Transactions on the Built Environment vol 7, © 1994 WIT Press, www.witpress.com, ISSN 1743-3509

VPT, a new systems architecture for planning and control of train traffic in The Netherlands

M. den Brok & R. Vissers
Ingenieursbureau Nederlandse Spoorwegen, Utrecht, The Netherlands

Abstract

In order to fulfil the expected increase in train traffic demand, Nederlandse Spoorwegen is making considerable investments in both expansion of infra-structure and in development of computer systems for better command of the production process. These systems encompass all processes involved with train traffic, and cover all phases, from planning to supervision. To enable a controlled and timely introduction of all systems involved, an overall architecture was developed. This paper describes the systems architecture and its parts.

1 Introduction

1.1 What is VPT, and why is it necessary?

Major investments are being made in Dutch rail infrastructure: tracks are doubled, junctions are redesigned to handle more traffic, bottlenecks are resolved, and from 1996 on Nederlandse Spoorwegen (NS) will introduce a three-traintype system. Vervoer Per Trein (VPT, 'Transport By Train') is the information and communication systems architecture that will enable NS to handle more traffic on more infrastructure in a fast, flexible, and customer-friendly way.

VPT encompasses the information system for the benefit of the primary production process of NS. Three clusters or subsystems are distinguished:

- planning of the overall timetable and availability of personnel and rolling stock,
- traffic control, concerned with the daily scheduling of train traffic,
- process supervision, concerned with the processes of train dispatching, shunting, traveller information, personnel, and rolling stock.

The three subsystems, in their functional hierarchy, are outlined in figure 1.

1.2 Goals of VPT

The overall goal of VPT is a better command of the production process, and thereby

a better product:
- more extensive analysis in the planning stage;
- better means for prioritizing of interests (passengers - freight, other priority rules);
- less (secondary) delays and fewer connections missed, better information service to passengers in case of irregularities;
- enabling short-notice responses to variations in demand;
- more efficient deployment of personnel and rolling stock;
- lower costs for traffic control and process supervision.

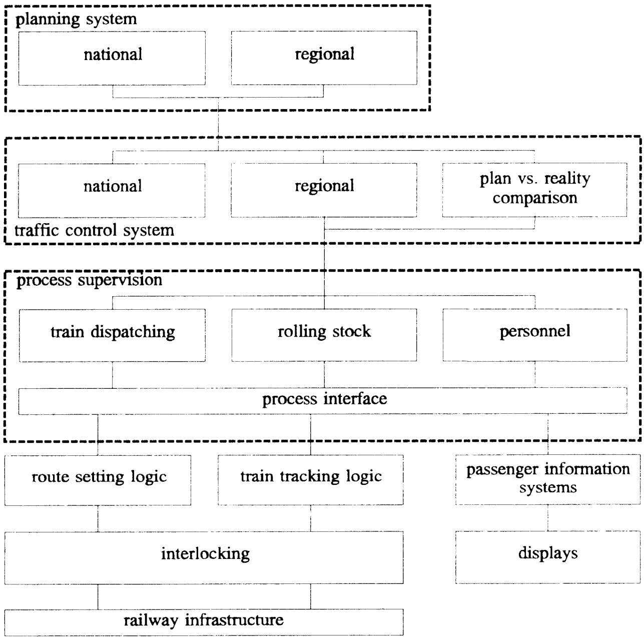

Figure 1 VPT and its three subsystems.

2 The three subsystems of VPT

A functional description of the three subsystems will be given, and technical implementation issues for traffic control and process supervision are addressed.

2.1 Planning

Planning is concerned with the overall timetable and availability of personnel and rolling stock, and is carried out in five phases:

1. a basic hourly pattern per major route;
2. detailing to an overall daily pattern ('Basic Hourly Pattern', year N+2);
3. production of the complete timetable including assignment of rolling stock and personnel ('Yearplan', year N+1);
4. modifications for days, weeks or months ahead in the current timetable (in the

Transactions on the Built Environment vol 7, © 1994 WIT Press, www.witpress.com, ISSN 1743-3509

now current 'Yearplan', year N);
5 daily modifications during actual production of traffic ('Daily Plan').

Two planning systems are in use already. The first one supports phases 1 and 2: the planner enters trainseries with their parameters and gets feedback by means of diagrams on a graphic display.

The second planning system consists of three subsystems, for respectively timetable, rolling stock, and personnel yearplans (phases 3 and 4). The timetable subsystem functions in basically the same way as the first planning system, except in much more detail; additional functionality is offered for decision support. The rolling stock subsystem offers support for assigning rolling stock to trains, for determining the circulation and maintenance of rolling stock, and carries out consistency checks. The personnel subsystem functions analogously. The last two subsystems are still under development, as far as graphical display and decision support is concerned.

2.2 Traffic control

Traffic control is concerned with the daily control of train transport within a certain area. The system supports this by presenting the planned production of rail traffic, the current situation, and bottlenecks to be resolved. Graphic displays show the timetable in diagrams and tables. Current train positions are visualized, and delays are automatically calculated and displayed. In a separate window textual messages are shown, to be acknowledged by the traffic controller.

Users of TTCS. The main interfaces of the Train Traffic Control System (TTCS) are to the traffic controller, the process supervisor, the train tracking logic, and to neighbouring TTCSs. The traffic controller uses different applications for Presentation & Mutation Timetable (PMT), Presentation Train Tracking (PTT), and Presentation & Management of Messages (PMM).

PMT presents information about today's timetable (adding information about rolling stock and personnel is currently under development). On a graphical display a diagram is shown, with time on the vertical axis and the route section with stations and junctions on the horizontal axis. The traffic controller can switch between route sections, check timetables of individual trains in detail, and modify the timetable. Modifications are transmitted automatically to all traffic controllers and process supervisors involved.

PTT allows the traffic controller to select a choice of route sections. Within every selected route section the positions of trains are shown, with trainnumber and delays (if any). Information on the display is updated every minute.

On a separate display PMM shows all messages relevant to the traffic controller. For each type of message a threshold can be defined (for example, presentation of delay messages only for delays of more than five minutes). All messages presented must be acknowledged by the traffic controller.

Train tracking logic provides information about the actual train positions to the TTCS. Based on this and the timetable any delays are calculated automatically. The process supervisor enters special conditions and the trainnumber (usually at the departure site only). An overview of the actual situation is presented to the process supervisor.

TTCS technical design. In figure 2 an outline of the design of the TTCS is given.

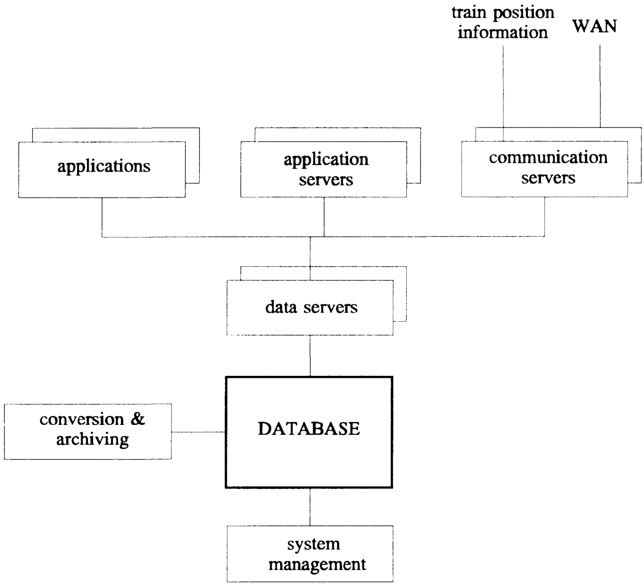

Figure 2 Train Traffic Control System technical design.

Applications are those functions having a user-interface to the traffic controller or process supervisor; the three most important ones were outlined above.
Application-servers function as a 'front-end' to the corresponding applications. For example, the PMT application-server maintains a copy of all data being used by the active PMT applications. The copy of the PMT data is synchronized with the database. Furthermore the application-servers monitor the applications for functioning properly.
Communication servers take care of the interfacing to other TTCS sites and to the train tracking logic. The process plan is sent from the central site to its neighbours; from there on it is sent to other sites in cascade, assuring that the plan is sent only once across a certain connection, thereby reducing the network load. Modifications in the plan by a traffic controller are sent to all relevant sites, to be stored in the database.

The data servers synchronize database accesses. Each data server handles its own set of database tables. The database stores four kinds of information:
- General reference data (for all sites, e.g. train attributes (type, number-series, special trainloads), network topology).
- Reference data for a particular site, e.g. thresholds for messages, presentation parameters for that site's route sections.
- The process plan, containing the timetable and information about rolling stock and personnel. There is one process plan per day, and 19 consecutive plans are available, starting with yesterday's plan.
- Messages concerning train delays and modifications of the plan. Messages are kept on-line for 24 hours, older messages are archived every hour.

National TTCS network. All TTCS sites are connected in a nationwide Wide Area Network (WAN). Figure 3 presents an overview of the network. For each area (indicated by a level 2 router) one TTCS is connected to the central, coordinating TTCS ('Utrecht HVL'). On failure of this connection the area can still be reached via one or two other areas.

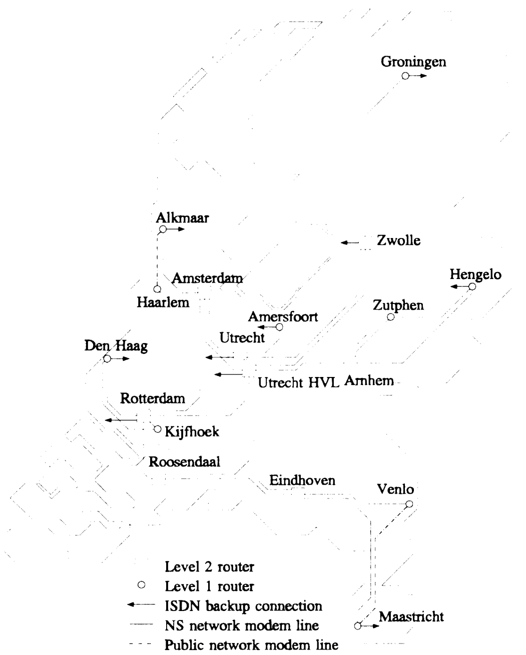

Figure 3 The Dutch national Train Traffic Control System network.

Ultimately every site in the network connects to at least two other sites, and after failure of a TTCS no more than three sites are in series, counted from Utrecht HVL. Within an area, rerouting is possible due to the triangular network structure. The data-rate of the connections is at least 19.2 kb/s, with the aim to eventually upgrading connections to 64 kb/s PCM links with ISDN backup.

2.3 Process supervision

The Process Supervision System (PSS) is concerned with the processes of traffic dispatching, shunting, passenger information, personnel, and rolling stock. Until now working practice is based on paper, pen, and telephone, which is neither sufficient nor efficient. The heart of the new PSS is the electronic process plan. Based on this plan the following improvements are achieved:

- Since there is only one valid process plan, deviations are detected automatically and will be passed on immediately to all parties concerned. Most of the oral communication overhead disappears, and multiple updates of the various plans are no longer necessary.
- Dispatching commands are generated automatically, presented to the process supervisor and/or carried out automatically. If-then scenarios will offer decision support and point out conflicts.

The PSS offers an integrated, uniform user interface to the various process supervisors. Tasks can be distributed in a flexible way over the available consoles and persons. The system and consoles were designed with high standards for availability and ergonomics.

Functional design of the PSS. Figure 4 shows the basic functions in the PSS. Shaded areas in the figure denote computer systems: on each site there will be multiple process supervisors' consoles (each consisting of two to four X-terminals), each having its own dedicated server. Only one process control system/computer is present per site.

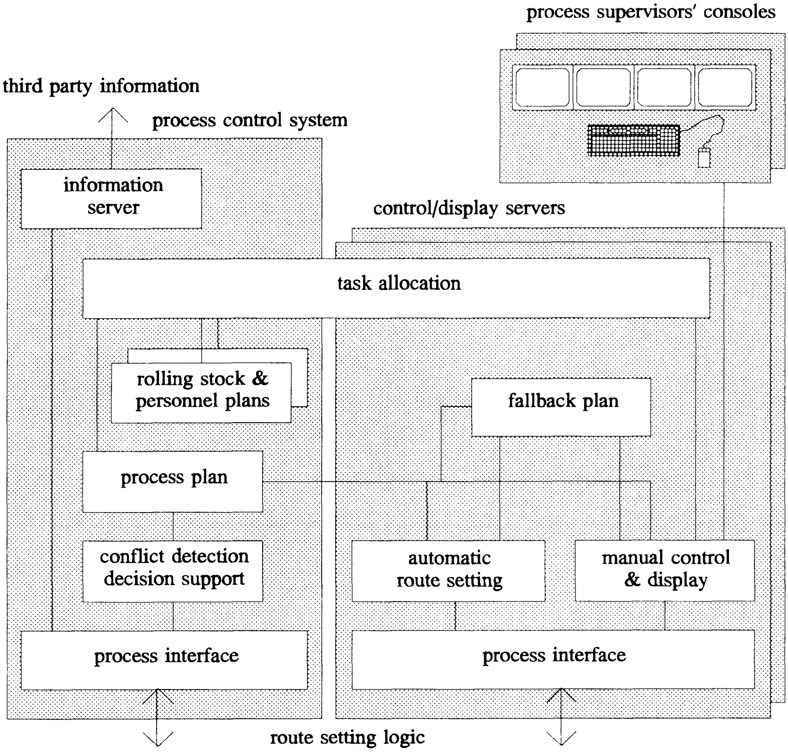

Figure 4 Basic functions of the Process Supervisor System.

'Task allocation' determines which specific tasks a supervisor will carry out, and over which area he or she will supervise. By specifying tasks and area on logging in, the process supervisor gets proper access to the system. The part of 'task allocation' that allows access to the system and starts other applications, is present on every control/display server. The part that monitors all allocation activities runs on the central process control system.

'Manual control & display' has four functions:

- accept commands from the process supervisor and pass these on to the 'process interface';
- show the status of the rail infra;
- judge the current rail infrastatus and generate proposals for commands to be carried out;
- pass messages from the route setting logic on to the supervisor.

Transactions on the Built Environment vol 7, © 1994 WIT Press, www.witpress.com, ISSN 1743-3509

'Task allocation' activates this application when a process supervisor has successfully logged on. The supervisor can enter commands directly, or select entries from a database. Commands are validated and transferred to 'process interface'. For showing the rail infrastatus there are three choices: a one-shot overview, a one-shot overview followed by all changes in infrastatus, or changes in status only. A few special events in the rail infrastatus are detected and reported to the process supervisor, together with a proposal for appropriate measures: a train passing a red signal, rail infra being taken out of service, and defects in rail infra.

'Process interface' handles commands, messages, and other data about the rail infra: storage, translation, and addressing. The application offers the other VPT applications a standard interface to the rail infra (via the route setting logic). 'Process interface' specifies to the route setting logic about which area infrastatus should be reported. Commands from 'manual control & display' are properly translated and sent to the appropriate route setting logic system. The application maintains an overview on infrastatus, which can also be consulted by other applications then 'manual control & display'.

'Process plan' is the electronic version of the timetable. It contains all planned train movements with departure and arrival tracks, and all relevant time stamps. The process supervisor can change the plan when necessary. 'Process plan' provides ready-to-enter commands to be selected by the supervisor.

Software for conflict detection and decision support is currently under development. In a first phase inconsistencies and impossibilities in the process plan will be reported, as well as deteriorations of the product (e.g. missed connections). Using what-if scenarios enable the process supervisor to look for solutions in an active and creative way. In a following stage Artificial Intelligence techniques will offer even more advanced support for decision support.

Local Area Network at a VPT control site. Figure 5 presents an overview of the typical VPT control site Local Area Network (LAN). Basically, the network consists of two LANs, one for the TTCS and one for the PSS, connected through a gateway.

The network hubs take care of the communication between consoles in the operator room and the network servers in the computer room. DEChub90 MultiPort Repeaters are used for this. In the same hubs Terminal Servers are used for

- connection of a radio-atomic clock (DCF77) to the TTCS and PSS;
- connection of a printer (in the operator room) to the TTCS;
- connection of TTCS read-only monitors for third parties (e.g. bus services; not shown in figure 5).

A supervisor or controller console can consist of two to four X-terminals, but only one keyboard and mouse will be used. By means of a switching device the supervisor will select the terminal to be operated.
In between the network hubs and the consoles a patch panel is used for making the actual connections (not shown in figure 5). Alternative connections can be realized quickly in case of maintenance activities or system failures.

The TTCS router provides the interface to the national TTCS WAN.

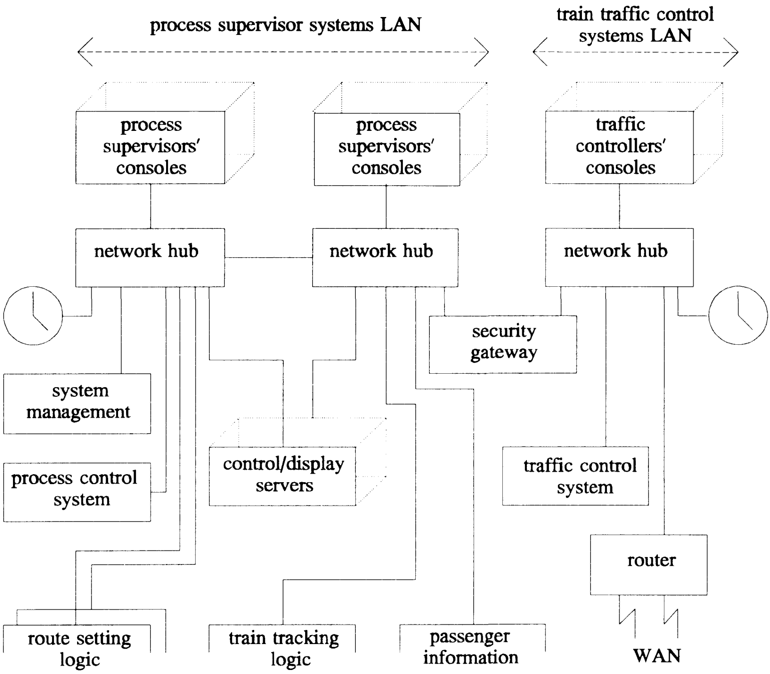

Figure 5 Local Area Network at a VPT control site.

The LAN for the PSS makes higher demands on network security than the TTCS LAN. The security gateway shields the two LANs from each other by explicitly defining which computers and applications are allowed to communicate with each other. In the PSS LAN two hubs are used, connected through Thinwire Ethernet.
Every supervisor's console is served by a control/display server, a VAX 3100/80 computer. The process control system is implemented with a VAX 3100/90 computer. The computer for system management (VAX 3100/40) provides services for collecting system logs, system and network monitoring, and loading new software and data into the computers.

3 Conclusion

Implementation of VPT means development of a large number of closely related systems for planning and control of train traffic. The complete development and investment schedule lasts over ten years. By basing the work on a sound, overall architecture it turns out that management of such a large complex project is very well feasable. A structured design of subsystems and interfaces allows the organization to meet changing wishes and demands.