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TRAIN OPERATIONS ON MUMBAI SUBURBAN (CENTRAL RAILWAY) THROUGH PERVASIVE COMPUTING

KAGRA H.[1]* AND EKRAM S.[2]
[1]Indian Railways, Mumbai, MS, India.
[2]CGL Global Research Center, Mumbai, MS, India.
*Corresponding Author: Email- hemantkagra@yahoo.co.in

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Abstract- The Mumbai (CR) Suburban train system, operating approx. 1470 trains & handling approx. 3.5 Lakh passengers daily, is a high density, high turnaround complex network which demands extremely fast & efficient train control system. The manual control is slow, tedious, stressful and doesn't involve holistic operational management. It is inadequate to handle the commuters' ever increasing demand of more trains/timely information. A Pervasive Computing based model of Train Operations Management System designed for Chatrapati Shivaji Terminus-Kalyan section accomplishes train operations control automatically. The train movement data is stored in dedicated servers at the stations, which are connected to a centralized UNIX server through WLAN Cloud, which commands the train movement. This shall increase punctuality & efficiency of train operations, facilitate running more trains and enhance passenger satisfaction.

Keywords- Confusion matrix, Data Mining, Decision tree, Neural Network, stacking ensemble, voted perceptron

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Introduction

On Chatrapati Shivaji Terminus-Kalyan section of Mumbai Suburban (Central Railway), total 1470 commuter trains are run and approx. 3.5 Lakh passengers are handled per day [1]. There are total 25 stations on this 100 Km. long section, as shown in [Fig-1].

Fig. 1- Mumbai suburban (CR) rail network

Such a vast and complex train operation demands extremely fast & efficient train control system. The suburban train operations management [2] mainly constitutes of allotting numbers to the commuter trains, instructing station managers regarding the train movement (precedence/crossing etc.), recording the movement of train on control charts etc. One important aspect of this is train operations in unusual circumstances viz. accidents, equipment failures, adverse law & order situations, natural calamities etc. This also involves generating various statistical data/analytical reports for managerial functions.

Constraints In Conventional Control

In the conventional train control system, all the activities viz. allotting numbers to trains, recording train movements, generating train control charts etc. are accomplished manually and the controller is dependent entirely on the station manager for information regarding the actual train movement. In case of any emergency, the controller gets the information from the driver/guard through the station manager. This system doesn't match the highly intensive traffic requirements of suburban train network and suffers from the following constraints:

- Manual recording of train movement is tedious, stressful and involves lot of time & manpower.
- Controllers don't have visual display of train movements nor

direct communication with the train on-board crew.

- Controllers are not able to cope up with emergencies as they merely record the events through telephonic reporting and do not have adequate data of ground realities.
- The station staff is overburdened with the train operation activities and doesn't have sufficient time to cater to other commercial/developmental functions.
- The manual system is not amenable to the commuters' ever increasing demands of more/faster trains.
- The managerial inputs required for optimal use of infrastructure regularly as well as during unusual occurrences are not available.
- Does not generate Train movement charts automatically.

Train Operations Management System

To address the limitations of the conventional train control system, a Pervasive Computing based automatic Train Operations Management System, encompassing the latest state-of-the-art Information & Communication Technology, has been designed for this section. The system is for the local or remote supervision & control of train traffic. It graphically presents the current status of train movement & of railway equipment viz. signals, points, track circuits etc. Automatic train tracking is also available. All events are collected and used for alarm generation and can be stored for later analysis if required. The remote control system controls the interlocking system and other signaling units through a data transmission system and is used during Centralized Train Control. Besides, the system automatically generates the train control charts and various other MIS reports used for enhancing the operational efficiency.

Pervasive Computing is defined as - all time computing, with or without human interaction, comprising of machines that fit the human environment instead of forcing humans to enter theirs [3]. Pervasive computing is actually 'Anytime–Anywhere-Any device-Any network-Any data' computing. It is also known as Ubiquitous Computing (UBICOMP) and is a model of human-computer interaction in which information processing has been thoroughly integrated into everyday objects and activities. The goal of pervasive computing, which combines network technologies with wireless computing, voice recognition, Internet capability and artificial intelligence, is to create an environment where the devices are embedded in such a way that the connectivity is unobtrusive and always available. In the course of ordinary activities, pervasive computing engages many computational devices and systems simultaneously, and the user may not necessarily even be aware of this. At its core, it consists of small, inexpensive, robust networked processing devices, distributed at all scales throughout everyday life and generally turned to distinctly common-place ends [4]. Thus, it provides convenient access to relevant information and applications through ubiquitous, intelligent appliances that have the ability to easily function when and where needed.

As pervasive computing involves many interconnected servers, it may so happen that some servers are more loaded than others. This shall result into loss of performance and unbalanced utilization of assets. Thus it is imperative that all the servers are charged optimally. Load balancing is the process of improving the performance of a parallel & distributed system through redistribution of load among the processors. A load-balancing algorithm is used for rationalizing the workload of a processor [5].

System philosophy

The train describer software automatically imparts numbers to the trains and facilitates automatic train tracking. The train movement data is stored in the station server, and is fed to the TOMS central server through WLAN Cloud. The central server commands the train movement as well as displays the train movement in the control center. The overall system arrangement is as shown in [Fig-2].

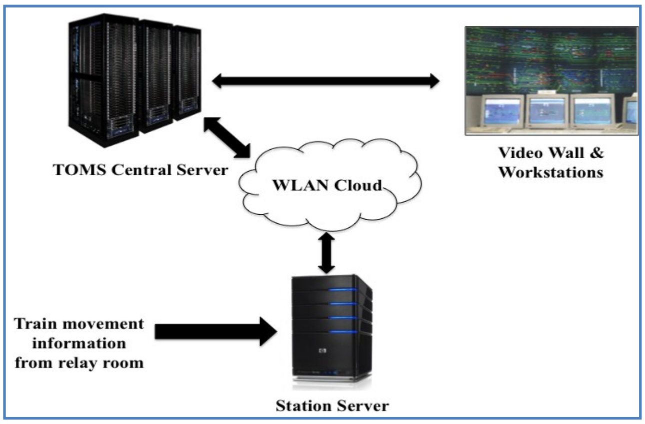

Fig. 2- Schematic arrangement of TOMS

The entire train movement data is stored in the central server and is used to generate train charts/historical replays/managerial reports etc.

Information & Communication Technology

TOMS uses the latest Information & Communication Technology and consists of a central server at Chatrpati Shivaji Terminus station. Dedicated client servers with workstations are installed at every station and connected through WLAN Cloud for transmission of train movement data from stations to the server and vice-versa. The entire system (hardware/software) is modular in nature, which makes it possible for easy successive addition of functionality. The configuration is as under:

Hardware

Application Server- The application server executes and controls all core functions and consists of a dual system (High end HP Itanium series machine) in hot standby (1+1 configuration) mode. The operating System is UNIX with Oracle & NDB databases. The server is extremely fast and at a time approx. 13000 instances are polled with a response time of less than 1 sec. The system uses 1+1 64 kbps channels for polling instances/sending commands. A UPS of 40 KVA (3phase) having 1+1 Standby with battery back up has been provided to ensure continuous power supply to the server.

Workstations- The workstations are commercial grade desktop computers connected through a high speed dual LAN to the switch, which is in-turn, connected to the router of the server. These have been provided to the train controllers at Chatrapati Shivaji Terminus, Station Managers at all the stations and to the maintainers at some maintenance rooms. The train controllers can enter inputs regarding scheduling of trains, entry of unusual events, traffic blocks etc. as per the rights assigned to them. The complete yard layouts of all the stations on the entire Chatrapati Shivaji Terminus - Kalyan section have been stored in all the workstation terminals and the real time train movements can be seen on them. The Station Managers/Maintainers can view the train movements but cannot enter any data.

For viewing the train movement, a video wall comprising of 2 X 8 nos. of 70” diagonal DLP screens with SXGA+ resolution (1400 x 1050), in arc shape, with seamless connectivity between the screens, as shown in [Fig-3], has been provided at the train control center at Chatrapati Shivaji Terminus. The video wall displays real time train movements as well as the status of signaling equipment viz. signals/points/track circuits/level crossings etc. over the entire stretch from Chatrapati Shivaji Terminus to Kalyan stations. The viewing is absolutely in real time, the response time between an event-taking place in field and its display on wall indication panel being less than 2 millisecond.

Fig. 3- Video wall with workstations

The indications being displayed have been mostly taken from the Operating cum Indication Panels and some from the relays in the relay rooms. Field Interface Units have been used at relay rooms to aggregate the real time data of all field equipment like signals, points, track circuits, gate open/closed position etc. and transmit to central server through station servers.

Software

The application software is structured on the client/server paradigm. The application server runs the TOMS application, which maintains the global status of the entire system and provides services to client workstations. The clients & servers are linked by an online Data Manager, which replicates all vital information to all clients and servers in real time, thus enabling fast switchover to standby processes without loss of data.

The storage and retrieval of data is accomplished through an online Network Database (NDB). It contains all valid system data at any given time. Status indications received from the field stations are stored directly in the NDB and from there distributed to application programs subscribing to the data. The Client Management Facility (CMF) monitors clients running on the workstation and ensures their correct functioning. All the work on the client workstation is done through a General Command Handler, which allows the controller to enter commands. All commands pass a validity check in the GCH, which includes: syntax, mode of operation and privilege, authority & blocked objects. The status monitoring and control (including remote reconfiguration) of transmission networks connecting the TMS with external hardware is done by the Network Management Facility (NMF). The authentication and validation of operator actions is done through the Operator Management Facility (OMF). An integrated Graphical User Interface is used for accessing/managing all the system functions integrated in the TMS system. The historical data is stored in a SQL compatible historic database and is used for reporting and statistical functions.

Network

The entire system is built on a WLAN cloud network, which provides communication between Central and station Servers. The WLAN cloud is the commercially available wireless Internet network working on IEEE 802.11 protocol. The high-speed network with a data transfer rate of up to 3.1 MBPS enables fast data transfer. As shown in [Fig-4], the cloud works on open wireless architecture [6] having an open wireless router with common access platform to the backbone PDM networks with WPA2 class Wi-Fi Protected Access for wireless security. The Cloud converges the wire line broadband networks, 3G networks, wireless LAN and broadband wireless access systems into one common infrastructure defined by the OWA frameworks and protocols so that the PDA users can be assured of the integrated broadband services and seamless mobility in a cost-effective way.

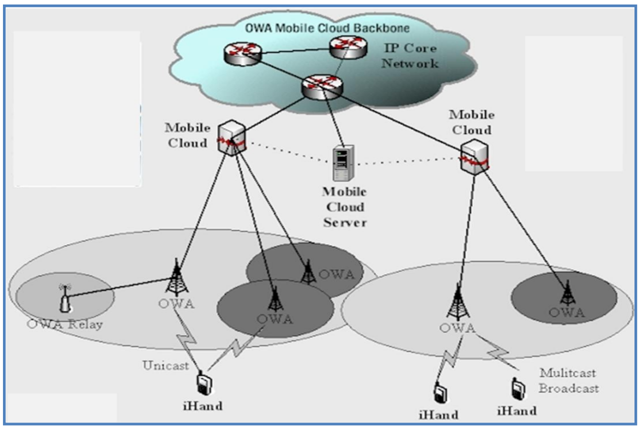

Fig. 4- WLAN Cloud Arrangement

The Station server-Video Wall/Workstations connection network has been built on 24 Fiber OFC cable. Route diversity has been provided for this, so that rupturing of cable at one point does not affect the system working.

System Working

An alphanumeric number is assigned to each train automatically by the train tracking system (it can be assigned either by a train controller or a station manager) as soon as it comes on the platform at Chatrapati Shivaji Terminus/Kalyan stations, which are the southern/northern limits (resp.) of the system’s functional area. On the track diagram, the train number is shown in red color next to the track circuits occupied and in green color next to track circuits where the train is expected to pass. As the train proceeds on its journey, the train-tracking algorithm in the Central Server propagates the train number throughout the train route and automatically erases it, as track circuits become free behind a train. The train tracking system can handle more than one train simultaneously. This movement of train can be viewed on the video wall in the control center, as shown in [Fig-5]. When the train reaches the terminal station, and starts its journey in the reverse direction, a new number is allotted to it and the same process is repeated.

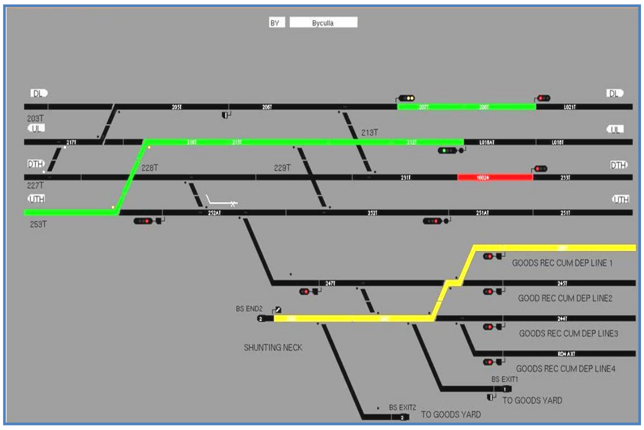

Fig. 5- Train movement as viewed on video wall in control Center

With the Centralized Train Control [7] facility, the signals/points at Dadar and Kurla stations can be operated from the Control office at Chatrapati Shivaji Terminus, as shown in [Fig-6]. This reduces the manpower requirement and aids in faster train operation.

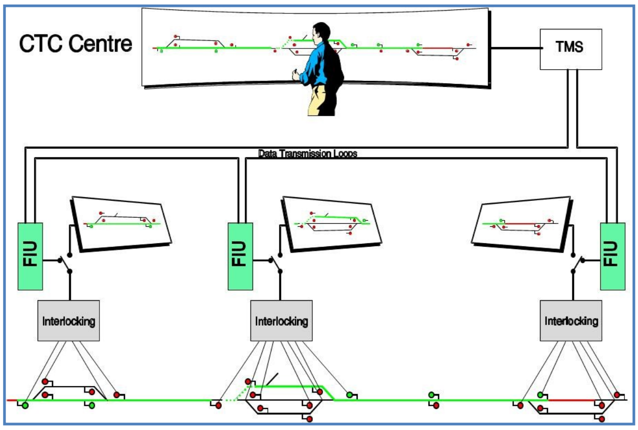

Fig. 6- Scheme of CTC working

The system logs all the station arrival and departure events and compares it with the scheduled timings. From this data, the system generates train charts [8] wherein, the scheduled and the actual movements are plotted on a distance/time graph as shown in [Fig-7].

The controller can assign reasons for the late running trains, and the system shall then generate punctuality reports giving the summary of percentage of trains delayed under each category. The system also logs the status of points, track circuits, signals, routes etc. chronologically which can be replayed for investigation purposes. Besides, the system also generates other MIS reports viz. bad train runner reports, unusual occurrence reports, Rake link reports etc.

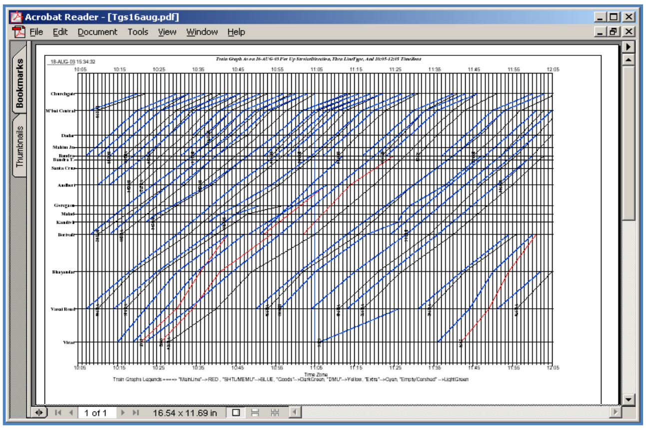

Fig. 7- Train Control Chart

Benefits

- The number of trains has increased from 1000 per day to record 1470 per day. The headway between trains has reduced from 8 minutes to 4 minutes, which is quite an advantage.
- The train operations are faster, efficient and better coordinated. Consequently, the punctuality of trains has increased to 97.64 %, which is an all time high.
- The train movements are managed & recorded automatically, thus saving time & manpower.
- Train Controllers have full view of the train movements and can communicate directly with the driving crew, thus streamlining the operations, especially in unusual circumstances.
- Since most of the train operation activity is automatic, the station staff is free to cater to other commercial/developmental functions.
- The train control chart and other managerial inputs viz. punctuality reports, timetabling information, asset utilization information, traffic & maintenance block planning etc. [9] required for optimal use of infrastructure regularly as well as during unusual occurrences are readily available in user-friendly format.

Conclusion

The Pervasive Computing based TOMS is the most effective application of Information and Communication Technology in train operations & passenger information system. The latest concepts in ICT have been used in this arrangement. Industry standard data & application servers/operator workstations and other hardware components have been used with an extremely user-friendly software. The Man machine interface is menu driven and Fault Tolerant Hardware & Software with Hot standby arrangement ensures almost 100% reliability & fail safety. The TOMS has streamlined the train operations and thus, has been, to a large extent, able to address the ever-increasing demand of more/faster trains. This has enhanced the customer relationship management and has boosted the brand image of Indian Railways.

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