Design and Development of Smart City IoT Solution

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***Abstract*— Smart city technology can make cities more effective and efficient, which is necessary given the projected rapid growth in urban populations over the next few decades.Currently, 23 billion devices are connected to the global Internet, with a total of 8,000 billion devices in the world. A robust and efficient network to handle the huge number of devices that collect information is the challenge to deployment of Smart City Internet of Things(IoT) solutions.**

The objective of this project is to design and develop modules for Smart City IoT Solution. The modules to be designed and developed are data acquisition layer consisting of data simulators, built using JavaScript and IoT gateway, designed using Node-Red and service bus used for communication of data across data acquisition layer, IoT platform and application layer. Service bus is setup on Apache Kafka Environment

***Keywords*___ Include at least 5 keywords or phrases**

I. INTRODUCTION

Smart city initiatives around the world are being enabled by new Internet of Things (IoT) applications. It enables remote monitoring, management, and control of devices, as well as the extraction of fresh insights and actionable data from huge quantities of real time data. A high degree of information technology integration and a broad application of information resources are two of the most important characteristics of a smart city.

Smart technology, smart industry, smart services, smart management, and smart life should all be included in the urban development of a smart city. Smart City IoT solution is a way to utilise technology to handle the exponentially increasing city population as well as increasing city limits. It can help the citizens improve their quality of life, help the administrative system tackle various issues with technological aid, hence making cities a more viable option for settlement.

II. LITERATURE SURVEY

IoT involves learning and interacting with millions of things like online services, sensors, drives and other items. This initiative extends the extent to which IoT may link devices on various platforms. This helps people in several industries such as home automation, networking, data monitoring and others without effort. The development of the interaction between human and machinery has altered dramatically through the years. The road of progress was via the keyboard, mouse, touch and now Voice.

Cities are moving towards a new way to build infrastructure like buildings, transportation, healthcare and public services. The most important objective of this development is to improve the quality of life by providing more efficient and well developed infrastructure such as transportation, digital technologies, sustainable economy, safety, water, energy and renewable energy and public services for better living. All this is possible by means of concept of smart city. It is projected that cities will make an extensive use of sensors and sensor networks to provide specific services, to control traffic, facilitate video surveillance, manage resources allocated to the city and many such things [1]..

Smart City has been an area of interest in the research domain as well as industrial domain. Smart City IoT solution can have various features according to the wide range of interpretations that can be made of the Smart City concept but it can generally be aligned to a generic three layer architecture.

At the lowest layer, urban infrastructure refers to the physical items that already exist in cities, such as bus stops and traffic lights. At the highest layer is the application or service that end users such as citizens, administrators can use to leverage the facilities developed by the smart city solution such as charging points, alert dashboard and information dashboard. The middle layer is often the most crucial and critical part of the smart city architecture that gives a solution its unique selling point by facilitating inclusion of various features such as scalable data communication and analytics approaches for the vast amount of city data that makes the platform efficient and desirable to use[2].

A smart city object can be as simple as a temperature sensor that sends data to the cloud or as complicated as a trip support service that is built from a carefully curated set of Smart City Objects from various domains like the transportation and energy domains[2].

The lack of uniform data and service integration platforms, the transition to digital cities frequently results in apps that represent discrete service and data silos.[2]

A comprehensive survey of M-IoT with an emphasis on architecture, protocols, and applications. Various multimedia applications supported by IoT are surveyed, and numerous use cases related to road traffic management, security, industry, and health are illustrated. We explore the importance of Quality-of-Experience (QoE) and Quality- of-Service (QoS) for multimedia transmission over IoT. We also present the need for better routing and Physical-Medium Access Control (PHY-MAC) protocols for M- mextile. We conclude by discussing the open research issues and potential research areas related to emerging multimedia communication in IoT[3].

The article starts by providing a horizontal overview of the IoT. Then, we discuss the issues considering the characteristics of multimedia. Finally, we explore the limitations of IoT for multimedia computing and present the relationship between the M-IoT and emerging technologies including event processing, feature extraction, cloud computing, Fog/Edge computing, and Software-Defined-Networks (SDNs) The Internet of Things (IoT) is envisaged as the network model to fill the gap between the cyber and physical world. Core con- cept of the IoT is to connect the pervasive objects around us, such as RFID tags, mobile devices, sensors and actuators to the Internet through a wired or wireless network[3].

IoT has created new opportunities for machines to communicate with each other. Currently, 23 billion devices are connected to the global Internet, with a total of 8,000 billion devices in the world.\cite{a2} The vision of integrating multimedia applications of every domain in IoT, developing a smart city and transforming human lives is the vision of the author.[3]

Towards Global IoT-enabled Smart Cities using Adaptive Semantic Adapter. The core idea behind our approach is to introduce interworking that will enable interworking between different platforms based on multiple standards. We present the system based on these proxies and evaluate it in Santander Smart City.\cite{a3} The results demonstrate that it is able to discover and manage IoT sensors connected to both oneM2M and FI Warehousing. It appears that the semantic approach provides flexibility and dynamic adaptivity needed for fast growing smart cities[4]

A. Smart Energy

Some practical applications for smart cities and smart power grids have been outlined to summarise current advances and best practises. The research demonstrates:

i. The importance of smart transducers and sensors in the future's electrical grids and cities[5].

ii.Design that is unique and approaches involving innovative elements with regard to development in relation to the current situation[5].

iii. The usage of smart sensors in several aspects of the smart city is explained, including optimising street lighting, improving surveillance tasks, increasing service efficiency, making buildings more efficient, and improving smart vehicle performance and functionality[5].

Similarly, in order to meet shifting energy demand, future smart power grids would require effective and active management of energy flows. Some of the new elements of the modern power grid include centralised and distributed power generation, multi-directional power flows, and power quality requirements. A vast amount of data from thousands of nodes must be handled for this purpose.The usage of smart power metres is advocated in the article as a way to improve the power grid's performance. Furthermore, satellite communications allows for instant access to information.[5].

Stop cascade by obtaining information from neighbouring grids.There are blackouts. This will improve energy management based on IoT systems for managing the smart power grid of the future[5].

The Energy Management System(EMS) notion has today been developed to be employed at metropolitan level, office building level, and home level, with the same purpose of sophisticated control by means of a computer aid and data acquired based on information communications. Many recent works have been specifically directed to high photovoltaic push for domestic consumers and the efficient use by the domestic energy management system (HEMS) of energy appliances, like storage batteries, heating, ventilating systems and air-conditioning systems for fuel cell cogeneration systems. These many layers of EMSs are crucial elements of the smart city [6].

B. Smart Waste Management

A technological technique for a waste management system is developed with a smart waste-bin. The real-time environment is achieved by utilising the network environment[7].

The implemented system's precise data could be used for the system for effective solid waste handling The system is capable of acquire reliable data in real time that can be used as a basis for future decisions.The load cell calibration methodology simplifies the calibration process so that it can be mounted to a common waste bin without being changed or modified. The level sensors can also be mounted to a regular trash can. As a result, the prototype is appropriate for use in traditional waste management infrastructure.[7]

In a research, open source database of Philadelphia was used to cluster the working area. In particular, an algorithm was developed that automatically creates the working environment. The garbage truck routes are clustered and calculated. Moreover, To forecast and update the weight, we use logistic regression of each garbage can They'll be used to make the next one. which is the best garbage route[8].

Future work must be done to improve the system, such as collecting data in a more efficient manner, that is, not only the amount of waste but also the status of hazard must be recorded. Furthermore, the traffic congestion information, fuel consumption, forecast news, and the ideal garbage truck routes within the input parameters of optimising trash truck routes should be added[8].

C. Apache Kafka and MongoDB for IoT

Big data is increasing because of the use of modern computers. Big data refers to a very big data volume that cannot be managed using typical ways in the database. Traditional database approaches have hit their performance limits and cannot process such data with good results.Big data volumes are going to be huge for any applications, including data-driven cloud applications, large-scale mobile cooperative web apps and user-focused big data-based systems, the scalability of databases and their processing capability would be a must [9].

The initial categorization of Big Data technologies as DB solutions and processing solutions on the market includes MongoDB, Cassandra, Apache Hadoop, Apache Spark and Apache Kafka. In order to improve the accessibility of unstructured data, NoSQL databases are surely the future. They are classed as a document, key value-based, graphical and column based.

D. Database

NoSQL databases are currently the favoured option of industry professionals and developers. Having quickly increasing data demands a suitable storage solution for effective data processing is the main concern. The traditional databases are outmoded due to this necessity and NoSQLs have been taken into account while taking qualities like schema-less data model, elasticity and scalability into account. Relational databases with various software and hardware needs were built at a distinct age. They have not been built to handle additional scalability[10]. Most data are noisy or unstructured and RDBMSs are unable to handle them. These systems are therefore not in a position to meet such issues. In contrast to the RDBMS, the NoSQLs are popular for tasks such as data recovery and collection when keeping consistent models. As noted before, NoSQL is the best solution if big data are saved and processed primarily. Some of the most essential aspects of NoSQL are their simplified architecture, horizontal scalability and their previous availability.

E. Java Script and NodeJS for Simulators

Node is a server- side JavaScript environment based on Google's "V8" engine. Node supports the eventing model at the language level. Java- Script's functional nature makes it extremely easy to create anonymous function objects. For applications such as Web servers, multiple threads enable applications to better use available pro- cessors. Each core simultaneously executing a dif- ferent thread with true parallelism, with each core simultaneouslyexecuting a separate thread[11].

Rather than wasting cycles waiting for a socket operation to finish, the processor sets the I/O operation in motion and executes another thread, thus keeping itself busy doing useful work. The processor switches its execution context to another thread when the current thread performs an I/o operation. It's easier to use than multithreaded programming techniques, such as those used in the Web, which can take many processor cycles to complete a single operation, for example. Instead of waiting for the operation to complete, the processors execute another thread and the current thread does the work, keeping it busy doing its own work, so it doesn't need to wait for the other thread to finish. Event-driven programming is a more efficient, scalable alternative to multithreaded programming[11].

It provides developers with more control over switching between application activities. Applications register interest in certain events, such as data being ready to read on a particular socket. When the event occurs, the notification- proprietary system notifies the application so it can handle the event. It prevents the application from get- neurotransting blocked while waiting in an I/O operation. It also gives the application an indication that further writing to a socket isn't currently possible[11].

F. Node-Red

As the cloud numbers expand, firmware has to be updated more often. That is fantastic. The installed devices are taken out, the code is changed and flashed back. Data and response can be processed elsewhere to address these problems. Node-Red, a visual wire tool, makes it easy to connect devices and quick and easy to establish connections[12].

Intelligent gadgets are widespread throughout these days. It is easy to govern them, but it is a challenging effort to connect them. This work offers a solution for this issue by offering a versatile framework for controlling all cloud IoT devices. This project enables the flexibility to change the reaction process. As an example, this allows the user to alter a report from sending an email to SMS or shutting off light to lessen the luminosity and much more. This process is made simpler with the aid of Node-Red. Node-Red is now running on the locally owned machine, such as Raspberry Pi or Linux. Node-Red may also be placed into the cloud using the IBM Bluemix platform as an additional step in this project[12]..

III. METHODOLOGY

The design methodology includes the following steps:

i. Conduct an analysis to determine the type of data to be simulated.

ii.Developing a prototype of the simulator using Node JS.

iii. Building the IoT gateway to enable data flows.

iv. Designing service bus to send data to the cloud.

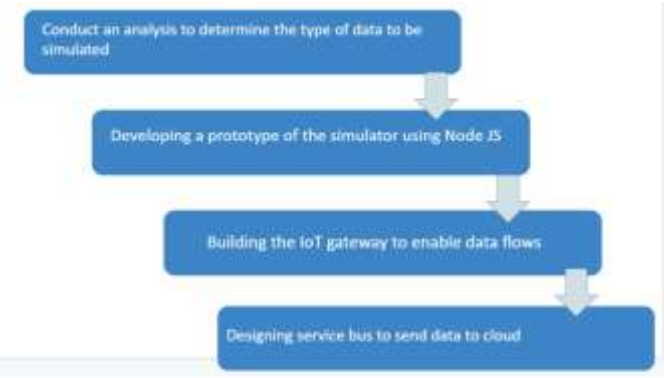

Fig 1: Brief methodology

An important part of developing a smart solution for cities using IoT is to design the solution with high level architecture to begin with the development of the solution and move on to the design and development of individual components. The architecture is ideally modular i.e all its modules are independently developed and then integrated so as to provide a generic solution that can be later expanded to different use cases and solutions can be developed for more problem statements.

A. Architecture

Building an IoT solution involves multiple layers going from physical layer to the application layer with middleware present between these two layers along with network protocols to enable communication. The design procedure begins with developing a high level architecture. A three layered architecture is popular among IoT Solutions developed for various problem statements. The three layers include:

i. Data Acquisition layer

ii.IoT platform

iii.Application layer

The architecture for this project has undergone many revisions and uses FIWARE architecture for Smart Cities as major reference for the design. Architecture is aligned to three layered architecture an example of which is shown in Figure 3.1 but with the modules as shown in Figure 3.2. and involves data security management for every layer. It is designed to be generic and modular in nature so as to accommodate different use cases that can be added to the solution and work independently with the modules already enabled on the platform.

This project mainly focuses on the design and development physical layer and IoT platform layer as it is aligned to the IoT vertical. This essentially involves providing an edge-to-cloud solution where a node at the physical layer is an edge and cloud is a remote computing device.

IV. CONCLUSIONS

The motive to create a Smart City Internet of Things(IoT) Solution is to create a region specific IoT solution by solving critical issues in cities to make city administration more efficient. Data acquisition layer plays an important role in developing this solution. Hence, data collection and aggregation are components of the bottom most layer in the architecture and is the first objective of this project. Data collection is typically done by sensors but in this case, it is being simulated by data simulators. The second objective is to aggregate this data at IoT gateway and create data flows for northbound communication of the data. The final objective is to make this data available for specific subscribers of data with the help of a data streaming environment, Apache Kafka.

The data collection was achieved with the help of data simulators developed using JavaScript. The data is simulated to emulate the working of real-time sensors and aggregated by IoT gateway with the help of data flows created using Node-Red tool. Message brokering system was enable with the design and development of service bus environment using Apache Kafka with application level consumers such as dashboard and middleware consumers such as database.

Data simulation helps in understanding the working of real-time senors and data collection system built using hardware components. The IoT gateway aggregates data at the edge and Kafka enables data communication across all layers of the IoT solution. These results cannot be measured quantitatively but are seen successfully running on a server.

V. FUTURE SCOPE

IoT has not helped the world reach the projection of over 20 billion devices connected to the internet due to absence of low power consuming and robust hardware that is inexpensive to use on a large scale.

One of the main deployment challenges under such heterogeneous wireless environment is to provide reliable communication links to the low cost or/and power-constrained IoT devices. Another main problem is the high failure rate of the low-cost and low-powered sensor nodes.

The implementation stage of the project would face challenges with respect to connection of different IoT devices to the network and setting up of the edge devices across various physical terrains.

In future, Smart City technologies are likely to expand in scope and revolutionize areas such as healthcare, education and policing, while also supporting the growth and development of engaged residents capable of understanding and utilising digital solutions and services.

ACKNOWLEDGMENT

I am deeply grateful to my mentor, M V Jagdish, Lead Architect, IoT, HPE for his guidance and help. I am indebted to my guide, Prof Sujata D Badiger, Assistant Professor, RV College of Engineering : for the wholehearted support, suggestions and invaluable advice throughout my project work and also helped in the preparation of this thesis.I also express our gratitude to my panel members Dr. Uttarakumari M, Professor
and Dr. Nethravati, Assistant Professor, Department of Electronics and Communication
Engineering for their valuable comments and suggestions during the phase evaluations.

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