Redundancy Path Implementation for Schedule Traffic

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***Abstract*—When the network technology is developing rapidly, network traffic also increasing significantly. Due to the development of In-Vehicle-Network (IVN), a lot of application about audio and video has been implemented. It causes the high requirement to IVN. In this case, IEEE 802.1 Audio/Video Bridging standard has been published. Therefore, IVN traffic's delay meet the millisecond level requirement. Go further, for control data, whose delay need to be guaranteed in the microsecond, IEEE 802.1 Time Sensitive network is being proposed. In this paper, we will verify the redundancy path which proposed in IEEE 802.1CB by simulation.**

Keywords—In-Vehicle-Network; Audio/Video Bridging; Time-Sensitive Network; IEEE 802.1 CB

I. INTRODUCTION

In recent years, vehicle network technology is developing rapidly, such as Vehicle-to-X (V2X) which can communicate with another vehicle or the infrastructure when it needed. Also, due to the development of In-Vehicle-Network (IVN), a lot of assistive technology like Advanced Driver Assistance System (ADAS), Lane Departure Warning System (LDWS), Lane Keeping Assistant System (LKAS) are presented. At the same time, the realization of those technology causes the IVN traffic increased significantly. There, a method which can efficiently be handling these traffic is imperative.

To solve the increasing traffic issue, IEEE 802.1 Audio/Video Bridging (AVB) standard has been published in 2013. AVB standard which has high-speed Ethernet communication also guarantees under 2 milliseconds (ms) end-to-end latency for highest priority traffic class in 7 hop networks. However, it's not enough for the application those using the sensor, radar, laser and camera which latency should be guaranteed in order of microseconds (µs). In this case, an enhancement of AVB is needed.

The enhance AVB is called IEEE 802.1 Time-Sensitive Network (TSN), which using time-triggered traffic to transmit control data and guarantees end-to-end latency by using the time division multiplexing access (TDMA). However, even schedule traffic who transmitted by time-triggered traffic has the highest priority in TSN standard, it still has the opportunity that packets get lost in transmission at special cases like switches or network nodes are terminated suddenly. In order to ensure the success of transmission, Redundancy path, the backup path using in AVB traffic for seamless redundancy, which has been proposed in IEEE 802.1 CB[1] standard. Therefore, this function can also try on schedule traffic, to ensure that it can compute the high-speed transmission.

In this paper, we present the simulation of comparison about schedule traffic using Redundancy path under different network conditions. And this simulation will be verified by OMNeT++ 5.0 with Core4INET which is an extension to the INET-Framework for the event-based simulation of real-time Ethernet in the OMNEST/OMNeT++ simulation system[2].

This paper is organized as follow. In Section II, we talk about AVB/TSN and IEEE 802.1 CB standard. In Section III, introducing the proposed mechanism and architecture. In Section IV, we present simulation and analyze the results. Finally, we conclude our work in Section V.

II. BACKGROUND

A. Overview of AVB & TSN

At the first time, IEEE Audio/Video Bridging (AVB) is developed for supporting real-time audio and video streaming in IVN area. It guaranteed bandwidth for high priory traffic like Stream Reservation (SR) class A/class B, which using Stream Reservation Protocol (SRP) by IEEE 802.1 Qat[3] standard in Ethernet AVB. This protocol will be reserved up to 75% bandwidth for AVB traffic. Therefore, thus, the real-time streaming application has low latency that can be achieving milliseconds level end-to-end delay.

Further, in TSN, IEEE 802.1 Qat standard upgrades to IEEE 802.1 Qcc[4] standard, which improve the performance. Also, enhance time-trigger transmission for control data, that all the nodes in the network will be synchronized and all the traffics will be handled by Time Aware Shaper (TAS) which specified in IEEE 802.1 Qbv[5] standard, then the schedule traffic can be sent at their regular time window immediately. Guaranteed by IEEE 802.1 Qbu[6,7] standard, the sending big frame would be preemption when the next frame has the highest priority. That is the low priory frames could stop transmitting at the beginning of another time window, and the

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remaining part of the frame could be sent after transmission of the time-triggered frame[9].

B. IEEE 802.1CB - Frame Replication and Elimination for Reliability

IEEE 802.1 CB is a standard for redundancy management mechanism. Working with this mechanism, at the source node of the AVB bridge network, the traffic frames are copied and transmitted in parallel over multi-paths through the AVB steam. To distinguish the frame is received or not, sequence number has been used. When the frames reach bridge end node, the redundant duplicates follow by sequence number are eliminated, then reconstruction for one seamless stream. So, even one of those nodes in the path is interrupted, destination node could receive frames from another path without additional delays for recovery.

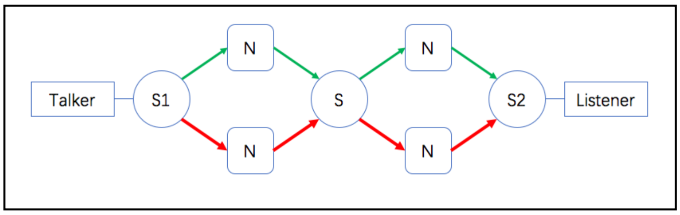

Fig. 1. *Concept of IEEE 802.1 CB*

Figure.1 show how the redundancy management mechanism working. At the switch 1, the frame will be copied, then, the duplicates going through with different path. In the end, switch 2 will drop the duplicated frame which the sequence number is bigger.

III. SIMULATION ARCHITECTURE

To verify the effect of schedule traffic by using Redundancy path, and how much delay will be generated. We implemented a simulation that using Redundancy path to transmit schedule traffic frame at 100Mbps and 1Gbps network environment, also compared with the case without Redundancy path.

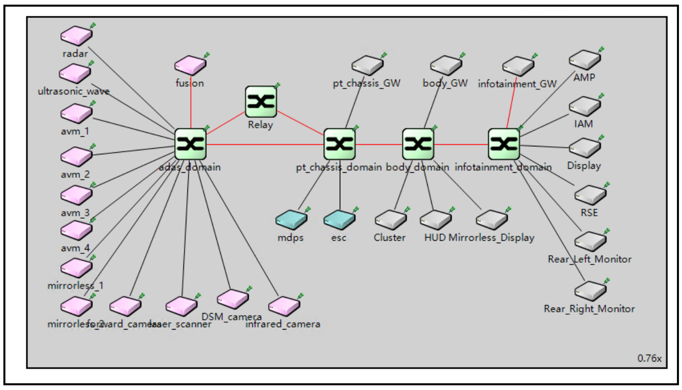

Fig. 2. Simulation architecture

This simulation is running on the virtual IVN network environment as shown in Figure.2. At first, we run the simulation for all schedule traffic, AVB traffic (contain with Class A and Class B) and Best-effort traffic and obtained the basic result. Next, we will be affecting the redundancy management mechanism for 100Mbps link path with 1 Hop, 100Mbps with 2 Hop(a) and 1000Mbps(1Gbps) with 2 Hop(b) in the part of PT/Chassis and ADAS network(in Figure.3). Moreover, the main traffic data type and size we used in the simulation will be shown in Table 1 at below, and the delay requirement by AVB and TSN are showing in Table 2[8].

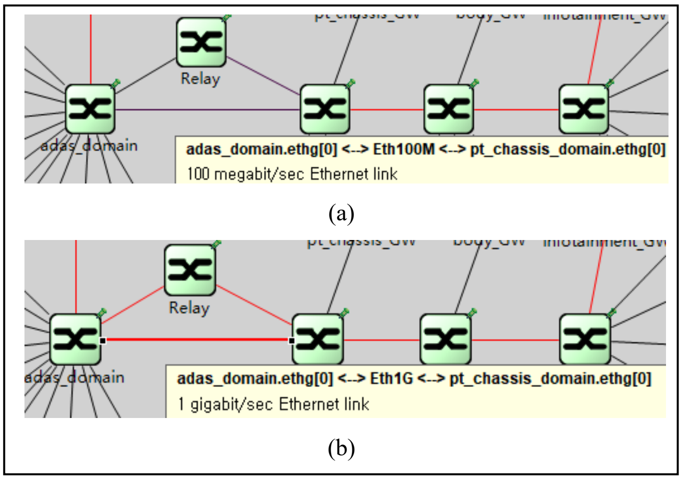

Fig. 3. The redundancy part(a,b)

TABLE I. MAIN TRAFFIC TYPE & SIZE

Traffic Type	*Size*	*Cycle*	*Path*
Schedule Traffic	230byte	10ms	PT/Chassis -> ADAS
Schedule Traffic	625byte	10ms	ADAS -> PT/Chassis
Schedule Traffic	625byte	10ms	ADAS -> PT/Chassis

TABLE II. DIFFERENT E2E DELAY REQUIREMENT

Service	**End-to-End delay requirement**
IEEE 802.11p	<100ms. For high dynamic data
	<500ms. For maneuver negotiation
AVB	<2ms. over 7 hops
TSN	<100µs. over 5 hops

IV. SIMULATION RESULT

As shown in Table 3, we can see that scenario 1 got the best result in our simulation which the lowest End-to-End delay is 74us, the added delay is only operation time in the switch. The scenario 3 got the second good result which delays time is 77us, almost same with scenario 1, based on the 1Gbps high link speed.

TABLE III. DELAY IN DIFFERENT PATH

End-to-End Delay(μs)			
Without redundancy	50.2	57.1	57.1
1 Hop(100Mbps)	74	81	80
2 Hop(100Mbps)	102	108	108
2 Hop(1000Mbps)	77	84	85

For the situation of scenario 2, resulting the double delay time compare with the basic result that does not meet the requirement. Given the highest priority of schedule traffic, we speculate that the reason for the delay is that the switch needs to receive two or more frames in the same transmission window time. In this situation, it requires that the switch needs to be extended the window time to confirm whether there is a duplicate frame exist. If there is duplication, first, the switch will deal with the duplicated frame (general, it will be drop), then the switch does the next transmission step, this process which is the main reason causing the delay.

At the same time, in scenario 2, the frames incoming time is different base on the 2 Hop model that the frame coming from redundancy path is always later than the other one. In our calculation, the difference will be late by one transmission period, nearly. It is also explant why scenario 2 got the double delay time.

V. CONCLUSION & FUTURE WORK

In this paper, we first study on the standard about AVB and TSN, focus on how to build the redundancy management mechanism from IEEE 802.1 CB. Therefore, we simulated those performances in IVN environment.

In conclusion, for the simulation, we summarize two reasons that there influences the traffic delay. One of them is the extended transmission window time, another one, which the situation that the path hops are different, frames from the longer path always being late by one transmission period, nearly.

In future, we will confirm the performance of longer redundancy path with same Hop in the other simulation.

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