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Smart City Solutions & 5G: A Survey

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ABSTRACT

This paper presents the smart city developments started in different regions of the world. 5G network capabilities will be assisting in the fast deployment of different services in the smart city. The main features of 5G are highly reliable links, enhanced broadband, and low latency that will be beneficial in improving connectivity performance within a smart city. Artificial Intelligence and machine learning are an integral part of smart city solutions. Various sensors are integrated into devices, buildings, vehicles, and other physical objects that continuously record the data and transmit them to the smart platforms for processing. Big data analytics and cloud computing also play a crucial role in a smart city. The Paper also presents various smart city solutions that are being made available by major companies such as Cisco, IBM, Ericsson, and Qualcomm.

Keywords : Smart City, Artificial Intelligence, machine learning, IoT, connected devices.

A smart city is a city where citizens have access to any information from anywhere and they receive prompt responses from different services available. IBM and Cisco started working on Smart City projects in the late 1990s. Singapore announced an intelligent island initiative in 1999. Then, France and Portugal also used IT solutions for urban scenarios. After 2012, the Government began taking initiatives for utilizing technological solutions for increasing the effectiveness of municipal department operations. United Kingdom (2013) started on improving city operations, and Korea (2014) started using Big Data for the small city operations. Intending to make transportation and energy operations smart, the US started working on smart cities in 2015. The Indian government also announced smart city projects based on the PPP model in 2015.

Recently, major companies are collaborating for R&D activities and developing use cases. Also, citizens are encouraged for investing in affordable projects such as solar panels for energy generation. Section 2 of the paper discusses smart city initiatives with 5G commercialization. Section 3 explains different technologies used

in smart cities and section 4 lists down different applications of smart cities. Section 5 discloses smart city solutions.

II. DEVELOPMENT OF SMART CITIES & 5G COMMERCIALIZATION

With the increasing urbanization, most of the population will be living in the cities. Also, as 5G commercialization has started, the digital world and human-machine interaction are becoming a reality. IoT networks comprising a sensor and battery-operated devices are deployed for real-time monitoring. As cloud implementation is adopted by average customers and enterprises, a large amount of data is collected. This is handled as Big Data and requires complex analysis for efficient storage and analysis of the huge volume of collected data. 5G commercialization will help in realizing smart city applications. 5G core is cloud-based and the main highlights are enhanced broadband services, higher data rates, low latency, and ultra-reliability. 5G will improve AR/VR experience, healthcare system, industrial automation, and IoT networks deployment. Therefore, 5G networks will play an important role in the rolling out of smart city solutions.

Singapore smart city project focuses on people-oriented services and includes digital government platforms and smart healthcare solutions. Singapore also geared up for 5G services and Infocomm Media Development Authority told that Singtel and JVCo operators will be working on 5G deployment. Smart transportation and smart sewage have been deployed by the USA in order to improve public services. USA is supporting research works on 5G by working with major Telecom companies such as T-Mobile. London, UK smart city view is about environmental monitoring that will provide efficient city planning, traffic control, and identification of green initiatives. Some of the solutions are real-time air quality monitoring, smart electricity meters, and garbage disposal systems. EE operator started 5G service in London in 2019. Other 5G network major players in Europe are Ericsson and Vodafone UK. China is also working towards the development of smart cities. Some of the solutions are digitized government platforms, smart transportation, IoT sensors, real-time traffic, and congestion control with big data analytics and cloud computing.

III. TECHNOLOGIES USED IN SMART CITY DEVELOPMENT

Some of the technologies that will be utilized for providing advanced services in a smart city are:

Artificial Intelligence and Machine Learning: When computing systems or machines can imitate human-like intelligence so that can solve a problem or make a decision, it is called artificial intelligence. Deep learning comprises neural network layers which work on a large amount of data and extracts information from them. Deep learning is modeled by training the model on a huge amount of data set similar to the working of the human brain. Machine learning focuses on building and updating the model regularly while processing data. Deep learning and machine learning are an integral part of AI platforms. Some of the AI applications are speech recognition, chatbots, image recognition, recommendation engines, etc.

Big Data Analytics: Big data is data that can be of any type and size. As the data varies and a large amount of data is to be processed, conventional databases cannot be used for the analysis of big data. As the number of sensors, and smart devices is increasing, the volume of data collected by them is also increasing. Advanced

analytics are employed in big data analytics for processing or structured and unstructured datasets. It helps in quickly analyzing a large amount of data and presenting useful results to the users.

Cloud computing: It will one of the main features of smart cities. This remote data center will be providing computing resources, analysis capabilities, storage, and servers for different types of applications. E.g., augmented reality or virtual reality applications will be depending on the cloud computing servers for providing network capabilities to support them on user devices. Different kinds of cloud implementations include private cloud, public cloud, or hybrid cloud. It is less expensive and can be scaled up depending upon the traffic requirement.

IoT and Smart wireless devices: Multiple sensors or battery-operated devices are deployed for real-time monitoring of the physical world. IoT networks in an area may comprise multiple devices that wirelessly communicate with the cloud to upload their data for further analysis. With the advancement in technology, various smart devices such as smart wearable devices including watches and digital eyewear will be providing smart services to the users. These smart sensors and devices will also help in the development of smart cities.

5G Capabilities: 5G Wireless communication network will provide high data throughput, reliable and low latency network coverage in the smart city. 5G network slicing will distribute network resources logically and isolate the virtual networks for providing different services with enhanced security. Industries will be able to privately use the public networks within the smart city. Mixed dynamic needs are catered in 5G such as customers are provided with the public network, however, employees are provided with a private network. Public and private air interfaces are multiplexed according to the requirement. Edge computing is utilized so that a large amount of data can be processed at endpoint nodes without transmitting them to core networks. 5G will handle critical applications efficiently such as vehicle operation, remote-controlled surgical operations by providing a reliable and low latency network. High throughput applications such as high-definition video services and media streaming services will also be supported by 5G.

IV. SMART CITY APPLICATIONS

Some of the smart city use cases are

- Smart governance – digital government platforms, facial recognition, public emergency management, quick warnings, and alerts
- Environment monitoring – smart garbage disposal and recycling system, real-time monitoring, and pollution level reports
- Smart security- automated security systems, biometrics enabled, advanced anti-theft systems, robotic patrolling, AI-assisted video surveillance, and high-definition image recognition.
- Smart Transportation – smart autonomous vehicles, drone deliveries, AR navigation, smart traffic control, fleet monitoring, and parking management
- Smart energy solutions – smart energy allocation, remote maintenance, and automatic monitoring.
- Smart Healthcare – automated logs of user medical history, remote surgery, and remote treatment.

- Smart education – smart interactive learning tools, AR/VR teaching, and learning applications.
- Smart Industry – AR/VR assisted research facilities, remote control of robots for handling production, etc.

V. SMART CITY SOLUTIONS

Smart city solution provides a real-time city view of sensors and systems to give authorities an overview of all the operations and they can take decisions timely. The general architecture of smart city solutions comprises:

- Sensor layer or Data collection layer – This layer is the lowest layer of the architecture that comprises sensors, cameras, battery-operated smart devices, smartphones, smart wearables, etc. that are monitoring different kinds of data by interacting with the physical world.
- Communication network layer or Data transmission layer – These are services that provide connectivity to the cloud or servers. E.g., 4G/5G wireless communication networks, broadband, and internet services.
- Platform service layer or Storage and computing services- This layer comprises the advanced software platforms. It provides scalable, efficient, and reliable computing resources implementing sophisticated analytics such as real-time streaming analysis, big data analysis, and cloud computing. A large amount of data is stored in a database and analyzed to provide useful results.
- Application layer scenarios- These are the end services with which the admin or users interact for accessing the data or the analysis. This covers all kinds of smart solutions available in the smart city such as smart healthcare, smart transportation, smart education, smart governance, smart energy, and environment monitoring.

Now some of the use cases presented by top companies are discussed below:

A. Dell EMC, Intel, SAP, and GDT

Dell EMC, Intel, SAP, and GDT collaborated to provide a smart city solution. The GDT Smart City Framework comprises sensors, GDT digital architecture, smart and connected digital platform, Dell EMC data center, then SAP software platforms that will provide data to the different applications with which end users will be interacting. The data from the different sensors and IoT networks are collected and stored in the SAP HANA repository. SAP HANA application platform analyzes these collected sensor data and turns them into real-time useful actions that can be implemented by city managers for improving the overall smart city user experience. These suggestive measures could help in improving different city services such as healthcare facilities, public safety, and with timely corrective actions, the life of the devices can be improved, and thus, the cost can be reduced. Dell EMC PowerEdge servers comprising Intel Xeon processors have great computing power and can be combined with Dell EMC software, storage, and networking products for better performance. The collected data can also be used for predictive analytics. The data architecture of smart cities should have the capability of storing and handling a huge amount of data i.e., big data components. The collected sensor data is first processed in SAP HANA fast engine and then open-source technologies such as data lake (Hadoop) and big data Hadoop clusters. The next major requirement is sharing of data as open-source so that it can be accessed by the public or authorities as per need. The implementation can be as Hybrid cloud or Off-premises Cloud. The hybrid cloud is a mix of a physical server, private and public cloud services provided by Dell EMC, and a

VMware platform. Off-premises managed cloud implementation is provided by Virtualstream and comprises public, private, and hybrid cloud.

B. IBM

IBM Garage is used for digital transformation and innovation in the public sector field for the development of smart cities. Digitization of services started before Covid-19, however, it got greatly accelerated due to the Covid-19 pandemic and demand for virtual services. AI, Hybrid cloud, and other latest features from IBM will assist the government and healthcare system in automating their different operations. IBM Garage can be customized for different organizations and it can be combined with multi-cloud data, IBM Watson, IoT, AI, machine learning, and security. IBM collaborated with Nova Scotia for Canada's first public sector Garage program in 2018. IBM provides a Garage solution to Nova Scotia that uses the latest technologies to deliver services efficiently. It also automated workflows e.g., IBM assisted Asan Medical Center (AMC) to use a smart platform for allocating beds automatically and thus minimizing the load on staff members. IBM Garage along with AI, machine learning, application interface, cloud integration helped in the development of solutions that are used in smart cities. Other solutions for smart cities include data security, edge computing, infrastructure asset management, and facilities management. Some of the case studies include traffic congestion solutions in Stockholm and the digitization of Rotterdam port using IoT and big data.

C. Cisco

Cisco Kinetics is a smart city IoT platform Cisco. Cisco Kinetics has an open architecture comprising three layers. The city domains layer is at the bottom that comprises different sensors, cameras, IoT networks. Next is the platform layer that has different components such as real-time engine, platform services, APIs for processing data collected from the city domains layers. The application layer provides visualization comprising analyzed data and statistics and a dashboard to the end-user. Cisco Kinetics is a subscription-based platform that provides consistent data, quick responses to concerned departments in case of any event, highly secure services, and efficient services to the public and city authorities.

D. Qualcomm

Qualcomm Smart Cities Accelerator Program launched in April 2019 provides Qualcomm technology-based solutions for bringing together government agencies, enterprises, public sector offices, and cities on a single platform. Verizon, Ayla Networks, Cradlepoint, Guardhat, Quantela, TSM, USI Global, Xingtera, Arrow, Askey, and other organizations are a member of this program. These members are experts in different fields such as hardware, cloud solutions, manufacturing, software, and smart cities end-to-end solutions. Qualcomm and Infinite Computer Solutions are working together for digital transformation and providing IoT as a service. Zyter SmartSpaces by Infinite Computer Solutions will be used in smart city solutions for providing smart and connected services.

E. Ericsson

5G Networks will play a crucial role in providing seamless and reliable connectivity to smart city applications. Machine-to-machine communications and mission-critical applications will be handled very efficiently by 5G. Ericsson provided advanced traffic management system solutions in Dallas for improving traffic congestion.

The system will provide secure sharing of data with other organizations, key performance indicator monitoring, a dashboard with a status view, and automated notifications.

VI. CONCLUSION & FUTURE SCOPE

This paper discusses the smart city concept and its implementation scenarios. The smart city could automate various public sector offices and provide efficient services to the users by reducing the workload on the employees. Automation and digitization of services were revolutionized due to the Covid-19 pandemic. It accelerated the development of digital and virtual services. The various government had launched smart city initiatives. Now with 5G commercialization, the network is capable of handling a variety of smart devices or applications requiring low latency and different bandwidths. Technologies such as AI, machine learning, big data analytics, cloud computing, and 5G network are utilized in developing smart city solutions. Then smart city solution general architecture is disclosed. Smart city solutions by major companies such as IBM Garage, Cisco Kinetics, Dell EMC, Intel, GDT, SAP platforms, Ericsson, Qualcomm, and Verizon are also discussed.

Smart city solutions have a great scope of development. As the number of smart and connected devices is increasing, different kinds of applications and services can be built to provide a better and efficient user experience. Currently, different services such as transportation, healthcare, vehicles, industries, offices, energy-saving solutions are implemented in the smart city. In the future, full-fledged smart city solution could be developed, where AR/VR interactive devices, prompt notifications for specific events, etc. services can be provided.

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