An intelligent Automated Traffic System for Crowded Arbaeen's Pilgrimage

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Abstract:

An effective Automated Traffic System for crowds is a serious difficulty in many countries, like the Republic of Iraq, where millions of tourists from all over the world pay their respects at the holy monuments. This religious rite necessitates enormous groups performing the identical behaviors at certain times, making crowd management vital and difficult. Disasters such as stampedes, suffocation, and congestion become more possible when crowds are not properly managed and controlled, as happened in 2019 during Tuwairij's Ashura run. Nowadays, an intelligent Automated Traffic System for Crowd represents excellent solutions for crowd management and control, loss minimization, and the integration of various smart technologies. Furthermore, an intelligent Automated Traffic System for Crowd allows strong interaction and diverse connections between different devices over the Internet, resulting in big data.

This study proposes a smart approach to an intelligent Automated Traffic System for Crowd technology to manage crowds while avoiding congestion at the entry and exit points of the area between the Two Holy Mosques (Imam Hussein and his brother Imam Abbas, peace be upon them) in Karbala. The study employs a proposed mechanism that classifies visitors based on the data collected and takes advantage of an intelligent Automated Traffic System for Crowd and cloud infrastructure to monitor crowds within a crowded area, identify evacuation routes for visitors, and guide visitors to avoid congestion in real time. In addition, the study aims to provide crowd safety and security based on actual scenarios by controlling and guiding visitor movements in accordance with potential hazard features, visitor behavior, and environmental factors.

Keywords: big data, cloud computing, crowd organization, intelligent crowd management, Internet of Things.

introduction:

The eternal tragedy of tuff occupied a temporal size that extended from the year (61 AH) to the present day and will continue to stand at the borders of the land of Karbala, but extends over every land witnessing a conflict between the forces of truth and the forces of falsehood until it became (all the land of Karbala and every day of Ashura) as we can see in the square and the daily scene of events and as shown in the analogy in Figure 1.

Figure 1: Illustrative Image of the Battle of Tuff (Pharaoh, 2015).

Cities that host major events, such as religious rites, pilgrimage seasons, and historical ceremonies, often have large crowds present at the event site. The Al-Arbaeen ceremony, which takes place every year in Karbala, Iraq, is a significant and unique occasion. Large crowds are drawn to Karbala for religious activities, causing the region to become extremely crowded throughout the year. The graves of Imam Hussein and his brother Abbas (peace be upon them) are located in the city's distinctive urban core, which attracts many visitors (Alrawe & Qasim, 2018). To analyze this large-scale gathering, it is essential to examine and forecast the areas occupied by visitors and to propose a design concept for visitor transportation to and from Karbala.

Semi-Annual Scientific Journal www.arbnj.com March 2025 - Ramadan 1446

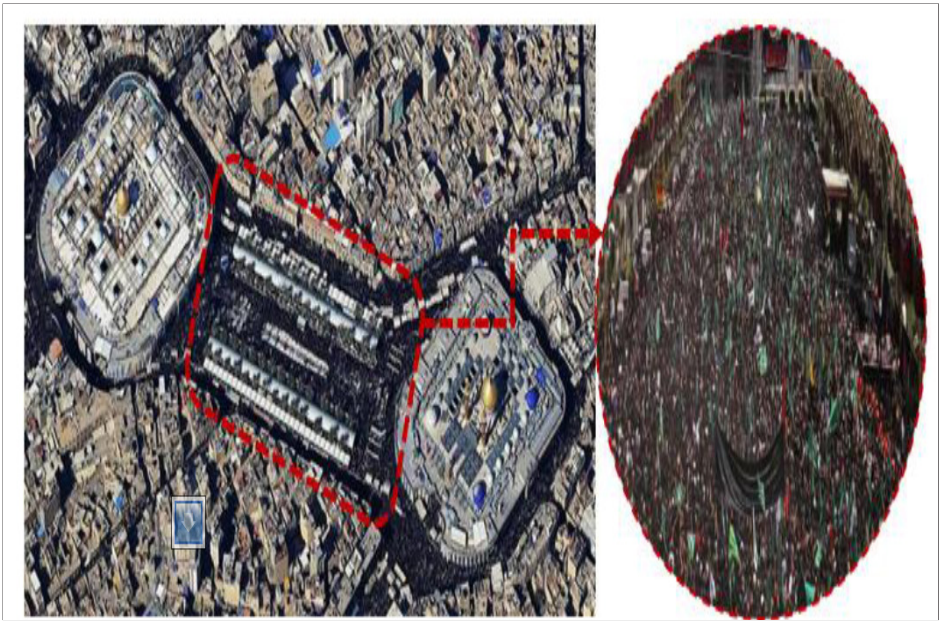
Research on crowd dynamics during Arbaeen, focusing on crowd density, occupied areas, smart scheduling, statistical estimates, and crowd modeling, has been limited. Conversely, previous research has addressed various subjects from a different perspective: the relationship between architecture and socio-cultural traditions was reevaluated by Merie and Farhan (2022), particularly in the historic core of Karbala surrounding the two holy shrines. Within the Al-Muheet Road ring, mosques and shrines comprise the majority of the city, covering an area of more than one square kilometer. Karbala is unique among Islamic cities, as its heart is represented by the shrines. Despite its religious significance, Karbala has managed to retain its socio-cultural and heritage identity, partly due to the green spaces that surround it and its ability to attract millions of Muslim pilgrims each year. According to Nikjoo, Sharifi-Tehrani, Karoubi, and Siyamiyan (2020), Iraq hosts one of the world's largest annual pilgrimages, with approximately 20 million Shia Muslims attending. Many pilgrims begin their spiritual journey on foot from various locations, primarily Najaf and Basra, to reach Karbala for the Arbaeen commemoration. The study found that pilgrims arrive in Karbala at different times, and not all remain until the day of Arbaeen. This suggests that further research is needed to determine the peak attendance of the crowd. According to UNWTO estimates, there are over 600 million religious trips made globally each year, with between 300 and 330 million visitors attending significant religious sites (Moufahim & Lichrou, 2019). The world's largest annual pilgrimage, Arbaeen, draws millions of pilgrims from both domestic and international locations, creating a significant demand for lodging and transportation services. As a result, ensuring the comfort and safety of pilgrims is essential and cannot be overlooked. Karbala is, therefore, an ideal setting for researching pilgrimage crowds. The work by Sharma, Bhondekar, Shukla, and Ghanshyam (2018) examined developments in crowd management technologies, such as data collection and processing, crowd modeling, and crowd control strategies. Various scientific and technical disciplines must collaborate to manage crowds effectively, as poor management can have disastrous consequences. It is an interdisciplinary field that requires knowledge of the psychological, social, and engineering aspects that influence crowd behavior and flow. Crowd management should be considered when planning public infrastructure in areas where high levels of congestion are anticipated. In addition to highlighting the safety concerns associated with large-scale mass gatherings, the authors of Karbovskii et al. (2021) offered a novel technique to forecast short-term crowd movement. Severe incidents, such as the Kumbh Mela stampede in Allahabad, India (2013), the Hajj crush in Mecca, Saudi Arabia (2006 and 2015), and the Love Parade disaster in Duisburg, Germany (2010), have occurred in recent history. Crowd management and behavior analysis are key components of safety assurance at such events. The ability to estimate crowd flows based on historical and current flows in a specific area poses a significant challenge in understanding crowd dynamics.

Alghamdi et al. (2022) focused on the necessity of realistic IoT-based smart modeling solutions to control crowding during religious events like the Hajj, where pilgrims' close contact during prayer, tawaf, and hotel stays can lead to the spread of illnesses. Intelligent scheduling and modifications in crowd flow can help curb the spread of infectious diseases and prevent stress and injuries from pilgrim collisions, particularly affecting elderly and female pilgrims. To better understand and replicate individual and collective pedestrian behavior in various scenarios, Gayathri, Aparna, and Verma (2017) conducted several experiments. These studies have the potential to enhance crowd safety. Nonetheless, there are notable distinctions between pedestrian behavior in public areas during regular events and that of large groups. A mass gathering occurs when more individuals than a certain number come together for a specific cause for a predetermined time at a designated location. Mass gathering events, especially during communicable disease alerts and responses, pose significant risks due to various factors, including densely populated areas, physical barriers preventing access, insufficient crowd control, and incomplete information about the surroundings and activities.

Problem Definition:

The Arbaeen pilgrimage, which takes place every year from the first to the twentieth of Safar, is most crowded on the twentieth due to the Ziyarat Alarbaeen ceremonies. This results in congestion in the areas surrounding the sacred sites, making it difficult for pilgrims to navigate. According to Figure 2, the increasing number of visitors necessitates the provision of sufficient space to prevent congestion and ensure a comfortable environment for the performance of Ziyarat Alarbaeen, which holds great spiritual significance.

Figure 2: An overhead picture of the Bayn Al-Haramayn zone and the crowd around the holy monuments (Abbas, Naji, Zainab, & Muneer, 2023).

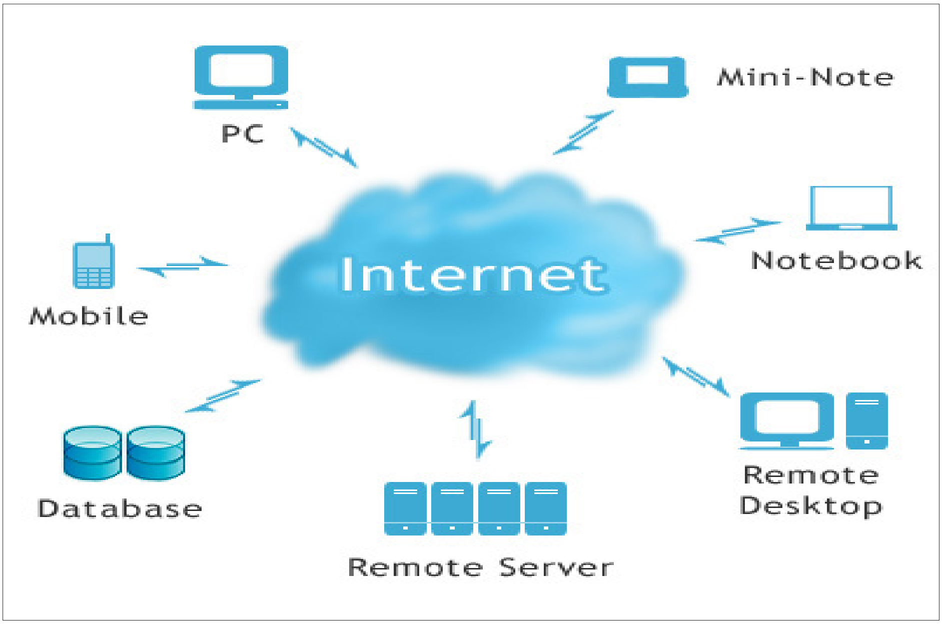


This research presents a method for analyzing visitor behavior using visitor data. By leveraging the Internet of Things (IoT) and cloud infrastructure, an efficient, safe, and reliable solution is implemented that utilizes connections and data available at the

Semi-Annual Scientific Journal www.arbnj.com Volume 2, Issue 2, Part 7, Year 2

cloud level, integrating various technologies to address crowd management-related tasks. Congestion scenarios are analyzed, and the primary types of visitor data affecting crowd management are classified. Additionally, by considering visitor behavior, environmental factors, and hazard characteristics, the study aims to enhance safety for the proposed evacuation routes and identify real-time evacuation pathways during crises. To ensure that public health criteria are met, the study also takes into account visitors' locations and governorates, as well as their medical conditions during evacuation (Figure 3).

Figure 3: Various Facilites of the Internet Cloud (Alghamdi et al., 2022).



The following is a summary of the study's primary findings:

The concept of crowd management through the Internet of Things (IoT) utilizes extensive data retrieved from various infrastructures related to shared and mass sensing.

The proposed strategy aims to enhance security and alleviate congestion in the Inter-Haramain neighborhood of the holy city of Karbala.

Development of effective crowd guidance methods to improve the security and safety of visitors.

Design of the selected area (between the two mosques) using geographic information systems (GIS).

Additionally, this study seeks to reduce or prevent disasters caused by congestion, which have previously led to injuries among many visitors during the pilgrimage (as occurred in 2019, when crowding resulted in the martyrdom and injury of numerous visitors). The goal is to provide a safe and reliable way to direct visitors to safer routes, thereby minimizing the impact of congestion-related accidents and creating a secure environment that allows visitors to perform their ceremonies easily and in an organized manner. The area of focus is the holy zone, which includes the two shrines and their surroundings, located approximately 100 km south of Baghdad, as shown in Figure 5. This area was chosen due to the presence of visitors performing the pilgrimage of Imam Hussein and Imam Abbas (peace be upon them), recognizing that it is relatively small compared to the number of visitors and the numerous service centers and Husseiniya processions along the streets and alleys within it. Consequently, most congestion incidents occur in this area.

Semi-Annual Scientific Journal www.arbnj.com Volume 2, Issue 2, Part 7, Year 2

Figure 4: The Old Area of the Holy City of Karbala (Farhan & Nasar, 2022).

Crowd-related scenarios

In this section, various crowd-related scenarios that could arise during the Arbaeen pilgrimage are outlined. Each of these scenarios is discussed briefly in the following text:

Normal scenario

Visitors begin their pilgrimage by entering the shrines of Imam Hussein and his brother Al-Abbas (peace be upon them). After that, they engage in religious rites, praying and reciting desired supplications as they move through the area between the two mosques. Following this, visitors head to the Husseiniya processions, where they rest and participate in additional rituals.

Finally, those wishing to leave can take the main or secondary roads to the nearest parking lot, which will provide transportation according to their destination.

Dangerous scenario

Visitors congregate at the entrances and exits of the sacred area, whereupon the flow of people gradually slows down until overcrowding occurs, impeding the public's ability to move freely. These incidents also lead to disorderly crowd behavior, which makes it challenging to finish the visitation ritual.

Exit scenario from entry roads

As mentioned, rituals in holy Karbala include during visitation, visiting holy shrines, praying and supplication. After that, visitors make the return journey and here there may be a mass exit of visitors from the holy area to the outside through alleys and streets. As these crowds enter the visit, most of them enter and exit the holy area using the same paths. This scenario may lead to a large stampede, posing a risk of injuries to visitors due to suffocation and panic.

Misdirection scenario

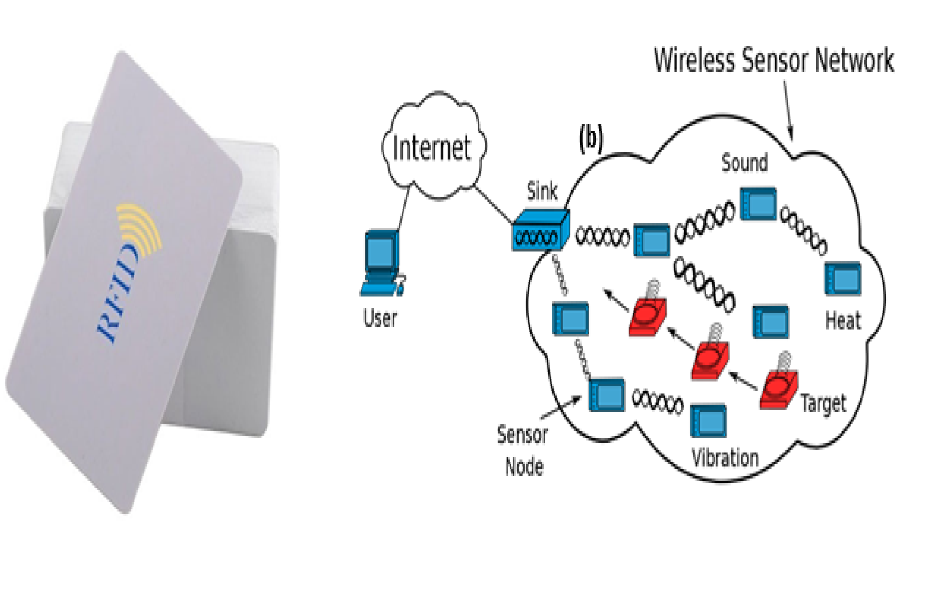
Due to the large number of visitors entering the holy city of Karbala, many visitors, especially vulnerable visitors, elderly or foreigners, may be separated from their families or groups so when missing visitors arrive in the holy city, they may find it difficult to return because they cannot leave from the same path from which they entered, which causes them to crowd in certain areas without others.

Globally applied technologies:

As mentioned in Figure 5, a variety of techniques are employed to achieve crowd control and avoid congestion in restricted spaces. These techniques include radio frequency identification (RFID), wireless sensor networks (WSN), and Internet of Things (IoT) systems that integrate various sensor technologies with intelligent methods.

The technology of wireless sensor networks was implemented at the Systems and Automation Research Center within the remote control project for smart irrigation gates in Najaf Governorate. This project facilitates supervisory control, data collection, and acquisition for irrigation gates, allowing for remote control through a central management system. Additionally, a monitoring project aims to establish a rapid interactive medium between citizens and security authorities, enabling immediate reporting of incidents and security breaches via smartphone applications. A national control center is responsible for receiving and processing these notifications, displaying them on the map of Baghdad city in real time for higher authorities and informing the relevant responders.

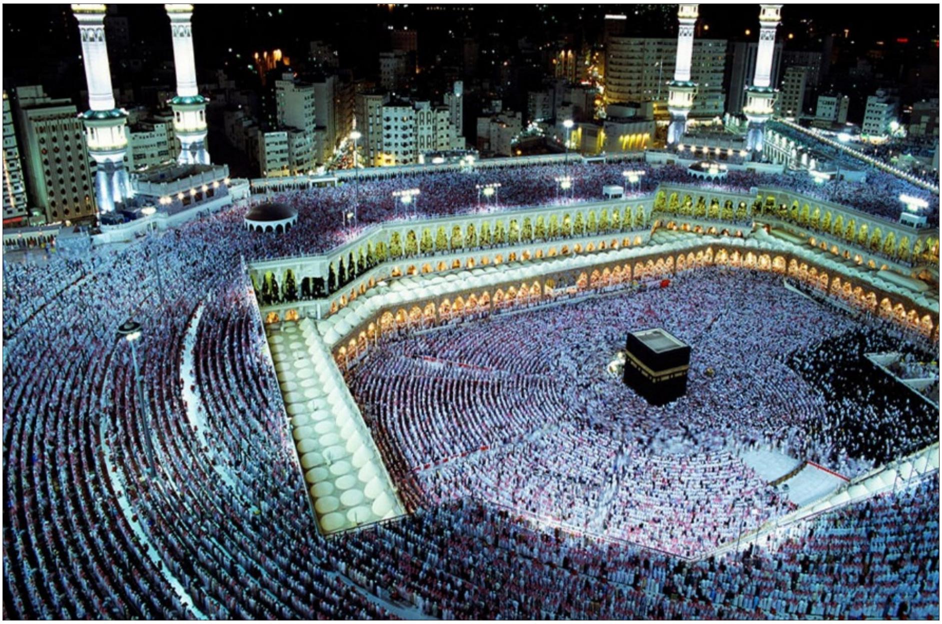
Figure 5: (a) Radio identification card, (b) environmental sensing system (Kukkala, Adechoubou, Negrin, Dinh, & Capayachi, 2009).



Recent research has explored the potential use of RFID technology in the Hajj management systems of Makkah Al-Mukarramah. In these systems, data can be wirelessly transferred without requiring human intervention, and the RFID sensors can read multiple tags simultaneously, even in large crowds, as illustrated in Figure 6. However, the research also examined the technological challenges and security risks associated with RFID tags. These challenges included the impact of environmental conditions on reliable radio transmissions, as well as security threats such as tag replication and eavesdropping.

Figure 6: Picture of

the Sacred House of God (STEVENSON, 2009).



It has been suggested to create an integrated system that combines CCTV, WSN, and RFID to track, monitor, and help individuals in a certain region. In order to provide any essential support, particularly in vital locations, the researchers divided the area into equal cells and used static readers to read each visitor's score within range. This data included blood pressure and heart rate. Modern technologies can help alleviate visitor difficulties due to their rapid processing of the huge amount of information and the high rate of data transfer, as these technologies enable the responsible authorities to Exchange information on visitor movements during the visit. Additionally, the researchers suggested a completely integrated closed-circuit television (CCTV) system that could use particle image velocity measurement to automate pedestrian traffic systems and predict pedestrian traffic distribution with high efficiency and accuracy using high-density video cameras.

This study suggests a hybrid solution that combines WSN, CCTV, and RFID technologies. It gathers visitor traffic data in order to identify and steer clear of congestion by pointing people toward alternate routes. It is noteworthy that these hybrid approaches share many of the benefits and drawbacks associated with crowd control during the Hajj. The cloud platform is also utilized. Thus, the two modules of the suggested approach are the on-premises module and the cloud unit.

Suggested methodology:

Before discussing the proposed study, it is necessary to show the realistic assumptions that must be taken into account when designing, where the hypotheses were formulated to suit the real scenarios of visitors and based on the information available in the volumes and related research, including:

1. Prior to traveling to Holy Karbala, every guest receives an RFID card in their home city. But any other wearable device, like pins, stickers, or RFID wristbands, can take the role of cards.
2. RFID cards are connected to the IoT infrastructure that is supposed to be built across Iraq.
3. Visitors carry their RFID cards at all times during the visiting days.
4. Culture of society on the subject.

Semi-Annual Scientific Journal www.arbnj.com March 2025 - Ramadan 1446

5. LCD screens are located in the sacred area connected to the cloud and consistently display the best route to guide visitors.

6. Visitors follow instructions and do not enter busy corridors as additional assistance and guidance for following instructions may be provided by security forces, as necessary.

7. Matching technology is used to determine crowd state from information gathered by cameras and other wireless sensor technologies in order to address RFID failure.

8. Since the cameras provide complete coverage of the area as well as data matching mechanisms provided by the RFID reader, the proposed method is based on the most accurate data provided by the cameras and RFID readers.

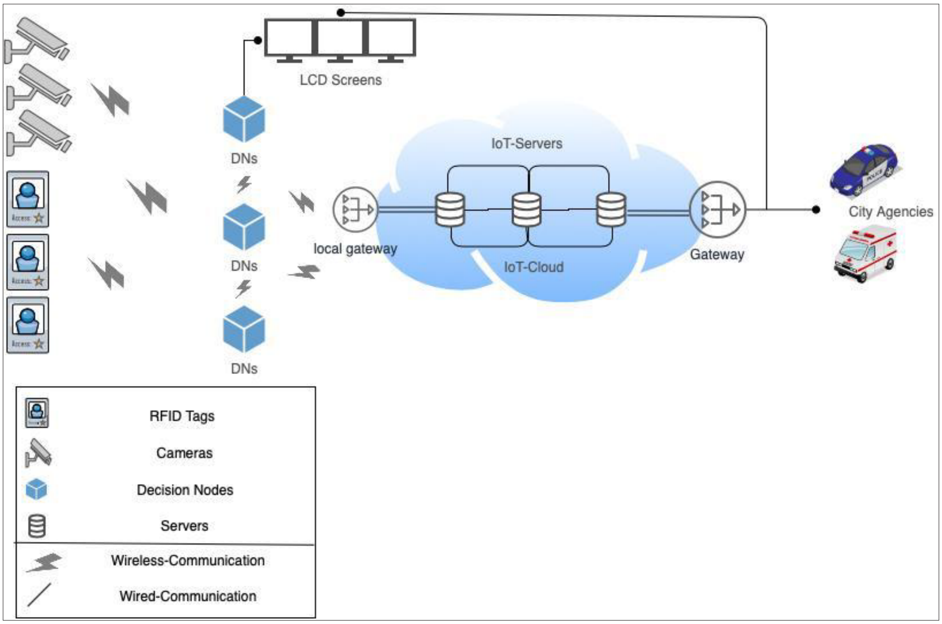
9. All one-way routes (entry or exit) have different priority levels, and each route has a specific capacity.

10. Cameras are placed in each track, with the quantity of cameras determined by the track's priority.

Organizational Structure of the Suggested System:

The suggested system is made up of several parts that work together to monitor, simulate, guide, and lead tourists to their desired locations inside the holy city of Karbala by using the most efficient routes. The general structure of the system and its components are shown as in Figure 7.

Figure 7: Organizational structure of the proposed system.

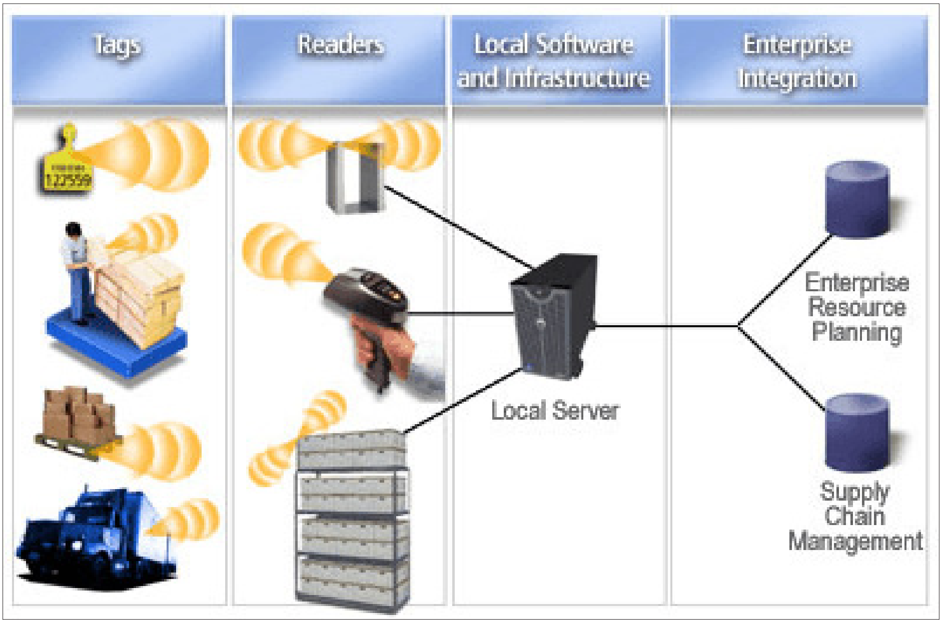


RFID Cards and Reader:

RFID cards are an essential component of the system design. These devices serve as the primary tracking device, monitoring visitor behavior. Figure 8 views that each visitor carries an RFID card with information about their health status, age, and gender.

Each track features one or more RFID readers, which read private information from RFID cards and collect visitor information.

Figure 8: RFID Card reader (Niu, Xu, Chen, & Liang, 2012).



Decision node contract:

DNs are dispersed throughout various densities of routes. DNs gather information from environmental sensors, cameras, and RFID cards. They then use this information to calculate risk factors, coordinate with other DNs to carry out local evacuations, display detailed evacuation instructions on LCD screens, and send data to cloud servers.

The cameras act as a second input source that monitors and captures the behavior of individuals during the visit, as in Figure 9, the cameras are connected to DN networks to transmit information related to the presence of congestion according to the visitor movements captured at each DN decision node.

Figure 9: Illustrative image of surveillance cameras (Sheng, Yao, & Goel, 2021).

Cloud Computer Components:

Input Data :

All system entities are accessible to the cloud. In this approach, data integration and exchange are the main tasks performed by the cloud. Moreover, when congestion is detected, the cloud makes the decision to evacuate. Moreover, the cloud can establish connections via LCD displays with tourists, local authorities, and the Baghdad Operations Center as necessary.

Semi-Annual Scientific Journal www.arbnj.com Volume 2, Issue 2, Part 7, Year 2

Digital Portals:

The on-premises gateway serves as a link between on-premises sensors and the cloud for data transmission. During the visit, the external gateway serves as an interface between the IoT cloud and the operations center in Baghdad.

LCD Screens:

In the holy city of Karbala, LCD panels are positioned at various intervals along every route. Depending on the route's length, priority, and number of intersections, each track has a varied number of screens with varying diameters that are deployed at different densities. For instance, a track with more priority and capacity can contain more screens. The paths determined by the cloud and decision nodes are continuously displayed on screens. Additionally, the efficient and user-friendly design of LCD screens is intended to give guests a simple route to their goal.

Departments participating in the Arbaeen' ziyara:

During the visit, local and federal authorities—such as representatives from the Ministry of Health, security forces, civil defense, and any associated parties—play a crucial role at holy shrines and municipal districts. When harmful conditions arise, these circuits receive an alert from cloud servers that include a copy of the information gathered, allowing them to take necessary action based on that information. Each route's designated DNs receive wireless transmissions of the data gathered from cameras and RFID readers. Under normal conditions, the DN collects data and sends it to the IoT cloud for processing through a local gateway, where it is further processed and reviewed. When an emergency occurs, DNs locally identify the best routes and display them on LCD screens; however, the courses could not be as precise locally as those determined centrally by the IoT cloud, which uses data provided by all system users. Consequently, the cloud updates the LCD screens and DNs immediately upon determining the optimal paths. Furthermore, when congestion and other risk factors exceed the threshold, the cloud alerts the relevant authorities.

Reading and analyzing crowd data:

Suggested method Data is collected via RFID sensors, cameras and environmental sensors. RFID devices collect visitor information including the visitor's name, age, gender, and location while in front of the camera. Environmental sensors obtain environmental information such as weather and humidity and from this information as shown in Plan No. 12 and the following steps:

Semi-Annual Scientific Journal www.arbnj.com Volume 2, Issue 2, Part 7, Year 2

a-Environmental conditions

Weather and air quality are examples of environmental circumstances that change with time and can be categorized into three types: favorable weather (sunny), medium weather (drizzle, fog, light wind), and unfavorable weather (dust and/or heavy rain). Environmental factors have a big impact on how visitors move. Furthermore, the hazards involved in evacuation are heightened by environmental factors.

b-Congestion level

There are six levels of congestion based on severity: very low, low, low to medium, medium to high, high, and dangerous. Congestion is tracked and evaluated using RFID tags, cameras, and sensors placed along all routes. Congestion reduction techniques are applied by the system when it reaches a certain level (low to medium).

c-Visitor Classification

Visitors must be categorized into distinct groups according to their age, gender, medical condition, and speed in order to be managed efficiently.

d-Classification of evacuation corridors

Routes are assigned a priority rating determined by how far they are from important services like restaurants, hospitals, entrances, exits, and other routes. The busiest routes are frequently those that are closest to these services.

Suggested Algorithm

The study of crowd motion and interactions in computer vision has been the focus of machine learning based agent motion modeling techniques (AMMT) in recent decades. In order to represent the crowd, we have extracted both individual and motion information from the recorded trajectories using several AMMTs.

The crowd representation is achieved by combining the geometry modeling based algorithms (Van den Berg, Lin, & Manocha, 2008), heuristic models (Reynolds, 1987), and social force patterns (Helbing & Molnar, 1995). Additionally, the physical position of each agent or crowd member in smart cities is analyzed using these learning models. Using circles in (2 − D) feature space, this approach locates the crowd agents. To facilitate training, certain parameters are needed, including the radius, maximum speed, and number of closest neighbors.

The AMMT is expressed as a parameter-controlled non-linear function (f), denoted by β. The function uses the current crowd state t X to estimate the crowds at the following time step (t +1). Equations (1-3) provide the following forecast for the subsequent step if the computation error is (Bt):

Algorithm I: pre-processing and improving the crowd database
Input: The tested video frames of the captured crowd movies $F=(F_1,F_2 ,......,F_N)$ /* *N is entire number of frames* */
1- A group of frames from a crowd database that has been saved is used as a sample. 2- The retrieved frames are pre-processed to convert the color picture to grayscale. The retrieved set of video frames (F) is cropped and resized to 500 by 500 pixels. 3- Images that have been cropped and scaled have their pixel intensity values converted into a grayscale image using the contrast-limited adaptive histogram equalization (CLAHE) algorithm (Kumar, Singh, Dutta, & Gupta, 2016a, 2016b; Kumar, Tiwari, & Singh, 2016). 4- Use the SIFT descriptor approach to identify and extract the set of features from improved pictures that are discriminating.
Output: Determine the similarity verifying percentage of spotted key-points of tested scene with stored dataset of crowd scene

Semi-Annual Scientific Journal www.arbnj.com Volume 2, Issue 2, Part 7, Year 2

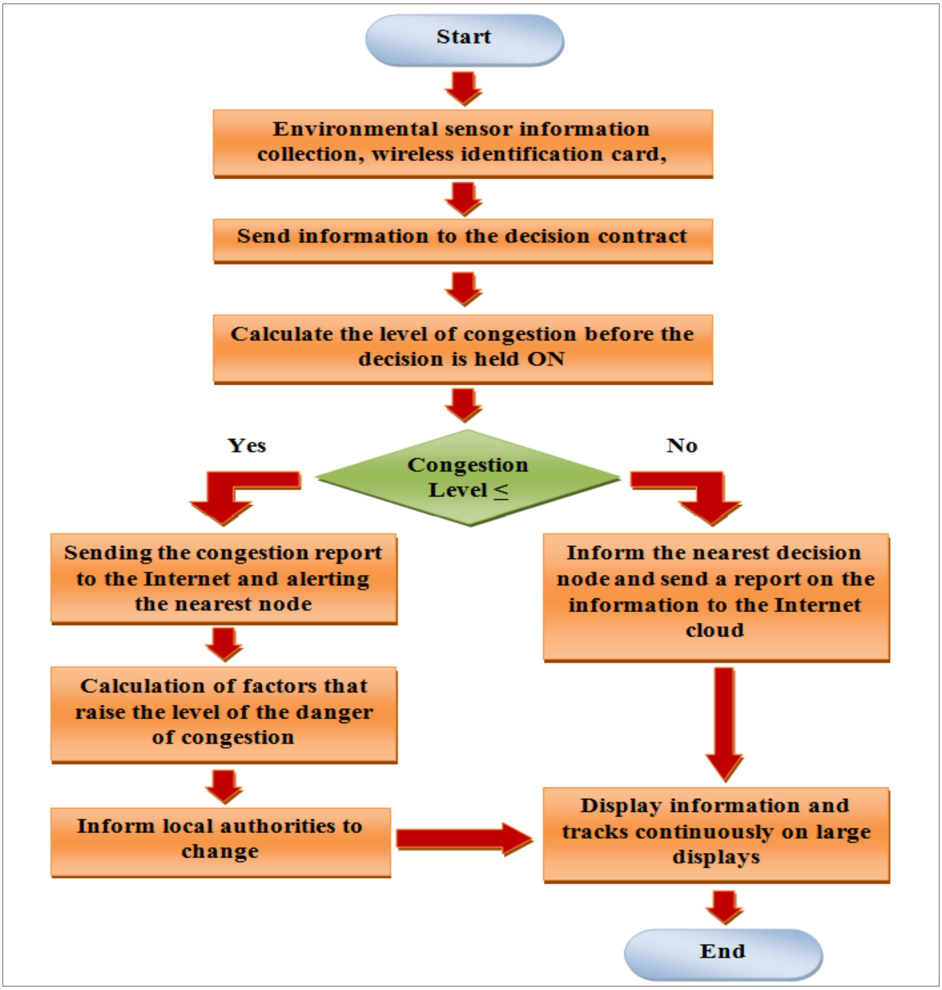
$$X_t = f(X_t) \qquad (1)$$

$$X_{t+1} = f(X_{t+1}) \forall t \in (1,2,3....,N) \qquad (2)$$

$$X_{t+1} = f(X_t) + Bt \qquad (3)$$

Finally, the flowchart of the suggested methodology is mentioned in Figure 10

Figure 10: Flowchart of the Proposed Methodology.



1-Conclusions:

Due to the significant increase in the number of visitors during the fortieth visit, the use of Internet of Things technology has become a necessity in the subject of crowd management, which uses data related to visitors and the environment to achieve rapid evacuation in crowded areas. Through the use of modern technologies such as digital cameras, environmental sensors and radio visitor card reader and processing them in real time, we have an accurate and adequate picture of the places of congestion and the most appropriate ways for visitors to exit after the successful completion of the visit without any obstacles. In future work, it is possible to expand the study by increasing the area controlled by the system to be information about visitors and their movements are many and accurate, and this study needs to be applied gradually and study unexpected cases and problems that may appear during the visit and develop appropriate solutions to complete the fortieth visit optimally.

2-Recommendations

Some of the content that individuals must implement in crowd management and apply has been presented, namely:

1. Commitment to the use of modern technology represented by surveillance cameras and remote sensors and other modern surveillance systems on the subject of crowd management.
2. Organizing training courses for cadres of local and central authorities on crowd management applications.

3. Using social media as a social activity to educate the community about modern technologies regarding the subject of RFID cards and its usefulness to the visitor during the visit.

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