

MODELLING ADAPTIVE SIGNAL CONTROL REALISTICALLY

Eva Martinez,
School of the Built Environment, Napier University, Edinburgh, Scotland.

John Spence,
JSTSM Ltd. 2, Riverside, Calne, Wiltshire.

Pete Sykes
SIAS Ltd. 37 Manor Place, Edinburgh, Scotland.

INTRODUCTION

Microsimulation has brought major improvements to modelling through a detailed and realistic representation of traffic behaviour. It is increasingly becoming an important tool in the assessment of a wide variety of transport aspects, including new transport schemes and signal installations, structure and local plans impact assessment, event planning etc. Very often, systems to be tested or the network to be modelled include signalised junctions controlled by fixed time, vehicle actuation, or the adaptive control systems SCOOT and MOVA. It has been possible to model fixed time and VA signals for a long time. However, it has not been until very recently that linkages to dynamic signal control systems and microsimulation have become available to modelling professionals.

The recent release of PCMOVA, the PC implementation of MOVA traffic signal control for microsimulation, now allows for a realistic representation of traffic and allied signal behaviour. Through tests involving PCMOVA and S-Paramics, this paper will provide a better understanding of how differences in modelling techniques, specifically those which determine characteristics of traffic flow arrivals at signalised intersections (i.e. variability and correlation) can affect the evaluation of performance of a MOVA controlled simulated junction. Results from these tests will show the effect of changes to these variables.

MOVA

MOVA (Microprocessor Optimised Vehicle Actuation) was developed by the Transport Research Laboratory (TRL) in the UK in the 1980s. It is a self-optimising signal system to control independent signal controlled junctions, and has been extended to control many co-ordinated control systems.

MOVA detects vehicles on the approaches using inductive loops, and is designed to cater for the full range of traffic conditions from very low flows through to oversaturated conditions. This is achieved through two operational modes: in its uncongested mode, MOVA seeks to optimise competing demands on the approaches by minimising delays; when congestion occurs on one or more approaches MOVA switches to a capacity maximising procedure.

ARRIVAL PATTERNS AND ADAPTIVE TRAFFIC CONTROL SYSTEMS

Numerous micro-simulation and field tests have compared a variety of adaptive systems to fixed time and vehicle-actuated control. In general terms, nearly all have proven the advantages of the former - see for example: Martin *et al.* (2003), Jhaveri *et al.* (2003), Thomas *et al.* (2004), Li *et al.* (2006) and Doshi *et al.* (2006)

Specifically to MOVA, the published evaluations come primarily from TRL. This consists of two project reports: PR/TT/096/97 '*M1 Junction 21 assessment of MOVA signal control*' (Vincent, 1997) and PR/TT/172/97 '*M1 Junction 21 further assessment of VA vs. MOVA control*' (Vincent, 1997). (Results of this study were published in TEC) And two research reports: RR 170 '*MOVA: Traffic responsive, self optimising signal control for isolated junctions*' (Vincent and Peirce, 1988) and RR 279 '*MOVA: The 20 site trial*' (Peirce and Webb, 1990). Other tests are Meehan (2003) and the evaluation reports from several junctions in Area 11, including M40-J15, M42-J10, and M1-J24 (TEC 2007).

These studies were done by testing real life installations which limited the scope of the study to the conditions found at those sites. Because it is based in simulation, in this study we are able to generate various sets of demand characteristics and examine a range of options.

The most important feature of ATCSs (Adaptive Traffic Control Systems) performance to be studied is their response to traffic demand characteristics. ATCSs perform well when operating with atypical demand, since atypical demand patterns require a dynamic variation in green times to adjust to conflicting demands. This behaviour is what an adaptive system is designed to provide. Simple modelling may give flat and similar demand on all approaches and the advantage of an adaptive system will be reduced. In effect it has no variation to which it can adapt.

TESTS

The purpose of this series of tests was to quantify the effect of variation in demand on the performance of a MOVA controlled model and to discover how much changing the modelling techniques may be able to influence the results of the tests.

The tests were carried out in S-Paramics with the controller PCMOVA V1.0.0. In simple terms, PCMOVA is a PC version of the on street MOVA M5 system for use in junctions modelled in microsimulation. The Paramics version of PCMOVA used here was developed in 2006 in collaboration between traffic and transportation consultancy SIAS Limited and TRL Limited.

For both tests, the effectiveness of the systems was measured by using the average time taken by vehicles to complete the journeys between origin and destination zones in the model.

Test no 1: variability and correlation

First, a stylised, hypothetical T-junction was modelled. This was an urban junction of standard lane widths (3.65 and 3.7 meters) and maximum permitted speeds of 30 mph. Separate lanes were available for right turners travelling from east to south and for those turning from the south into the major road. Demands from each zone were programmed into the model and a MOVA database was created to control the junction. Figure 1 shows the junction .

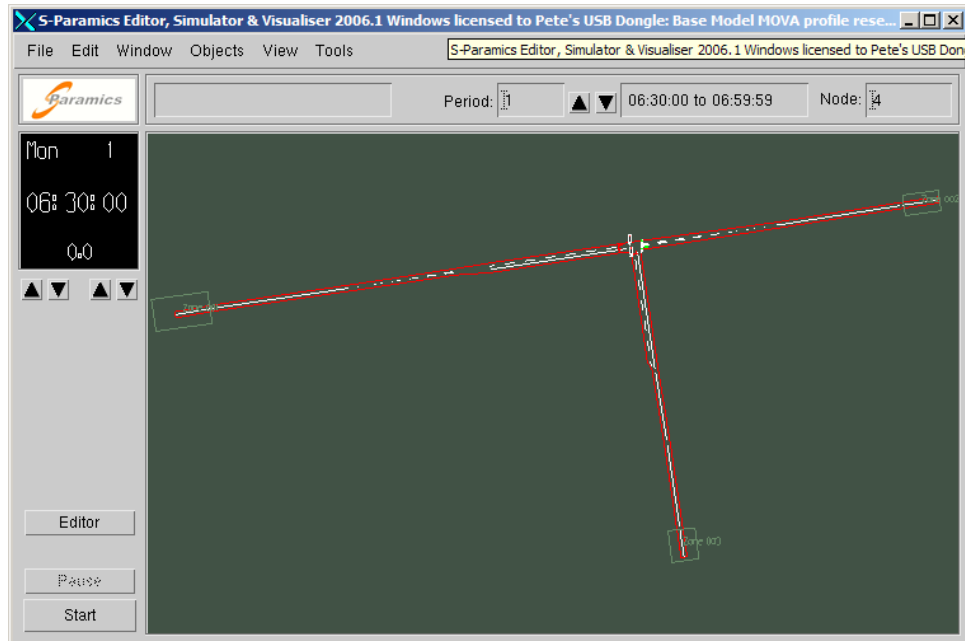


Figure 1. The modelled junction

In order to quantify the performance of the model with signal control under different situations a range of release profiles were created. Profiles describe the total demand for a specified period in 5-minute intervals. Demand for each 5 minute block is set by the user, which allows for the controlled creation of peaks and troughs in the demand during the period. For simplicity, the junction ran on two profiles: profile 1 was applied to the movements coming from the east and west and profile 2 was applied to demand from the south. Total demands were designed to represent moderately saturated conditions.

Variability in the demand was achieved by means of adjusting these profiles and the variability measured with the standard deviation. Standard deviation values used are shown in table 1. The range of values was chosen to give realistically sized queues on each arm of the junction and to be subjectively in agreement with ranges anticipated in reality.

Correlation between the two profiles describes how the flows in each profile change in relation to each other. A correlation coefficient of 1 indicates that one flow rate rises and falls in synchronisation with the other, a value of -1 indicates that one is rising as the other is falling and a value of 0 means that they are varying independently.

Table 1 shows the values that were used in the tests.

Standard deviation	Correlation
0.0	1.0
0.005	0.7
0.010	0.2
0.015	0.0
0.020	-0.2
0.025	-0.7
	-1.0

Table 1. Standard deviation and correlation values

Standard deviation and correlation values were combined to create 36 possible scenarios. In each profile, flows changed every 15 minutes to represent traffic variations within the peak. Figure 2 shows profiles 1 and 2 from an example of a scenario used. In this case the

correlation of -0.7 indicates that as one flow rises, the other falls which is clearly seen in the profiles.

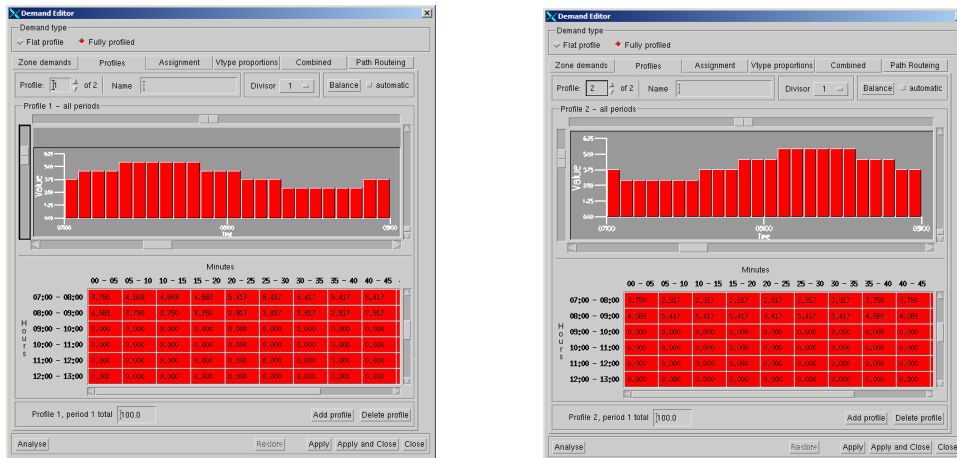


Figure 2. Test Scenario: Standard deviation 0.01, Correlation -0.7

First, in order to create a baseline, the junction was modelled with an optimised fixed time plan with a cycle of 120 seconds. Then the same model was run with PCMOVA and the same path times measured.

The use of PCMOVA required that loops were positioned in the model as they would be in a real MOVA installation on each approach. The position of the IN and X-detectors is shown in Figure 3. Detector positions are calculated based on the speed of vehicles as they discharge during the green time.

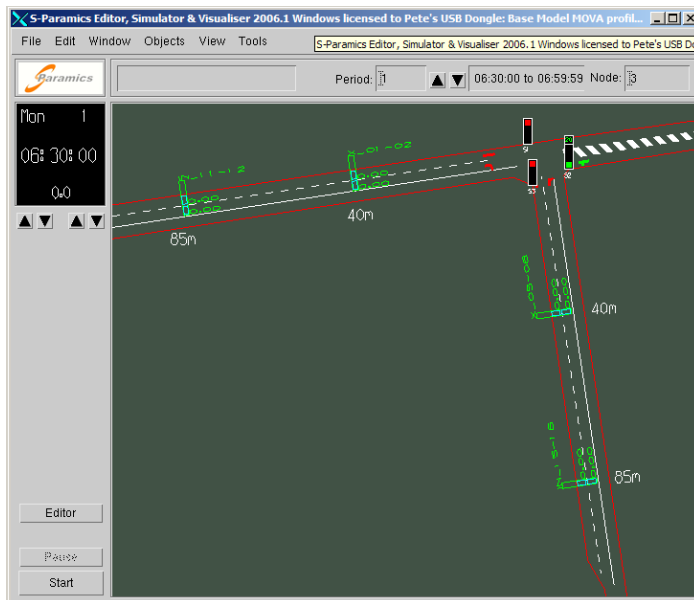


Figure 3 Positions of MOVA loops

Test no 2: gaps in arrival flow

The second test was designed to measure the effect of gaps in arrival flow on MOVA performance. Two T-junctions were modelled for this experiment. Junction 1 (fig. 4) was designed including long lead-ins, gradients and curves. This design was devised to facilitate

the creation of platoons along the arms, which will inevitably lead to gaps in arrivals. An additional detector placed next to MOVA IN-detector was used to measure headways between vehicles and therefore gaps. As a control, the same junction was modelled with short lead-in arms to reduce platoon formation.

In this test journey times from origin to destination zones would not be comparable and hence statistics were collected for paths leading up to the junction. The same paths are used in both models ignoring the long arms lead-ins so that results are comparable.

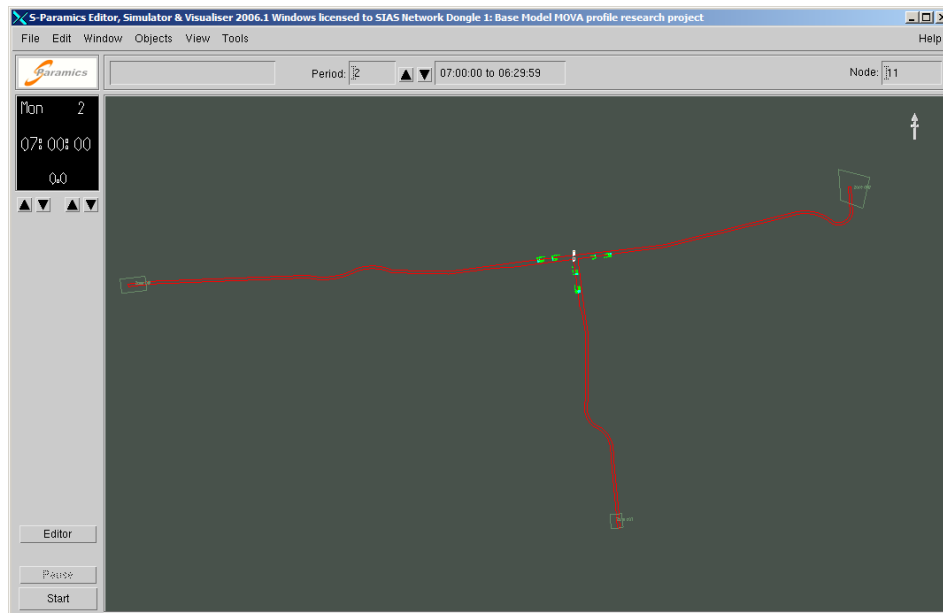


Figure 4 Model with long lead-ins for platoon formation.

S-Paramics simulates the variation in behaviour of vehicles through their aggression and awareness properties. As vehicles proceed along the longer arms towards junction 1 the variation in target speed leads to platoon formation and hence to formation of gaps. The size and number of gaps may be influenced by various modelling parameters.

- Aggression and awareness. A distribution of these two attributes leads to a variation in vehicle behaviour.
- Headway. Larger headways imply more widely spaced, less compact platoons.
- Signals on the approach arms. This modulates flows to create waves of vehicles.

In the baseline case awareness and aggression were set to be the same for all vehicles and hence platoon formation and gap availability was minimised. A custom version of S-Paramics was also made available in which vehicles were released at regular intervals with no random variation in gaps.

Results and future work

The results of these tests will be presented at the JCT symposium. It is expected that the results will demonstrate how the performance of MOVA, measured in the model, is influenced by different modelling techniques.

Further work will be required to determine how real traffic variations can best be modelled using the parameters available. Then modellers and reporting authorities will be in a position

to evaluate if the model used to evaluate the MOVA installation was truly representative of the location where MOVA may be installed.

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