Development of Internet of Things (IoT) and its Substantial Impact in the Field of Smart Cities

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Abstract—More than 25 billion devices would be associated through wireless communication by 2020. The Internet of Things (IoT) is a novel prototype that associates aspects and technologies coming from different approaches. The fast urban population growth demands that, facilities and an infrastructure be delivered to meet the needs. Thus, there has been an upsurge in the demand for embedded devices, foremost to significant business potential for the new era of the IoT. By placing intelligence into daily matters, they are turned into smart matters capable not only to gather information from the surroundings, but also interconnected with each other through Internet to altercation of data and information. The intense urbanization in modern cities needs smart solutions to tackle critical matters. With this knowledge, this paper presents a review of major technologies of IoT-based smart cities. It starts with introduction of IoT, definition of IoT, IoT enabling technologies in smart cities and IoT key issues and challenges in smart city applications.

Keywords—*IoT (Internet of Things); Networks; Smart Cities; Key Issues and Challenges;*

I. INTRODUCTION

In the course of the past few years, the notion of connecting day-to-day things via the prevailing networks turns out to be extremely auspicious with the development of smart devices and their progresses [1]. It has become an interesting assignment for researchers to noticeably ascertain the optimal potential of Internet usage. With the passage of time, the Internet world has been connected with things and is nowadays being recognized as Internet of things (IoT) [2]. As the name illustrates, things are connected thorough Internet by the use of smart communication technologies including Wireless Sensor Networks (WSN), Radio-frequency Identification (RFID), Bluetooth, Near-field communication (NFC), Long Term Evolution (LTE) etc [3]. IoT ensued from the development of conventional networks that link zillions of devices is currently the talk of every city [1].

IoT is centered on mixtures of several practices comprising recognizing, detecting, networking, and computing. It permits significant of technological innovations and value-added facilities personalizing users' interaction with many "things" [4]. It saw an incredible growth in every sector, from connected health, connected cars, smart retail, smart farming, roads, smart cities, smart homes, wearable's, to smart grids for energy management [5]. In 2018 there were more connected IoT devices than connected non-IoT devices [6]. That means that there are now more connected cars [7], meters [8-9], machines [10], wearable devices [11-12], smart homes, smart cities, smart grids, and similar IoT endpoints than there are PCs, laptops, tablets, and smartphones [13].

According to IoT Analytics estimations, there are approximately 7 billion linked IoT devices at the end of 2018. The number of total connected IoT devices is expected to reach 22B by 2025 [6]. Table 1 shows the top 10 stories of major developments around IoT technology (in chronological order), according to IoT Analytics, throughout 2018 [6].

IoT uses are almost unlimited while empowering unified integration of the cyber-world with the physical world. Individuals are now using capillary devices in IoT for health applications [14]. In the same way, there are numerous other areas in which IoT simplifies human life in a noteworthy way, together with transportation, healthcare, automation, and emergency responses to manmade and natural disasters [15]. IoT permits an object to see, listen, hear, and communicate together. Accordingly, IoT converts those objects from being usually smart by incorporating its worldwide and universal computing, embedded devices, communication technologies, sensor networks, Internet protocols and applications to improve human life [15]. Thus the Internet will be no longer considered a network of computers, whereas, it will comprise billions of smart devices together with embedded systems. Consequently, the IoT will meaningfully upsurge in size and scope, providing new opportunities along with challenges [16-18].

However, even with the massive efforts, there are still many problems to deal with in order to reach the full potential of IoT [19-20]. In such a complex situation, this paper goals to provide an easy approach to recognize the concept and further wishes to contribute towards its channelization to serve in the best optimal manner. This paper illustrates research articles linked to the field of smart cities using IoT, in order to extract the most valuable content and distinct researches. This paper has been distributed into five sections. Section I is the introductory, along with the reason for the motivation of this paper. Table 1 depicts the most important Acquisitions, investments, research findings and announcements in IoT in 2018. Section II highpoints the basics of IoT. Section III addresses IoT applications in smart cities. Section IV addresses

IoT key issues and challenges. Section V is the concluding portion of this paper.

Table 1: The most important Acquisitions, investments, research findings and announcements in IoT in the year 2018 [6].

Company	Acquisitions, investments, research findings and announcements
Microsoft	In April 2018, Microsoft doubled down and announced a further $5 billion investment into IoT technologies over 4 years.
Sonos	Speaker manufacturer Sonos went public on August 1, 2018, announcing its Initial Public Offering in IoT
Rockwell Automation	Industrial automation powerhouse Rockwell Automation in June 2018 announced a $1 billion equity investment in IoT Platform.
Chinese regulators	Chinese regulators disapprove of Qualcomm-NXP merge.
General Electric	On July 30, 2018, the Wall Street Journal reported that General Electric, the pioneer of the “Industrial Internet” was looking to sell GE Digital and with its IoT Platform Predix.
Bain & Company	In August 2018, Bain & Company published a study called “Unlocking Opportunities in the Internet of Things”. The publication delivered a broad overview of the priorities, viewpoints and challenges of more than 600 IoT end-users and 180 IoT vendors.
California Cyber security Law	After several failed attempts to introduce an IoT cybersecurity bill to the US senate, California jumped ahead in late August 2018 and became the first state to pass an IoT cybersecurity law.
5G network	In October 2018, Verizon Communications became the first operator in the world to officially launch a 5G network in 4 US cities (Los Angeles, Houston, Indianapolis, and Sacramento).
IBM to purchase Red Hat	In November 2018, IBM announced its intention to purchase Red Hat in a deal valued at $34B – the largest software deal ever.
View	View, a US-based company that constructs IoT-based building windows received $1.1B in Series H money in November 2018.

II. INTERNET OF THINGS (IOT)

IoT is a stage where daily devices become smarter, every day handling becomes intelligent, and daily communication becomes informative [21].

A. Definitions

The term “Internet of Things” (IoT), invented back in 1999 by Kevin Ashton, in his presentation delivered at Procter & Gamble, linking the innovative idea of RFID in Procter & Gamble's supply chain to the then-red-hot topic of the Internet [22-23].

The definition provided by the International Telecommunication Union (ITU) [24] is:

‘‘A global infrastructure for the information society enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies”.

According to Atzori and colleagues [25] IoT can be recognized in three paradigms-internet-oriented (middleware), things oriented (sensors) and semantic-oriented (knowledge).

The RFID cluster [26] defines the IoT as:

”The worldwide network of interconnected objects uniquely addressable based on standard communication protocols”.

According to Gubbia et al. [26] the more user centric definition of the IoT is:

“Interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications. This is achieved by seamless ubiquitous sensing, data analytics and information representation with cloud computing as the unifying framework”.

B. IoT architecture

From a technical perspective, the IoT architecture is generally divided into three layers [27]:

i) Perception layer: its function is to identify objects and collect the information. It is designed primarily out of sensors and actuators, monitoring stations (including cell phone, tablet PC, smart phone, cameras etc.), nano-nodes, RFID tags and readers/ writers.

ii) Network layer: it comprises united network made up of wired/wireless privately owned networks, Internet, network administration systems, etc. It consists of Gateways, ZigBee, Bluetooth, PLC, Wi-Fi, 2G, 3G, 4G and 5G. Its key task is to transmit information obtained from the perception layer.

iii) Application layer: it is a set of intelligent solutions that relate the IoT technology to gratify the requirements of the users. It includes demand response, fault detection, power lines, electric vehicles, renewable energy sources, and smart cities.

III. IOT APPLICATIONS

IoT has an enormous potential for developing intelligent applications in almost every sector such as smart transportation, smart healthcare, smart home, smart cities etc. For example, there are many IoT applications that have been already successfully implemented; based on overall popularity the major applications of IoT include smart home, wearables, smart city, smart grid, industrial internet, connected car, connected health, smart retail, smart supply chain and smart farming [6]. IoT applications convey a set of functionalities and capabilities which can be gathered according to domain of utilization into four areas: monitoring devices, control of devices functions, optimization of device performances, and autonomous operations of devices [28]. Most of the everyday applications are now smart but they are incompetent to communicate with each other and empowering them to interconnect with each other and sharing of beneficial information will produce a wide range of innovative applications [29]. These evolving applications with some autonomous capabilities would definitely progress the quality of our lives. A few of such applications are now in the market. There are a number of possible future applications that can be of pronounced advantage. In this section, we present these applications in smart cities

A. Smart Cities

With development of IoT paradigm, devices and systems are substituted with ´Smart´ devices and systems that could capture, process, analyze and even make intelligent decisions aided by sensors, actuators, data mining and evolutionary techniques. One of the booming IoT applications is development of a ´Smart City´. In 2015, Government of India launched Smart Cities Mission, sometimes referred to as Smart City Mission, which is an urban renewal and retrofitting program by the Government of India with the mission to develop 100 smart cities across the country building them citizen friendly and sustainable. This section provides an opportunity for academicians and industry professionals to discuss current developments in the field of smart city technologies and IoT, including progress, application, strategies and policies.

Alavi et al. [30] in their paper "Internet of Things-Enabled Smart Cities: State-of-the-Art and Future Trends" presented a broad review of key features and applications of the IoT for sustainable development of smart cities. Significance is given on existence of the IoT solutions with other subsidiary technologies containing RFID, robotics, cloud computing, wireless communications, and micro-electromechanical systems (MEMS). Also an IoT-based working prototype for real-time monitoring of civil infrastructure has been demonstrated.

Bresciani and colleagues [31] in the paper "The management of organizational ambidexterity through alliances in a new context of analysis: Internet of Things (IoT) smart city projects" used structural equations modeling with data collected from 43 IoT smart cities of Italy, has tested and found the evidence that multinational enterprises must improve knowledge management capabilities combined with ICT for superior performance.

The paper "A hybrid approach, Smart Street use case and future aspects for Internet of Things in smart cities" by Ahmed and Rani [32] presented that, the Smart City Project is complex idea and has numerous obstacles and can simply be resolved through IoT. Urban IoT was designed to support the upcoming vision of smart cities with hybrid technologies and provided the value added services to the citizens. It was recommended that in Urban IoT framework the first layer will be Data Layer with sensor platform using the AODV-SPEED protocol. This approach has displayed enhancement over delay, energy, miss ratio of the packet transmission and packet delivery rate over traditional SPEED protocol which is appropriate for IoT applications.

In "An IoT-based smart cities infrastructure architecture applied to a waste management scenario", [33] the paper proposed a multilevel IoT-based smart cities infrastructure management architecture and the case study of waste management problem is presented. The results proved the concept of the architecture, displaying management of 3902 garbage bins at once. The garbage bins properly separated organic and recyclable waste in both indoor and outdoor situations with low response times and good quality experience.

In paper entitled "A relational exploratory study of business incubation and smart cities - Findings from Europe" by Blanck and colleagues [34] presented a quantitative investigation on the relation amongst the incubation mechanisms and local urban development as per the concept of Smart City. Practically, canonical correlation analysis was done between two sets of elements: variables associated to business incubation and variables related to smart city characteristics. The research focused on 157 medium- and large-sized cities from 25 European countries.

The paper "An effect of big data technology with ant colony optimization based routing in vehicular ad hoc networks: Towards smart cities" by Lakshmanaprabu et al. [35] introduced the application of Big Data technologies to Vehicular adhoc network (VANET) to improve traffic management process. In the course of the real-time processes, the VANET produced large data, and the VANET characteristics are mapped to Big Data attributes. Moreover, ant colony optimization (ACO) algorithm is in employment for steering in vehicular networks over Hadoop Map Reduce standalone distributed framework and over multi-node cluster containing 2, 3, 4 and 5 nodes.

In the paper "A novel code data dissemination scheme for Internet of Things through mobile vehicle of smart cities", Teng and coworkers [36] have proposed a novel low-cost code dissemination model for distribution of the update code using the mobile vehicles in the city with an opportunistic communication style. For improving the performance, a coverage based greedy deployment scheme for code stations and an optimized code selection algorithm are projected to maximize coverage of code dissemination over the city with low cost and duration. Extensive simulation experiments validated the effectiveness of the proposed schemes through a real taxi trajectory dataset.

The paper "Data fusion technique in SPIDER Peer-to-Peer networks in smart cities for security enhancements" by Mocanu and colleagues [37] presented two data fusion techniques applied to the SPIDER Peer-to-Peer overlay. The rings and chains are used in designing SPIDER overlay with both chain and ring methods. The two case scenarios of IoT in Smart Cities are presented. The first presented a novel approach to Smart-Streets and the second described a waste recycling IoT scenario.

The paper "Smart cities and the citizen-driven internet of things: A qualitative inquiry into an emerging smart city" authored by Rama Krishna Reddy and colleagues [38] builds theory to understand the role of institutional environment in developing economies inspiring citizens to create IoT-based involvements in Hyderabad (India). It was seen that, the supportive regulatory environment aids in creating positive regulatory and cognitive institutional context, whereas the normative institutions endure to depress the positive environment that this context has created leading to a 'talent-in and talent-out' situation and reducing the entrepreneurial potential of the cities. It was recommended that, the city administration need to concentrate on building regulatory environment alnogwith creating a conducive environment to inspire and encourage citizen-led IoT interventions resulting in building inclusive smart cities.

In the article "Web Services in the Internet of Things and Smart Cities: A Case Study on Classification Techniques" Purohit and Kumar [39] have discussed a tripplanning case to highpoint the role of web services in a smart cities, and six learning models for web service classification are described.

In "Towards Establishing Cross-Platform Interoperability for Sensors in Smart Cities", Chaturved and Kolbe [40] have presented a new Java-based lightweight web service termed InterSensor Service permitting simply to link to multiple IoT platforms, simulation specific data, databases, and simple files and retrieving their observations deprived of worrying about data storage and the multitude of various APIs. The service encodes these findings "on-the-fly" rendering to the standardized external interfaces including OGC Sensor Observation Service and OGC SensorThings API. The service can be installed by the users to connect to different sources alnogwith service providers and stakeholders to increase additional interfaces to their platforms realizing interoperability according to international standards. This service is successfully used for the district Queen Elizabeth Olympic Park in London.

In the study "Success of IoT in Smart Cities of India: An empirical analysis" Chatterjee et al. [41] have identified factors influencing fruitful implementation of information system empowering IoT coupled with Artificial Intelligence in the projected Smart Cities of India (SCI). The study revealed that Perceived Information Quality (PIQ) and Perceived System Quality (PSQ) affect the usage of IoT by the Smart Citizens of projected SCI.

The paper "Intelligent Passenger Information System Using IoT for Smart Cities" authored by Anudeep and Prakash [42] proposed an IoT established intelligent real-time passenger information system updating the public in reducing passenger waiting time through Android-based mobile app. The system focused on the present position of the bus, projected arrival time and available seats. The execution is completed using NodeMCU with GPS module as vehicle node and bus information is guided to the cloud through MQTT protocol.

Vashishtha et al. [43] in the paper "Smart Cities in India: Revamping the Street Lighting System Using IOT" have enclosed the specific spectrum of smart cities and environment. Humidity sensors and LDR were used to improve the bad weather conditions. Microcontroller was the brain of the system.

Gyrard and colleagues [44] in the paper "Sensor-based Linked Open Rules (S-LOR): An automated rule discovery approach for IoT applications and its use in smart cities" presented an automated rule discovery approach for IoT device data and its application in smart cities. S-LOR is built following Linked Open Data (LOD) standards and provides support for semantics-based mechanisms to share, reuse and execute logical rules for interpreting data produced by IoT systems.

Abdullah and coworkers [45] in the paper "IoT-based smart waste management system in a smart city" presented a review of public waste management models and proposed an enhanced waste management design. This proposed esign considers and deals with population and urban growth by using different truck sizes according to waste type and IoT devices.

Singh et al. [46] in the paper "IoT-based smartbots for smart city using MCC and big data" proposed a Smartbot gathering huge amount of data and process it to provide intelligent solution to the user, using MCC and Big Data technology. The architecture used Hadoop and Spark ecosystem for the real-time simulation and presents the realization of Smartbots integrated with the IoT devices, smart data processing with analytics, networking with cloud, and other data visualization systems.

Kumar and Nath [47] in the paper "Study and design of smart embedded system for smart city using internet of things" provided a comprehensive idea of the concept of the smart city with the help of IoT.

Mohbey [48] in the paper "An efficient framework for smart city using big data technologies and internet of things" has discussed various IoT communication techniques with big data technologies. Also a framework is proposed for handling big data generated from smart city applications. The proposed framework primarily focused on problems related to smart city vision for real-time decision-making.

In the paper "Blockchain Technology in Smart City: A New Opportunity for Smart Environment and Smart Mobility" Orecchini and colleagues [49] have investigated the possibility to integrate the innovative and multi-purpose Blockchain Technology in the smart city evolutionary process, and in particular in the Smart Environment and Smart Mobility by allowing renewable energy sources traceability and by providing information about the kind of energy used to refuel the selected vehicle.

The paper "A Development on Air Pollution Detection Sensors based on NB-IoT Network for Smart Cities" by Duangsuwan et al. [50] presented a development of air pollution detection sensors and monitoring for smart city, in Bangkok, Thailand. The development is designed by using five standard sensors, and web monitor shows the graph of the air quality index. To monitor the air quality, the data processing is computed by using Arduno MEGA 2560 and Respberri Pi 3 to connect with Narrowband Internet of Things (NB-IoT) module network.

As discussed above, there are several domains specific IoT based smart city applications. While reviewing different areas of implementations, it is found that smart city related practices are dominant over other segments.

IV. KEY ISSUES AND CHALLENGES

IoT based systems are complex due to a remarkable impact on all aspects of human lives as well as its various technologies deployed to enable data exchange between embedded devices. The main issues in application of IoT for smart cities are Networking and Transport, Security, Heterogeneity, Denial of service, and Big Data management. Development of IoT has an impact on various aspects of human lives. Therefore, IoT related issues and challenges need to be considered from various aspects such as enabling technologies, services and applications, business models, social and environmental impacts. Analysis of recent contributions and research papers show that the most of the open issues arise due to an increasing number of connected devices causing increased traffic demands. Other issues are related to the integration of various technologies, heterogeneous environment (e.g. various devices, data types, and network technologies), increased data storage and processing demands, privacy and security risks, etc.

V. CONCLUSIONS

In this paper, an overview of the progress of IoT and its substantial impact in the field of smart cities has been provided. To realize the concept of a smart city, IoT technologies are one of the most essential elements in carrying forward detailed plans of a smart city. The establishment of demonstration sites for testing IoT technology within smart city and government-led demonstrations of complex sites for promoting the smart city industry and markets needs to be addressed while implementing IoT in smart cities. In addition, to retain the sustainability of an urban environment with an ecosystem, a data-oriented smart city infrastructure should be developed and established. Based on the results of the current study, it is meaningful to present both necessary and priority issues regarding the aspects of IoT technologies for the successful establishment of a smart city infrastructure and its related services. Although the current study evaluated the importance of IoT technologies with regard to the concept of a smart city, in-depth discussions and debates among experts and engineers in fields related to smart cities and IoT technologies should be continuously conducted.

REFERENCES

[1] Bhagya Nathali Silva, Murad Khan, Kijun Han, "Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities", Sustainable Cities and Society, vol. 38, pp. 697–713, 2018.

[2] B. Ahlgren, M. Hidell, E. C. Ngai, "Internet of Things for Smart Cities: Interoperability and Open Data", IEEE Internet Computing, vol. 20, pp. 52-56, 2016.

[3] E. Giaccardi, "Things Making Things: Designing the Internet of Reinvented Things", IEEE Pervasive Computing, vol. 17, pp. 70-72, 2018.

[4] Alem Čolaković, Mesud Hadžialić, "Internet of Things (IoT): A review of enabling technologies, challenges, and open research issues", Computer Networks, vol. 144, pp. 17-39, 2018.

[5] V. A. F. Almeida, D. Doneda, M. Monteiro, "Governance Challenges for the Internet of Things", IEEE Internet Computing, vol. 19, pp. 56-59, 2015.

[6] https://iot-analytics.com/iot-2018-in-review/ last accessed on 01 February 2019.

[7] Hussein Khaleel, Davide Conzon, Prabhakaran Kasinathan, Paolo Brizzi, Claudio Pastrone, Ferry Pramudianto, Markus Eisenhauer, Pietro A. Cultrona, Fulvio Rusinà, Gabriel Lukáč, Marek Paralic, "Heterogeneous Applications, Tools, and Methodologies in the Car Manufacturing Industry Through an IoT Approach", IEEE Systems J., vol. 11, pp. 1412–1423, 2017.

[8] F. Abate, M. Carratù, C. Liguori, V. Paciello, "A low cost smart power meter for IoT", Measurement, vol. 136, pp. 59-66, 2019.

[9] Samet Tonyali, Kemal Akkaya, Nico Saputro, A. Selcuk Uluagac, Mehrdad Nojoumian, "Privacy-preserving protocols for secure and reliable data aggregation in IoT-enabled Smart Metering systems", Future Generation Computer Systems, vol. 78, pp. 547-557, 2018.

[10] Stefano Tedeschi, Jörn Mehnen, Nikolaos Tapoglou, Rajkumar Roy, "Secure IoT Devices for the Maintenance of Machine Tools", Procedia, CIRP vol. 59, pp. 150-155, 2017.

[11] Florence Hudson, Chris Clark, "Wearables and Medical Interoperability: The Evolving Frontier", Computer, vol. 51, pp. 86–90, 2018.

[12] Orlando Arias, Jacob Wurm, Khoa Hoang, Yier Jin, "Privacy and Security in Internet of Things and Wearable Devices", IEEE Transactions on Multi-Scale Computing Systems, vol. 1, pp. 99–109, 2015.

[13] Somayya Madakam, R. Ramaswamy, Siddharth Tripathi, "Internet of Things (IoT): A Literature Review, Journal of Computer and Communications", vol. 3, pp. 164-173, 2015.

[14] M. Mazhar Rathore, Awais Ahmad, Anand Paul, Seungmin Rho, "Urban planning and building smart cities based on the Internet of Things using Big Data analytics", Computer Networks, vol. 101, pp. 63–80, 2016.

[15] Tiago M. Fernández-Caramés, OrcID, Paula Fraga-Lamas, "Towards The Internet of Smart Clothing: A Review on IoT Wearables and Garments for Creating Intelligent Connected E-Textiles", Electronics, vol. 7, pp. 405-480, 2018.

[16] Parvaneh Asghari, Amir Masoud Rahmani, Hamid Haj Seyyed Javadi, "Internet of Things applications: A systematic review", Computer Networks, vol. 148, pp. 241-261, 2019.

[17] Yang Lu, Savvas Papagiannidis, Eleftherios Alamanos, "Internet of Things: A systematic review of the business literature from the user and organisational perspectives", Technological Forecasting and Social Change, vol. 136, pp. 285-297, 2018.

[18] Irene C. L. Ng, Susan Y. L. Wakenshaw, "The Internet-of-Things: Review and research directions", International Journal of Research in Marketing, vol. 34, pp. 3-21, 2017.

[19] Prachin Bhoyar, Parul Sahare, S. B. Dhok, R. B. Deshmukh, "Communication technologies and security challenges for internet of things: A comprehensive review", AEU - International Journal of Electronics and Communications, vol. 99, pp. 81-99, 2019.

[20] Oladayo Bello, Sherali Zeadally, "Toward efficient smartification of the Internet of Things (IoT) services", Future Generation Computer Systems, vol. 92, pp. 663-673, 2019.

[21] P.P. Ray, "A survey on Internet of Things architectures", Journal of King Saud University – Computer and Information Sciences, vol. 30, pp. 291–319, 2018.

[22] Kevin Ashton, "That 'internet of things' thing", RFiD J., vol. 22, pp. 97–114, 2009.

[23] S. Huckle, R. Bhattacharya, M. White, N. Beloff, "Internet of Things, Block chain and Shared Economy Applications" Procedia Computer Science, vol. 98, pp. 461–466, 2016.

[24] "ITU work on Internet of things", ICTP workshop, (2015) [last accessed on 01 February 2019]

[25] L. Atzori, A. Iera, G. Morabito, "The Internet of Things: a survey", Computer Networks, vol. 54, pp. 2787–2805, 2010.

[26] Jayavardhana Gubbi, Rajkumar Buyya, Slaven Marusic, Marimuthu Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions", Future Generation Computer Systems, vol. 29, pp. 1645-1660, 2013

[27] Mari Carmen Domingo, "An overview of the Internet of Things for people with disabilities", Journal of Network and Computer Applications, vol. 35, 584-596, 2012.

[28] Alexander Gluhak, Srdjan Krco, Michele Nati, Dennis Pfisterer, Nathalie Mitton, Tahiry Razafindralambo, "A Survey on Facilities for Experimental Internet of Things Research", IEEE Communications Magazine, Institute of Electrical and Electronics Engineers, vol. 49, pp. 58-67, 2011.

[29] Pallavi Sethi, Smruti R. Sarangi, "Internet of Things: Architectures, Protocols, and Applications", Journal of Electrical and Computer Engineering, (2017) https://doi.org/10.1155/2017/9324035

[30] A.H. Alavi, P. Jiao, W.G. Buttlar, N. Lajnef, "Internet of Things-Enabled Smart Cities: State-of-the-Art and Future Trends", Measurement, vol. 129, pp. 589-606, 2018.

[31] Stefano Bresciani, Alberto Ferraris, Manlio Del Giudice, "The management of organizational ambidexterity through alliances in a new context of analysis: Internet of Things (IoT) smart city projects", Technological Forecasting and Social Change, vol. 136, pp. 331-338, 2018.

[32] S.H. Ahmed, S. Rani, "A hybrid approach, Smart Street use case and future aspects for Internet of Things in smart cities", Future Generation Computer Systems, vol. 79, pp. 941-951, 2017.

[33] Patric Marques, Diogo Manfroi, Eduardo Deitos, Jonatan Cegoni, Rodrigo Castilhos, Juergen Rochol, Edison Pignaton, Rafael Kunst, "An IoT-based smart cities infrastructure architecture applied to a waste management scenario", Ad Hoc Networks, vol. 87, pp. 200-208, 2019.

[34] Mery Blanck, José Luis Duarte Ribeiro, Michel J. Anzanello, "A relational exploratory study of business incubation and smart cities - Findings from Europe", Cities, vol. 88, pp. 48-58, 2019.

[35] S. K. Lakshmanaprabu, K. Shankar, S. Sheeba Rani, Enas Abdulhay, N. Arunkumar, Gustavo Ramirez, J. Uthayakumar, "An effect of big data technology with ant colony optimization based routing in vehicular ad hoc networks: Towards smart cities", Journal of Cleaner Production, vol. 217, pp. 584-593, 2019.

[36] Haojun Teng, Yuxin Liu, Anfeng Liu, Neal N. Xiong, Zhiping Cai, Tian Wang, Xuxun Liu, "A novel code data dissemination scheme for Internet of Things through mobile vehicle of smart cities", Future Generation Computer Systems, vol. 94, pp. 351-367, 2019.

[37] Bogdan Mocanu, Florin Pop, Alexandra Mihaita (Mocanu), Ciprian Dobre, Aniello Castiglione, "Data fusion technique in SPIDER Peer-to-Peer networks in smart cities for security enhancements", Information Sciences, vol. 479, pp. 607-621, 2019.

[38] Rama Krishna Reddy, Kummithaa Nathalie Crutzen, "Smart cities and the citizen-driven internet of things: A qualitative inquiry into an emerging smart city", Technological Forecasting and Social Change, vol. 140, pp. 44-53, 2019.

[39] Lalit Purohit, Sandeep Kumar, "Web Services in the Internet of Things and Smart Cities: A Case Study on Classification Techniques", IEEE Consumer Electronics Magazine 8, pp. 39-43, 2019.

[40] Kanishk Chaturvedi, and Thomas H. Kolbe, "Towards Establishing Cross-Platform Interoperability for Sensors in Smart Cities", Sensors, vol. 19, pp. 562 (1-29), 2019.

[41] Sheshadri Chatterjee, Arpan KumarKar, M.P.Gupta, "Success of IoT in Smart Cities of India: An empirical analysis", Government Information Quarterly, vol. 35, pp. 349-361, 2018.

[42] Polamarasetty Anudeep, N. Krishna Prakash, "Intelligent Passenger Information System Using IoT for Smart Cities", Smart Innovations in Communication and Computational Sciences. Advances in Intelligent Systems and Computing, vol 851, pp. 67-76, 2018.

[43] Akash Vashishtha, Saru Dhir, Madhurima Hooda, "Smart Cities in India: Revamping the Street Lighting System Using IOT", Advanced Informatics for Computing Research, vol. 986, pp. 536-546, 2018.

[44] A. Gyrard, M. Serrano, J. B. Jares, S. K. Datta, M. I. Ali, "Sensor-based Linked Open Rules (S-LOR): An automated rule discovery approach for IoT applications and its use in smart cities", 26th International World Wide Web Conference 2017 pp. 1153-1159, 2019.

[45] N. Abdullah, O. A. Alwesabi, R. Abdullah, "IoT-based smart waste management system in a smart city", Advances in Intelligent Systems and Computing, vol. 843, pp. 364-371, 2019.

[46] P. K. Singh, R. K. Verma, P. E. S. N. Krishna Prasad, "IoT-based smartbots for smart city using MCC and big data", Smart Inno., Systems and Technologies, vol. 104, pp. 525-534, 2019.

[47] A. Kumar, V. Nath, "Study and design of smart embedded system for smart city using internet of things", Lecture Notes in Electrical Engineering, vol. 511, pp. 397-408, 2019.

[48] K.K. Mohbey, "An efficient framework for smart city using big data technologies and internet of things", Advances in Intelligent Systems and Computing, vol. 714, pp. 319-328, 2019.

[49] F. Orecchini, A. Santiangeli, F. Zuccari, A. Pieroni, T. Suppa, "Blockchain Technology in Smart City: A New Opportunity for Smart Environment and Smart Mobility", Advances in Intelligent Systems and Computing, vol. 866, pp. 346-354, 2019.

[50] S. Duangsuwan, A. Takarn, P. Jamjareegulgarn, "A Development on Air Pollution Detection Sensors based on NB-IoT Network for Smart Cities", ISCIT 2018 - 18th International Symposium on Communication and Information Technology 8587978, pp. 313-317, 2018.

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