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Train to Train Communication using Wireless Network

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Abstract: Today's progressive railroads find themselves compelled to consider a CBTC upgrade because of its promises of increased safety, reliability, availability and associated reduction of maintenance costs; increased system capacity using the same civil infrastructure and its ability to reduce downtime during an upgrade. The urban rail transit systems has rapidly developed around the world, and due to increasing traffic pressure, there is a high demand to improve the efficiency of rail transit system. Communication based train control (CBTC) network is an automated control network for railways that ensures the safe and efficient operation of rail vehicles using data communications.

Keywords: CBTC, Minimum Turn-Back Interval Time, Turn-Back Capacity, ATO.

I. INTRODUCTION

Recently, urban rail transit systems have been rapidly developing around the world. Due to huge urban traffic pressure, improving the efficiency of urban rail transit systems is in high demand. As a key subsystem of urban rail transit systems, communication-based train control (CBTC) is an automated train control system using train–ground communications to ensure the safe and efficient operation of rail vehicles. CBTC can improve the utilization of railway network infrastructure and enhance the level of service offered to customers. [1][2][3][4][5][6]
Building a train control system over wireless networks is a challenging task. Due to unreliable wireless communications and train mobility, the train control performance can be significantly affected by wireless networks. Since CBTC systems are safety. critical, trains usually run according to the front train's state, including velocity and position. When a wireless network brings large communication latency caused by unreliable wireless communications or hand-offs, the current train may not be able to obtain the accurate state information of the front train, which would severely affect train operation efficiency, or even cause train emergency braking.[2][3][4]

II. ASSUMPTIONS AND DEFINITIONS

Communication-Based Train Control (CBTC) System- Whereas a conventional signaling system determines train location using Interlocking Controllers ("Interlocking") that monitor track circuits or axle counters, a CBTC system employs Carborne Controllers (CCs)[5] to determine train location primarily from wayside devices such as transponder tags or inductive loops. The CC typically augments this information by reading finer positioning devices such as tachometers, speed sensors, radar and/or accelerometers, and transmits fine resolution position, speed and direction status information to wayside Movement Authority Controllers (MACs)[6], each of which communicates with CCs and interlocking, to collect the status of all trains and routes in its control area.

III. PROCEDURE

The stock market database is provided by the client. This database includes the contents of every company's profit and loss percentage and the maximum investment ratio that the client wants to invest in. the database provided by the client can contain redundant data. This data could take much time to compute and so can reduce the efficiency of the system. So this database provided by the client is put through a process of data cleansing. This data cleansing consists of de-normalization of the database. After redundant data is removed, the dataset is used. The dataset consisting of company's maximum investment ratio and quarter wise profit and loss % is then put through a process of discretization, where the data is converted into a binary form (also called as binarization) for an efficient process. The discretized data is then provided as a dataset. The decision tree algorithm is applied where the number of investment ratios and the investment ratios are taken as input. Along with weight and coverage problem this dataset is split into patterns by cut points. [4] The cut points separate the dataset on the basis of the constraints.

The K-nN algorithm is used to group the nearest value data in this case the dataset with nearest possible profit % and investment ratio. [5] Now from the pattern developed, the classified data is provided to the client.

IV. FUNCTIONAL ARCHITECTURE

For the purposes of this paper, a CBTC system is assumed to provide the classical Automatic Train Control (ATC) functions of Automatic Train Protection (ATP), Automatic Train Operation (ATO), and Automatic Train Supervision (ATS), generally in accordance with the requirements of [1], summarized as follows:

- ATP functions provide for fail-safe protection against collisions, excessive speed, and other hazardous conditions through a combination of train detection, train separation, and route locking;[8]

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- ATO functions typically include automatic speed regulation, automatic programmed station stopping, and automatic door control; and[8]
- ATS functions typically provide all monitoring, control and automation necessary to fully support[9] and coordinate system wide train movements: This includes tracking of trains during normal operations and facilities to support degraded service due to external conditions such as equipment failure or environmental factors; the adjustments can be to the performance of individual trains to maintain schedule, or corrective action to be taken by Control Centre staff.

Based on the principles of CBTC train control, whether the MA is timely transmitted decides the performance of the whole CBTC system. MA is the basis for ATO and ATP decisions, which is generated from ZC according to the state information of the front train. An MA is generally defined as a physical point on the track. [4]

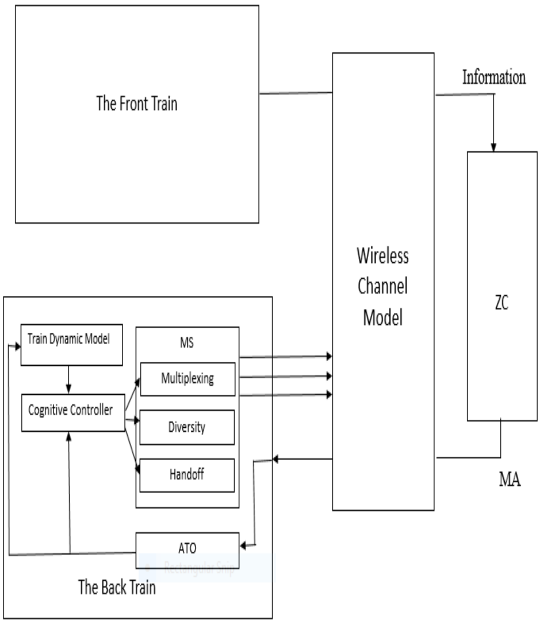


Fig. 1 Architecture

In CBTC systems, the current train needs the information of the front train to control acceleration/deceleration at every communication cycle. If ZC can send the accurate information to the current train, which means the current train can get sufficient information, the current train can make correct decisions. In CBTC systems, ZC transmits an MA to the current train according to the information sent from the front train.[7][8]

As a result, we can see that the information gap in CBTC systems is the difference between the derived state of the front train from the received MA sent by ZC and the actual state of the front train.

V. MODULES

This system is aimed to give a better out look to the user interfaces and to implement concurrent train simulations like:

- **Auxiliary Counter**: Auxiliary counter counts the number of wheels of the train. It is placed a few distances away before the station and after the station, beside the tracks.[5]
- **Track Circuit**: The track circuit is used to change the tracks. This circuit will change the route of the train from one track to another.[6]
- **IB Section**: By using this inter block section, only one train is allowed to pass through the same track in the same direction. IB section covers up to some distance only.[7]
- **Color Light Signaling Panel**: Color light signaling panel are placed in the cabin of the station, it is used to send the signals to the color lights which are present beside the tracks.
- **Panels**: The word "podNoor" which indicates a scientist name who invented it. In this panel there are 53 buttons. This panel is placed in the cabins of the railway stations, the entire display of the railway tracks are present on this panel.
- **24 Conductor slots**: Another important module in this project is the conductor slot. It have 24 points of connection.

VI. MATHEMATICAL MODEL

Train turn-Back Capacity Analysis

Turn-back capacity refers to the maximum trains every hour in the turn-back station [5]. We can calculate the turn-back capacity using the following formula

$$N_{tb} = \left[\frac{3600(s)}{T_{headway}} \right]$$

N_{tb} - number of trains in every hour;

$T_{headway}$ - time interval between the consecutive train;

$[\ ]$ - achieving the nearest integer.

Headway Time Interval Analysis

The headway between the consecutive train is mainly affected by the signal system [6].

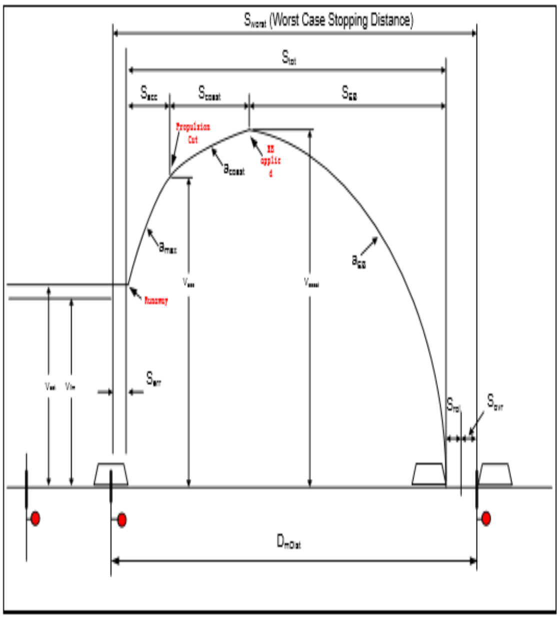
$$T_{headway} = \left[\frac{D_{mDist}}{V_{avg}} \right]$$

D_{mDist} - minimum safety distance between trains;

V_{avg} - average speed running in the safety distance.

Train Turn-back Capacity Algorithm Design

It's necessary to precisely simulate above times when calculating the train turn-back interval through the above analysis [8][9]. At the same time, when calculating the minimum turn-back interval, also need to consider the consecutive train interact each other. For example, the ahead train leaves turn-back station into the turn-back zone, the following train can't enter turn-back station because the condition isn't valid for it to create route. [9]



VII. FLOW-CHART

This flowchart gives an overall working of the system.

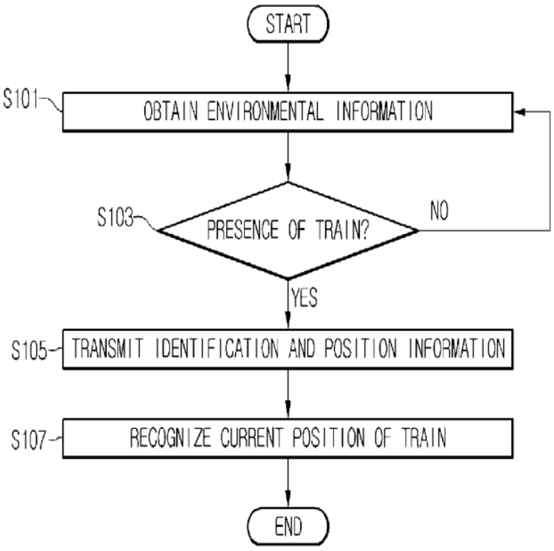


Fig.3 Flow-chart

VIII. CONCLUSION

In this paper, we have presented a cognitive control approach to CBTC systems to improve the train control performance, considering both train–ground communication and train control. In the proposed cognitive control approach, we introduced the information gap, which is defined as the difference between the derived state of the front train and the actual state of the front train in CBTC systems. Linear quadratic cost for the train control performance in CBTC systems was considered in the performance measure. In addition, the information gap was formulated in the cost function of cognitive control to quantitatively describe the effects of train–ground communication on train control performance. Based on the cognitive control formulation, RL was used to get the optimal policy. Moreover, the wireless channel was modeled as finite-state Markov chains with multiple state transition probability matrices, which can bring much more accuracy than the model with only one state transition probability matrix. Simulation results were presented to show that the cognitive control approach can significantly improve the performance of train control compared with other policies.

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