INNOVATION TECHNOLOGY – FOR SELECTED VEHICLE PRIORITY

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ABSTRACT

Leeds City Council has pioneered new ways of harnessing bus AVL technology to provide greater journey time benefits. As well as making more sophisticated use of local priority, new 'STM' software has been developed to deliver programmable bus priority.

The programmability provided by 'STM', is complemented by the flexibility of the AVL system to provide a very powerful tool capable of solving almost any priority problem.

This paper shows how these technical solutions were developed and how they are being implemented along a Showcase bus priority route across the city of Leeds. The aim of which is to deliver a 5 minute journey time saving, and improve the bus timetable variability.

INTRODUCTION

Leeds, as part of the West Yorkshire Local Transport Plan (LTP), is actively involved in the Yorkshire Bus Initiative. A large part of this initiative relates to delivering Real Time Passenger Information (RTPI) across the entire bus network via a contract with ACIS. ACIS, using Automatic Vehicle Location (AVL) technology, started rolling out RTPI in the summer of 2006 to the two main bus operators in Leeds.

However, the RTPI technology is being harnessed to provide bus priority at traffic signals, both via local and central radio links. Where central radio is used, signal priority is provided by a complementary technology - a centralised software system known as 'STM' (Strategic Traffic Management). STM began its development as a Priority Tool developed by Leeds City Council under the DfT sponsored UTMC01 project (*Connection of Multiple UTC tools at the In-station*). After successful trialling a prototype (known as SPRUCE) version of the software in both Sheffield and Leeds, Leeds City Council funded a software development contract with TSEU (Microsense) to develop the software as 'STM' into a more robust software product.

As part of the Yorkshire Bus Initiative a showcase route across the city has been selected. This will run new FTR 'Future' buses (fig 1), with signal priority provided across the entire route. This paper relates to this showcase route, which consists of 11 junctions and 9 pedestrian crossings.

Leeds has committed to saving 5 minutes during an AM or PM peak round trip.

Fig 1

NEW APPROACHES

Automatic Vehicle Location (AVL)

The RTPI system uses AVL technology to track the buses. To provide bus priority using local priority hardware, the system uses designated trigger points ('virtual loops') to determine the location of the bus (fig 2).

Where 'local' priority is specified, when a bus reaches the designated trigger point a message is sent via low power radio to the traffic signals several hundred metres away. To extend the use of AVL to the centrally controlled STM software, the buses are also capable of transmitting a radio signal at a higher power which is picked up by a radio mast sited within Leeds.

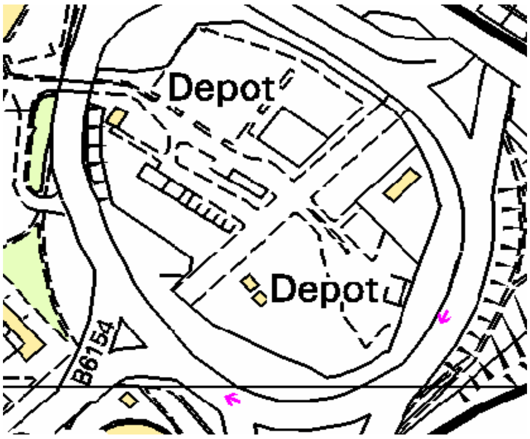


Fig 2

Local Priority Hardware

The local priority hardware consists of a relay card and PSU card mounted within the traffic signal controller casing. A cable is run to the receiver aerial which is mounted within the traffic signal head, ensuring complete protection from the environment and vandalism.

Fig 3

The standard controller inputs are used, commonly called ‘priority vehicle bits’ which will hold the vehicle stage for the duration that the appropriate relay is active. This continues until either the bus passes the clear loop, or the override timer is reached, at which time any stored pedestrian demand will be served.

Also, two simple junctions are to be fitted with units. Again the relay inputs can use the standard controller inputs to provide ‘Hurry calls’ and ‘green holds’, or by specifying logic within the controller to provide more subtle control.

Below is a schematic of how a simple local controlled junction/crossing would work:

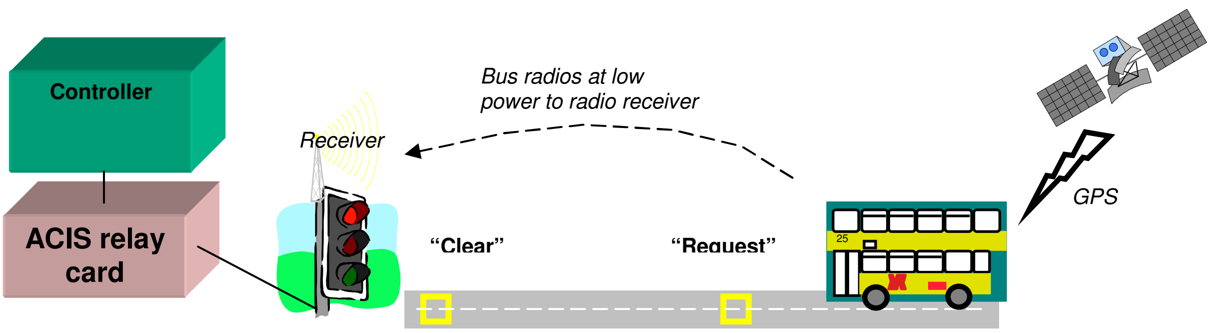


Fig 4

PROGRAMMABLE BUS PRIORITY (STM)

A system was needed to give far more flexibility than the simple ‘Hurry call’ or ‘green hold’ provided by the local priority units. Junctions are often unsuitable for local priority, either because of the control environment or by their complexity. In particular the junctions controlled under fixed time Urban Traffic Control (UTC), in and around the city centre of Leeds, need strict coordination for vehicle progression and safety. So clearly a system was required which was capable of maintaining necessary coordination, whilst also allowing bus priority to be implemented. This could only be achieved using a centrally delivered priority system such as STM.

STM functionality

STM is a software based priority system, capable of overriding the control messages from a centrally delivered UTC system, in ways which can be pre-programmed. STM in fact provides near unlimited programmabilty, allowing signal designers the flexibilty to write ‘special’ logic capable of solving most priority problems.

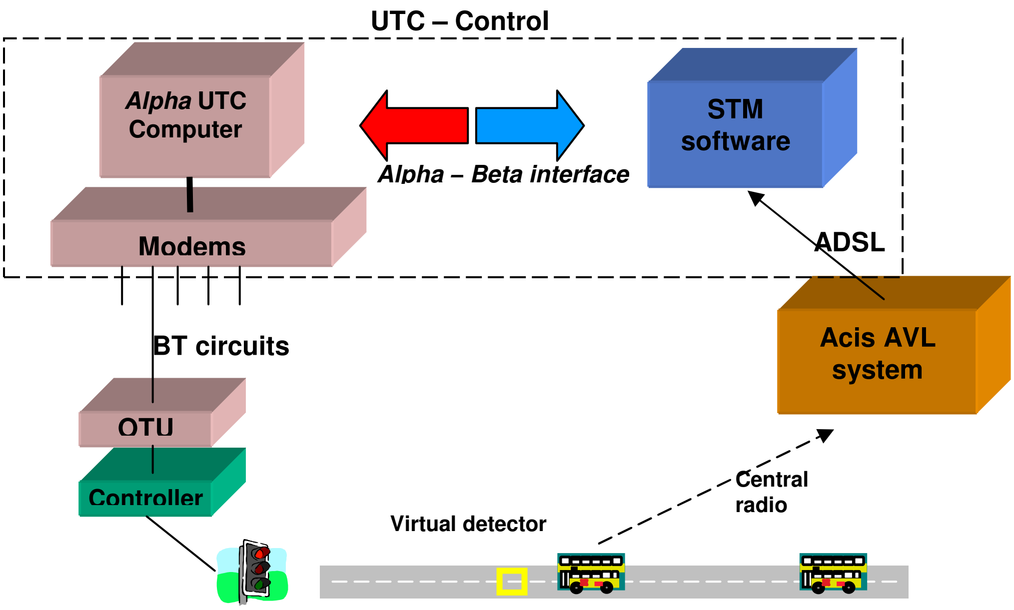


Fig 5

The flexibility provided by STM, is complemented by that provided by the AVL system. The AVL ‘virtual bus’ detectors can be so easily relocated or replicated so that they can be positioned and fine-tuned to match the logic developed in a particular STM strategy. This makes it possible to tackle more complex situations, for example allowing selective priority through a signalised roundabout, but also to achieve more effective results than by any other means. STM, by virtue of its powerful user programmable logic and its ability to allow programmed plan changes, can effectively provide a comprehensive ‘toolbox’ of strategies, based on the cumulative experience gained in such locations as Leeds and Sheffield.
Several example strategies have been developed by Leeds over the previous 6 years using the prototype version of STM. Two were implemented on street, and are outlined below:

Sheffield Tram, Manor Top (from 2000) –Average tram delay reduction through 2 junctions is 13 seconds per junction.

Leeds Bus Guideway, Halton Dial (from 2002) – Average bus delay reduction, through 2 junctions is 12 seconds per junction.

STM Architecture

The architecture of the developed version of STM is based around an SQL database. This stores the data required to run; node configurations, plans, AVL detector inputs, and the programmable logic that drives the system.

The system is synchronised to the UTC 'Alpha' computer, and when controlling signals on-street it monitors detector inputs, processes logic, runs plans, and outputs the necessary stage forces every second. The components making up the system are outlined below (fig 6):

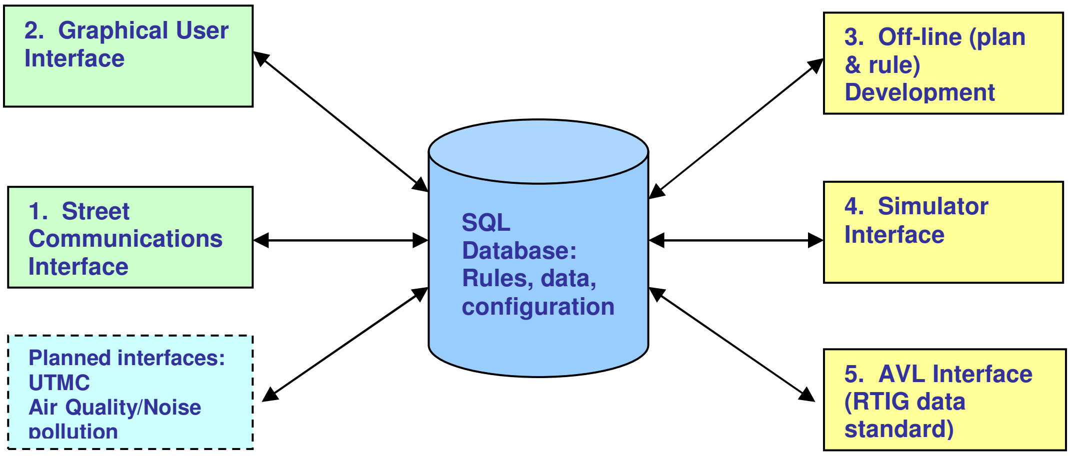
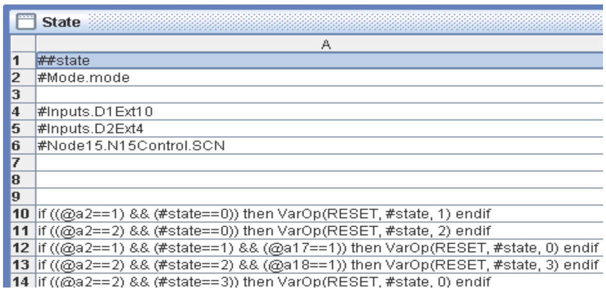


Fig 6

1. Street Communications Interface
The database interfaces to the street communications via existing UTC infrastructure. It achieves this via a specific (UTMCO1) interface, which enables STM to take control of a traffic signal network via a host UTC system. In one direction STM receives vehicle detector data and Green confirmation information, and in the other direction it sends back signal control messages.

2. Graphical User Interface (GUI)
A GUI is provided to enable the user to both monitor and influence STM run-time operation.

3. Off line (plan & rule) Development Tool (ODT)
The ODT is used entirely off-line to configure plans and related logic sheets. Users are provided with a 'cell based' language to configure plan selection logic, this includes pre-defined maths, Boolean, time-related and plan-related functions. Users can also define their own functions where repetitive logic elements are required (fig 7).



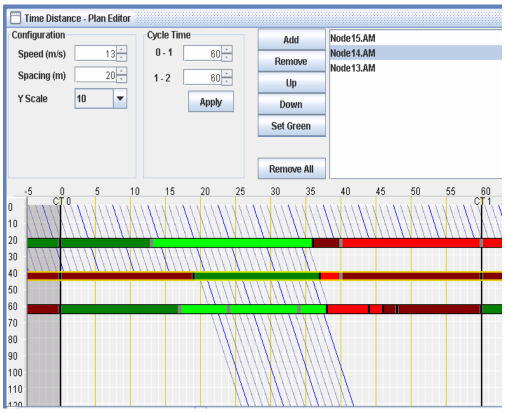


Fig 7

Theatrically presented with a 'blank sheet' for each logic configuration, in practise users will often re-use elements of previously generated code, and will be actively encouraged to adopt standardised logic and structures by the STM User Group.

4. Simulation interface
An interface to micro-simulation models will allow new plans and control logic to be designed and tested using traffic simulations, before these are transferred to the online database for deployment on-street.

5. Automatic Vehicle Location (AVL) Interface
An interface to an AVL system is provided based on the RTIG data standard. This allows buses to communicate their position at trigger points to STM, via a centralised AVL system.

IMPLEMENTATION

So choice of local or central priority depends on the characteristics of each set of signals. The signals on the Showcase route in Leeds can be split into three technology groups:

Local priority - Pedestrian Crossings (Latched mode), 9 on route
Simple pedestrian crossings can be dealt with effectively using the local priority radio link.

Local priority – Junctions (RTIG2 mode), 2 on route.
Simple junctions not under central UTC control, can be dealt with using local priority in a similar manner to pelicans

Central priority – Junctions (STM), 9 on route
There are 4 junctions on the Showcase route located just outside the city centre transport loop, these are centrally controlled by the UTC computer and will be implemented with STM. A further 5 junctions outside the city centre will also be controlled via STM due to their complexity.

The commercial version of STM, engineered by TSEU, has now completed it initial testing and is being used to implement bus priority along the showcase route in Leeds. Several junctions have now been implemented with the remaining junctions due to be completed Summer 2007.

Central priority example

Woodpecker junction is located at the intersection of several radial roads and the Leeds Inner Ring Road, it is a complex multi-node junction and close to saturation. However, it is 'multi-node' junctions, in which the various traffic conflicts are controlled by separate coordinated nodes, for which STM is arguably best suited.

The Woodpecker junction is based on a system of five signalised nodes and whilst the increasing traffic has not fully saturated any of the nodes, it has led to increased bus delays – particularly on the north-south movement (through nodes 1-2-3).

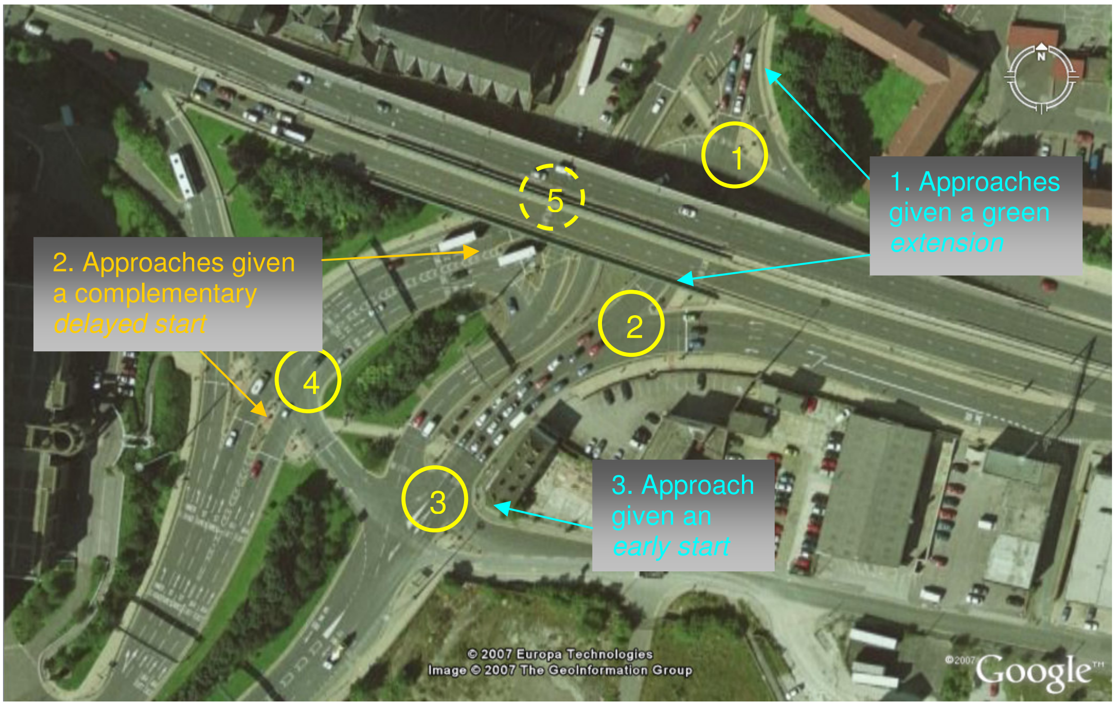


Fig 8

It has so far proved impossible to significantly reduce the peak period bus delay, despite the introduction of a bus lane on the approach to node 1 from the north. The situation is made more difficult by a requirement to maintain strict coordination between the various nodes, which makes the provision of a significant level of dynamic bus priority virtually impossible with current UTC systems in the UK. However, with the availability of STM, it is now possible to code up a priority strategy to make priority changes at one node, and to complement these by making changes at adjacent nodes.

The target delay reduction for inbound buses in the peak periods at Woodpecker is 30 seconds (10% of the total), and current progress suggests that this is likely to be substantially achieved. This delay reduction is largely to be provided by ‘extending’ the inbound green on the approach to node 1 from the north. *Extensions* are usually particularly effective because they provide a substantial benefit to that proportion of buses which suffer the worst delay; those buses which have ‘just’ missed the green. This has the advantage of reducing the delay ‘variability’ in addition to reducing the delay ‘average’. Specifically, because of the coordination in place at the Woodpecker junction, *extensions* are considered the only sensible option for node 1.

In order to preserve coordination throughout the 5 nodes, the provision of an *extension* at node 1 requires the following complementary measures to be implemented via STM:

- *Extending* the southbound green at node 2 (approach below the flyover in Fig. 8)
- *Delaying* the start of the north bound green at nodes 4 and 5 (node below the flyover in Fig. 8)

The overall strategy is completed by ensuring that the southbound green at node 3 is started earlier than normal, in order to clear the extra queuing traffic released from nodes 1 & 2 by the green extension.

Such dynamic priority can cause a dis-benefit to other vehicles and sometimes other buses – in this case the northbound approach suffers some extra delay. In specific cases the use of ‘compensation’, where average green time is restored over subsequent cycles, will be advantageous. In general, however, there will be a relationship between the amount of priority which can in practise be given, and the frequency of the priority events. One advantage of *extensions* is that, provided the extension given is a small proportion of the cycle time, they will tend to occur infrequently - and will therefore coincide with buses on conflicting approaches even less frequently. Using the related AVL system to only flag up ‘late’ buses, is another way of reducing the effective frequency of priority events.

APPENDIX

Title of figures