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Centralised Traffic Control Centres (CTC)

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Abstract

This paper describes the computerised CTC's developed by Alcatel for the Portuguese Railways. The system is the last generation of Centralised Traffic Control Centres and is based on the concept of high-availability and safety. These CTC's are currently being installed in a increasing number of locations where they control the signalling of different types of lines: single track (Beira Alta line), double track (North line) and suburban (Sintra line, the line with the most n° of passengers per day in Europe). These CTC control Alcatel electronic interlockings ESTW L90.

1 Introduction

The primary objective for the implementation of the CTC's was to increase the quality of the railway service in terms of punctuality, to achieve smooth train connections, reliable public information and reduce the operational costs.
The basic features of the CTC are:
- Remote control of electronic interlockings
- Automatic collection of train movement information
- Train Describer System
- Automatic Train Routing
- Generate and display the Time-Distance Graphs and area overviews
- Statistical Information
- Passenger Information

2 Technical Implementation

Alcatel basic idea was to make the CTC system as modular as possible, using commercially available hardware and software. More than ten years of experience of computerised Centralised Traffic Control Centres supported Alcatel in the decision to implement these systems in the form of distributed logic, that is, based on Local Area Networks (LAN).

The personal computer is ideally suited for certain areas of work. The performance of the PC has increased considerably in recent years and price/performance ratio is outstanding. In conjunction with high-power VAX and ALPHA computers in LANs, the PC is almost ideal for the task in hand. Besides powerful software, however, there was a need for a tried and tested operating system and network software that had been proven in service all over the world.

3 System Module Concept

3.1 Local Area Network (LAN)

A powerful bus consisting of a coaxial cable Ethernet, carries all information to and from the connected computers at a transmission speed of 10 Mbit/s. The CTC's are structured as two separate Ethernet-base LAN's. In order to ensure decoupling of the software modules, there are two central computers which, in turn, are doubled for reliability reasons. One computer pair handles the communication with the interlockings and the elements display whilst the other pair handles the ESTW commands and the other software modules.

This LAN separation allows the operators in the CTC to make all types of commands, including the emergency commands even if the image module is not intrinsically safe.

3.2 Duplication and Redundancy

It has now become accepted that, in the event of a failure of part of a safety related system, the fall-back working procedures are likely to lead to a degradation of the safety of the overall system. For this reason, the availability of a system is an important factor in determining the overall system safety. As a safety related system one of the requirements for the CTC's is high availability.

In order to meet the availability requirements for the CTC's in any configuration it was necessary to duplicate every subsystem component and both the signalling and information networks. Master and standby units are identical and interchangeable for each function. This duplication produces the usual design problem of keeping the standby units in step with those that are currently operating each function (the master unit). There are three types of standby processes: hot standby, warm standby and cold standby. The philosophy used in the Portuguese CTC's is the warm standby. Warm standby is where most of the initialising of the standby (passive) unit is complete, hence it is able to update itself quickly from its data sources when it becomes active in the event of failure of the other unit. Warm standby concept tries to combine the advantages of the hot standby and cold standby: the switching time must be as short as possible thus it is possible to avoid the software problems due to previous errors, that in case of hot standby can cause problems in both systems (active and passive).

The linking to the interlockings is also duplicated. Two asynchronous 1200 Bd channels are available per interlocking on each of the two redundant transmission systems. On the image channel, information on the condition of track elements (points, signals, track circuits, etc.) are transmitted from the ESTW to the CTC. If both image channels on both transmission paths (optical fibre and copper) are available, the information is transmitted synchronously on both channels. For safety reasons the information in the image channels are inverted in relation to each other. On the other channel (command channel) which is also designed with redundancy, the interlockings receives (operator inputs and train control automatic commands) and sends to the CTC test messages (fault messages and mirroring of auxiliary commands).

4 System Functionality

4.1 Remote Control of Electronic Interlockings

All the interlockings connected to a CTC can be remotely operated from each of the workplaces.

4.1.1 Operating Areas

The complete track section of each line can be served from each operator place. Operating areas can be assigned to the operator places in a flexible way, but for one area only one operator is responsible. At the start of the

shift, the operator logs into the system with his password and has to decide for which area he will be responsible. The smallest area is one interlocking.
The commands are made with mouse over the monitors. With area overview display (Berue) only non-safety-critical operations can be made.

4.1.2 Display
Four image monitors are available at each workplace. There are two types of images: one identical in representation to the images in the operator place of the interlockings (Lupe) and an area overview which is not as detailed as on the Lupe (Berue). The image information on the condition of the track elements are transmitted by the interlocking, processed in two program branches and then transmitted to the monitor server (MOS) for display. The MOS assumes the control of the graphic monitors. This method offers high reliability against transmission errors. In the event of failure of one of the two transmission channels, the information from the interlockings is still available to the operator in the CTC. Safety critical operations can not be done in this situation (fail safe display).

In addition to the graphic monitors the complete overview of the line is constantly displayed in form of an area overview. There are two different possibilities: video projection or LED panel.

4.1.3 Control Monitor
The control monitor is used to display text messages from the interlockings and is used particularly for auxiliary operations and to display fault messages from the interlockings. The keyboard of the control monitor can be used to input commands for the interlockings, particularly in the event of a failure of the mouse operation.

4.2 Train Describer System

The train describer system monitors the train movements in the whole monitoring area using element messages (track circuits, signals, points, etc.) transmitted by the interlocking. The passing of a train number from the start to the destination section is effected either with the automatic signal closing or when the start section is cleared and the destination section becomes occupied. The locations of the trains are displayed on the area overview and on the lupe.

The train number of a new train entering the monitored area or a train starting in the area is entered by the operator and is then passed on as described above. The nominal/actual comparison is also carried out in the train movement tracking module. A planned position for each train is determined by comparing the central schedule data in which the schedule times of the individual trains are stored with the actual pass-on times. This representation takes the form of a two-digit deviation in minutes and a sign for plus and minus position (before schedule or behind schedule). Furthermore, identification of this representation is supported by a different coloured background behind train number and planned position as well as between before schedule, on schedule and behind schedule.

4.3 Train Control and Schedule (Automatic Train Routing (ATR))

Train control is performed using the unambiguous identifying train number and a train control plan stored in the train control computer. The train control plan contains all the relevant data for the control of each train. The train control plan essentially contains the movement diagram and additional parameters necessary for the control of the trains. Each train contained in the train control plan can be controlled fully automatically through interlocking areas covered by the train control computer. The train control covers the whole monitoring area of the CTC. The function of the train control is described briefly in the following sections.

4.3.1 Timing of Train Routesetting

The train route setting is essentially based on the train locations transmitted by the train movement tracking system. The train location together with the information from the train control plan - determines the automatic temporal sequence of the train route settings.

In special cases, the exact time for the train route setting can be determined more precisely with the additional processing of the following information:

- signal-specific by using elements from the signal image such as e.g. track occupancy
- train-specific by adding in an individual delay time

The train-specific delay time generally depends on the train type. The above conditions permit an optimum temporal setting of train routes, thus preventing the blocking of a station gridiron by the routes being set too early as well as preventing the level crossing barriers being closed too early. The timing of the train route setting can, however, also be determined by the train schedule, e.g. by automatic setting of the station exit in the event of a scheduled stop.

4.3.2 Influence of the Traffic Controller in the Train Control

The inclusion of additional trains (e.g. special trains) in the train control plan is possible via a corresponding data handler. If necessary, this allows changes to the train control plan to be carried out e.g. daily.

In addition to these changes which can be recorded in the schedule, the operator is also able to intervene directly in the train control process. The operator can influence directly any signal in his area of responsibility.

He can also influence any train in the train control plan as long as this train is already in the train control monitored area.

Any automatic train control process can be influenced as follows:

By signal-selective barring of the train control system

By train-selective barring of the train control system

4.3.3 Signal-Selective Train Control ON/OFF

As a rule, the train control will be switched on at every signal. Trains for which a train control plan has been drawn up and whose control has not been barred will thus be guided through the entire train control area by automatic setting of the train routes.

By barring a signal for the train control, i.e. train control status "OFF" at a signal, all trains will not be automatically controlled at this signal. A train route whose start signal is in train control status "OFF" will not be driven by the train control system. All other train routes are not affected by this and can be automatically set by the train control system. The train control status of a signal is indicated accordingly on the lupe and on the area overview.

4.3.4 Train-Selective Train Control ON/OFF

Each train included in the train control plan is assigned the "train control status ON" by the train control computer. In order to give the operator the opportunity of guiding a particular train "by hand" through the train control area in exceptional cases, each train can be assigned the train control status "OFF". Only trains whose train control status is "ON" are automatically controlled by the train control system.

In addition to the possibility of switching the train control status ON or OFF by hand, the train control status of a given train can be scheduled to be switched to OFF. This automatic barring of the train control for a

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given train can be employed, e.g. in cases where the intervention of the operator is desired.

The train control status of a train is identified by the colour of the train number on the monitor.

4.3.5 Barring Check

The barring check, i.e. the check of the chances of success before the setting of a train route, is performed on the basis of the track occupancy by the trains and the interlocking information of the signal image. All set train routes, including intersecting routes, form the basis for the barring check. In addition, further interlocking information can be included in the barring check, e.g. fixed points in trapping position, track occupancies in the stations, etc. This additional message information is taken into consideration only in exceptional cases.

Before a train route is automatically set, the train control computer checks the available interlocking information for a possible success of the entry into the train route.

In the event of a negative result of the advance barring check, the operator's attention will be drawn to a possible conflict situation. This will be carried out at a time when the operator can still intervene in the train traffic to avoid such a conflict.

4.3.6 Setting Order and Setting Control

If the barring check provides a positive result, the train control system transmits a train route setting order to the interlocking.

A defined time after the setting order has been given, the requested train route setting is checked. If the setting check produces a negative result, a second setting attempt will be triggered. If the second setting attempt is also unsuccessful, the train route processing will be aborted with a system message.

4.3.7 Operation and Display

The signal-selective activation/de-activation of the train control system is an ESTW operation and is performed via the graphic monitor. The train-selective activation/de-activation of the train control system is performed via a dialogue on the work monitor.

4.4 Time-Distance Graphs / Train Monitoring

In addition to the display of the train numbers and the planned location on the area overview monitors, a graphic representation of the train movements in the form of time-distance graphs is provided on a separate monitor display for comprehensive monitoring.
The time-distance graph image represents the current detail from the image schedule for the actual traffic day in question, whereby the actual train movement is automatically added. In order to further facilitate the planning work, planning time-distance graphs can also be displayed.

4.4.1 Storing and Automation

The CTC supplies all train operation data in a processed form for traffic management, i.e. conflict-oriented and on time. The system thus supports the finding and implementation of the conflict solutions. Train operation data and conflict decisions are stored in the system and will be available later on for several statistical evaluations.

4.4.2 Conflict Detection

The automatic conflict detection and automatic conflict solution for line conflits (e.g. train sequence, opposing trains, route lockings, etc.) are displayed in the time-distance graph. They can be handled in a dialogue on the basis of the solution alternatives offered by the system. For example an extraordinary stop for overtaking.

4.4.3 Map Display

The route survey provides a graphical representation of the route network in the form of several maps. In addition to statical data such as stations, lines, background, etc. a number of dynamic process data can be displayed in these maps.

This includes e.g.:

- trains with
  train current position and their relativ positions
  their journeys, connection relations and connection journeys
- additional delays sudivided according to locations and codings
- routes locking
- route loads
- route delays
- route conflicts

For supporting traffic management a window displays additional information which before has been input on the management area concerned by the scheduling service, e.g. civil works, speed restrictions, extraordinary stops, etc. Here also ad-hoc permissions for extraordinary stops can be issued which will be automatically taken into account in the train operation forecast.

4.5 Statistical Information

The evaluation system of the CTC supports a variety of statistics and analyses for delayed trains and the performance of stations and lines. The delay explanations available from the traffic management system allow analytic assessment and assignment of delay causes.
The evaluations are supported by:
- interactive and automatic generation of evaluations
- result representation in graphs and figures
- flexible evaluation criteria

Fast access to analyses over longer periods is ensured: existing data is stored in the system for one year and specific data in a compressed form over three years. The train operation data is backed up on tape and will be available for comparing evaluations with past periods even after many years.

4.6 Public Information System

The Public Information System is intended to give general information to the passengers, such as train arrivals and departures times as well as other important messages to the passengers.

The CTC as a link to the Public Information System to provide to this vital information, such as train number, train location and timetable deviation.

5 Conclusion

CTC is an indispensable element in the command, supervision and control of high-performance tracks.
Computer integration of main operations and the application of modern traffic control technology form the basis for optimal intelligent utilization of rail resources.

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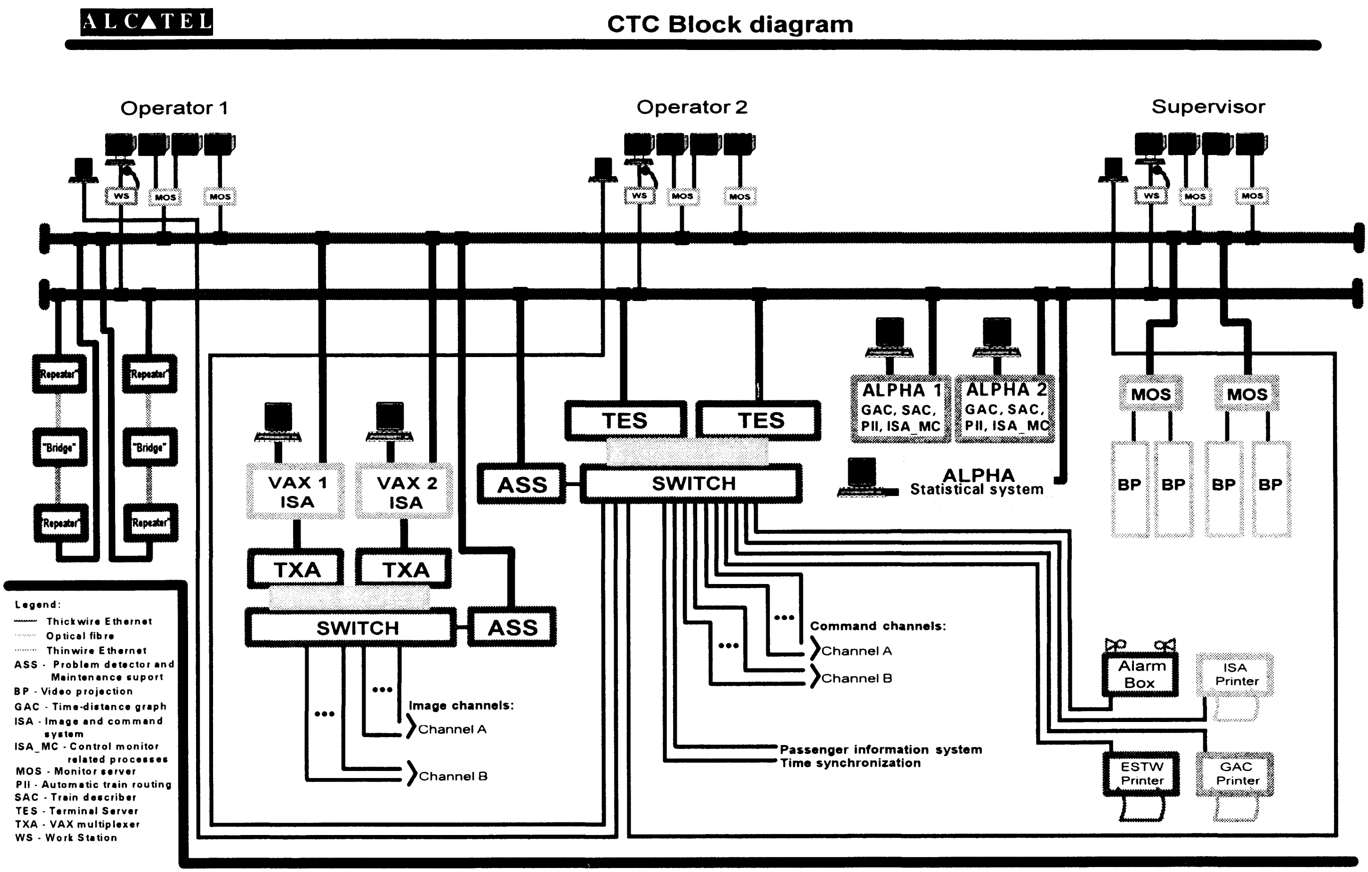

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