are not captured in the same database. Moreover, lack of expertise in GIS systems results in city planning on more primitive software with the use of paper drawings. Major reasons for this are a lack of training in GIS for urban planners working at the city level and absence of incentives or strictly enforced guidelines to adopt GIS.

2.2.2 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. 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[16].

Indeed this has been put into practice in cities such as Singapore and Masdar 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[17]. 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[18]. The figure below depicts one example of smart water distribution control (by Hitachi).



Source: Hitachi[19]

Improvements in water management are particularly significant in India which faces high water stress i.e. high ratio of withdrawals to total renewable supply[20]. Smart water management is the need of the hour as 22 cities with high population densities face demand and supply shortages ranging between 30 per cent (for example Kanpur, Hyderabad, Madurai, Meerut) and 70 per cent (Jamshedpur) while other cities such as Delhi report leakages as high as 40 per cent[21]. The UN's prediction that water demand will exceed supply by 40 per cent by 2030 also makes water optimization a key risk mitigation strategy for businesses as well.

2.2.3 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.

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. 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 this electric car while controlling features like Air Conditioning. The app also sends timely alerts to customers about damaged parts. 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 connectivity[22].

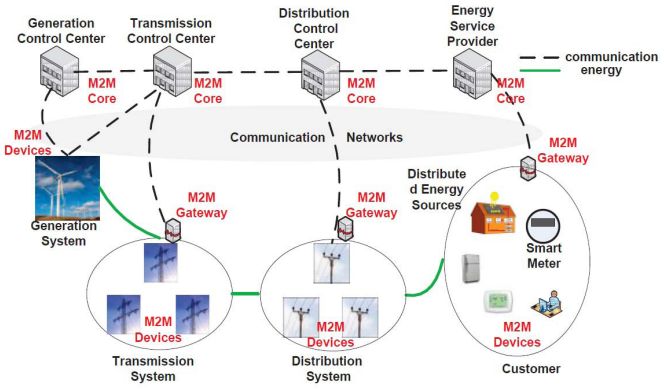
2.2.4 Energy Management

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[23]. Moreover, this demand for energy also includes a strong desire for uninterrupted access to energy that is available 24X7.

Therefore, there is an urgent need for ambitious energy efficiency and low-carbon energy programmes for cities. 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[24] and the Energy Cloud[25]. 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.

For example, in the city of Amsterdam, the local utility (Liander) collaborated with an energy management company (Plugwise) to allow 250 households to test an energy management system for four months without any cost. By providing insights into energy consumption of each connected appliance, online monitoring, remote controls and tips to cut energy bills the project succeeded in sensitizing people while identifying leaders and early adopters.

The figure below shows mapping of communications architecture on M2M architecture for smart grids developed by the European Telecommunications Standards Institute (ETSI)



Source: Lopez, G., Moura, P. et. al. in journal Energies[26]

A similar 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 analyze real-time information from smart meters and data from ICT infrastructure. It is hoped that the solution will help Tata Power empower its over 1.3 million electric consumers to manage their own energy usage[27].

Such energy efficiency measures through smart ICT are vital in the Indian context as it is estimated that India can save $42 billion every year by reducing energy waste in buildings. The challenge for the M2M and IoT sector companies in India lies in developing appropriate business models to realize this potential. With technologies such as smart meters comprising less than one per cent of the 200 million energy meters in India[28], there is a tremendous opportunity for pilot projects to exhibit the value smart energy management.

2.2.5 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[29]. Therefore, solutions that can help realize the objectives of policies such as the Energy Conservation Building Codes are much needed.

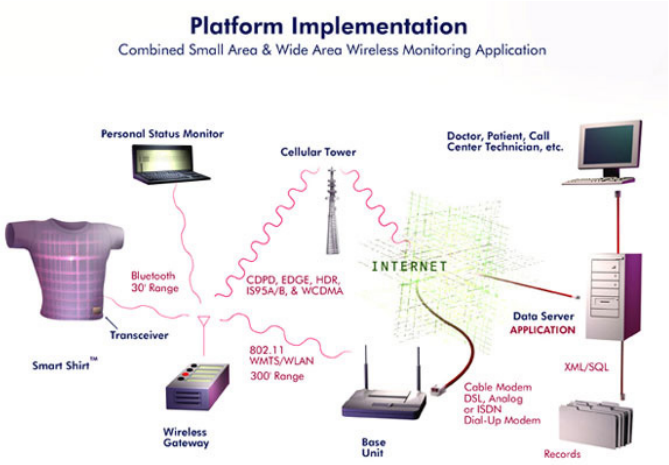
The ICT sector has the expertise to facilitate delivery of sustainable buildings through solutions for simulation, modelling, analysis, monitoring and visualisation - all vitally needed for a whole building approach to designing and operate buildings. With India's microclimate drastically different from Western economies there is a need for combining technologies with indigenous expertise.

2.2.6 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, 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[30].

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[31]. The figure below 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.

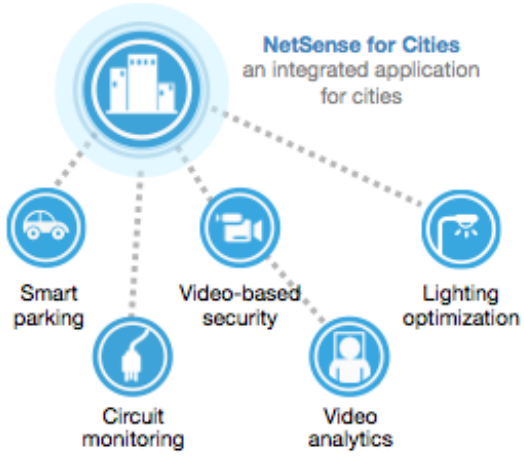


Source: Park, J. for Stanford University, Original source Sensatex[32]

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.

2.2.7 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.



Source: Sensity[33]

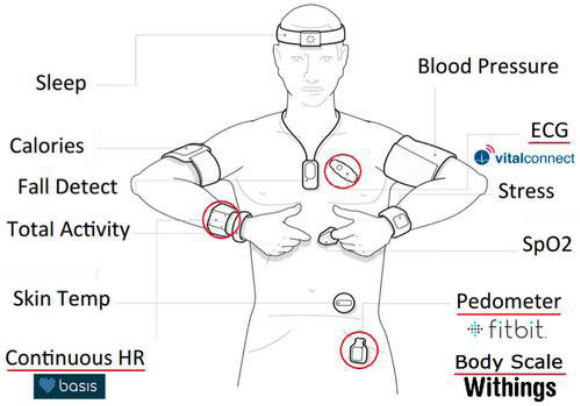
2.2.8 e-governance

An emerging, yet significant aspect of good governance is smart administration that employs new channels of communication such e-governance that can allow faster delivery of services and a wider reach[34]. Besides extending the reach of governance, e-governance, is viewed as a prerequisite for enabling smart cities by involving citizens and keeping the decision and implementation process transparent[35]. India, in particular, has shown a favourable predisposition towards e-governance. In 2012, there were 98,000 Common Service Centres providing e-governance services; over 600 out of 1100 citizen and business services are available electronically[36]. There is tremendous potential to increase the coverage, quality and range of public services.

2.3 Envisioning smart cities of the future

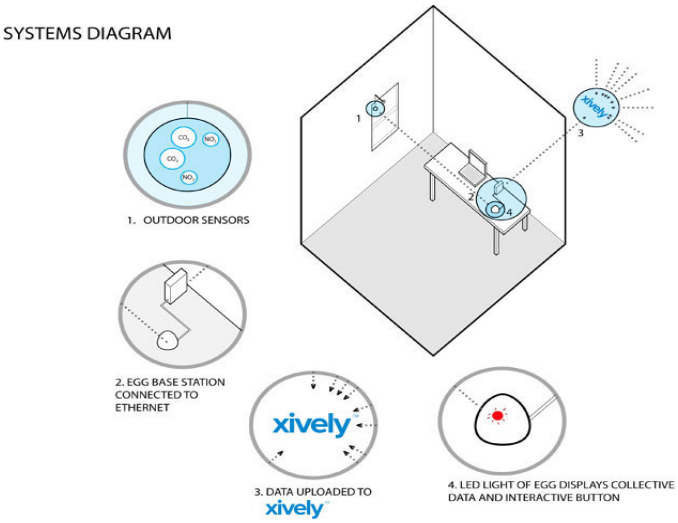
To present a better understanding of the applications of IoT driven technologies in a smart city the following section attempts to envision life in a smart city.

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[37] - 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.



Source: Concept for SAMI (Samsung Architecture Multimodal Interaction) by Samsung[38]

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[39] 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.



Source: 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 NoiseTube - an application that transforms smartphones into an acoustic detector to measure noise pollution and aggregates crowd-sourced data[40].

Source: Invest in Trentino[41]

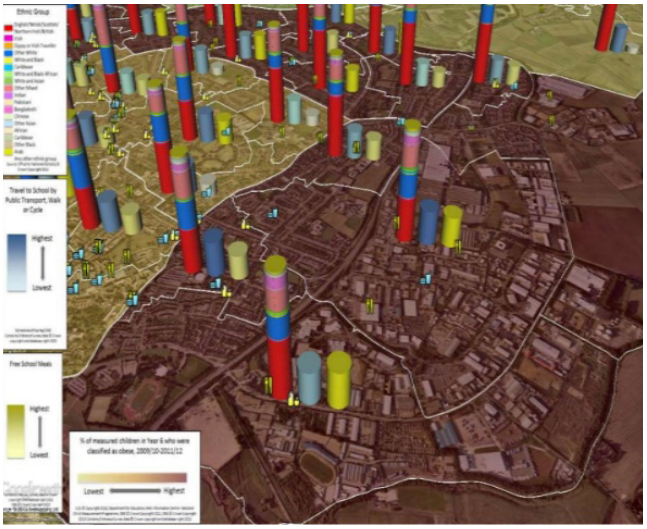
As you prepare for work smart meters, for both water and energy, help you monitor your resource consumption while encouraging you to eliminate wastage. Let us suppose that you decide to take the bus to work. In a smart city, your bus stop will most likely be connected to the city's fibre optic network 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[42]. 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.

Source: Ecofriend[43]

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[44].

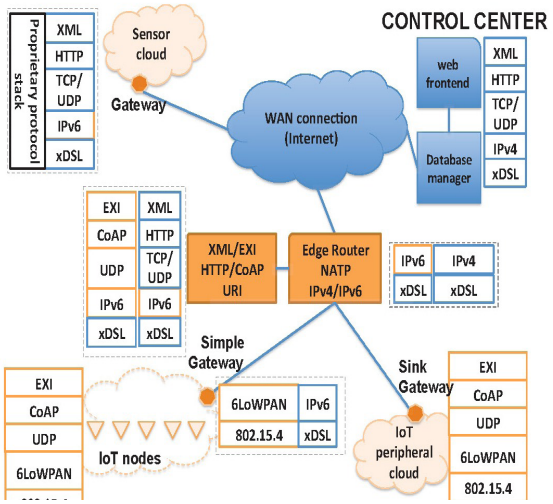
Assuming your destination is a business district you will enter an area with buildings committed to improving energy efficiency[45] and powered by smart-grids[46] in an urban area with a healthy mix of green spaces. While you work in your office you can use smart phone applications like NEST to operate devices at home - move them to power saving modes[47] or run the washing machine during off-peak hours.

This can happen while the local city government captures trends in water consumption, energy use and transportation to create 3-D visualizations that help service providers to plug leakages, leverage flexible energy generation or simply inform consumers about economical choices - emulating efforts seen in Peterborough[48]. The figure below shows an example of such visualizations - comparison of parameters (such as electricity consumption, childhood obesity, housing stock etc.) across the city.



Source: Paul Davidson and Trevor Gibson, Department for Communities and Local Government[49]

In a smart city of the future, such services will most likely be possible through a combination of GIS (Geographic information system) enabled city planning, data capture technologies such as sensors and CCTV cameras and handheld devices for great user control. The figure below presents one of many conceptual representations of how IoT and M2M technologies would be distributed in an urban setting.



Source: Concept of urban IoT network based on web service approach Zanella and Vangelista

While this is a futuristic vision that is far removed from the current reality of Indian cities, nonetheless, it is important to recognize that IoT and M2M technologies are central towards making incremental improvements in city management. These examples are only indicative and their mention in this paper does not imply that these solutions are ready to be transplanted into Indian cities. It is important to view these examples as manifestations of the possibilities represented by smart cities.

2.4 Challenges in creating m2m + IoT powered 'Smart Cities'

2.4.1 Interoperability and the need for standards

Today a major technical hurdle standing in the way of IoT-powered cities is finding common ground for operability of heterogeneous technologies used across the urban landscape[50]. An expansion of sub-technologies and subsystems (devices, appliances, buildings, vehicles, component services, etc.) necessitates standards for interoperability, seamless integration and real time communication between machines manufactured by different vendors interacting through a wide range of propriety and/or open source protocols[51].

This is reiterated by the M2M Alliance that views integration of individual solutions into ecosystems as the principal challenge to rolling out 'smart solutions'[52]. Furthermore, behind the hubris of 'connected societies' the possibility of interconnecting or integrating several different subsystems increases the risk of failure and errors in ICT projects[53].

Though not necessarily aimed at smart cities, the table below lists initiatives to develop standards for IoT driven services.

AllJoyn	AllJoyn is an open source project intended to enable compatible smart devices to "recognize each other and share resources and information across brands, networks, and operating systems," according to AllJoyn's website. The project, initially developed by Qualcomm Innovation Center is now a collaborative open source project of the AllSeen Alliance. The alliance includes Cisco, Microsoft, LG, and HTC.
Google's - The Physical Web	The idea behind Physical web is create a reality where people can - "walk up to any smart device — a vending machine, a poster, a toy, a bus stop, a rental car — and not have to download an app first. Everything should be just a tap away."
Open Interconnect Consortium	The consortium consists of Intel, Atmel, Dell, Broadcom, Samsung, and Wind River, focuses on "defining a common communications framework based on industry standard technologies to wirelessly connect and intelligently manage the flow of information among personal computing and emerging IoT devices, regardless of form factor, operating system or service provider."
Thread	A new IP-based wireless networking protocol, is a collaborative effort between Google's Nest, and Samsung Electronics, ARM Holdings, Freescale Semiconductor, Silicon Labs, Big Ass Fans, and Yale Locks & Hardware.

Source: By Joe McKendrick on ZDNet[54]

2.4.2 Need for appropriate business models

Another major barrier to the deployment of IoT and M2M solutions lies in identifying the appropriate business model. Global economic corrections and consequent reduction in money available for investments in public services has also stymied deployment of Smart Cities.

Gartner's hype cycle assessment of Smart Cities suggests that the smart city vision is attractive, but faces complexities in implementation. While technology companies desire solutions to be locked in for longer periods, cities are realising the need for more flexibility and resilience in providing services. A pertinent question around smart cities is how do companies earn revenue that from wealth that will be created in the future?

With cities acting as a point of convergence for challenges and resources, companies offering solutions cannot think and act in isolation. Technology and service provides must be cognizant of their limitations and explore open innovation, collaboration or outright acquisition of capabilities to create solutions that cater to the entire value chain[55].

2.4.3 Reliability and accuracy

A challenge, that is likely to become a major concern in the

future is ensuring reliability and accuracy of the data collected through IoT-driven services. The M2M Alliance envisages that by 2020, products that collect real-time data, communicate with each other and enable automation will be pervasive in the personal sphere and in cities[56]. With India expected to see major growth in the market for smart phones and other connected devices accurately processing and analysing large amounts of data generated by IoT-driven services is important to ensure reliability.

This is crucial in applications for Smart Healthcare where the user's health and life are both directly impacted by technology and areas like traffic management where identifying trends accurately is a prerequisite for making the appropriate interventions[1]. So far, reliability has not been given a high priority, however, it is essential to retain customers and engender confidence in future users of smart city technologies[57].

One response to this call has come from the European Commission that launched the FP7-SmartCities-2013 project RERUM to develop an architectural framework for dependable, reliable, and secure networks of heterogeneous smart objects supporting innovative Smart City applications[58]. To mitigate security risks, the Trusted Computing Group, an industry standards groups advocates a standards-based approach wherein IoT devices have additional piece of hardware such as a Trusted Platform Module responsible authentication and remote verification.

Industry alliances must consider it incumbent upon themselves to develop measures that address privacy and security concerns outside the realm of hardware - for example clear guidelines on stakeholders with access to data generated by individuals and the usage of such data[59].

2.4.4 Energy and e-waste management demands

The number of IoT powered devices in operation by 2020 is estimated to be anywhere between 25 billion and 75 billion[60]. Assuming the number is 50 billion, at a minimal power rating of 10 milliwatts, the additional energy demand from these devices alone will be 500 MW (not counting the energy required to run related network and IT infrastructure).

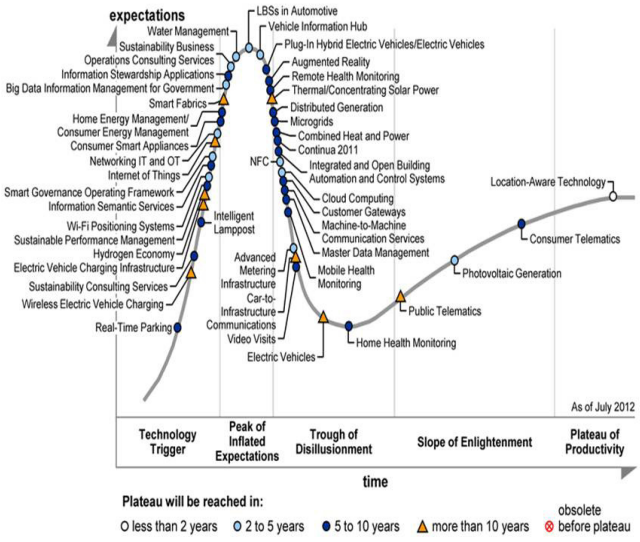
In a carbon constrained world with growing energy demand, it might be necessary for smart city technologies to incorporate *ultra-low-power designs, thin-film energy storage, harvesting of ambient energy, and advanced power-management techniques to supply power only when and where needed will be critical considerations*.[61]

On average, these numbers imply 3.3 devices for every man, woman and child on the planet, without counting a projection of 7.3 billion smartphones and tablets by 2020[62]. Disposal of e-waste, in particular batteries, must form an important part of any IoT solutions provider's strategy.

2.4.5 Resisting the hype

Apart from technical and economic issues, the smart cities discourse must avoid inflated expectations and hype. Experts suggest that cities, and companies providing solutions, must focus on solving fundamental problems, assess current needs and thereafter ask the question - "what technology should we acquire?"[63]

The market intelligence firm Gartner also warns that the enthusiasm for IoT has not yet percolated to cities and asserts that the smart cities vision relies on emerging technologies that are yet to mature[64]. This is captured in the Gartner Hype Cycle for Smart City Technologies shown below.



Gartner Hype Cycle for Smart City Technologies[65] - Source: Gartner

2.4.6 Citizen engagement

A city cannot be smart if its citizens do not have the capacity to own, use and leverage ICT technologies. Equally significant is creating the desire to collaborate, share and actively participate in matters pertaining to the neighbourhood and city at large[66]. Educating citizens and increasing access to smart devices is an important prerequisite for commercial scale deployment of smart solutions[67]. Therefore it is in the interest of companies operating in this space to take up pilot projects to showcase the proof of concept and business case for smart meters, apps and other services while disseminating and showcasing results. Inspiration can be drawn from smart city pilot projects and subsequent knowledge sharing efforts in cities such as Amsterdam[68], Barcelona[69] and Hamburg[70] that have created active websites to track projects and share experiences.

2.5 Sectors with a significant role in the 'smart cities' agenda

Sectors that are expected to play a major role in building cities with such technologies are shown in the figure below

1. IT and ITes
2. Telecommunications
3. Electronics
4. ICT manufacturers
5. Infrastructure
6. Energy
7. Environment
8. Transportation
9. Materials

10. Healthcare
11. Building Automation
12. Industrial Electronics

The following section presents a brief overview of the sectors with the responsibility for, and opportunity to make the Smart Cities initiative successful. 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.

2.5.1 Information Technology and IT enabled services

India's preeminent position in IT services and a growing start-up ecosystem will make IT and IT-es among the most important sectors in realizing the smart cities vision. The IT driven economy in India has an estimated revenue generation of USD billion $118 billion and with over 16,000 firms operating in the IT-BPM space, it is estimated that this sector provides direct employment to over 3.1 million people while providing indirect employment to an additional 10 million people[71].

Microsoft estimates that by 2025 India will have 700 million internet users out 4.7 billion users across the world thereby emerging as a leading player in virtual services. 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. It augurs well that despite slower economic growth in recent years the IT-ITeS industry exhibited a resilient growth of 19.2% in production[72].

A few examples of IT sector driven smart city solutions in India include

1. **Smart Water Services Platform by Capgemini -** 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 it allows integration with any radio data collection solution, meter data management system, or ERP system including SAP and Oracle. It is also offered with turnkey services to enhance integration with existing infrastructure.
2. **Nano Ganesh,** allows farmers to use mobile phones to remotely monitor and switch on irrigation pumps in remote locations. The app, developed by Ossian Agro Automation (Pune), works in conjunction with Tata Teleservices phones.

2.5.2 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. Reinforcing the push for digital India and smart cities, the sector is witnessing exponential growth with the Groupe Speciale Mobile Association (GSMA) expects the sector to generate 4.1 million additional jobs[73].

While future projections are promising, current growth has also been impressive. According to Ericsson, India witnessed the fastest growth in new mobile-phone connections with 18 million net additions in the third quarter of 2014. An MBit Index by Nokia Siemens Networks (NSN) states that data traffic powered by third generation (3G) services grew at 146 per cent in India during 2013, higher than the global average that grew at 100 per cent[74].

According to GSMA, the broadband services user-base in India is expected to grow to 250 million connections by 2017 and over 250 million users on either 3G /4G by 2017. The focus on Telecom under the National Manufacturing Policy and the creation of a Telecom Sector Skills Council is aimed at realizing this potential.

2.5.3 Electronics

The electronics sector encompasses nearly all types of physical infrastructure (connected devices) that any smart city must have. This includes electronic components, sensors, communication and broadcasting equipment, telecom products, and other hardware that goes into making the M in M2M technologies.

The sector is expected to witness phenomenal growth in the next 8 to 10 years with the global electronics market projected to grow at a CAGR of 16 per cent over the next decade - from USD 69.6 billion in 2012 to USD 400 billion in 2022[75]. With India's electronics services and design manufacturing (EDSM) demand expected to touch USD 94 billion by 2015, the sector presents a strong investment opportunity for electronics manufacturers[76].

However, 65 per cent of India's current internal demand is met by imports and as of 2011-2012 India's share in global electronics exports was less than 1 per cent with China cornering 30 per cent of the market[77]. To address this situation the Government has taken several steps such as the Make In India initiative, Electronic Manufacturing Clusters (EMCs), the Electronics Development Fund (EDF) and a Skills Development Scheme focused on Electronics.

At present, in India, the top 10 electronic products contributing about 70 per cent of the total revenue from this sector include - Mobile Phones; Flat Panel TVs; Notebooks; Desktops; Digital Camera; Inverters and UPS; Memory Cards & USB Drivers; 4W EMS; LCD Monitors and Servers[78]. With the penetration of technologies such as consumer electronics and wireless controllers that enable smart services currently below 20 per cent, India also offers plenty of scope for diversifying to manufacturing smart meters, e-healthcare, digital energy management and traffic management systems.

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.

3. Government of India's role in facilitating private sector participation

3.1 Government of India's IoT policy framework

The private sector has an extremely important role in realising the vision for a 100 smart cities. This has been acknowledged by Minister of Urban Development and he has stressed that the key to building smart cities is private investments[79].

Apart from attracting investment in areas such as energy, brick and mortar infrastructure, socio-economic opportunities etc. the Indian Government envisages that the plan for developing 100 smart cities in the country could lead to a massive and quick expansion of IoT in the country[80]. Acknowledging the need for providing a policy framework that supports private sector companies, particularly those operating in the IoT and M2M space, the Department of Electronics and Information Technology,(DeiTY) has come out with a draft IoT Policy document which focuses on the following objectives:

i. To create an IoT industry in India of USD 15 billion by 2020. It has been assumed that India would have a share of 5-6% of global IoT industry.
ii. To undertake capacity development (Human & Technology) for IoT specific skill-sets for domestic and international markets.
iii. To undertake Research & development for all the assisting technologies.
iv. To develop IoT products specific to Indian needs in all possible domains.

Relevant to the discussion on smart cities, the government plans to setup demonstration centers to develop domain specific strategies for IoT including green buildings, smart grid, industrial monitoring, agriculture, smart cities, healthcare, connected homes, telematics and supply chain, safety and security, forest and wild life, automotive, natural disasters, etc.

DeiTY will further allocate INR 125 crores as 50 per cent funding (PPP mode) for 5 projects to be executed over a period of 3 years under the following areas

i. Smart City
ii. Smart Water
iii. Smart Environment
iv. Smart Health (Remote)
v. Smart Waste Management
vi. Smart Agriculture
vii. Smart Safety
viii. Smart Supply Chain and Logistics

3.2 Aligning existing programmes with the smart cities agenda

Between the years 2007 and 2011, hi-tech exports from India witnessed a CAGR of 26% with exports touching $21 billion compared to $8 billion in 2007[81]. This was despite industry organisations raising concerns about regulatory barriers, slow recovery in global markets and lack of infrastructure. This suggests that India has the underlying capabilities to take up the challenge of designing, manufacturing and selling smart city technologies.

With a view to increasing supply-side advantages for manufacturing the Government of India has launched the "Make in India" campaign. Proposed by the Prime Minister of India this new national program is designed to facilitate investment, foster innovation, enhance skill development, protect intellectual property and build best-in-class manufacturing infrastructure. The initiative has a target of increasing the share of manufacturing from 16 per cent to 25 per cent by 2022.

3.2.1 Enabling framework for manufacturing m2m technologies

Among the 25 sectors proposed for the "Make in India" programme, Construction, Electronics, Renewable Energy and Tourism all feature strongly. These four sectors, other than being of industrial importance have a direct impact on capabilities for improving city infrastructure.

The MoUD has also identified IT capabilities and web enabled platforms to facilitate citizen engagement as a feature for a citizen friendly smart city. Furthermore, the push for Smarter Cities is expected to mandate digitized spatial and GIS maps along with the creation of Open Data Platforms that are regularly updated. The availability of such information can be leveraged to create the kind of apps, services and technological tools discussed above. This is likely to have a significant impact on the electronics, telecom and IT sectors - particularly boosting the demand for handheld smart devices.

In fact it is estimated that the projected demand in smartphones will cross 2,700 million by 2014, and grow at 15 per cent compounded annual growth rate, to cross 6,100 million by 2020[82]. To promote product development and manufacturing of telecom equipment in units backed by promoters and technical experts of Indian origin or Indian start-ups the National Manufacturing Competitiveness Council has proposed a US$ 1 billion government-sponsored fund to seed 'Made in India' technologies.

3.2.2 National Optical Fibre Network (NOFN)

To complement this impending the growth in smart devices the government has the National Optical Fibre Network (NOFN) - a project to provide broadband connectivity to over two lakh (200,000) Gram panchayats of India at a cost of Rs.20,000 crore ($4 billion). The project is intended to enable the government of India to provide e-services and e-applications nationally. The National Optical Fibre Network has proposed to lay about 7 lakh kilometres of optical fibre network to connect all village panchayats by high speed broadband services by 2016. The spread of digital infrastructure will lead to explosion of e-commerce, e-entertainment and host of other services around the country.

3.2.3 National Knowledge Network

Besides attempting to lay down large scale network infrastructure, the government is also promoting the ongoing National Knowledge Network (NKN) that aims to build quality institutions with requisite research facilities and a pool of highly trained persons.

The NKN comprises of an ultra-high speed CORE (multiples of 10 gigabits per second), complimented with a distribution layer at appropriate speeds. The network is designed to support Overlay Networks, Dedicated Networks, and Virtual Networks. Advanced applications in areas such as Health, Education, Science & Technology, Grid Computing, Bio informatics, Agriculture, and Governance will be an integral part of NKN. While the current maximum connectivity in Indian educational institutes through the NKN is 1 GBPS the government plans to increase this to the international connectivity speed of 10 gigabits[83].

The NKN is also envisaged as platform for delivering effective distance education with real time interaction between teachers and students - an effort to increase access to education while addressing mitigating factors such as geography and lack of infrastructure facilities.

However, coupled with the urgent need to build capacity on the ground - in city agencies and municipalities - government driven incentives for missions such as the Swacch Bharat Abhiyaan, National Knowledge Network (NKN) and National Optical Fibre Network would require innovation, originality and monitoring. Nonetheless, it is clear that these missions can be the foundation stone for the smart movement in India with the smart cities programme emerging as point of convergence.

3.3 Establishing a policy framework to address concerns

3.3.1 Data Privacy

It is clear from the above discussions that smart city technologies offer avenues to improve efficiencies, planning and standards of living. While they enable new frontiers such as knowledge economies one of the major concerns of an IoT-drive environment that uses geo-tagging, geo-location services and monitors individual choices is data privacy. It is vital for the government to encourage industry partners, alliances and developers to treat this issue with utmost priority to ensure maximum buy-in from citizens.

3.3.2 Embedding environmental sustainability at the heart of smart cities

While embedding safety and privacy is imperative, considering the trillion dollar outlay envisaged for meeting the burgeoning demand for urban services and bringing existing Indian cities to international standards, it is also important to embed principles of sustainable development in planning and implementation of smart cities.

For example, nearly 70 per cent of India's building stock that will exist in 2030 is yet to be built. The planning processes, regulatory framework, levels of awareness and capabilities of the construction sector will determine the characteristics of new build. Consequently, the quality of new building stock, particularly in smart cities will determine several factors such as energy demand for thermal comfort, provisions for renewable energy generation and promotion of low-carbon construction materials. A sustainability perspective in the buildings sector will promote 'systems thinking' and optimise environmental and economic benefits from new building stock.

Similarly, integrating provisions for fibre optic networks in the design phase for infrastructure such as roads, buildings, open spaces and pipeline networks can substantially reduce costs, energy expenditure and carbon emissions. Such sustainability principles extend to other areas such transportation, water and waste management. Encouraging industries to adopt metrics such as carbon foot printing, lifecycle analysis and embodied energy can help inform better choices for cities.

3.3.3 Promoting energy efficient smart technologies

There is little argument that IoT and M2M technologies are expected to reduce environmental externalities by optimising resource consumption. However, it is important for all stakeholders to recognize that the ICT sector also has a substantial footprint associated with manufacturing, power requirements and generation of e-waste. It is estimated that with the increase in connected technologies the global ICT sector will emit about 1,100 million tonnes of CO2e by 2020 with its contribution estimated to increase from 1.3% in 2007 to about 2 per cent in 2020[84].

Therefore it is important to dovetail a push for manufacturing smart city technologies with a 'green manufacturing approach'. This is significant as stewardship of resources will be an important prerequisite for business to thrive in the coming decades

3.4 Opportunities created by the 'Smart Cities' initiative

3.4.1 Economic Opportunities

Globally, the concept of smart cities is viewed as a driver for economic growth and employment generation. For example, the UK Department for Business, Innovation and Skills (BIS) evaluated the global market for smart solutions across five sectors –water, energy, transport, waste and assisted living – and estimated its value to reach $400 billion by 2020 of which 10 per cent existing in the UK's mature economy[85]. Adopting a more general definition - which includes smart building and urban and cyber security among other technologies - the U.S Market research firm Markets and Markets estimated the market at $1 trillion by 2016[86].

In the India context, industry associations forecast tremendous growth potential for M2M services to meet requirements generated by the Government of India's INR 7,000 crore 'Smart Cities' initiative[87].

3.4.2 Employment generation

With the government's emphasis on programs such as Digital India, Make in India and 100 Smart Cities, recruitment platforms are envisaging that the year 2015 will witness the creation of 9.5 lakh new jobs with IT and ITeS sectors emerging as major employers[88].

Over a longer term horizon, the Government of India estimates that Smart City projects can create 10-15 per cent rise in employment[89]. As an example, The Forum for Future Cities estimates that the Gujarat International Finance Tec-City (GIFT) smart city, by itself, could create as many as 1 million jobs for skilled and unskilled workforce in Gujarat[90].

Besides the IT, Electronics and Telecom, one sector that is expected to witness significant employment generation is the energy sector, particularly solar. Based on the target of 20 GW of solar energy by 2022, set by the previous Government, the Ministry of New and Renewable Energy, in the year 2013, estimated that the solar sector created 50,000 direct jobs between 2010 and 2013.

With the current Government increasing the target by 5 times i.e. 100 GW by 2022, the potential for job creation is substantially hire. More significantly, with plans to raise the target for distributed solar energy to 40 GW by 2022 energy generation in cities will likely become a major focus area. In January 2015, The Ministry of Urban Development has launched a mission to generate 100 MW of solar power in the next two years through roof mounted solar panels[91]. The uptake of decentralised energy is also expected to generate jobs in energy management, finance, manufacturing and semi-skilled labour. However, as with most opportunities linked with the smart city agenda, emphasis on finding the appropriate business model will yield maximum benefit for all stakeholders.

4. 'Smart' examples from India and solutions offered by companies

4.1 Examples of ongoing deployment of smart city solutions

Considering our large population and medium to low quality of life in major cities, the uninitiated may believe that Indian cities are a far cry from adopting smart practices. However, India is witnessing the development of various strands of smart cities across different cities. The table below presents examples of smart and/or good practices adopted by different cities or agencies.

Smart / Good practices	Agency / City
GIS Mapping of the city to improve property tax collection, enforcement of regulation and mapping utilities	Ahmadabad Municipal Corporation
Waste segregation at the source and diverting different waste streams for appropriate actions - recycling, composting etc.	Pune Municipal Corporation
Electrified mass rapid transit	Delhi Metro
Green low-carbon transport (Allocating space for walking and bicycle tracks in planning road infrastructure)	NMT infrastructure in Nanded
Initiating a green building initiative (Mandating energy conservation codes for all buildings in the municipal area)	Pimpri Chinchwad Municipal Corporation
ICT enabled health records (E-health records, centralized database and quick access of data)	State of Gujarat
Smart Mobility	NextBus, Parking Management - DIMTS
Smart Water Management (GIS mapping of all pipelines, call centres for customer relationship management, quality assurance and compliance with national standards)	Bombay Municipal Corporation
Smart Policing (Indigenous and local commerce messaging app 'Lookup' has partnered with Bangalore police to help the public connect with the police over chat[92])	Koramangala Police Station, Karnataka Police
Diligent Traffic enforcement (Mobile governance in tracking enforcement through hand-held blackberry devices and printing devices connected with a centralized server using GPRS / EDGE mobile connectivity followed by process automation	Bangalore Traffic Police
eICU, a remote intensive care unit (ICU) (The eICU system will help hospitals in Chennai, Hyderabad and Kolkata to act as a hub and the telemedicine centers at districts and smaller towns will act as spokes offering intensive care.)	Apollo Hospitals, Chennai

Sources: NIUA, Based on information available in the public domain

4.2 Companies providing smart city solutions

The table below gives a brief description of smart city solutions provided by different companies.

TRANSPORTATION	
Laird	Is the world-leader in the integration of multiple RF functionalities into compact form factors for use in vehicles. Our product line offers the lowest form factor antennas with high-gain cellular performance, and built-in GPS antennas including Low-Noise Amplifiers (LNAs) that deliver optimum performance. Their diverse range of asset tracking modules is designed for professionally certified, installer-fitted antennas mounted on the roof, in the exterior trim or inside cars, trucks, and trailers.

Novatel Wireless	Delivers a wide range of solutions for the commercial and consumer telematics markets including applications for driver behavior, fleet applications (over-the-road-carriers, small operators, service, private, and transit vans), and additionally applications catering to transportation/trucks, construction, and emergency response vehicle segments.
SMART WATER METERS	
Telog RTUs (Recording Telemetry Units)	Developed by **Telog Instruments Inc**. there RTU's provide a monitoring solution for virtually every sensor, meter, instrument and application found throughout water conveyance systems. Telog's data management system delivers information and alarms to your own software application, Telogers Enterprise or a data hosting web service.
Capstone's IntelliH$_2$O®	This Intelligent water meter is a self-reliant, sensor-rich, communications platform designed for a remote, distributed network and incorporates an on/off valve that can be controlled by centralized, analytical management software. The IntelliH$_2$O® Water Management System is a robust cloud-based water management solution that fully integrates with the suite of IntelliH$_2$O® meters.
ZELITRON SA	Pperates as a Metering Operator, aiming to provide consumption telemetry services to Water distribution companies, Municipalities, Municipal Enterprises for Water Supply – Sewage and to the final consumer. The ALTAIR V4 meters with IZAR RADIO record, collect and send data once a day or more from the water meters, using the GPRS network, to the Vodafone Data Center, their telecom partner.
WM-AMR-WATER®	Is an industrial measuring and remote data collection device which matches with the reliable GPRS-based network to transmit the metering data from the pulse signal of wired or wireless water meters (as signal changes of the meter). The product won the Hungarian IndustriAutomation 2012 prize, and won a special product prize at the EloSys 2012 international exhibition in Slovakia.
WATER QUALITY SENSORS	
Waspmote Smart Water by Libelium	Is suitable for potable water monitoring, chemical leakage detection in rivers, remote measurement of swimming pools and spas, and levels of seawater pollution. The water quality parameters measured include pH, dissolved oxygen (DO), oxidation-reduction potential (ORP) conductivity (salinity), temperature, and dissolved ions such as Ca+, Cl-, K+. The Waspmote Smart Water platform is an ultra low-power sensor node designed for use in rugged environments and deployment in Smart Cities in hard-to-access locations to detect changes and potential risk to public health in real time.
Global Water's	Rugged, industrial grade water quality sensors designed for direct immersion or insertion into water streams. They have a multitude of sensors ranging from ph sensors, temperature, conductivity, dissolved oxygen and redox sensors.
SMART LEAKAGE DETECTION	
GE Choice Alert Wireless Alarm System Water Leak Sensor	is used widely as a front-end detector of an alarm system of laboratory, museum, warehouse, wareroom, storehouse, depot, depository, depositary, generator room, machine room, engine room, base transceiver station, diesel generator rooms, engine room, transformer substations, telecommunication equipment rooms, power supply systems and so on.
ENERGY MANAGEMENT	
Wi-Next	Wi-Next is one of the most innovative Italian Wi-Fi Vendors of SmartNode solutions. Low-power SmartNode is a unique appliance that is able to monitor in real-time the electrical consumption and the operation of industrial machines, using a Wi-Fi Sensor Mesh Network. SmartNodes can automatically disconnect the machinery in case of overcurrent and also guarantees the control of the power switch via commands sent by third-party cloud applications over Wi-Fi.
CellReader	Is one example of the **Trilliant's** M2M Smart Metering System, which provides Machine-to-Machine (M2M) smart metering communication capabilities using cellular/mobile networks. Purpose-built for Smart Meter deployments, the Smart Metering M2M system is secure, scalable and flexible
Bosch's	Smart Meter Gateway Manager can help ensure the successful operation of your smart metering system infrastructure. **Their Virtual Power Plant Manager** enables you to group distributed energy generation facilities into virtual power plants.
Daintree ControlScope™	Is an open standards-driven energy management and monitoring solution for lighting, temperature, and other energy control. The solution delivers up to 70% energy savings, operational efficiencies, and occupant-friendly work environments while providing actionable decision-support information through Big Data analytics. Using the **Daintree Enterprise** Internet of Things™ (E-IoT™) approach, the solution can also support monitoring of other environmental conditions such as air quality, humidity, food safety, and more that comprise the networked ecosystem of an organization.
BUILDING AUTOMATION	
WEBs-AX Automation Controllers by **Honeywell**	Is a web-enabled building management system (BMS) for small to large facilities. It is a one control system for HVAC, security, access control, surveillance, lighting and metering without added software. It's based on the NiagaraAX platform, which allows integration with products from different manufacturers using different communication protocols.
RXL room controllers from **Siemens**	The desired room temperature can be straightforwardly reached at the right time while ensuring individual and optimum comfort – be it in public buildings, office buildings, schools or hotels. The RXL room controllers can be integrated into existing or new systems from Siemens, such as Desigo™ or Synco™. These advanced products are compatible far into the future.

Source: Compiled by m2mpaper.com

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