Visual Analysis of Reactionary Train Delay from an Agent Based Model

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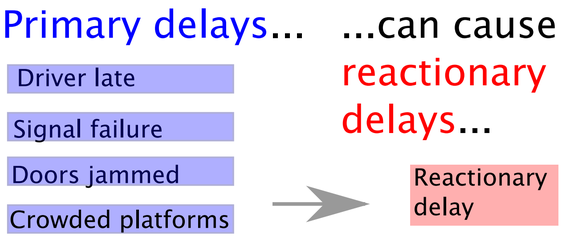
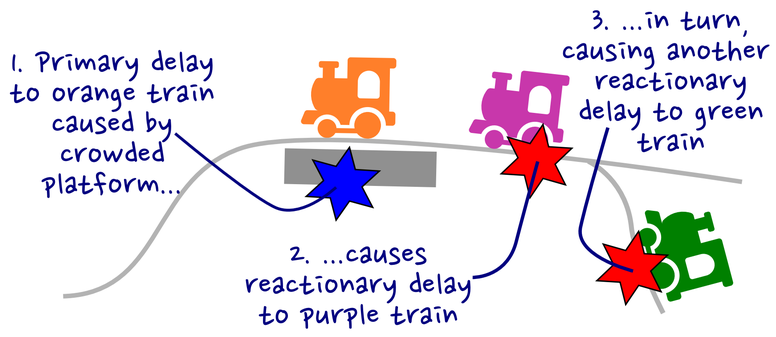
Problem

Reactionary ("knock-on") delay is an increasing problem for UK train operators and is hard to understand. Train operators want to know the key locations and reasons, so they can **design interventions**.

What is reactionary delay?

Primary delays... ...can cause reactionary delays... ...which are the knock-on effects that are hard to predict.





Our approach

We build an **Agent Based Model** that explictly models interactions between trains, then design **interactive visualisation** to help understand the problem to **inform designing interventions**. We can then run the model again to see if this works.

Agent Based Model

The agent-based model stochastically generates primary delays including small natural variation) according to historical data, the interactions between trains and the resulting reactionary delay. The model runs 150 times (Monte-Carlo style) and it generates thousands of delays for hundreds of trains.

Interactive visualisation

Our interactive visualisation takes the model's output and [**A**] provides the **association between primary and reactionary delay location**, **[B]** gives the **uncertainty** around this result through model run agreement, and **[C]** explains the **mechanism** of the chain of delays.

[A] Association between primary and reactionary locations

The matrix shows the association between locations where primary delays occur (columns) and where the resulting reactionary delays (rows) occur.

All primary delay is "subthreshold"

This mode shows relative proportion of primary delay type for each location pair

See colour key below

Each cell is a primary-reactionary delay location pair

Blue shading is the number of primary delay minutes - here it is more than the resulting reactionary minutes

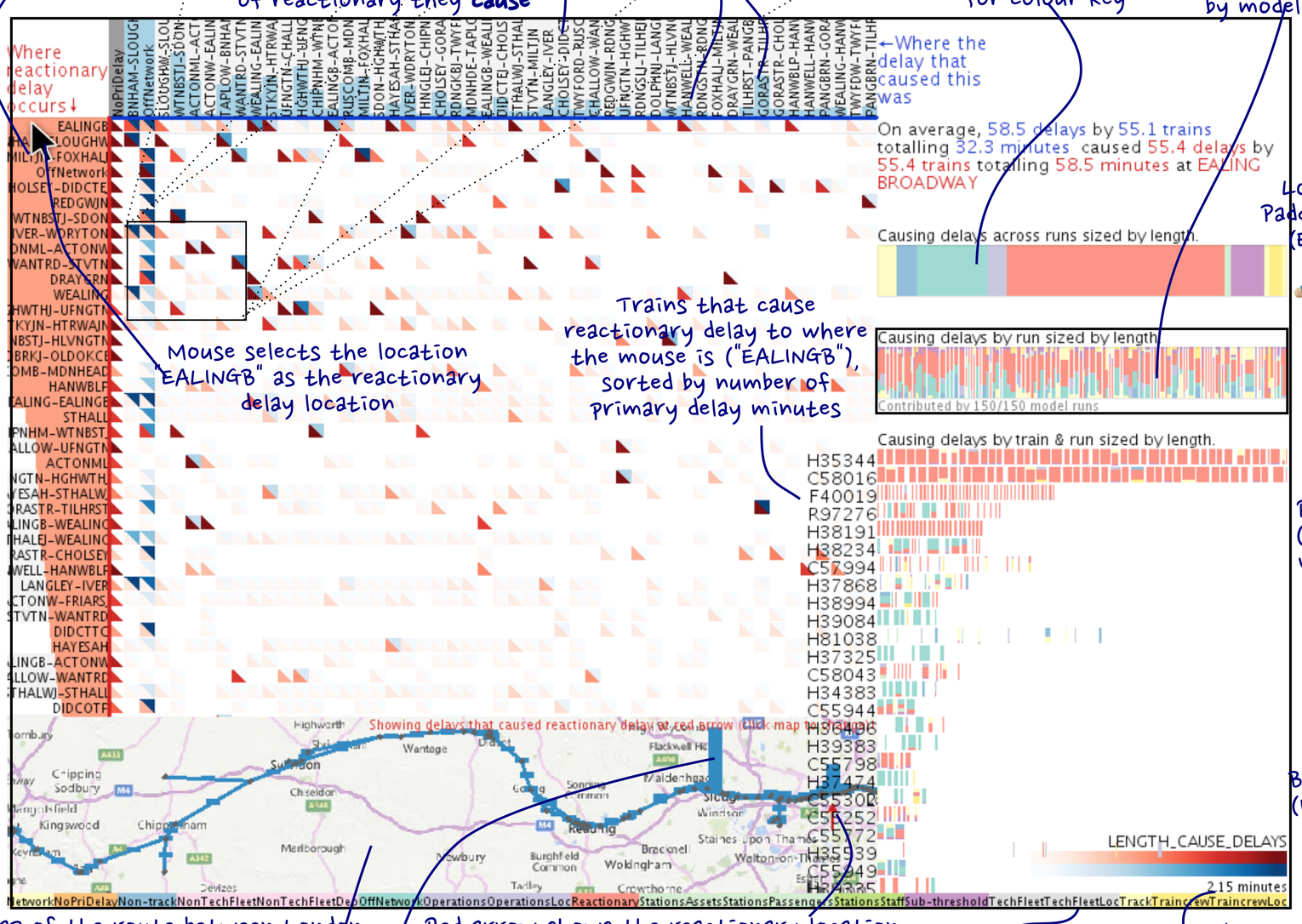
Red shading is the number of reactionary delay minutes - here it was caused by a smaller amount of primary delay minutes

rows are locations where reactionary delays occur, ordered by total reactionary delay

columns are locations where primary delays occur, ordered by amount of reactionary they **cause**

Bars are total number of primary delay minutes

Delay types by proportion of primary delay minutes for mouseovered location ("EALINGB") - see bottom for colour key



Mouse selects the location "EALINGB" as the reactionary delay location

Trains that cause reactionary delay to where the mouse is ("EALINGB"), sorted by number of primary delay minutes

Map of the route between London (East) and Bristol (West)

Red arrow shows the reactionary location where the mouse pointer is ("EALINGB"). (If on a cell, it would additionally show a blue arrow).

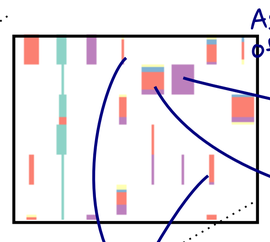
The blue bars are the primary delay minutes that cause the reactionary delay at "EALINGB" where the mouse cursor is

colour legend for primary delay types

colour scaled to

[B] Uncertainty, through comparison of model runs

Looking at the variation between model runs indicates the certainty (or liklihood) of that outcome



As left, but width indicates proportion of models runs that generate a delay

Most model runs undicate "subthreshold" primary delay

A primary delay only occurs rarely

Most model runs undicate "reactionary" causing delay causes reactionary delay, but a minority of runs attribute this to "subthreshold" and "offNetwork"

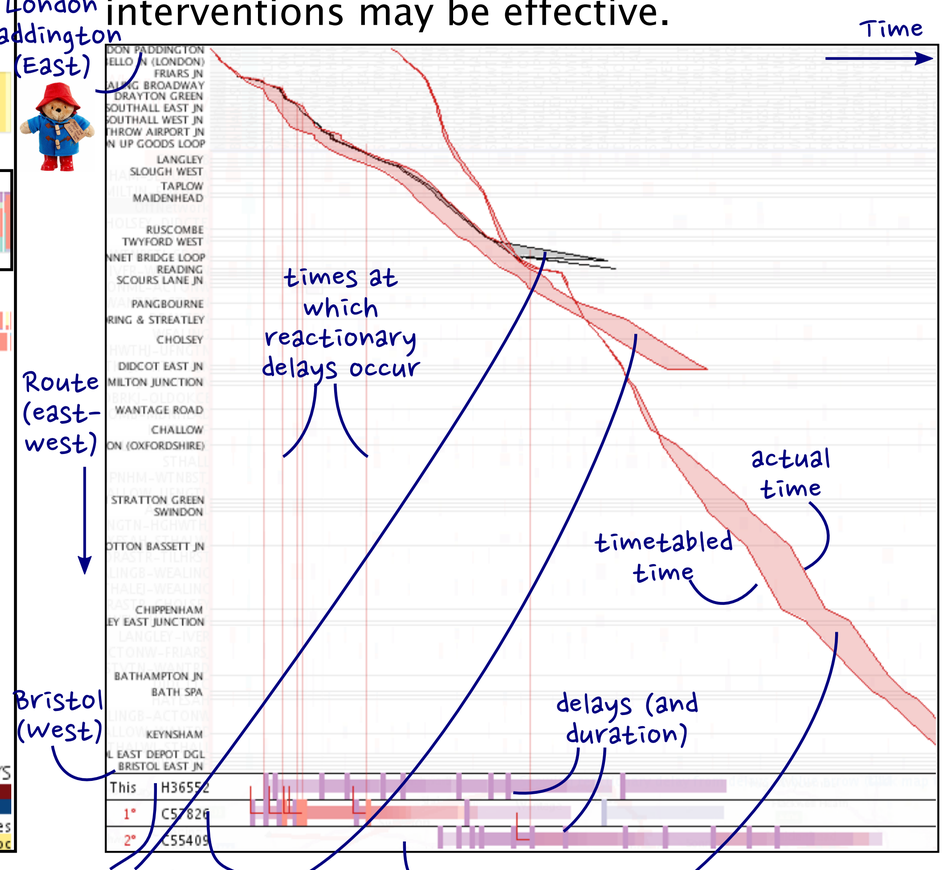
"Reactionary" and "offNetwork" both feature in most model runs, but occur in different amounts, but "track" and "network" only happen in some model runs.

Each vertical bar is a model run, its width is the primary delay minutes and the relative proportions of delay type shown in the bar.

As the chart above it, but by model run.

[C] Explain mechanism of reactionary delay chains

Looking at the interaction between trains helps understand what kinds of interventions may be effective.



selected train (grey)

train this causes delay to (red)

train at end of reactionary chain (also red)

risksolutions
leave nothing to chance

RSSB

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