Tram and Bus Tracker: A Dynamic Web Application for Public Transit Reliability

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Abstract—*Currently transit quality information such as timetable adherence, bus arrival times and route performance has usually been disseminated through static environments on web-pages, paper documents or other different media. This paper describes a dynamic Geographic Information System-based Web application which displays the same information through a dynamic web application. Using data collected from an Automatic Vehicle Location System (AVL), a map-based interface has been created to allow travellers and operators to see routes, stops and buses in motion. The collected information is archived for off-line analysis. The system allows users to query and display day-to-day management of operations as well as to generate static performance reports to provide a complete view of the transit system reliability.*

I. I INTRODUCTION

Environmental occurrences such as traffic congestion or urban construction present new obstacles for transportation. Designing and implementation of a distributed transit vehicle information system will help reduce stress as well as improve confidence in and perception of transit systems [1]. Tram and Bus Tracker delivers real-time transit vehicle location and progress information highlighting any deviations from the published time-table or any bad services symptoms such as bunching of vehicles due to traffic conditions or incidents. Recent advanced techniques in communications, computing technology have made real-time transit information system an interesting area of research. In this project a web based application system has been developed to explore techniques of showing transit vehicle performance. This system was built using the PHP scripting language, a MySQL database, client-side JavaScript, XML and Microsoft Virtual Earth API.

This system has the ability to display transit vehicles locations in near-real-time on a map and offers user and operator interactive querying on a specific bus or route. In addition, it allows the operator to monitor and measure the vehicle fleet so as to improve the transit services provided.

II TRANSIT SYSTEM'S RELIABILITY INDICATORS

Improving the reliability of services is one of the main objectives of transit agencies. Many performance indicators have been developed to assess transit performance, the choice of which indicator depending on the frequency of the service. For high-frequency routes (a vehicle at least every ten minutes) these include Excess Waiting Time (*EWT*) [2], Headway Regularity Index (*R*)[3], Headway Reliability (*RH*)[4] and Travel Time Reliability (*RT*)[4]. On high frequency routes passengers are more concerned with regularity, whereas for low frequency their concern is more with punctuality.

EWT [2] is defined as "the measure of the additional wait experienced by passengers due to irregular spacing of buses or those that failed to run". EWT can be calculated by subtracting scheduled waiting time (SWT) from average waiting time (AWT) i.e.

$$EWT = AWT - SWT \qquad (1)$$

The term headway is used for the time interval between successive vehicles on the same route and in the same direction as they pass a particular point on that route [5].

The headway regularity index is a reliability performance indicator for buses at a stop, route, or system level [3]. Service regularity is measured by comparing the actual with the scheduled headway. A high headway index (R) indicates a regular service whereas low numbers indicate headway irregularities.

$$R = 1 - 2\sum_{r=1}^{n} \frac{r(h_r - H)}{\frac{2}{n^* H}} \qquad (2)$$

where:
r rank of headway (1..n)
n total number of headway measures
hr series of headways
H mean headway

When the headway measures are equal for n observations the headway regularity index will be 1. In this paper the headway regularity index was calculated for one bus route in both directions.

Many factors such as traffic conditions, route characteristics, passenger characteristics, and operational conditions contribute to bus unreliability. The term reliability can be defined as "the ability of the service to provide consistent service over a period of time" [5]. In this paper two types of bus reliability are measured, travel time reliability and headway reliability.

Travel time reliability measures the variability in bus journey time for a specific bus route within a specific time interval at a specific level of service [4]. The travel time reliability is defined as the mean over standard deviation of travel time.

$$RT = \frac{\mu_t}{\sigma_t} \qquad (3)$$

The higher value of *RT* indicates a good reliability.

Maintaining the scheduled headways by keeping regular spacing between buses will minimise the average passenger wait time and eliminates buses bunching. Bunching of buses happens in the absence of service during the scheduled time causing high passenger demand for the next bus. Headway Reliability is another proposed reliability indicator; it is defined as the standard deviation over mean headway:

$$RH = \frac{\sigma_t}{\mu_t} \qquad (4)$$

Smaller values of *RH* indicate better headway reliability.

III TRAM AND BUS TRACKER

Tram and Bus Tracker (www.bustracking.co.uk) is a joint project between NUIM and Blackpool Transport that uses various reliability measures to visualize the behaviour of vehicles in ways to allow the operator to better assess and improve the quality of service. The system uses off-the-shelf GPS/GPRS integrated units programmed to transmit location at regular intervals (45 seconds approximately) while the vehicle is in motion. The data is stored on a server and can be displayed through a standard web browser to show views representing current locations of vehicles in close-to-real-time. The system displays real time locations of buses pictorially, textually and, using the facilities provided by the Microsoft Virtual Earth API, with 2D and 3D maps(figure 1).

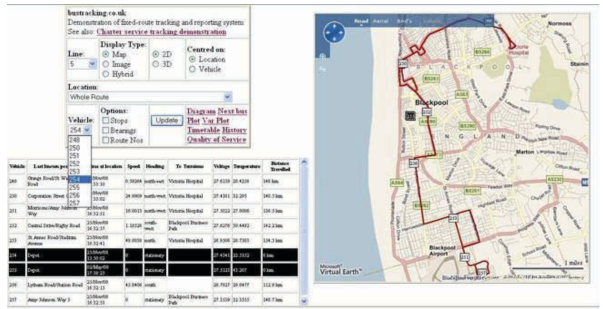

Fig (1) The public interface showing updating textual display plus moving locations on Microsoft Virtual Earth.

In order to improve services, as well as providing real-time information, this system builds up an archive of data that can be analysed and mined for information that can show behaviour of the transport system over time, indicating problems such as vehicle bunching and delays due to congestion. In addition, to qualify for public subsidies, operators must report Quality of Service metrics to government. These are usually calculated manually but the existence of a full archive of data gives the potential for automation.

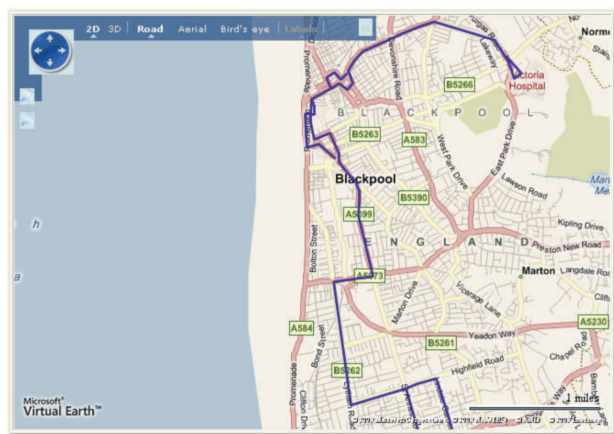

Fig (2) Route 5 in Blackpool city

IV. BLACKPOOL ROUTE 5

The City of Blackpool, UK lies along the coast of the Irish Sea. It has a population of 142,900, making it the fourth-largest settlement in North West England. The bus services in the city are operated by Blackpool Transport Services. For the purpose of demonstrating the analysis and evaluation of bus services in Blackpool, Line 5, a high frequency route, was selected to be a test case. This bus route contains 73 bus stops in both directions, 14 of which are timing-points where departure times are quoted in the public timetable. Figure 2 shows Line 5 in Blackpool.

V. Implementation

Excess Waiting Time (EWT) is a standard metric used to measure the quality of service on high-frequency public transport. This indicator is a key performance indicator since it denotes how much time passengers had actually to wait in excess of what they would have expected if the service were perfect. EWT is calculated by subtracting Scheduled Waiting Time (SWT) from Average Waiting Time (AWT) and it is this which is used as the measure of reliability. The greater the EWT, the less reliable is the service [2]. EWT can be calculated on a daily, weekly or monthly basis. Figure 3 shows EWT values in a certain day for all bus stops along route 5 in Blackpool.

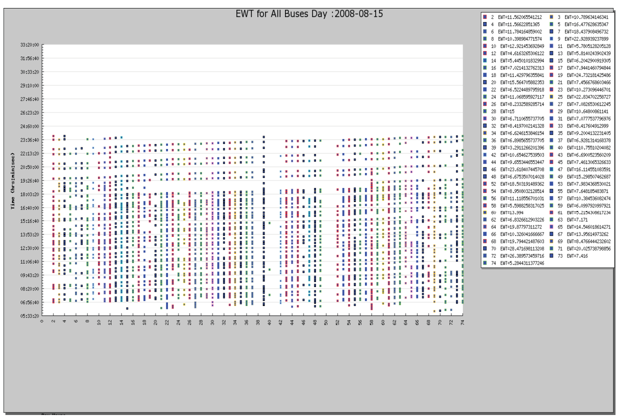

Fig (3) EWT values for different bus stops in route 5

Buses bunching and headway overlapping can easily be noticed. The headway regularity index indicator was calculated to measure the quality of service; the result is shown in figure 4. High index numbers indicate a regular service whereas low numbers indicate headway irregularities.

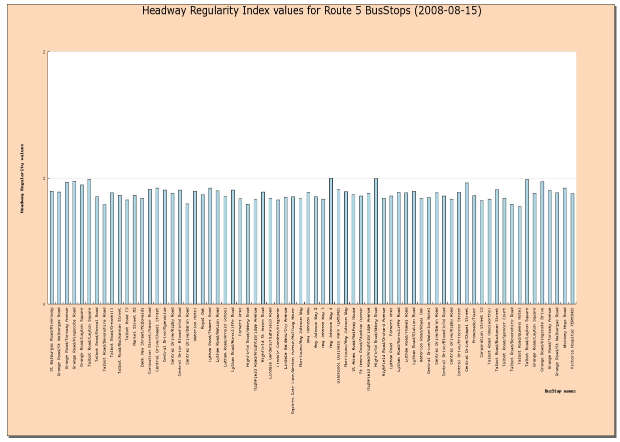

Fig (4) Headway regularity index values

It shows that there is a trend towards higher headway regularity for all bus stops on the day the headway index was calculated. Starting from the bus terminus, travel time reliability was measured for each bus stop in the same direction; figure 5 shows different bus stops with travel time reliability measure.

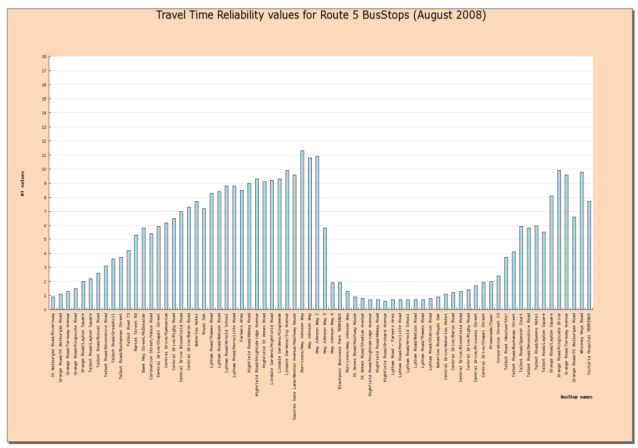

Fig (5) Bus stops with travel time reliability measure.

Bus stops located on the south direction have higher travel time reliability than stops on the north, which means that they have a more reliable travel time.

For headway reliability, a smaller values indicates better reliability. Headway reliability values seem to be high on the second segment of the route and tend to be lower before the end of the route (figure 6).

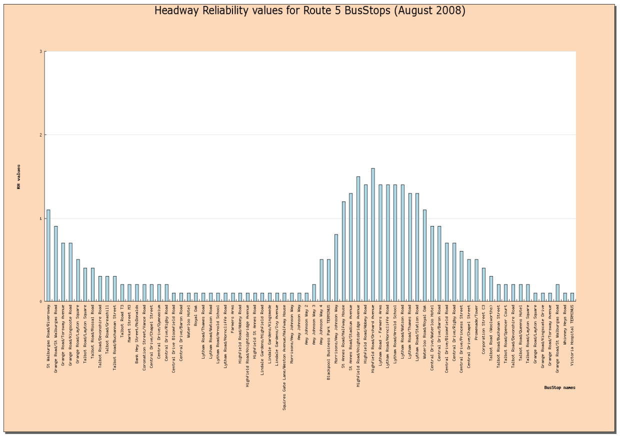

Fig (6) Bus stops with headway reliability measures

VI CONCLUSION AND FUTURE WORK

Tram and Bus Tracker is adynamic web application system with an intuitive interface and the ability to measure transit services' reliability. The system can be useful to users (travellers) and the operators in that, as well as providing transit information in close to real-time, it also provides tools to analyse performance and see where improvements are needed. The system architecture can be developed to be applicable to different transit services or regions.

VII ACKNOWLEDGEMENTS

Thanks are due to Blackpool Transport Ltd for facilitating this project and particularly to Oliver Howarth for his comments and feedback. One author is supported by a PhD studentship from the Libyan Ministry of Education.

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