IoT Solutions for Smart Cities

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Abstract. In recent days, the amount of people migrating to urban regions increases in a notable way. Hence this relocation forces to provide better valuable services to the publics. With the advancement of metering and digital technology, smart cities can be made more smarter with the usage of IoT technology, wherein a lot of real time devices can be smartly interconnected to a centralized network to arrive better engineering solutions. The aim of this article is to provide a wide-ranging review of the various concepts involved in IoT and its several applications. Furthermore, the general architecture of IoT environment and the main challenges posed in the development of IoT environment are also explained.

Keywords— Internet of Things (IoT), Smart City, Smart Buildings, Smart Grids

1. Introduction

Urban areas are developing obstinately and the amount of people migrating to urban places increased by six-fold in the past 20 years. People dwelling in Urban areas face more real time problems related to traffic maintenance, trash removal, water supply, parking maintenance, air quality monitoring and many more. The IoT technology may be welcomingly utilised in the urban environment to develop brilliant IoT solutions so as to provide value added digital services to the public and companies[1].

IoT is not an own technology; moderately it is an amalgamation of sundry technologies that work together in coordination to get both economic and effective digital solutions. The Internet of things(IoT) is a growing smart digital system which is expected to flourish in the forthcoming years to come, where real time simple objects we use every day will be equipped with microcontrollers, transceivers, actuators, smart sensors which gathers the data from users and environment and utilize protocol stack to communicate with the other devices and users to send the gathered data[1]. The data collected by the peripheral nodes are stored physically and analysed to arrive useful inferences out of it. The expanding prevalence of the IoT idea is additionally because of the continually developing number of capable gadgets like cell phones, tablets, portable PCs and sensors that can link the Internet.

In this work an insight to the diverse applications of IoT are discussed. An overview of the IoT system architecture for setting up in an urban environment is also deliberated. Finally, the last section presents the various challenges involved in the deployment of IoT technology in the Urban environment.

2. Attributes of Smart City

According to recent Researches on Smart Cities, the investment on smart city projects are expected to reach 16 billions by 2020. The diverse applications for the deployment of IoT in urban zone are of solid interest in the context of Smart city because they can provide win–win statefor both citizens and public administration. The citizens will get value-adding digital smart services out of IoT
and public administration committee can do better city administration at decreased operational cost by making use of IoT technology.

2.1 A smart solution to Traffic crowding
Traffic crowding are really unavoidable and annoying in a busy city life due to the growth of civilization. IoT provides a smart solution to overcome this complication. Smart traffic lights play a keyrole in this regard. Instead of fixed timing signalling system followed by conventional traffic systems, sensor-based smart traffic systems use a variety of technologies which work on real time vehicular data and changes the signal lights according to current traffic pattern on any intersection or junction[2]. These smart traffic systems will have sensors embedded in it and make use of artificial intelligence structures to take decisions dynamically based on traffic conditions. The types of sensors used may vary based on location and solutions required for the application.

![Fig.1 Smart Traffic Lights](image_url)

In this fig.1 as shown clearly the whole structure of smart traffic lights is centred on real time vehicular data where smart traffic lights are equipped with sensors and cameras that sense volume and velocity of approaching traffic and finally we use this massive amount of data to analyse the traffic pattern and the traffic lights will respond as per the data collected[4]. Even the traffic light can also be embedded with sensors to detect the level of Carbon-dioxide and Nitrous oxide in the air to monitor the level of Pollution at any junction or intersection.

Mohali, a city in Punjab has implemented India’s first 3-D smart traffic lights which regulates traffic sensing the real time traffic on the roads based on the gravity of traffic approaching the signals through self-sensing technique. This smart system will just cost 1% of the fixed signal cost and will save cost and time spent waiting in the traffic signal. This will in turn reduce the reduce the fuel consumption and gas emissions too.

2.2 Smart Trash Management System
Trash management is the main problem in many modern cities, mainly because of the cost involved in the process of disposal of wastes and problem of dumping wastes in landfills as most of the lands in urban zone will be occupied by buildings[2]. The smart solutions to this problem will make a drastic change in the ecology and the users will get better clean environment to dwell upon. Furthermore, it also saves money. IoT makes it happen with the use of intelligent waste containers, which sense the level of load in the container and if the container is about to overflow, it will immediately send information to the control center to take action. The control center will then schedule the pickup of truck accordingly to eliminate overflow.
The IoT technology can also be used to identify optimal path on the way to carry waste containers to reduce the economy involved in transportation of garbage.

2.3. Smart Air Quality Monitoring
Atmospheric conditions continue to get worse each year due to the advancement in civilization and rising gas releases from industries and all types of vehicles. According to the World Health Organization (WHO) recent report, 90% of the population now inhale polluted air both inside the home and outdoor too. Most of the people residing in urban areas get respiratory problems due to continuous inhalation of polluted air.

An IoT based smart air quality monitoring system can be developed to keep an eye on the levels of gases in the air to determine its purity. It provides suitable methods to observe the quality of the air in crowded areas, parks and many public places [2]. The air pollution sensors can be used both in indoor and outdoor environments that monitors the level of pollution in the surrounding area. Even though there are various kinds of air pollution sensors accessible, the majority of the sensors concentrate on the level of four major components: ozone, particulate matter, carbon monoxide and nitrous oxide in the air.

As shown in Fig. 2, the data collected by the air pollution sensors are then communicated to the centralised web server. In the web server the data is analysed using various data science methods and machine learning models to arrive at inferences out of it. This observations about air quality can then be made accessible to the personal fitness applications running on citizen’s mobiles, so that they can select the healthiest route to reach their workplace or home and to perform their outdoor fitness activities like walking, jogging and many more.

2.4. Smart Lighting System
Traditional lighting scheme consumes more energy and power. The manual lightning method is expensive and one of the greatest suppliers to energy waste. IoT technology can be utilized along with automation process enables by sensors which cuts down power consumption by almost 30%. This automation method collaborated with IoT can be made a better alternative to conventional street light systems[5].

Lighting is the basic component to be fixed in all the buildings and the luminaire (an entire light system that produces light) is connected to a source of power. It is the perfect device to gather data on what is happening in the building at any given time. Sensors are embedded in the luminaire and they will act as a data node in the network[5]. The Luminaire will collect the data about the
surrounding environment light conditions, which will then be sent to the centralised server where decisions will be taken to automate light on/off positions and increase the intensity of light if required.

![Fig. 3 Smart Lighting System enabled by IoT](image)

As shown in Fig.3, Smart Lighting provides a lot of rewards- It saves energy to a greater extent and remote accessing and controlling of lights are made possible which reduces the operation time in a notable way. Even safety alarms can be set and sent to the controller’s mobile as notifications to take necessary actions as per the environmental lighting condition.

2.5. Smart Water Supply and Management System

Water, the precious commodity is becoming scarce rapidly. It is estimated that by 2030 almost half of the urban population will dwell in areas with more water scarcity. Thus, IoT (Internet of Things) based smart water management digital solutions are essential in order to evade a pre-anticipated water crisis.

A Smart water management system consists of physical devices such as pipes, reservoirs with in-built sensors which senses the leakage and malfunctions at different locations. Smart IoT water flow meter manages the water flow between multiple distribution lines. It senses the water flow through a particular line and allocate water supply accordingly which reduces the operational cost in traditional water management system [2]. Smart IoT water valves which detects pipe bursts can be used in piping which can be accessed and controlled via internet to avoid water wastage if a pipe gets damaged and water leaks through it. IoT smart water management system provides to municipalities to reduce operational cost which includes construction, maintenance and more.

3. Urban IoT Architecture

There is no universally accepted common architecture for IoT environment. Researchers propose different architectures in their own perspectives. There are three types of architecture commonly proposed for IoT. They are- Three-layer, Four-layer and Five-layer architecture. One of the architectures described here is a five layered architecture- which comprises of five layers: Perception layer, Network layer, Processing layer, Application layer and Business layer.

![Fig. 4 Five Layer IoT Architecture](image)
As shown in Fig.4, the five layered architecture for IoT environment works as described below.

The perception layer also known as physical layer includes sensors and actuators for sensing and gathering data from the environment. It recognizes other smart objects or peripheral nodes in the environment and communicate with them thereby transmit the collected data to the centralized control center. The network layer transfers the sensed data from the perception layer to the processing layer and vice versa making use of various types of communication protocol such as LAN, wireless system, Bluetooth and RFID[5].

The middleware layer is also known as the processing layer stores, analyses, and processes enormous amounts of data received from the transport layer. It can be able to deliver a varied set of services to the lower layers. It makes use of many background processes such as maintain databases, cloud environment, artificial intelligence and big data analysis to design smart solutions [5].

The application layer is responsible for delivering application services to the user such as smart homes, smart traffic, smart lighting and many more. It includes protocols like CoAP, AMQP, DDS, HTTP. The business layer manages the applications, business models, and users’ privacy, the entire IoT system as a whole. It integrates certain graphsand models making use of the data received from the application layer to make it presentable for better analysis and take actions accordingly.

4. Challenges of Smart City through IoT

This section describes the notable challenges that may arise in the deployment of IoT in Urban zone.

4.1. Data Security & Privacy

Security is one of the most important concern to be focused on through the implementation of IoT for smart city. With the growth in number of devices connected in IoT network, the risks of network becoming vulnerable to attacks through weak devices is higher. Most of the connections with IoT peripheral nodes will be enabled through RFID and these are vulnerable to hacks. The hacker doesn’t need to hack every device but just hacking one weak device in an interconnected IoT environment will make the entire city vulnerable. Such hacks can be more insecure and to the worst case can even affect people’s health and security as the whole smart city services will be interconnected starting from simple coffee shops to big hospitals.

Securing IoT devices can only be successful if the complete IoT network involving all peripheral nodes, links and technologies be protected well against attacks. To achieve this IoT network designers and sensor developers must focus on security as a compulsory requirement through the product development. Making use of tamper-proof hardware, secure software will strengthen the security of the environment. Some of the notable IoT security practices are listed below:

- IoT devices have to be developed including security component right from the initial stage itself. Making use of secure hardware and secure software patches can reduce the risk of data hacking by the hackers.
- The user Login credentials should be simply coded. The users have to be instructed to change their login credentials at reasonable times. They should prefer biometrics for user validation.
- Network security has to be ensured while establishing IoT infrastructure in urban zone. Making use of antivirus software can secure the system. Installing hardware and software firewalls and blocking unauthorized IP addresses are some of the commonly used practices to design a secure environment[2].
- Users of IoT play a crucial role in making the entire designed IoT network secure. The consumers have to be educated about the threats to IoT systems and have be taught with the secure practices they have to adopt to stay secure[2]. The Software developers have to keep in touch with end users, and emphasize the importance of proper security measures. IoT is only becoming more prevalent, and end users may be one of the best defences against breaches.
5. The Future of IoT
As detecting and communication technologies continue to become cheaper as day passes, more and more devices are introduced in the market that connect to internet thereby with IoT network. This will put the IoT environment under total risk and hence security features need to be hard coded. Most companies for IoT are at the initial stage of development. However, as the number of connected devices continues to increase, our home environment as well as working environments are becoming overheard with clever IoT devices which will be of great use and most of the people are openheartedly welcoming the new era of smart devices providing smart solutions to many real time urban problems.[9]

6. Conclusions
In this paper, we have thrown light on smarter applications of IoT which can be deployed in the Urban zones. Furthermore, the various challenges involved in the execution of the smart city have been addressed. The discussed technologies are about to be standardized shortly, and industries are more interested in the production of devices that utilizes these technologies to deliver varied applications of interest to the users of today era. Eventually the inference is that smart city is a great idea which focusses on all the basic services and if implemented cautiously it surely helps us to arrive smarter solutions to urban region complications in an effective way.

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