Implications of Internet of Things (IoT) in Indian Smart Cities

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Abstract

In the growing era of development and advancement in digital technologies smart cities are being developed or being improvised to make them smarter by using the upcoming or emerging smarter technologies. The Smart Cities Project is working on the principle of convergence which will bring together several technologies and policies. This naturally syncs it with the Digital India movement. The technologies have a big role to play in the development of Smart cities which have been equipped with different electronic & digital devices on the basis of Internet of Things (IoT) and cloud, and hence becoming smarter than before.

The IoT aims to unify everything in our world under a common infrastructure, giving us not only control of things around us, but also keeping us informed of the state of the things. This paper aims at providing a comprehensive review on the concepts of smart cities in Indian scenario and on their motivations and applications. Moreover, this survey describes the IoT technologies for smart cities and the main components and features of a smart city. Furthermore, practical experiences over the world and the main challenges are of a smart city are explained.

Keywords— Internet of Things (IoT), Smart City, Smart Grids, Smart Buildings, Sensor System Integration, Demand Response, Smart Governance, Digital India

I. INTRODUCTION

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. The IoT model is subject to smart and self-configuring objects that are connected to each other through a global network infrastructure. The IoT can be applied to things like transportation networks: "smart cities" which can help us reduce waste and improve efficiency for things such as vehicular traffic congestion , water usage increase, increased electricity demand, roads, water sewage , energy use and health care services etc.; this helping us understand and improve how we work and live. I India **Urban population** was reported at 32.75 % in 2015, according to the World Bank collection of development indicators, compiled from officially. The Government of India has started working on its urban renewal and retrofitting program **Smart Cities Mission** to develop 100 cities all over the country making them citizen friendly and sustainable. [1] The Union Ministry of Urban Development is responsible for implementing the mission in collaboration with the state governments of the respective cities. The government has a vision of developing 100 smart cities as satellite towns of larger cities by modernizing the existing mid-sized cities.

Rapid population growth in urban cities, infrastructure and services are required to provide the necessities of the city residents. A significant increase for digital devices, e.g. sensors, actuators, and smartphones has driven to huge business potentials for the IoT, since all devices can interconnect and communicate with each other on the Internet [2].

IoT is mostly considered as real objects, broadly scattered, with low storage capability and processing capacity, with the target of improving reliability, performance and security of the smart city and its infrastructures [3]. it certainly opens the door to a lot of opportunities but also to many challenges

Worldwide the Smart cities have become smarter than before thanks to the recent developments of digital technologies. A smart city is equipped with different electronic elements employed by several applications, like street cameras for observation systems, sensors for transportation systems, etc. In addition, this can spread the usage of individual mobile devices. Some of the main aspects [4. 5] of a smart cities of future are shown in Fig. 1.

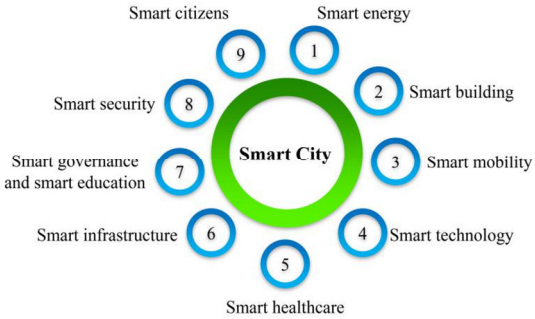

Fig. 1. The main aspects of a smart city

The IoT works on the devices integrated based on the geographic location and evaluated by using an analyzing system. Particular data are collected using devices and sensor services monitoring of cyclists, vehicles, public parking lots, etc. Interconnecting [6] through internet as shown in Fig. 2

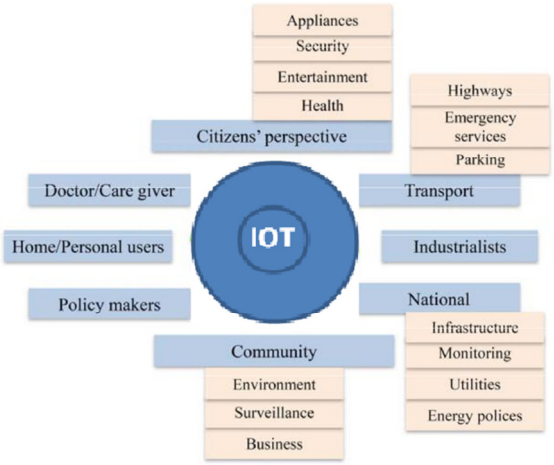

Fig. 2. IoT-based interconnections

Consequently, the IoT will affect the lives and lifestyle of people in smart cites like health, security, and transportation and also it can play an important role at the national and international level concerning the policy decisions, remote monitoring, and required infrastructure.

2. IOT TECHNOLOGIES FOR SMART CITIES

On the technical side, the most relevant issue consists in the non-interoperability of the heterogeneous technologies currently used in city and urban development unleashing the potential of the Smart City vision [7, 8]. The IoT is a broadband network that uses standard communication protocols [9, 10] while its convergence point is the Internet. The main concept of the IoT is the universal presence of objects that can be measured, inferred, understood and that can change the environment.

The IoT consists of three layers, including the perception layer, the network layer, and the application layer, as shown in Figure 3. The perception layer includes a group of Internet-enabled devices that are able to perceive, detect objects, gather information, and exchange information with other devices through the Internet communication networks Radio Frequency Identification Devices (RFID), cameras, sensors, Global Positioning Systems(GPS) are some examples of protection layer devices. Forwarding data from the perception layer to the application layer under the constraints of devices' capabilities, network limitation and the applications' constraints is the task of the network layer. IoT systems use a combination of short-range networks communication technologies such as Bluetooth and ZigBee which are used to carry the information from perception devices to a nearby gateway based on the capabilities of the communicating parties [4].

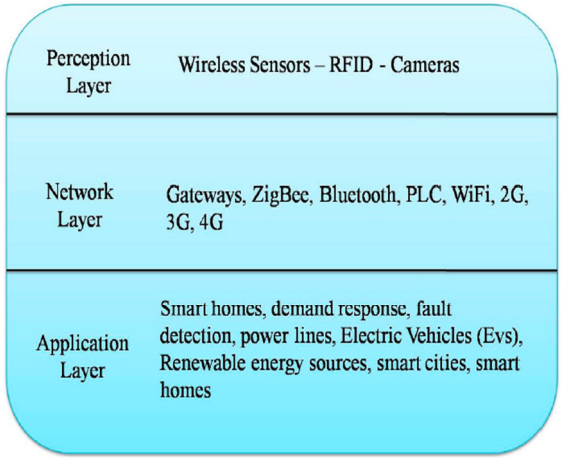

Figure 3. IoT layers.

On this basis, IoT is enabled by the developments of various objects as well as communication technologies. Involved things in the IoT consist of smart devices including mobile phones and other objects like foodstuff, appliance, landmark, monument, work of art [9, 10] that can cooperate together to provide a common target. The impact of the IoT on the life of users can be considered as its key feature [11]. Some of the IoT-related technologies are discussed in the following.

2.1 Radio-Frequency Identification (RFID)

These systems consisting of readers and tags are playing a key role in the context of the IoT. By applying these technologies to any involved object, it is possible to carry out their automatic identification and assign a unique digital identity to each object, in order to be incorporated in the network and related to the digital information and service [12].

2.2 Wireless sensor network (WSN)

WSNs can provide different suitable data and also may be used in many cases such as healthcare, government and environmental services and seismic sensing [13]. Furthermore, WSNs could be integrated with RFID systems to gain some goals like obtaining information regarding the position, movement, temperature, etc.

2.3 Addressing

As well as the Internet can enable a remarkable interconnection of people, the existing trend in the IoT can similarly provide an interconnection of objects and things, in order to establish smart environments [6]. To this end, the capability of uniquely identifying objects is crucial for favorable outcomes of the IoT. This is due to the fact that uniquely addressing the large-scale combination of objects is vital for controlling them via the Internet. In addition to the mentioned uniqueness concept, reliability, scalability as well as persistence denote the key requirements to develop a unique addressing scheme [6].

2.4 Middleware

As a result of some issues related to the heterogeneity of contributing things, to the restricted storage and process capability, as well as to the enormous diversity of applications, the middleware plays a critical role in the interconnection of the objects to the application layer. The key objective of the middleware is, indeed, to concisely integrate the functionalities and communication capabilities of all involved devices.

3. IOT ACTUAL APPLICATIONS FOR SMART CITIES

The IoT utilizes the Internet to incorporate heterogeneous devices with each other. In this regard and in order to facilitate the accessibility, all available devices should be connected to the Internet. In order to achieve this target, sensors can be developed at different locations for collecting and analyzing data to improve the usage [3]. Fig. 4 illustrates the main applications of the IoT for smart cities. The main aims in this area of knowledge are explained as the follows.

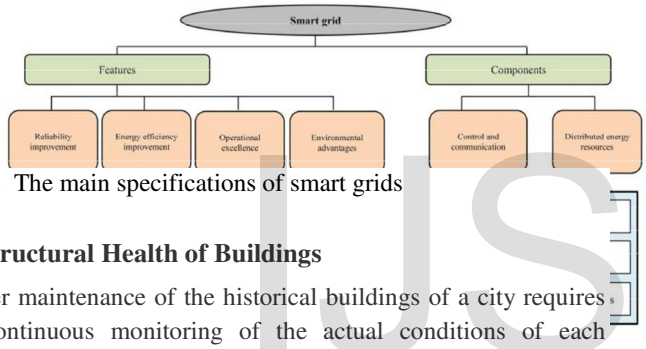

Fig. 4. The main specifications of smart grids

3.1 Structural Health of Buildings

Proper maintenance of the historical buildings of a city requires the continuous monitoring of the actual conditions of each building and identification of the areas that are most subject to the impact of external agents. The urban IoT may provide a distributed database of building structural integrity measurements, collected by suitable sensors located in the buildings, such as vibration and deformation sensors to monitor the building stress, atmospheric agent sensors in the surrounding areas to monitor pollution levels, and temperature and humidity sensors to have a complete characterization of the environmental conditions [14, 15]. This database should reduce the need for expensive periodic structural testing by human operators and will allow targeted and proactive maintenance and restoration actions. Finally, it will be possible to combine vibration and seismic readings in order to better study and understand the impact of light earthquakes on city buildings. This database can be made publicly accessible in order to make the citizens aware of the care taken in preserving the city historical heritage. The practical realization of this service, however, requires the installation of sensors in the buildings and surrounding areas and their interconnection to a control system, which may require an initial investment in order to create the needed infrastructure.

3.2 Waste Management

Waste management is a primary issue in many modern cities, due to both the cost of the service and the problem of the storage of garbage in landfills. A deeper penetration of ICT solutions in this domain, however, may result in significant savings and economical and ecological advantages. For instance, the use of intelligent waste containers, which detect the level of load and allow for an optimization of the collector trucks route, can reduce the cost of waste collection and improve the quality of recycling [16]. To realize such a smart waste management service, the IoT shall connect the end devices, i.e., intelligent waste containers, to a control center where an optimization software processes the data and determines the optimal management of the collector truck fleet.

3.3 Air Quality

The European Union officially adopted a 20-20-20 Renewable Energy Directive setting climate change reduction goals for the next decade.[4] The targets call for a 20% reduction in greenhouse gas emissions by 2020 compared with 1990 levels, a 20% cut in energy consumption through improved energy efficiency by 2020, and a 20% increase in the use of renewable energy by 2020. To such an extent, an urban IoT can provide means to monitor the quality of the air in crowded areas, parks, or fitness trails [14, 15]. In addition, communication facilities can be provided to let health applications running on joggers' devices be connected to the infrastructure. In such a way, people can always find the healthiest path for outdoor activities and can be continuously connected to their preferred personal training application. The realization of such a service requires that air quality and pollution sensors be deployed across the city and that the sensor data be made publicly available to citizens.

3.4 Weather and water systems

Weather and water systems can utilize some sensors to provide suitable information like temperature, rain, wind speed, and pressure and can contribute to enhance the efficiency of the smart cities [14].

3.5 Smart Parking

The smart parking service is based on road sensors and intelligent displays that direct motorists along the best path for parking in the city [17,18,19]. The benefits deriving from this service are manifold: faster time to locate a parking slot means fewer CO emission from the car, lesser traffic congestion, and happier citizens. The smart parking service can be directly integrated in the urban IoT infrastructure, because many companies in Europe are providing market products for this application. Furthermore, by using short-range communication technologies, such as Radio Frequency Identifiers (RFID) or Near Field Communication (NFC), it is possible to realize an electronic verification system of parking permits in slots reserved for residents or disabled, thus offering a better service to citizens that can legitimately use those slots and an efficient tool to quickly spot violations.

3.6 Noise Monitoring

Noise can be seen as a form of acoustic pollution as much as carbon oxide (CO) is for air. In that sense, the city authorities have already issued specific laws to reduce the amount of noise in the city centre at specific hours. An urban IoT can offer a noise monitoring service to measure the amount of noise produced at any given hour in the places that adopt the service [20, 21]. Besides building a space-time map of the noise pollution in the area, such a service can also be used to enforce public security, by means of sound detection algorithms that can recognize, for instance, the noise of glass crashes or brawls. This service can hence improve both the quiet of the nights in the city and the confidence of public establishment owners, although the installation of sound detectors or environmental microphones is quite controversial, because of the obvious privacy concerns for this type of monitoring.

3.7 Traffic Congestion

On the same line of air quality and noise monitoring, a possible Smart City service that can be enabled by urban IoT consists in monitoring the traffic congestion in the city. Even though camera-based traffic monitoring systems are already available and deployed in many cities, low-power widespread communication can provide a denser source of information. Traffic monitoring may be realized by using the sensing capabilities and GPS installed on modern vehicles [17,18,19] and also adopting a combination of air quality and acoustic sensors along a given road. This information is of great importance for city authorities and citizens: for the former to discipline traffic and to send officers where needed and for the latter to plan in advance the route to reach the office or to better schedule a shopping trip to the city Centre.

3.8 City Energy Consumption

Together with the air quality monitoring service, an urban IoT may provide a service to monitor the energy consumption [22,23,24,25] of the whole city, thus enabling authorities and citizens to get a clear and detailed view of the amount of energy required by the different services (public lighting, transportation, traffic lights, control cameras, heating/cooling of public buildings, and so on). In turn, this will make it possible to identify the main energy consumption sources and to set priorities in order to optimize their behavior. This goes in the direction indicated by the European directive for energy efficiency improvement in the next years. In order to obtain such a service, power draw monitoring devices must be integrated with the power grid in the city. In addition, it will also be possible to enhance this service with active functionalities to control local power production structures (e.g., photovoltaic panels).

3.9 Smart Lighting

In order to support the 20-20-20 directive, the optimization of the street lighting efficiency is an important feature [26]. In particular, this service can optimize the street lamp intensity according to the time of the day, the weather condition, and the presence of people. In order to properly work, such a service needs to include the street lights into the Smart City infrastructure. It is also possible to exploit the increased number of connected spots to provide WiFi connection to citizens. In addition, a fault detection system will be easily realized on top of the street light controllers.

3.10 Surveillance systems

In a smart city, security is the most important factor from the citizens' viewpoint. For this purpose, the whole smart city should be continuously monitored. However, analyzing the data and detecting crimes are very challenging [3, 27].

3.11 Environmental pollution

A city cannot be considered as a smart one if its citizens are unhealthy. To this end, a smart city should monitor the environmental pollution and deliver the related information to citizens, especially to those with health care conditions [14, 15].

4. IOT POTENTIAL APPLICATIONS FOR SMART CITIES

Some of the future applications of the IoT for the smart cities that are discussed in this section.

4.1 Smart cities and communities

The implementation of the IoT can result in the generation of some services that have an interaction with the environment. Hence, it could introduce some opportunities for contextualization and geo-awareness. Furthermore, collective intelligence will improve the processes of decision making and empower the citizens [22]. It should be mentioned that sensor virtualization could be utilized to decrease the gap among the current technologies and the potential customers [28, 29].

4.2 Smart homes

Through the IoT platform in the home, the heterogeneous devices will enable the automation of common activities. In fact, by transforming objects into information appliances that are connected to each other by using the Internet may perform services via the web interfaces. A large number of smart-home applications use sensor networks. The mentioned applications realize smart devices' connection to the Internet to observe or control them remotely [21, 30]. For example, smart lighting has been highly investigated in recent years [28]. Nineteen percent of global electricity consumption is for lighting that may cause six percent of emission related to greenhouse gasses [22]. In this regard, up to forty five percent of the required energy for lighting could be saved by using the smart lighting control mechanisms [23,25].

4.3 Responsive customers

Transactive controllers and many other smart devices can be utilized to manage smart homes [29, 30]. In a home gateway is introduced in order to allow the home controller to cooperate

with the aggregator who is responsible to collect data from many homes. Based on the signals from transactive controllers, the aggregator is able to specify the electricity purchasing prices from the electricity market and send the signals about the acceptance/rejection of bids to these devices.

The possibility for monitoring and controlling the electrical appliances can enhance the participation of the active customers in the operation of the system that is well-known as demand response. Demand side activities are reported by the International Energy Agency (IEA) to be the key option in every energy policy decision, due to the operational and economic advantages [31]. According to DR, electricity consumers can adjust the electricity usage pattern with the aim of reliability enhancement or to prevent the power price spikes

4.4 Smart energy and smart grids

The utilization of the IoT can furnish intelligent management of energy distribution and consumption in heterogeneous circumstances. The IoT nodes have some abilities such as sensing and networking which raise the possibility of optimal scheduling of energy suppliers. This management can also be extended to emergency conditions. One of the most important results of this extension is fault location, isolating and service restoration (FLISR) [32,33]. Implementing this property thanks to the IoT provides an advanced tool which determines the position of the defective parts, separates them, and applies switching task to recover the largest number of healthy part of the affected energy feeder. Also, at the advanced level, this function can be developed by using self-healing methods that are able to activate the participation of the customers as well as of dispersed generation units [35]. Implementing these strategies leads to increase the reliability, power quality and profits [35]. Some of the main specifications of the smart grids are categorized in Fig. 5.

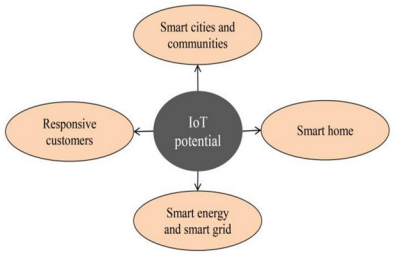

Fig. 5. IoT potentials for the smart cities

5. CHALLENGES

This section is devoted to the analysis of challenges raised by the application of the IoT-based smart cities.

5.1 Security and privacy

When all the data are collected and analyzed in a common IoT platform, the system can be subjected to several attacks (e.g., cross-site scripting, and side-channel). Besides, such a system is exposed to important vulnerabilities. Furthermore, multi-tenancy of this system can also bring out the security issues and cause the leakage of data [27].

5.2 Heterogeneity

The IoT system has typically evolved with distinguished solutions in which every system component is knitted to the particular application context. Accordingly, the authorities must analyze their target scenarios, determine the required computing hardware and software and then integrate these heterogeneous subsystems. The existence of such infrastructures and the provision of a suitable collaborating scheme between them can be truly a big challenging task for the IoT system.

5.3 Reliability

There are some reliability issues that have arisen in the IoT-based system. For instance, because of the vehicles' mobility, the communication with them is not reliable enough. Furthermore, the presence of numerous smart devices will cause some reliability challenges in terms of their failure.

5.4 Large scale

Some specified scenarios require the interactions between large numbers of embedded devices which are possibly distributed over wide area environments. The IoT systems provide a suitable platform that can analyze and integrate data coming from different devices. However, such large scale of information requires suitable storage and computational capability collected at high-rate which makes typical challenges harder to overcome. On the other hand, the distribution of the IoT devices can affect the monitoring tasks because these devices must handle the delay related to dynamics and connectivity.

5.5 Legal and social aspects

The IoT system may be service based on the user-provided information. For such cases, the service provider has to be in accordance with different local and international laws. Also, the users should have enough incentives to participate in the defined scenarios and data collection. It will be more convenient if opportunities are given to the users to select and take part in submitting data which denote a thing [36].

5.6 Big data

Considering about 50 billion devices, it is certainly necessary to pay attention to transferring, storing and recalling and also analyzing such a huge amount of data produced by them [37, 38, 39]. It is obvious that the IoT infrastructures will be some of the major resources of big data.

5.7 bSensor networks

Sensor networks can be considered as one of the most important technologies to enable the IoT [40]]. This technology is able to shape the world by providing the ability of measuring, inferring, and understanding environmental indicators. Recent developments and improvements in technologies and smartphones are associated with a diversity of sensors and, consequently, they enable a variety of mobile

applications in several areas of IoT. To this end, the major challenging task is to process the large-scale data of the sensors in terms of energy and network limits and various uncertainties.

5.8 DR barriers

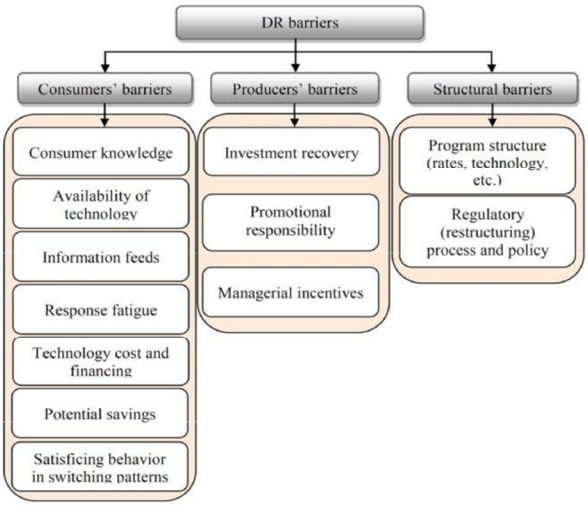

Fig. 6. DR barriers

6 SMART CITIES IN INDIA

India is in the midst of an "urban revolution." According to the 2011 census of India, 31.2 percent of the total population—or 377 million people—lives in urban areas. When it comes to the rate of urbanization, India ranks far behind other emerging economies of other countries. For the most part, over the last century India's population has resided in rural areas, but this rural-urban divide is shrinking quickly.

Indeed, the scope of India's Smart Cities effort is quite ambitious. Its initial five-year window is from 2014-2015 to 2019-2020 with a total budget of INR 48,000 crore ($7.2 billion). The central government, moreover, plans to invest INR 500 crore ($75 million) per city during this period, and respective governments, ULBs, and private investors are expected to raise a matching amount. The initiative focuses on creating new business incentives, pushing state governments and ULBs to create a more business-friendly environment, and attract additional private capital for long-term infrastructure projects. Accordingly, 10 percent of the budget is reserved for incentive payments to respective state governments or union territories.

Developing citizen friendly and economically viable cities is an urban initiative by the Government of India. Cities are engines of economic growth, and it is anticipated that 40% of India's population will live in cities by 2030. With the rapid rise in the proportion of people living in urban areas, there is an increasing requirement for sustainable cities. Hence, Prime Minister Narendra Modi's mission of Smart Cities [41, 42] is intended to transform the lives and living conditions of the citizens of the country. Recognizing smart cities as an important platform to drive progressive change, the 4th Smart Cities India 2018 Expo will be supported by 4 other co-located expos to create "One Mega Event".

7. CONCLUSION

The IoT technologies have brought a revolution for the development of Smart Cities in the world. In this paper it has been emphasized that how the actual IoT technologies could be implemented for their practical and potential applications to the Smart Cities. It has been observed that for Effective implementations of IoT systems it requires large investment as well as effective motivation to the people using them.

Considering the expected growth in India's urban population, the launch of the Smart Cities Mission offers an overarching opportunity and underscores India's urban challenges. The opportunity lies in using digital technologies in each of the proposed Smart Cities to improve growth trajectories, both in terms of quality of life and economic output. The challenge is confronting the significant hurdles to achieving such growth. Serving the urban population, especially the urban poor, will require dramatic improvements in basic amenities to achieve a decent standard of living.

Although, the IoT can facilitate the participation of the responsive loads in the system, there are still various kinds of barriers that can limit the penetration of DR.

The challenges which arise when implementing the IoT system were thoroughly explained. In this regard, the combination of the IoT platform with other autonomous and intelligent systems for providing smart and widespread applications is one of the most interesting future trends. Furthermore, providing a mechanism to overcome some of the essential challenges like the privacy right of the citizens is still an area of interest. The IoT with its functionality and features should, in fact, utilize intelligent systems and sensors to preserve the rights of the smart city citizens of India in future..

8. REFERENCES

[1] "Mission Statement and Guidelines - Smart Cities" (PDF). Ministry of Urban Development, GOI. Retrieved 1 February 2016.

[2] Muhammad Mazhar Ullah Rathore, Awais Ahmad, Anand Paul and Suengmin Rho, Urban Planning and Building Smart Cities based on the Internet of Things using Big Data Analytics, Elsevier, Computer Networks Volume 101, 4 June 2016, Pages 63-80

[3] A. Botta, W. de Donato, V. Persico, A. Pescap´e, Integration of cloud computing and Internet of Things: A survey, Future Generation Computer Systems (2015), http://dx.doi.org/10.1016/j.future.2015.09.021

[4] D. Kyriazis, T. Varvarigou, A. Rossi, D. White, and J. Cooper, "Sustainable smart city IoT applications: heat and electricity management & Eco- conscious cruise control for public transportation," IEEE 14th International Symposium and Workshops on World of Wireless, Mobile and Multimedia Networks, pp. 1–5, 2013.

[5] "Strategic opportunity analysis of the global smart city market", http://www.egr.msu.edu/~aesc310-web/resources/SmartCities/Smart%20City %20Market%20Report%202.pdf.

[6] J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions," Future Gener. Comput. Syst., vol. 29, pp. 1645–1660, 2013.

[7] J. M. Hernández-Muñoz, J. B. Vercher, L. Muñoz, J. A. Galache, M. Presser, L. A. Hernández Gómez, J. Pettersson, "Smart Cities at the forefront of the future Internet", The Future Internet Lect. Notes Comput. Sci., vol. 6656, pp. 447-462, 2011.

[8]. C. E. A. Mulligan, M. Olsson, "Architectural implications of smart city business models: An evolutionary perspective", IEEE Commun. Mag., IEEE, vol. 51, no. 6, pp. 80-85, Jun. 2013.

[9] L. Atzori, A. Iera, and G. Morabito, "The internet of things: a survey," Comput. Netw, vol. 54, pp. 2787–2805, 2010.

[10] A. Bassi, and G. Horn, "Internet of Things in 2020: A Roadmap for the Future," European Commission: Information Society and Media, 2008.

[11] "Strategic opportunity analysis of the global smart city market", http://www.egr.msu.edu/~aesc310-web/resources/SmartCities/ Smart%20City%20Market%20Report%202. pdf.

[12] A.K. Evangelos, D.T. Nikolaos, and C.B. Anthony, "Integrating RFIDs and smart objects into a Unified Internet of Things architecture," Advances in Internet of Things, vol. 1, pp. 5-12, 2011.

[13] R. Petrolo, N. Mitton, J. Soldatos, M. Hauswirth, G. Schiele, et al. "Integrating wireless sensor networks within a city Cloud," Swansity workshop in Conjunction with IEEE SECON 2014, 2014.

[14] M. Lazarescu, "Design of a wsn platform for long-term environmental monitoring for IoT applications," IEEE J. Emerg. Sel. Top. Circuits Syst., vol. 3, pp. 45–54, 2013.

[15] N. Mitton, S. Papavassiliou, A. Puliafito, and K.S. Trivedi, "Combining cloud and sensors in a smart city environment," EURASIP J. Wirel. Commun. Netw. Vol. 1, pp. 1–10, 2012.

[16] M. Yun, and B. Yuxin, "Research on the architecture and key technology of Internet of Things (IoT) applied on smart grid," International Conference on Advances in Energy Engineering (ICAEE), pp. 69–72, 2010.

[17] N. Neyestani, M. Y. Damavandi, M. Shafie-khah and J. P. S. Catalão, "Modeling the PEV traffic pattern in an urban environment with parking lots and charging stations," PowerTech, 2015 IEEE Eindhoven, Eindhoven, 2015, pp. 1-6.

[18] M. Yazdani-Damavandi, M. P. Moghaddam, M. R. Haghifam, M. Shafie-khah and J. P. S. Catalão, "Modeling Operational Behavior of Plug-in Electric Vehicles' Parking Lot in Multienergy Systems," IEEE Trans. Smart Grid, vol. 7, pp. 124-135, 2016.

[19] N. Neyestani, M. Y. Damavandi, M. Shafie-Khah, J. Contreras, and J. P. S. Catalão, "Allocation of plug-in vehicles' parking lots in distribution systems considering network-constrained objectives," IEEE Trans. Power Syst., vol. 30, pp. 2643-2656, 2015.

[20] M. Shafie-khah, E. Heydarian-Forushani, M.E.H. Golshan, P. Siano, M.P. Moghaddam, M.K. Sheikh-El-Eslami, and J.P.S. Catalão, "Optimal trading of plug-in electric vehicle aggregation agents in a market environment for sustainability," Appl. Energy, Volume 162, 15 January 2016, Pages 601-612.

[21] W. He, G. Yan, and L.D. Xu, "Developing vehicular data Cloud services in the IoT environment," IEEE Trans. Ind. Inf., vol. 10, pp. 1587–1595, 2014.

[22] D.M. Han, and J.H. Lim, "Smart home energy management system using IEEE 802.15. 4 and zigbee," IEEE Trans. Consum. Electron., vol. 56, pp. 1403–1410, 2010.

[23] P. Siano, and D. Sarno, "Assessing the benefits of residential demand response in a real time distribution energy market", Appl. Energy, vol. 161, pp. 533–551, 2016.

[24] G. Graditi, M.G. Ippolito, R. Lamedica, A. Piccolo, A. Ruvio, E. Santini, P. Siano, G. Zizzo, "Innovative control logics for a rational utilization of electric loads and air-conditioning systems in a residential building", Energy Build., vol. 102, pp. 1-17, 2015.

[25] P. Siano, G. Graditi, M. Atrigna, A. Piccolo, "Designing and testing decision support and energy management systems for smart homes", J. Ambient Intell. Humanized Comput., vol. 4, pp. 651-661, 2013.

[26] L. Martirano, "A smart lighting control to save energy," IEEE 6th International Conference on Intelligent Data Acquisition and Advanced Computing Systems (IDAACS), Vol. 1, pp. 132–138, September 2011.

[27] G. Suciu, A. Vulpe, S. Halunga, O. Fratu, G. Todoran, and V. Suciu, "Smart cities built on resilient Cloud computing and secure Internet of Things," 19th International Conference on Control Systems and Computer Science (CSCS), pp. 513–518, 2013.

[28] H.R. Arasteh, M. Parsa Moghaddam, M.K. Sheikh-El-Eslami, A. Abdollahi, "Integrating commercial demand response resources with unit commitment", Electr. Power Energy Syst., vol. 51, pp. 153–161, 2013.

[29] M. Yun, and B. Yuxin, "Research on the architecture and key technology of Internet of Things (IoT) applied on smart grid," International Conference on Advances in Energy Engineering (ICAEE), pp. 69–72, 2010.

[30] S.Y. Chen, C.F. Lai, Y.M. Huang, and Y.L. Jeng, "Intelligent home-appliance recognition over IoT Cloud network," Wireless Communications and Mobile Computing Conference (IWCMC), pp. 639–643, 2013.

[31] IEA, "Strategic plan for the IEA demand-side management program 2008-2012," IEA Press; 2008. <http://www.iea.org> [accessed 03.12].

[32] P. Siano, "Demand response and smart grids – A survey", Renew. Sust. Energ. Rev., vol. 30, pp. 461-478, 2014.

[33] R. F. Arritt, R. C. Dugan, "Distribution system analysis and the future smart grid," IEEE Trans Ind Appl., vol. 47, pp. 2343-2350, 2011.

[34] H. Arasteh, M. S. Sepasian, and V. Vahidinasab, "An aggregated model for coordinated planning and reconfiguration of electric distribution networks," Energy, vol. 94, pp. 786-798, 2016.

[35] G. Zhabelova, and V. Vyatkin, "Multiagent Smart Grid Automation Architecture Based on IEC 61850/61499 Intelligent Logical Nodes," IEEE Trans. Indus. Elec., vol. 59, pp. 2351-2362, 2012.

[36] C. Atkins, et al., "A Cloud service for end-user participation concerning the Internet of Things," International Conference on Signal-Image Technology & Internet-Based Systems (SITIS), pp. 273–278, 2013.

[37] C. Dobre, and F. Xhafa, "Intelligent services for big data science," Future Gener. Comput. Syst., vol. 37, pp. 267–281, 2014.

[38] D. Corsar, P. Edwards, N. Velaga, J. Nelson, and J. Pan, "Short paper: addressing the challenges of semantic citizen-sensing," 4th International Workshop on Semantic Sensor Networks, CEUR-WS pp. 90–95, 2011.

[39] A. Zaslavsky, C. Perera, and D. Georgakopoulos, "Sensing as a service and big data," 2013. ArXiv Preprint arXiv:1301.0159.

[40] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "Wireless sensor networks: a survey," Comput. Netw, vol. 38, pp. 393–422, 2002.

[41] http://www.smartcitiesindia.com/

[42] https://www.bloomberg.org/program/government-innovation/india-smart-cities-mission/