Abermule Railway Station: Agent-Oriented Task-Centric Empirical Modelling

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Abstract

This paper presents and discusses an approach to modelling the situation at the Abermule Train Station immediately leading up to the train disaster of 1921. The incident itself is summarised and a modelling approach introduced and presented that is based on the principles behind Empirical Modelling (EM) and yet also around the notion of tasks. A corresponding model, built with EM software tools, is introduced and referenced throughout. The model itself, and the overall approach are evaluated and some comparisons with previous work in the field are included. Significantly, the appropriateness and position of such a task-centric modelling approach within the seemingly non goal-oriented empirical mindset is addressed. Finally, the suitability of current EM tools for such an approach is assessed and some suggestions proposed.

1 Introduction

At approximately 12:06pm on the 27th January 1921 an express train from Aberystwyth and a stopping train from Whitchurch, both carrying passengers, collided head-on, one mile south-west of Abermule train station in mid-Wales (UK), at an estimated combined impact speed of 60mph. According to the official report (Pringle 1921), 11 passengers were killed and 36 were injured including the driver and fireman of one of the trains, although a historian's article on the matter (Burkhill-Howarth 2007) states that there were as many as 17 fatalities. The "disastrous results" of this event are still remembered around the area.

The blame and responsibility for the accident was distributed across several members of Cambrian Railways staff, but the crux of the matter was the unlikely chain of poor practices and misunderstandings that took place at the Abermule train station immediately prior to the collision. This report focuses on and discusses an attempt to capture and model the situation at Abermule train station leading to the collision, with the aim of providing a model to help explain and understand the causes of the collision.

As part of this study, some issues are raised concerning the place of tasks and processes within the Empirical Modelling mindset, and how effectively the current tools lend themselves to the convenient incorporation of such concepts.

2 The Incident at Abermule

It is useful at this stage to give a brief summary of the system in place at Abermule, on the respective section of railway on the day of the disaster and the cause of the collision itself. The terminology used throughout this report is introduced and explained here also.

Much of the information regarding the system in place on the Cambrian Railway at the time, and any details of the incident itself are taken from the officially commissioned report written by J.W. Pringle three months following and the article written by historian David Burkhill-Howarth in 2007, as part of a book he has researched and written about the subject.[1]

The account given here has been significantly simplified from the reports. This is because, for the purposes of the modelling exercise, the complex scenario was cut-down. This report reflects that same simplification.

Furthermore this section also partially represents the *results* of the modelling process. The development of, and interaction with, this model has enabled the author to thoroughly explore elements of the situation at the Abermule railway station immediately preceding the disaster. This has resulted in

[1] Details of these sources may be found in the References section at the foot of this document.

an augmented conceptual model of the working processes at the station

2.1 The Tablet System

The section of track was a single-track line, and so no train could travel on the same stretch in different directions at the same time. To deal with this situation an electric tablet system (using the Tyers No. 6 instrument) was in place at each station along the way. A driver was permitted to proceed along a stretch of track only if he had in his possession a tablet bearing the engraved name of the section of track in question.

There was a Tyers instrument for a stretch of track at the two stations at either end, and they were wired to each other. An instrument would only vend a tablet if there was no other tablet already 'out' for that section.

2.1.1 Handling Tablets

To reduce the chance of human-error affecting the tablet system, there were strict regulations concerning interaction with this tablet-vending machine. The stationmaster was primarily responsible for personally handling tablets and, in his absence, the signalmen was to take over his duties. Both were required to visually inspect a tablet just before handing it to a driver to ensure it was correct. Each was specifically trained for this job.

Furthermore it was the responsibility of the driver of a train to carefully inspect a tablet given to him to ensure that it indeed corresponded to the section of track he was about to travel down.

The system was thought to be foolproof.

It is important to note that it was common practice to treat these regulations lightly, and it was frequently the case that unauthorised persons would operate the machine, that tablets would be passed around by hand between station staff and that drivers would not check tablets before proceeding.

2.2 Station Location

The Abermule Railway Station lay between Newtown (to the west) and Montgomery (to the east). These will be abbreviated to A, N and M respectively. Therefore the stretches of track between each of the three stations are referred to, west-to-east, as follows:

- **N-A** The Newton-Abermule line.
- **A-M** The Abermule-Montgomery line.

There are corresponding tablets for each of these stretches (see subsection 2.1 above) referred to as the N-A and A-M tablets.

These stretches of track were single-line, but there were passing loops at the stations themselves. Trains were able to pass each other at the stations only. As such there were two platforms at the station (the *up* and *down* platforms, serving the west-east and east-west directions respectively).

2.3 Trains

The two trains involved in the collision were as follows:

- **Down Train**. The slow, stopping train travelling east-west. That is, in the Montgomery-Abermule-Newtown direction.
- **Up Train**. The express train travelling west-east. That is, in the Newtown-Abermule-Montgomery direction.

There was a driver and fireman controlling each vehicle.

2.4 Railway Workers

There are three main humans in the situation who are directly relevant to the scenario for this modelling study. These are:

- Stationmaster Lewis.
- Signalman Jones.
- Booking-Clerk Thompson.

Each is listed roughly in order of rank at the station. Only Lewis and Jones were permitted to work the Tyers instrument and handle tablets. In reality, however, all station workers frequently performed these tasks.

2.5 Cause of the Collision

The disaster at Abermule was due to a confluence of various misunderstandings and poor working practices at the station. For the sake of brevity full details of the events leading up to the disaster are not given here. It is sufficient to know that the heart of the misunderstanding is considered by the modeller to be the set of false assumptions made by Stationmaster Lewis as the down-train was sitting in Abermule station.

These assumptions were made as Lewis who, being away in the yard during the arrival of the down-train and prompted by the view of its arrival ran back to the main station building. There he was met by Thompson who had just collected the A-M tablet from the driver and, seeing Lewis – and some passengers needing their tickets collected – handed Lewis the tablet with little explanation.

For various reasons, Lewis made the assumption that Thompson had already been into the instrument room and exchanged the tablet. Hence Lewis incorrectly assumed that he was now holding the N-A tablet, allowing the down-train to proceed. He personally handed this tablet to the driver of the train and neither checked it to see that it was false.

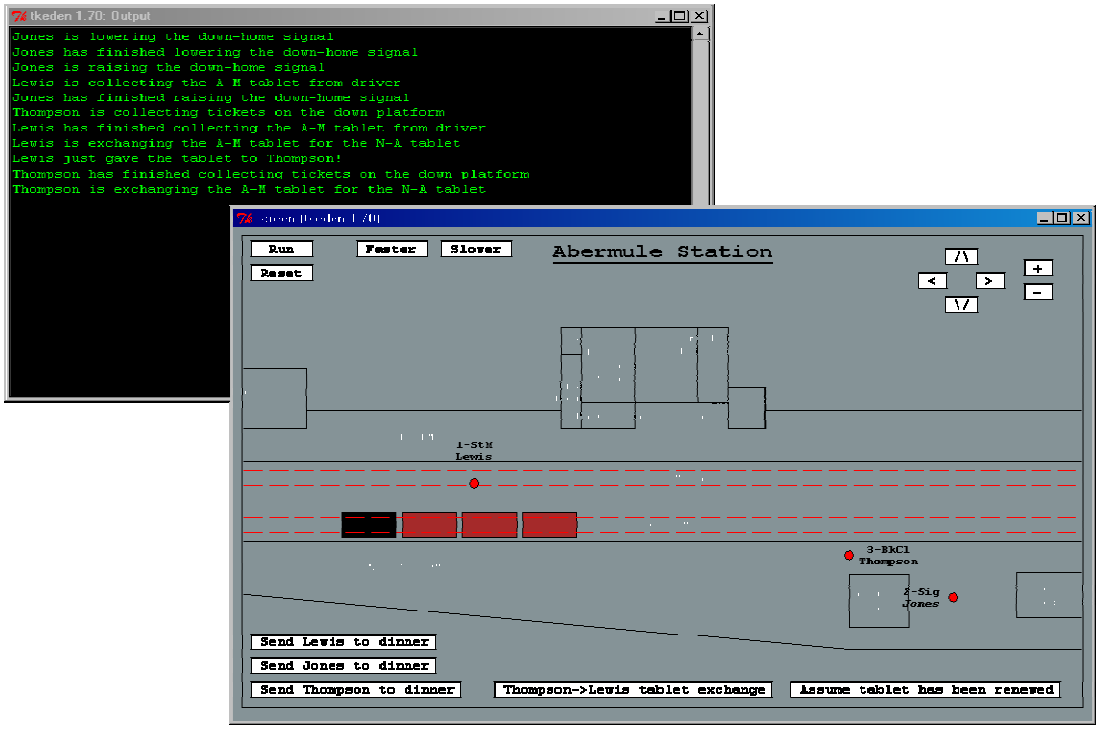

Figure 1: A screenshot of the graphical interface to the Abermule model and the text output

This model deals with understanding the effects of making such assumptions and proposes a framework for further exploring such mistakes of 'protocol'.

3 A Modelling Approach

A goal of this project was to develop an Interactive Situation Model (ISM) of Abermule station immediately leading up to the incorrect authorisation of the departure of the down train, to aid and to develop understanding of the event itself.

A model was developed in EDEN, DoNaLD and SCOUT – see Figure 1 for a screenshot of this model at the time of writing. This section details a task-centric modelling approach and contrasts it with the Abermule railway model developed alongside. Evaluation of the model is included here also.

3.1 Agent-Oriented

In accordance with EM principles, the primary agents within the system were identified from the situation as the humans involved at the station[2], referred to in the model as *players*. These players correspond to the list found in subsection 2.4. In this case the players are very similar to each other, each with a shared set of observables roughly organised into the categories:

- *Physical* – Interpreted as those that directly correspond with physical dimensions of the player – colour, location, dimensions etc.
- *Attributes* – Personal qualities of each human, such as name and title. Note that these were rarely defined by dependency, but rather were convenient for modeller-interaction purposes (e.g. labels)
- *Task* – These kept track of what each player was doing at a given time.

It is the existence and dependency of these 'task-related' observables that begin to outline the most interesting and unique aspects of the Abermule model.

3.1.1 Modelling Agency in `tkeden`

The LSD notation is purpose-built for modelling the agents within a system, allowing classification of each agent's observables into those that they can see ('oracles') those that they can change ('handles') and those that they simply own (Beynon 1986, 2006).

Note however that the current release of `tkeden` does not support modelling directly in this

[2] Note, however, that it is perfectly ordinary for non-human entities to be modelled as agents. Ch'en (2001) succinctly defines an agent as a "state-changing entity…a family of observables".

notation[3]. As such the agents were modelled each as a DoNaLD entity, something which allowed them to have the same observable names in them without naming conflicts.

Since each agent is essentially the same as each other with a few minor dissimilarities (e.g. Name), this model forms an excellent example of a situation where object-oriented design is desirable in `tkeden`[4].

3.2 Task-Centric

This model focuses heavily on the concept of task, of what each player is doing at a given time, and what they might be doing next. It must be immediately stated that at first glance, such an approach may risk seeming incongruous with the Empirical Modelling mindset. As such a brief explanation of the approach is given here.

3.2.1 Explanation

It is important to understand that the Empirical Modelling approach is one of "experience and experiment" – an "observation-oriented" perspective (Ch'en 2001, p97-99). Beynon *et al.* (1998) further state that "an ISM does not necessarily represent goal-oriented knowledge" in their definitive "Distinctive Characteristics of Interactive Situation Models".

It is therefore important to understand that the modelling approach here proposed is not one that contravenes these guidelines. The aim here is not to build a model to suit an agenda, or perform a preordained task. Rather it is this: To explore the affect that the existence of a pre-arranged set of tasks has on agents within a system.

It is to place agents within an environment which is centred on task, and to model the interaction of these agents with what they perceive about these "processes of the institution"[5].

To a greater or lesser extent it is assumed that it is common knowledge among the agents exactly *what* these tasks are that define their environment.

Therefore the questions the modeller is asking include the following: What is the relationship (i.e. dependency) between what each agent can see ('oracle') and their assumptions about which tasks need doing, which tasks they could do, which task they should do and who (out of all the agents) is currently performing a task?

Process Note that it is possible for such tasks to be implicitly dependent upon each other. For example it is sensible for one task to have, as a prerequisite for its acceptance, the completion of some other tasks. This would then lead an agent to have a dependency between his understanding of the completion of these previous tasks (does it 'look' to him like they are done?) and whether or not he takes up this new task. In this way a process (i.e. interdependent chain of tasks) can be modelled.

3.2.2 Abermule

It is relevant to involve the notion of task and process in the Abermule station scenario. It seems accurate to claim that the heart of Lewis' false assumption was that he concluded that 'things' were in a different position in some understanding of 'the process' then they really were. The clearest example is his assumption that Thompson was one step ahead of where he really was. It is the claim of this paper that all of the mis-conclusions that caused the accident (including those not covered by this model) can be precisely conceptually modelled in this way.

As such a set of tasks was defined. For the purposes of clear visualisation, each was associated with a screen location (where the task must be completed). Each task had a globally defined (since it is assumed that basic task understanding is shared among all agents) acceptance condition and completion event. These tasks implicitly formed a chain – a process – since their acceptance conditions were typically dependent on the completion state of previous tasks.

Furthermore each task has, associated with it, an ordered list of agents who are capable of completing this task. For example the task "lower signal" is first attributable to signalman Jones and then Stationmaster Lewis. It is never attributable to Thompson, since he was not able to work the signals.

3.2.3 Handling Tasks in `tkeden`

Following the definitions of task above there are several approaches that may be taken when modelling in the EDEN interpreter. At it most basic, it would be plausible to make no attempt to 'single-out' the tasks within the system and model them specifically. The process and tasks could instead be 'hard-coded' implicitly within the dependencies between agents. However, it is certain that this approach does not best fit the general problem of developing task-centred models. This is simply true because it does not allow for easy re-definition of tasks, or the introduction of new institutional tasks into the system, without significantly redesigning most of the definitions. It is clear therefore, that this

[3] It is supported, however, in the distributed version of the software (`dtkeden` – Beynon *et al.* 2003), although this was not used for this project.

[4] Work is being done in this area by Nicolas Pope through the `Cadence` framework, and its associated `tkeden` notation.

[5] A term coined by Dr Meurig Beynon (University of Warwick).

approach does not fit the conceptual understanding of a modeller of this kind of situation.

Another possibility is to consider the tasks (or perhaps a collection of tasks) as agents themselves. This seems to fit the definition of an agent as "a state-changing entity", and may be worth further investigation – particularly if LSD is available to be used.

Another suggestion is that a new Eden notation be developed to allow the easy incorporation of global tasks into a model. Such a task may be similar in many ways to an agent, but a new notation may be able to introduce convenience methods for integrating these task-sets with agents. Therefore perhaps this notation would be best developed with relation to LSD, where agents are already supported.

Task management in the model developed as part of this project is implemented in a simplified manner – an abstraction of the conceptual model, rather than a complete ISM in itself. This was due to not unreasonable time constraints surrounding the thorough modelling of a situation as complex as Abermule.

The tasks are defined as an EDEN list, and the delegation of such tasks across the agents is performed procedurally in a global nature. The tasks are distributed across agents in accordance with acceptance conditions and agent preference definitions. This task distribution procedure is run on every clock cycle, and the result is an animation of the order of events leading to the down-train's release from the station.

It is possible to intervene either by the explicitly provided SCOUT buttons (which are sufficient to recreate the passing of the incorrect tablet to the train driver) or by inputting definitive scripts directly into the EDEN interpreter.

4 Conclusion

The key observations about this project lie in the simplified approach to reality that it took. Since the model abstracts the task delegation into a global procedure, it assumes that each agent knows everything about each other's movements and activities.

Note, therefore, that this model does not explicitly take into account the empirically interesting considerations of a personalised understanding of a position along a process (e.g. agent1 things we're at step A but agent2 things we're at step B). This is something which, as aforementioned, is the crux of the matter behind Lewis' mistake at Abermule. Instead the model here is a simulation of such a situation.

In order to constitute a complete precedent for task-centred Empirical Modelling it would be necessary to personalise the position in the process to each agent, and develop a more robust set of definitions that determine where along the process each agent assumes the world has got to. It is the choice of such dependency that will cause the model to closely resemble reality – in theory anything is possible here (e.g. "Can I see the down-train?", "Does Stationmaster Lewis look like he has been running?").

4.1 Results

This project has demonstrated an example of a scenario where the oracles of human agents are affected by their understanding of a position in a globally defined set of tasks. It points towards the benefits of establishing a convenient method of modelling such tasks, in and of themselves – either by considering them as simply agents, or by the invention of a new Eden notation to easily define and interact with them.

The model also provides an example where object-oriented EM is desirable.

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