Design of High-Level Data Structure Model for Adopting DDS Communication into Real-time Railway Safety Monitoring and Control System

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Abstract— Real-time integrated railway safety monitoring & control system is for real-time surveillance & decision making to reduce railway accidents and maintenance costs. For this system, the unified data format for data exchange and efficient network traffic management mechanism is required. In this paper, we introduce the design of high-level data structure model that is consists of Train Signal, Train Car, Power Facility, and Machine/Communication for real-time railway safety monitoring and control system using DDS-based network communication.

Keywords—railway safety; real-time monitoring and control; data distribution service; DDS; data structure

I. INTRODUCTION

Real-time integrated railway safety monitoring & control system is for reducing railway accidents and maintenance costs by providing information about real-time railway facility status, real-time risk assessment, and big data based accident prediction [1-3]. This system consists of real-time railway safety monitoring and control platform, safety detection interface data acquisition device and heterogeneous and complex railway field devices and facilities. The platform is for railway safety management by supporting safety monitoring and control, accident prediction and safety decision making. Essential functions of this platform are provided by processing data from existing railway field devices and facilities. The interface device is located near railway field to relay data from field to platform. There are many kinds of railway field devices and facilities that related with railway safety such as train signal, train car, power and communication facilities and so on.

For transmitting existing data to the platform in a uniform way from different kind of devices, interface device should transform existing data formats to the other particular format. More than this, efficient network traffic management mechanism is required for efficient data acquisition. We select Data Distribution Service (DDS) [4] middleware for the management of data transfer between platform and interface device. DDS is a data-centric publish/subscribe communication middleware for distributed real-time systems. DDS provides the powerful set of QoS-based network control policies such as reliability, transport priority, durability, deadline, destination order, ownership and so on [5]. Acquired data from the field should be transformed into DDS format in the interface device and this transformed data is transferred to the platform for railway safety monitoring & control. Proposed data structure is described in fig 1.

Fig. 1. Overall architecture of real-time integrated railway safety monitoring & control system

In this paper, we introduce the design of high-level data structure model for real-time railway safety monitoring and control system using DDS-based network communication.

II. DESIGN OF HIGH-LEVEL DATA STRUCTURE MODEL

A. Korean Railroad Route Tree for Safety Management

Currently, Korean railroad is managed per railroad route. Fig 2. presents Korean railroad route in the form of the tree diagram. There are three high-level railways such as conventional railway, high-speed railway and urban railway. Each railway contains actual railway such as Gyeongbu high-speed railway and Honam high-speed railway. Each low-level route line and major stations contain core field devices and facilities. Under low-level of railway tree, high-level data
structure models could be attached. Each route line contains its own data sets from data structure depend on its field devices and facilities.

Fig. 2. Korean Railroad Route Tree and High-level Data Structure Model

B. High-level Data Structure Model for Railway Safety Monitoring and Control

There are many kinds of railway safety-related field devices and facilities. Moreover, there is no standard for classifying those devices. However for all that, existing railway management system partially and limited supports for integration data acquisition per purposes such as signal control, train control, power facility management, and other machine/communication management. For interoperable data transfer between the interface device and the platform, we design a high-level data structure model to match those purposes. Fig 3. describes high-level data structure model of railway safety monitoring and control system that is classified into train signal data, train car data, power facility data and machine communication data. Under this high-level data model, actual standard based or manufacturer based data model is defined.

Fig. 3. High-level data structure model of railway safety monitoring and control system

III. DDS-BASED DATA TRANSFER STRUCTURE

DDS middleware provides publish/subscribe network communication using DDSI protocol. For data exchange through each DDS middleware, the definition of predefined data format is required before development of the DDS-based system. Generally, DDS data format is defined as an interface definition language (IDL) document. The platform and the interface device have its own DDS middleware for network communication management. Both contains predefined DDS IDL data format for data publish/subscribe. There is an example that adopts suggested data structure model into DDS communication as described in Fig 4. It defines KRS-SG-0062 standard compatible data format (low-level data model) to exchange train signal data (high-level data model) in Gyeongui Line (low-level of railway tree) which is one of the conventional railway (high-level of railway tree) in Korea.

Fig. 4. An Example of DDS-based Data Transfer Structure Adopting Suggested Data Structure Model

IV. CONCLUSIONS

We have designed railway safety monitoring and control data structure model and DDS-based data transfer structure through adopting DDS communication into real-time railway safety monitoring and control system. This high-level data structure classifies diverse field devices and facilities into four categories and supports efficient data transfer and management mechanism. Further research would contain the definition of the low-level data structure model for actual field data transfer to the platform for integrated real-time railway safety monitoring and control.

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