Intelligent Traffic Light Control System Based on Fog Computing

Weiwei Sheng, Yidian Li
School of Software, Zhengzhou University, 450000

***Abstract*—This paper designs an intelligent traffic light control system based on Fog Computing. Due to the huge amount of real-time urban traffic condition data and traffic light control data, it is difficult for the system to adopt traditional central node data processing and control methods. Therefore, this paper uses the characteristics of fog computing, such as low delay, distributed computing and wide geographical distribution, and integrates with the existing adaptive system to form an intelligent traffic light control system based on fog computing. The system is mainly composed of fog node module, fog server module and data transmission module.**

Keywords—Fog Computing; Intelligent traffic lights; Control system

I. Introduction

Because the traffic flow on the road is increasing greatly every year, the traditional traffic light control method can not achieve the purpose of dynamic adjustment of traffic lights according to the real-time traffic flow of the intersection, resulting in the intersection congestion. Therefore, building an adaptive intelligent traffic light control system to improve the traffic capacity of intersections is an important key issue in the field of intelligent transportation. The goal of Intelligent Transportation System (ITS) is to work closely with people, cars and roads to increase the passing rate of traffic intersections and ease the congestion of urban traffic. Traffic lights can ensure the orderly and smooth passage of vehicles throughout the road network. This paper designs an intelligent traffic light control system based on Fog Computing. Due to the huge amount of real-time urban traffic condition data and traffic light control data, it is difficult for the system to adopt traditional central node data processing and control methods. Therefore, this paper adopts a distributed data acquisition, storage, processing and control system. The data viewing and management terminal can access and collect relevant data of each fog node as required, without uploading all data to the terminal regardless of whether it is required or not. The system consists of fog node module, fog server module and data transmission module. The fog node module data is cached locally. Fog servers are connected with each other through the Internet of things transmission protocol, interconnected in a certain area, which can form a real-time monitoring of a region, and there is a local traffic signal scheme generation and control system in a small area. The data transmission module is built by NB-IoT technology, and the overall data transmission adopts a mixed wired and wireless networking mode between different modules of the system.

II. System Framework

This system adds the application platform of fog computing to the existing traffic light adaptive control mode. The system mainly includes fog node module, data transmission module and fog server module. The system framework is shown in Figure 1. The fog node module comprises an image acquisition module, an image processing module, a data cache module and a traffic light control module. the fog server module comprises a data processing module, and the data transmission module is mainly responsible for sending and receiving data (the data transmission module is indicated by a black solid arrow in Figure 1).

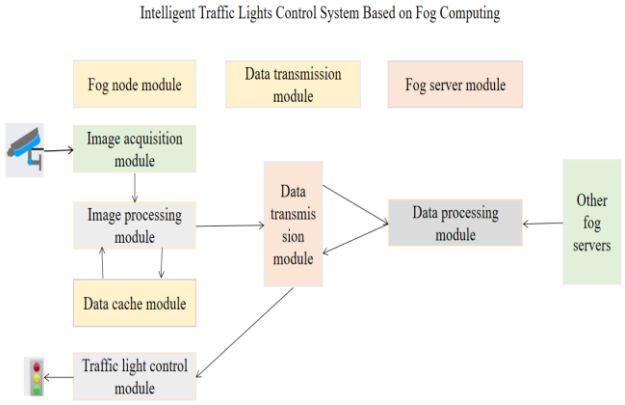

Figure 1 Frame diagram of intelligent traffic light control system

The system collects traffic information images through cameras distributed at intersections, the collected traffic information images are analyzed, filtered and processed by a data processing module in a fog node, and the processed results are transmitted to the data processing module as traffic light control algorithm parameters by a data transmission module. The data processing module transmits the results obtained after the implementation of the traffic light control algorithm to the traffic light control module in the fog node module through the data transmission module, and the traffic light control module regulates the intelligent traffic light according to the algorithm results. In the fog node module, the image processing module can transmit data to the data cache module for caching, and the fog server module can transmit data between them. The data processing module performs the traffic light control algorithm by receiving the data transmitted by other non server modules.

III. FOG NODE MODULE

A. Image acquisition module.

In the image acquisition part, the high-definition CCD camera capture host is used as the main acquisition equipment, real-time recording and acquisition are carried out on passing vehicles according to fixed time intervals, and the acquired images are transmitted to the image processing module of the fog node.

B.Image processing module.

In the image processing, according to the system identification requirements and the actual snapshot situation, the noise and interference in the image are filtered, the image edge is enhanced, the contrast is enhanced by histogram equalization method, and the automatic white balance and automatic exposure processing are carried out [1].

In the process of image recognition, image recognition based on convolutional neural network is used. Image recognition is carried out according to the trained model, and the parameters of image recognition results are extracted. Through the recognition of a large number of pictures in a certain time interval, we can get the traffic volume of the intersection, the length of queue when passing the intersection and other parameters. These parameters are the original data required by the algorithm in the traffic light control module, and then these data are sent to the data transmission module and transmitted to the regional fog server.

If these data are transmitted to the fog server, it will cause bandwidth waste and delay waiting. An intelligent traffic control system will be run on the fog node to analyze the data in real time. According to the actual situation of the road surface, intelligent traffic signal lamps will be used to reduce the traffic jam on the road surface [2].

C. Data cache module.

Fog node has the capability of caching and calculation. When fog node filters data, part of real-time traffic data is located in the fog node cache area in the data cache module as backup data. When the data processing module needs data again, it calls directly from the data cache module, which effectively reduces the data transmission in the network and relieves the load of the fog server.

D. Traffic light control module.

The traffic light control module is responsible for receiving the data sent by the data processing module and sending the obtained control signal to the traffic light display to display the traffic state [3].

IV. FOG COMPUTING MODULE

Fog Computing module in this system mainly includes data processing module.

At present, there are three commonly used methods for traffic light timing control: timing control, induction control and adaptive control [4]. With the increase of urban traffic flow in recent years, the traffic light control methods commonly used in the past, i.e. timing control and induction control, can not meet the current demand of easing urban traffic congestion due to their inability to adjust traffic lights according to real-time traffic conditions. However, the flexibility, availability and optimality of the adaptive control method can effectively alleviate traffic congestion, so the use of adaptive control method to control urban traffic lights has become a mainstream scheme. At present, the self-adaptive timing methods of timing signal mainly include TRRL method (also known as Webster method), ARRB method in Australia and HCM method in the United States, and "stop line method" and "conflict point method" in China. Among them, Webster timing method is commonly used, and its principle and steps are classic in traffic timing method [5]. Therefore, the control scheme generation module of this system uses the now mature Webster timing algorithm to process the current traffic status data and give the traffic light timing scheme.

In this system, the Nb IOT data transmission module of the fog node transforms the collected image data into the current traffic flow, queuing length and waiting time parameters to the data processing module of the regional fog server, and calculates the traffic light timing scheme through the specific algorithm. At present, the traffic flow per unit time, queue length and waiting time of the traffic light timing scheme are the best.

The dispatching result is the traffic light timing scheme, including the red and green periods in all directions and the time occupied by red, yellow and green lights respectively. These data are sent from the regional fog server to NB IoT data receiving module of the control fog node. After receiving these data, the control fog node will control the signal lamp according to the period and time ratio of the signal lamp

V. DATA TRANSMISSION MODULE

The data transmission protocols commonly used in the Internet of Things system include Bluetooth, WiFi, ZigBee, LoRa and NB-IoT.

Although Bluetooth protocol has low power consumption, it is difficult to apply in ITS due to its short transmission distance, low transmission rate and few access devices. WIFI transmission rate is high, and the corresponding power consumption is also high. It is difficult to bear the access of many foggy nodes due to less accessible devices. ZigBee technology is one of the main protocols in the Internet of things system, which requires low power consumption and can access a variety of devices. Because the transmission distance is only 200m to 400m, and the distance between the intersection fog node and the fog server is often up to km, it is difficult to meet the communication needs of its.

LoRa modulation technology is improved from LFM spread spectrum technology. It can allow multiple radio devices to use the same frequency band, and can realize data transmission in a long distance, low power consumption and wide range, but the transmission rate is slow. LoRa works in the unlicensed frequency band of Sub-1G and can set up network equipment without application. The network architecture is relatively simple, and there is no extra communication cost in actual application. Moreover, because it is an open frequency

band, it is widely used in practice, but it is easily interfered by other equipment in the same frequency band. Therefore, although LoRa can achieve a transmission distance of 20 kilometers in suburbs with less interference, it is often only 1 to 2 kilometers in cities. Although LoRa can basically meet the communication requirements of the system, but in the system requiring real-time monitoring and control, the lack of stability of LoRa makes it difficult to be the best choice.

Narrowband internet of things (NB-IoT) is an important branch of low power wan technology. NB-IoT is built in a cellular network and consumes only about 180kHz of bandwidth. It can be directly deployed in GSM network, UMTS network or LTE network [5]. NB IoT and cellular communication use the authorized frequency band provided by the operator, so the interference is much less. Although a certain amount of communication cost needs to be paid in practical application, the signal service quality is better and the security is more guaranteed. And its transmission distance can reach more than 10 kilometers stably, which can fully meet the communication needs of the fog node and the fog server in this system.

Through the above analysis of various communication protocols, the intelligent traffic light control system based on fog computing uses NB IoT technology to build data transmission module. The overall data transmission adopts the mixed networking mode of wired and wireless in different modules of the system. Between the image acquisition module and the image processing module, there is a large number of image data, and the image data processing fog node is located at the intersection, which is very close to the camera, so the wired transmission mode is adopted. However, the fog node only sends a series of parameters of the current traffic condition to the fog server, such as traffic flow, queue length and waiting time, etc. The fog server only sends a traffic light control timing scheme based on the traffic condition parameters in the region to the fog node. The amount of data is small, and the distance between the fog node and the region fog server is far, so NB-IoT wireless network is adopted.

VI. SUMMARY

Through the above analysis of the system framework, the intelligent traffic light control system based on Fog Computing in this paper mainly uses the existing image acquisition hardware-camera, the existing relatively mature intelligent traffic light control system and the characteristics of low time delay and distributed computing of Fog Computing to solve the problems of increasing traffic information data flow and heavier broadband load of data transmission. The system also consists of fog node module, fog server module and data transmission module. Because the fog node has the ability of calculation and storage, so the fog node directly processes the image data collected by the camera, and transmits the effective data as parameters to the fog server to participate in the implementation of the traffic light control algorithm, which effectively alleviates the congestion of data transmission to the fog server, reduces the data transmission delay, and improves the performance of its.

REFERENCES

[1] Zhang Mingsheng, Gao Weizi. Research on Application of Image Recognition Technology in Urban Traffic Management [J]. Information and Computer (Theoretical Edition), 2018(06):106-108.

[2] Shi Weisong, Sun Hui, Cao Jie, Zhang Quan, Liu Wei. Marginal Computing: A New Computing Model in the Age of Interconnection [J]. Computer Research and Development, 2017,54(05):907-924.

[3] He Fanfan. Research on Intelligent Traffic Light Regulation Based on fog computing [D]. Xi 'an University of Technology, 2018.

[4] Han Jizhi. Design of signal timing algorithm for urban intersections and VISSIM simulation research [D]. Qingdao University of Science and Technology, 2015.

[5] Dong Mengli, Jin Jianning, Chen Chuan, Cheng Bin. NB-IoT Key Technology Analysis and Optimization Practice [J]. Jiangsu Communications, 2018,34(06):43-47.