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Design of an Emergency System Based on Wireless Sensor Networks through Cloud Computing/A Proposed Model at the University of Mosul

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Abstract: Wireless sensor networks are frequently used during evacuations (WSN). Improved evacuation procedures can be achieved using modern means of communication, including the Internet, wireless networks, mobile phones, and more. To aid evacuees in avoiding danger, WSN enables target monitoring, hazard sensing, data collecting, and sharing. This research aims to find ways to reduce road congestion during evacuations. Its purpose is to evenly disperse persons who must evacuate across the available exits in a congested region (i.e., building, campus, zoo, etc.). The concept of wireless sensor networks is central to our strategy. Evacuation routes are expected to be adaptive, dynamic, and traffic-free.

Keywords: WSN, Cloud, CPN, Random Neural Network, WSNs.

1. INTRODUCTION

Larger and more intricate building designs in the modern era make evacuating in urgent situations more difficult [21]. This is due to the increased frequency of natural disasters such as earthquakes, fires, and building collapses. Innovative infrastructure development, smart cities, intelligent control systems, etc., all made possible by recent WSN installations, have altered the rate and direction of global transformation [22]. The goal of an evacuation is to quickly and safely remove individuals from the danger zone after an emergency. People must be led swiftly, carefully, and precisely to the best exits in an unstable region so they can leave the area without injuring themselves or others.

Most emergency evacuation plans include two primary metrics: survival rates and evacuation timelines. When an emergency occurs, it aims to direct people away from the danger zone and toward the exits or other safe zones. Evacuation success can be gauged mainly by looking at how quickly people are being evacuated and how many of them can survive. Fires,

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Terrorist attacks, natural disasters, and traffic congestion are all examples of emergencies. Robust mechanisms for planning and preparing for disasters are necessary for modern cities with large populations to maintain economic and national security. People cause congestion when they rush to exits without considering how sure crowded exits are compared to other, less-favored exits that are just as safe. Because congestion occurs in the here and now and alters people's behavior, it typically comes as a surprise.

This study proposes a Wireless Sensor Network and Cloud-based Adapted Congestion-aware Evacuation System (ACES). Provides a load-balanced evacuation guidance system in a condensed form, freeing up the mental capacity to focus on other tasks. A real-time algorithm determines the best path to the nearest exit. The evacuation path is determined by the capacity of the exits and the proximity to the threat. The duration of the evacuation and the safety of the evacuees are therefore expected to worsen. Our real-time monitoring of the building's systems aims to inform a model that accounts for peak network throughput and potential bottlenecks during an emergency. To do this, an intelligent routing system must be developed to distribute traffic and reduce congestion at designated entry points, exits, and throughways. High-traffic zones will be identified and removed from the approved routes.

The quality of services provided by government agencies can be enhanced by monitoring the conditions inside their buildings. Wireless sensor networks (WSNs) help monitor both public and private buildings [4] because of their ability to use light and heat to control and discover possible risks. The importance of emergency medical services (EMS) is rising due to the growing population and the increasing complexity of structures. For this reason, a new class of management systems is required to monitor and safeguard these buildings [2].

2. Background

2.1 WSN and wireless technology

Distributed throughout a vast region, Wireless Sensor Networks (WSNs) comprise many tiny wireless endpoints. These terminals keep an eye on the local environment and communicate the data they collect about the world around them and any observable physical events. Multiple wireless nodes, or sensors, collect information and relay it to the hub, or sink, at the base station (BS) in a WSN. The WSN is an advanced network setup. Memory, sensors, CPUs, batteries, peripherals, and an RF transceiver are just a few components that make up a sensor node [22].

While wireless sensor networks (WSNs) were initially developed for military purposes [19], their applications have now expanded to encompass transportation, healthcare, and environmental study. WSNs were first used to watch the battle for military research, according to a separate source [24]. WSNs are deployed in business, research, and manufacturing [20]. One of the essential innovations of the 21st century, WSNs enable remote sensor nodes to send and receive data [25] automatically. Wireless sensor networks are at the forefront of cutting-edge research for indoor emergency navigation (WSN) usage. Given its low cost, ease of implementation, wireless connectivity, and resilience in the face of

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a node failure, WSN is a promising technology for indoor EMS [20]. Listed below are some often-used terms when discussing WSNs.

- One definition of a sense function is transforming a physical phenomenon into a usable signal (such as an electrical impulse) for use by some other instrument.
- Sensor nodes are the building blocks of a WSN; each node has its battery, processor, memory, and wireless modem.
- A network topology can be represented as a linked graph with the sensor nodes serving as the vertices and the communication lines serving as the edges.
- "Routing" refers to the method used to determine the most efficient path between two points.
- The main components of a WSN are sensing nodes, processing nodes, energy nodes, communication links, and storage nodes.
- Data storage (memory) is a WSN's capacity to handle run-time systems that may be localized at producing nodes, dispersed uniformly throughout network nodes, or linked to numerous endpoints [34].

2.2 The pros and cons of WSN
Wireless sensor networks (WSNs) feature low costs, low learning curves, and high monitoring efficacy [25]. The node's coordinates or position are among the data collected and used by the Global Poisoning System (GPS). GPS is only helpful in these networks, and it takes a considerable amount of time to predefine the locations of all the nodes. When using WSNs to keep tabs on the world around us, one of the trickiest difficulties is how long the network will have to stay up and run. Topology control techniques and power management are becoming more critical as the deployment of nodes necessitate longer lifetimes for some nodes and the putting of some nodes to sleep [25]. Effective resource utilization, particularly in routing and data transfer, is crucial for the rapid rollout of applications utilizing WSNs [21].

2.3 Applications of WSN
WSN applications provide multiple opportunities to test whether or not WSNs can be employed in decision-making systems by observing how data from sensor nodes impacts resource allocation [20]. WSNs have a wide variety of potential uses, from protecting the environment to managing military and surveillance operations, from businesses to hospitals and clinics, from traffic lights to farms. Various environmental conditions, variables, and metrics [26], including threats and habitat, are monitored by a network of sensor nodes.
Second, since the invention of WSNs, the military has employed them for surveillance purposes. Combat surveillance, intelligent guidance, and remote sensing are just a few WSN applications increasingly necessary for military intelligence systems [26]. Third, manufacturing equipment and production processes can be monitored with WSN deployment in industrial and manufacturing domains [26]. WSN is a fascinating field since it can be applied to developing convenient, high-tech dwellings for people [26].

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2.4 Cloud computing

Cloud computing is now able to share infrastructures, platforms, services, and applications. Users can access valuable services and request as-needed services (pay-as-you-go) using a pool of shared hardware, software, and networking infrastructures. For users, fast, low-cost, and low-maintenance service delivery is possible [21]. There is a rising number of cloud computing use cases for various distributed computing system designs. In addition, more people are embracing cloud platforms to process and store data as demand increases [21].

The cloud computing model consists of infrastructure as a service (IaaS), software as a service (SaaS), and a platform as a service (PaaS). Critical data storage, computing power, and processing capabilities can be made available to users using the IaaS paradigm. Large data sets and intensive workloads are fine for a pooled set of infrastructure resources. For instance, Amazon offers various IT infrastructure products, including servers, data centers, storage systems, and networking gear [22]. SaaS is a service delivery approach in which customers access the desired functionality via remote servers. A single instance of a cloud service deployed to several client computers can support many end users. Users are not required to purchase licenses or set up servers. SaaS model, for instance, classifies Google's offerings as services [22]. A service provider can provide a development environment, such as pre-installed software, allowing the creation of more complicated applications using the Platform as a Service (PaaS) concept. Examples of PaaS include Google App Engine [22], where users can build and deploy their programs on a preconfigured platform that already includes an OS and application servers.

There are four distinct approaches to cloud computing: public, private, shared, and hybrid models. In the public mode, the client's slice of the same cloud-based infrastructure and resource pool is also maintained by a third party since the cloud components are owned and managed by the cloud provider. It has been argued [22] that using this mode reduces your service alternatives, configuration flexibility, and security. In private cloud mode, the underlying infrastructure is owned and operated by a single company but controlled by remote administrators. The primary objective of this deployment model is to create a private cloud inside an organization, maximizing the efficiency with which resources are used and ensuring the security of data while minimizing the cost of transferring data from internal private infrastructure to external public infrastructure [21].

Both public and private cloud modes are used concurrently in a hybrid cloud setup. Outsourcing some or all of a service's delivery can give providers more leeway in allocating resources [21]. The infrastructure of a community cloud is the result of a collaborative effort by multiple businesses that agree on a standard set of guidelines for allocating and utilizing the cloud's resources. The cloud infrastructure can be hosted by an organization or an external company (service provider) .

Both virtual and physical servers coexist in cloud computing settings. Cloud applications are run by service providers of online services and web apps using powerful servers housed in massive data centers. Cloud applications require access to the Internet and a web browser.

Some of the most salient aspects of cloud computing are listed below .

- **On-demand services:** Customers can request access to cloud resources, and their demands will be fulfilled immediately and without any intervention from a human.

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- **Resistant to demand:** clients can make automatic requests for resources and return them when they are through using them. Because of this, their application is not constrained by a specified period or any agreement.
- **Abstraction:** Users are only able to interact with resources in an abstract sense without being able to see them, discover their locations, or understand how data is retrieved or stored.
- **Customers** can access cloud applications from any device with an Internet connection, including desktop computers, notebooks, smart phones, and personal digital assistants.
- **Service management:** Users in a multi-tenant environment can access and utilize a cloud environment's shared and pooled computing resources. Cloud infrastructure metering allows for the monitoring of resource consumption.

2.5 The integration of WSN with Cloud

Combining WSNs with cloud computing simplifies acquiring and analyzing real-time data. This way, an internet-based data gathering, and processing service are available. Two emerging service models are "sensing as a service" (SaaS) and "sensor event as a service" (SEaaS). These new services provide cloud customers access to sensor data, contributing to the expansion of cloud infrastructure and the proliferation of cloud applications and services.

3. Motivation

Sensors in a cell-based network Not every WSN node can perform routing due to constraints such as battery life or processor power. The nodes in a WSN are mobile devices, and they communicate with one another using ad hoc connections, whether the network is decentralized or centralized. To facilitate analysis at a later time, the data collected by sensor nodes is encoded before being transmitted to the base station. Cloud computing provides an efficient and scalable means of processing and storing data from a large number of wireless sensors, which is essential to the success of this investigation.

This study aims to examine current practices in the area, address the issue of traffic congestion, and develop and analyze the most effective means of achieving these goals. The effectiveness of the proposed WSN-Cloud-integrated strategy will be measured by its ability to lessen congestion, speed up total evacuation times, enhance load balancing, and guarantee the safety of its users. We have demonstrated a more efficient approach that merges cloud computing with mobile wireless sensor networks

3.1 Architecture

Each sensor node is in charge of collecting data, which is then sent to the base station. The base station is to put together the information collected by each sensor node. After the data is collected, it is sent straight to the cloud or through a number of nodes in a process called "multi-hop." In this case, the Cognitive Packet Network (CPN) model sends Cognitive Packets (CP). This makes it possible to monitor the network and find a route. Each node in the CPN has a standard Random Neural Network (RNN) that has neurons for the other nodes in the network. Because of this, each node should keep its routing database with a set number of reserved routes.

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CPN can send three different types of data transmissions: Smart Packets (SP), Acknowledgement Packets (ACK), and Dumb Packets (DP). SP is used to find information and find ways to get there. Every packet can choose the next hop with the highest activation neuron value or let chance lead it to unmeasured paths. When the SP reaches its final destination, the data are put together into an ACK and sent back to the source node via the inverted way. When the ACK information gets to the source node, the routing table is updated, and reinforcement learning is used to train a random neural network (RL). DP always sends payloads along the route in the routing table with the shortest distance.

SP route discovery is a tool that can be used to look for existing paths and gather information about them. This has to be done because the emergency evacuation environment is constantly changing. DP is also used to ensure that the base station gets correct information in an emergency. The ACK command sends the received information back to the node that sent it. This changes the amount of neuronal activity in each node that the signal goes through. The routing table is set up from best to worst, and DP will always choose the path with the best chance of success. This makes it faster to collect data, process information, and get people out of the building. Figure 1 shows the link between cloud computing and wireless sensor networks. It shows the end users using mobile devices inside buildings with sensing services. Because these mobile nodes are connected to the base station, which is directly connected to the cloud, they can use highly efficient and scalable resources.

Figure 1: How Cloud Services and WSN Work

3.2 Proposed model

The proposed model has nodes that can be separated into two different groups. Classical Nodes (CNs) and Master Nodes (MNs) are the two types of nodes (MNs). CNs are mobile, resource-constrained nodes (e.g., people that have smartphones). MNs are nodes that do not

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move. They stay in the same place and have access to more resources. The vast majority of the time, MNs are used as routers. Class A CNs have nodes at its, Class B CNs have nodes at corridors, and Class C CNs have nodes elsewhere (nodes located at offices). There are two different kinds of exits, which are called Main-Exits (ME) and Sub-Exits (SE), respectively (SE). The MEs are the most common ways to get out of the building. The SEs are the doors, stairs, and elevators used to get out of the building. Any node that is neither a controller node nor a classical node is called an "exit node." This model has two places where things could go wrong: the base station, which is in charge of sending data, and the key exits, which are along the escape route with the shortest travel time, the best chance of survival, and the best load balancing (most minor congestion). Any node in a graph that is not a primary exit node is called a "source node." The sensors installed permanently are called "nodes," and the extra passageways are at the edges of the backbone.

Figure 2 shows the basic layout of the suggested model, which takes load balancing, shorter evacuation times, and less congestion into account than the current model. Unlike previous methods, the suggested model considers where the threat is coming from. This means that the network's topology can be changed on the fly whenever there is a threat. It is also set up so that there is an equal distance between fixed-location nodes called controller nodes (MNs). MNs are used to share work between nodes and reduce the resources used by mobile nodes called classical nodes. This is done so that there is the same amount of space between nodes that stay in the same place. This architecture has 29 classic nodes, 11 controller nodes, and five exits. The controller nodes do not move, but the classic nodes do.

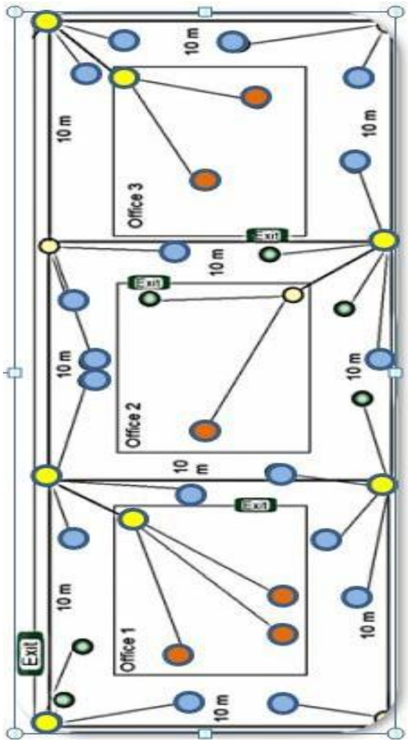

Figure 2: Simple Architechture of Proposed Model

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Before an emergency evacuation can happen, the following things must be in place: A ready-made area graph showing how many central exit nodes and how long each Edge is. All nodes regularly send the information they have gathered to the base station. The base station is where the data is collected, and then it is sent to the cloud. After that, the cloud looks at the data and reports what it found to the sink. The base station will then let each node know what the results are. The modified Dijkstra method described in this paper calls for the cloud to choose, for each mobile node, the departure node that is best in terms of safety, speed, and proximity to other nodes. When cloud analysis finds a possible risk, the maximum lifetime, or the number of hops the risk can make before being stopped, is calculated for each SP. In this case, the possible hops equal the number of MNs in the network plus one. MN residents are encouraged to talk to their CN neighbors about the newly found risk by giving them information. The proposed algorithm for load balancing and being aware of congestion is based on the idea that MNs, which are sensors close to MEs, can find and keep track of possible blocked arrivals. In this way, the number of people entering and leaving the ME and the current state of the exit node is both factors that affect congestion. When the number of people expected to leave is less than the average number of people leaving multiplied by the average number of people arriving, and this number is greater than the capacity of the central exit node, congestion is likely to happen.

4. DISCUSSION

Within the scope of this investigation, we propose several alterations to the CPN framework that are adapted to the necessities of rapid evacuation procedures. Since centralized nodes (CNs) and mobile nodes (MNs) are both examples of wireless sensor nodes, these criteria apply to both types of nodes. Traditional Nodes (TNs) can locate possible danger zones and sound an alarm to alert people. For the wireless sensor nodes to be able to send the data they have gathered, they must first establish a connection with their related (or nearest) MN neighbor. The MNs that make up a wireless CPN serve double duty as a router and a transmitter for the network. As depicted in Figure 3, an MN will be present in every room and corridor. MN is typically utilized within a CPN in the capacity of a stationary packet-sending node (for example, on the ceiling). The maker of the EMS must have an early comprehension of this network architecture. To ensure that passengers are led to the most convenient exit, each CN is given the MN that is located closest to it according to a distance criterion that the user defines. Because of this, the maximum distance between any two MNs is equal to the distance between their deployed CNs; typically, more than one CN is present to ensure a comprehensive watch.

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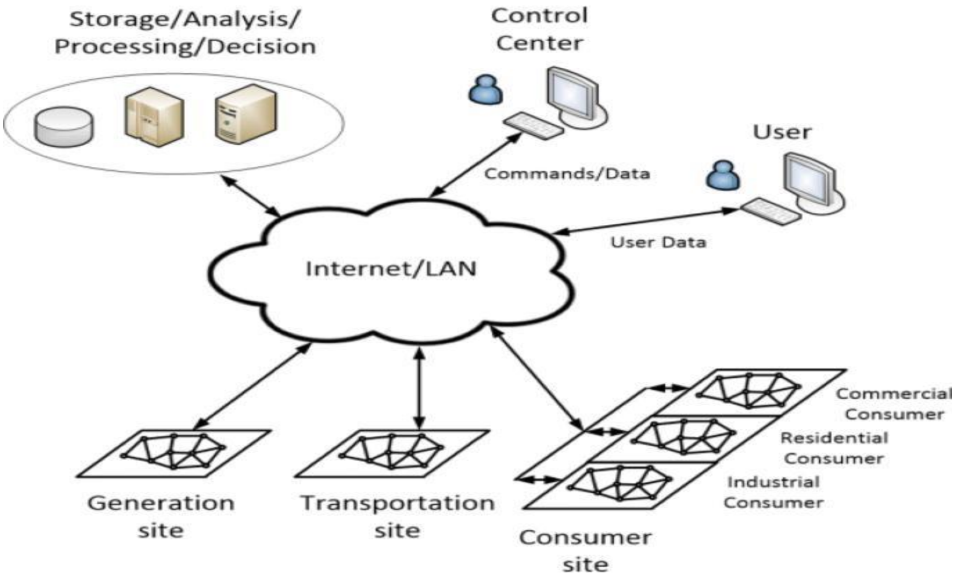

Figure 3: Proposed Architecture of WSN and Cloud for Emergency System

Each MN will, at regular intervals, provide its CNs with an update on the current state of the connections to its surrounding MNs and CNs, as well as the exits. In addition, each SP can request exits and routes to MNs, who can inquire about the conditions of all CNs in the region. MNs utilize the CPN algorithm to determine the most appropriate exit to obtain routing information by the present position. MNs send data to the base station on potential escape routes for the base station to investigate.

Every person being evacuated receives a briefing on the particulars of their escape routes, including exits, areas with high traffic, and any potential impediments they may face. As people leave using the path utilized the least lately, the number of nodes (including sub-exit nodes) that are located before the main exit is displayed.

Evaluation

Two different quality of service indicators are utilized by EMS personnel in order to ascertain which evacuation route will prove to be the most effective for each patient. Time Metric (TM) and Safety Metric are these measurement systems (SM) names. TM selects a path in the surrounding area to assist those individuals who do not live close to the critical evacuation hubs (i.e., Class A evacuees in the EMS). TM chooses exits to get people out of the building as quickly as feasible. In high-density or high-threat circumstances, the SM survival rate will be employed for all evacuees to boost their survival chances. It is possible to determine a route's SM based on the frequency with which that route is used.

The network comprises a total of 45 nodes, two of which are the primary exits, three of which are secondary exits, 29 regular nodes, and 11 controller nodes that are permanently stationed at their respective places. Every node has its MN, and CNs link any two MNs next to one another. The multiple ways to traverse the structure are represented by the edges of a graph, which are the lines that connect the nodes at even intervals. At least one CN will be located on each side of the road.

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Figure 3 shows that the 29 normal nodes must be moved to one of the two doorways for the diagram to work correctly. A sufficient buffer zone must be kept between each mobile node and the nearest exit. It is anticipated that the capacity of the main exit will be 15 seconds, while the capacity of the second exit will be 5 seconds. For each classical node, we may use equations (1) and (2) to calculate how long it will take to reach an exit, factoring in the node's speed, the direction of the threat, and the time needed to evacuate everyone. Suppose there is a node in one of the three workplaces within the MN neighborhood and three meters away. A node will be routed to the second exit if the primary exit has congestion of more than 15, and it is required for the node to migrate to an exit with no congestion. This node will be sent toward the primary exit using a modified version of the Dijkstra algorithm.

Nodes located at enormous distances require significantly less time to travel to evacuate as a direct result of the adaptability and responsiveness of this technique. Cloud computing can be leveraged to manage the enormous amounts of data created by base stations because these stations receive data from all wireless sensor nodes. Using this method allows you to use the cloud's scalability, storage capacity, and computing power. We created an algorithm that considers congestion by employing the proposed architecture, which combines cloud computing and WSNs.

5. CONCLUSION

The investigation aims to discover ways to fix the traffic problems that developed as a direct result of the evacuation. Its goal is to distribute the number of people who need to leave across the numerous routes that pass through confined areas as evenly as possible (such as a building, campus, zoo, etc.). The WSN strategy is at the core of our approach. It is possible to make adjustments to it in real-time in order to adapt to changes, and it can compute alternative evacuation routes in order to avoid crowded regions. In the suggested updated version of Dijkstra's algorithm, which is identical to the original version of Dijkstra's technique for finding the path of least resistance, a time metric is substituted for a distance metric. You can use the cloud-based modified Dijkstra technique to determine the cheapest or shortest path to any other node in a graph if you have a starting (traditional) node. Dijkstra developed this approach. In subsequent work, we will put into practice the three methods that are discussed in this study. The model will be validated using network simulation to improve congested areas, overall evacuation times, load balancing, and the safety of evacuees.

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