A Simulator for the Performance Evaluation of the FieldBus(Train Communication Network)

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Abstract: This paper presents a Train Communication Network simulator (TCNS) that can be used to evaluate the performance of TCN. TCN was accepted as the standard of the protocol for the communication network in trains. We carry out some simulation tests using the TCNS to show practical uses of the simulator. Results of some simulation tests are also reported

Keywords: Communication system, TCN, Communication simulation

1. Introduction

A Simulator for the Performance Evaluation of the Train Communication Network

This paper presents a Train Communication Network simulator(TCNS) that can be used to evaluate the performance of TCN. TCN was accepted as the standard of the protocol for the communication network in trains. TCN of fieldbus was adopted as international standardization IEC 61375 in 1999. It has been operating on G7 train in korea. This paper developed TCNS(Train Communication Network simulator) as a simulator for performance evaluation. We can verify TCNS for preventing many kinds of occurring problems between the devices in data-communication. This study was developed TCNS as a simulator for the performance evaluation. We analyzed correlation between token, transmission data per paket and transmission speed of bus, through the TCNS, also analyzed result according to error rate of TCN. We carry out some simulation tests using the TCNS to show practical uses of the simulator. Results of some simulation tests are also reported.

2. Train Communication Network (TCN)

2.1 International standard of TCN

An international standardization of data communication is necessary at both the train and vehicle levels. Trains with varying composition during daily service-such as metros, or suburban and international trains-need a standard form of data communication for train control, diagnostics, and passenger information. Such communication should configure itself when vehicles are coupled on the track. At the vehicle level, a standard attachment of equipment would serve manufacturers, suppliers, and operators. Manufacturers could assemble pretested units, such as doors manufactured by subcontractors, which include their own computers. Parts suppliers who interface with different manufacturers could reduce development costs by adhering to one standard. Railroad operators could reduce spare parts and simplify maintenance and part replacement. The TCN architecture addresses all relevant configurations found in rail vehicles. It comprises the train bus connecting the vehicles and the vehicle bus connecting the equipment aboard a vehicle or group of vehicles, as shown in Figure 1.

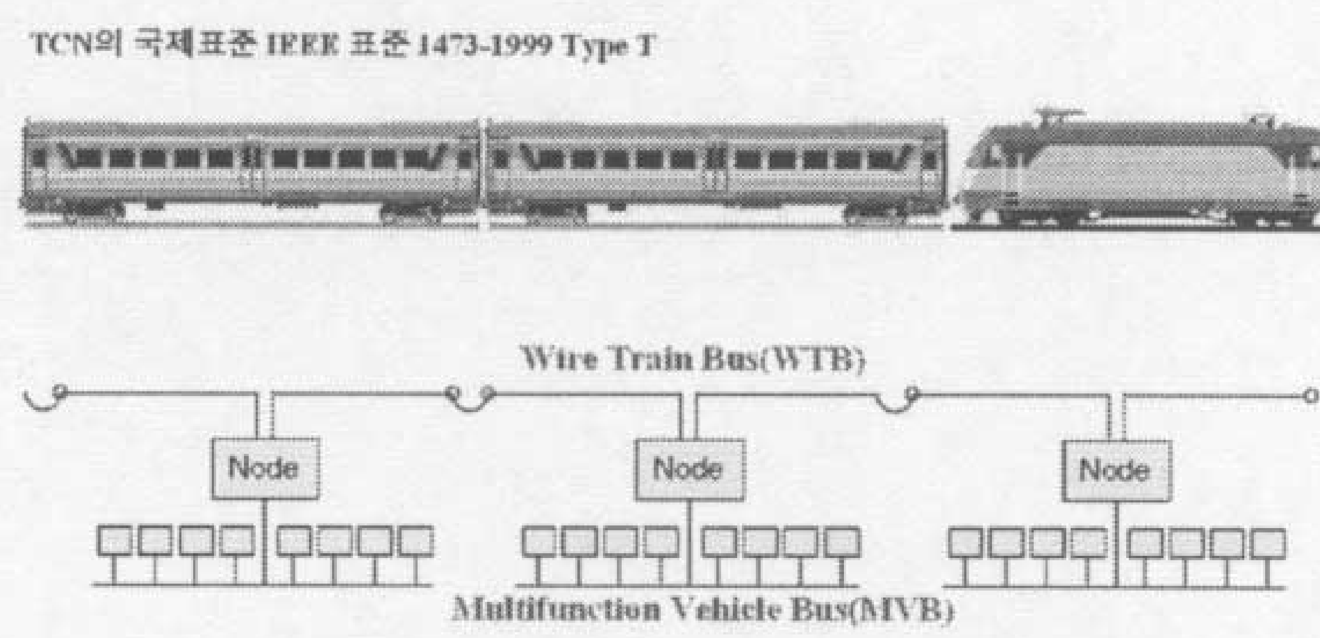

Figure 1. Train Communication network

2.2 WTB

The WTB interconnects vehicles over hand-plug jumper cables or automatic couplers, as shown in Figure 2. The WTB's most salient feature(and a unique trait in the railroad industry) is that it automatically numbers nodes in sequential order and lets all nodes distinguish between the train's right and left sides and aft and fore direstion. Each time the train composition changes, for example, after adding or removing vehicles, the train bus nodes execute the inauguration procedure, which connects electrically and assigns a sequential address to each node. In general, there is one node per vehicle, but, as shown in Figure 2, there may be more than one or none at all. At the end of the inauguration, all vehicles recognize the train topography, including

- their own address, orientation(right and left), and position with respect to the bus master(aft and fore)
- other vehicles' number and position in the train.
- other vehicles' type and version(locomotive, coach, and so on) and their supported functions.
- their own and other vehicles' dynamic properties.

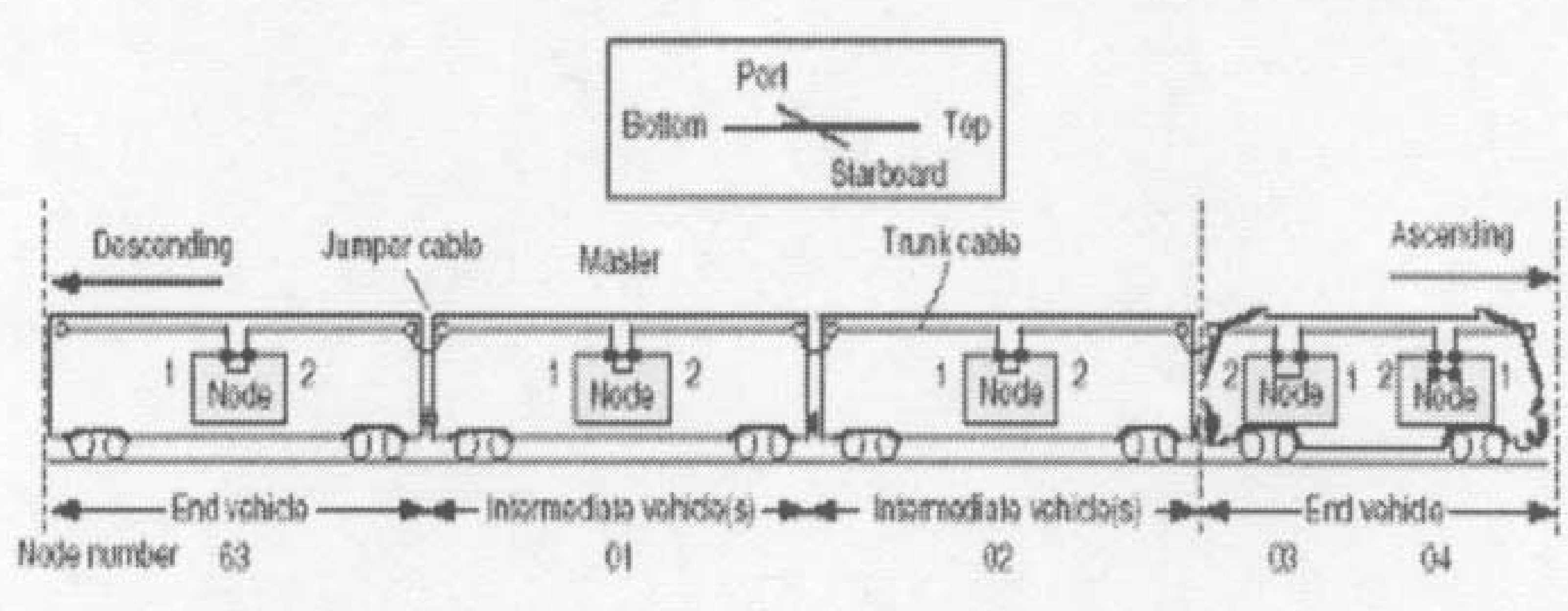

Figure 2. WTB layout

2.3 MVB

To simplify assembly, commissioning, and subsystem reuse, the TCN architecture specifies the Multifunction Vehicle Bus(MVB) as a vehicle bus. The MVB connects equipment within a vehicle or within different vehicles in closed train sets. Figure 3 shows MVB layout in train . The MVB operates at 1.5 Mbps and over the following media.

-Optical fiber for distances over 200 meters and for environments sensitive to electromagnetic interference.

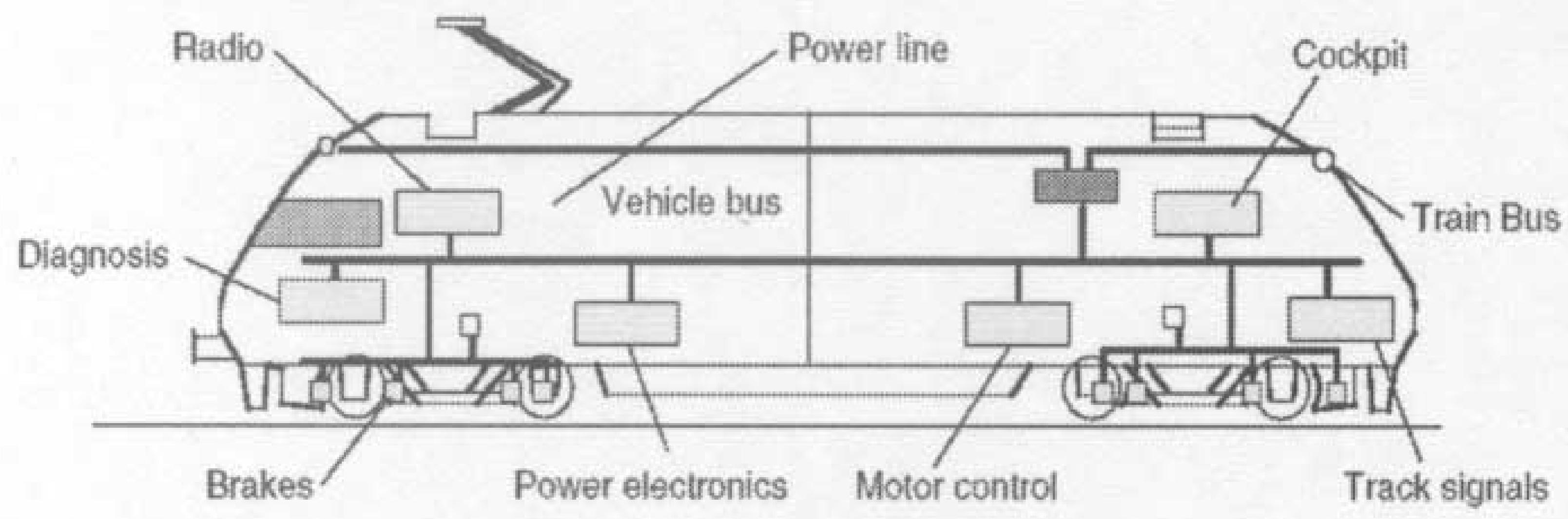

Figure 3. MVB layout

A dedicated master controls the MVB and can have backup from redundant masters to increase availability. The MVB controller provides redundancy at the physical layer: A listens to only one while monitoring the other. Other features include high integrity against data corruption and, due to its robust Manchester encoding and checksums.

2.4 Data traffic

In spite of physical and layer difference WTB and MVB have same operation. TCN bus transmit data of two type that are Process Variables and message data. Process Variables are know status of train such as velocity, current of motor and driver's command etc. TCN transmission time between coaches must be below 100msec. TCN periodically transmit process variables. Message data sporadically ocurr and it has many information such as diagnosis data and passenger data. Traffic about data has periodic and sporadic and they correspond to process variables and message traffic. They hold bus in common.

Traction control over the vehicle bus requires guaranteed delivery forom application to application for all critical variables within less than 16 ms. To guarantee these delays, the train communication network transmits all process variables periodically. Message data carry infrequent, but possibly lengthy information. Message length varies between a few bytes to several kilobytes. Messages transmission delay must be short on the average, but the application tolerates delays up to several seconds. This slackened requirement lets the TCN transmit messages on demand. Traffic is occurred according to basic period in MVB and TWB. In order to reducing traffic load important data transmit as basic period of bus.

Each devices transmit once per 2 period(50ms), 4 period(100ms), 8 period(200ms) according to its importance. But all period don't overflow 1024ms. TCN basic protocol use token ring method because of guaranteeing decided transmission time.

Alternating periodic and sporadic data transmissions lets a single bus transmit both types of data. Process variables are transmitted at regular intervals(1ms) and after transmission, the bus checks for sporadic traffic demand and transmits, if requested, a message packet, if the guard time is respected.

One device acting as master controls periodic and sporadic data transmission, which guarantees deterministic medium access. To accomplish this, the master alternates periodic and sporadic phases, as shown in Figure 4. Traffic is divided into basic periods of fixed duration - either 1 or 2 ms on the MVB and 25 ms on the WTB. At the start of a period, the master polls the process variables in sequence during a certain time period - the periodic phase. To reduce traffic, urgent data are transmitted every period and less urgent variables are transmitted with an individual period every second, forth, eight, and so on basic period, with the longest period being 1,024 ms. After transmitting the process variables, the bus master checks for sporadic data to transmit. On the WTB, a flag in the periodic data signals that a node has sporadic data pending.

On the MVB, an arbitration procedure ensures that one of several devices gets serviced. If there are no sporadic data to transmit, the sporadic phase remains unused. If there are data, the master checks that sufficient time remains until the start of the next period(it respects the guard time), and if so, invites a device to transmit its sporadic data. A highly precise start of the next period is needed because the first master frame of a period serves to synchronize all clocks with a jitter of some microseconds.

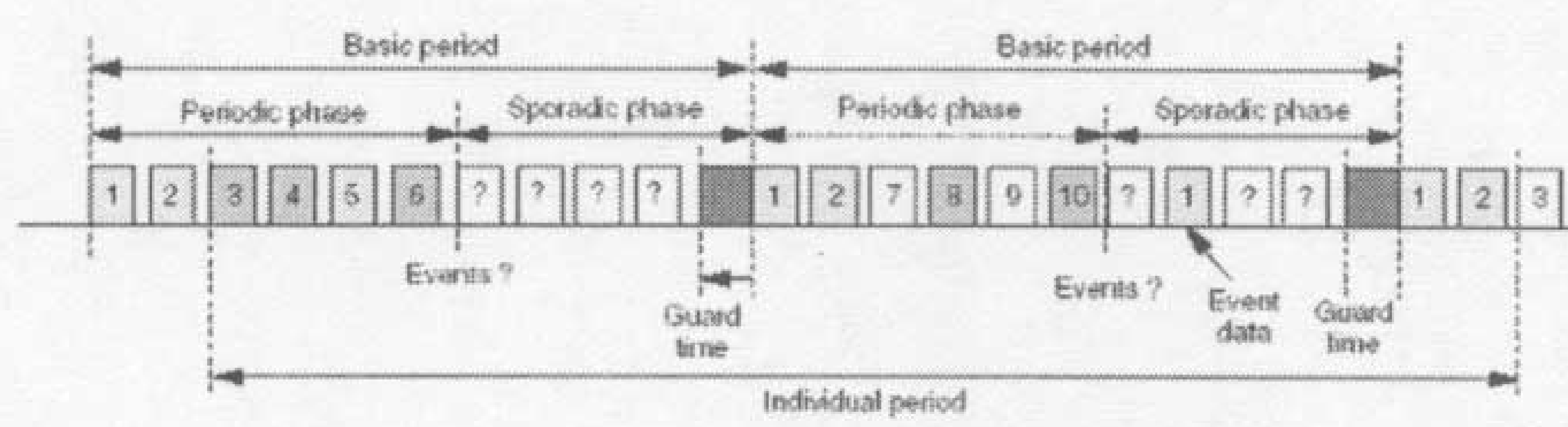

Figure 4. Basic period

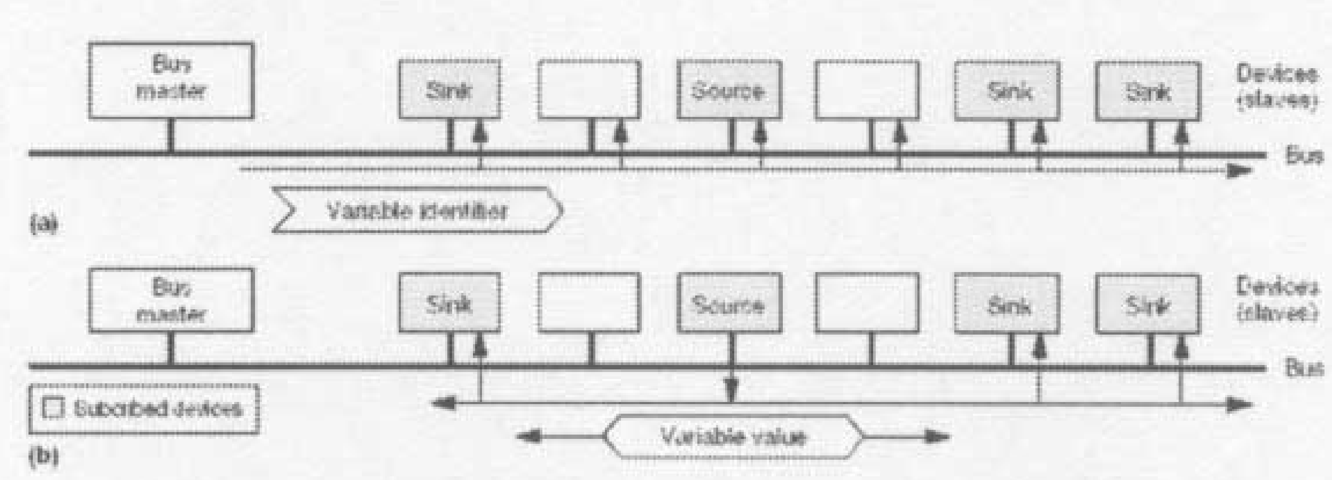

Figure 5. Source-address broadcast

In the first phase of process variable transmission, the master broadcasts a frame to trigger transmission of a certain variable without specifying the source device. In a second phase, the source device answers by broadcasting a frame containing the requested value to all devices. Each device interested in this variable picks up the value, as shown in Figure 5.

3. Train Communication Network Simulator (TCNS)

To performance evaluation of communication system, simulation method is applied. Through simulation we previously observe operation status of communication system and setup all kind of parameter values and find problems. So we can draw up a plan. In this paper we developed Train Communication Network Simulator(TCNS) for performance test of TCN. We used commercial simulation software AweSim! ver 3.0 and visual C++ 6.0 to develop TCNS.

3.1 Characteristic of Awesim

AweSim! ver 3.0 is generally used in network simulation field. AweSim is a developed simulation software based on C language. This consist of many function appropriating communication network and can add user's sub-routine using visual c++ and visual basic. TCNS consist of 7 modules according to function and role of TCN. Based on attribute of AweSim, each modules was developed.

3.2 Simulation start module

Figure 6 show main function module of TCNS. Awesim generate object as many as coach's number.

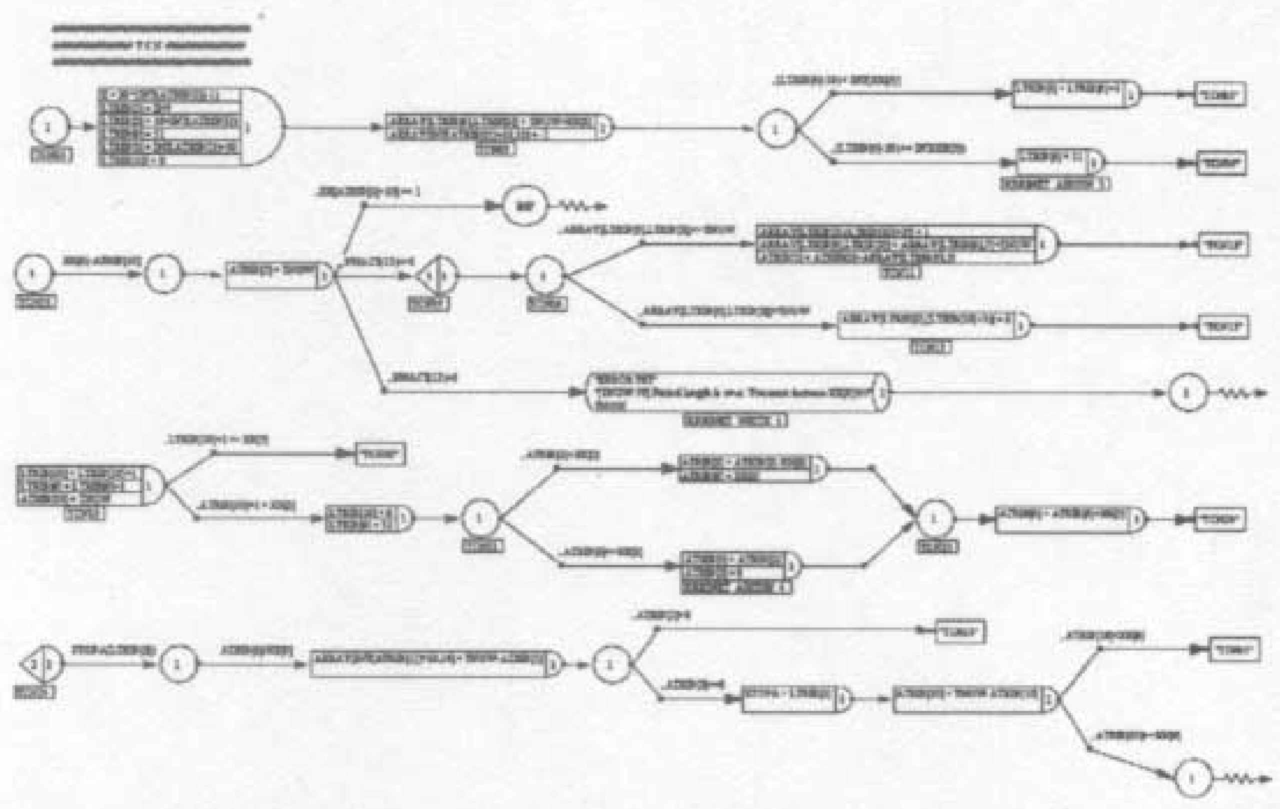

Figure 6. TCN main module using Awesim

Table 1. variable of AweSim

variable	characteristic
ATRIB	Local variable depended on each objects. If value change, activated object value change. This value is realnumber (float)
LTRIB	This value is integral number(integer)
XX	Global variable If value change, global variable value change. This value is realnumber (float)
LL	Global variable If value change, global variable value change. This value is integral number(integer)
ARRAY	Global variable 2 dimension value

3.3 Train movement animation

ATP transmit train velocity and preceding train information when the train pass by ground-antenna. In this paper we build program as separating wireless communication transmitting data from ground-antenna and wired communication transmitting data from ATP to master computer. This program execute performance evaluation of wireless communication parts at train movement animation.

3.4 Vehicle Module

When the variable transmit from bus master, vehicles module transmit value of process variable.

3.5 Packet transmission module

In this paper we decide token period according to following formula.

$$\text{token periodic} \le \frac{\text{packet} + \text{headbit}}{\text{bus transmission time}}$$

$$\text{transmission time} = \frac{\text{busspeed(Mbps)}}{1000\text{ms}} \quad - \ (1)$$

3.6 Token Module

TCN basic protocol use token ring method because of guaranteeing decided transmission time.

3.7 TCN Module

This is module to play role of bus master. Table 2 show role of bus master.

Table 2. Function of TCN

Function of bus master
variable setup
calculating transmission quantity for transmitting to vehicles transmitting packet
transmitting process variable
Error check of wired and wireless communication

3.8 TCNS execution

Figure 7 show animation screen when simulation.

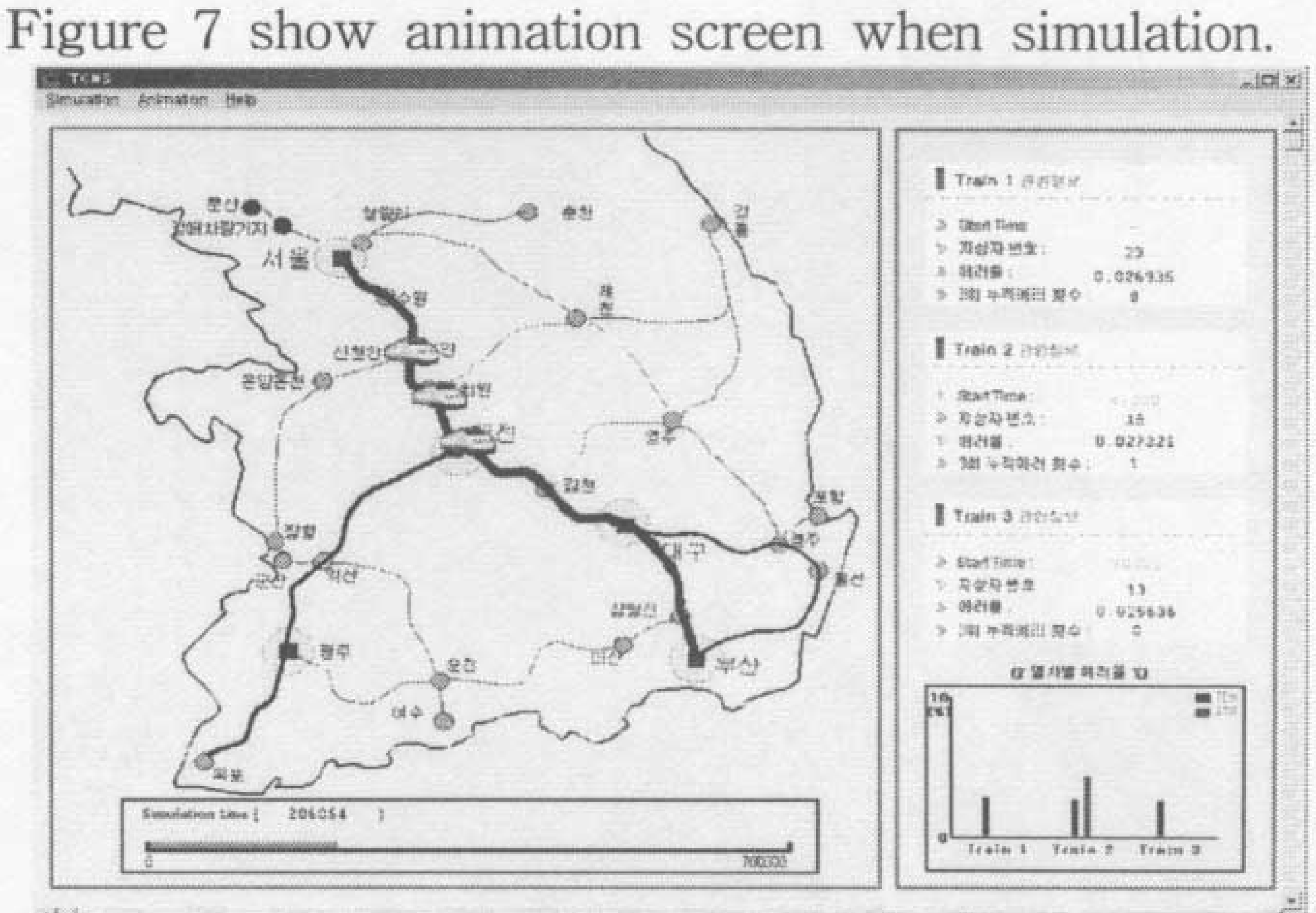

Figure 7. TCNS execution screen

4. Test and analysis result

Through the TCNS, we study performance test of TCN and wireless communication. For performance test, we study simulation to calculate time and distance taken in running from seoul to busan.

4.1 To analysis correlation token occurrence periodic and transmission quantity each packet

As making an alternative such as table 3 according to formula (1), we carry out simulator in applying 0.001 packer error rate. Results of the simulation, alternative 4 and 6 was selected that are under 1% error rate like figure 8 and not occurring error for three times running and WTB transmission quantity 1Mbps not defining in standard TCN

4.2 Periodic traffic running time of TCN

In this chapter we analyze about running time of periodic traffic. To carry out simulation we setup 0.25ms occurred token period selected chap table 5. To select traffic running time, we accomplished simulation as proposal like table 5. Figure 9 show result. Results of carrying out proposal 2 and 3 have spare time that is able to manage sporadic traffic. A packet(256bit) transmission quantity of proposal 2 increase error rate. So, selected proposal 3.

Table 3. correlation of token, packet and bus speed

proposal	token period	packet	bus speed
1	0.1ms	64bit	2Mbps
2	0.15ms	96bit	1.5Mbps
3	0.2ms	128bit	1.3Mbps
4	0.25ms	160bit	1Mbps
5	0.3ms	196bit	1.1Mbps
6	0.35ms	228bit	1Mbps

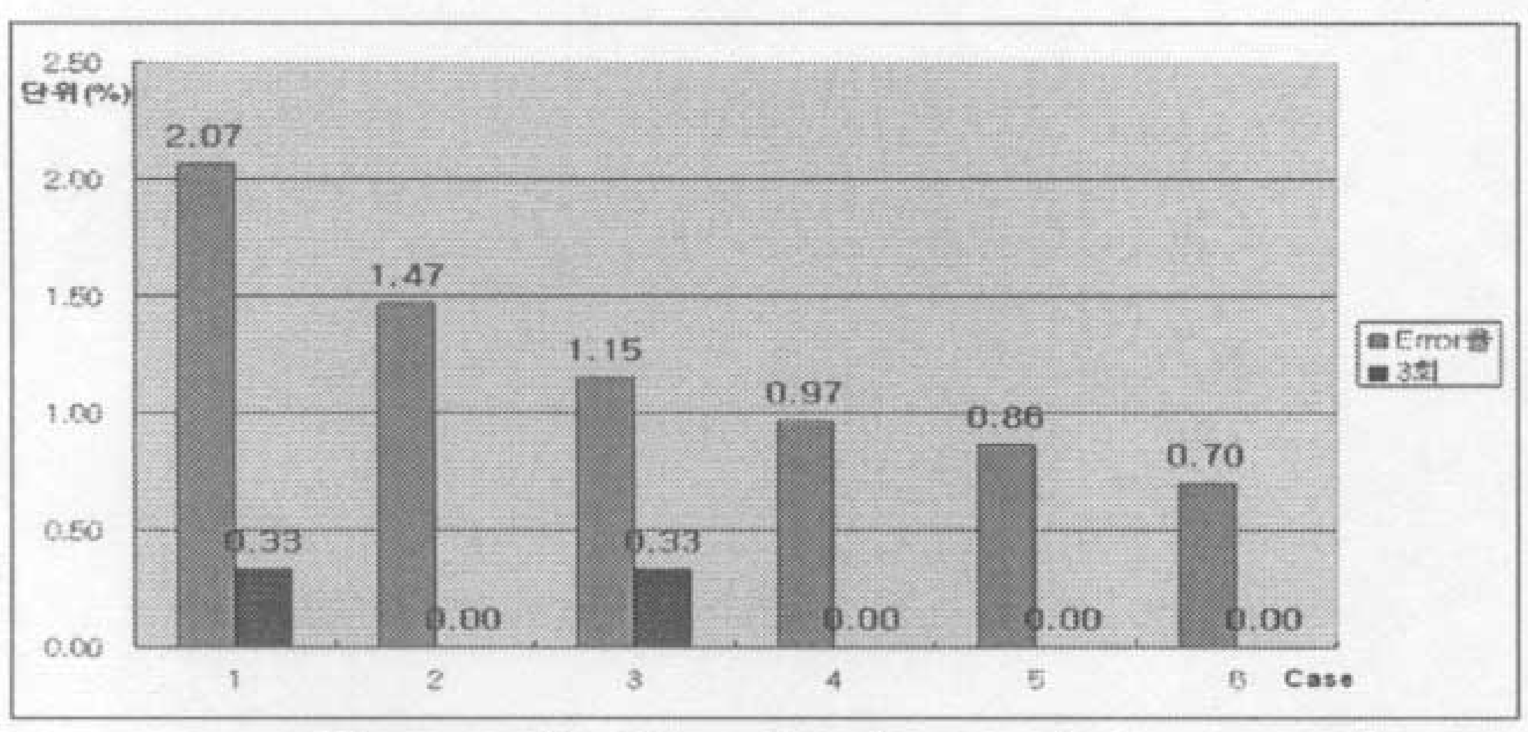

Figure 8. Result of simulation

Table 6. Running time of periodic traffic

proposal	packet	token period	bus period
1	128bit	0.27ms	25ms
2	256bit	0.35ms	25ms
3	128bit	0.25ms	25ms

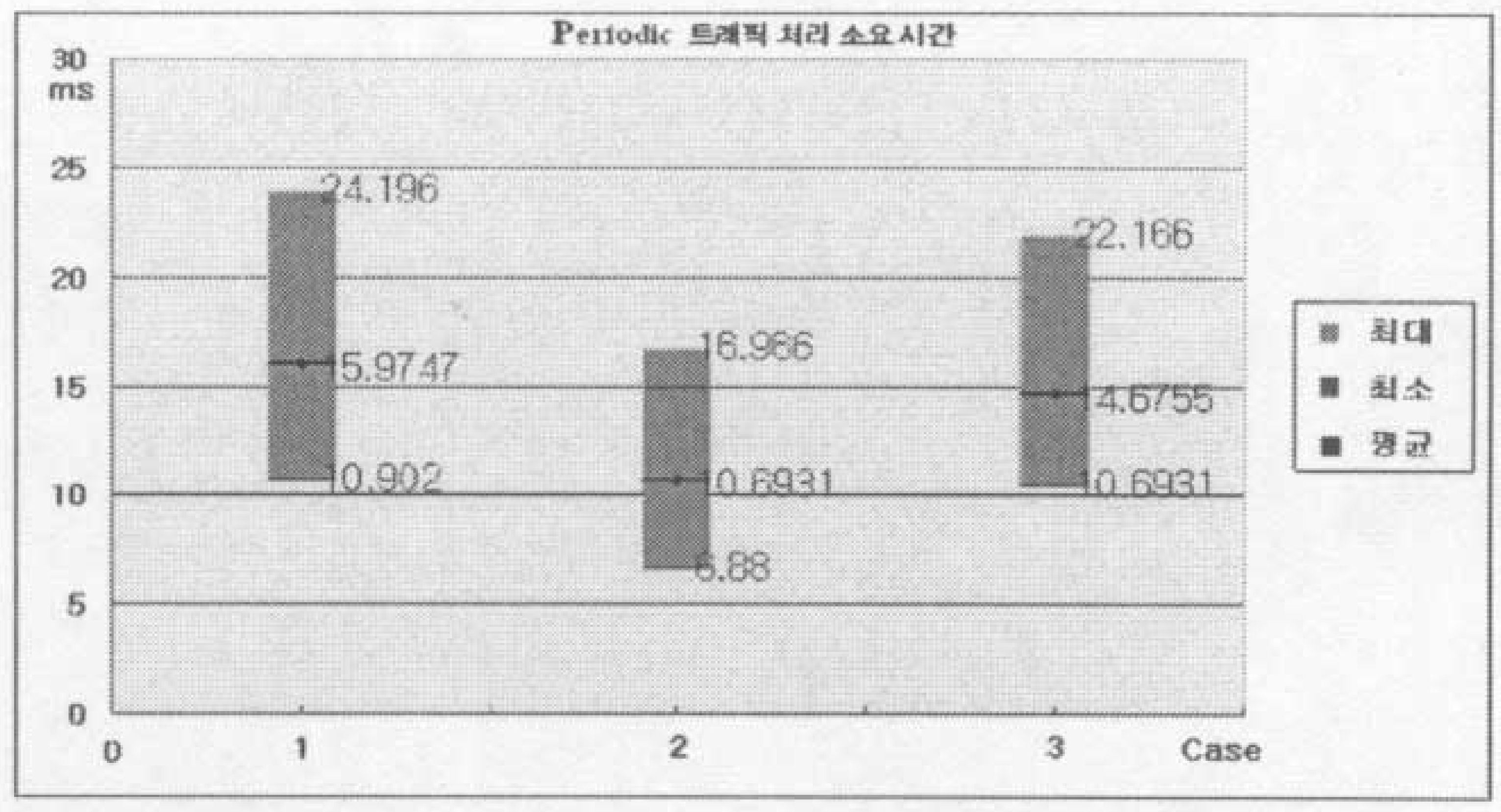

Figure 9. Simulation result of table 6.

5. Conclusion

In this study, we developed TCNS as simulation for fieldbus performance test. For the purpose of testing simulator's effect through TCNS, we analyze correlation between transmission quantities each packet and bus transmission speed. So system parameter being suitable for international standard was produced out. TCNS is kept studying to realize more information and function.

[Reference]

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