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SCATS Virtual Bus Priority & Information System - Dublin City

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Abstract

Dublin City Council (DCC) has designed a selective bus priority solution that utilises their investment in SCATS traffic management and GPS-based bus tracking and information systems technology (AVLC) to deliver selective priority services with no additional roadside infrastructure. Bus priority schemes typically require roadside devices to instigate priority, but the Dublin solution makes use of a new centralised software solution that establishes virtual detection zones across the City to effect priority based on a defined set of parameters. SCATS incorporates an API allowing external applications to interface with traffic signal operation. Dublin Bus AVLC system provides a SIRI VM data feed which contains the position of each in-service bus in the fleet at a polling period of approximately 20 seconds. Data on whether the bus is in congestion or free-flowing and if the bus is loading passengers at a bus stop is also contained in this data feed. The new Dublin Public Transport Interface Module (DPTIM) bridges the gap between SCATS and the AVLC systems by integrating these systems through a specially designed and low cost software solution implementing traffic signal priority for the City's bus network, particularly along Dublin's strategic corridors.

Keywords:

SCATS Bus Priority

Introduction

In Dublin City, day to day traffic management is provided via SCATS (Sydney Coordinated Adaptive Traffic System). The main mode of Public Transport is by bus and the main operator is Dublin Bus, a State owned company with a fleet of over a 1,000 buses, most of which terminate in, or pass through, the city centre area; real-time passenger information is delivered through a GPS-based bus tracking solution (AVLC) and information signs to display next bus information. These solutions are commonplace throughout the World.

Dublin City Council (DCC) has designed a selective bus priority solution that utilises their investment in SCATS and AVLC to deliver selective priority services without the need for additional roadside infrastructure. Priority schemes typically require roadside devices to instigate priority, but the Dublin system uses a centralised software solution that establishes virtual detection zones across the City to effect priority based on defined parameters.

SCATS incorporates an API allowing external applications to interface with traffic signal operation. The Dublin Bus AVLC management system provides a SIRI VM data feed which contains the position of each in-service bus in the fleet at a polling period of approximately 20 seconds. Data on whether the bus is in congestion, free-flowing or loading passengers at a bus stop is also contained in this data feed.

The new Dublin Public Transport Interface Module (DPTIM) bridges the gap between SCATS and the Dublin Bus AVLC management system by integrating these systems through a specially designed and low cost software solution implementing traffic signal priority for the City's bus network.

The new software solution for DPTIM processes data inputs and outputs to/from bus feeds to SCATS. It accommodates a comprehensive database management system for processing data received from the buses and stores and manages a geospatial information system that permits map-based displays to be provided.

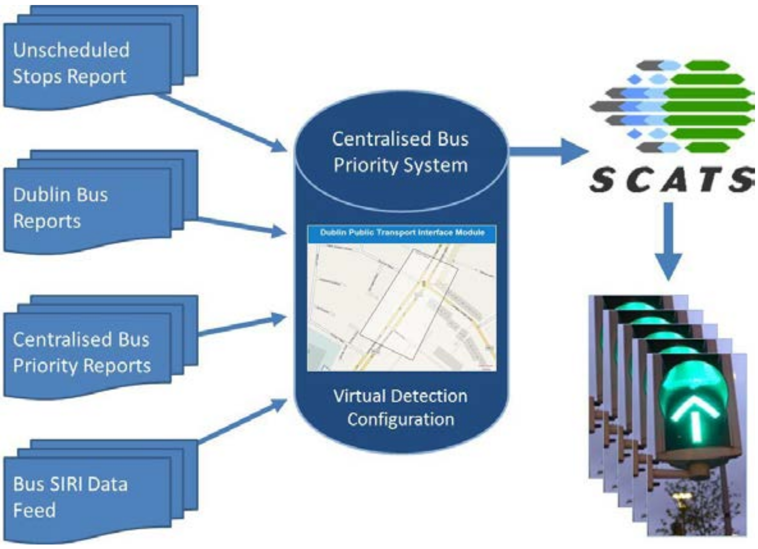


Figure 1 – System Overview

The map-based user interface displays the latest status of the locations of the public transport vehicles by mapping the real-time SIRI VM data feed. The application provides a drawing interface which allows the user to map out virtual detectors to be used as hot-spots and detector points within the road network. These virtual detectors can be configured for specific route/journey patterns with individual threshold values. Such thresholds can include, for example queuing time, the number of buses located within the geospatial area of that detector, or an acceptable journey time. Should the real-time values of these thresholds be breached, then the application calls a command on the SCATS/API. The execution of priority commands uses a number of different ITS port functions (Action Lists, Dwells) and manages detector behaviour at different time-of-day periods through a programmable scheduler.

Since implementation, DPTIM has produced significant improvements in average journey times which is easily quantified using the system's reporting function providing access to, and analysis tools for, collected data. All information is recorded and events and route performance can be reviewed at any time using the simulation mode. The new DPTIM application delivers a centralised network response to bus problem locations, not just an individual junction response but to corridors and city-wide routes via multiple junction adjustments.

Background

In Dublin City, the main mode of Public Transport is by bus; the main operator is Dublin Bus, a State owned company with a fleet of over a 1,000 buses, most of which either terminate or pass through the city centre area. Quality Bus Corridors are an initiative to give dedicated road space and traffic signal priority to buses in Dublin, in order to reduce journey times and improve service consistency.

Dublin City Council has invested significantly in ITS technologies over many years, including a comprehensive SCATS (Sydney Coordinated Adaptive Traffic System) network and Bus management and passenger information systems. This investment also included pilot and trial schemes using a SCATS API and real-time SIRI VM data feeds from Dublin Bus to explore the potential of centralising public transport priority. This application is known as DPTIM (Dublin Public Transport Interface Module).

This work over the past 3 years has shown the concept to be viable, but crucial to the design of any system that could be rolled-out across the network was the ability to very quickly handle the extensive bus data that would be presented from the fleet every 20 seconds, process and manage this data and instigate calls for priority to SCATS.

Nicander were engaged by Dublin City Council in 2014 to review this pilot and trial work and to develop a new processing engine capable of handling a network-wide implementation. The processing engine on the server side was implemented in 2015 and a new management interface was developed and installed by Nicander in May 2016. The new management interface has enabled more effective information management and reporting services to support Dublin's capability to understand behaviour and refine the management of its algorithms and virtual detector zones to further improve bus corridor performance.

In addition to the DPTIM solution, Nicander has delivered a new database solution to store the performance data of the quality bus corridors which will be provided monthly by Dublin Bus. This database will then be used as a base for a suite of reports to visualise the performance of the quality bus corridors in the city.

Solution Made Simple

The Dublin Bus AVL system provides a SIRI VM data feed which contains the position of each in-service bus in the fleet at a polling period of approximately 20 seconds. Data on whether the bus is in congestion or not and if the bus is loading passengers at a bus stop is also contained in this data feed. SCATS comes equipped with an ITS API, and third party applications such as DPTIM can connect to this API. The application can then receive data from the system and also make changes to the operation of any junction or junctions on the road network.

For bus priority intervention, the methods of giving priority are:

- Introduce a Bus Priority Timing Plan, which involves providing the timing adjustments for priority via a dedicated timing plan which can be automatically brought in for a specific time. This allows the traffic signals to be dynamically altered but still allowing the junction to stay in coordination with the overall route. In order to keep coordination, SCATS requires one complete cycle time prior to bringing in this bus priority intervention. At peak times, the maximum cycle time can be 120 seconds.
- Introduce an Immediate Green signal on detection of a bus. This method is very effective but the junction loses coordination with its adjacent junctions and thus SCATS needs time to recover.
- Implement a bias for the side road. This automatically configures the traffic signal behaviour to allow the main road to gap off thus ending its green signal if not busy. Then the green signal is released to the side road. This reduces wait times for buses on side roads.

The client DPTIM application is a map based user interface displaying the latest status of the locations of the public transport vehicles by mapping the real-time SIRI VM data feed. The application provides a drawing interface which allows the user to map out virtual detectors to be used as hot-spots and detector points within the road network. These virtual detectors can be configured for specific route/journey patterns with the threshold values. Such thresholds would be allowed for queuing time, or the number of buses located within the geospatial area of that detector, or an acceptable journey time. Should the real-time values of these thresholds be breached, then the application calls a command on the SCATS/API.

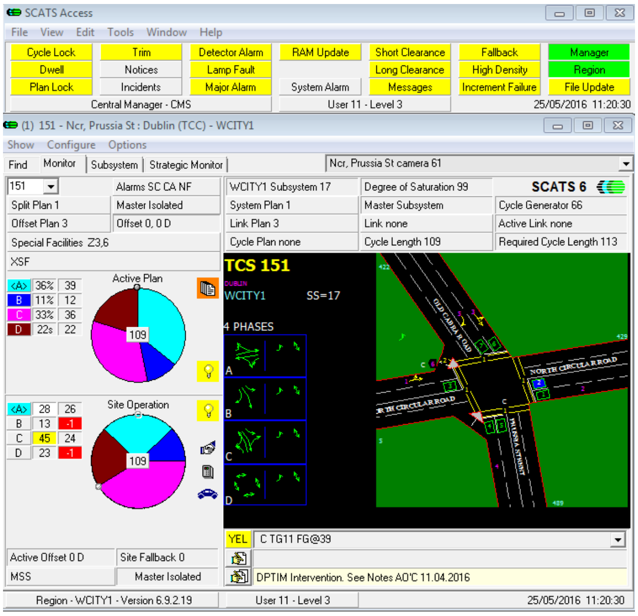


Figure 2 – SCATS Access

DPTIM Data Loader (Application Server)

The data loader is a C# component that runs on the DPTIM Application Server and subscribes to the AVLC SIRI data feed. It listens for SIRI standard XML messages via HTTP. On receipt of a message it parses it based on the SIRI VM documentation. The vehicle monitoring data received is written to the database.

DPTIM Server Component (Database Server)

The database receives bus position data from the data loader. It parses the data using a suite of stored procedures. The main procedure is constantly running and checks for new data to parse. Other procedures fire at configurable intervals using SQL Server Jobs. The database places messages that need to be sent to SCATS as a result of the calculations onto a queue.

DPTIM SCATS Bridge (Application Server)

This application provides a bridge between the business logic in the database and SCATS. It listens for XML messages, received via MSMQ, from the database and then makes calls into SCATS based on these requests.

DPTIM Client (Web Proxy)

The client is web based and uses PHP and ajax calls to interact with the database. It uses a map display as its main interface. It is used to configure the virtual detectors (or add new ones) and can display buses based on selected journey patterns.

DPTIM Reports

There is a suite of reports created in SQL Server Reporting Services.

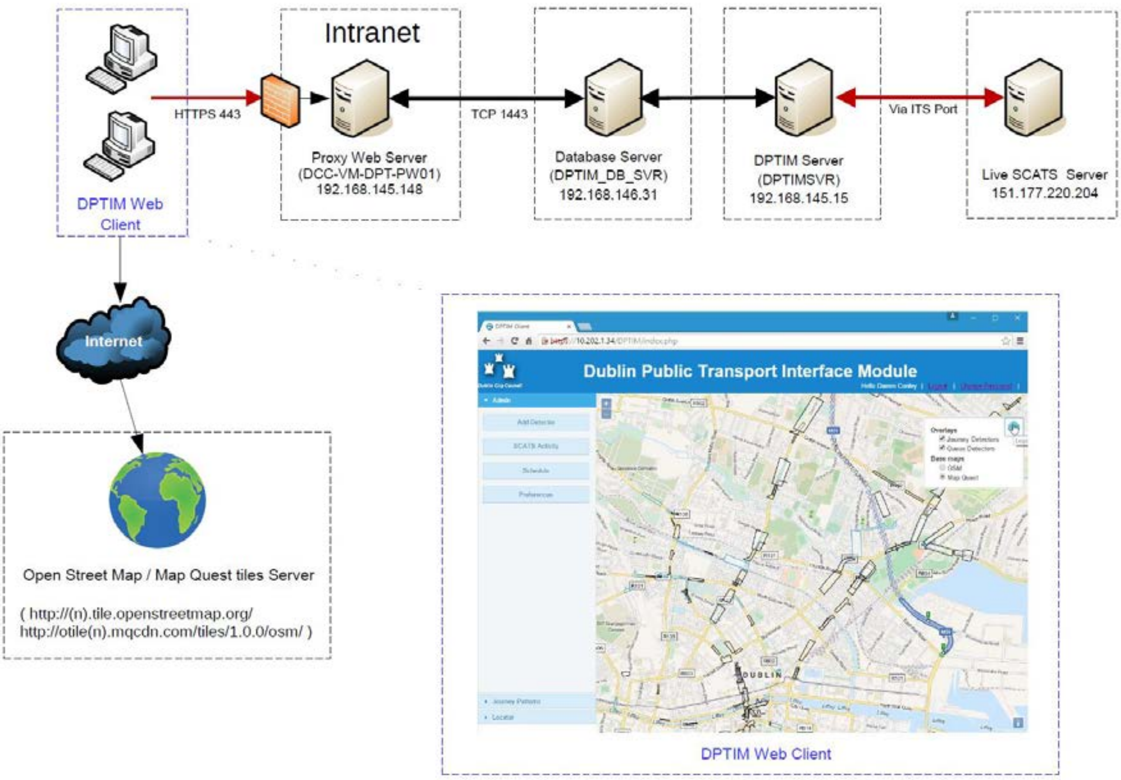


Figure 3 - DPTIM Client Network Diagram

Making the Data More Transparent

The new DPTIM solution provides Dublin City Council with a tool to make more sense of the data gathered and understand in far more detail the performance of its 16 bus corridors, bus routes and network pinch-points. In order for Dublin to evolve their understanding, Nicander has developed the software to enable the Dublin ITS team to create, manage, report and refine all parameters through configuration and not software coding. This means that they are fully in control of their analysis and operational delivery of bus priority signalling across the City.

Their objective has been to focus on the worst performing corridors and stop locations through the implementation of three options for resolution:

- Virtual Detection Priority (the focus for this paper)
- Civil works
- Traffic signal optimisation

The Dublin ITS team meet with the Dublin Bus operator every week to discuss and analyse Quality Bus Corridor route performance. Journey times are analysed and interventions are focussed on short distance management. All interventions are assessed using data from 3 days prior to the intervention and for 3 days after. Experience has shown that any interventions created are largely correct, but it is the ability to make minor changes to the virtual detection zones that is making key improvements to operational performance.

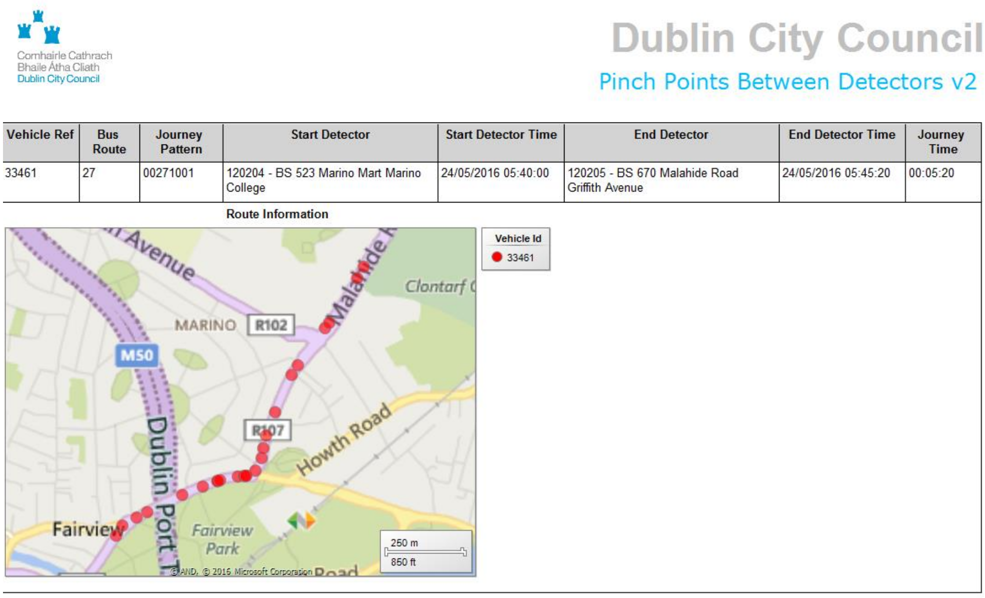
As the Dublin ITS team and Dublin Bus are still learning from the implementation of the new system, and only now have the tools to fully understand the impact of their priority interventions, they have decided their strategy is to keep things simple and to implement a straight-forward priority request at defined junctions on the network. The system has the functionality to use other data parameters to determine the applicability of a priority request to SCATS, but Dublin will introduce these through a continual improvement process rather than all at once. As each additional element of functionality is introduced, the Dublin ITS team and Dublin Bus will review each improvement to fully understand its benefits.

With a significant amount of data being processed by the application one advantage this provides is the different levels and views of transparency on the usage of the road network. The Journey Time Detector report gives the performance of each route/journey pattern for a defined section of the road network. Even though it is the same section of road, this may differ for each route/journey pattern and the buses for certain route/journey pattern may stop at different stops along the route and have different passenger on/off loading times.

The DPTIM system is configured to capture journey times for defined corridor segments. This journey time data is used as the basis of the Comparsion report, which is used to present “Before” and “After” performance regarding traffic management changes, ensuring a consistent level of service.

The Unscheduled Stops report identifies locations on the routes where a bus has been delayed for longer than a set parameter, e.g. 30 seconds. Such delays are referenced as the number of metres before or after the nearest bus stop. Thus the report consists of a list of bus stops with such delays ranked on the impact to the service servicing that bus stop. For each bus stop list, other quantifiable details are the number of times a bus was delayed, the number of trips when the delay occurred, and the average delay time. A corridor view of the Unscheduled Stops provides a more manageable method of addressing the delays. This report has proved to be very useful in highlighting delays and in providing a “before” and “after” picture as means of monitoring the impact bus priority would have in lowering the ranking of the delay and its impact on the service.

Further analysis can be provided in investigating the peaks of a journey time in the Comparison report. This is provided via the Pinch Points Between Virtual Detectors report. Taking the time values at the peak graph value, the pinch point reports present the vehicles that took the longest time for this corridor segment and also plots out their location at 20 second intervals on a map.



Vehicle Ref	Bus Route	Journey Pattern	Start Detector	Start Detector Time	End Detector	End Detector Time	Journey Time
33461	27	00271001	120204 - BS 523 Marino Mart Marino College	24/05/2016 05:40:00	120205 - BS 670 Malahide Road Griffith Avenue	24/05/2016 05:45:20	00:05:20

Figure 4 – Pointing the Way to Key Issues

Making Information Clearer

One of the issues of the previous pilot and trial implementations was the lack of clarity of data being presented. It became too difficult for the Dublin ITS team and Dublin Bus to identify performance improvements or negative impacts of interventions. Situational awareness was also lacking. Information was presented in numbers and graphs, but it was very difficult to quickly understand issues. It was very difficult to compare like-for-like to understand change.

This was a key requirement for the new Nicander system – to present information to enable ease of understanding and the flexibility to easily modify system configuration and reporting to cope with change. It was also a requirement to enable data to be used by other reporting engines to provide further insight into junction and corridor performance. The new platform makes it easy to filter information presentation to enable the user to quickly understand and analyse the data being presented.

Making the Data More Visual

The key change in the new system is to present users with 'Patterns' rather than simply numbers and to 'Visualise' problems. The ability to quickly drill-down into maps and reports to more easily make sense of the data was a critical requirement. The ability to layer information presentation would clear-up the displays so that issues could more readily be understood. The new system has enabled the data to tell the user where the problems are, and for the patterns to quickly show opportunities for improvement.

There a number of products on the market today, to help users visualise patterns. Once such product the Dublin ITS team is currently using is Tableau, as shown in Figure 5 below.

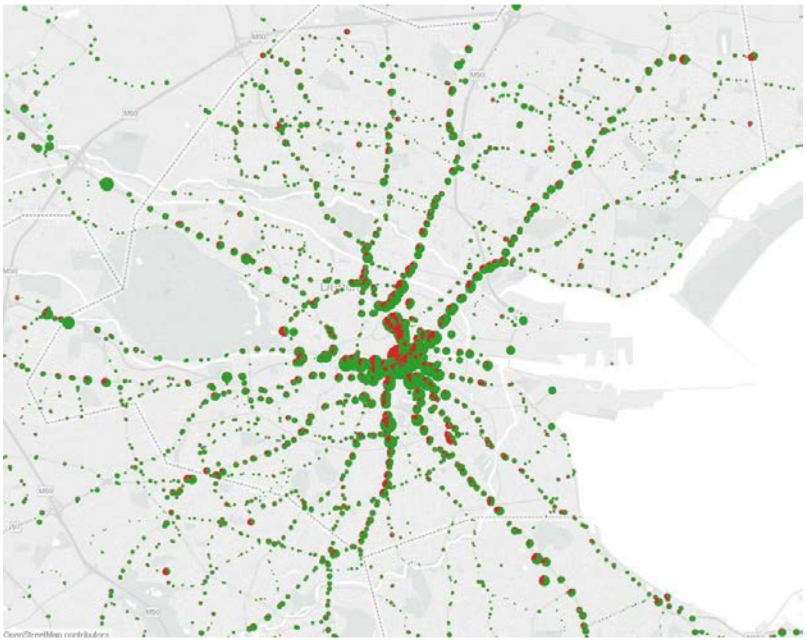


Figure 5 – Visualising Network Performance

The new system is enabling the Dublin ITS team and Dublin Bus to change their analysis of specific points on the network to analysing whole routes. They are able to visualise the performance of each route through all stops to understand how the bus fleet performs across the network. Since implementation, Dublin Bus has been able to use reports provided by the system to refine their routes to improve their overall performance and service to the travelling public. Through better managing their fleet, they have even been able to take buses off the road, whilst still increasing their service levels.

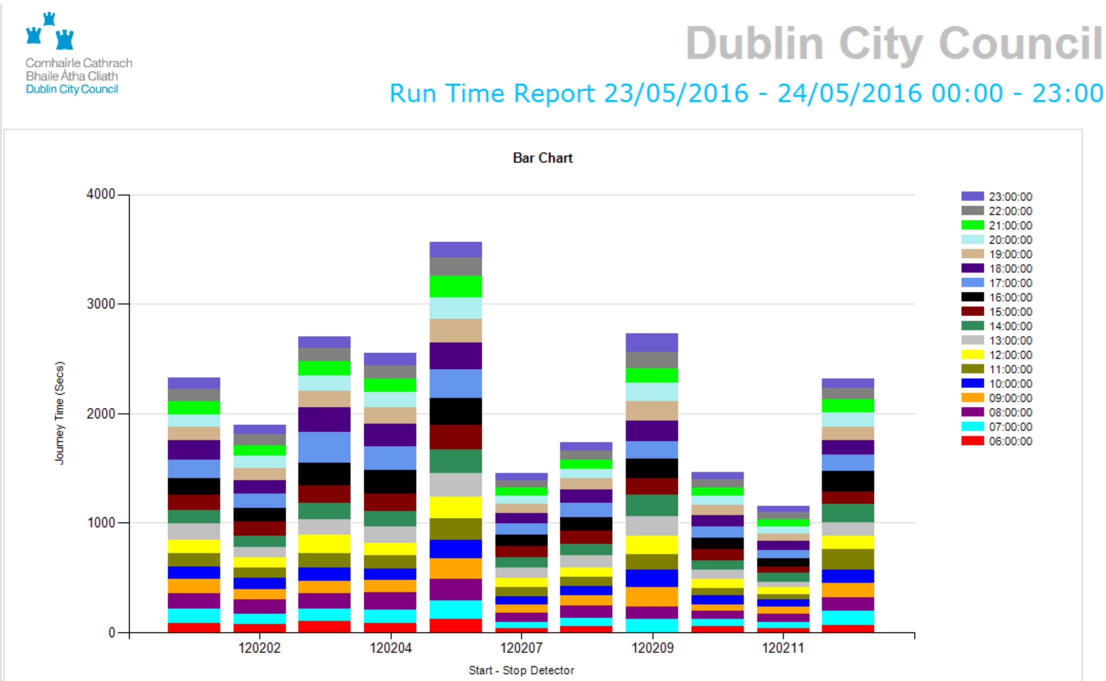


Figure 6 – Using Patterns to Understand Behaviour

Conclusion

DPTIM is significantly smoothing and reducing journey times for buses across the Dublin network. The following reports highlight smoother and reduced Average Journey Times = 22%.

Before:

After:

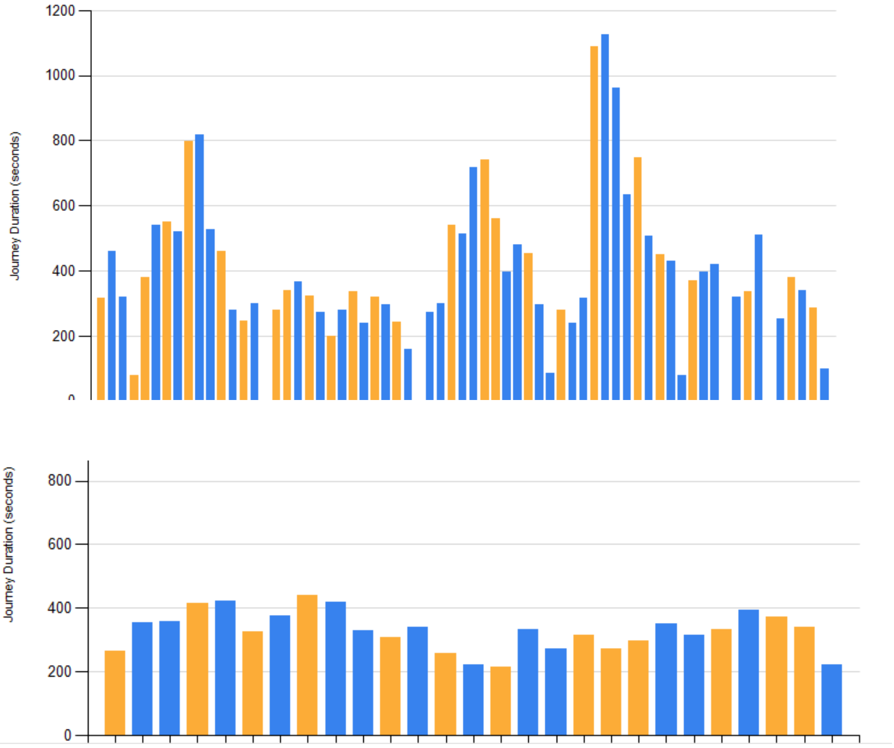


Figure 7 – Reducing and smoothing average journey times by 22%

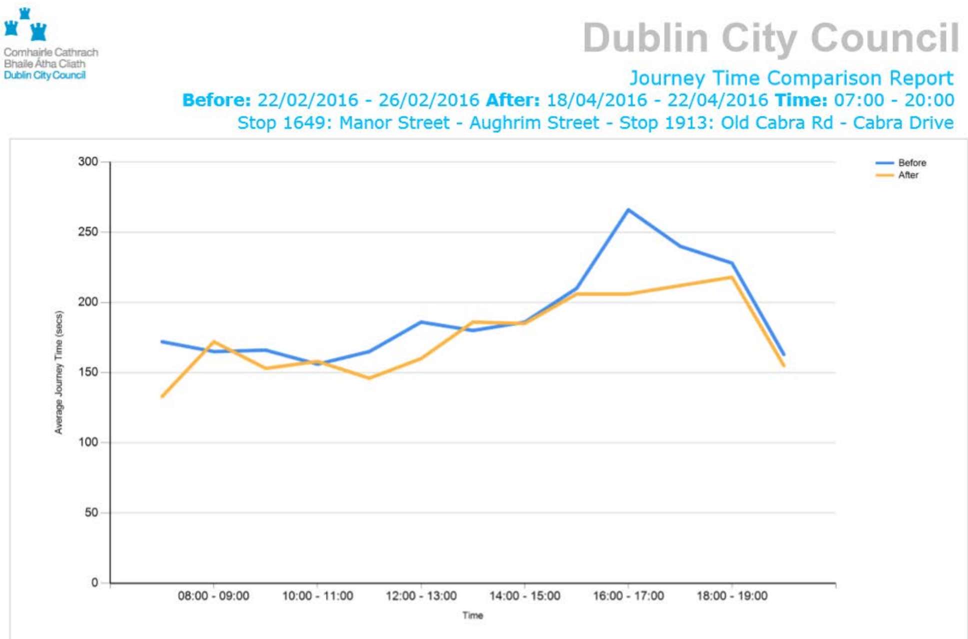


Figure 8 – Reducing Peak Hour Journey Time Spikes

Improved Efficiencies

- DPTIM has achieved its main purpose of helping Dublin Bus deliver a reliable, efficient service to all of its customers.
- Operationally, the new DPTIM, with its faster updates, enables greater visibility of issues on the roads. Combined with the CCTV system DPTIM users are able to use this information to detect serious incidents on the network and react accordingly.
- Average Queue times have significantly reduced, particularly during peak periods, resulting in shorter journey times for passengers.

Sustainability

- By increasing the potential number of bus users with access to the city there is an expected benefit to the commercial and retail sectors in Dublin. This will help drive investment, sustainability and economic growth in the city.
- With smart vehicles able to capture more information such as passenger count, energy consumption and improved communication means, this will support new cooperative ITS solutions with a common objective of delivering continual improvement in sustainable transportation.

Reduced Costs

- The use of a standard SIRI interface to obtain the data generated by existing AVL infrastructure installed by Dublin Bus which provides a significant cost saving.
- DPTIM is able to use DCC's existing SCATS traffic signal control system to affect bus movements into and out of the city.
- More efficient bus routes reduce operational costs.
- No extensive civil works required

Environmental Benefits

- DPTIM helps DCC to achieve their objectives to reduce congestion and safer roads.
- Buses flowing freely and not queuing, enhances the ambience in areas of the city where queues and congestion occurs.
- Increased efficiency of public transport through DPTIM encourages more bus users with reductions in the number of cars travelling into the city.

Operational Service Improvements

- Faster status information on all buses including real-time 'in congestion status
- Map-based and colour coded display to assist operator intervention
- Geospatial monitoring of occupancy, journey times queuing etc.
- Ability to alleviate 'bus bunching'
- Opportunity for complete corridor analysis

Bus priority via a centralised approach has proved effective and provided good results in a highly effective low cost method. The system's flexibility in client reconfiguration and reporting is enabling the client and bus operator to fully understand performance and the benefits delivered for each measure introduced.

The solution needs to be taken in the context of physical measures, such as road layout and approach lane design, signing and lining, and in a number of areas, DPTIM has enabled significant improvements in vehicle throughout that would typically have required an extensive and expensive civil works programme. The flexibility of the DPTIM solution enables the 'tweaking' of configuration to continually improve performance and responding to changing conditions, something which is extremely difficult to achieve when using physical measures only.

The DPTIM solution has proven a very low cost solution to utilise existing systems infrastructure to deliver significant public transport time savings with no extra on-site street equipment being necessary. The system continues to evolve in its improvement. The Dublin ITS team and Dublin Bus are exploring the use of other data to research improvements. To solve a limitation of 20 second position data from buses due to the bus operator's communications system, Nicander will be delivering an enhancement to predict bus position between these 20 second intervals; this will enable the client to further refine detection zone boundaries and algorithms to further improve signal priority and bus performance.

The next phase of enhancements will remove the stored procedures from the database. A C# Windows Service will be produced to take the business logic away from the database and the bus data from the Dublin Bus fleet will be pushed directly to this Windows Service to provide real-time updates to the DPTIM Client. The database will be used purely to store the data and provide the basis for the reports. This will reduce the load on the database server and reduce the number of jobs running on this server significantly. The DPTIM Client will no longer talk directly to the database but will talk to the new C# Windows Service. The DPTIM Reports will be incorporated into the DPTIM Client so that they can be viewed from within the site.

From the success of this work, it has initiated new discussions, views and requirement awareness in the area of Smart Cities and in a smarter way to providing public transportation priority, particularly as we move into the new world of connected vehicles.

References

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