The Undecided - Final Report - 7CCSMGRP

Nathalie Caliacmani, Amar Menezes,
Belema Norman-William, Paul Orlean-Taub, Tony Sellen

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Abstract

Since its development, the car has had a huge economic and social influence. It has created industries and caused others to crumble. The popularity of the automobile has had an impact on city planning due to its effects on employment, trade, manufacture and even basic social interaction.

As the popularity of these vehicles in both a private and public context has increased, transport planners and civil engineers have had to adjust our road networks accordingly often through the development of mathematical models for traffic flow (of varying accuracy).

This project is our attempt at producing a software package that shows the effects of changes to pre-existing networks (i.e. increase/decrease in demand, adding lanes, changing existing lanes into bus lanes) on the overall flow. The primary output will be data that can be fed into an appropriate statistical package for professional analysis.

Contents

1 Introduction

In 1769, Cugnot developed the first steam powered auto-mobile [4] (self propelled vehicle not operating on tracks). As these vehicles spread to the UK, the government passed the locomotive acts providing a framework for the automotive industry here to develop and regulating the use of these machines; The act of 1861 imposed speed limits, determined tolls, set fines, and stated design requirements; the act of 1865 tightened these regulations and required that a man waving a red flag would be required to walk ahead of all of these vehicles; and the 1878 act assigning the powers.

In 1886[1] Karl Benz filed his patent for the petrol powered "moterwagen" [3] sparking the production of uniform vehicles that could travel long distances. The uptake of these machines leading to further regulations and the requirement for licensing. From this time onwards there was a steady increase in car ownership, primarily amongst the wealthy and private businesses.

In 1908, the Ford Motor Company developed the Ford Model T, and with it, the automatic assembly line allowing the production of these cars in 93 minutes. The increase in production speed allowed costs to be optimised and made the car affordable to the mass market.

In the years that followed, cars became a primary mode of transportation. In response to increased usage, the British government passed laws that were less restrictive on car use, and optimised road networks to cope with an increase in vehicles that were larger, heavier, and faster than those for which they were originally developed.

Nowadays cars are widespread, and finely engrained in our culture[5][1]. However new developments lead to large changes in ownership rates and road demand, and many economies rely on the optimisation of traffic flow, with traffic engineers often needing to change factors in order to artificially increase and decrease congestion [2]. These engineers use mathematical models to simulate flow through a network and often need to trial the effects of various changes.

This project is our attempt at producing a piece of software to model a road network and create artificial (and hopefully realistic) data that will allow a civil engineer to perform the appropriate analysis and determine the best way to optimise our pre-set systems

2 Review

2.1 Overview

Computer simulation is getting popular in the field of science. Individuals tackle diverse experimental issues using computer control through simulating artificial testing environments. They use these simulated environments to test scientific models in order to prove or disprove their feasibility and correctness.

[1] The same year Coca Cola was invented

Today's high machine power gives people the capacity to simulate environments at a rate much quicker than any real environment, thus any experiment carried out in the simulated medium would provide results minutes, hours, days and often weeks, months and years ahead of what the same experiment would provide if executed in the real world.

One of the frameworks or systems that are best considered using a computer simulation is a traffic network. It is typical to experiment with traffic networks in a computer-simulated environment because experimenting with traffic in the real environment is impractical.

2.2 Simulation models

A typical classification method for simulation models is based on the variability content that represents the deterministic nature of simulation that represents the static or dynamic characteristics of simulation. Regarding how frequent the activity of the traffic network is updated and the statistics on traffic performance is collected, the most frequently used classification method is based on the details a model intends to simulate, namely, microscopic or macroscopic modelling.

2.2.1 Microscopic modelling

Microscopic simulation modeling methods are based on car-following and lane-changing theories, which can represent the traffic operations and vehicle/driver behaviors in detail. The car-following theory describes the longitudinal movement of vehicles. The classical car-following approach is quite straightforward, i.e., each vehicle attempts to advance at its desired speed while maintaining a safe following distance from the vehicle ahead. [4] Microscopic simulation modelling incorporates queuing analysis, shock-wave analysis, and other analytical techniques.

2.2.2 Macroscopic modelling

Macroscopic models do not consider car-following behaviour in detail, but instead model traffic as an aggregate fluid flow. To better understand the collective behaviour of traffic and analyse flow conditions in a dynamic fashion, continuum models, either simple or high-order, are usually employed in macroscopic simulation modelling. The simple continuum model consists of a continuity equation representing the relationship between the speed, density, and flow generation rate. [5] Although the existing high-order models look promising, they have not as yet proved truly superior to the simple continuum models at least in medium-to-congested flow conditions [6]

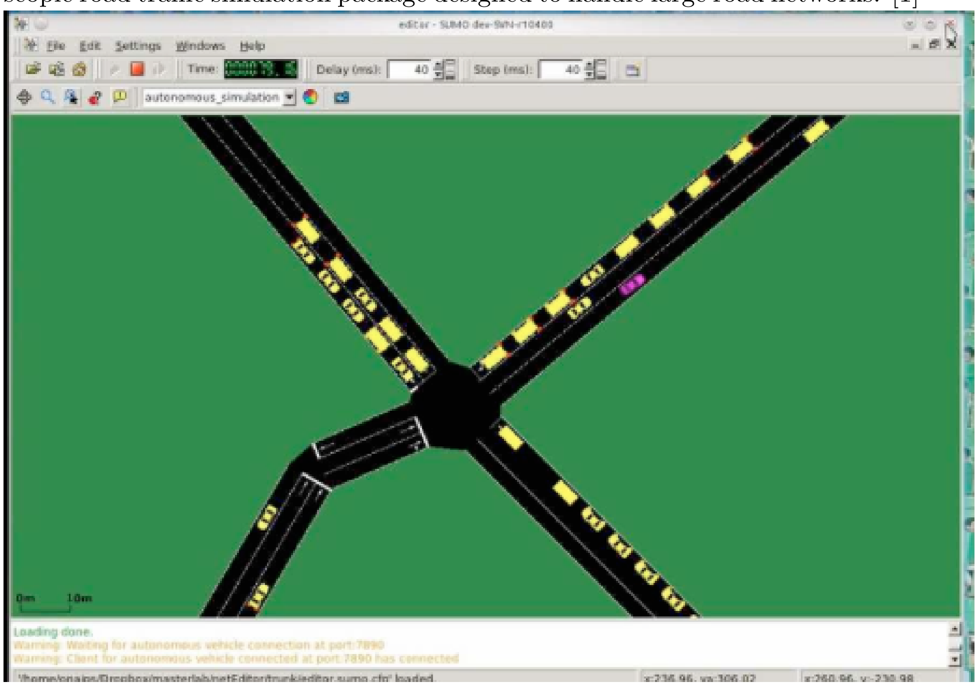
2.3 Comparison of different traffic simulation packages

We will briefly review the following well known and widely used simulation packages;

- Simulation of Urban Mobility (SUMO)
- Quadstone Paramics Modeller
- Aimsun

2.3.1 Simulation of Urban Mobility (SUMO)

Simulation of Urban Mobility (SUMO) is an open source, very compact, microscopic road traffic simulation package designed to handle large road networks. [1]



3 Requirements and Design

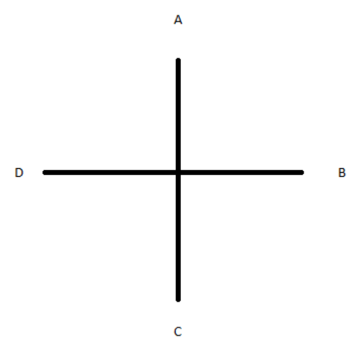
4 Implementation

4.1 Output

We designed the software to output individual car journeys for a transport consultant to analyse using statistical analysis packages. The basic idea is that the software is used to support decisions about changes to the road network or for supporting planning decisions. We present two scenarios here. Instead of using a statistical analysis package such as SPSS we wrote a custom python script to summarise the data. The script also serves as a sanity check for the output of our software. The python script is included in the appendix to this report.

4.1.1 Shopping Centre Development

We have a simple network as shown below. The consultant does a survey to measure existing traffic movements which we translate into a *demand matrix* for the road system. The demand matrix is just a count of car movements between each end point of the network over a given time period. We are keeping things simple in our example and only considering one vehicle type. In reality the model would take into account of other vehicle types and our software does allow for that. We convert this demand matrix into a table which specifies the probability of a car entering the network at for each combination of origin and destination for each tick of the simulation clock. This drives the creation of vehicles in our simulation for the base case.
The consultant runs other models, based on the size of the new shopping centre and proximity of other centres to estimate a new demand matrix for when the centre is built. Our software is then run in the base case and the modelled case using the new demand matrix and reports are generated showing the effect on journey times.



Network diagram

We used the following trip matrix for the base case:

	A	B	C	D
A	0	0.3	0.3	0.3
B	0.3	0	0.3	0.3
C	0.3	0.3	0	0.3
D	0.3	0.3	0.3	0

and the following matrix, showing extra demand to and from the shopping centre at C

	A	B	C	D
A	0	0.3	0.8	0.3
B	0.3	0	0.8	0.3
C	0.5	0.5	0	0.5
D	0.3	0.3	0.8	0

The output shows the expected behaviour: proportionally more cars going to and from C and the average journey times to C increased. The output for the two cases is shown below

Base case

```
Total number of cars: 49
Average journey duration: 87

From A:
     Total: 12, Average time: 104
     A->B:: Total: 5, Average time: 109
     A->C:: Total: 4, Average time: 96
     A->D:: Total: 3, Average time: 109

From B:
     Total: 13, Average time: 71
     B->A:: Total: 5, Average time: 68
     B->C:: Total: 3, Average time: 61
     B->D:: Total: 5, Average time: 80

From C:
     Total: 13, Average time: 92
     C->A:: Total: 6, Average time: 82
     C->B:: Total: 3, Average time: 107
     C->D:: Total: 4, Average time: 95

From D:
     Total: 11, Average time: 83
     D->A:: Total: 4, Average time: 89
     D->B:: Total: 4, Average time: 72
     D->C:: Total: 4, Average time: 91

To A: Total: 15, Average time: 79
To B: Total: 12, Average time: 96
To C: Total: 10, Average time: 84
To D: Total: 12, Average time: 92
```

Planned Shopping Centre

```
Total number of cars: 49
Average journey duration: 87

From A:
      Total: 12, Average time: 104
      A->B:: Total: 5, Average time: 109
      A->C:: Total: 4, Average time: 96
      A->D:: Total: 3, Average time: 109

From B:
      Total: 13, Average time: 71
      B->A:: Total: 5, Average time: 68
      B->C:: Total: 3, Average time: 61
      B->D:: Total: 5, Average time: 80

From C:
      Total: 13, Average time: 92
      C->A:: Total: 6, Average time: 82
      C->B:: Total: 3, Average time: 107
      C->D:: Total: 4, Average time: 95

From D:
      Total: 11, Average time: 83
      D->A:: Total: 4, Average time: 89
      D->B:: Total: 4, Average time: 72
      D->C:: Total: 4, Average time: 91

To A: Total: 15, Average time: 79
To B: Total: 12, Average time: 96
To C: Total: 10, Average time: 84
To D: Total: 12, Average time: 92
```

4.1.2 Congestion Charge

This scenario is similar to the Shopping Centre example but this time we are reducing demand for journeys to one node in the network by introducing a toll in the road system. We should see a reduction in journey times as congestion is reduced.

In this case we used the following trip matrix and got the output below, which supports the case for a congestion charge at C reducing journey times

	A	B	C	D
A	0	0.5	0.1	0.3
B	0.3	0	0.1	0.3
C	0.3	0.3	0	0.3
D	0.3	0.5	0.1	0

Planned Shopping Centre

```
Total number of cars: 66
Average journey duration: 61

From A:
     Total: 12, Average time: 88
     A->B:: Total: 5, Average time: 92
     A->C:: Total: 3, Average time: 83
     A->D:: Total: 4, Average time: 88

From B:
     Total: 21, Average time: 56
     B->A:: Total: 8, Average time: 46
     B->C:: Total: 3, Average time: 46
     B->D:: Total: 10, Average time: 67

From C:
     Total: 7, Average time: 109
     C->A:: Total: 1, Average time: 162
     C->B:: Total: 3, Average time: 115
     C->D:: Total: 3, Average time: 86

From D:
     Total: 26, Average time: 41
     D->A:: Total: 7, Average time: 37
     D->B:: Total: 18, Average time: 40
     D->C:: Total: 18, Average time: 74

To A: Total: 16, Average time: 49
To B: Total: 26, Average time: 59
To C: Total: 7, Average time: 66
To D: Total: 17, Average time: 75
```

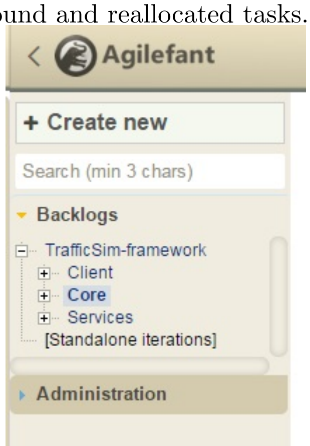
5 Teamwork

We started out by assessing the skills of each team member and breaking down the task into smaller sub tasks. We then made an initial allocation of team members to sub tasks based on our assessment of matching skills to the tasks.

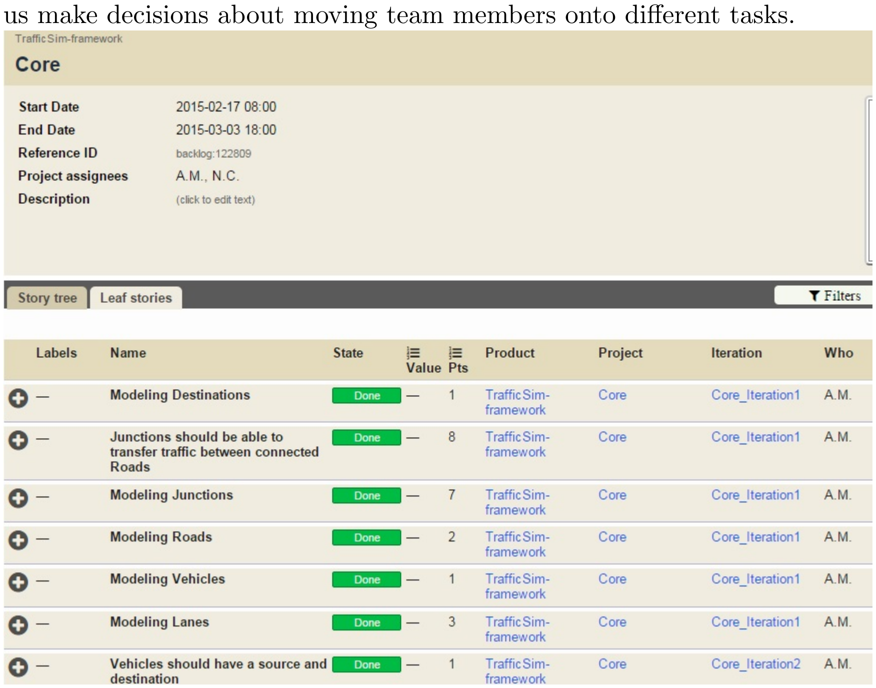
On a day-to-day basis we tracked the progress of the project by using an online task and project management web system called Agilefant.

Agilefant allows one to set up projects, assign team members, break the project down into major tasks and split the tasks down into smaller sub tasks and set up dependencies between the small tasks.

In our case we broke the software down into core, client and services and initially allocated at most two team members to each section. As time progressed, based on how quickly we were getting different sections done and depending on if there were dependencies which needed to be worked on, we moved people around and reallocated tasks.



Agilefant allowed us to see at a glance how the small tasks within each of the major subtasks was going and how we were progressing towards our target. It also alerted us to any dependencies which needed doing urgently and helped us make decisions about moving team members onto different tasks.



TrafficSim-framework

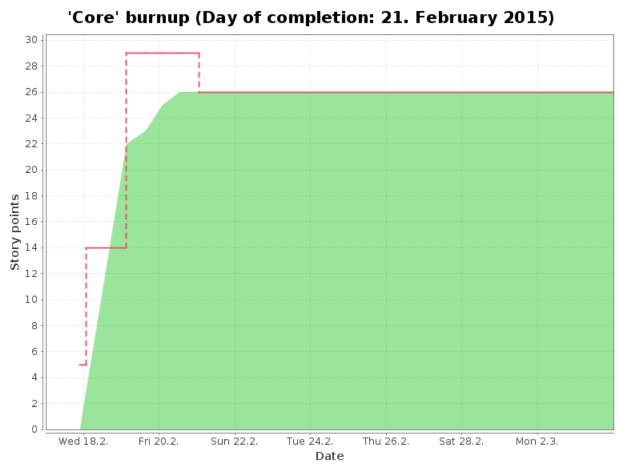
Core

Start Date	2015-02-17 08:00
End Date	2015-03-03 18:00
Reference ID	backlog:122809
Project assignees	A.M., N.C.
Description	(click to edit text)

Story tree | Leaf stories | Filters

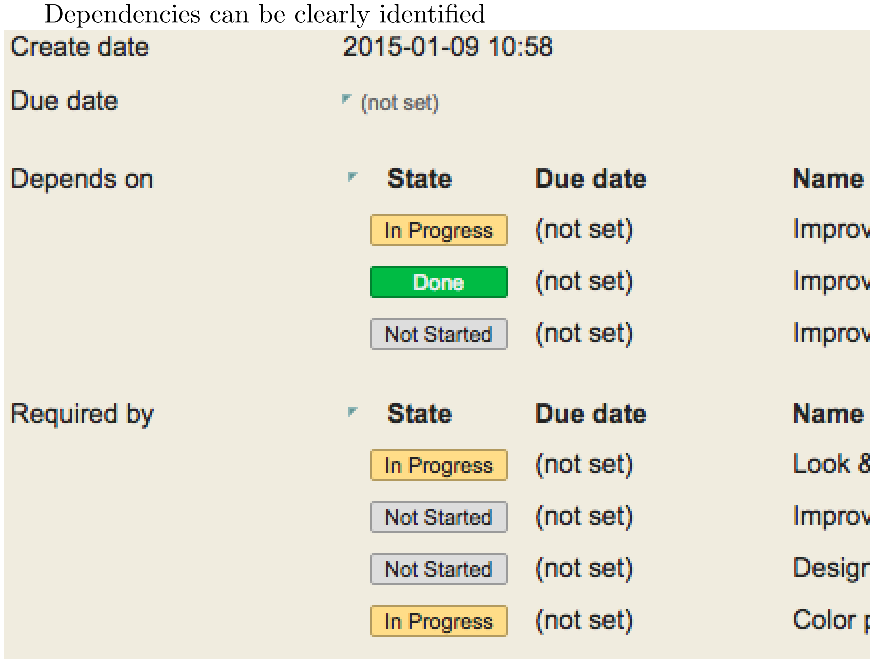
Labels	Name	State	Value	Pts	Product	Project	Iteration	Who
—	Modeling Destinations	Done	—	1	TrafficSim-framework	Core	Core_Iteration1	A.M.
—	Junctions should be able to transfer traffic between connected Roads	Done	—	8	TrafficSim-framework	Core	Core_Iteration1	A.M.
—	Modeling Junctions	Done	—	7	TrafficSim-framework	Core	Core_Iteration1	A.M.
—	Modeling Roads	Done	—	2	TrafficSim-framework	Core	Core_Iteration1	A.M.
—	Modeling Vehicles	Done	—	1	TrafficSim-framework	Core	Core_Iteration1	A.M.
—	Modeling Lanes	Done	—	3	TrafficSim-framework	Core	Core_Iteration1	A.M.
—	Vehicles should have a source and destination	Done	—	1	TrafficSim-framework	Core	Core_Iteration2	A.M.

The burnup chart shows completed tasks in green against the total scope of



the sub-project.

Dependencies can be clearly identified



The sub-teams for the sub-projects core, client and services each consisted of one or more team member(s) at any one time. There was overlap as any team member might be in more than one sub-team at any one time. We allocated one person to be the team leader for each sub team at any one time. The team leader was responsible for allocating tasks within the sub-team and also for identifying any problems and dependencies. The sub-teams worked independently from each other and could organise their own meetings or ways of working as they saw fit.

We had weekly whole team progress meetings to evaluate how each sub-team was performing and discuss any necessary changes to the overall structure of the group or of the project. The team leaders for each sub-team reported to the whole group and made recommendations about resourcing which were discussed and agreed upon at the meeting. Any changes agreed were recorded and subsequently emailed to all team members.

6 Evaluation

6.1 Initial aims

6.2 Changes

6.3 Possible improvements

6.4 Future work

As a group we discussed ways we would improve this project

7 Peer Assessment

Name	**Points**
Nathalie Caliacmani	20
Amar Menezes	20
Belema (Emily) Norman-William	20
Paul Orlean-Taub	20
Anthony Sellen	20
Sum	**100**

References

[1] Daphne Berdahl. " go, trabi, go!": Reflections on a car and its symbolization over time. *Anthropology and Humanism*, 25(2):131–141, 2000.

[2] WR Blunden. Congestion-friend or foe? In *University of Wollongong Vice-Chancellor's Seminar, 1983 Wollongong, New South Wales, Australia*, 1983.

[3] Benz & Co. Fahrzeug mit gasmotorenbetrieb. Patent, January 1886.

[4] E. Eckermann. *World History of the Automobile.* Society of Automotive Engineers, 2001.

[5] D. Miller. *Car cultures.* Materializing culture. Berg, 2001.