Research on prediction weighted interpolated polling dynamic bandwidth allocation for optical fiber bus based on gigabit passive optical network

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Abstract. Optical fiber bus technology is an important research direction in communication systems of electronic devices in special vehicle platforms. According to the requirements for communication quality between devices in special vehicle platforms, an optical fiber bus based on gigabit passive optical network topology is proposed. A data cache-based predictive weighted interpolated polling dynamic bandwidth allocation method is presented and investigated for the optical fiber bus's upstream bandwidth allocation. The network controller establishes a weighted buffer area for the communication requirements in the polling period according to the type and data volume of the network terminal (NT) data stream and dynamically allocates the bandwidth of each optical NT to better meet the communication requirements for different data within the special device platform. Verification is done by means of OPNET software simulation and the establishment of a NT simulation test system in the laboratory. This proves that the proposed dynamic bandwidth allocation algorithm can reduce the end-to-end delay of RS422 port data by more than 50% and meet the Ethernet and controller area network port data delay requirements. © *The Authors. Published by SPIE under a Creative Commons Attribution 4.0 International License. Distribution or reproduction of this work in whole or in part requires full attribution of the original publication, including its DOI.* [DOI: 10.1117/1.OE.61.10.106104]

Keywords: optical fiber bus; gigabit passive optical network; predictive weighted interpolated polling dynamic bandwidth allocation; OPNET.

Paper 20220611G received Jun. 9, 2022; accepted for publication Sep. 21, 2022; published online Oct. 17, 2022.

1 Introduction

With the development of the electronic system of special vehicle platforms, many types of special vehicles have been equipped with an increasing number of electronic devices, monitoring instruments, and the total amount of exchanging data, sharing information and processing information between these devices and instruments, which puts forward higher-level requirements for the special vehicle data bus.[1] At present, the most common special vehicle platforms adopt three communication networks: the RS422 bus, the controller area network (CAN) bus, and the Ethernet.[2] The advantage is the high reliability, but the disadvantage is the diversified interface, for it is difficult to achieve networking without a unified interface. Some special vehicle platforms also adopt MIL-STD-1553B bus;[3] its advantage is the unified interface, but the disadvantage is the limited bandwidth of lower than 1 Mbps, which is difficult to meet the requirement of high bandwidth. The mature FC-AE bus in the field of aviation integrated electronics can meet the requirement for special vehicle platforms in terms of networking, high bandwidth, and high reliability,[4,5] but it has a high cost. Therefore, it is necessary to develop a fiber optical bus technology that can both meet the network communication requirements of special vehicle platforms and be cost effective. The passive optical network (PON) technology provides an effective solution for optical bus communication of special vehicle platforms.

Gigabit passive optical network (GPON) technology is a point-to-multipoint optical fiber access technology. It could be widely applied in the commercial field because of the advantages

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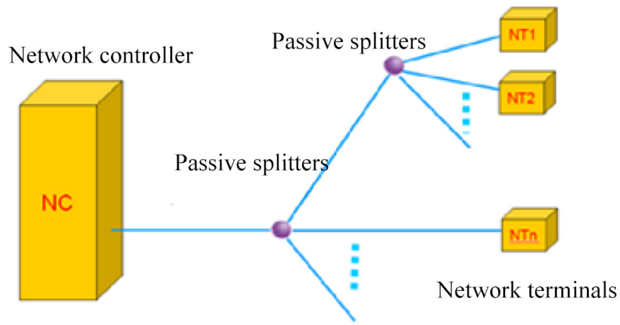

Fig. 1 Topology diagram.

of low power consumption, high throughput, simple networking, high reliability, and low cost.[6] GPON is mainly composed of three parts, namely optical line terminal (OLT), optical distribution network (ODN), and optical network unit (ONU). Its downstream data transmission adopts the time division multiplexing (TDM) broadcast mode, and upstream data transmission adopts the time division multiple access (TDMA) mode.[7]

The optical fiber bus technology provides the communication between electronic devices in special vehicle platforms. Special vehicle platforms require an operating temperature between −40°C and +85°C. Therefore, the GPON that meets this temperature range should be adopted. The optical fiber bus topology based on GPON is a topology in which each node is connected together through passive optical splitters, including a network controller (NC) and several optical network terminals (NTs). The topology diagram is shown in Fig. 1. The passive optical network replaces the active multiplexer or switches with a passive optical splitter, which simplifies the design of the ODN and improves the reliability of the transmission link. Therefore, operation, maintenance, and management are easy.[8] At present, the maximum number of branches in practical applications is 32,[9] that is, 1 NC is connected to 32 NTs.

The GPON network uses optical fiber bus technology based on the GPON topology. The downstream data transmission adopts the TDM broadcast method, and the upstream data transmission adopts the TDMA method. The big challenge in the engineering application of the technology is how to reasonably allocate the bandwidth resources of the GPON network through the online dynamic bandwidth allocation algorithm to guarantee the high reliability and real-time communication requirements for various types of the data among electronic devices in special vehicle platforms.[8]

In this paper, according to the optical fiber bus communication requirements of Ethernet, CAN, and RS422 of the special vehicle platform electronic device, a predictive weighted interpolating polling dynamic bandwidth allocation (PW-IPACT) algorithm based on data cache is presented. For this approach, the data of each NT are cached and predicted by the NC, and the bandwidth of various types of data is dynamically allocated to meet the high reliability and real-time communication requirements of different communication data. At the same time, according to the proposed dynamic bandwidth allocation algorithm, the upper bound calculation model of the end-to-end delay of different data in the GPON network is established using network calculus theory. Then the OPNET is adopted for simulation, and the simulation results show that the proposed dynamic bandwidth allocation algorithm effectively improves the communication efficiency. Finally, in the laboratory, an NT simulation test system is created to ensure that the algorithm fulfills the bus communication needs of data with various real-time requirements.

2 PW-IPACT Scheme Based on Data Cache

2.1 *Classical Bandwidth Allocation Algorithm*

The OLT uses a polling method to assign and regulate the bandwidth of the ONU terminal, and its upstream channel bandwidth allocation system incorporates static and dynamic bandwidth allocation, according to the GPON network topology.[10] At present, the most classical PON network bandwidth allocation methods include the IPACT algorithm[11,12] based on absolute priority and the IPACT algorithm based on weight proportional allocation. Different from the traditional telecommunication network, the optical fiber bus network based on GPON topology puts forward strict requirements on the real-time performance of data information. If the IPACT algorithm based on absolute priority is adopted, when the bandwidth of the GPON system is insufficient, the phenomenon of "starvation" of low-priority services will occur. If the bandwidth allocation scheme based on weight ratio is adopted, when the number of ONU terminals in the GPON system is large and the polling period is too large, the delay performance of the data with high real-time requirement will be seriously affected. In Ref. 13, an IPACT-GE algorithm based on authorization estimation is proposed. This algorithm significantly improves the delay of IPACT algorithm under the condition of a light load rate, but the improvement is poor under the condition of a high load rate.

2.2 *PW-IPACT Algorithm*

With regards to the high real-time requirements of optical fiber bus NT communication, a predictive weighted polling algorithm based on data buffering is proposed to overcome the shortcomings of existing GPON network bandwidth allocation methods. The algorithm first calculates the bandwidth requirements of Ethernet, CAN, and RS422 of the NT through the NC. The Ethernet port data rate supports 1000 M/100 M/10 Mbps; the CAN port data rate supports 500 kbps/1 Mbps; and the RS422 port data rate supports 1.2 kbps to 12 Mbps. Based on the above, the algorithm calculates the NT data buffer at different times during the polling period. Finally, the algorithm establishes the port data buffer area and weighted data virtual buffer area to dynamically allocate the real-time bandwidth requirements of each NT.

2.2.1 *Calculation of data bandwidth requirements for NT terminal ports*

To fully reflect the data communication requirements of each port of the NT terminal, an information collection C_i^k is established; it is defined as

$$C_i^k = C_i^k(S_{i0}^{\mathrm{Eth}k}, V_i^{\mathrm{Eth}k}, S_{i0}^{zk}, V_i^{zk}, t^k). \tag{1}$$

In this formula, $S_{i0}^{\mathrm{Eth}k}$ is the Ethernet data buffer size when the i'th NT terminal stops sending information. $V_i^{\mathrm{Eth}k}$ is the Ethernet data buffer rate of the i'th NT terminal. The data cache rate, that is, the data write cache rate, is obtained by calculating the type of Ethernet data to be transmitted under fault conditions and nonfault conditions and the lengths of various data frames. S_{i0}^{zk} is the comprehensive weighted buffer size of CAN data and RS422 data when the i'th NT terminal stops sending information. V_i^{zk} is the weighted cache rate of the i'th NT terminal CAN data and RS422 data. Among them, the calculation method for parameter S_{i0}^{zk} and V_i^{zk} is as follows:

$$\begin{cases} S_{i0}^{zk} = S_{i0}^{\mathrm{CAN}k} + \frac{W_{\mathrm{RS422}}}{W_{\mathrm{CAN}}} S_i^{\mathrm{RS422}k}, \\ V_i^{zk} = V_{i0}^{\mathrm{CAN}k} + \frac{W_{\mathrm{RS422}}}{W_{\mathrm{CAN}}} V_i^{\mathrm{RS422}k}. \end{cases} \tag{2}$$

In this formula, W_{CAN} and W_{RS422} are the weight values of CAN data and RS422 data, respectively, to ensure the bandwidth requirements of various data. The size of the data weight value takes the priority of the data and the maximum data flow of the data per unit time as indicators and is preset by the analytic hierarchy process. t^k is the change time of each data buffering rate of the NT during the k'th polling period. If the bus network fails at t^k, the data buffering rate of each NT terminal increases rapidly. If the bus network does not fail, the data buffering rate of the NT terminal does not change. At this time, $t^k = 1$.

2.2.2 *Virtual weighted cache calculation*

After receiving the response frame uploaded by the NT terminal, the NC controller reads the buffer information of the NT terminal. Whether the data buffering rate of the NT terminal changes is determined based on t^k. If the data buffering rate of the terminal does not change, then according to Eq. (3), a virtual buffer queue of Ethernet data and a virtual buffer area of weighted data in the k'th polling cycle of the NT terminal are established:

$$\begin{cases} S_i^{\mathrm{Eth}(k+1)} = S_{i0}^{\mathrm{Eth}k} + v_i^{\mathrm{Eth}k}\left(\sum_{j=i+1}^{N} \Delta t_j^k + T_k\right), \\ S_i^{z(k+1)} = S_{i0}^{zk} + v_i^{zk}\left(\sum_{j=i+1}^{N} \Delta t_j^k + T_k\right). \end{cases} \tag{3}$$

In this formula, $S_i^{\mathrm{Eth}(k+1)}$ is the Ethernet data buffer size that the i'th NT terminal needs to transmit in the $k+1$'th polling cycle. $S_i^{z(k+1)}$ is the weighted data comprehensive buffer size that the i'th NT terminal needs to transmit in the $k+1$'th polling cycle. Δt_j^k is the size of the transmission time window obtained by the j'th NT terminal in the k'th polling cycle. T_k is the polling cycle and $\sum_{j=1}^{N} \Delta t_j^k = T$.

2.2.3 *Virtual weighted dynamic bandwidth allocation algorithm*

By the established virtual buffer area, the NC controller can know the real-time bandwidth requirements of each NT terminal in the bus network. According to the actual bandwidth of the GPON system, the bandwidth requirements of each datum of the NT terminal are allocated. According to Eq. (4), the size of each data bandwidth of the NT terminal is allocated:

$$\begin{cases} \Delta S_i^{\mathrm{Eth}(k+1)} = S_i^{\mathrm{Eth}k}, \\ \Delta S_i^{z(k+1)} = \left(S - \sum_{i=1}^{N} S_j^{\mathrm{Eth}(k+1)}\right) \frac{S_{i0}^{zk}}{\sum_{i=1}^{N} S_i^{zk}}, \\ \Delta t_i^{k+1} = \Delta t_i^{\mathrm{Eth}k} + \Delta t_i^{z(k+1)} = \frac{\Delta S_i^{\mathrm{Eth}(k+1)} + \Delta S_i^{z(k+1)}}{C}. \end{cases} \tag{4}$$

In this formula, $\Delta S_i^{\mathrm{Eth}(k+1)}$ is the buffer size of Ethernet data allowed to be uploaded in the $k+1$'th polling cycle. $S_i^{z(k+1)}$ is the amount of weighted data buffer allowed to be uploaded in the $k+1$'th polling cycle of NT terminal weighted data. S is the buffer size of the GPON system in one polling cycle. C is the overall bandwidth.

In summary, the weighted dynamic bandwidth allocation algorithm of NC controller bandwidth allocation algorithm flowchart is shown in Fig. 2. In Fig. 2, $S_1^{(k+1)}$ is the sum of the virtual buffer amount of all of the port Ethernet data of the NT terminal in the $k+1$'th polling cycle, and

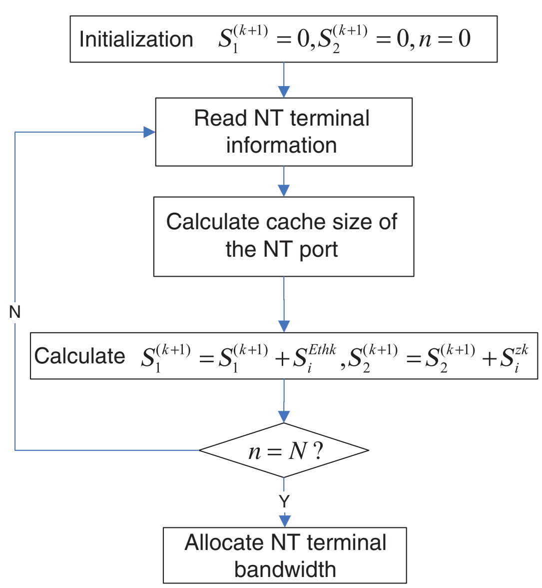

Fig. 2 NC controller bandwidth allocation algorithm flowchart.

$S_2^{(k+1)}$ is the sum of the virtual buffer amount of the CAN and RS422 data in the $k+1$'th polling cycle.

3 Delay Upper Bound Calculation Based on Network Calculus

3.1 *Network Calculus Theory*

The two basic tools of network calculus theory are arrival curve and service curve, which are used to calculate the maximum service delay and maximum cache accumulation of network nodes.[13] The arrival curve refers to a given function $a(t)$, with $a \in F$ and $t \geq 0$. If the data flow input function R satisfies $R \leq R \otimes a$, then a is called the arrival curve of R. The leaky bucket arrival curve is one of many network arrival curves. It is indicated as $A_{\sigma\rho}(t) = \sigma t + \rho$, where σ is the maximum sustained rate of data and ρ is the maximum burst length of data. The service curve refers to a given data stream input function R, for $\beta \in F$, $\beta(0) = 0$. If the output function of the data stream satisfies $R* \geq R \otimes \beta$, the system provides a service curve $\beta(t)$ for the data stream. The rate service curve is defined on the service node as $\beta_{R,T}(t) = R(t-T)^+$, where the parameter R is the rate at which the data stream is received and T is the time that must be waited before the service.

The maximum data service delay $D^{\max}$ refers to a data flow with $a(t)$ as the arrival curve passing through a system with a service curve $\beta(t)$. The upper bound of the maximum service delay $D^{\max}$ in the network at time t is

$$D^{\max} = T + \frac{\rho}{\mathrm{R}}. \tag{5}$$

3.2 *Calculation of Upper Bound of Data Delay for Different Ports*

With the use of the network calculus theory, the random arrival curve and random service curve of the port data of each NT node in the optical fiber bus are modeled, and the data arrival curve of the same port is deduced. According to the random network calculus theory, the upper bound of the end-to-end delay of each port data queue is obtained.

First, it is assumed that the service curve of the NC terminal is $\beta_{\mathrm{NC}}(t) = C(t-T)^+(T=0)$. C is the total bandwidth, and according to the working characteristics of GPON, the NC service curve is the sum of the service curves of each NT terminal, i.e., $\beta_{\mathrm{NC}}(t) = \sum_{i=1}^{N} \beta_{\mathrm{NT}i}(t)(t \geq 0)$. The service curve of each NT in the k'th cycle is obtained as

$$\beta_{\mathrm{NT}}^k(t) = C(t - T_{\mathrm{NT}i}^k)^+, \tag{6}$$

where $T_{\mathrm{i}}^k = \sum_{j=i+1}^{N} \Delta t_{\mathrm{NT}i}^{(k-1)} + \sum_{j=1}^{i-1} \Delta t_{\mathrm{NT}i}^k$, $T_{\mathrm{NT}i}^k$ is the maximum waiting time required for the i'th NT terminal to work, and t_{i}^k is the actual waiting time.

According to the port data type and quantity of the NT, the service curve of the NT terminal is $\beta_{\mathrm{NT}}^k(\mathrm{t}) = \sum_{j=1,e=1} \beta_{\mathrm{NT}(i,j,e)}^k(t)$, where j is the data priority type of the NT terminal and e is the number of each data stream. After each aperiodic data stream and periodic data stream are controlled by the leaky bucket, the leaky bucket arrival curve is expressed as

$$a_{(i,j,e)}(t) = \sigma_{(i,j,e)} + \rho_{(i,j,e)}(t), \tag{7}$$

where σ is the maximum burst length and ρ is the maximum arrival rate.

Therefore, the service curve of each data queue at time $t \in (kT_k + \sum_{j=1}^{i-1} \Delta t_i^{(k-1)}, kT_k + \sum_{j=1}^{i} \Delta t_i^k)$ is as shown in Eq. (8). During time $t \in (kT_k - \sum_{j=i+1}^{N} \Delta t_i^{(k-1)}, kT_k + \sum_{j=1}^{i-1} \Delta t_i^k)$, the receive rate in each data service curve is 0:

$$\begin{cases} b_i^{\mathrm{Eth}k}(t) = C(t - T_i^k)^+, \\ b_i^{\mathrm{CAN}k}(t) = \left(C - \sum_{j=1}^{n1} \rho_{i,j}^{\mathrm{Eth}}\right)(t - T_i^k - T_i^{\mathrm{Eth}k})^+, \\ b_i^{\mathrm{RS422}k}(t) = \left(C - \sum_{j=1}^{n1} \rho_{i,j}^{\mathrm{Eth}} - \sum_{j=1}^{n2} \rho_{i,j}^{\mathrm{CAN}}\right)(t - T_i^k - T_i^{\mathrm{Eth}k} - T_i^{\mathrm{CAN}k})^+. \end{cases} \tag{8}$$

$T_i^k = \Delta t_i^k$ is the waiting time of the NT terminal before the k'th polling period. $T_i^{\mathrm{Eth}k} = \Delta t_i^{\mathrm{Eth}k}$ is the transmission time of the Ethernet data during the k'th polling period, and $T_i^{\mathrm{CAN}k} = \Delta t_i^{\mathrm{CAN}k}$ is the transmission time of the CAN data during the k'th polling period. According to Eq. (8), the average service rate of each data in the i'th NT terminal in the k'th polling cycle is shown in the following equation:

$$\begin{cases} R^{\mathrm{Eth}} = C\frac{\Delta t_i^k}{T_k}, \\ R^{\mathrm{CAN}} = \left(C - \sum_{j=1}^{n1} \rho_{i,j}^{\mathrm{Eth}}\right)\frac{\Delta t_i^k}{T_k}, \\ R^{\mathrm{RS422}} = \left(C - \sum_{j=1}^{n1} \rho_{i,j}^{\mathrm{Eth}} - \sum_{j=1}^{n2} \rho_{i,j}^{\mathrm{CAN}}\right)\frac{\Delta t_i^k}{T_k}. \end{cases} \tag{9}$$

At the same time, the time that each data in the i'th NT terminal must wait before the k'th service is shown in the following equation:

$$\begin{cases} T^{\mathrm{Eth}} = T_i^k, \\ T^{\mathrm{CAN}} = T_i^k + \Delta t_i^{\mathrm{Eth}k}, \\ T^{\mathrm{RS422}} = T_i^k + \Delta t_i^{\mathrm{Eth}k} + \Delta t_i^{\mathrm{CAN}k}. \end{cases} \tag{10}$$

Because the minimum working time of the NT terminal is greater than $T_{\min}$, i.e., $T_{\min} \le \Delta t_i^k$. Therefore, the maximum service waiting time of each data is obtained as shown in the following equation:

$$\begin{cases} T_i^k \le 2T_k - (N+1)T_{\min}, \\ T_i^k + \Delta t_i^{\mathrm{Eth}k} \le 2T - NT_{\min}, \\ T_i^k + \Delta t_i^{\mathrm{Eth}k} + \Delta t_i^{\mathrm{CAN}k} \le 2T - NT_{\min}. \end{cases} \tag{11}$$

σ/R in Eq. (5) is calculated with the combination of Eqs. (7) and (9), as shown in the following equation:

$$\begin{cases} \frac{\sigma_i^{\mathrm{Eth}}}{R^{\mathrm{Eth}}} = \frac{\sigma_i^{\mathrm{Eth}} T_k,}{C\Delta t_i^k} \\ \frac{\sigma_i^{\mathrm{CAN}}}{R^{\mathrm{CAN}}} = \frac{\sigma_i^{\mathrm{CAN}} T_k}{(C-\rho_i^{\mathrm{Eth}})\Delta t_i^k}, \\ \frac{\sigma_i^{\mathrm{RS422}}}{R^{\mathrm{RS422}}} = \frac{\sigma_i^{\mathrm{RS422}} T_k}{(C-\rho_i^{\mathrm{Eth}}-\rho_i^{\mathrm{CAN}})\Delta t_i^k}, \end{cases} \tag{12}$$

where σ_i^{Eth}, σ_i^{CAN}, and $\sigma_i^{\mathrm{RS422}}$ are the sum of the maximum burst lengths of the three types data streams and ρ_i^{Eth}, ρ_i^{CAN}, and ρ_i^{RS422} are the sum of the sustained arrival rates of the three types data streams, respectively. Because $T_{\min} \le \Delta t_i^k$, the maximum buffering delay of each port data of the NT terminal is obtained as shown in the following equation:

$$\begin{cases} D_{\max}^{\prime\mathrm{Eth}} = \frac{\sigma_i^{\mathrm{Eth}} T_k}{CT_{\min}} + 2T_k - (N+1)T_{\min}, \\ D_{\max}^{\prime\mathrm{CAN}} = \frac{\sigma_i^{\mathrm{CAN}} T_k}{(C-\rho_i^{\mathrm{Eth}})T_{\min}} + 2T_k - NT_{\min}, \\ D_{\max}^{\prime\mathrm{RS422}} = \frac{\sigma_i^{\mathrm{RS422}} T_k}{(C-\rho_i^{\mathrm{Eth}}-\rho_i^{\mathrm{CAN}})T_{\min}} + 2T_k - NT_{\min}. \end{cases} \tag{13}$$

Then the sum of the maximum buffering delay $D'^{\max}$ and the propagation delay T_{link} is the upper bound of the maximum delay of each port data of the NT terminal, as shown in the following equation:

$$\begin{cases} D_{\max}^{\mathrm{Eth}} = D_{\max}^{\prime\mathrm{Eth}} + T_{\mathrm{link}}, \\ D_{\max}^{\mathrm{CAN}} = D_{\max}^{\prime\mathrm{CAN}} + T_{\mathrm{link}}, \\ D_{\max}^{\mathrm{RS422}} = D_{\max}^{\prime\mathrm{RS422}} + T_{\mathrm{link}}. \end{cases} \tag{14}$$

4 Simulation of Data Delay Based on OPNET

4.1 *Simulation Environment*

To test whether the proposed PW-IPACT algorithm meets the performance requirements of the optical fiber bus, a GPON system is built through OPENT for simulation verification. The number of NTs in the GPON system is set to 32; the NT buffer queue is 2 columns; the uplink and downlink rates are 2.5 Gbps; the maximum distance between the NC terminal and the NT terminal is 200 m; the fiber inherent delay T_{link} is at most 1 μs; the NC cycle polling time T_k is 1 ms, and the NT terminal minimum service time $T_{\min}$ is 10 μs.

4.2 *Delay Simulation Analysis*

The proposed PW-IPACT algorithm serves the optical fiber bus network bandwidth allocation of special vehicles and is limited by the communication requirements and port data type of the special vehicle platform. Delay is the greatest concern of the platform after the original RS422 bus, CAN bus, and Ethernet networks are upgraded to the optical fiber bus network, so this paper focuses on the analysis of the delay. The built GPON system is simulated for 3 s, and the maximum delay of the load scheduling algorithm based on data cache (PW-IPACT) and the load scheduling algorithm based on absolute priority (IPACT) under different load rates is compared in this section.

Figure 3 shows the maximum data delay of IPACT algorithm and PW-IPACT algorithm. Noted that the maximum delay of each data under the two scheduling algorithms increases with the increase of the load rate. Under different network load rates, the maximum random delay of the Ethernet data and RS422 data of the PW-IPACT algorithm is significantly improved compared with that of the IPACT algorithm. The RS422 port data in the special vehicle platform belong to the response command data. If the IPACT algorithm is directly adopted, the RS422 port data delay is unacceptable, but the delay of Ethernet and CAN port data can meet the requirements, so the focus is on improving the delay performance of RS422 port data. Although the maximum delay of CAN data based on the PW-IPACT algorithm is slightly higher than that of

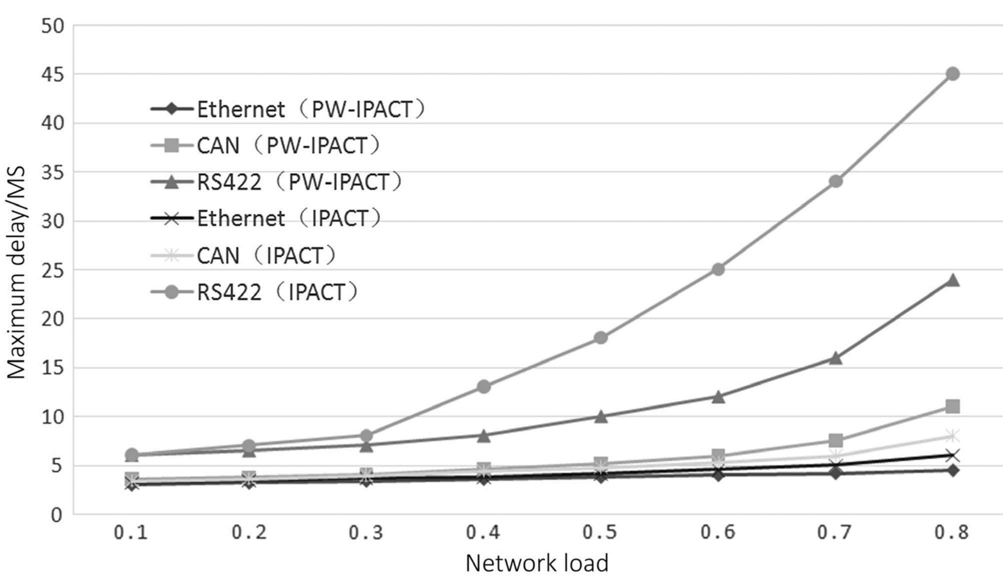

Fig. 3 Maximum data delay of the IPACT algorithm and PW-IPACT algorithm.

the IPACT algorithm, it is not sensitive to the delay performance requirements and is within the allowed delay of the traditional CAN bus. Therefore, the maximum time delay of CAN data under the PW-IPACT algorithm can meet the communication requirements of the optical fiber bus.

In summary, the PW-IPACT algorithm improves the real-time performance of high-priority data and takes into account the low-priority data, which meets the optical bus communication requirements of NT node Ethernet, CAN, and RS422 port data.

4.3 *Hardware-in-the-Loop System Test*

To verify the working efficiency of the proposed PW-IPACT algorithm on the embedded platform, three NT optical bus network test and verification systems are built. The schematic diagram of three-device node system is shown in Fig. 4, and the three-device node physical test system diagram is shown in Fig. 5. The system includes NC, passive optical splitter, optical fiber, and three NT devices (NT1, NT2, and NT3). They are implemented on a unified embedded hardware platform. The three communication devices, NT1, NT2, and NT3, are simulated by a computer, covering the three port data types of Ethernet, CAN, and RS422.

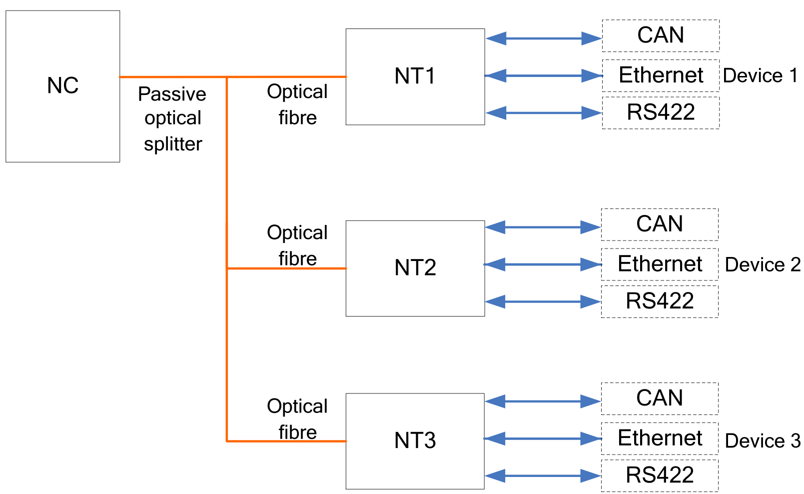

Fig. 4 Schematic diagram of the three-device node system.

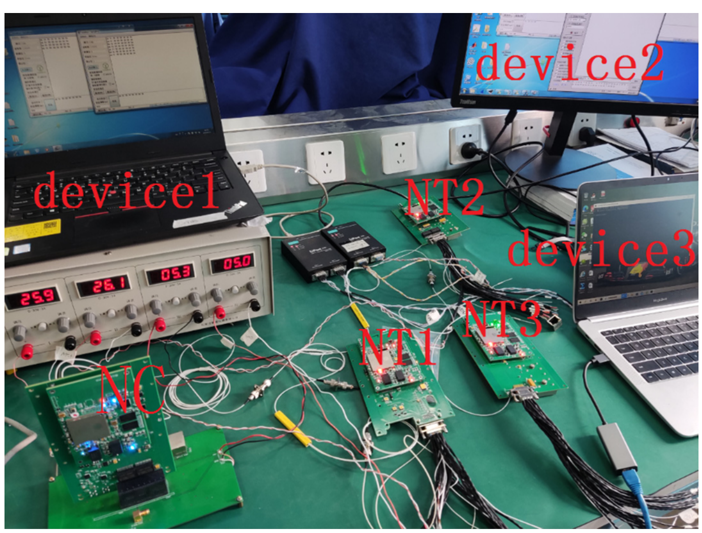

Fig. 5 Three-device node physical test system diagram.

By building a physical test system with three device nodes and simulating different network loads of Ethernet, CAN, and RS422 data ports with a computer, the end-to-end delay of various port data is measured with an oscilloscope. The test results show that the PW-IPACT algorithm improves the real-time performance of high-priority data and takes into account the low-priority data, which meets the optical bus communication requirements of NT nodes Ethernet, CAN, and RS422 port data.

5 Conclusion

With the advancement of electronic systems for special vehicles, a growing number of electronic gadgets and monitoring instruments are being integrated into various types of weaponry and equipment.The total amount of data transferred, shared, and completely processed between these equipment and devices is continually increasing. For the electronic data bus of special vehicles, higher-level standards have been proposed. This work offers a virtual weighted dynamic bandwidth allocation algorithm based on data buffering that effectively improves the efficiency of data exchange in special vehicle platforms.

1) Through the online analysis of the port data cache of each NT terminal of the optical fiber bus of special vehicle platforms, the real-time bandwidth demand of each NT terminal in the future polling cycle is calculated, and the dynamic bandwidth allocation is carried out accordingly.
2) According to the network calculus theory, a calculation method for the end-to-end delay upper bound of the port data of each NT terminal of the optical fiber bus of the special vehicle platform is established.
3) The OPNET simulation results show that, compared with the traditional IPACT algorithm, the proposed PW-IPACT algorithm significantly improves the real-time performance of data communication. On the basis of meeting the delay requirements of the Ethernet and CAN port data, the algorithm improves the end-to-end delay waiting time of RS422 port data by more than 50%.
4) By building a physical test system of three equipment nodes and simulating different network loads of Ethernet, CAN, and RS422 data ports with a computer, it is verified that the PW-IPACT algorithm can better meet the communication requirements of each NT node of the optical fiber bus of the special vehicle platform.

Acknowledgments

This project was supported by a vehicle-mounted reconnaissance platform project of Xi'an Institute of Applied Optics.

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