A Study on the Application of Real-Time Object-Oriented Modeling Technique For Real-Time Computer Control

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ABSTRACT – This paper considers the design technique of the real-time control algorithm to implement the electronic interlocking system which is the most important station control system in railway signal field. The proposed technique consists of the structure design and the detail design which are based on the ROOM(Real-Time Object-Oriented Modeling)

This proposed technique is applied to the typical station model in order to prove the validity as verifying the performance of the modeled station.

1. INTRODUCTION

To contrive a good efficiency of transmitting, there has been a great improvement of railway systems about speed, transport units and frequencies. Therefore railway systems are becoming very complicated and when a train accident is happening, it could be a disaster. To prevent collisions and derailment, to get reach a destination safety, railway systems providers are deep concerning about signal preservation problems.[1-2]

Especially, signal and point are very frequently controlled at the railway stations for the works that switching railway, and arrival, stating and shunting of trains. It is not only hard to prevent to accident by an operator's control but improve the efficiency. Therefore, an interlocking system is practically used that works by right sequence though improper control is used.[3]

Moreover, interlocking system is able to overcome a locked control. Generally used two major category of interlocking systems are relay interlocking and electronic interlocking system using micro-computer.[4] Relay interlocking is designed for the safe operation. A system is not developing to a dangerous situation as a result of a damage or a breakdown. Relay interlocking has been widely used for several decades as the most safe signal secure system that works quickly and responses promptly.

However, some problems are proposed for a time about conforming standard of interlocking logics, interlocking tests, design automation, organization and extension. Micro-computer based electronic interlocking device is developed for the purpose of overcoming above problems, and minimize the cost and maintenance when the system is need to be rebuilt or expanded. However, it is difficult to determine a exact decision though a problem of just one device, moreover, there are plenty of things to be prospected, so most of all, the stability is guaranteed as much as relay interlocking to maximize the effects of appliance of electronic interlocking system. The stability can be guaranteed by cooperation with the design of hardware and software. Stability of interlocking software is decided by reliance and efficiency of realizing interlocking and by convenience of conserve and maintenance. Variable approaching methods[5] to improve the stabilities of interlocking software have been proposed. Electronic interlocking software realizing method, which is used with fuzzy algorithm, is proposed in reference.[6]

Our development establishes interlocking software designing algorithm that can compensate characteristics and problems of described system. Design strategy step and modeling strategy procedure, that are the most proper approaching method at the beginning of real-time Object-Oriented Modeling[7] method, are algorithm is based on object oriented analysis method [8] that is useful in real-time problem, it is top-down design method similar as structural analysis method so not only convenient for standardization, expansion and maintenance but also can contribute to rise reliability and stability of electronic interlocking system.

Proposed method, based on real-time object oriented model, is organized with structure design and detail design. At the structure design, designed by modeling heuristic method, we should focus and analyze the demand of feature and then design it based on that demand. Detail

design builds reliable system and rises accuracy because it is designed right after comparing and examining data and after repeatedly modeling a acceptable value.

2. THE CONCEPT OF INTERLOCKING

2.1 Constructing Electronic Interlocking System

Hardware method that rises stability, utility, and reliance is used for constructing the hardware of electronic interlocking system. Electronic interlocking system can not only control directly each train but grip the flow of every sections of railroad. For realizing those, electronic interlocking system has CTC that can control the traffic of train, electronic interlocking device for processing interlocking logics. LCP that controls local stations, and TFM that controls field equipments for signaling.

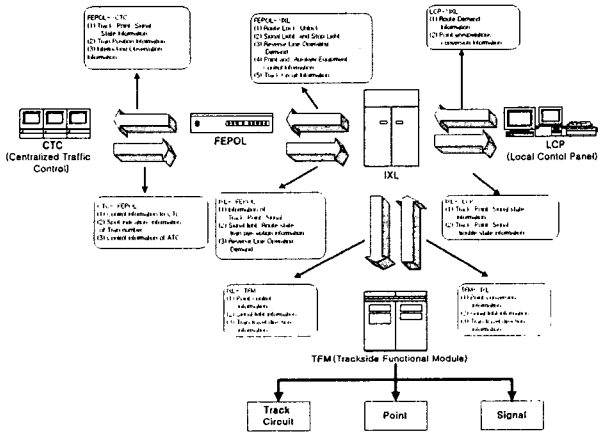

Fig. 1 The Electronic Interlocking System Construct model

The main processor of electronic interlocking system is VRTX based on SUN workstation. An operator uses general IBM PC or former display. IBM PC also display monitor, and has input and output abilities bout data. Electronic interlocking system has three communication networks for the aspects of cost and stability.

2.2 Strategies of Electronic Interlocking system

Railway system is composed of railroads stations. There are multiple double line railroads in a station for stopping and passing of train and for easy to load the cargos. When a train is entering to about a station, CTC (centralized traffic control) calls train entrance admittance to interlocking system for safe guiding the train. Right this time, electronic interlocking system checks safeties from train position information of point and signal in the station, then determines whether permit entering or not.

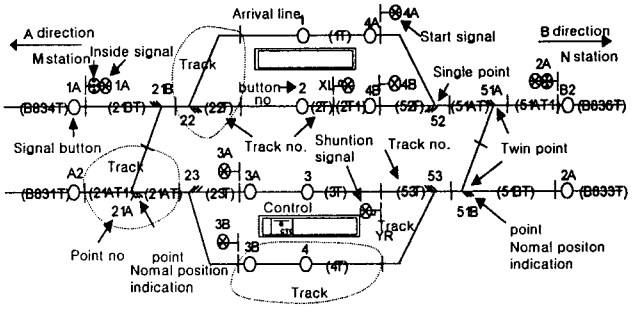

Fig. 2 The typical station model

3. DESIGNING INTERLOCKING SYSTEM WITH ROOM METHOD

Design method proposed on this paper is based on ROOM method for building a precise and simple system model and for designing a recursive processor structure. Interlocking system must response the incoming response and calculate given data in a limited time. All system structures seem complicated because should process in a real-time. To solve these complication, we are considering the system devices as objects and modeling repeatedly. Design strategy follows heuristic method. First, who should focus and understand specified requirements, then do detail design based on system requirements. In order to model inside system structure, required scenario need to be analyzed then Message Sequence Chart(MSC) is framed. Objects that are caught from inside structure modeling are modeling logical relations between each objects. Afterward modeling system, creating optimized model by comparing with required scenario

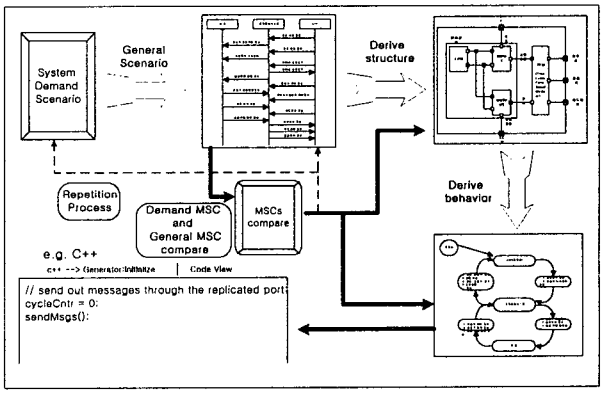

Fig. 3 The Software Design Strategy of Interlocking System

As seen in Fig.4, in the modeling strategy, the momentous things are, advantage of object oriented, essentially the important new paradigm, is fully applied, and model has characteristic and powerful concepts in real-time field, also, it is easy to build precise and simple system model. Besides, it is possible to catch the elucidative system structure and records, detect requirements of design fault with providing active models by surmising all concepts of leveling in a early stage.

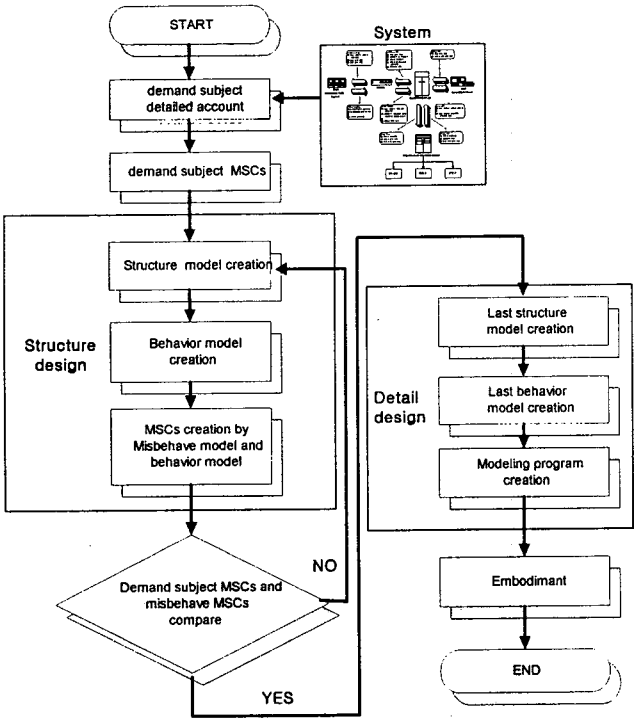

Fig. 4 The Modeling Flow chart of Real-Time Control System Software Development Strategy

3.1 System requirements Scenario

Scenario is basic method to system requirements. Scenario identifies whole usage of a system and act orders for inner elements. Because scenarios focus on order of messages between object and object, they are very useful to deduce their elements and requirements. Scenario about establish the rout of electronic interlocking system s bellowed.

Scenario 1] Order the rout selection from LCP to electronic interlocking system.

Scenario 2] Electronic interlocking system demands state information of track.

Scenario 3] After receiving the information of track, command the point order to the specific train.

Scenario 4] If the point of train is completed, receive the track information again.

Scenario 5] Electronic interlocking system commands signal exposure order,.

Scenario 6] After the signal exposure order, receive the track state information again every route.

3.2 Interlocking System Modeling

Fig. 5 shows the first stage model of electronic interlocking system limits. At the figure, let the system a block box, and shows how the system outer interface correlates with outer objects-LCP and field installation on this paper.

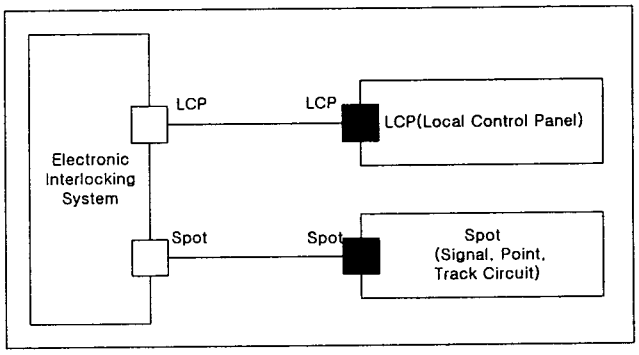

Fig. 5 The First Stage Model : Electronic Interlocking System Limits

According to the first stage model of system limits, we can make MSC as Fig. 6 This makes system a black box for the aspect of electronic interlocking system, Local Control Panel (LCP) and dissolved signal installations (point, signal, track circuits). Because starting a modeling of objects that sampled from just a overall system looking, deference between each objects are not appeared and relation between each objects as well.

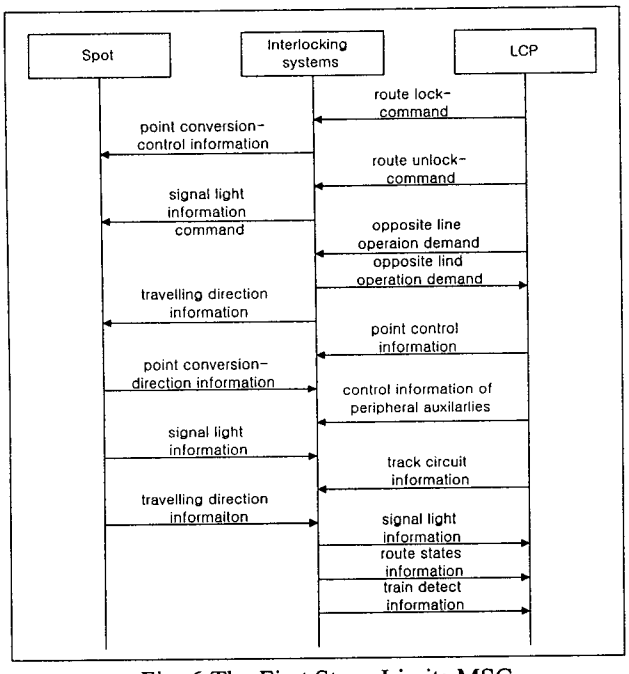

Fig. 6 The First Stage Limits MSC

Fig. 7 Shows behavior examination between user and system. Rounded rectangles mean states or substates.

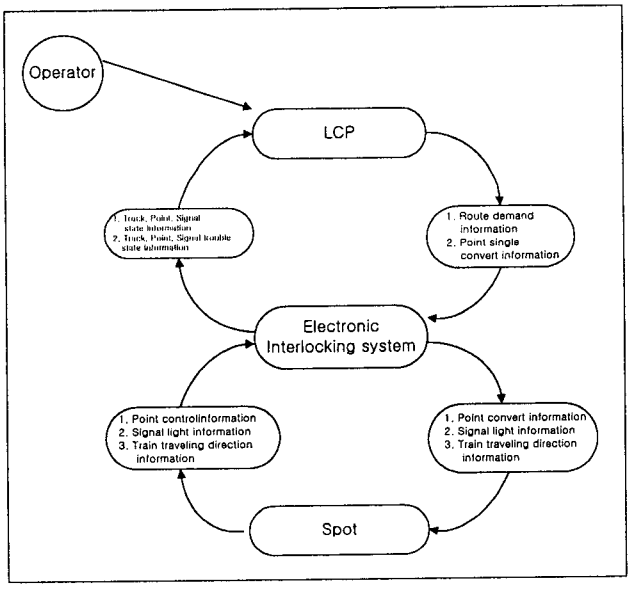

Fig. 7 The User Behavior

The next stage of the first stage is Fig. 8 about the system at the point of outer and inner view. This is the concentrated view of Fig. 5 MSC is reconstructed by system structure model. At this stage, system is not a black box like Fig. 5 system is embodied with LCP, electronic interlocking system, signal, trains, track circuits and so on. System requirement scenario is represented as MSC.

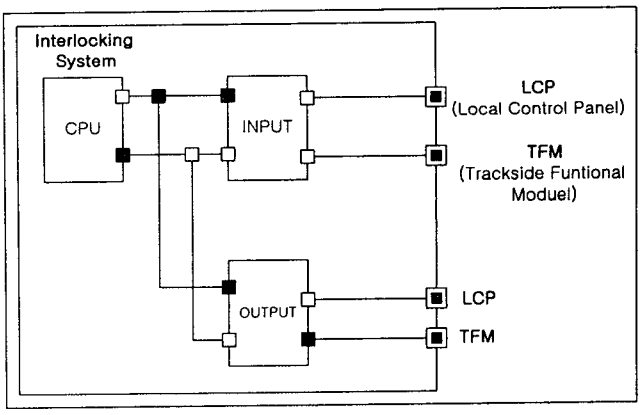

Fig. 8 The System Structure

A various and complicated last scenario can be defined recurrently by other scenario. Since request condition scenario focuses objects and messages sequence between objects, they are particularly useful in pulling out their terms desired. The following step presents interlocking system in Fig. 8 more concretely. Every system behaviour and interface are not clear yet and there is no systematic relations between users respectively. Fig. 9 shows every inner devices of interlocking system and systematic message transfer routines.

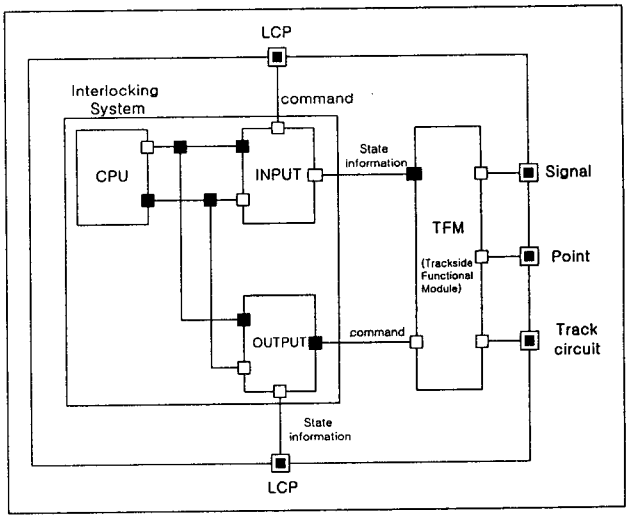

Fig. 9 The Last Interlocking System Structure

Fig. 10 is the final specific MSC made by repetitive processes for each object's message interface relations. It presents detailed contents of message communication between each object and can be added in feed back by repetitive processes.

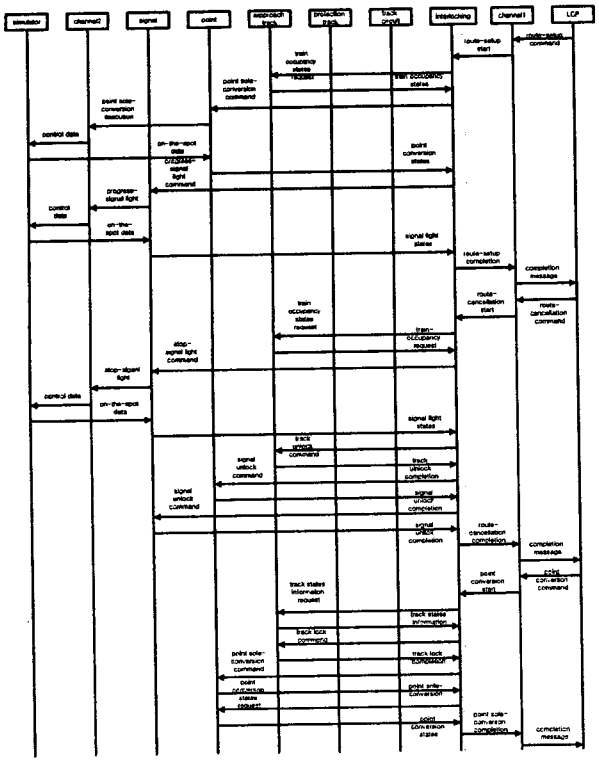

Fig. 10 The Last Interlocking Scenario MSC

4. SIMULATION RESULTS

This paper verifies the performance for a railway station of city railway system in order that inspects precise chain relations and controls. We verify reliability and efficiency of development design strategy of proposed control algorithm. Fig. 11 plays a role of LCP and on-the-spot simulator as a device for experimenting.

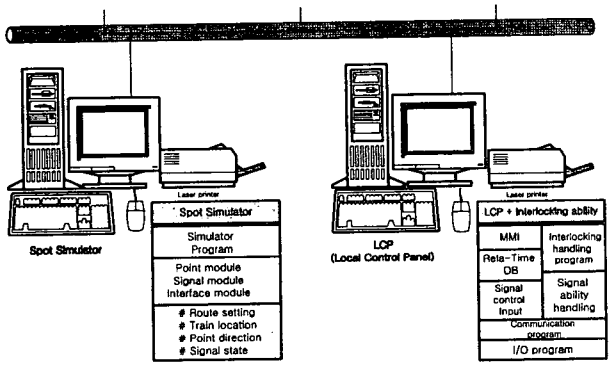

Fig. 11 The Configuration of Simulation Equipment

The Simulator saves status information of on-the-spot signal, point and a track, outputs on-the-spot data when requiring in interlocking systems, and behaves like a real job-site if control information of signal or point are transferred.

Inverse model Fig. 2 for verifying performances consists in total eight regulation routes including 4 up-lines and 4 down-lines. In the based of requirement scenario of interlocking system for each regulation route, verifications is taken over various scenarios that might be originated in lock, detector locking, signal control and approach locking region-mutual chain relations. First we inspect if in approach locking regions, it succeeds in lock precisely and high efficiency and reliability by experimenting route-cancellation-setup, sole point conversion, etc in working circumstances as same as real job-site. Interlocking functioning, that is algorithm designed by means of proposed technique, verifies if it can monitor route locking, lock point, detector, signal control, block locking, direction lever, particle lever, chasing vehicles, etc. in a little time, and whether or not "out of order" in separate conversions of each signal and point, etc frequently running, and if it detects artificial error when making control-data file.

Fig. 12, 13 shows MMI of experiment equipments.

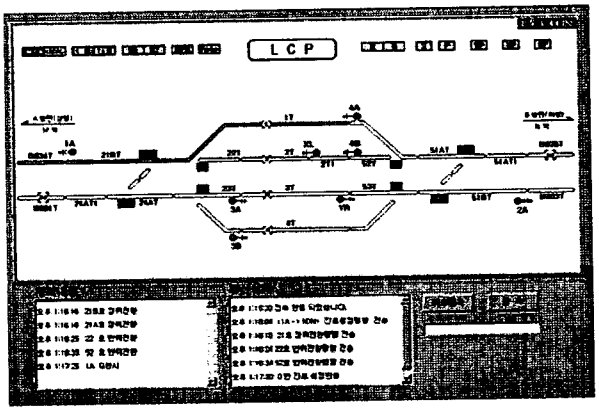

Fig. 12 Local Control Panel Tool

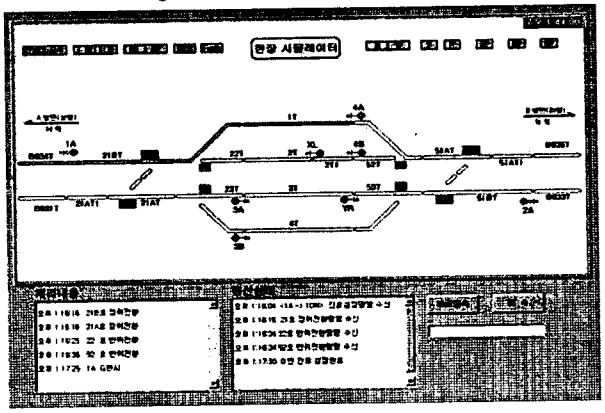

Fig. 13 The Actual Simulator Tool

Point states are converted form no. 21, 51 to the normal position(N), and from no. 22, 52 to the reverse position(R) and locked altogether. Moreover, it is locked so as not to convert the point by trains and vehicles in case there is trains or vehicles within track circuit including point by trains and vehicles in case there is trains or vehicles within track circuit including point. Track circuit(21BT, 22T, 1T) controls signal lights and in direction locking, trains or vehicles go into the direction locking, track(21BT, 22T) are locked. So as not to convert point on the route by trains or vehicles until it passes relational track circuits though repositions the signal lever. In a approach locking, signal is locked so as not to change route(B834T) unconditionally route until 60 seconds goes on after lighting stop sign in signal.

Table 1.The Simulation Result for Regulation Route

Reg. route \ Verif/Cont	Point state	locking	Detector locking	Signal control	Route locking	Approach locking	Train occupancy track section	Signal state	Approach locking timer	Result
(1A.1)	21:N 22:R 52:R 51:N	21 22 52 51	21BT 22T 1T	21BT 22T 1T	(21BT) (22T)	B834T	B834T 21BT 22T 1T	G R R	90 sec	Success
(4A.B2)	52:R 51:N	52 51	52T 51AT 51AT 1B836T	52T 51AT 51AT 1 B836T	52T 51AT 51AT1	1T	1T 52T 52T.51A T B836T	G R R Y	90 sec	Success
(1A.2)	21:N 22:N 52:N 51:N	21 22 52 51	21BT 22T 2T 2T1	21BT 22T 2T 2T1	(21BT) (22T) 2T1	B834T	B83T 22T.2T 2T	G R R	90 sec	Success
(4B.B2)	52:N 51:N	52 51	52T 51AT 51AT 1 B836T	52T 51AT 51AT 1 B836T	52T 51AT 51AT1	2T	2T 52T 52T.51A T1 B836T	G R R Y	90 sec	Success
(2A.3)	51:N 53:N 23:N 21:N	51 53 23 21	51BT 53T 3T	51BT 53T 3T	(51BT) (53T)	B833 T	B833T 53T.3T 3T	G R R	90 sec	Success
(3A.A2)	23:N 21:N	23 21	23T 21AT 21AT 1 B831T	23T 21AT 21AT 1 B831T	23T 21AT 21AT1	3T	3T 23T 23T.21A T B831T	G R R Y	90 sec	Success
(2A.4)	51:N 53:R 23:R 21:N	51 53 23 21	51BT 53T 4T	51BT 53T 4T	(51BT) (53T)	B833 T	B833T 53T.4T 4T	G R R	90 sec	Success
(3B.A2)	23:R 21:N	23 21	23T 21AT 21AT 1 B831T	23T 21AT 21AT 1 B831	23T 21AT 21AT1	4T	4T 23T 23T.21AT B831T	G R R Y	90 sec	Success

The performance verification results presents that a chain relation between signal equipment is correct over each regulation route. Besides, we have verified that in case error happens to each signal or point, correct route is not transmitted and that in case LCP transmit route-command, IIKBAG[5] embodied exactly by means of auto-generated data. That is, we verified its reliable compatibility.

5. CONCLUSION

A new on-line interlocking handle control algorithm that can be devoted to improvement of reliability of interlocking system and safety as well standardization, expansion ability, and convenience of maintenance has been presented. The new strategy designs so that it constructs a reliable control system, through repetitive process modeling, and by verifying control system requirements by modeling systems in a little time, detect design flaws in a good time and enhance precisions.

The new method designs control algorithm as a module for each unit and interlocking data as file structure that display interlocking conditions with forms such as connection status of a railway line. The algorithm verifies the performance in regard to a representative model station and establishes the validity and efficiency by means of indicating exactly interlocking relations and executing.

REFERENCES

[1] H. Yoshimura, S. Yoshikoshi, "Railway Signal", JASI, Toyko, pp 91 – 21, 1983

[2] E.J. Phillips Jr, "Railroad Operation and Railway Signaling", Simmons- Boardman Publishing, N.Y., 1953.

[3] A.H. Cribbens, "Solid-State Interlocking(SSI) : An Integrated Electronic Signalling System For Mainline Railway", IEE Proc. Vol. 134. pp 148 – 158, MAY, 1987

[4] C.R. Brown, R.D.Hollands, D.Barton, "Continuous automatic train control and safety system using microprocessors", in Proc. Int'l Conf. Electric Railway Systems for a new New Centry, London UK, 1987.

[5] Yun-Seok Ko, Jong-Sun Kim, "Software Development for Auto-Generation of Interlocking Knowledgebase Using Artificial Intelligence Approach", KIEE Trans, Vol. 48A, No 6, pp.800 -806, June 1999.

[6] Ivar Jacobson, "Object-Oriented Software Engineering", Addison Wesley, 1992.

[7] B. Selic, G.Gullekson, and Paul T.Ward, "Real-Time Object-Oriented Modeling", John Wiley & Sons, 1994.

[8] E. Gamma, R. Helm, R. Johnson, and J.Vlissides, Design Patterns : Elements of Reusable Object-Oriencted Software, Reading, MA: Addison-Wesley, 1994