http://dx.doi.org/10.11142/jicems.2013.2.4.473
Journal of International Conference on Electrical Machines and Systems Vol. 2, No. 4, pp. 473~477, 2013

A Study on the Routing of Onboard Oriented Control System by Operation Scenario

Jong-Hyen Baek *, Yong-Gyu Kim *, Yong-Soo Song *, Se-Chan Oh *, and Dong-Ho Shin *

Abstract – The railway developed countries in Europe, Japan such as ERTMS Regional, FFB, COMBAT, it is the stage of development or testing the train control system for the signal system of branch interval of low density. Similar to the signal system used by the mainline and branch sections of low density domestic portions not suitable in terms of maintenance operational efficiency in accordance with the installation and operation in many cases. Therefore these low-density branch railway lines required that oriented train control system of wireless communication to improve the operation efficiency and line side equipment controlled on board the train. In this paper, We was published a route on setting is the operation of the new on-board oriented train control system for controlling a line converter of the train so that it is possible to improve the operational efficiency of the branch of the low density.

Keywords: **Onboard, Operation scenario, route, Control system, Movement authority**

1. Introduction

The railroad has been highlighted as a new transportation means that will lead the logistics revolution in the high-speed age. In addition, the Korean railroad system has jumped to the high-speed era from the traditional one with focus on logistics. The current railroad system that connects the whole country in 2 hours is leading a new transportation culture. Accordingly, the operational efficiency and safety of the railroad signaling system have been actively investigated. The Korean railroad signaling system has employed the traditional trackside signal phase and ATS (automatic train stop). Recently, major lines (Gyeong-bu Line and Ho-nam Line) have been improved to employ ATP (automatic train protection) system. In this situation, there are a number of ground structures as shown in Fig. 1, leading to considerable burdens in light of maintenance persons and costs. ATP system may be suitable for the Gyeong-bu Line and other major lines with busy operation. However, employment of the same expensive control system as used in major lines in minor lines where daily operation is not frequent may not be appropriate in the light of operational efficiency. European ERTMS Regional and the German FFB Project developed the onboard-oriented railroad control system for routes with low traffic volumes and are now performing field tests for the purpose of practical application. Accordingly, in order to improve operational efficiency of branch lines that are operating at a loss in Korea, the onboard-oriented railroad control system based on a new concept, as shown in Fig. 2, is needed. In this study, the establishment of routes based on operation scenarios during development of railroad control System was investigated [1]-[6].

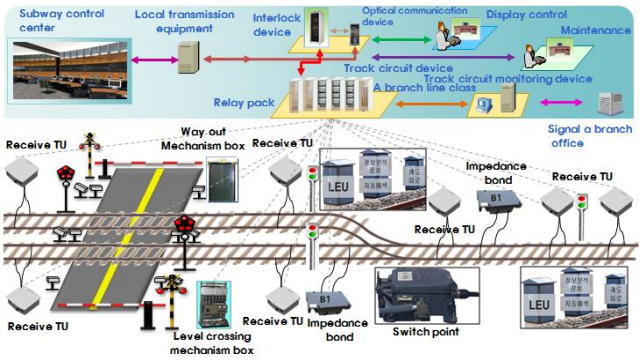

Fig. 1. Train control system of the existing branch line

2. Operation Scenario of On-board Oriented Control system

The onboard control system is based on wireless communication technology. The onboard control systems equipped on trains control the trackside signaling systems

* Korea Railroad Institute, Korea. (jhbaek@krri.re.kr, ygkim1@krri.re.kr, adair@krri.re.kr, soh@krri.re.kr, dongho15@krri.re.kr).
Received 20 October 2013; Accepted 19 November 2013

and use the transponder tags and tachometers installed on the ground to detect locations and speeds of trains and to operate the whole system. As shown in the following figure, the operation scenarios of onboard control system are based on 3 basic steps of "Before Entering ICT Zone", "Running in ICT Zone" and "After Entering ICT Zone" and consist of normal operation scenario and abnormal operation scenario. Figs. 3 and 4 show diagram and flowchart of operation scenario [7]-[9].

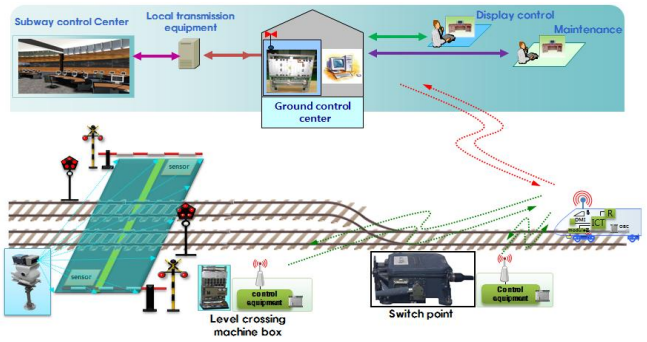

Fig. 2. On-board oriented train control system

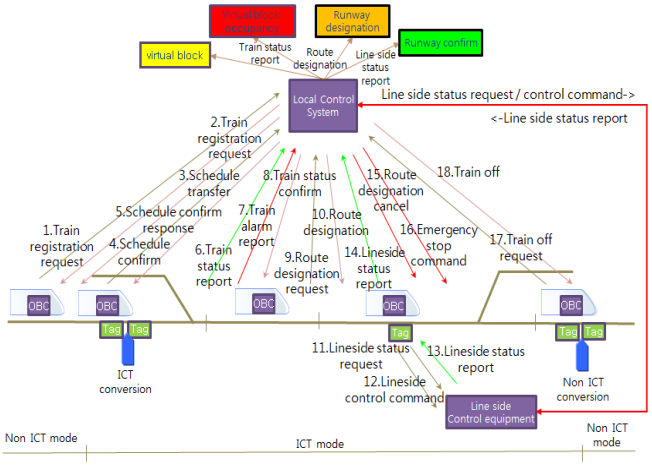

Fig. 3. Diagram of operation scenario

3. Logic for Decision of Movement Authority Based on Virtual Block

Figs. 5, 6 and 7 show the logic to decide the movement authority of trains running in the ICT zone. The train onboard control system asks the ground operation management system to determine the next running route as scheduled and the ground operation management system verifies if the requested rout opens and then, approve the route.

3.1 Setting of Route for Request of Route Designation Approval

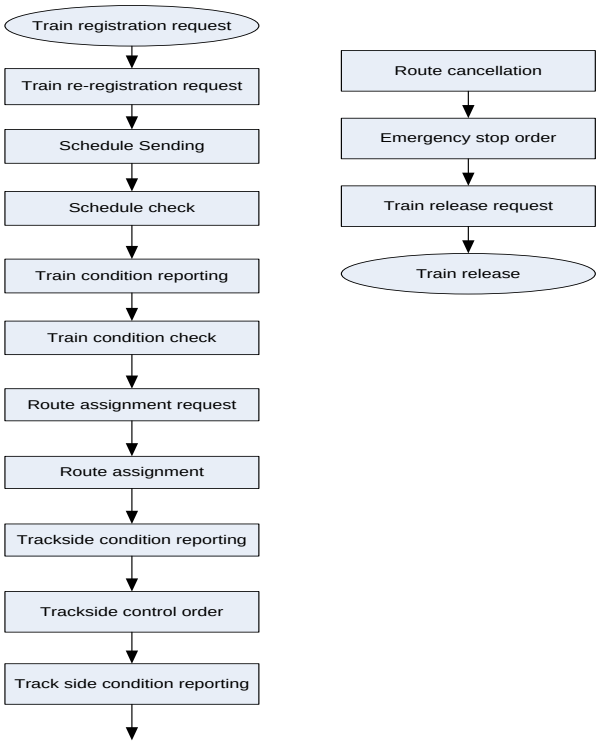

Fig. 4. Flowchart of operation scenario

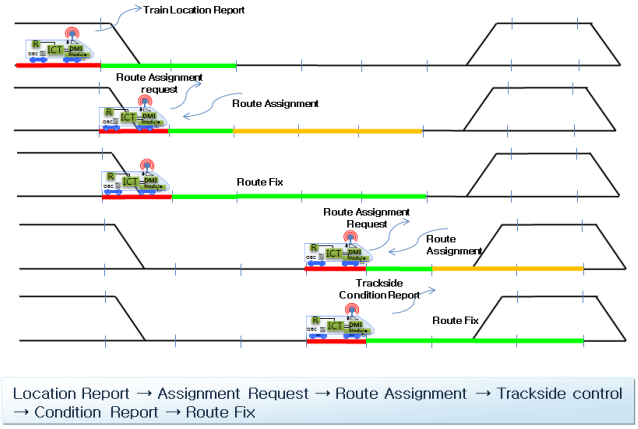

Fig. 5. Route assignment and request of operation scenario

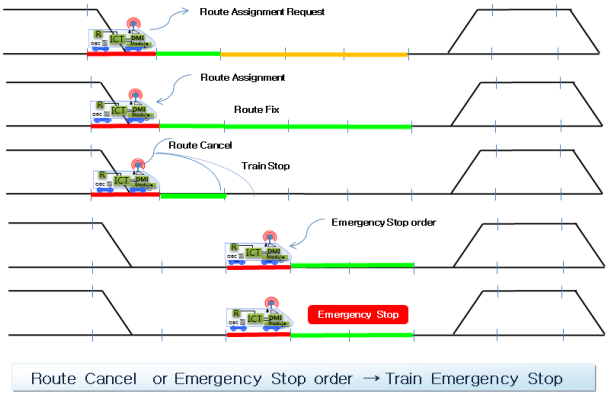

Fig. 6. Route cancel or Emergency stop of operation scenario

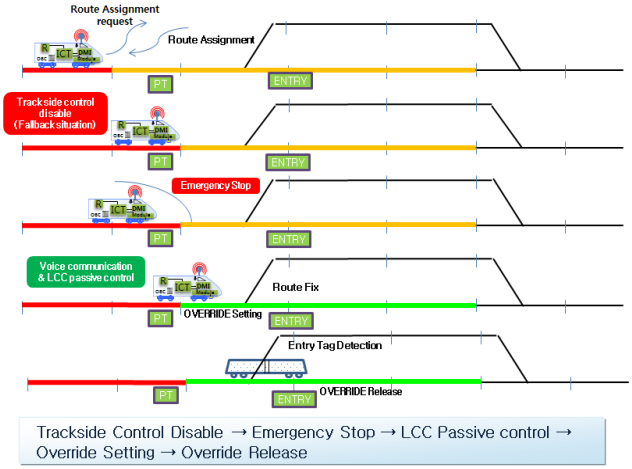

Fig. 7. Trackside control disable of operation scenario

If any route is not found even when the destination is not reached, the fact has to be notified to the engineer and operation management computer and the service brake or emergency brake has to be activated. To assure safe running on the searched route, the train onboard control system has to send the message requesting the approval of the relevant routes together with train data, to the operation management computer. The train onboard system has to observe the previously approved route until approval of the new route is received. The static speed profile relating to the previously approved route has to be fully followed. The train onboard control system has to verify if the received route is consistent with the requested on. If not consistent, the train onboard control system has to request the route again. If the request route is not decided even when requesting is made again, the train onboard control system has to activate the service brake or emergency brake and report it to the engineer and operation management computer. If approval of route is confirmed, the train onboard control system has to accept such approval of route.

3.2 Manual Route Approval by Operation

The train onboard control system has to ask the ground control system to approve a new route before the previously approved route comes to the end. If the train onboard control system receives the message rejecting the requested route, the train onboard control system has to follow the previously approved route and notify such rejection to the engineer to make the engineer report it to the administrator responsible for operation management computer. If the message approving manual route (such as information on bypass routes) is given from operation management computer, the train onboard control system's database has to be searched to find appropriate one. If manual route approval can apply, the train onboard control system has to apply manual route approval. If not, the train onboard control system has to show the relevant message to the engineer and follow the previously approved route.

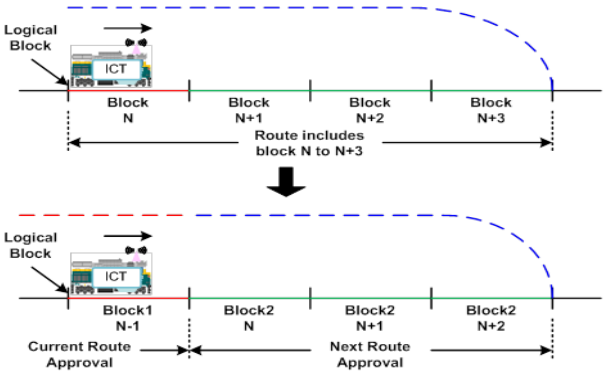

Fig. 8. Concept of route assignment approval

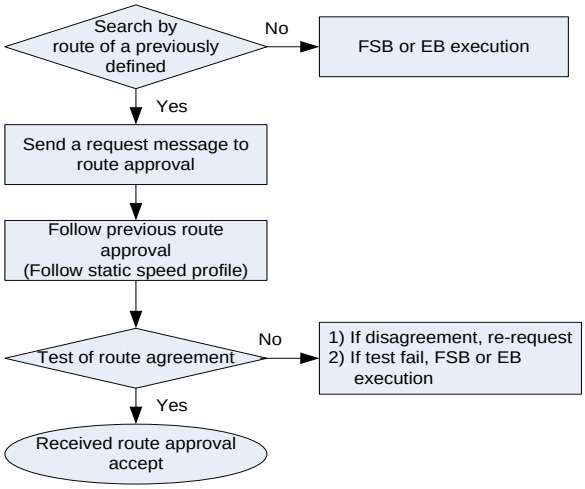

Fig. 9. Flow chart of route assignment approval

Fig. 10. Concept of manual route approval

4. Movement Authority Control Module

In the train control system, decision logic on movement authority(MA) for operating train implements functions such as the process where designation of driving route is requested from onboard control system to wayside operation management system on a radio basis, the process where the requested operation management system designates a driving route, and the manual designation of

driving route in case where an emergency situation is occurred due to the operational problem, etc. The control flow of decision logic on movement authority(MA) by virtual block to be implemented in this train control system is shown as follows.

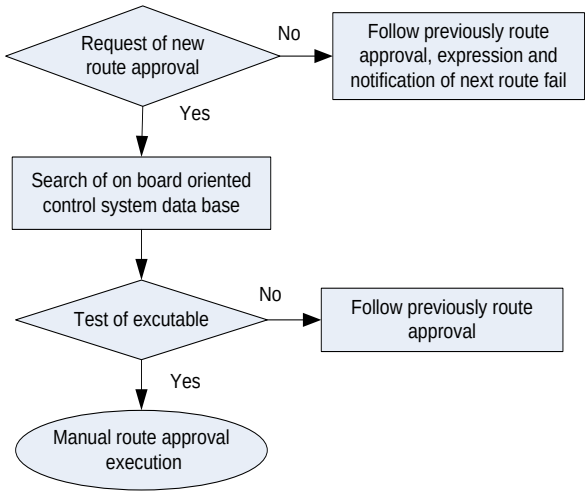

Fig. 11. Flow chart of manual route approval

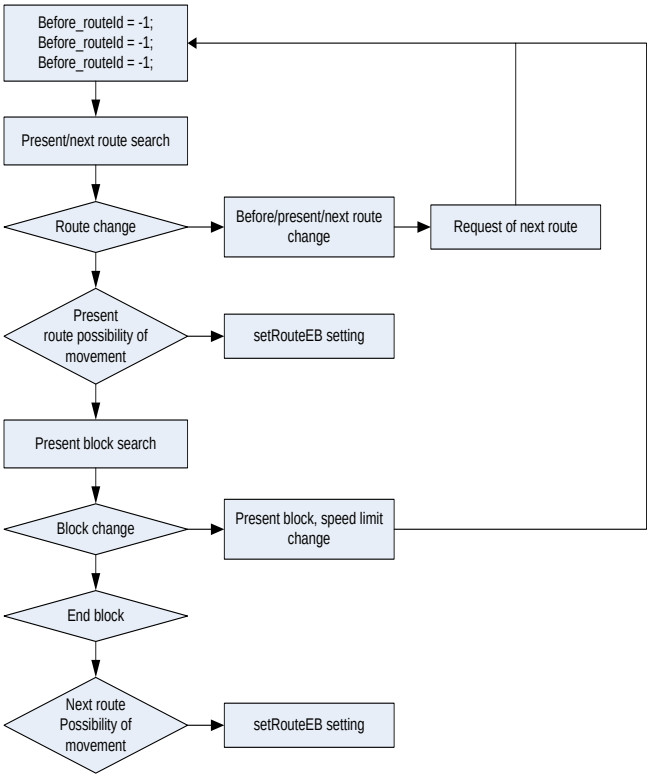

Fig. 12. Flow chart of MA control module

In the train control system, the block diagram, data flow chart among processors and event processing diagram for modules which implement designation of driving route in the onboard control system for implementing its decision logic on movement authority (MA) for operating train, and which implement approval on driving route, etc. in the operation management system can be seen through following figures.

- On the basis of the present location of train, current driving route is determined by searching routes received at the operation management computer.
- Process the request for following driving route concerning the determined driving route.
- Calculate and determine the target distance to be driven by the train.

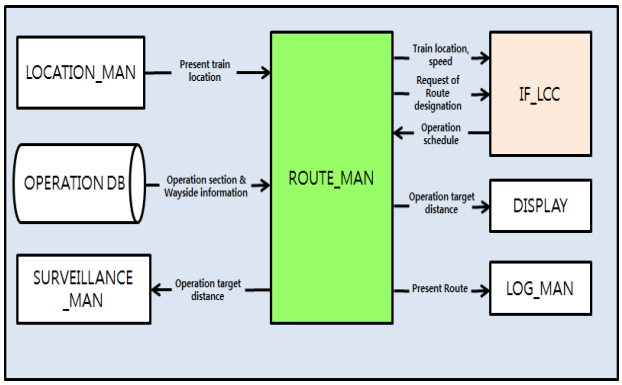

Fig. 13. Data flow chart of MA control module and processer

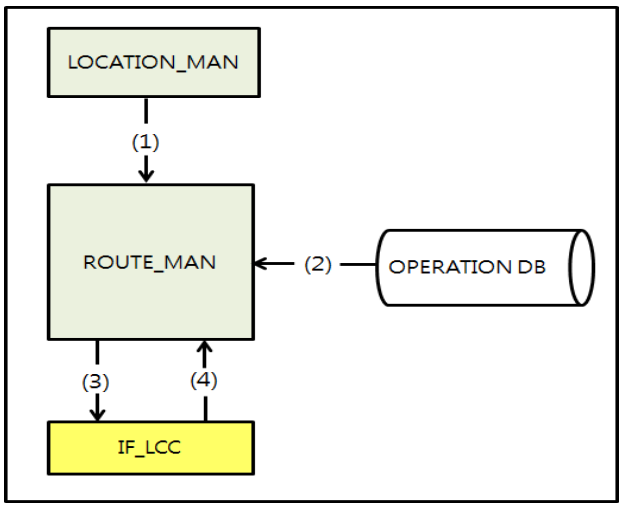

Fig. 14. Event processing diagram of MA control module

- M_<LOCATION_MAN>_<ROUTE_MAN>_BLOCKID : It delivers the block where a train is located currently
- Inspect whether the received block is the section requested by operational DB for designation of driving route.
- M_<ROUTE_MAN>_<IF_LCC>_ROUTEREQ: Transmit the request for designation of next driving route to the local control console (LCC).

- M_<IF_LCC>_<ROUTE_MAN>_ROUTE: Save the approved driving route and determine the target distance accordingly.

5. Conclusion

This study suggests the setting of routes by train onboard control system that can directly control the trackside systems on the basis of the advanced information and communication technology. Such route setting is an important part of operation scenarios of the train onboard control system. For normal operation scenario and emergency operation scenario, it is required throughout the whole process from startup of train control system, through train registration, running, route assignment, to train release. Based on scenarios about such setting of routes, functional tests will be performed with use of simulator and test bed. In addition, it is planned to produce the trial product of the train onboard control system and conduct the vehicle test. If the vehicle test is successful, the trackside control systems can be minimized, leading to reduction of maintenance and operation costs and dramatic improvement of operational efficiency. In addition, this kind of study is actively done in the advanced countries. When considering the advanced information and communication technology, the technology competitiveness can be realized through this study. Especially, the research on improvement of operational efficiency via integration of train control and ICT fields will be more meaningful and contribute to realization of higher productivity.

References

[1] G. Ministry of Land, "A research report on development of automatic operation & control system for the large train station with high-density operation," *Transport and Maritime Affairs, Korea Institute of Construction & Transportation Technology Evaluation and Planning*, final report of the 5th year, 2008.

[2] Jong-Hyen Baek, and Chang-Goo Lee, "A study on the technology of train separation control using balises to enhance the speed of exiting line", *Journal of the Korea Academia-Industrial cooperation Society*, vol. 10, no. 2, pp. 256-263, 2009.

[3] Jong-Hyen Baek, and Chang-Goo Lee, "A study on the technology of train separation control using balises to enhance the speed of exiting line," *Journal of the Korea Academia-Industrial cooperation society*, vol. 10, no.2, pp.256-263, 2009.

[4] Korea Railroad Research Institute, "Development of technology to enhance ICT based safety of train operation and operational efficiency," final report of the 1st year, 2011.

[5] Young-Hoon Kim, and Won-suk Choi, "Analysis of operational issues for ICT-based on-board train control system", *Journal of The Korean Society For Railway*, vol. 14, no. 6, pp. 575-583, 2011.

[6] Radio-based Train Control Research Team, "The on-board oriented train control system" output document, 2012.

[7] Hyun-Jung Jo, Jong-Hyen Baek, Gon-Yop Kim, Kang-Mi Lee, and Yong-Kyu Kim, "A study on the on-board centered train control system to enhance efficiency of low-density railway line", *Journal of the Korea Academia-Insdustrial cooperation society*, vol. 13, no.11, pp. 5434-5441, 2012

[8] Korea Railroad Research Institute, "Development of Technology to enhance ICT based Safety of Train Operation and Operational Efficiency," final report of the 2nd year, 2012.

[9] Jong-Gyu Hwang, Hyun-Jung Jo, and Rak-Gyo Jeong, "Analysis on Software Static Testing Results of Railway Signaling System", *Journal of The Korean Institute of Electrical Engineers*, vol. 62, no.1, pp. 30-35, 2013

Jong-Hyen Baek received Ph.D degree in mechatronics engineering from Chonbuk university. His research interests are intelligent systems and system engineering systems.

Yong-Gyu Kim received Ph.D degree in control engineering from institute national poly technique de Lorraine, France. His research interests are Auto control systems and intelligent systems

Yong-Soo Song received M.S degree in control and measurement engineering from Yonsei university. His research interests are intelligent systems and bioengineering.

Se-Chan Oh received M.S degree in information and communication engineering from GIST. His research interests are intelligent systems and communication networks.

Dong-Ho Shin received B.S degree in electronic engineering from Dankook university. His research interests are train control systems and radio communications.