A new user interface for the train traffic control system

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Abstract

The number of trains is increasing rapidly to accommodate the transport capacity required. The Netherlands Railways manages an average of 6000 trains per day, which results in highly intensive usage of the infrastructure. The routing process has changed over the last decade, shifting from manual route setting on huge switchboards to automatic routing using computer systems. If all trains are running according to the published timetable, there is little or no intervention by the train traffic controller. When there are no disrupting factors, almost all routes can be set automatically by the computer systems. However, even relatively small disturbances can lead to large disruptions if not handled appropriately.

The train traffic controller must therefore be able to handle all potential conflicts early enough to keep the route schedule up to date and free of conflicts. To perform this task effectively, the train traffic controllers need a user interface with functionality that supports their primary tasks. User interfaces nowadays are focused on controlling the infrastructure (e.g. points and signals). They support the setting of routes for each individual train movement (e.g. arrival and departure).

A new approach is to focus more on the predicted train process on the open track and on the station tracks. Based on the timetable and the actual situation, the new user interface shows the train traffic controller the predicted train process for the next 20 to 30 minutes together with the trains' current positions and potentional conflicts. This information is presented in two graphs: a time-distance graph for the open track and a track occupancy graph for each station. Potential conflicts that have to be resolved are highlighted to attract the train traffic controller's attention. Such a user interface controls the process at the train level rather than at the level of each individual route.
Keywords: predicted train process, train traffic control, time-distance graph, train traffic controller graphical user interface.

1 Introduction

The rail infrastructure in the Netherlands is being used more and more intensively. The number of trains increases every year in order to meet the demand for transportation of passengers and goods. There are over six thousand trains every day. The train traffic controller is responsible for getting all these trains routed correctly and on time. Before computerisation, this was all done manually using push-buttons, switches, control panels and display boards. The introduction of computer systems means that much of the manual work is handled automatically nowadays. This has caused the route setting process to change over the last ten years, and it will evolve further (Makkinga, Zigterman [1]). Because of this, the train traffic controller's focus has shifted. In the past, the traffic controller's responsibility was the execution of the route setting tasks. Since these are now largely handled automatically, the focus can shift to managing what is known as the 'route schedule'. After all, if the route schedule contains no conflicts, then the automated systems can handle it without problems. The traffic controller must ensure that the route schedule is free of conflicts.

In order to examine what can be done to help the train traffic controller do this, Holland Railconsult took the initiative of starting a research and development project at the end of 2001. The aim of the project was to raise the route setting process to a higher level and to define the resources required for this. This will allow the traffic controller to keep the route schedule free of conflicts for longer periods and means that he/she will be less involved with controlling the actual infrastructure, the points and the signals.The current control interface as used at the moment by the train traffic controllers for managing the route schedule is shown in chapter 2. Chapter 3 describes the new functionality that allows the traffic controller to be proactive in keeping the route schedule free of conflicts for longer periods. Future developments are described in chapter 4 and the conclusions are set down in chapter 5.

1.1 The research and development project

The research and development project examined how the traffic controller can get a better understanding of the anticipated train process and be less involved with the actual tasks and technology. The project was carried out jointly with ProRail Railverkeersleiding (rail traffic control) and InTraffic. Railverkeersleiding is a business unit within ProRail, the management and upkeep organisation for the railway infrastructure in the Netherlands. Within ProRail, Railverkeersleiding is responsible for the direction of traffic within the public railway network and for the provision of a neutral, transparent, and reliable divison of rail infra capacity amongst the railway network users. InTraffic specialises in the development and implementation of guided transport control systems and is working for ProRail on the further development of the current generation of train control systems.

2 The route setting process

The route setting process in the Netherlands is highly automated. If all trains are running according to the timetable, almost no route setting intervention will be required from the traffic controller. However, if trains experience delays or if there are disruptions in the infrastructure, then the traffic controller must intervene and make appropriate changes to the route schedule in good time. If this is not done or is done too slowly, then what is known as the 'oil-slick' effect can occur: more and more trains are affected by a delayed train or a fault in the infrastructure, for example.

The current man-machine interface (MMI) for the scheduling component of the current control system is shown in figure 1. All the information about the scheduled routing is displayed as text to the traffic controller.

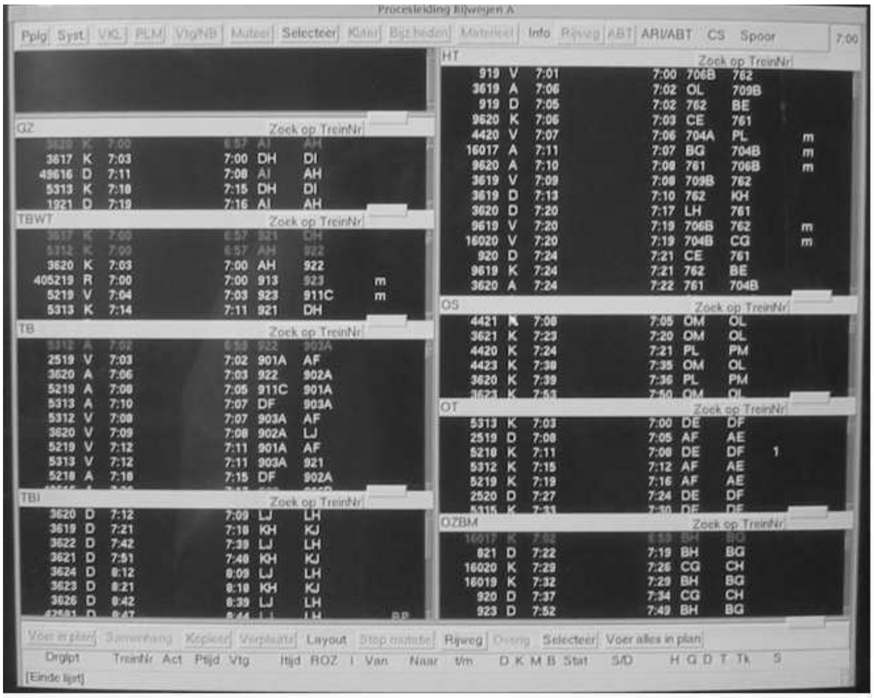

Figure 1. The current route schedule representation

The MMI shows the trains for which the traffic controller must set the routes. The trains are grouped by railway yard (e.g. GZ, TBWT) and are sorted according to the scheduled setting time for the route. Each line provides the train number, the activity (arrival, departure, passing, etc.), the scheduled time for the activity according to the train timetable, the scheduled setting time for the route, and the from-track and the to-track for the activity. This MMI does not support the traffic controller in anticipating and recognising conflicts.

The traffic controllers must use the information displayed in figure 1 as the basis for creating a picture for themselves of the anticipated usage of the infrastructure by the trains. If the traffic controller expects there will be a conflict, for example of platform track occupancy, then the schedule must be changed. Changing the schedule is taken care of manually by altering the information displayed; for the conflict in the example it could be done by changing the arrival track and the corresponding departure track. However, in the event of a complex disruption in an area, practice has shown that the traffic controller will decide to switch off the automated systems in that area. All routes then have to be set manually. There is, therefore, very little time to find the optimum solution for the problems in every case. In some cases, routes are set without reference to the schedule. An additional disadvantage associated with this working method is that other users of the system such as a station announcer or platform attendant can no longer be certain of the information shown in the route schedule and must be informed by the traffic controller. This situation must be avoided for as long as is possible and so it became the reason behind the research and development project.

3 Controlling the train process

In order to have the train process run as smoothly as possible, the traffic controller must ensure that there are no conflicts when the route schedule is in effect. In many cases, that would cause delays in the train process to accumulate. It is therefore important that the traffic controller has resources available that support a proactive response and effectively counteract the 'oil-slick' effect. During the analysis phase, a study was made of the supporting functionality that the traffic controller needs when handling a fault in the infrastructure or a disruption in the train process.

3.1 Proactive response

As long as the trains are running according to the timetable, the required routes are set automatically. As soon as a fault occurs in the infrastructure (defective points) or a disruption arises in the train process (a train delayed by ten minutes or a broken down train on track 3), then the traffic controller must alter the route schedule appropriately and in good time. Changing the route schedule can be seen as a solving a puzzle. The appropriate solution can be characterised as the one that produces a minimum level of disruption to other trains. If there is enough time, the traffic controller can search for a solution that causes no disruption (or as little as possible) to the other trains. The traffic controller can solve the puzzle, for example by making a train take a different path, having it arrive on a different platform, not having it wait for a connection or giving it higher priority.

The following functionality is needed for supporting the traffic controllers in responding proactively:

1. an overview of the way the train process is expected to be realised, based on accurate predictions
2. suitably early notification (display or warning, 15 to 20 minutes before realisation) of potential conflicts
3. providing an understanding of possible solutions in terms of both time and space
4. obtaining an understanding of the consequences for the train process, depending on the solution chosen
5. implementing the chosen solution (automatically) in the route schedule

Figure 2 depicts the system architecture which supports the traffic controllers in responding proactively (Makkinga, Metselaar [2]).

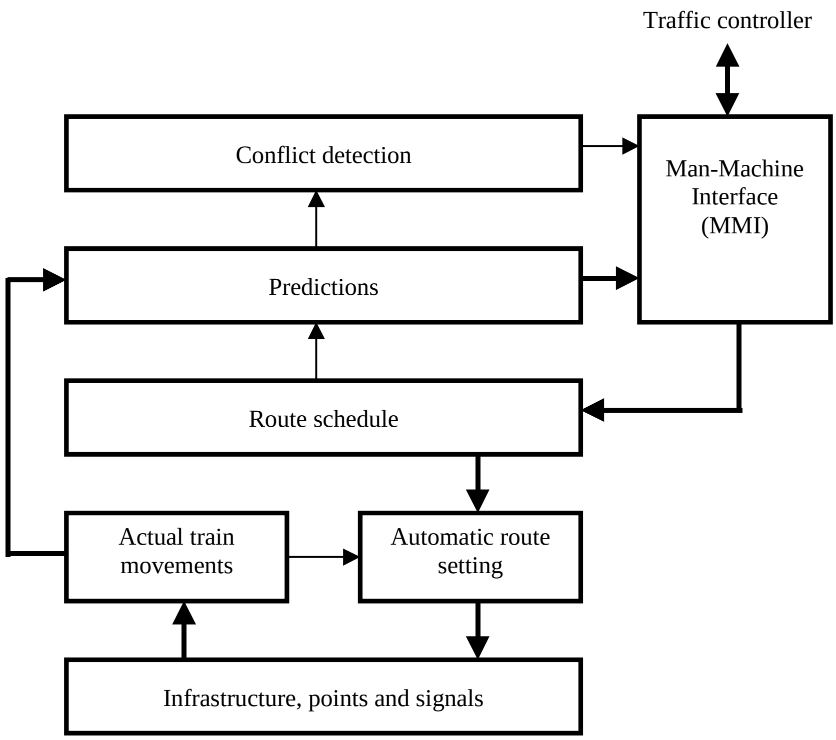

Figure 2. The system architecture which supports proactive response

Based on the actual train movements and the route schedule, predictions are made on the train process. These predictions serve as input for conflict detection. Both the predicted train process as well as the potential conflicts are shown to the traffic controller who uses the new user interface.

3.2 Visualising the train process

In the next phase of the project, the design phase, a specification for the new man-machine interface was produced. The specification describes a two-dimensional visualisation of the way the train process is expected to run. This train process is shown on the space axis (horizontal axis) and the time axis (vertical axis). Displaying the way the train process is expected to run in visual form supports the traffic controller in responding proactively. This means that the traffic controller can not only make better decisions but can also take them more quickly, avoiding unnecessary delays. The visual representation gives the traffic controller an overview of the expected utilisation of the platform tracks at the stations and the open track between stations, and also shows the current positions of the trains. An actual example is given in figure 3.

3.3 PRISMA prototype

A prototype has been developed to test the new visual representation. This prototype, PRISMA (Planning van Railvoertuigen op de InfraStructuur en Monitoring Actuele toestand – *scheduling railway vehicles on the infrastructure and monitoring the current situation*) has been used to assess four control areas of practical importance. Figure 3 shows the new user interface for controlling the train process. This shows the way the train process is expected to run during the next 26 minutes (Andersson, Sandblad [3]). If a delayed train generates a platform track conflict with another train, for example, then this is immediately visible. The traffic controller can determine visually whether there is still time and space on another platform track, for example. Using the facilities offered by modern graphics systems, the traffic controller can drag and drop the train to a different platform, for example.

The new user interface then ensures that all necessary changes involving the arrival route and the departure route are automatically implemented in the route schedule. Figure 3 shows the same trains and routes as shown in figure 1. This form of representation and interaction provides the traffic controllers with a better understanding of what is going on and what they can expect, makes the work more challenging and raises the control and adjustment processes to a higher level. It means that the route schedule will reflect the anticipated realisation of the train process for longer periods. This has a positive effect on quality and punctuality. Other users of the system, such as a station announcer or platform attendant, can also be informed in good time about changes that the traffic controller has made. The carriers' customers, the passengers, can then be informed in good time about platform changes, for example.

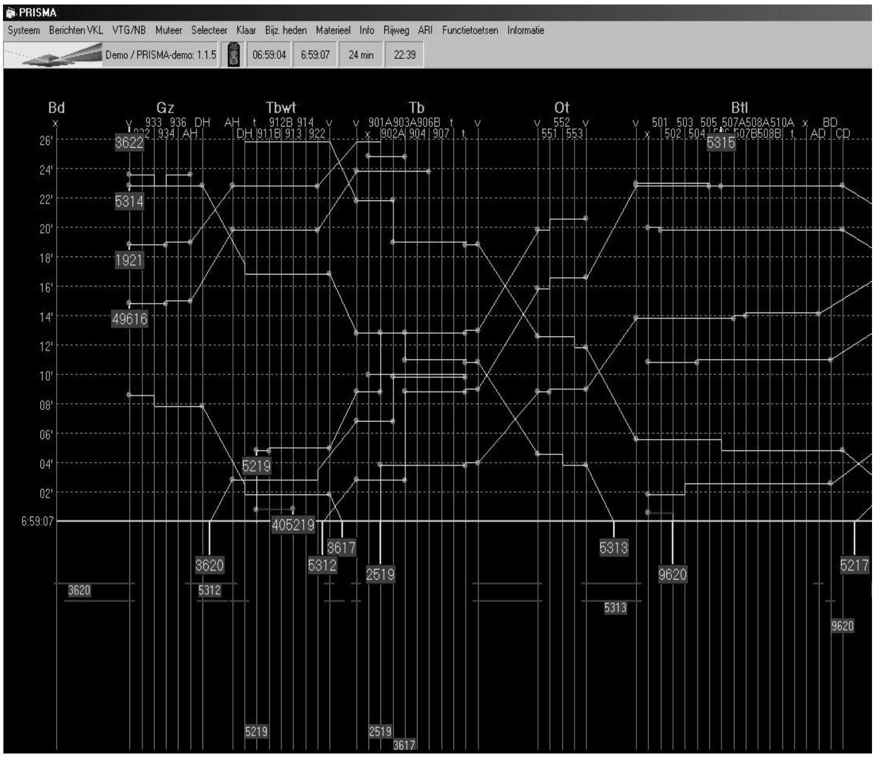

Figure 3. The new route schedule representation

4 Future development

In a two-dimensional representation, the anticipated train process is displayed on two axes (time and space). Along the horizontal axis, the infrastructure is shown as an abstract model. Whether or not two trains really will be in a routing conflict at a series of points can only be determined by an experienced traffic controller with a detailed knowledge of equipment and infrastructure or by complex conflict detection software. For that reason, the project is now studying whether it is possible to display the way the train process is anticipated to behave using three axes.

The infrastructure is displayed in a plane using two horizontal axes (the x-axis and the z-axis). The time axis (the vertical y-axis) is used to display the expected utilisation of this infrastructure by the train. By using three axes, it becomes possible to animate the anticipated train process.

By carrying out tests using actual practical data, the question whether a three-dimensional animation gives the traffic controller a better understanding than the two-dimensional visualisation can be studied. The contribution made by a combination of two-dimensional and three-dimensional representations will also be examined.

5 Conclusion

The route setting process in the Netherlands is highly computerised; the current man-machine interface, however, does not support traffic controllers in responding proactively. If the traffic controller is allowed to keep the route schedule free of conflicts for longer, then the automatic systems can issue the appropriate route setting commands in good time. Holland Railconsult has carried out a research and development project to examine the functionality that the traffic controllers need to do this. The anticipated train process is displayed visually for the traffic controller by means of a new man-machine interface. This has been implemented in the prototype PRISMA (Planning van Railvoertuigen op de InfraStructuur en Monitoring Actuele toestand – scheduling railway vehicles on the infrastructure and monitoring the current situation). In the event of a conflict situation, the traffic controller can now resolve the conflict visually. The new man-machine interface then ensures that all necessary changes in the route schedule are implemented automatically.

The research and development project is being expanded to include a follow-up study into the possibility of three-dimensional animation of the anticipated train process.

References

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