PISP: A New Practical Information Shared Platform on Intelligent Buses for Campus

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ABSTRACT. This research presents the implementation of a new practical information sharing platform (PISP) for intelligent school buses. Through the developed vehicle monitoring equipment, vehicle information can be uploaded to a server, which then implements a multi-stop comparison (MSC) mechanism to determine the direction and status information of each vehicle. To optimize the vehicle time schedule, a ride demand fitting (RDF) algorithm was added to determine the best vehicle scheduling plan for the various numbers of students arriving at different time slots every day. The RDF could be jointly designed with the time criteria to generate a customized travel plan. Simultaneously, a pop-out screen with time information could be integrated with the school bus information. A class weighted scoring algorithm was also utilized to sort bus popularity information and thus improve the efficiency of information sharing. Finally, the integration of the campus information inquiry portal could be realized, solving the low efficiency and poor timeliness of information inquiries. The statistical results of the PISP showed that the average number of departing buses could be reduced by 15 trips per day, the average full load rate could be increased by 20% per vehicle, and the average waiting time could be reduced by 27 minutes for each bus.
Keywords: information shared platform, vehicle monitoring equipment, pop-out screen, Intelligent school bus, waiting time

1. **Introduction.** School bus services are divided into many operating modes, such as a single school, a single load for multiple schools, and mixed loads for multiple schools, etc. Currently, research in this field mainly focuses on three aspects: route planning, trajectory tracking, and information sharing.

In the context of route planning, to address the constraints and different objectives of school bus route planning with homogeneous or heterogeneous buses, this paper proposed a metaheuristic algorithm framework based on local search [1]. In the United States, an integrated single framework algorithm for path planning is employed in school bus routing, successfully addressing the optimal route generation for high school, middle school, and elementary school buses [2]. For optimal time planning [3], they utilized Bertsimas' robust discrete optimization theory to develop a robust optimization model for multi-school mixed-load bus routes under uncertain road segment time impedance conditions. This model aims to achieve a balance between the shortest travel time for students and the lowest total operating cost for buses. A seamlessly integrated reinforcement learning with

genetic algorithm is proposed, improving the efficiency of genetic algorithms to generate near-optimal schedules in a shorter time [4]. Moreover, deep learning-based methods have been increasingly applied in traffic and transportation systems to estimate vehicle speed, traffic flow, and density, thereby optimizing scheduling and route planning [5]. This aligns with recent advances in traffic information estimation that rely on deep learning models, which improve accuracy and performance for intelligent transportation systems (ITS).

An Arrival Time Prediction Method (ATPM) based on the idea of random neural networks (RNNs) is designed for predicting the arrival time of vehicles between stops [6]. To address school bus scheduling between different schools, numerous articles discuss intelligent vehicle scheduling solutions from various perspectives [7, 8, 9]. For instance, the Cross-School Bus Scheduling Problem (SBPP) is decomposed into routing and scheduling sub-problems, and a two-step heuristic travel-compatible solution is proposed [10]. Using optical flow detectors, the number of passengers on buses is detected to achieve intelligent scheduling of vehicles [11].

In the field of vehicle trajectory tracking technology and applications, to track school bus trajectory information for real-time display on mobile devices, addressing communication gaps between parents and schools regarding child safety, it developed an Android application for tracking school bus trajectories using mobile GPS positioning [12]. The application sends notifications to passengers' mobile devices when the bus approaches their location. They deployed Internet of Things (IoT) applications and devices on school buses, continuously tracking students using RFID and GPS technologies, reporting student boarding and alighting times, real-time bus location, and speed [13]. A Bus Navigation Maintenance Scheme (BNMS) guided by smart cards is introduced, supported by IoT, enabling real-time information display through IoT programs [14]. A school bus boarding and location notification system using Global Positioning System (GPS) tracking and Radio-Frequency Identification (RFID) are designed, monitoring bus routes and estimating arrival times [15]. Recent advancements also propose edge-computing-based surveillance models that have applications in real-time vehicle and student safety monitoring, improving communication and reliability in intelligent transportation systems [16]. Furthermore, energy harvesting and wireless information transfer are essential in improving the sustainability of transportation networks. Recent research on multi-hop clustering routing protocols for RF energy harvesting-based cognitive radio sensor networks introduces solutions that balance energy distribution among nodes, extend network lifetimes, and enhance the efficiency of routing protocols [17].

To ensure the accuracy of navigation technology, the Edge-empowered Cooperative Multi-camera Sensing (ECoMS) System is proposed [18], tracking vehicles across multiple cameras and assisting public institutions in collecting linked travel time and speed information. They introduced algorithms, interfaces, and technical solutions for the development of a university campus navigation information system, overcoming major limitations in indoor navigation systems [19].

In the construction of platform information sharing, to establish a unified data sharing and exchange center enabling data sharing among various business systems [20]. An AI chatbot based on university information systems to help students improve information retrieval efficiency is proposed [21]. A campus intelligent platform based on augmented reality (AR) is constructed, combining GPS, sensors, AR technology, and learning applications to provide personalized learning content for students [22]. A campus-based information sharing and communication system is established, creating an intelligent social network community for collaboration and decision-making [23]. The Universitas Muslim Indonesia (UMI) created a fully integrated and well-managed campus information system by dividing large applications into smaller interconnected components [24]. Chen et

al. demonstrated a novel privacy-preserving authentication framework for digital twin-enabled AV environments using physical unclonable functions, while Wu et al. proposed an SGX-enhanced authentication protocol that reduces computational overhead by 38% in fog computing scenarios [25, 26]. This platform adopts a hybrid approach combining PUF-based device authentication with lightweight cryptographic operations to balance security and real-time performance.

A piece of information must be published in multiple channels to gain sufficient exposure, and the information circulation process is cumbersome and inefficient. Because information is extremely scattered and there is no integrated entrance platform, it is impossible to obtain all information through one channel. Currently, in order to improve the efficiency of campus information sharing, a number of apps (based on the Android operating system) have been designed [27, 28]. However, as different information appears on various platforms, users need to install numerous apps to obtain more comprehensive information, which leads to the low efficiency and low timeliness of information queries.

To deal with the above practical issues, this article presents the implementation of a new practical information shared platform (PISP) for intelligent school buses. The primary innovative contributions of this platform (PISP) system are as follows:

(1) This paper proposed a multiple stop comparison (MSC) algorithm to process unstable GPS signals on the vehicle to obtain accurate position, travel direction, travel speed, travel status and other vehicle location-related information.

(2) The intelligent scheduling of school buses could be realized through the ride demand fitting (RDF) scheduling algorithm.

(3) In response to the high-frequency demand of students for school bus location information, a campus information sharing platform using school bus information as the carrier was built to achieve the integration of information query portals.

(4) An effective information sharing mechanism with high frequency is proposed to solve the problem of low efficiency and low timeliness of information query.

The rest of this article is organized as follows: Section II describes the architecture and algorithm of the practical information sharing platform (PISP), including the multi-stop comparison algorithm (MSC), vehicle scheduling algorithm, time algorithm, and so forth. Section III presents the evaluation and analysis of the time-sharing scheduling (TSS) and ride demand fitting (RDF) schemes. Finally, the conclusions are described in section IV.

2. **Architectures and Algorithms of the Practical Information Sharing Platform.** The core design goal of this PISP platform was to accurately obtain school bus location information. There are many different kinds of location information query schemes. The first scheme is based on people in a vehicle sharing ride information. This scheme has the lowest cost, but it is unstable and difficult to ensure data integrity, since school bus information is high-frequency demands. The second scheme is based on installing customized positioning hardware on the school bus and sending information to a server in real time. The advantage of this scheme is that it can obtain positioning information steadily. In order to meet the requirements of positioning accuracy, PISP prefers to use the hardware in the second scheme. Five main algorithms were implemented in PISP, including the multi-stop comparison algorithm (MSC), vehicle scheduling algorithm, time algorithm, and so forth.

2.1. **A Multi-stop comparison algorithm.** The hardware equipment required for positioning included a GPS module and a camera. In this system, the GPS data and image data are transmitted to a Raspberry Pi. After being sorted by the Raspberry Pi, the data are sent to a server. After the server receives the data, the data content of the database is

calculated and fed back to a WeChat applet for interactive communication with the user, and then responds to the Raspberry Pi. Finally, the Raspberry Pi performs the correct operation and outputs the information through a speech synthesis module.

In the operational scenario of this system, users on campus can query school bus information through the visual monitoring platform and mobile application (app), as shown in Figure 1. At the same time, people can use the app to publish and query popular information about school buses.
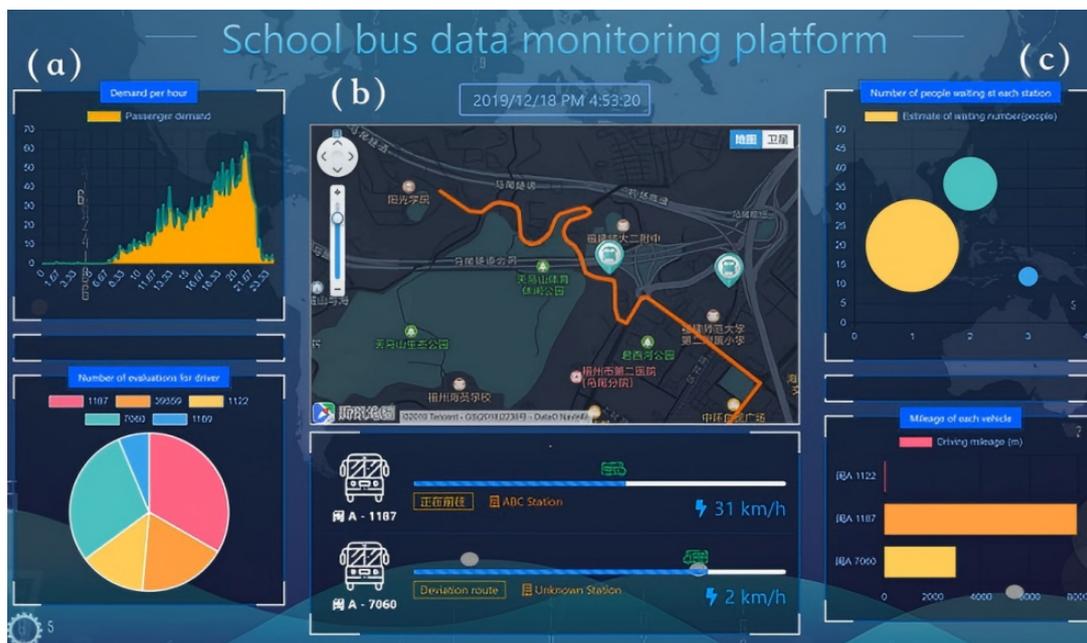

Figure 1. (a) Display information of the riding demands in terms of the number of passengers and evaluation of the driver; (b) display information on the location and status of the school bus; (c) the number of people waiting information and vehicle mileage in terms of the fuel efficiency.

Numerous mature vehicle information query systems have already been developed. Due to the large number of obstructions on campus, GPS and Beidou (A search energy) satellite signals are too weak to generate the position deviations. Hence, an algorithm was needed to correct the information coming from the hardware equipment and to determine the direction of the vehicle. To correct the position deviation, the bus stop position was utilized and a multi-stop comparison (MSC) algorithm was developed to reduce the position error caused by obstructions on campus. The MSC algorithm could divide the driving routes into N breakpoints, after which the exact position of each breakpoint could be determined. Then, a deviation correction criterion was designed to update the bus position if a position deviation occurred. This criterion could be checked at each breakpoint to allow the bus position deviation to be fixed periodically. Also, the direction of the vehicle could be determined by comparing the current number of breakpoints to the last number of breakpoints. The pseudocode of the MSC algorithm is shown in Table 1, and it compares the MSC with other existing solutions, as detailed in Table 2.

Here is an illustrated example to introduce the MSC algorithm. Suppose a school bus driving route has four sections, including the starting station, stop 1, stop 2, and the terminal stop (where stopN=1, 2, 3, 4). In MSC, this route can be divided into 100 segments, and each segment will have a corresponding latitude and longitude. As a result, the position value of each breakpoint can be recorded as bpM=1, 2,..., 100.

Table 1. Multi-stop comparison (MSC) pseudo code

Initialization: Split driving routing into N breakpoints (test to find the most suitable N)
Input: Get exact location of every breakpoint (bpN), every vehicle stop (StopN), and the real-time location of the vehicle (reLot)
Output: Display the remaining distance and time for the arrived station N
If reLot too far from all bpN then
show vehicle deviates from scheduled route
else
find the closest bpN to reLot and set current position equal to it
find out the direction of the vehicle by comparing local bpN to the last bpN
end
While (local bpN a certain stop N) do
show the vehicle has arrived at station N and display the remaining distance and time
end

Table 2. Comparative Analysis

Feature	PISP (Proposed)	Traditional Systems	Ref.
GPS Deviation Correction	MSC Algorithm	Basic GPS Filtering	[6, 13]
Dynamic Scheduling	RDF Algorithm	Static Time-Table Scheduling	[3, 7]
Information Integration	Unified WeChat Portal	Multiple Disconnected Apps	[28, 29]
Timeliness Mechanism	Barrage + Class Weighting	Manual Updates	[22, 24]

Assuming stop1=bp1, stop2=bp23, stop3=bp84 and stop4=bp100, the bpM distance of all road sections can be calculated by the longitude and latitude obtained from GPS. The bpM station with the shortest distance between bpM and stopN can be determined as the current station. If the shortest distance between bpM and stopN exceeds a threshold value, it can be known that the bus has deviated from the route, and the position needs to be replaced by the position of bpM. Also, when the bus slows down at the corresponding stopN position, it is assumed that the bus is picking up passengers. On the other hand, the remaining distance divided by the average speed can be used to obtain important travel parameters (such as the remaining arrival times) according to the MSC algorithm.

2.2. **Vehicle scheduling algorithm.** Although the number of school buses is fixed, the number of vehicles required will change over time due to passenger distributions. Hence, it was necessary to reduce this contradiction through the use of a suitable vehicle scheduling algorithm that could find the optimal balance between the number of vehicles and the demand for vehicles. Therefore, this study created a school bus app to collect seven-day bus demand data and calculate the average need. Figure 2 shows the relationship between the amount of vehicle demand trip data by hours per day.

For a school bus, the time to run one trip is set as t_0, the number of passengers carried during one trip is P_0, and the number of vehicles is set as $g(t)$ at time t. This model assumes that the number of people waiting for a certain bus stop every day is $f(t)$ at time t and the number of people waiting for any other bus stop on the driving route is in line with $f(t)$ every day. Hence, the number of people waiting for all stops every day at time t can be expressed by $C_1 f(t) + C_2$. Because the research model is for school buses, most passengers get on at the first and get off at the last stop. Therefore, the model can focus on the starting station and the terminal station. The number of passengers waiting at these two stations is $Af(t) + B$ and $Cf(t) + D$, and this equation can be used analyze the
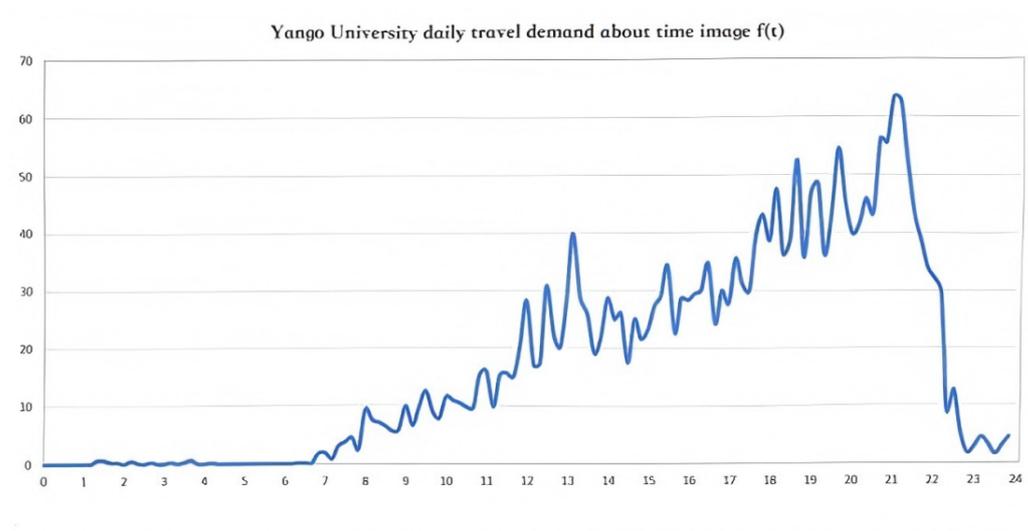
Figure 2. The amount of vehicle demand trip data in a day

waiting problem. At the starting station, the school bus system needs to solve the number of people waiting for $P_0 g(t)$, after which the remaining number of people waiting for the bus is $Af(t) + B - P_0 g(t)$. Similarly, at the terminal station, the remaining number of people waiting for the school bus is $Cf(t+t_0) + D - P_0 g(t+t_0)$, therefore the total number of people waiting for the bus is $Af(t) + B - P_0 g(t) + Cf(t+t_0) + D - P_0 g(t+t_0)$. Ideally, the result of this equation is expected to equal 0, indicating that the waiting requirements of all stations have been met. Among these factors, $f(t)$ can be obtained through the daily statistics, while A, B, C, and D can be collected by the peak number of people in a day. The time offset and other time-related factors can also be evaluated.

It is also necessary to determine the required number of departure buses $g(t)$. To solve the equations for the total waiting number, the resulting value is set as 0. Then, the equation relationship satisfied by $g(t)$ can be solved. Because $g(t)$ is a special function, it describes the number of buses at t each day, and $g(t)$ can be assumed by a discrete function. The number of departures and the departure intervals should be integers; hence, we assume that $g(t)$ is a discrete function. Solving this equation directly is a difficult problem. In order to simplify the problem, we regard the required amount of departure buses as an impulse function. The Gaussian function is likely to be equivalent as the impulse function. As a result, $g(t)$ can be decomposed into the addition of multiple sets of Gaussian functions, and each set of Gaussian functions can be assigned to a bus driver.

Figure 3 shows the statistics of the scheduling algorithm according to $f(t)$, which can be converted into an actual bus departure proposal. For example, one bus can operate from 8:00 a.m. to 12:30 p.m., and two buses can operate after 12:30 p.m. to 1:30 p.m. From 1:30 p.m. to 2:30 p.m., one driver can take a break, after which two buses can continue to operate until 6:00 p.m. From 6:00 p.m. to 9:00 p.m., three buses need to operate together. Finally, one bus can operate after 9:30 p.m. In order to be closer to practical needs and make good utilization of statistical data, the algorithm automatically computes the data of the previous seven days to adaptively solve the scheduling algorithm. The computation results of the algorithm can provide better scheduling recommendations to the drivers and assign buses more efficiently. This algorithm was implemented in the WeChat app, and the dispatch of bus drivers and the feedback of passengers were well evaluated.
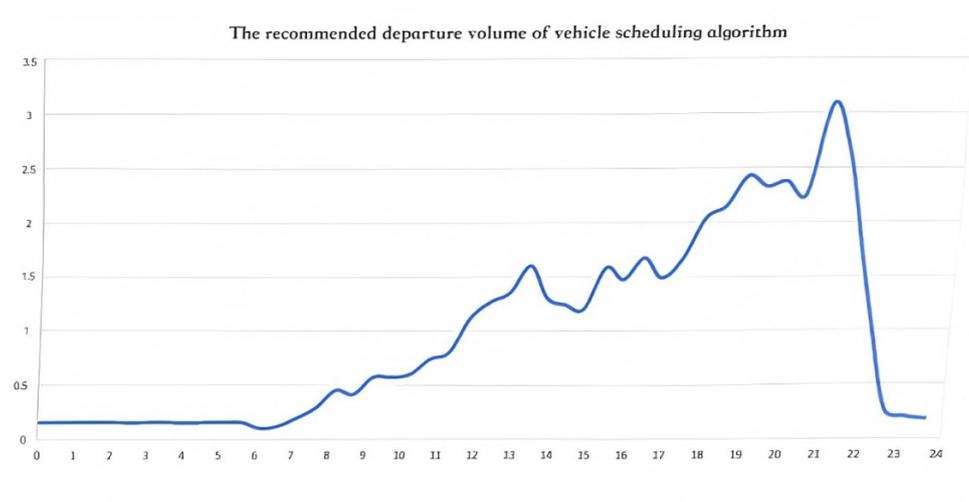
Figure 3. Recommended departure volume of the vehicle scheduling algorithm

2.3. **Time algorithm.** Once the school bus dispatch information is obtained, customized travel plans for individual purposes can be provided. The travel time algorithm provides the user with a departure time by calculating the distance between the user's location and the nearest bus stop and adding this to the time needed for the nearest bus to return to the station. For example, if a student in a dormitory want to leave, he/she just needs to click "I want to go" in WeChat. The algorithm then calculates the recommended schedule (in this example, five minutes later) for the user to leave the dormitory and go to the bus station. At the same time, a WeChat notification is sent to the user with a reminder to leave after five minutes. As another example, students who want to go back to school after visiting a supermarket can also use this method to customize the travel time needed to get to the bus stop.

3. **Integration of information query portals.** School campuses have many different inquiry portals, kinds of information, and publishing platforms, which can result in low information exposure and low query efficiency for users. As mentioned above, the school bus is the most important transportation tool on campus, and the frequency of school bus information queries is extremely high. Therefore, this study built a campus-wide information sharing platform using school bus information as the entrance to integrate all kinds of valuable information on campus. This platform could allow students to query various types of information and publish their own information directly from the WeChat app.

The system interface opens with the main map on the school bus app, which can alternatively switch the identity by students, teachers, drivers, and administrators. In the main map, floating on the electronic map in the form of a barrage, and click on the barrage to reply. In addition, there are displays for the location of vehicles, and boarding-related information can be shown on the main map in real time, as shown in Figure 4.

The detailed information on the display includes information items, vehicle status, and reserved advertising column interface. The advanced information pages include information items, scheduling suggestions, and management permissions, etc. Also, the topic square includes topic entries, a "select topic content" button, post reply content, and a reply box. Figure 5 shows the detailed information in the school bus app.
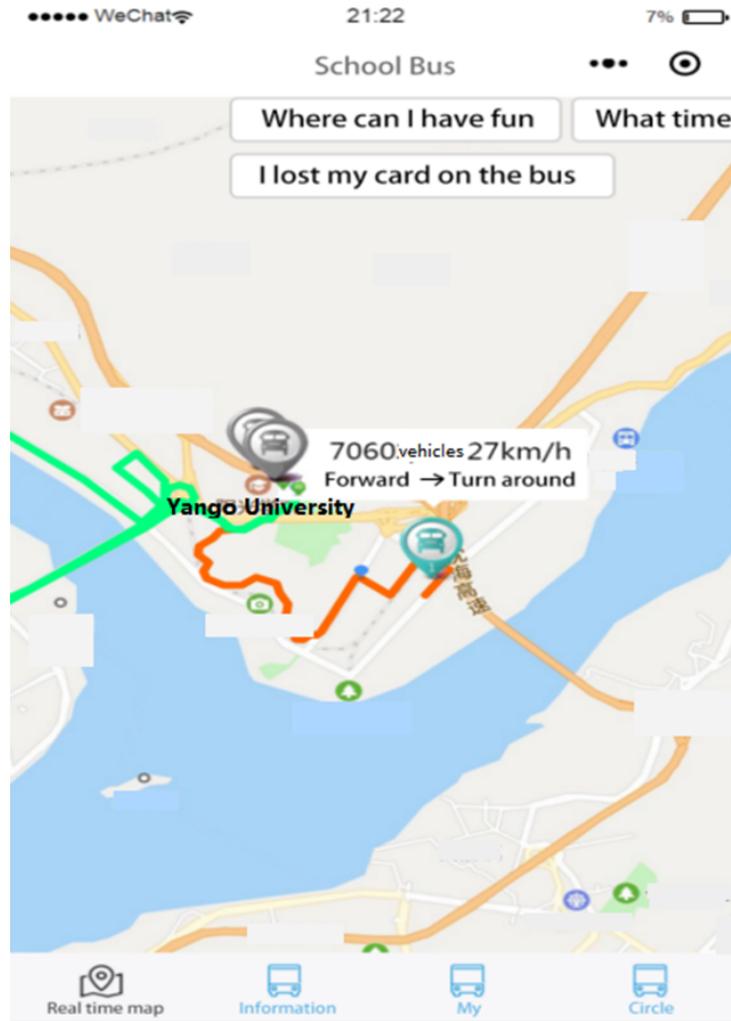
Figure 4. The main map of the school bus app

3.1. **A. Time-sensitive information sharing mechanism.** The timeliness of information is extremely important, and information on the first page or the first few pages should be highly time-sensitive (known as hot information). In order to improve the timeliness of information, a barrage mechanism design can ensure the efficiency of information sharing and the information popularity.

The recommendation of barrage such as the push notification mechanism is completely dominated by algorithms, and its design is as follows. Using the class weighted scoring method to give a reference value N, set the number of manual clicks on the barrage as C, set the number of replies to topic posts as P, set the total number of reply words as W, and set the number of likes as B. If the publication time is within one hour, $T = 1.5$; if it is within one day, $T = 1.2$; otherwise, $T = 1$. We give $N = T(0.5C + 0.1CP + CW/P + 0.2BC)$ by calculating and sorting the N value of all posts and then loading the top 30 posts on the school bus map in a floating display. As a result, this design can maximize the timeliness of information.

At the same time, all users under this interface design can share one information stream to display the latest topic posts. Clicking on the barrage will display the corresponding topic thread at the top of the news stream. This platform expects to complete a design principle, that is, all information on the entire platform should be new, which is a hot topic nowadays. This design is different from ordinary forums and moments. If a topic loses
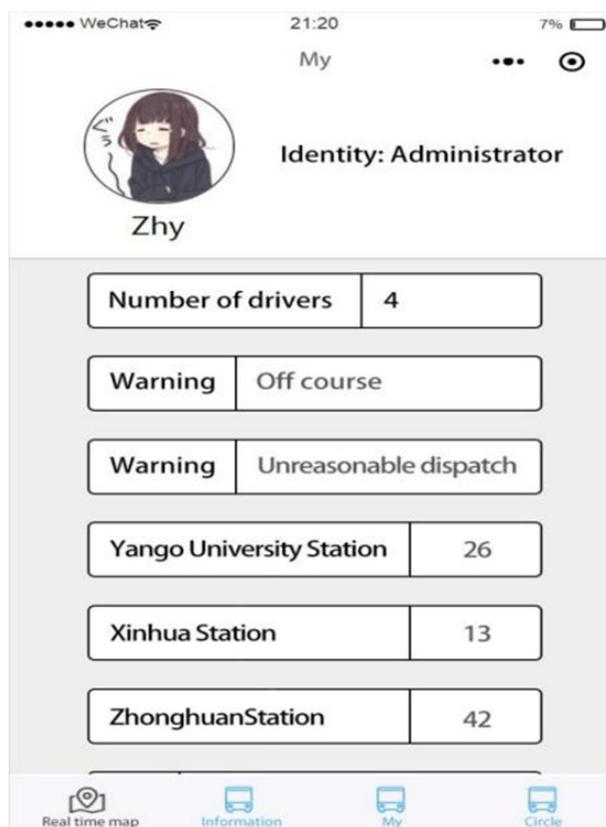
Figure 5. Detailed information in the school bus app

discussion interest, it will be removed directly. According to time, the results of the above algorithm will display periodic reports in the background. By comparing with the actual situation, the weight parameters of the time-sensitive information sharing algorithm can be fine-tuned.

3.2. **Evaluation and Analysis.** The proposed platform was used for a period of time in the college where the author was located, and the user population covered 50% of the entire school population within one month. The frequency of utilization indicated the efficiency and convenience of the platform in querying information for users. With the assistance of the RDF algorithm, the bus management department was able to realize the intelligent dispatch of campus buses. Before using the RDF algorithm, the school had adopted time-sharing scheduling (TSS). During peak hours, it was fully loaded with multiple round-trips. During idle times, one bus would depart every 30 minutes, requiring a total of 66 vehicles each day. The statistics revealed that the average load factor per vehicle was 61.4% and that the average waiting time for each vehicle was 30 minutes. However, after implementing the RDF algorithm, the total number of daily trips required was 51, which is 15 fewer trips than under the TSS method and 7 fewer trips than under the DSS method. Results show that the average vehicle load rate reached 81.4%, representing a 20% improvement compared to the TSS method and a 9.3% improvement compared to the DSS method. Additionally, the average waiting time was reduced to 3 minutes, which is a 27-minute decrease compared to the TSS method and a 9-minute decrease compared to the DSS method. For the message usage performance of our integrated platform, students want to publish a message to 90% of the entire students to be notified before using this platform. Usually, they would need to publish information on an average of five websites or apps. After using this integrated platform, they only needed to publish information

once. The results showed that this time-sensitive information sharing algorithm achieved the expected results.

Table 3. Measurement results of TSS and RDF

	TSS	DSS [4]	RDF
Average number of buses per day	66	58	51
Average full load rate	61.4%	72.1%	81.4%
Average waiting time (minutes)	30	12	3

4. **Conclusions.** This article aimed to build a lightweight and convenient university campus information sharing platform (ISP) and proposed a school bus information platform that could use high-frequency demand information on campus as the entrance to integrate all other campus information inquiry portals. Through the designed hardware and algorithm, the precise position, direction of travel, route, and location status of a school bus could be accurately obtained. Also, efficient school bus scheduling could be realized through the designed algorithms, including the multi-stop comparison algorithm (MSC), vehicle scheduling algorithm, time algorithm and so forth. In the human-machine interface part, through the barrage and information flow mechanism, the high exposure and high timeliness of hot information could be realized. At the same time, the platform was presented in the form of a small applet loaded on WeChat to achieve the goal of providing a lightweight information platform. In terms of operation, this project was implemented stably in the author's university for more than one year, and it maintained a significant access rate and timeliness efficiency every day. The statistical results showed that the average number of bus departures could be decreased by 15 trips per day, the average full load rate could be increased by 20% per vehicle, and the average waiting time could be reduced by 27 minutes for each bus. The results verified that the proposed PISP system had realistic and efficient features.

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