

Development and Research of Intelligent Emergency Evacuation Indicator System Based on 4G Communication Technology

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Abstract:

Due to the increasing number of large-scale commercial complexes, entertainment places and commercial office buildings in the country, the complexity of building design and the emergence of underground buildings have led to the crisscrossing of building passageways, at present, the function of the emergency evacuation indicator is single, which cannot meet the daily needs. The aim of this project is to develop an intelligent emergency evacuation indicator system to adapt to the dynamic disaster changes, taking 4G communication technology as the main means of communication technology, the information transmission and feedback of control system and equipment layer are completed, and an intelligent emergency evacuation indicator system based on 4G internet of things is formed.

Keywords:

Indicator Light System, Emergency Evacuation Indicator Light, 4G Communication Technology, Information Transmission, Building Access

1. Introduction

With the increasing demand of high-rise, large-scale and complex-function buildings, the quality and performance of buildings as well as the economy and safety of buildings should be considered in architectural design. Fire is a frequent accident in buildings, which poses a great threat to people's life and property. At the same time, because of the high density of people inside the buildings, evacuation channels are complex, the risk of fire is greatly increased. Therefore, in civil buildings, in order to facilitate people in emergency escape and personal safety, we need to design a scientific, reasonable, intelligent evacuation indicator system [1].

This paper mainly studies the design and implementation of intelligent emergency evacuation indicator in case of fire. Compared with the traditional light system, the intelligent emergency evacuation light system is different in nature. The intelligent

light will be equipped with fire sensors, and fire information will be transmitted in time by TCP/IP protocol. In the case of fire, with the help of algorithm, the server predicts the exact location of the fire and the possible location of the fire, and intelligently chooses the best evacuation route for people. In general, the intelligent indicator light system has the following characteristics [2]:

- Any place in a building equipped with the indicator light system, in case of fire, with the help of algorithmic software, an optimal evacuation route is constructed automatically, and the direction of the optimal evacuation route is indicated by the indicator.
- The indicator light system is based on TCP/IP protocol to achieve 4G communication transmission, the transmission form is more stable, more rapid.
- The LED light source is used in the light system of the indicator lamp, which has lower energy consumption and certain light transmittance, and can guarantee the effective indication effect in the fire.
- The indicator light can provide multi-angle indication function, which is different from the traditional indicator light system. The indicator light system can provide indication for the front, left and right directions at most at the same time, so as to ensure the clear communication of the evacuation route.
- The indicator lamp is equipped with a fire sensor which can transmit the fire information in each environment back to the main control room in time.
- Single-thread and multi-concurrent connection mode is used to ensure the stability and speed of data transmission.

2. The Necessity of Intelligent Emergency Evacuation Indicator System in Fire

At present, in many cities in China, there are more and more large-scale commercial complexes, entertainment places and commercial office buildings, along with the complexity of building design and the emergence of underground buildings, as a result, the buildings' passageways are crisscrossed more and more complex, and the serious psychological phenomenon of crowd following under the condition of crowd crowding and panic has not been well solved during the routine emergency evacuation drill at the airport, as a result, a fire or other emergency in a building can often have serious consequences [3].

At this stage, the traditional emergency evacuation light has a fatal flaw, is that it can only indicate a fixed direction of escape, usually pointing to the nearest security door, as shown in Figure 1.



Figure 1. Traditional emergency evacuation light.

If there is a fire in the direction indicated or smoke is spreading, or if the safety door fails to open automatically due to a malfunction, or if the fire emergency lights in the building are not maintained in real time during normal times, in a crisis situation, the traditional emergency and evacuation lights do not function as they should.

When a fire occurs in the building, a lot of smoke will be generated, and the traditional emergency evacuation indicator light transmittance in the smoke state is not good, as shown in Figure 2.



Figure 2. *The light transmittance of traditional emergency lights.*

In addition, the traditional evacuation lights can not meet the real-time adjustment of the best evacuation path, emergency, people blindly follow the crowd to escape, often easy to make everyone into dangerous areas. In addition to the distance from the exit, the design of the emergency evacuation indicator should also take into account other factors in the stadium, such as visibility, smoke concentration, congestion and fire spread. In order to shorten the evacuation time, it is necessary to take into account the dynamic change of the personnel's current location, to provide more reliable evacuation route command scheme for exhibitors in different areas [4].

Overall, the emergency evacuation indicator at this stage has a single function, the road force optimization algorithm of the system can not adapt to the change of the dynamic disaster well, and the optimal path planning is easy to lead to the backoff behavior and low computational efficiency. Therefore, the development of a dynamic intelligent emergency evacuation indicator system has a good application prospects.

3. Intelligent Communication Structure of Emergency Evacuation Indicator Lam

3.1. Advantages of TCP

Figure 3 shows the OSI seven-tier architecture. From this diagram, we can see that TCP/IP in the OSI benchmark model mainly acts on the network layer and the transport layer. IP protocol finds the logical address in the protocol layer, realizes the function of path selection between different networks, and realizes the communication between two network devices TCP/UDP protocol is responsible for format verification of data to be transmitted in the transport layer to ensure that it conforms to the communication protocols of both parties. At the same time, the TCP/UDP protocol transfers the data from the session layer to the network layer to realize the data transmission. In the transmission layer, we can select the appropriate communication protocol according to the requirements of practical application and realize the design requirements of the system [5].

At present, the common network communication protocols, such as browsing web pages, transferring files, sending data, are based on TCP or UDP TWO protocols for data transmission. TCP and UCP are the transport layer in the network structure, and the target is to transfer data between programs. The biggest difference between them is that TCP is based on connection, uDP is connectionless.

First of all, UDP protocol is based on non-connected, data transmission process is to package the data packets, through the network card to send the data packets. There is no relationship between packets in the process of transmission. It is this simple method that results in less performance loss and less resource occupation in the process of transmission. However, there is some packet loss in this mode, which leads to the instability in the process of data transmission.

The TCP protocol is based on connection, which is different from UDP in establishing connection, determining connection and closing connection. From Figure 4, we can see that TCP is through “Three handshakes” to establish the connection, through the client to send SNY packets to the server to ask whether to establish a connection, the server agrees to establish the connection by replying to the SNY packet and the ACK packet. Finally, the client sends the ACK packet to realize the establishment of the connection. This way of establishing the connection can realize the establishment of reliable connection in the unreliable network connection. Secondly, the data transmission between the client side and the server side of TCP protocol is through setting up the sending buffer, and allowing many times to cut and send, and according to the serial number of the message sent, the data is pieced together completely, this reduces packet loss [6].

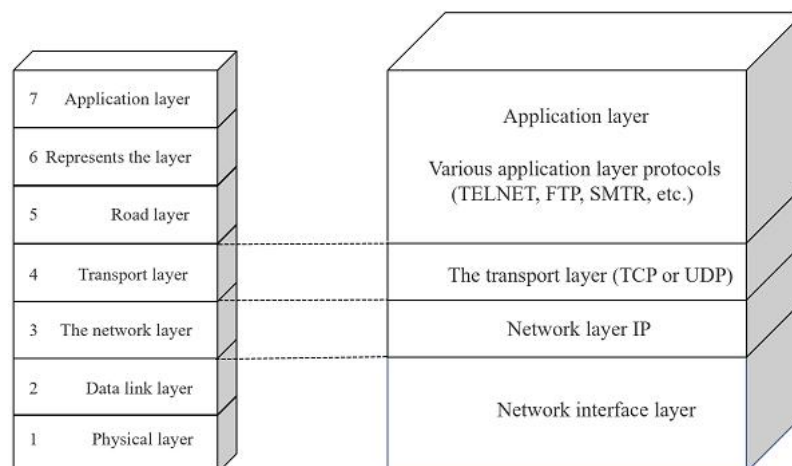


Figure 3. OSI seven-tier architecture.

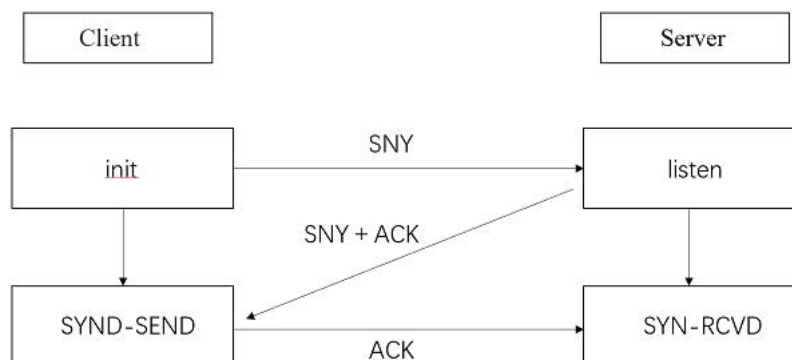


Figure 4. Three handshakes.

3.2. Indicator lamp operation structure

The indicator and server are connected via TCP/IP. The indicator consists of network transmission unit, sensor unit, optical unit, etc.. Using TCP/IP protocol to realize the transmission of signal between indicator lights and monitoring signal strength, improve the ability of information interaction between hardware and software, the completion of the emergency evacuation lights can be dynamically adjusted in the face of dynamic disasters and the first time in the disaster will be able to accurately transmit the signal to each light so as to achieve the goal of improving protection efficiency and reducing casualties and property losses.

A wireless network in an area is composed of the indicator lights in different positions and the simple actuators in the indicator lights, which can realize the measurement and feedback of the environmental fire situation and provide the correct instructions for the evacuation of personnel. When the thermal runaway occurs in the outside environment, the thermal runaway indicators are detected and collected by the internal components of the indicator lamp, and the data collected by each indicator lamp is transmitted to the server through a single-process multi-connection, through collecting and processing data, information decision-making, the server transmits the operation execution instruction to each indicator lamp to realize the quick response of the indicator lamp. The application structure of the light is shown in Figure 5 [7].

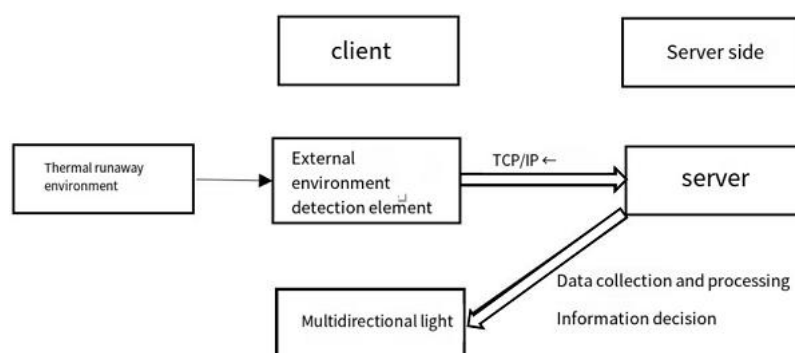


Figure 5. Indicator light operation structure.

3.3. The choice of network communication structure

Because of the latent nature of the fire and the uncertainty in the spreading process, the multiple emergency evacuation lights placed in the area must establish a fast and reliable connection with the server. Because a single CPU core can only execute a single thread at a time, when using multi-thread concurrent connection, once the number of threads, it will inevitably block the transfer of data. In the case of fire, the data has a certain timeliness, once the data packet loss, blocking and other circumstances, may further lead to the loss of continued expansion. Therefore, when a large number of lights need to transfer data to the server at the same time in a short period of time, if using the traditional multi-thread concurrent approach is not feasible. Here we chose Python to build the connection channel, using the select module to achieve data single-threaded multi-concurrent.

Select cleverly used the asynchronous principle, the original synchronization of the multi-thread concurrent connections in the blocking, with the help of sockets ever through Select to accept multiple connections at the same time, this way will change the original multi-thread connection into single-thread multi-concurrent, in the case of a large amount of data, can greatly reduce the CPU overhead and pressure. As the

client connects to the server, the server registers the file handle and polls the list. At the same time, in order for the main process to be able to send and receive information between connected clients and establish contact with new clients, the polling speed must be extremely fast (dead-loop) to the list of file handles to which the client is connected. When the client sends a message, and the server receives the data, there will be another list to receive the information returned by the client, and then continue to refresh this list, refresh out and then return to the client, the communication with the client ends, and although the connection to the client is not broken, it moves on to the next poll[8].

3.4. Python-based network connector

The application Python realizes but the single thread multi-concurrent server constructs, mainly realizes through the following way:

A function that converts a string to bytecode

Slices the input string, separated by spaces.

A loop converts hexadecimal characters in a string into decimal integers, which are then stored as bytecode.

Returns the converted bytecode.

Create a socket object and set it to non-blocking mode.

Bind the address, set the listener, and start waiting for the client to connect.

Create three lists: inputs, outputs, and message to store socket objects and data.

Create a dictionary D, a counter P, and a variable O to determine the state in the program.

Use the while loop to keep listening and call select. Select function to wait for the file descriptor to be ready, and if none of the file descriptors are ready, the program will keep blocking here.

Traversal the ready-to-read file descriptor RLIST.

If R is a server object, then a new client is connected, call the accept function to establish the connection, add the new connection to the inputs list, and create a new queue to store the data, add it to the message dictionary.

If R is not a server object, then a client sends data, calls the RECV function to read the data, and splits the data into different fields for processing. It then checks whether the data it receives is null or, if not, puts it on a queue for processing. If the received data is null, the client has disconnected, delete the corresponding key-value pair in the message, clean up the disconnected connection.

If an error occurs while reading the data, the client disconnects, cleans up the disconnected connection, and removes it from the outputs and inputs list.

Traversing the writable file descriptor WLIST to retrieve the next message to be sent from the queue, doing nothing if the message queue is empty, and sending the message in the queue to the client if the queue is not empty. If the delivery is complete, remove the client socket from the outputs list.

If an error occurs while sending the message, the client disconnects, cleans up the disconnected connection, and removes it from the outputs and inputs list.

Pseudo-code:

Begin

import socket

import select

server_socket = socket.socket(socket.AF_INET, socket.SOCK_STREAM)

server_socket.setblocking(0)

server_socket.bind(('IP address',port number))

server_socket.listen(5)

message_queues = {}

inputs = [server_socket]

while inputs:

 readable, writable, exceptional = select.select(inputs, [], [])

 for s in readable:

 if s is server_socket:

 client_socket, client_address = s.accept()

 client_socket.setblocking(0)

 inputs.append(client_socket)

 message_queues[client_socket] = []

 else:

 data = s.recv(1024)

 if data:

 message_queues[s].append(data)

 if s not in outputs:

 outputs.append(s)

 else:

 if s in outputs:

 outputs.remove(s)

 inputs.remove(s)

 s.close()

 del message_queues[s]

 for s in writable:

 try:

 next_msg = message_queues[s].pop(0)

 s.send(next_msg)

 except IndexError:

```
        outputs.remove(s)
    for s in exceptional:
        inputs.remove(s)
    if s in outputs:
        outputs.remove(s)
    s.close()
    del message_queues[s]
End
```

4. Experimental simulations

For the sake of safety, the fire evacuation experiment referred to in this paper is a simulation operation based on table-top exercise, which aims to prove that the emergency evacuation indicator can meet the needs of actual fire scene, in a relatively short time, it can provide guidance to pedestrians in many directions and realize the safe evacuation of pedestrians. The intelligent emergency evacuation indicator system used in this experiment will establish a stable connection with the server through the TCP/IP protocol and calculate the server port through the co-evolutionary path algorithm, to provide the shortest safe evacuation path for people in different directions. Figure 6 shows the external structure of the emergency evacuation light in this experiment, which is significantly different from the evacuation light which can only provide the safety exit indication in the past. From a single direction, the indicator light can provide the direction of the forward, left and right, as well as the no-go: from a multi-direction, the indicator light can be provided to people in a number of different directions of the indicator light. Due to the change of the scene fire, the indicator light will also be updated with the Co-Evolutionary path optimization (Co-Evolutionary path optimization) deduction in the server to meet the evacuation requirements [9].

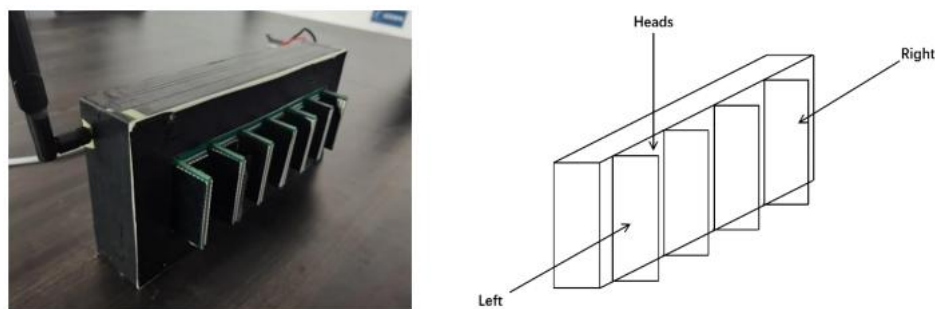


Figure 6. Indicator light graphics.

Figure 7 is the plan of the experiment site. The emergency evacuation lights are placed at every intersection, and the position of the lights is clear enough to provide clear instructions for the people on site. As the spread of the fire takes a certain time, we default when people reach the safety exit is a safe evacuation. At the same time, the fire in the experiment will show the characteristics of dynamic change, which means that the fire will be different from other disasters, it has spread, spread, in the evacuation process, the evacuation route will be protected from fire.

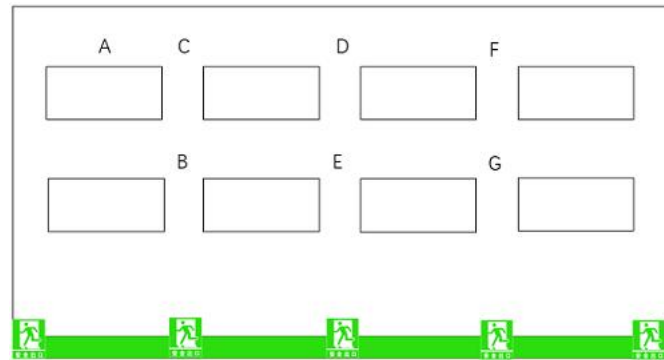


Figure 7. The plan of the experiment site.

When a fire breaks out at point B and the pedestrian is at point A, the building has fire detectors and intelligent emergency evacuation lights that respond quickly to the fire. The fire detectors in the buildings will send out an alarm to inform the people of the fire, but they can not tell the location of the pedestrians accurately. They need to cooperate with the emergency evacuation lights, use the emergency evacuation lights to guide you to a safe exit.

As shown in Figure 8, at $T = 0$ time, according to the calculation of the shortest path, the choice of Path 1 must be the fastest to reach the safe evacuation site, but because of the fire at Point B, the pedestrian can not get to the safe exit through path 1. The server will send a light to run the code. The c-point light will provide the pedestrian with a light to move on, avoid the fire.

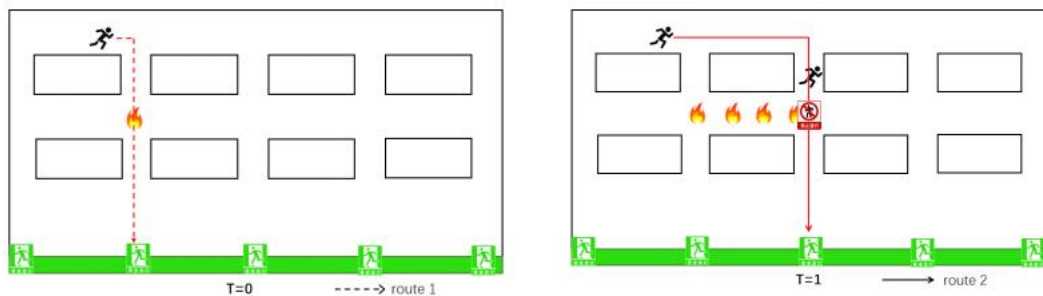


Figure 8. Evacuation route map.

At $T = 1$, the pedestrian reaches the intersection at D, the shortest path at this moment should be the same as through Path 2, the fastest to reach the safe evacuation point. Since fires are dynamic, the plan may not have developed at point E when pedestrians reach point D, but once pedestrians reach the intersection at point E, the intersection may be impassable due to the spread of the fire. In this paper, we use the co-evolutionary path algorithm (Cepo) to calculate the fire spread and the shortest path of people dynamically, and then get the Route 3 from the safety and the shortest path.

According to Figure 9, at $T = 2$, the pedestrian reaches the g-spot through path 3 as indicated by the light. In the path given by Cepo, the fire spread has not yet reached the g-spot, according to the conclusion of the algorithm, the indicator is transmitted to each indicator by TCP/IP protocol, and the indicator meets the established requirements and is quick to respond.

Based on TCP/IP protocol and CEPO, the emergency evacuation indicator can provide the direction according to the given requirements, and the indication signal is stable and clear.

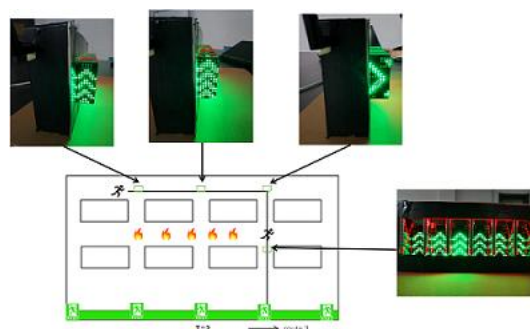


Figure 9. desktop walkthrough.

5. Conclusions

In this paper, the necessity and communication structure of the intelligent emergency evacuation indicator system are described in detail. The experimental simulation shows that the developed indicator system can meet the needs of personnel safety, the future research directions of the system are as follows [10]:

(1) At present, because of the function of the indicator lamp needs, there are many functional modules inside, making the overall quality larger. Future development could consider using micro-motor technology (MEMS) to make the light weight.

(2) The existing indicator lamp is difficult to develop and has complex function structure, which leads to high overall cost. In the future, we can consider to carry on the lightweight design, realize the factory production and reduce the cost on the premise of ensuring the function to meet the requirements.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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