BACHELOR OF SCIENCE IN ELECTRONIC AND TELECOMMUNICATION ENGINEERING

Design and Analysis of an IoT Based Framework for Crowd Management

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DEDICATION

This thesis work is dedicated to all of our honorable teachers and parents.

CERTIFICATE OF APPROVAL

The thesis entitled as “Design and Analysis of an IoT Based Framework for Crowd Management.” submitted by Md. Mohiuddin Joy, bearing ID No: T173037, to the Department of Electronic and Telecommunication Engineering (ETE) of International Islamic University Chittagong (IIUC) has been found as satisfactory for the partial fulfillment of the requirements for the Degree of Bachelor in Electronic and Telecommunication Engineering and approved as to its style and contents for the examination held on 19th November 2022.

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CANDIDATES DECLARATION

It is hereby declared that the work presented in this thesis has not been submitted elsewhere for the award of any degree or diploma, does not contain any unlawful statement.

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ABSTRACT

Modern technology aims not only to make people's life easier but also more safely. Being in a highly crowded country like Bangladesh tends to make you think about crowd problem. Which requires immediate solution. Very high Crowd may result on pushing, mass panic, stampede, crowd-crush and causing an overall control loss. Our current work introduced a IoT based crowd management system. The system consists of two main sides. Admin side and User side. Consisting of four layers: Sensor, Networking, Service and Interface Layer. The aim is to strongly support administrators controlling and distributing visitors over the given place. The sensor layer is responsible for crowd data acquisition. The networking and service layer acts as management layer. It includes web services which are responsible for collecting and analyzing the data coming from the sensors. It then notifies administrators about overcrowded areas to take the suitable decisions. Server side is connected to IP cameras to detect crowd level in certain locations to report it to admin side. while the interface layer is for different users to receive data and alarm from the admin side. The suggested frame work provides an effective method to connect and alert all of the users immediately, preventing high crowd level danger.

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ABBREVIATION

IoT	Internet of Things
IEEE	Institute of Electrical and Electronic Engineers
RFID	Radio Frequency Identification
WSN	Wireless Sensor Network
SOA	Service Oriented Architecture
GPS	Global Positioning System
CMF	Crowd Management Framework
SP	Shortest Path
GSM	Global System for Mobile communication
FSC	Forest Stewardship Council
2D	Two Dimension
VSWR	Voltage Standing Wave Ratio
WCC	Wireless Communication Centre
HFSS	High Frequency Structure Simulator
Wi-Fi	Wireless Fidelity
ICT	Information and Communication Technology

Chapter 1

Introduction

1.1 Internet of Things(IoT):

As an emerging technology, the Internet of Things(IoT) is expected to offer promising solutions to transform the operation and role of many existing industrial systems such as transportation systems and manufacturing systems. For example, when IoT is used for creating intelligent transportation systems, the transportation authority will be able to track each vehicles existing location, monitor its movement, and predict its future location and possible road traffic. The term IoT was initially proposed to refer to uniquely identifiable interoperable connected objects with radio-frequency identification (RFID) technology. Later on, researchers relate IoT with more technologies such as sensors, actuators, GPS devices, and mobile devices. Today, a commonly accepted definition for IoT is a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'Things' have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network [1].

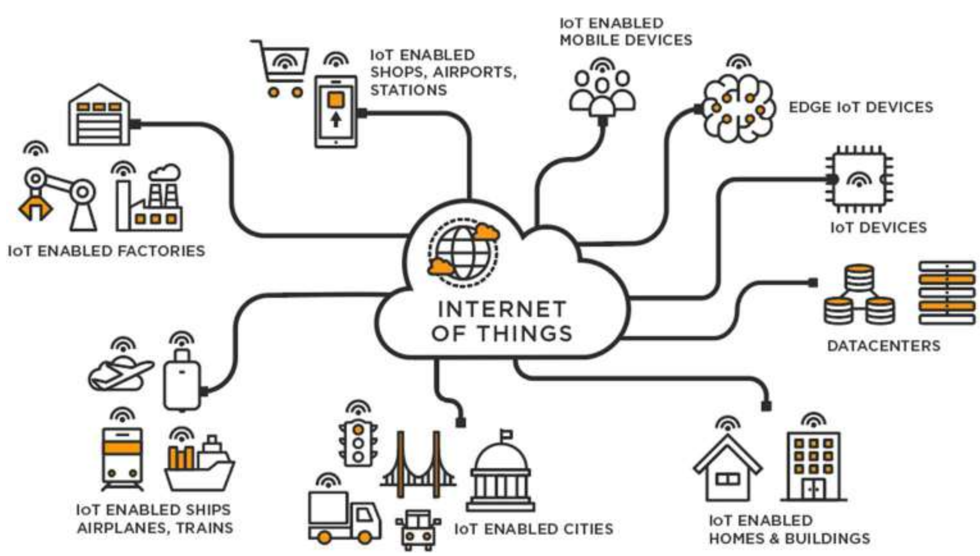

Figure 1.1: Internet of Things (IoT).

Specifically, the integration of sensors/actuators, RFID tags, and communication technologies serves as the foundation of IoT and explains how a variety of physical objects and devices around us can be associated to the Internet and allow these objects and devices to cooperate and communicate with one another to reach common goals. There is a growing interest in using IoT technologies in various industries. A number of industrial IoT projects have been conducted in areas such as agriculture, food processing industry, environmental monitoring, security surveillance, and others.

1.2 Background and Current Research of IoT:

IoT can be considered as a global network infrastructure composed of numerous connected devices that rely on sensory, communication, networking, and information processing technologies [2]. A foundational technology for IoT is the RFID technology, which allows microchips to transmit the identification information to a reader through wireless communication. By using RFID readers, people can identify, track, and monitor any objects attached with RFID tags automatically. RFID has been widely used in logistics, pharmaceutical production, retailing, and supply chain management, since 1980s . Another foundational technology for IoT is the wireless sensor networks (WSNs), which mainly use interconnected intelligent sensors to sense and monitoring. Its applications include environmental monitoring, healthcare monitoring, industrial monitoring, traffic monitoring, and so on.

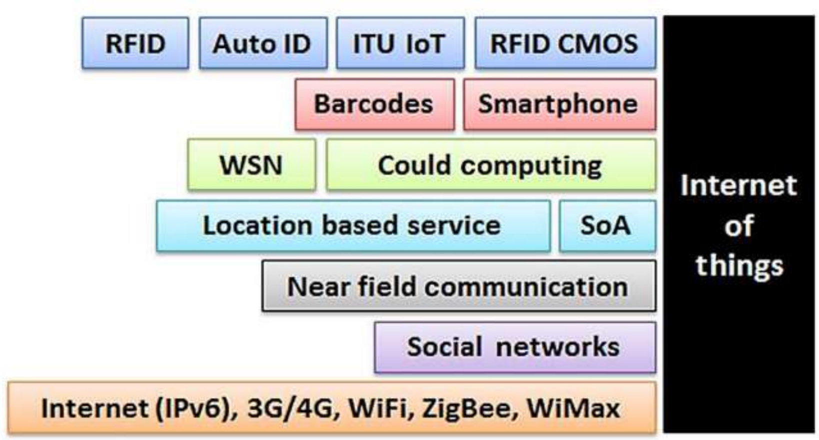

Figure 1.2: Technologies associated with IoT.

The advances in both RFID and WSN significantly contribute to the development of IoT [3]. In addition, many other technologies and devices such as barcodes, smart phones, social networks, and cloud computing are being usedto form an extensive network for supporting IoT (see Fig. 1.2). So far, IoT has been gaining attraction in industry such as logistics, manufacturing, retailing, and pharmaceutics. With the advances in wireless communication, smartphone, and sensor network technologies, more and more networked things or smart objects are being involved in IoT. As a result, these IoT-related technologies have also made a large impact on new information and communications technology (ICT) and enterprise systems technologies (see Fig. 1.3).

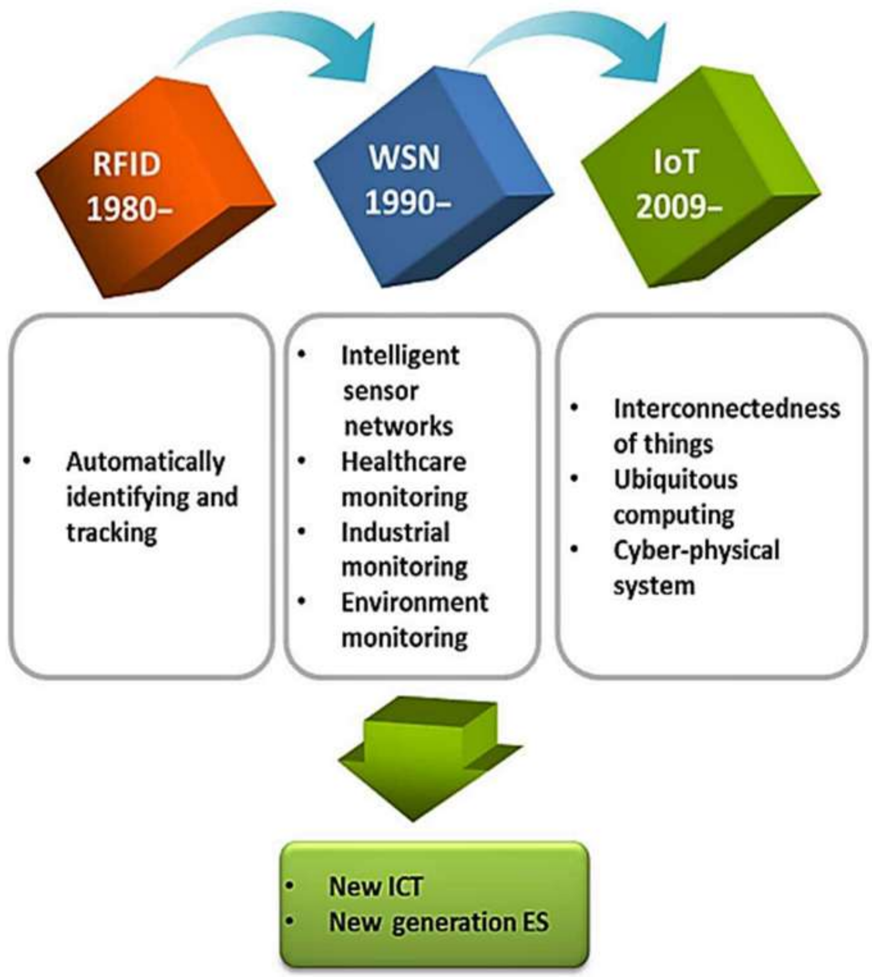

Figure 1.3: IoT-related technology and their impact on new ICT and enterprise systems.

In order to provide high-quality services to end users, IoT's technical standards need to be designed to define the specification for information exchange, processing, and communications between things. The success of IoT depends on standardization, which provides interoperability, compatibility, reliability, and effective operations on a global scale. Many countries and organizations are interested in the development of IoT standards because it can bring tremendous economic benefits in the future. Currently, numerous organizations such as International Telecommunication Union, International Electro-technical Commission, International Organization for Standardization, IEEE, European Committee for Electro-technical Standardization, China Electronics Standardization Institute, and American National Standards Institute are working on the development of various IoT standards. As so many organizations are involved in the development of IoT standards, a strong coordination. between different standardization organizations is necessary to coordinate and govern the relationships between international standards organizations and national/regional standards organizations. By establishing widely accepted standards, developers and users can implement IoT applications and services that would be deployed and used on a large scale, while saving the development and maintenance cost in the long run. The standardization of the technologies in IoT will also accelerate the wide spread of IoT technology and innovations. So far, many countries have significantly invested on IoT initiatives. The U.K. government has launched a £5 m project to develop IoT. In Europe Union, the IoT European Research Cluster (IERC) FP7 (http://www.rfid-in-action.eu/cerp/) has proposed a number of IoT projects and created an international IoT forum to develop a joint strategic and technical vision for the use of IoT in Europe [5]. China takes IoT seriously and plans to invest $800 million in the IoT industry by 2015. China aims to take a leading role in setting international standards for IoT technologies. In the U.S., IBM and ITIF (The Information Technology and Innovation Foundation) reported, in 2009, that IoT can be an effective way to improve traditional physical and information technology infrastructure, and will have a greater positive impact on productivity and innovation. Japan launched u-Japan and i-Japan strategies, respectively, in 2008 and 2009, in order to use IoT to support daily lives [6].

1.3 SOA for IoT:

IoT aims to connect different things over the networks. As a key technology in integrating heterogeneous systems or devices, SOA can be applied to support IoT. SOA has been successfully used in research areas such as cloud computing, WSNs, ands vehicular network. Quite a few ideas have been proposed to create multi-layer SOA architectures for IoT based on the selected technology, business needs, and technical requirements. For example, the International Telecommunication Union recommends that IoT architecture

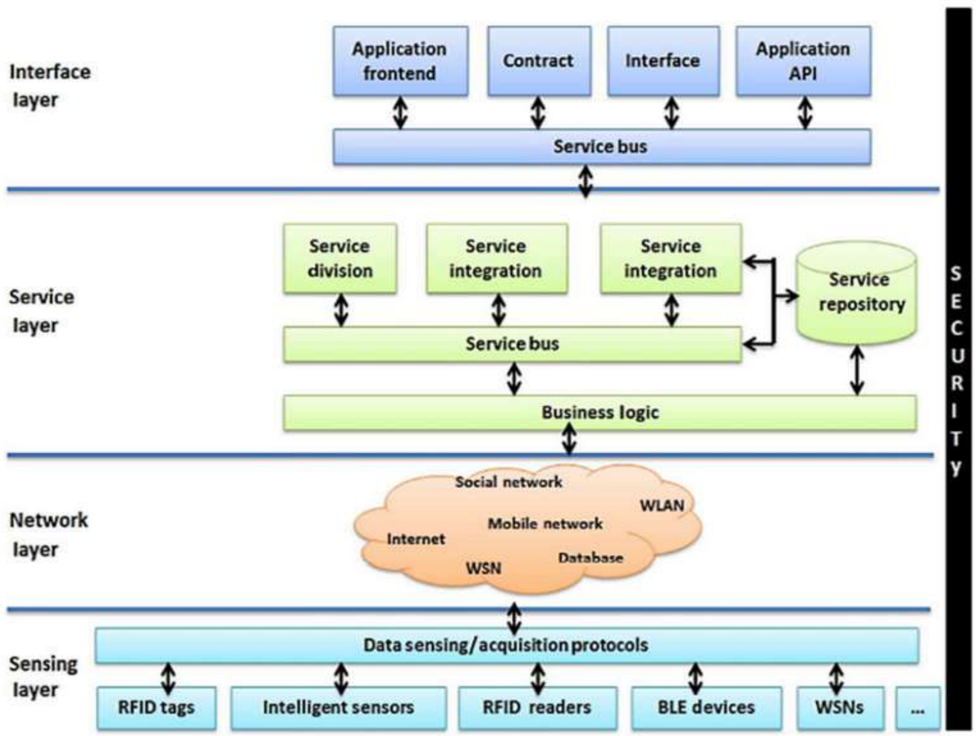

Figure 1.4: SOA for IoT.

consists of five different layers: sensing, accessing, networking, middleware, and application layers. Jia.and Domingo propose to divide the IoT system architecture into three major layers: perception layer, network layer, and service layer (or application layer). Atzori developed a three-layered architectural model for IoT which consists of the application layer, the network layer, and the sensing layer [3]. Liu designed an IoT application infrastructure that contains physical layer, transport layer, middleware layer, and applications layer. From the perspective of functionalities, a four-layered SOA of IoT is shown in Table 1. From the technology perspective, the design of an IoT architecture needs to consider extensibility, scalability, modularity, and interoperability among heterogeneous devices. As things might move or need real-time interaction with their environment, an adaptive architecture is needed to help devices dynamically interact with other things. The decentralized and heterogeneous nature of IoT requires that the architecture provides IoT efficient event-driven capability. Thus, SOA is considered a good approach to achieve interoperability between heterogeneous devices in a multitude of way.

TABLE I. A FOUR-LAYERED ARCHITECTURE FOR IOT [3].

Layers	Description
Sensing Layer	This layer integrated with existing hardware (RFID, sensors, actuators, etc.) to sense/control the physical world and acquire data
Networking Layer	This layer provides basic networking support and data transfer over wireless or wired network
Service Layer	This layer creates and manages services. It provides services to satisfy user needs
Interface Layer	This layer provides interaction methods to users and other applications

1.3.1 Sensing Layer:

IoT can be considered as a world-wide physical inner connected network, in which things can be connected and controlled remotely. As more and more devices are equipped with RFID or intelligent sensors, connecting things becomes much easier [5]. In the sensing layer, the wireless smart systems with tags or sensors are now able to automatically sense and exchange information among different devices. These technology advances significantly improve the capability of IoT to sense and identify things or environment. In some industry sectors, intelligent service deployment schemes and a universal unique identifier (UUID) are assigned to each service or device that may be needed. A device with UUID can be easily identified and retrieved. Thus, UUIDs are critical for successful services.

1.3.2 Networking Layer:

The role of networking layer is to connect all things together and allow things to share the information with other connected things. In addition, the networking layer is capable of aggregating information from existing IT infrastructures (e.g., business systems, transportation systems, power grids, healthcare systems, ICT systems, etc.). In SOA-IoT, services provided by things are typically deployed in a heterogeneous network and all related things are brought into the service Internet. This process might involve QoS management and control according to the requirements of users/applications. On the other hand, it is essential for a dynamically changing network to automatically discover and map things in a network. Things need to be automatically assigned with roles to deploy, manage, and schedule the behaviors of things and be able to switch to any other roles at any time as needed. These capabilities enable devices to be able to collaboratively perform tasks. To design the networking layer in IoT, designers need to address issues such as network management technologies for heterogonous networks (such as fixed, wireless, mobile, etc.), energy efficiency in networks, QoS requirements, service discovery and retrieval, data and signal processing, security, and privacy [5].

1.3.3 Service Layer:

Service layer relies on the middleware technology that provides functionalities to seamlessly integrate services and applications in IoT. The middleware technology provides the IoT with a cost-efficient platform, where the hardware and software platforms can be reused [6]. A main activity in the service layer involves the service specifications for middleware, which are being developed by various organizations. A well-designed service layer will be able to identify common application requirements and provide APIs and protocols to support required services, applications, and user needs. This layer also processes all service-oriented issues, including information exchange and storage, data management, search engines, and communication.

1.3.4 Interface Layer:

In IoT, a large number of devices involved are made by different manufacturers/vendors and they do not always follow the same standards/protocols. As a result of the heterogeneity, there are many interaction problems with information exchange, communication between things, and cooperative event processing among different things. Furthermore, the constant increase of things participating in an IoT makes it harder to dynamically connect, communicate, disconnect, and operate. There is also a necessity for an interface layer to simplify the management and interconnection of things. An interface profile (IFP) can be seen as a subset of service standards that support interaction with applications deployed on the network. A good interface profile is related to the implementation of Universal Plug and Play (UPnP), which defines a protocol for facilitating interaction with services provided by various things. The interface profiles are used to describe the specifications between applications and services. The services on the service layer run directly on limited network infrastructures in order to effectively find new services for an application, as they connect to the network [6]. Recently, a SOCRADES integration architecture (SIA) has been proposed to effectively interact between applications and services. Traditionally, the service layer provides universal API for applications. However, the recent research results on SOA-IoT reported that service provisioning process (SPP) can also effectively provide interaction between applications and services. The SPP first performs a "types query" that sends a request for services with a generic WSDL format, and then uses a "candidate search" mechanism to find potential services. Based on the "Application context" and "QoS information," all service instances are ranked and a "On-Demand service provisioning" mechanism will be used to identify a service instance that matches the application's requirements. In the end, a "Process Evaluation" is used to evaluate the process.

1.4 Key Enabling Technologies:

IoT primarily exploits standard protocols and networking technologies. However, the major enabling technologies and protocols of IoT are RFID, NFC, low-energy Bluetooth, low-energy wireless, low-energy radio protocols, LTE-A, and WiFi-Direct. These technologies support the specific networking functionality needed in an IoT system in contrast to a standard uniform network of common systems.

1.4.1 Identification and Tracking Technologies in IoT:

The identification and tracking technologies involved in IoT include RFID systems, barcode, and intelligent sensors. A simple RFID system is composed of an RFID reader and an RFID tag. Because of its ability to identify, trace, and track devices and physical objects, the RFID system is increasingly being used in industries, such as logistics, supply chain management, and healthcare service monitoring [7]. Other benefits of the RFID system include providing precise real-time information about the involved devices, reducing labor cost, simplifying business process, increasing the accuracy of inventory information, and improving business efficiency. So far, the RFID system has been successfully used by numerous manufacturers, distributors, and retailers in many industries.

1.4.2 Communication Technologies in IoT:

IoT can contain many electronic devices, mobile devices, and industrial equipment. Different things have different communication, networking, data processing, data storage capacities, and transmission power [8]. For instance, many smart phones now have powerful communication, networking, data processing, and data storage capacities. Compared to smart phones, heart rate monitor watches only have limited communication and computation capabilities. All these things can be connected by networking and communication technologies.

1.4.3 Service Management in IoT:

Service management in IoT refers to the implementation and management of quality IoT services that meet the needs of users or applications. The SOA can be used to encapsulate services by hiding the implementation details of services such as protocols used. This makes it possible to decouple between components in a system and therefore hide the heterogeneity from end users [9]. An SOA-IoT allows applications to use heterogeneous objects as compatible services. On the other hand, the dynamic nature of IoT applications requires IoT to provide reliable and consistent services. An effective SOA can minimize the impact caused by device moves or battery failure. A good example is the OSGi platform that applies a dynamic SOA architecture to enable the deployment of smart services. As an effective modular platform for service deployment, OSGi has been employed in diverse contexts (e.g., mobile apps, plug-in, application servers, etc.). In IoT, the service composition based on OSGi platform can be implemented by Apache Felix iPoJo.

1.4.4 Key IoT applications in Industries:

IoT applications are still in its early stage. However, the use of IoT is rapidly evolving and growing. Quite a few IoT applications are being developed and/or deployed in various industries including environmental monitoring, healthcare service, inventory and production management, food supply chain (FSC), transportation, workplace and home support, security, and surveillance. Atzori and Miorandi provide a general introduction to IoT applications in various domains. Different from their discussions, our discussion specifically focuses on industrial IoT applications. The design of industrial IoT applications needs to consider multiple goals.

1.4.5 IoT in the healthcare service Industry:

IoT provides new opportunities to improve healthcare. Powered by IoT's ubiquitous identification, sensing, and communication capacities, all objects in the healthcare systems (people, equipment, medicine, etc.) can be tracked and monitored constantly. Enabled by its global connectivity, all the healthcare-related information (logistics, diagnosis, therapy, recovery, medication, management, finance, and even daily activity) can be collected, managed, and shared efficiently. For example, a patient's heart rate can be collected by sensors from time to time and then sent to the doctor's office. By using the personal computing devices (laptop, mobile phone, tablet, etc.) and mobile internet access (WiFi, 3G, LTE, etc.), the IoT-based healthcare services can be mobile and personalized [14]. The wide spread of mobile internet service has expedited the development of the IoT-powered in-home healthcare (IHH) services. Security and privacy concerns are two major challenges.

1.4.6 IoT in FSC:

Today's FSC is extremely distributed and complex. It has large geographical and temporal scale, complex operation processes, and large number of stakeholders. The complexity has caused many issues in the quality management, operational efficiency, and public food safety. IoT technologies offer promising potentials to address the traceability, visibility, and controllability challenges. It can cover the FSC in the so-called farm-to-plate manner, from precise agriculture, to food production, processing, storage, distribution, and consuming. Safer, more efficient, and sustainable FSCs are expectable in the future [12].

1.4.7 IoT for Safer Mining Production:

Mine safety is a big concern for many countries due to the working condition in the underground mines. To prevent and reduce accidents in the mining, there is a need to use IoT technologies to sense mine disaster signals in order to make early warning, disaster forecasting, and safety improvement of underground production possible. By using RFID, WiFi, and other wireless communications technology and devices to enable effective communication between surface and underground, mining companies can track the location of underground miners and analyze critical safety data collected from sensors to enhance safety measures. Another useful application is to use chemical and biological sensors for the early disease detection and diagnosis of underground miners, as they work in a hazardous environment. These chemical and biological sensors can be used to acquire biological information from human body and organs and to detect hazardous dust, harmful gases, and other environmental hazards that will cause accidents. A challenge is that wireless devices need power and could potentially detonate gas in the mine. More research is needed regarding safety characteristics of IoT devices used in the mining production.

1.4.8 IoT in Transportation and Logistic:

IoT will play an increasingly important role in transportation and logistics industries. As more and more physical objects are equipped with bar codes, RFID tags or sensors, transportation and logistics companies can conduct real-time monitoring of the move of physical objects from an origin to a destination across the entire supply chain including manufacturing, shipping, distribution, and so on. Furthermore, IoT is expected to offer promising solutions to transform transportation systems and automobile services. As vehicles have increasingly powerful sensing, networking, communication, and data processing capabilities, IoT technologies can be used to enhance these capabilities and share under-utilized resources among vehicles in the parking space or on the road.

1.5 What is Crowd:

An assembly of persons large enough to produce a sense of considerable mass, casually gathered together without organized discipline or order. A company of persons associated by a common tie, a densely packed assembly; a throng, in which space is insufficient. Crowds are not a new phenomenon. The daily rush hour in major cities and towns, the crowd celebrating the New Year, or a local football or ice hockey game all represent occasions when large numbers of people concentrate in a relatively small area for a particular purpose. Most large gatherings do succeed in assembling and then dispersing peacefully without injury or damage to the individual or to property or issues of antisocial behavior. However, a crowd does have the potential for disorder, antisocial behavior, and violence and, by extension, danger. The element of danger has led sociologists to study the behavioral characteristics and that has allowed them to identify crowds as either passive or active [15].

1.6 Technological advancement in Crowd Management:

The recent advancement of the Internet of Things has controlled several surveillance applications, specifically in crowd monitoring. Over the past few years, surveillance systems enabled with the IoT devices and sensors provide a useful and accurate system to manage and monitor crowds of people in public gatherings. Recently, crowd surveillance has been increasingly prevalent in smart cities due to its widespread usage in security and surveillance applications [14]. It has continuously gained importance in the area of computer vision, machine learning, and deep learning. A variety of methods have been developed for the automatic monitoring of people in different environments, including supermarkets, train stations, airports, indoor campuses, and other public places. It has a large-scale of applications, such as crowd management, monitoring, crowd analysis, anomalous activity detection, door access control, employee activities monitoring, and so on. Likewise, with these applications, it is considered as challenging task for researchers because of variable visual appearance, particularly with regard to a person's size, shape, body articulation, and pose.

1.7 Advantages of IoT:

- **Minimize human effort:** As IoT devices interact and communicate with each other, they can automate the tasks helping to improve the quality of a business's services and reducing the need for human intervention.
- **Save time:** By reducing the human effort, it saves a lot of our time. Saving time is one of the primary advantages of using the IoT platform.
- **Enhanced data collection:** Information is easily accessible, even if we are far away from our actual location, and it is updated frequently in real-time. Hence these devices can access information from anywhere at any time on any device.
- **Improved security:** If we have an interconnected system, it can assist in the smarter control of homes and cities through mobile phones. It enhances security and offers personal protection.
- **Efficient resource utilization:** We can increase resource utilization and monitor natural resources by knowing the functionality and how each device works.
- **Reduced use of other electronic equipment:** Electric devices are directly connected and can communicate with a controller computer, such as a mobile phone, resulting in efficient electricity use. Hence, there will be no unnecessary use of electrical equipment.
- **Use in traffic systems:** Asset tracking, delivery, surveillance, traffic or transportation tracking, inventory control, individual order tracking, and customer management can be more cost-effective with the right tracking system using IoT technology.
- **Useful for safety concerns:** It is helpful for safety because it senses any potential danger and warns users. For example, GM OnStar is an integrated device that

identifies a car crash or accident on the road. It immediately makes a call if an accident or crash is found.

- **Useful in the healthcare industry:** Patient care can be performed more effectively in real-time without needing a doctor's visit. It gives them the ability to make choices as well as provide evidence-based care.

1.8 Disadvantages of IoT:

- **Security issues:** IoT systems are interconnected and communicate over networks. So, the system offers little control despite any security measures, and it can lead to various kinds of network attacks.
- **Privacy concern:** The IoT system provides critical personal data in full detail without the user's active participation.
- **Increased unemployment:** Unskilled workers or even the skilled ones are at a high risk of losing their jobs, leading to high unemployment rates. Smart surveillance cameras, robots, smart ironing systems, smart washing machines, and other facilities are replacing the humans who would earlier do these works.
- **The complexity of the system:** The designing, developing, maintaining, and enabling the extensive technology to IoT system is quite complicated.
- **High chances of the entire system getting corrupted:** If there is a bug in the system, it is possible that every connected device will become corrupted.
- **Lack of international standardizations:** As there is no international standard of compatibility for IoT, it is problematic for devices from different manufacturers to communicate with each other.
- **High dependency on the internet:** They rely heavily on the internet and cannot function effectively without it.
- **Reduced mental and physical activity:** Overuse of the internet and technology makes people ignorant because they rely on smart devices instead of doing physical work, causing them to become lethargic and inactive.

1.9 Research Problem:

Reviewing the papers, we have found out that most papers have been researched and studied on Hajj and other more relevant crowd. But the crowd problem in our country seems to be minimal but has a bad impact in our life specially in the last pandemic situation. In the pandemic situation there is a urgency of crowd management. We have tried to create a proper crowd management framework in this paper.

1.10 Objectives:

The main objective of this paper is to create a proper crowd management system for our country. For this to happen we tried to create a diagram and a flow chart that will resolve these crowd problem of our country.

1.11 Thesis Organization:

The first chapter of this book is "Introduction". In this chapter, we discussed about IoT , research done in IoT, different fields of IoT, IoT in our day to day life. Then we discussed about crowd and crowd management system. Evaluation of crowd management in the world. The second chapter, "Literature Review" contains a summary of different papers which have been published in the recent past. The papers were selected based on the techniques and requirements relating to this work and works done in recent years. “Methodology” is the third chapter of this book. This part describes the steps which are followed to design this framework. The whole procedure of this work is mentioned there. Following this, the "Result Analysis" part is discussed in the fourth chapter of this book. In this part, the performance of the framework and flow chart is well described with several situations. which are discussed with proper explanation. Fifth chapter contains "Conclusion" part where we summarized our whole work, limitations and future work to be done. At the very end of this book, there is "References". While doing this research work, different types of important pieces of information were collected from different papers which will compliment this work. Those papers are mentioned in this chapter with proper identifications.

Chapter 2

Literature Review

2.1 Paper Review:

In this section, the works by other researchers that are related to this thesis " Design and Analysis of an IoT Based Framework for Crowd Management" will be reviewed, which is an essential part to ensure the success of this research.

1. Research Paper on, "A Low Cost IoT Based Crowd management system for public transport." [16]

In this paper, The study presented the management of the crowd using iot method in which the crowd is managed by Mobile application. This paper shows the crowd management system using iot devices like mobile phones. but, which application is developed and how it works for crowd management that is not written in that.

2. Research Paper on, "Crowd Analysis For Congestion Control Early Warning system On Foot Over Bridge." [17]

In this paper, the proposed congestion control technique exhibits quite significant result on the proposed dataset made from the virtual simulation of FOB(foot over bridge) scenario. Early Warning System(CCEWS), for congestion control with the help of object detection and object tracking technique. Objectdetection is performed by following the faster R-CNNarchitecture in which Google inception model is used as a pre-trained CNN model and with Tt the help of proposed object tracking techniquethe crowd abnormality is analyzed.

3. Research paper on, "Vehicular Crowd Management: An IoT Based Deprature Control and navigation System." [18]

In this paper, Large sports and entertainment events such as soccer games or concerts attract an immense number of fans, most of whom use personal vehicles to get to the event. Such a large number of cars presents a "vehicular crowd" that needs to leave in an organized, timely, and safemanner after the event. This crowd manage through vdc module and navigation system and local cameras.

4. Research paper on, "A Privacy Aware Crowd Management System for Smart Cities and smart Buildings." [19]

In this paper, we describe a novel system architecture for real-time crowd recognition for smart cities and smart buildings that can be easily replicated. The described system proposes a privacy- aware platform that enables the application of artificial intelligence mechanisms toassess crowds' behavior in buildings employing sensed Wi-Fi traces.

5. Research paper on, "A review on technological advancement in crowd management system." [20]

In this paper, The study discussed the crowd modelling aspects during theplanning of crowded scenarios, and the technological advancements in crowd data acquisition techniques (based on vision, wireless/ Radio frequency (RF) and web/Social- Media data mining technologies during executionof crowded events.

6. Research paper on, "One M2M Architecture Based IoT Framework for Mobile Crowd Sensing in Smart Cities." [21]

In this paper, The Paper shows The futuristic smart cities must have the capabilities to withstand the growing challenges on the urban infrastructure in terms of public safety, resource management, co-operative mobility management and more. To tackle these challenges, the cities are increasingly using next generation of ICT. A plethora of the ICT based innovations are taking place on a wide range of domains (i) cloud and mobile edge computing, (ii) sensing and actuation, (iii) low power communication, (iv) mobile crowd sensing and (v) big data analysis. These can be united under the umbrella of IoT and Machine-to-Machine Communications.

7. Research paper on, "A Survey on Mobile Crowd Sensing and its Application In IoT Era." [22]

In this paper, Mobile crowd-sensing (MCS) is a new sensing paradigm that takes advantage of the extensive use of mobile phones that collect data efficiently and enable several significant applications. MCS paves the way to explore new monitoring applications in different fields such as social networks, lifestyle, healthcare, green applications, and intelligent transportation systems. Hence, MCS applications make use of sensing and wireless communication capabilities provided by billions of smart mobile devices, e.g., Android and iOS-based mobile devices.

8. Research paper on, "Priority based and secured traffic management system for emergency vehicle using IoT." [23]

In this paper, Intelligent Traffic System (ITS) is one of the most recent research topics in the Internet of Things (IoT). The ever increasing number of vehicles in modern cities it creates heavy traffic congestion. To reduce the traffic congestion, a number of research have already been done to provide a clear pathway to the emergency vehicles in the urban area. However, they often fail to meet the target travel time of an emergency vehicle set by the Department of Treasury and Finances Budget and Financial Management Guidance (BFMG). To address this issue directly, an innovative ITS system considering the priorities of emergency vehicles based on the type of an incident and a method for detecting and responding to the hacking of traffic signals have been proposed in this paper.

9. Research paper on, "IoT based Positive Emotional Contagion for Crowd Evacuation." [24]

In this paper, In emergency evacuations, crowds often become congested and stampeded because of extreme panic, resulting in injuries and fatalities. Safety officers can spread positive emotions and reduce crowd panic by issuing information or appeasement, which is an effective way to ensure evacuation safety. However, how to deploy safety officers appropriately and maximize positive emotional contagion to cover the largest number of chaotic individuals is still a challenging problem. To solve this problem, we propose an IoT-based positive emotional contagion (IoT-PEC) method for crowd evacuation.

10. Research paper on, "A Feedback Control Based Crowd Dynamics Management in IoT System." [25]

In this paper, the paper proposed The development of technologies related to the Internet of Things (IoT) provides a new perspective on applications pertaining to smart cities. Smart city applications focus on resolving issues facing people in everyday life, and have attracted a considerable amount of research interest. The typical issue encountered in such places of daily use, such as stations, shopping malls, and stadiums is crowd dynamics management.

11. Research on, "UAV- Based IoT Platform: A Crowd Surveillance Use Case." [26]

In this paper, unmanned aerial vehicles are gaining a lot of popularity among an ever growing community of amateurs as well as service providers. Emerging technologies, such as LTE 4G/5G networks and mobile edge computing, will widen the use case scenarios of UAVs. In this article, we discuss the potential of UAVs, equipped with IoT devices, in delivering IoT services from great heights. A high-level view of a UAV-based integrative IoT platform for the delivery of IoT services from large height, along with the overall system orchestrator, is presented in this article.

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12. Research on, "Simultaneous Information and Energy Flow for IoT Relay Systems with Crowd Harvesting." [27]

In this paper, shows the improvement in the energy efficiency of information transfer between small devices, we review state-of-the-art research in simultaneous wireless energy and informationtransfer, especially for relay-based IoT systems. In particular, we analyze simultaneousinformation and energy transfer from the source node, and the design of time-switching and power-splitting operationmodes, as well as the associated optimization algorithms. Wealso investigate the potential of crowd energy harvesting from transmission nodes that belong to multiple radio networks. The combination of source andcrowd energy harvesting cangreatly reduce the use of battery power and increase theavailability and reliability for relaying.

13. Research on, “Crowd Management the Overlooked Component of Smart Transportation System.” [28]

In this paper, the paper proposed,Governmental, scientific, and industrial initiatives are developing a new era of smart transportation systems, ambitiously aimed atovercoming the limitations of current transportation infrastructures. These initiatives are designed to cooperate safer, efficient, eco-friendly, and enjoyable transportation for people and goods in large areas. However, current research on smart transportation systems has neglected a fundamental building block: smart crowd management. In a smart transportation system, the smart crowd management component will be demanded for identifying and controllingthe congestion that can occur during commutesand routine travel.

14. Research on “Automated Crowd Management in Bus Transport Service.” [29]

In this paper, presents an Automated Crowd ManagementSystem using the algorithms of Machine Learning and IoT Technologies.

15. Research on, “Smart Crowd Control Management System For Light Rail Transit.” [30]

This study presents the integration of embedded system and different software applications to manage thecrowd of all stations LRT platforms and trains intelligently.

16. Research on, “A Low cost IoT Based crowd management system for public transportation.” [31]

In This paper, aims to demonstrate a low cost IoT based solution to the crowding problem by using smart seats that can detect and display the seat occupancystatus in real time over an internet or mobile application.

17. Research on, “Demystifying the crowd Intelligence in Last Mile Parcel Delivery for Smart Cities.” [32]

In this paper, The paper proposed, Advances in the Internet of Things,however, have enabled vehicle information to be readily accessible anytime anywhere, forming an Internet of Vehicles (IoV), which further enables intelligent vehicle scheduling and management.

18. Research on, “Application of Cognitive Computing for Smart Crowd Management.” [33]

Discuss the human cognition capability and its application for smart crowd management.

19. Research on, “Smart waste Management System Using IoT.” [34]

In this paper, The described system proposes a privacy-aware platform that enables the application of artificialintelligence mechanisms toassess crowds' behavior in buildings employing sensed Wi-Fi traces.

20. Research on, “Smart and Effective Crowd Management with a novel scheme of big data analytics.” [35]

The paper presents a novel scheme that can perform a precise extraction of knowledge from the massive streaming of live data of the scene from the crowded place.

2.2 Summary:

As it was mentioned earlier that the main concern of this book is to create a proper crowd management system which will solve the crowd problem in the overcrowded areas. Last pandemic situation inspired us to work on crowd management which seems to be severe in any pandemic situation. Papers from different sites have been reviewed and studied. The papers which were reviewed were based on the same criteria that this work needs. Most of those papers have been designed and studied on large amount of people like Hajj and other large social gatherings. But we are trying to create a crowd management system for our country. For the crowd that seem to be minimal but has a negative effect on our daily life. Which will make our paper different and more effective from others.

Chapter 3

Methodology

The methodology is the analysis of the principles or procedures of inquiry that are followed by researchers in a specific field. It characterizes the information to be analyzed, gives the conceptual tools and strategies necessary to perform an examination, it sets forward the limits of the investigation. Methodology fundamentally envelops the three aspects of exploration, description, and explanation. All methodologies include a system of analysis that is used as a backdrop for organizing, collecting, and interpreting data. However, a methodology does not set out to afford solutions it is thus, not the same as a method. Instead, a methodology deals with the theoretical reinforcement for understanding which method or set of methods can be realistic to a specific case.

3.1 Research Design:

Research design is the structure of research methods and techniques chosen by a researcher to established a research question through the collection, interpretation, analysis, and discussion of data. The design of research can be either qualitative, quantitative, or mixed. Under these research designs, researchers can choose between different types of research methods; experimental studies, surveys, correlational studies, or quasi-experimental review studies.

3.2 Crowd Related Scenario:

In the following sections, we identify and discuss several crowd-related scenarios that are frequently experienced in crowded area.

- Normal Scenario
- Hazardous Scenario
- Stampede Scenario
- Misguidance Scenario

3.3 Conceptual Design:

Figure 3.1 presents the conceptual design of the framework. DNs periodically receive various data regarding the current situation from several devices.

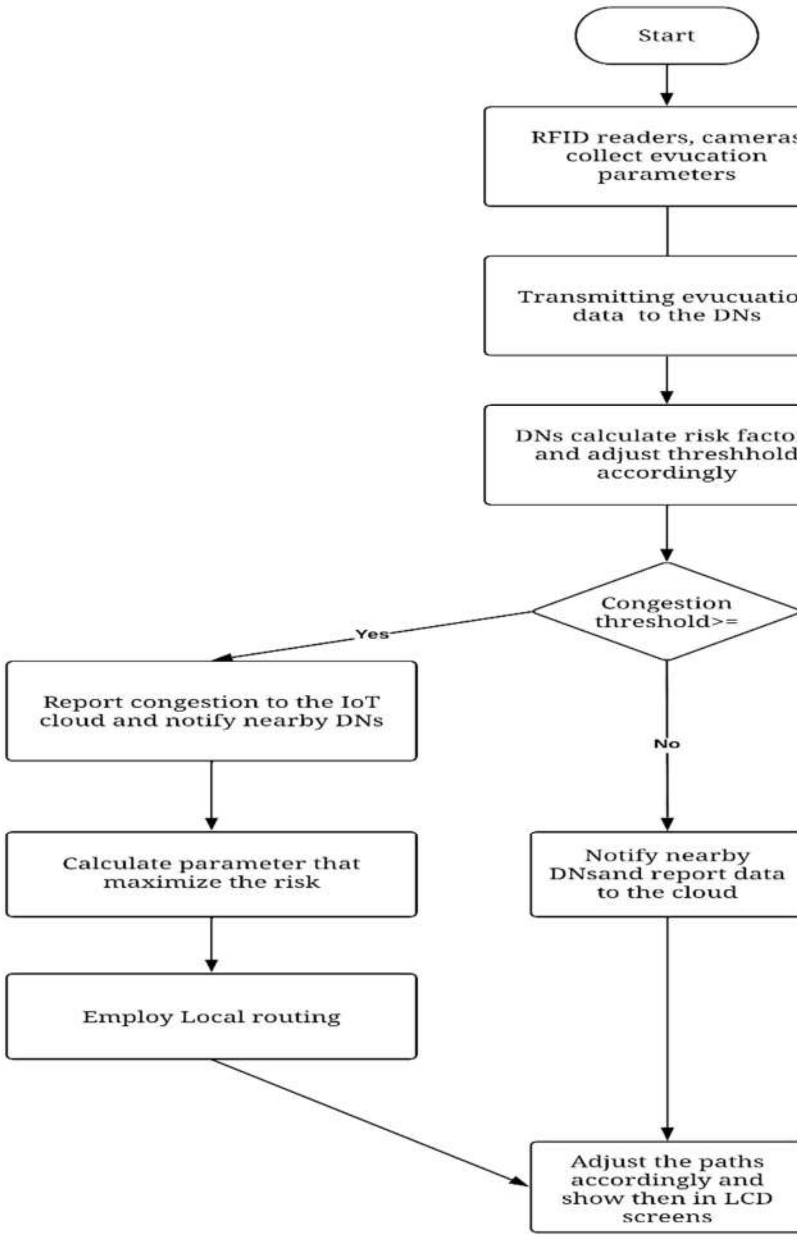

Figure 3.1 Overall design.

The DNs will perform certain computations and display the safest paths on LCD screens through the IoT cloud. The main steps performed by our system in real-time are as follows:

Step 1. At time T, each DN will receive evacuation parameters from the RFID sensors, cameras, sensor nodes.
Step 2. The DNs will calculate the risk factors, which depend on the classification of the paths, current load, and crowd condition.
Step 3. The DNs will compare the calculated risk with a threshold for each path and will decide the presence of congestion in any of the surrounding paths.
Step 4. Based on the result, if congestion is detected or predicted, the DNs will report congestion to the cloud and nearby DNs.
Step 5. The DNs will calculate the parameters that maximize the risk according to the information derived from the RFID tags to decrease the threshold value.
Step 6. If the congestion is less than the threshold, the DNs will execute the local evacuation plan and notify the nearby DNs.
Step 7. The system will adjust the paths and display them on the LCD screens.

3.4 Crowd Information Acquisition and Management:

Before discussing the design, we outline the following realistic assumptions that are considered in designing and specifying the area of interest. The key assumptions are as follows:

1. Each person will be provided an RFID when they arrive at the destination (like: Rail Station, Fair etc.). In this study, RFID cards would be used to locate the crowd density. However, cards can be replaced with any alternative wearable technology.
2. The RFID cards will be connected to the admin IoT infrastructure.
3. LCD monitors will be presented in the area, which are connected to the cloud and will continuously display the best path.
4. People will follow the instructions and will not enter congested paths, although it is considered that the people may not follow the instructions

with a certain level of randomness (randomized movement). Additional help and guidance for following the instructions will be provided by security guards, as necessary.

5. To address RFID failures, a matching technique will be adopted to extract the crowd status from data collected by cameras and other wireless sensor technologies. The collected crowd data will be the input to the proposed framework to provide the appropriate guidance.
6. As cameras will provide full coverage over the area, in addition to the mechanisms to match the data provided by the RFID reader, the proposed approach relies on the most accurate data provided by cameras and RFID readers.
7. All paths will be unidirectional with different levels of priority, and each path will have a specific capacity.
8. Cameras will be installed in each path, with the number of cameras depending on the priority of the path.
9. Data provided by the RFID cards and other entities will be legitimate.

3.5 Crowd Management Framework:

The framework consists of a number of components used for monitoring, simulating, routing and guiding people to their intended destinations within the non-crowded area through the best available paths. The overall framework and components are shown in Figure 3.2.

1) RFID Cards and Readers:

RFID cards represent the primary component of the framework. These devices act as the main tracking device to monitor the crowd situation. Each person will carry an RFID card. Each path will have one or more RFID readers to detect the signal from the RFID cards and collect information to help calculate the cognition level of the crowd and most suitable path.

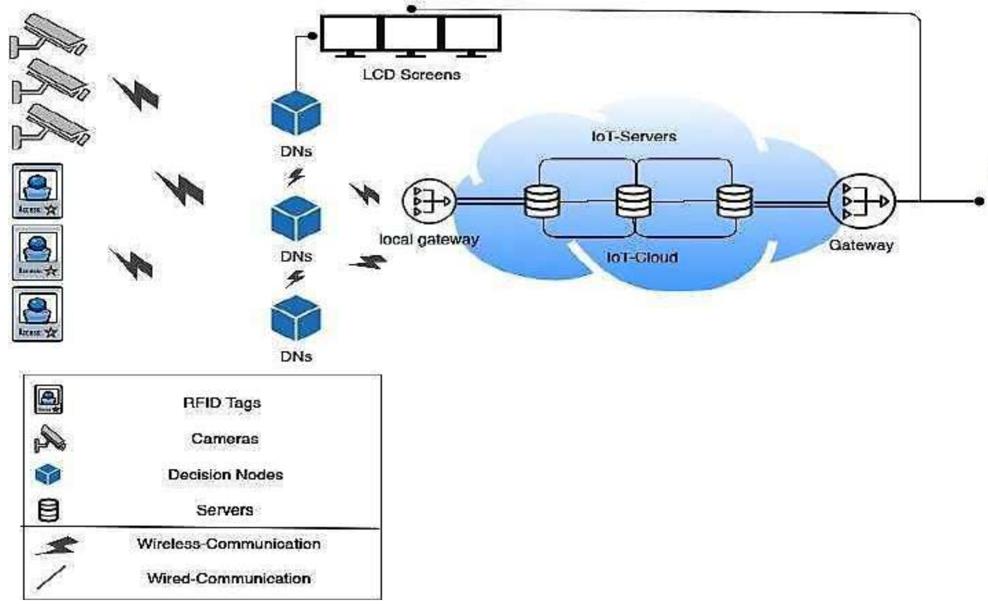

Figure: 3.2 Crowd Management Framework (CMF).

2) Decision Nodes (DNs):

DNs will be distributed over paths with different densities according to the path capacity. The DNs will receive data from the RFID tags, cameras. As soon as a DN receives the data, it starts calculating the risk factors and communicates with its nearby DNs to execute local evacuation in a cooperative way, shows the determined evacuation directions on LCD screens, and reports the data to the cloud servers.

3) Cameras:

Cameras will act as the secondary input source that monitor and capture the crowd situation. The cameras will be connected with DNs to transmit the information regarding the presence of congestion according to situation of the crowd to the decision nodes.

4) Cloud Components:

The cloud has access to all entities of the system. The main role of the cloud in this approach is to manage the data exchange and information integration. Moreover, the cloud is responsible for formulating the evacuation decisions when congestion is detected.

5) Gateways:

The local gateway will act as an interface between the local sensors and cloud for data transmission. The outer gateway is an interface of the IoT cloud.

6) LCD Screens:

LCD screens will be distributed in multiple points over all paths. Each path will have different number of screens that have different dimensions and are deployed with different densities depending on the path capacity, priority, and number of intersections. For example, a path with a higher capacity, priority and number of intersections may have a larger number of screens. The screens continuously display the paths that have been identified by the decision nodes and cloud. Moreover, the LCDs are assumed to have an efficient and user-friendly design to provide guidance to the crowd in a way that is easy to understand and follow.

3.6 Acquisition and Analysis of Crowd Data:

In the framework, data will be collected via RFID sensors, cameras and environmental sensors. The RFIDs will collect the crowd information. Cameras collect images of the current situation.

1. **Congestion Level**

   The congestion will be monitored and evaluated by tracking the RFID tags, cameras, and sensors located throughout the paths. The congestion is classified into six levels depending on its intensity, namely, extremely low, low, medium to low, medium to high, high, and dangerous. Once the congestion reaches the medium to low level, the system will initiate the congestion-avoidance approach.

2. **Classification of Evacuation paths**

   The priority of paths will be classified into different levels based on crowd situation.

3.7 IoT architecture for Crowd data management:

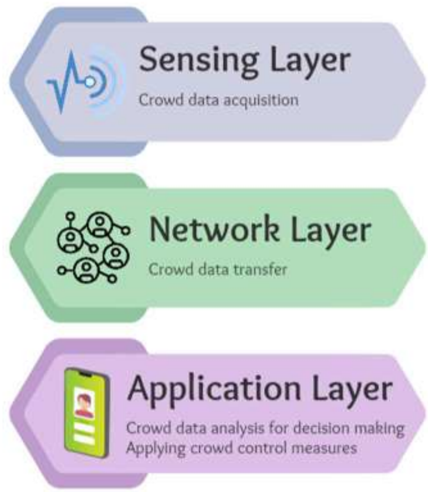

Figure: 3.3 IoT Architecture for crowd data management.

Sensing the crowd by normal sensors and managing it is a challenging problem. Crowd management requires several stages including crowd data acquisition via sensor layers, data transferring via network layers, data analysis for decision making, and applying crowd control measures via application layer; see Fig. 3.3 Using different sensor devices, it is possible to gather information about visitors' crowds and determine which areas are overcrowded. This information is then transmitted to the management layer where the administrator can decide to close some doors and roads. The management layer shall be equipped by a smart service that can recommend which doors to be opened/closed to direct the crowd flow. The admins then decide whether to publish this information to the public or not. The visitors receive the publicly available information through a mobile application which informs them about (1) current open roads and doors, (2) how to find non crowded areas, or (3) how to locate their groups and friends. These services will lead to great save in time and efforts in managing the crowd flow.

3.8 Main Modules:

Our approach involves three main modules. Namely: Monitoring, Simulation and routing, and Guidance module. Figure 3.2 shows the interaction among the three modules and the main processes.

3.4.1 Monitoring module:

Information regarding each crowd. Furthermore, the data from nearby nodes are collected in a localized manner instead of independently collecting data from each node. The system enables communication between nodes to obtain an overall view of the crowd movement and congestion points.

3.4.2 Simulation and Routing Module:

The simulation and routing module will utilize the information provided by the monitoring module. In Figure 3.2, in the first two steps associated with the simulation and routing module, the collected evacuation data parameters will be transferred to DNs to calculate the risk factors. The value of the risk factors is a function of the crowd data and path state. congested area increase the level of risk. The amount of people affect the row of paths, movement, and speed. The framework calculates the factors related to each path, such as its capacity, priority, and level, and predicts the load for each path in the specific destination. Next, the DNs will start identifying the optimal routes to all possible destinations based on the factors collected from the previous monitoring module. Next, we calculate the congestion factors for all nearby paths and verify the occurrence of congestion in each path. If the congestion level is higher than the threshold, alternative evacuation paths are determined. Moreover, the module reports congestion to the nearby paths to perform rerouting and avoid congestion. The detected congestion is immediately reported. This module continues to process all paths, identifies the least congested paths and performs rerouting through these paths. Next, the paths will be displayed on LCD screens to guide the crowd, and the collected data and processed results are reported to and stored in cloud servers.

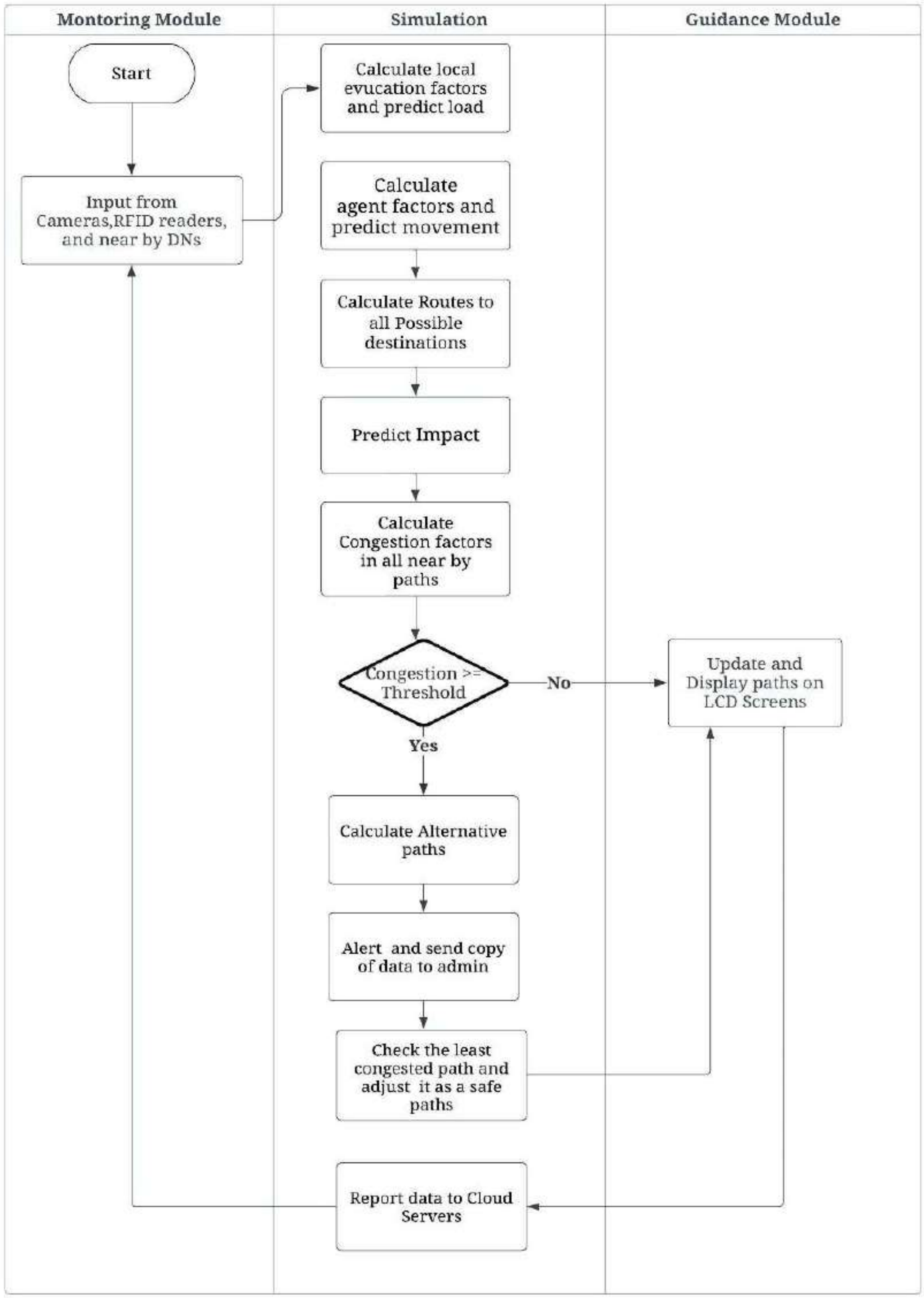

Figure: 3.4 Interaction among system module.

These processing steps are repeated to ensure updated information is available for providing guidance to the crowd and addressing the path congestion. The framework performs classified routing, considering human factors, path priority, and path condition. The paths are classified depending on their capacity, priority (distance from key point), and usual congestion level. The priority of the paths will be classified into different levels based on their distance. The capacity of the paths will be calculated from the available information. In addition, the usual congestion level of each path is considered.

3.4.3 Guidance Module:

The last module is the guidance module. The primary function of this module is to continuously update and display the most and least congested routes. The information collected by the DNs at each link is used. To obtain accurate results, instead of identifying the congestion in a link-wise manner, the system evaluates it that eventually leads to congestion. To realize this aspect, the system allows nearby DNs to communicate with one another and share their congestion levels; in this manner, if the current path is congested, the system alerts predecessor paths to reroute. Similarly, if the DN at the current path detects congestion at the successor path, it begins rerouting to avoid congestion. These design considerations and the above mentioned modules can address the scalability aspects of crowd management during any event.

Chapter 4

Result Analysis

In this chapter, the results that are obtained after performing a simulation of the designed framework are presented and analyzed.

4.1 Experimental Design:

In this section, we present the results of experimental framework of the proposed approach. We discuss the characteristics of the crowd, input variables, and performance factors.

In the following section, we discuss the mobility of our model. We implement our experiment using a multi-method simulation modeling tool known as AnyLogic [47]. AnyLogic provides an efficient simulation engine that allows the user to easily create high accuracy models of large complex systems. We took 30000 people named as agents as reference to simulate our diagram. To add agents, we created a network of nodes and links between an assumed destination that all agents must pass to reach their final destination. For simplicity, we identify and consider the destination as traditional trade fair, as shown and labeled in Figure 4.1. In the modeled area, all the main paths are unidirectional. Each path has a different capacity and threshold. The capacity depends on the priority and width of the actual path. For example, the capacity of paths 1 and 2 is larger than that of the other paths. Using the tools provided by AnyLogic, we identify four main key services. These services are considered as the main destination points in our simulation, and each service has a delay to represent the real-life congestion that occur near the Specified destination is not considered a service and instead treated similar to the other points since it is the destination point for most crowd in the simulation and suffers from extreme congestion.

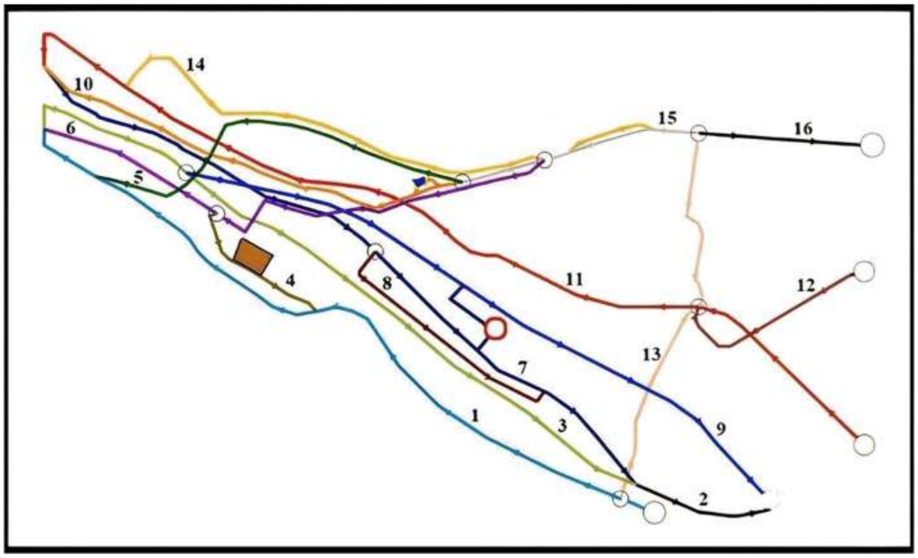

Figure 4.1: Modeling the roads using Anylogic

TABLE II. SIMULATION INPUT VARIABLES

Input Variable	Values
Number of Agents	30,000 agents divided over 3 sources
Agents Speed	1.5mile/hour (Male) 1.4 mile/hour (female)
Agent Gender	Male (0) Female (1)
Agent Source	The determination of the original source of each agent at the beginning of simulation
Agent Destination	Random number of agents reaching their destination

4.1.1 Input Variables:

In this part, we describe the input variables used to implement the proposed framework and design the experiments. Table 2 defines the range of values allowed for the input variables along with any randomness or probabilities considered in determining these values. For the input variables, as explained previously, the following factors that affect the congestion, routing and mobility of agents are considered:

- Number of agents.
- Routing requirements.
- Factors that affect agent's mobility: Speed and gender.

As shown in Table 2, we deploy 30,000 agents to act as agents in our simulation. The speed changes dynamically during the simulation process; for example, the agents' gender is equally distributed, with 50% males and 50% females. The ages are randomly generated ranging from 0 to 80 y. We considered the following age groups: (0 to 15 y), (16 to 44 y) and (45 y or older). The speed of the younger (0 to 15 y) and older (45 y or older) groups is decreased from the normal speed by 0:2 and 0:6 *mph*, respectively. These values affect the path threshold, which increases the risk. The increased risk affects the evacuation procedure.

4.1.2 Performance Factors:

The main performance factors considered to assess the performance of the approach are as follows:

- **End-to-end delay:** Time for agents to move from the starting point, pass the intended destination and reach a specific termination point. The delay is calculated as the difference between the ideal time to reach the final destination and actual time required to reach the destination.
- **Delay-Jitter:** Jitter is calculated considering the standard deviation for each delay per path.
- **Number of congestion points:** Total number of congestion points with a value exceeding a maximum value.
- **Critical congestion points:** Total number of congestion points with a value exceeding a value, which may trigger high-risk congestion.
- **Delay per paths:** Additional time added to each congested path.

4.2 Implementation and Performance Discussion:

In this section, we describe the characteristics of the different algorithms and techniques used to implement the proposed approach. Moreover, we discuss the performance of the proposed approach. Many tools can be used to simulate crowds. However, various tools have different features. To identify the optimal tool with features suitable in the context of the proposed model, a number of crowd simulation environments and their associated features are compared. AnyLogic is a licensed multi-method simulation modeling tool developed by The AnyLogic Company. AnyLogic models can be developed through any main simulation modeling method, such as discrete event, systems dynamics, and agent based techniques. The animation and visualization in AnyLogic are remarkable, the flowcharts can be converted into interactive movies, and sets of graphical objects are available to visualize people, vehicles, buildings, and other items. Models can be presented in a visually attractive manner. Many features of AnyLogic can help model, simulate and implement the approach, as a certain layer can be a map of the imagined destination, or an image of the map of that destination can be uploaded to easily create paths. Therefore, we use AnyLogic to simulate the proposed approach and test its efficiency with respect to several risk factors. Next, we evaluate the results using common performance factors. To assess the efficiency of the proposed approach in avoiding congestion and allowing safe evacuation, we compare its performance to that of the conventional shortest path based evacuation approach, which chooses the shortest path leading to the destination, regardless of the congestion level.

4.2.1 Varying the Numbers of Agents:

This experiment examines the impact of the number of agents on the performance of the crowd management algorithm and compares it to the shortest path-based algorithm. Table 3 shows the average delay and number of congestion points when the number of agents varies from 10,000 to 30,000. The number of agents in the first, second, third, fourth and fifth iterations is 10K, 15K, 20K, 25K and 30K, respectively.

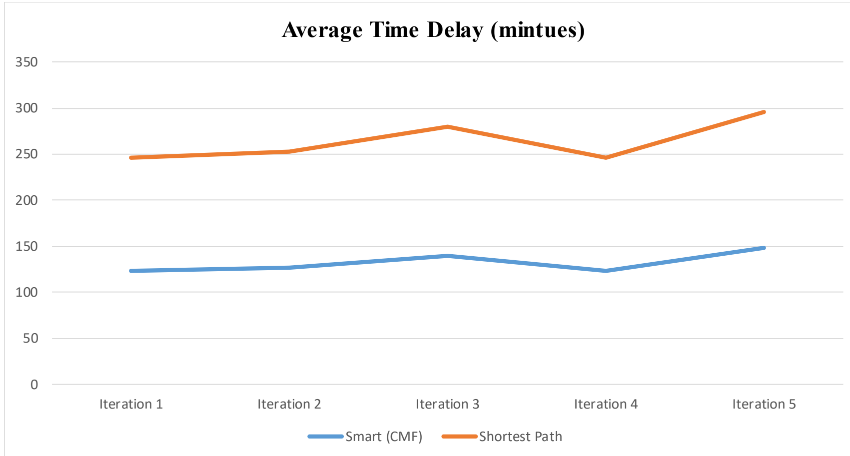

Figure 4.2 Average evacuation time when no. of agents varies between 10000 and 30000.

As shown in Table 4, an increase in the number of agents increases the number of critical and noncritical congestion points in both approaches. However, the proposed approach can more effectively minimize the evacuation time and number of critical congestion points. Figure 4.2 show the average delay time in minutes between the crowd management framework and shortest path approaches. In all the iterations, the average delay of the proposed approach is less than that of shortest path.

TABLE III. IMPACT OF VARYING NUMBER OF AGENTS ON THE EVUQUATION AND CONGESTION AVOIDANCE

Performance factors / Iteration	**CMF Approach**	**SP Approach**
Iteration 1		
Number of Congestion points	6	5
Number of Critical Points	2	4
Average Delay Time	118	172
Number of agencies Alerts	2	3
Number of Total Arrivals	9251	6182
Iteration 2		
Number of Congestion points	5	11
Number of Critical Points	2	9
Average Delay Time	126.5	182
Number of agencies Alerts	2	8
Number of Total Arrivals	13923	9362

Iteration 3		
Number of Congestion points	5	12
Number of Critical Points	4	10
Average Delay Time	138	193
Number of agencies Alerts	3	11
Number of Total Arrivals	19897	12340
Iteration 4		
Number of Congestion points	9	21
Number of Critical Points	4	14
Average Delay Time	122	196
Number of agencies Alerts	4	13
Number of Total Arrivals	24785	15720
Iteration 5		
Number of Congestion points	11	21
Number of Critical Points	8	14
Average Delay Time	148	196
Number of agencies Alerts	7	14
Number of Total Arrivals	29187	1870

TABLE IV. PERCANTAGE OF RESOLVED CONGESITION POINT

Number of agents	**10000**	**15000**	**20000**	**25000**	**30000**
Normal	6	5	5	9	11
Critical	2	2	4	4	8
Percentage of Resolved Congestion	57%	51%	0%	53%	38%

4.3 Final Remarks on performance result:

The key objective is to build a congestion avoidance approach that can route agents to their destinations through the safest available paths. We evaluated the efficiency of the proposed framework in reducing the number of congestion points. A comparison of the results obtained using the proposed framework and the shortest path-based approach indicated that the proposed approach can significantly reduce the number of critical and noncritical congestion points. We adopted 30,000 agents in our experiments as a typical crowding scenario. However, this number may increase, especially in the case of more crowded situations. To simulate such situations, we must increase the number of agents. To ensure the scalability, it is necessary to use a machine with higher resources. This scalability aspect will be considered in our future work. Based on the performance evaluation, the following findings can be summarized: 1) The impact of the available area should be considered while managing crowds to avoid congestion in short area. 2) According to the results, when the number of agents is increased, the number of congestion and critical congestion points are increased; however, when the proposed algorithm is adopted, the number of critical congestion points that may cause injury is considerably lower than that associated with the shortest path algorithm. Accordingly, our algorithm can more effectively control the crowd. 3) According to the results of Experiment, by considering the impact of the imagined area, our approach yields a lower number of congestion points and critical congestion points. 4) According to the results of Experiment, the number of evacuation path is directly affected by the number of agents. In conclusion, the proposed approach can reduce the number of congestion points by utilizing the data collected using classified routing IoT-based technologies to communicate the risk factors on each path.

Chapter 5

Conclusion

In this research, a crowd management system was established to avoid crowd problem.

5.1 Achievements:

The proposed framework will solve the crowd problem in certain area in our country and will benefit in near future for any pandemic situation. The framework consists of three layers: sensors, management, and interface. It helps administrators and visitors to avoid crowd disasters as it informs them about (1) current opening roads and doors, (2) how to find non crowded areas, and (3) how to locate their groups and friends. The proposed framework will effectively save time and efforts to help administrators controlling and distributing visitors via low-cost sensors manipulated by smartphone. Which makes the framework highly reliable and more useable.

5.2 Limitation:

The proposed framework has some limitations. It is based on current crowd problem of our country like small gathering and fair. As other researched frameworks were for large number of people. Which gives the framework room for improvement.

5.3 Further work:

The proposed framework can be modified and introduced to large number of crowd. In the future there will be a chance to study the framework and modify it for larger crowd for any scenario. Which will make the framework more versatile.

References

[1] K. Ashton. (2009, Jun.). Internet of things. RFID J. [Online]. Available: http://www.rfidjournal.com/articles/view?4986

[2] R. van Kranenburg, The Internet of Things: A Critique of Ambient Technology and the All-Seeing Network of RFID. Amsterdam, The Netherlands: Institute of Network Cultures, 2007.

[3] R. van Kranenburg, E. Anzelmo, A. Bassi, D. Caprio, S. Dodson, and M. Ratto, “The internet of things,” in Proc. 1st Berlin Symp. Internet Soc., Berlin, Germany, 2011, pp. 25–27.

[4] Y. Li, M. Hou, H. Liu, and Y. Liu, “Towards a theoretical framework of strategic decision, supporting capability and information sharing under the context of Internet of Things,” Inf. Technol. Manage., vol. 13, no. 4, pp. 205–216, 2012.

[5] L. Tan and N. Wang, “Future internet: The internet of things,” in Proc. 3rd Int. Conf. Adv. Comput. Theory Eng. (ICACTE), Chengdu, China, Aug. 20–22, 2010, pp. V5-376–V5-380.

[6] X. Jia, O. Feng, T. Fan, and Q. Lei, “RFID technology and its applications in internet of things (IoT),” in Proc. 2nd IEEE Int. Conf. Consum. Electron., Commun. Netw. (CECNet), Yichang, China, Apr. 21–23, 2012, pp. 1282–1285.

[7] C. Sun, “Application of RFID technology for logistics on internet of things,” AASRI Procedia, vol. 1, pp. 106–111, 2012.

[8] E. W. T. Ngai, K. K. Moon, F. J. Riggins, and C. Y. Yi, “RFID research: An academic literature review (1995–2005) and future research directions,” Int. J. Prod. Econ., vol. 112, no. 2, pp. 510–520, 2008.

[9] S. Li, L. Xu, and X. Wang, “Compressed sensing signal and data acquisition in wireless sensor networks and internet of things,” IEEE Trans. Ind. Informat., vol. 9, no. 4, pp. 2177–2186, Nov. 2013.

[10] W. He and L. Xu, “Integration of distributed enterprise applications: A survey,” IEEE Trans. Ind. Informat., vol. 10, no. 1, pp. 35–42, Feb. 2014.

[11] D. Uckelmann, M. Harrison, and F. Michahelles, “An architectural approach towards the future internet of things,” in Architecting the Internet of Things. D. Uckelmann, M. Harrison, and F. Michahelles, Eds., New York, NY, USA: Springer, 2011, pp 1–24.

[12] S. Li, L. Xu, X. Wang, and J. Wang, “Integration of hybrid wireless networks in cloud services oriented enterprise information systems,” Enterp. Inf. Syst., vol. 6, no. 2, pp. 165–187, 2012.

[13] L. Wang, L. Xu, Z. Bi, and Y. Xu, “Data filtering for RFID and WSN integration,” IEEE Trans. Ind. Informat., vol. 10, no. 1, pp. 408–418, Feb. 2014.

[14] L. Ren, L. Zhang, F. Tao, X. Zhang, Y. Luo, and Y. Zhang, “A methodology towards virtualization-based high performance simulation platform supporting multidisciplinary design of complex products,” Enterp. Inf. Syst., vol. 6, no. 3, pp. 267–290, 2012.

[15] F. Tao, Y. Laili, L. Xu, and L. Zhang, “FC-PACO-RM: A parallel method for service composition optimal-selection in cloud manufacturing system,” IEEE Trans. Ind. Informat., vol. 9, no. 4, pp. 2023–2033, Nov. 2013.

[16] Vidyasagaran, S., Devi, S. R., Varma, A., Rajesh, A., & Charan, H. (2017). A low cost IoT based crowd management system for public transport. 2017 International Conference on Inventive Computing and Informatics (ICICI), 1–13.

[17] Punn, N. S., & Agarwal, S. (2019). Crowd Analysis for Congestion Control Early Warning System on Foot Over Bridge. 2019 Twelfth International Conference on Contemporary Computing (IC3), 1–13.

[18] Elbery, A., Hassanein, H. S., & Zorba, N. (2020).Vehicular Crowd Management: An IoT-Based Departure Control and Navigation System. ICC 2020 - 2020 IEEE International Conference on Communications (ICC),1–20.

[19] Santana, J. R., Sanchez, L., Sotres, P., Lanza, J., Llorente, T., & Munoz, L. (2020).A Privacy-Aware Crowd Management System for Smart Cities and Smart Buildings. IEEE Access, 8, 135394–135405.

[20] Sharma D, Bhondekar AP, Shukla AK, Ghanshyam C (2016) A review on technological advancements in crowd management. J Ambient Intell Humaniz Comput:1–11.

[21] Datta, S. K., Ferreira da Costa, R. P., Bonnet, C., & Harri, J. (2016). oneM2M architecture based IoT framework for mobile crowd sensing in smart cities. 2016 European Conference on Networks and Communications (EuCNC), 1–30.

[22] Abualsaud, K., Elfouly, T. M., Khattab, T., Yaacoub, E., Ismail, L. S., Ahmed, M. H., & Guizani, M. (2019). A Survey on Mobile Crowd-Sensing and Its Applications in the IoT Era. IEEE Access, 7, 3855–3881.

[23] Chowdhury, A. (2016). Priority based and secured traffic management system for emergency vehicle using IoT. 2016 International Conference on Engineering & MIS (ICEMIS),1–60.

[24] Zhang, G., Lu, D., & Liu, H. (2020). IoT-based Positive Emotional Contagion for Crowd Evacuation. IEEE Internet of Things Journal,1.

[25] Kawamoto, Y., Yamada, N., Nishiyama, H., Kato, N., Shimizu, Y., & Zheng, Y. (2017). A Feedback Control Based Crowd Dynamics Management in IoT System. IEEE Internet of Things Journal, 4(5), 1466–1476.

[26] Motlagh, N. H., Bagaa, M., & Taleb, T. (2017).UAVBased IoT Platform: A Crowd Surveillance Use Case. IEEE Communications Magazine, 55(2), 128–134.

[27] Guo, W., Zhou, S., Chen, Y., Wang, S., Chu, X., & Niu, Z. (2016).Simultaneous Information and Energy Flow for IoT Relay Systems with Crowd Harvesting. IEEE Communications Magazine, 54(11), 143–149.

[28] Boukerche, A., & Coutinho, R. W. L. (2019). Crowd Management:The Overlooked Component of Smart Transportation Systems.IEEE Communications Magazine, 57(4), 48–53.

[29] Meghana, A. V., Sarode, V., Tambade, D., Marathe, A., & Charniya, N. (2020).Automated Crowd Management in Bus Transport Service. 2020 International Conference on Electronics and Sustainable Communication Systems (ICESC), 15–45.

[30] Goh, M. L. I., & Goh, J. E. E. (2019). Smart Crowd Control Management System For Light Rail Transit (LRT) 1. 2019 International Conference on Computational Intelligence and Knowledge Economy (ICCIKE),1–29. https://doi.org/10.1109/iccike47802.2019.9004316

[31] Vidyasagaran, S., Devi, S. R., Varma, A., Rajesh, A., & Charan, H. (2017).A low cost IoT based crowd management system for public transport.2017 International Conference on Inventive Computing and Informatics (ICICI), 15–55.

[32] Wang, F., Wang, F., Ma, X., & Liu, J. (2019). Demystifying the Crowd Intelligence in Last Mile Parcel Delivery for Smart Cities. IEEE Network, 33(2), 23–29.

[33] Varghese, E. B., & Thampi, S. M. (2020). Application of Cognitive Computing for Smart Crowd Management. IT Professional, 22(4), 43–50.

[34] Santana, J. R., Sanchez, L., Sotres, P., Lanza, J., Llorente, T., & Munoz, L. (2020).A Privacy-Aware Crowd Management System for Smart Cities and Smart Buildings. IEEE Access, 8, 135394– 135405.

[35] Awaghad, S. (2016). SCEM: Smart & effective crowd management with a novel scheme of big data analytics. 2016 IEEE International Conference on Big Data (Big Data), 55–60.

[36] A. H. Al-Hashedi, M. R. Mohd Arshad, A. S. Baharudin, and H. H. Mohamed, ‘‘RFID applications in Hajj management system,’’ in Proc. IEEE Int. Conf. RFID-Technol. Appl. (RFID-TA), Sep. 2013, pp. 1–6.

[37] M. Mohandes, ‘‘A case study of an RFID-based system for pilgrims identification and tracking,’’ in Sustainable Radio Frequency Identification Solutions.2010.

[38] E. A. Khan, ‘‘An RFID-based system for pilgrim management in king abdul aziz international airport,’’ in Proc. Int. Conf. Inf. Manage., Innov. Manage. Ind. Eng., Nov. 2011, pp. 124–129.

[39] M. Naser, M. Rafie, R. Budiarto, and W. A. H. Ali alsalihy, ‘‘Security considerations in embedding RFID in ‘Hajj’ system,’’ Eur. J. Sci. Res., vol. 42, no. 1, pp. 133–138, 2010.

[40] M. Naser, M. A. Majaly, M. Rafie, and R. Budiarto, ‘‘A framework for RFID Systems’ security for human identification based on three-tier categorization model,’’ in Proc. Int. Conf. Signal Acquisition Process., Apr. 2009, pp. 103–107.

[41] N. Nasser, M. Anan, M. F. C. Awad, H. Bin-Abbas, and L. Karim, ‘‘An expert crowd monitoring and management framework for Hajj,’’ in Proc. Int. Conf. Wireless Netw. Mobile Commun. (WINCOM), Nov. 2017, pp. 1–8.

[42] A. Tufail, ‘‘Pilgrim tracking and location based services using RFID and wireless sensor networks,’’ Int. J. Comput. Sci. Netw. Secur., vol. 18, no. 6, p. 112, 2018.

[43] O. A. Almoaid, ‘‘Hajj crowd management via a mobile augmented reality application: A case of the Hajj event, Saudi Arabia,’’ Tech. Rep., 2015, pp. 1–217.

[44] R. Reffat, ‘‘An intelligent computational real-time virtual environment model for efficient crowd management,’’ Int. J. Transp. Sci. Technol., vol. 1, no. 4, pp. 365–378, Dec. 2012.

[45] M. M. U. Baqui, ‘‘Automated monitoring of high density crowd events,’’ Partial Fulfillment Requir. Degree Philos. Comput. Sci. Informat., vol. 53, no. 1, p. 67, 2018.

[46] M. Gilli, D. Maringer, and E. Schumann, ‘‘Basic methods,’’ Numer. Methods Optim. Financ., pp. 287–336, Dec. 2011.

[47] AnyLogic. (2019). AnyLogic: Simulation Modeling Software Tools & Solutions for Business. Accessed: May 18, 2019. [Online]. Available: https://www.anylogic.com

[48] S. J. Alsunaidi, A. M. Almuhaideb, N. M. Ibrahim, F. S. Shaikh, K. S. Alqudaihi, F. A. Alhaidari, I. U. Khan, N. Aslam, and M. S. Alshahrani, ‘‘Applications of big data analytics to control COVID-19 pandemic,’’ Sensors, vol. 21, no. 7, p. 2282, Mar. 2021.

[49] F. Alhaidari, A. Almuhaideb, S. Alsunaidi, N. Ibrahim, N. Aslam, I. U. Khan, F. Shaikh, M. Alshahrani, H. Alharthi, Y. Alsenbel, and D. Alalharith, ‘‘E-triage systems for COVID-19 outbreak: Review and recommendations,’’ Sensors, vol. 21, no. 8, p. 2845, Apr. 2021.