Modelling Railway Signal Asset Management

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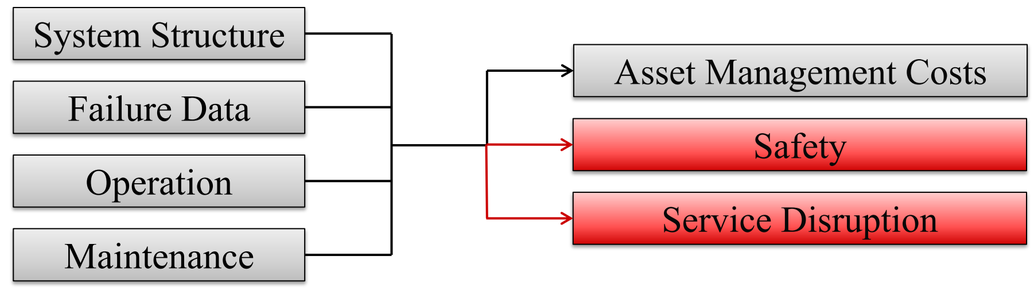
Research Aim and Objectives

The *aim* is to produce an asset management model for the signalling system developing the safety and service disruption level outputs.

Objectives:
1. To produce a PetriNet model of the signalling structure of a chosen site.
2. To include the safety and traffic disruption consequences in case of a failure.
3. If enough data, to calculate the risks of failure and to include consequently the risk and asset management costs.

The Next Generation of Asset Management

The current Asset Management system study the system structure, the operation of the line, the failure data and the maintenance process to calculate the Asset Management Cost. However the importance of safety on the Railways isn't to be proved anymore, as is the customer satisfaction. The next generation of Asset management will therefore have to include safety and delay management.



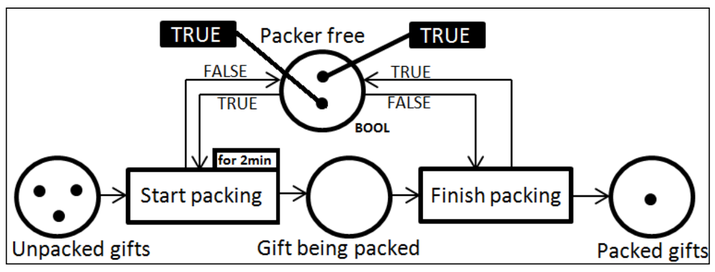
The Railway Signalling System

The Signalling on the railway network is a complex system consisting of many different interdependent devices.

- Signalling (Semaphore signals, Electrical signal with bulbs or LED)
- Track Occupancy Detection (axle counters, track circuits)
- Interlocking and traffic control centre
- Control system (AWS, TSS, OSS)
- Power supply
- Level crossing
- Vehicles (Trains, cars)

A Timed Coloured Petri Net Model

Coloured PetriNets is a graphical oriented language for design, specification, simulation and verification of systems. The example on the right describes a simple gift packing protocol. The circles, called places, describe the states of the system. The rectangles, called transitions, describe the actions. The arrows, called arcs, carry expressions describing how the state of the system changes when the transitions occur. Each place contains a set of tokens carrying a data value of a given type.



The signalling system of the part of the East Sussex Coast Line has been modelled using a Coloured Petri Nets software called "CPN Tools". The part of the line studied runs from Pevensey & Westham to Bexhill. Then, incidents and their risk to happen have been implemented in the model.

Train information:

Train name, Train type (passenger/goods), Number of axles, Departure time, Planned time of arrival at the different stations.

Timetable:

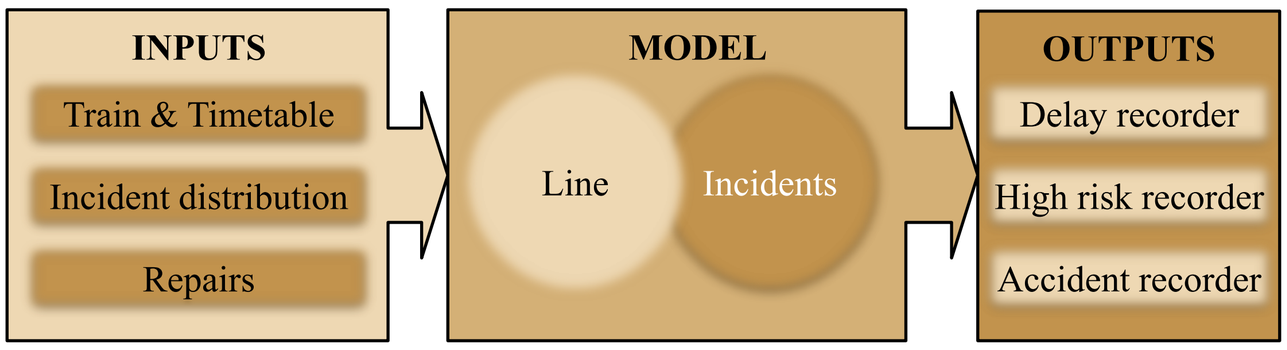
20 trains a day, every 20 minutes, line empty at the beginning of each day.

Incident distribution:

Exponential distribution

Repairs:

Fixed delay between incident and repairs



The line:
- 6 stations,
- 26 blocks delimited by 27 axle counters,
- 9 three-aspect signals,
- 9 Automatic Warning System,
- 4 level crossings

Incidents:
- Axle counter – Miscount,
- Axle counter – Deficiency,
- Signal – Signal Passed At Danger,
- Signal – Electricity failure,
- Signal – Blown bulb,
- Signal – controller error,
- AWS – electronic error,
- AWS – electromagnetic error,
- AWS – driver's failure to react,

Delay recorder:

Comparison of the actual time of arrival at the station against the timetable of the train. The output specifies: the name of the train, the station, whether the train is on time or late, and the delay.

Accidents:

Recorded every time there are 2 trains in the same axle counter block.

High danger:

Recorder every time there are two trains in the same signal block.

LIMITATION TO CPN TOOLS:

The risk of an incident to happen isn't constant over time, but increase as a device get older. Therefore the model could be improved by changing the exponential distribution used to model incidents into a Weibull distribution. However, the software "CPNTools" doesn't allow the use of the Weibull distribution.

Next Steps

- Convert the model into a C program.
- Decouple the signalling system models from the traffic flows (trains + cars).
- Modularise the signalling system features with a view to longer term putting them in a library for the optimisation.

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