International Journal of Innovative Computing, Information and Control
Volume **11**, Number **4**, August **2015**
ICIC International ©2015 ISSN 1349-4198
pp. 1317–1323

NEW EFFICIENT TRANSMISSION TECHNIQUE OF VEHICLE ORIENTED TO BURST SERVICE

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Received January 2014; revised March 2015

Abstract. *Concerning on highly efficient transmission of amounts of burst service in the Space Information Network (SIN), which easily happens during the process of disaster relief, the paper proposes a highly efficient transmission algorithm based on data priority. The algorithm includes probability division of network data and distribution of drop probability on the basis of burst level, thereby solving the problem that important and time-sensitive data are easily discarded because of jam. We discuss the new algorithm in the condition of ideal buffer and fixed buffer, and simulation results show that the algorithm has obvious advantages in end-to-end delay, throughput and burst processing efficiency, which has important implications for disaster relief and other emergency communications.*
Keywords: Priority, HETA-P algorithm, Highly efficient transmission, Burst service

1. **Introduction.** In recent years, earthquakes, snowstorms and other severe nature disasters occur frequently, resulting in great loss of lives and properties to mankind. When severe disasters occur, the local communication infrastructure will suffer different levels of damage, leading to the interruption of terrestrial communication. Through erecting temporary link of satellite communication, Satellite Emergency Communications Vehicles (SECV), an indispensable part of disaster relief, play an important role in many aspects, such as communications, command, and control. During the process of disaster relief, burst service happens frequently in SIN. When transmitting or dispensing, burst service has the probability of causing jam due to restrictions of terminal's buffer. What is worse, key or time-sensitive data will risk being discarded, which affects efficient transmission of burst service, and the same to relief.

The way of controlling jam recommended by the Internet Engineering Task Force (IETF) is Active Queue Management (AQM), which is applied at those nodes which have routing function. AQM is that queue should drop packets with certain probability for newly arrived before it overflows. Currently, domestic and foreign researches of AQM are listed as follows. Literature [1] proposes AQMS_PLR algorithm, which uses exponential moving average to calculate the drop ratios of network packets. Based on it, the drop probability of packets arrived next moment is marked. In literature [2], there is a combination of packets' importance in real-time transportation stream and drop ratios of overtime packets, aiming at proposing a concept – weighted drop ratio of overtime packets. Compared to traditional algorithms, the new algorithm can provide better quality of service. Literature [3] introduces self-similarity parameter into the drop ratio of RED algorithm; therefore, it improved the stability of the queue length, and reduced the drop ratios, queue delay and queue jitter. Algorithm above can achieve better management of queue by optimizing the allocation of the drop probability. However, emergency communications are not allowed to discard some important data, while these algorithms do not take data's importance and timeliness into consideration. Therefore, the key to solve efficient transmission of burst service is not only ensuring better queue management, but also ensuring the arrival ratio of the data which cannot be abandoned at the same time. Therefore, the paper proposes a High-Efficiency Transmission Algorithm Based on Priority (HETA-P for short below). The algorithm considers allocating drop ratios for different levels of data, which will better ensure the arrival rate of important data, thus ensuring a better quality of service, thus achieving better management of the queue ultimately.

2. High-Efficiency Transmission Algorithm Based on Priority.

In order to avoid time-sensitive and important data of SIN to be discarded by the effect of vehicle's queue capacity, data with important information and timeliness requirement need to be disposed preferentially. Therefore, these data need to be graded, to be identified furthermore.

2.1. Division of data priority.

According to the characteristics of data that vehicle receives from SIN, these data can be divided into three categories: important data, which means that the data frame carries important information; common data, which means that the data frame carries common information; unimportant data, which means the data frame carries non-critical data and can be discarded if necessary.

The division of importance will inevitably lead to data's competition of queue which has the same importance. Thus, we divide data's timeliness requirement into three categories, which are based on data priority: high timeliness requirement, which means that the data frame carries time-sensitive data; common timeliness requirement, which means the data frame carries data with common timeliness; the least timeliness requirement, which means the data frame is requested no time.

Therefore, the bits of the data transmitting over the SIN which carry priority information are defined as:

$$V_i = [D_i\ T_i] \tag{1}$$

where, D_i represents data's importance priority and T_i means data's timeliness priority. D_i and T_i are composed of 2 bits; we can judge data frame's priority with the value of V_i.

2.2. HETA-P algorithm model.

The backbone node that has the ability of superposition provides two buffers, a receive-buffer used to receive data, and a send-buffer used to send data. The node firstly reads the data's prior information successively when receiver is receiving data from a channel. The read data stream into the receiver sequentially to queue; the data with high priority come first. When the send-channel is idle, the node allocates back-off time on basis of data's priority accessing the send-channel, so data with high priority access send-channel with great probability.

Those burst service leads to the increase of the amount of data. For different types of receive-buffer, we will discuss burst service in the following two aspects.

(1) If receive-buffer size is ideal and large enough to accommodate all burst data, all the data in the receiver will re-queue according to data's priority. If these data have the same importance, they will re-queue and wait to be sent according to the level of data's timeliness requirement.

(2) If receive-buffer is a fixed value, the buffer may not be able to accommodate all the burst data, and the node is still receiving normal data. Therefore, it may cause jam due to restriction of buffer. The case is unbeneficial for those data that carry high priority especially for those data that feature high timeliness requirement. The case is more complex than the former, but it is a common case.

HETA-P algorithm proposes a new processing mechanism: the backbone node randomly selects any source nodes to notify the jam, so they can reduce the send-ratio to ease network jam before buffer overflows. At the same time, receive-buffer always discards those data that already exist based on drop probability to accommodate all burst data regardless of their priority. After completing burst service processing, the node will notify source nodes to resume normal transmission. Data drop mechanism is described below.

Before burst data arrive receive-buffer, the backbone node calculates average length l_{avg} based on real length of the current queue l. We assume that the maximum length and minimum length of queue are MAX_{th} and MIN_{th}. Burst data will enter the queue to queue if the average length of the queue is less than MIN_{th}. The backbone node will discard data from queue based on drop probability until all burst data enter queue if the average length of the queue is between MAX_{th} and MIN_{th}. Figure 1 shows the buffer. The parameters of receive-buffer set as follows: $MAX_{th} = k$, $MIN_{th} = 2k/3$, H is value of Hurst, and $H > 0.5$.

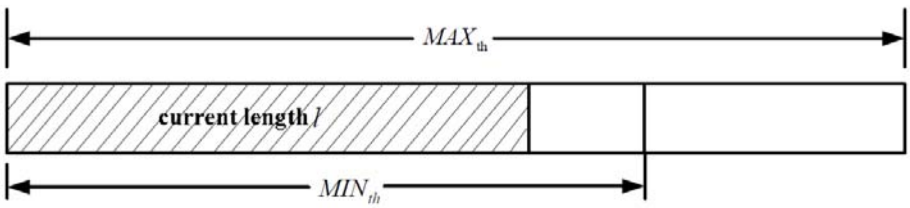

FIGURE 1. Sketch of receive-buffer

How the new algorithm sets the drop probability should satisfy the following two respects: (1) Different drop probability should keep consistent with the setting of priority in case of the constant Hurst; (2) In terms of different Hurst, the larger the Hurst is, the lower the drop probability of high prior data should have. Therefore, we set drop probability as follows:

$$1 = p_1 + p_2 \tag{2}$$

where, p_1 refers to the sum of all probabilities that are high priority data's; p_2 refers to the sum of all probabilities that are low priority data's. Drop probabilities of high priority data set are as follows:

$$p_0 = \begin{cases} (1-H)P_{\max} \times \left(\frac{l_{avg}-MIN_{th}}{(MAX_{th}-MIN_{th})}\right)^{2H}, & priority: 0000 \\ (1-H)P_{\max} \times \left(\frac{l_{avg}-MIN_{th}}{(MAX_{th}-MIN_{th})}\right)^{2-2H}, & priority: 0001 \\ H \times P_{\max} \times \left(\frac{l_{avg}-MIN_{th}}{(MAX_{th}-MIN_{th})}\right)^{2H}, & priority: 0100 \\ H \times P_{\max} \times \left(\frac{l_{avg}-MIN_{th}}{(MAX_{th}-MIN_{th})}\right)^{2-2H}, & priority: 0101 \end{cases} \tag{3}$$

2.3. **Simulation parameters.** In allusion to HETA-P algorithm for efficient transmission scheme, we describe delay, throughput and efficiency of burst processing as reference standard.

(1) Delay

Delay usually refers to time interval between the send-side sending the first bit and the receive-side receiving the last bit. The time interval of SIN includes certain delay (transmission, propagation) and random delay (processing), it usually consists of the following components in detail:

- Transmission delay: time needed to complete sending the data;

- Propagation delay: time used for the transmission on the link;
- Processing delay: time needed for data queuing and processing, etc.

Delay of the satellite to the receiver vehicle can be calculated by using the following formula:

$$T = \sum_{i=1}^{n} \left(\frac{L}{C_i} + \frac{D_i}{R_i} + P_i + Q_i \right) \tag{4}$$

where, L represents the length of data, C_i, D_i, R_i represent the physical link bandwidth, link length and propagation speed respectively, and P_i, Q_i represent data's queuing delay and processing delay for the ith node.

(2) Throughput

Throughput means the average throughput of the send-channel; it is the average value of data volume successfully transmitted from the backbone node in unit time.

(3) Efficiency of burst processing

Efficiency of burst processing describes relationship between the retransmitted data that were discarded because of burst traffic and the overall burst data. If we do not consider priority, the formula of burst processing efficiency is:

$$\eta = \frac{C_{sud} - C_{imp}}{C_{sud}} \times 100\%,\ 0 \leq \eta \leq 1 \tag{5}$$

where, C_{sud} means the burst size of data, and C_{imp} means the size of data that should be retransmitted.

If we consider data's priority, efficiency of burst processing can be calculated as follows:

$$\eta = \frac{k_0 - \sum_{i=1}^{4} k_i}{k_0} \times 100\%,\ 0 \leq \eta \leq 1 \tag{6}$$

where, k_0 indicates the size of burst data, and k_i represents data size of different levels that are discarded in the process of receive-buffer (except those with the lowest priority). The greater η is, the fewer efficient data discarded by receive-buffer is, the fewer retransmissions are, the higher efficiency of burst processing is.

3. HETA-P Algorithm Simulation Analysis.

3.1. **Simulation scenarios.** Simulation scenario is shown as in Figure 2. The backbone node receives data from different sources; each data source generates data by ON/OFF data model. The lengths of ON and OFF lasting obey Pareto distribution. When the backbone node is processing conventional data, the second source terminal generates burst data and then forms burst service. The backbone node deals with these burst data according to HETA-P algorithm.

3.2. **Simulation and analysis.** The network data comply with Pareto distribution. Simulation parameters are set as shown in Table 1.

When burst service occurs on the condition that the buffer is an ideal size, the simulation results and analysis of delay that high-priority data frame waiting for transmission are shown in Figure 3 ($H = 0.7$ now).

The whole trend of two algorithms is that the waiting time of high-priority data frame decreases gradually along with the simulation time.

All data in queue fight for opportunity to be transmitted for their having no priority, which brings out much delay for the data. When burst data enter buffer, the backbone node should deal with data with high priority firstly, so the data has increasing delay temporary.

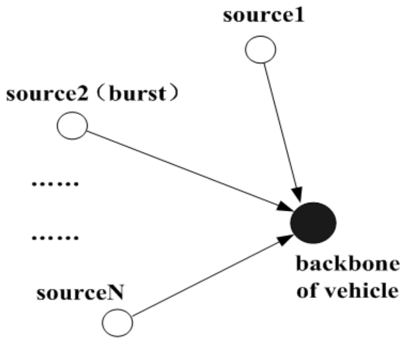

FIGURE 2. Simulation scenario

TABLE 1. Simulation parameters

parameter	value
simulation time	$10s$
bandwidth	$1Mbps$
link length	$36000km$
MAX_{th}	$75packets$
transmission speed	$40packets/s$
buffer size	$100packets$

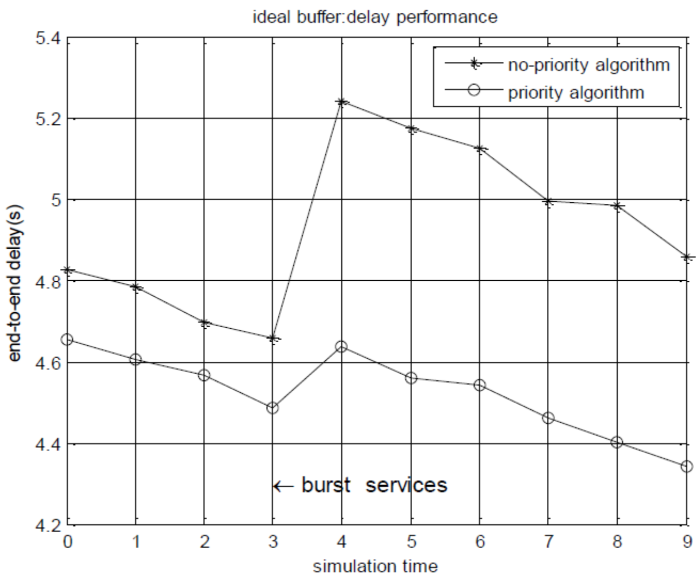

FIGURE 3. Performance comparison of data's delay in ideal buffer

Concerning on priority, low-priority data have no choice but to wait to be sent on the basis of HETA-P algorithm. As a result, the number of competing send-channel is smaller relatively, the queuing delay is also smaller, the ratio of delay growth is smaller when burst service occurs, and the end-to-end delay of data is significantly different. After processing all burst data by the backbone node, the delay of the data waiting for transmission continues to decrease.

When burst service occurs, while the buffer is a fixed one, the simulation results and analysis of delay that high-priority data frame waiting for transmission are shown in Figure 4 ($H = 0.7$ now).

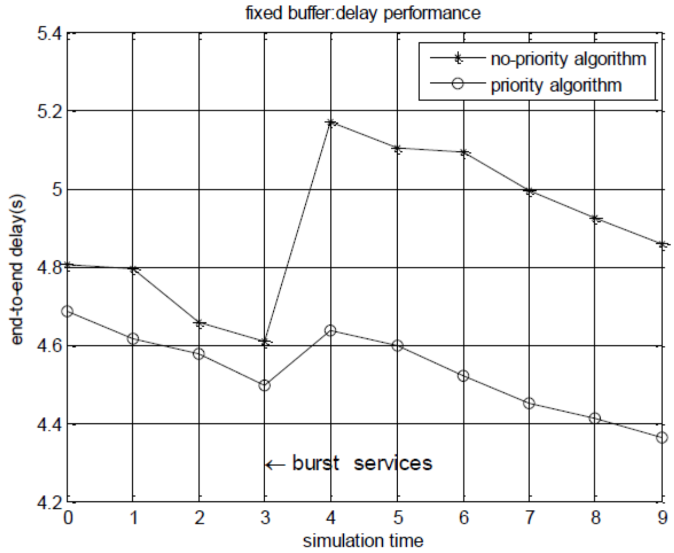

FIGURE 4. Performance comparison of data's delay in fixed buffer

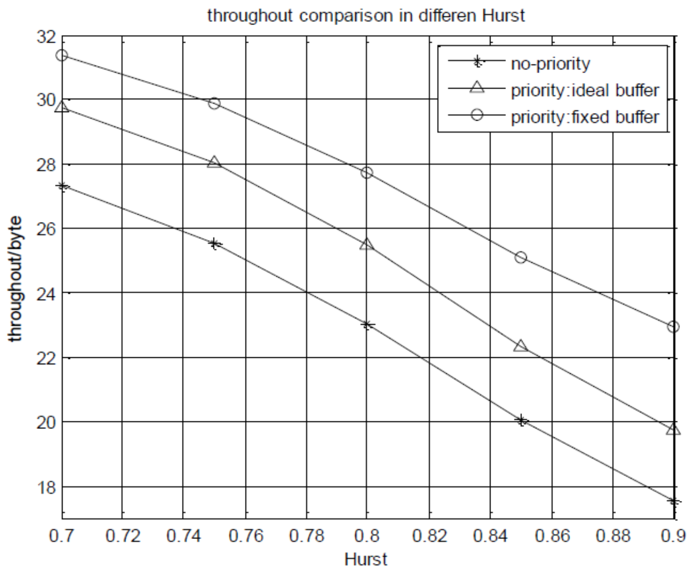

FIGURE 5. Comparison of throughout over different Hurst

Obviously, simulation shows HETA-P algorithm without delay growth priority algorithm only about 30%, and HETA-P algorithm has obvious advantages; it not only reduces the delay, but also can reduce delay jitter. This is because HETA-P algorithm may discard much of data based on drop probability in the fixed buffer, so the delay of waiting to transmit may be lower.

In terms of throughput, when there are burst service, the simulation results and analysis for different types of buffer and different Hurst are shown in Figure 5.

Simulation results show that data throughputs under ideal cache and fixed cache increase about 8%, respectively, and 14.1%. When the network flow is big, the data has much more collision and delay when they are queuing for transmission in backbone node's buffer without priority algorithm. The node sends data according to priority if HETA-P algorithm is applied, helping decentralize competitive pressures and reduce conflict. More data will arrive at destination nodes in unit time, and the throughput improves to some extent. With the Hurst increasing, there will be more conflict and fewer throughputs. Fixed buffer has higher throughput efficiency than the ideal one; it is because the node discards some data. The results of Figure 5 show that the greater Hurst is in HETA-P algorithm, the more evident the throughput efficiency is.

If we do not consider priority, the efficiency of burst processing is $\eta = 93\%$. Considering priority, efficiency of burst processing is $\eta = 98.4\%$.

4. **Conclusion.** This paper analyzes the defects of traditional algorithms in the process of disaster relief and other emergency communications, and followed HETA-P algorithm is proposed based on the importance and timeliness of the data network, given the drop probability of new algorithms and mathematical models of different priority data. Finally, the ideal simulation of the performance trends caching and data caching is fixed according to the given index. Simulation results show that compared with the traditional algorithm, HETA-P algorithm has a significant performance advantage in data end-to-end delay, throughput and burst handling efficiency. In a word, HETA-P algorithm can achieve the purpose of transmission to be highly efficient.

Acknowledgment. This work was supported by a grant from the National High Technology Research and Development Program of China (863 Program No. 2012AAXX36), Program for Innovative Research Team and University Key Laboratory of Liaoning Province Educational Committee (No. L2012440, No. L2012217).

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