

Comprehensive Survey on Smart Cities Architectures and Protocols

Syed Waqar Shah¹, Tahira Magsi¹, and Ahthasham Sajid^{1,*}

¹Department of Computer Science, Faculty of ICT, Balochistan University of Information Technology Engineering and Management Sciences, Quetta, Baluchistan, Pakistan

Abstract

The world has advanced more than two centuries in the last 20 years in every aspect of existence. Every day, new inventions are made that improve our quality of life and make our lives easier. One aspect of contemporary innovation is the idea of the smart city. Many businesses and governments are embracing the idea of the "smart city" to improve quality of life for citizens while cutting costs. This model is made up of a variety of different technologies. Internet of Things, cloud and fog computing, UAV, and other technologies are among them. On the other hand, in order to achieve these important goals, it is necessary to provide the multiple system components with the necessary synchronisation and mechanism, which calls for well-organized interaction and communication protocols. In this study, we categorise the networking requirements and characteristics of smart.

Keywords: IoT, Cloud Computing, UAV.

Received on 19 June 2022, accepted on 05 September 2022, published on 07 September 2022

Copyright © 2022 Syed Waqar Shah *et al.*, licensed to EAI. This is an open access article distributed under the terms of the [CC BY-NC-SA 4.0](#), which permits copying, redistributing, remixing, transformation, and building upon the material in any medium so long as the original work is properly cited.

doi: 10.4108/eetsc.v6i18.2065

*Corresponding author. Email: ahthasham.sajid@buitms.edu.pk

1. Introduction

The Smart Cities concept brings revolution to urban planning. In 1994 Amsterdam formed a virtual digital city to endorse internet procedures [3]. They are the result of knowledge-intensive and ground-breaking policies, pointing at refining sensible enactment of cities [4]. Smart cities are based on an auspicious combination of human capital, and commercial capital [4]. The smart cities concept is a superlative typical urban gathering, but in actuality, we note numerous smart appearances in urban systems, such as creative districts, smart urban villages, or sustainable knowledge-based urban spaces [4]. The contextual idea of smart cities is built on the circumstance that cities house, in principle, a variety of inventive talents and can offer novel and justifiable solutions [1]. The accumulation compensations generated in modern urban groups are critical limitations for developing the potential benefits of innovative urban spaces. It has been projected

that by almost 2050, two-thirds of the world's inhabitants will be living in urban regions, which will be around 7 billion people. Hence, equipping the cities with smart technologies and analytics can make it resilient and efficient. A large number of cities like Dubai, Singapore, Amsterdam, New York etc., around the globe start using the Smart City concept to facilitate their citizens using city infrastructure. These smart services help to improve the working techniques of different departments e.g. Education, Transportation, Healthcare, and many others. The Smart City concept is based on many advanced technologies like I.O.T, Wireless Sensor Networks (WSN), Robotics, Unmanned Aerial Vehicles (UAV), Cyber-Physical Systems (CPS), Big data analytics, etc. [5]. A major step toward the practical understanding of the Smart City concept comprises the growth of a communication setup capable of gathering data from a large diversity of unlike devices in a typically constant and seamless manner, according to the Internet of Things (IoT) paradigm [2]. The Internet of Things (IoT) period is progressing into a sensor-initiated, actuation-driven, and

Where every management and operation is monitored through a centralized platform. At the bottom, of the pyramid, there lies a smart infrastructure that includes all the devices that are employed in this project. Following that in the middle tier, there lie smart database resources, smart building management, and smart infrastructure; which keep a record of all the data being generated. While at the top of the helm, lies the smart city itself which take care of all the affair of the city.

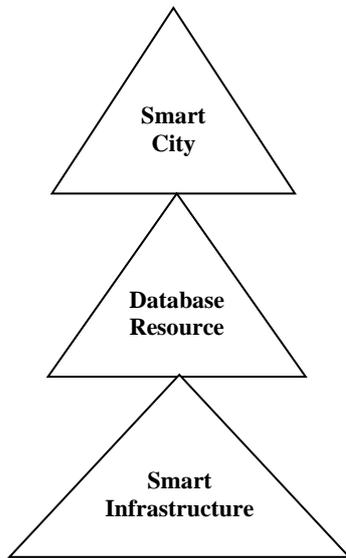


Figure 3. Centralized Operational Platform

2. Three layer Architecture: Three-layer architecture was proposed by Harrison et al, whose crux is that a city will be divided into three halves for better management. According to this model, the Instrumented layer captures and integrates the live world data with the help of the sensors, like water reading meter or water quality measurement, etc. Then it's the onus of the Interconnected Layer to act as the middleman and integrated the data collected and maps numerous outputs into some useful information. In the end, the intelligent layer processes the desired data into a broader context to identify city-related issues and analyze them to take action upon them.

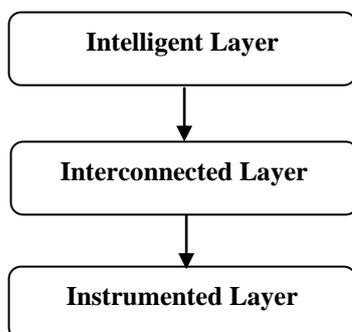


Figure 4. Three Layers Architecture

5. Networking Characteristics of Smart Cities

5.1 Bandwidth

Bandwidth ranges from Low, Medium, and High (L, M, H) [15]. For example, if those applications which only control commands required a small bandwidth then those applications which utilized image and video data required Medium or High bandwidth.

5.2 Delay Tolerance

Delay tolerance varies from application to application in smart city architecture. In some applications where immediate control is essential, a delay means disaster e.g. collision between cars While in some applications, such as UAVs required data for future dispensation.

5.3 Power Consumption

Power consumption is a vital need for a smart city system. However, it is visible in table 1 [14] that those applications which have a local energy source, easily deal with high power consumption and those applications which have low energy capacities have low power consumption.

5.4 Reliability

Reliability levels vary from one application to another. As shown in Table 1 [14] smart water networks have medium dependability necessities and smart grids and intellectual conveyance have a high-reliability ratio.

5.5 Security

Security importance is the same as reliability. For example, some applications due to it critical data required high security and some applications required medium security level i.e. monitoring applications.

6. Routing Protocols of Smart Cities

Smart city is an amalgamation of heterogeneous networks and technologies. So, every component that gets embedded in the digital city base has its own characteristics and requirement. Therefore, all relevant protocols are to be followed to take maximum utilization from that component. Wireless Technology: In the smart city if wireless technology is deployed then its only communication mode will be Wi-Fi, GPRS, or 3G networks. Short-range applications are designed where the required energy is limited and are compact in size. They

don't need frequent battery changes. Applications that are short-range and installed are in smart buildings; water and grid prefer IEEE 802.15.4 ZigBee protocol [20].

Table 1. Networking Protocols for Smart City Applications

Protocol	Data Range	Transmission Range	Applications
Satellite	10 Mbps (for upload) 7 1 GBPS (downloads)	Satellite can cover 100's km to entire Earth	UAV, monitoring UAV, Intelligent Transport
Cellular 4G/ LTE	300 Mbps to 1Gbps	Normally 1 km area diameter	Pipeline monitoring, Smart Grid, UAVs, smart water -do-
Cellular 3G	144 kbps (mobile) To 42 mbps (stationary)	1km to several stationery	-do-
WiMAX 802.16	2- 75mbps	Up to 56km	-do-
802.11n	15,30,45,60,90,120,135, 150 mbps	250m outdoors	All
802.11g	6,9,12,18,24, 36,48,54mbps	140m outdoors	All
802.11b	1,2,5.5, 11mbps	-do-	All
802.11a	24,36,48,54 mbps	120m outdoors	All
Bluetooth 802.15.1	1mbps	10 to 100 m	Smart water, Grid and building
Zigbee 802.15.4	20kbps to 250kbps	10 to 20m	Smart water, Grid and building

Bluetooth uses IEEE 802.15.1 which serves as master/slave Time Division Duplex (TDD) protocol. It ranges from 10 to 100 m. (WiMAX), Cellular 3G, Cellular 4G/LGT, and Satellite use IEEE 802.11a, IEEE 802.11b, IEEE 802.11b, IEEE 802.11 g protocols respectively. These protocols are the most frequently used in all urban city systems. 3G and 4G are used in smart grid applications, water management, pipeline monitoring, and UAVs While satellite communication is employed for UAVs, pipeline monitoring and intelligent transport. Table 1 further describe the details of protocols with features.

7. Conclusion

With each passing day, all technical platforms—including Cloud computing, the Internet of Things, wireless networks, robotics, etc.—have experienced a growth. The

goal is to create a city that is smart and capable of coping with the constantly expanding population as well as their demands through the convergence of all these technologies. To provide the greatest utility with the least amount of overhead costs, every vista is being investigated. The core of smart technology relies entirely on reliable routes for communicating information. The only paradigm for turning a town or metropolis into an intelligent one is a quick and dependable transmission route. People do absolutely contribute to technology when they are connected to it directly through applications.

Acknowledgements.

We would like to thanks our teacher Dr. Ahthasham Sajid to motivate and guide us for the understanding and writing of a survey paper as class assignment during MS (CS) course.

References

- [1] Ermacora G, Rosa S, Bona B (2015) Sliding autonomy in cloud robotics services for smart city applications. In: Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction Extended Abstracts. ACM. pp 155–156
- [2] A. Cenedese, A. Zanella, L. Vangelista and M. Zorzi, "Padova Smart City: An urban Internet of Things experimentation," Proceeding of IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks 2014, 2014, pp. 1-6, doi: 10.1109/WoWMoM.2014.6918931.
- [3] Hadi Habibzadeh, Tolga Soyata, Burak Kantarci, Azzedine Boukerche, Cem Kaptan, Sensing, communication and security planes: A new challenge for a smart city system design, Computer Networks, Volume 144, 2018.
- [4] Giordano A, Spezzano G, Vinci A (2016) Smart agents and fog computing for smart city applications. In: International Conference on Smart Cities. Springer. pp 137–146
- [5] Mohamed N, Lazarova-Molnar S, Al-Jaroodi J (2017) Cloud of things: Optimizing smart city services. In: Proceedings of the International Conference on Modeling, Simulation and Applied Optimization. IEEE. pp 1–5
- [6] Zanella A, Bui N, Castellani A, Vangelista L, Zorzi M (2014) Internet of things for smart cities. IEEE Internet Things J 1(1):22–32
- [7] Centenaro M, Vangelista L, Zanella A, Zorzi M (2016) Long-range communications in unlicensed bands: The rising stars in the iot and smart city scenarios. IEEE Wirel Commun 23(5):60–7
- [8] Leccese F, Cagnetti M, Trinca D (2014) A smart city application: A fully controlled street lighting isle based on raspberry-pi card, a zigbee sensor network and wimax. Sensors 14(12):24408–24
- [9] Wan J, Di L, Zou C, Zhou K (2012) M2m communications for smart city: An event-based architecture. In: Computer and Information Technology (CIT), 2012 IEEE 12th International Conference on. IEEE. pp 895–900
- [10] Jin J, Gubbi J, Luo T, Palaniswami M (2012) Network architecture and qos issues in the internet of things for a smart city. In: Communications and Information Technologies (ISCIT), 2012 International Symposium on. IEEE. pp 956–961.

- [11] De Poorter E, Moerman I, Demeester P (2011) Enabling direct connectivity between heterogeneous objects in the internet of things through a network-service-oriented architecture. *EURASIP J Wirel Commun Netw* 2011(1):61
- [12] Transform, Transformation agenda for low carbon cities. Online: <http://urbantransform.eu/about/smart-energy-city/>[Accessed: July 2016].
- [13] Elaborated by the authors based on (Stawasz & Sikora-Fernandez, 2016; Zanella et al., 2014; Caragliu et al., 2011).
- [14] Gurgun L, Gunalp O, Benazzouz Y, Gallissot M (2013) Self-aware cyber-physical systems and applications in smart buildings and cities. In: *Proceedings of the Conference on Design, Automation and Test in Europe*, pages 1149–1154. EDA Consortium.
- [15] Lombardi M, Pascale F, Santaniello D. Internet of Things: A General Overview between Architectures, Protocols and Applications. *Information*. 2021; 12(2):87. <https://doi.org/10.3390/info12020087>
- [16] Jawhar, I., Mohamed, N. & Al-Jaroodi, J. Networking architectures and protocols for smart city systems. *J Internet Serv Appl* 9, 26 (2018). <https://doi.org/10.1186/s13174-018-0097-0>
- [17] Benatia, S.E., Smail, O., Boudjelal, M., Cousin, B. (2019). ESMRsc: Energy Aware and Stable Multipath Routing Protocol for Ad Hoc Networks in Smart City. In: Hatti, M. (eds) *Renewable Energy for Smart and Sustainable Cities. ICAIRES 2018. Lecture Notes in Networks and Systems*, vol 62. Springer, Cham. https://doi.org/10.1007/978-3-030-04789-4_4
- [18] EL-Garoui, L.; Pierre, S.; Chamberland, S. A New SDN-Based Routing Protocol for Improving Delay in Smart City Environments. *Smart Cities* 2020, 3, 1004-1021. <https://doi.org/10.3390/smartcities3030050>
- [19] Ketu, S., Mishra, P.K. A Contemporary Survey on IoT Based Smart Cities: Architecture, Applications, and Open Issues. *Wireless Pers Commun* 125, 2319–2367 (2022). <https://doi.org/10.1007/s11277-022-09658-2>
- [20] Khatoun, Rida & Zeadally, Sherali. (2016). Smart cities: Concepts, architectures, research opportunities. *Communications of the ACM*. 59. 46-57. 10.1145/2858789.