Meeting Rural Transport Needs through Demand Responsive Transport Scheduling (Bwcabus)

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Introduction

The following system demonstration presents an approach to demand responsive transport (DRT) that has been developed and is currently being used in the real world environment of West Wales. The system has been developed by the University of South Wales in conjunction with the local government organisations covering the test area, namely Carmarthenshire and Ceredigion County Councils. Other project partners include the Welsh national public transport information organisation Traveline Cymru and bus operators. The demonstration will introduce Bwcabus as a case study, describe the scheduling system and identify the system challenges associated with managing passenger demand and expectations.

What is Bwcabus?

The traditional models of public transport delivery (based on fixed timetables and routes) can fail to meet the needs of passengers in rural areas because services can be too infrequent and inflexible. It is suggested that Demand Responsive

Transport (DRT) can be used to address social exclusion and rural accessibility by providing a more flexible and customer responsive service.

Bwcabus is a DRT service covering rural Carmarthenshire and Ceredigion. The service commenced in August 2009 funded by the Welsh Government, the European Convergence Fund and Carmarthenshire and Ceredigion County Councils.

DRT are services that provide transport on demand, scheduled to pick up and drop off passengers in accordance with their needs. Bwcabus is therefore a 'hybrid', falling somewhere between a conventional timetabled bus service and a taxi (Gerrard, 1974). A DRT timetable is not fixed and will vary each day. This form of 'dynamic' scheduling allows passengers greater flexibility to book journeys at the times (or close to the times) they require.

Bwcabus is integrated with strategic public transport services, providing connections at designated hubs. Communications technologies are deployed to maximise the efficiency of the service and ensure connections are guaranteed. Therefore Bwcabus facilitates a large number of journey options between the fixed and demand responsive services. A similar scenario is presented in Hall et. al. (2009).

The System

At the heart of the Bwcabus operation is the scheduling system. The complete system includes journey scheduling, booking management and public transport information import and management.

The scheduling system is based upon the selection of either combinetrics or Simulated Annealing (Baugh et. al, 1998; Uchimura et al 2002) depending on the number of unique locations visited on a trip. Where a limited number of locations (less than five) are visited it has been demonstrated the optimal methodology is the use of combinetrics, that is to say the generation of every single journey permutation. At larger numbers of locations Simulated Annealing becomes optimal. The simulated annealing parameters vary in line with the number of locations visited.

The following section presents a high-level overview of the system operation:

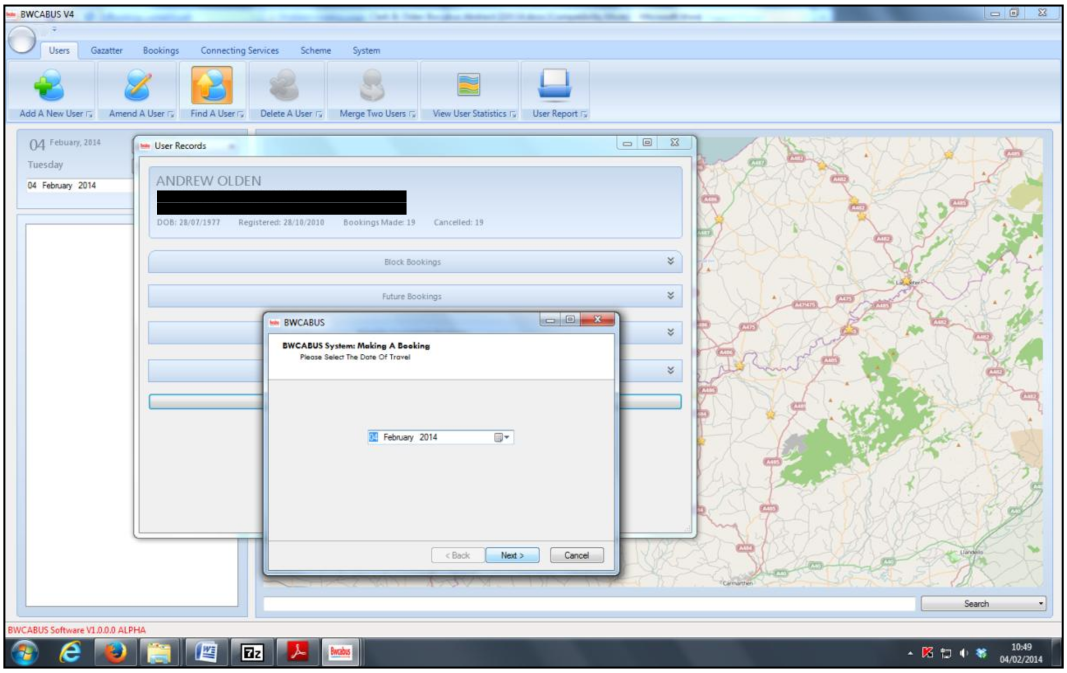
- Load all bookings from system database for required day
- Split bookings into groups or journeys
  - Based upon the start and perceived end times of each booking in the system, any bookings running concurrently are grouped together.
- ***For each journey determine optimal journey pattern a (s1)***
  - If unique location <=5 Use Combinetrics
  - If unique locations > 5 Use Simulated Annealing
    - If unique locations > 8 decrease cooling temperature
- ***Acquire required journey information (s2)***
- determine optimal journey pattern **b** (including new locations)
  - If unique location <=5 Use Combinetrics
  - If unique locations > 5 Use Simulated Annealing
    - If unique locations > 8 decrease cooling temperature
- Validate optimal journey pattern **b** based on effects on pattern **a**
  - If **b** is valid add to list
- Check if journey can be made as a standalone trip, separate to others using journey pattern **a** as a constraint model.
  - If possible Add to list

The highlighted sections (***s1*** and ***s2***) in the high-level overview may be operated independently of each other. That is to say when acquiring information required to make a new booking the system is optimizing an existing days journeys using multi threading. By the time the acquisition process is complete the schedule for that day will have been optimised ready to attempt the integration of the new booking.

The system operates in a number of modes, dependant on the end users and uses Web Services to enable the interrogation of a central database (located in South East Wales). Where the user is a ‘scheme manager’ located in the local authority

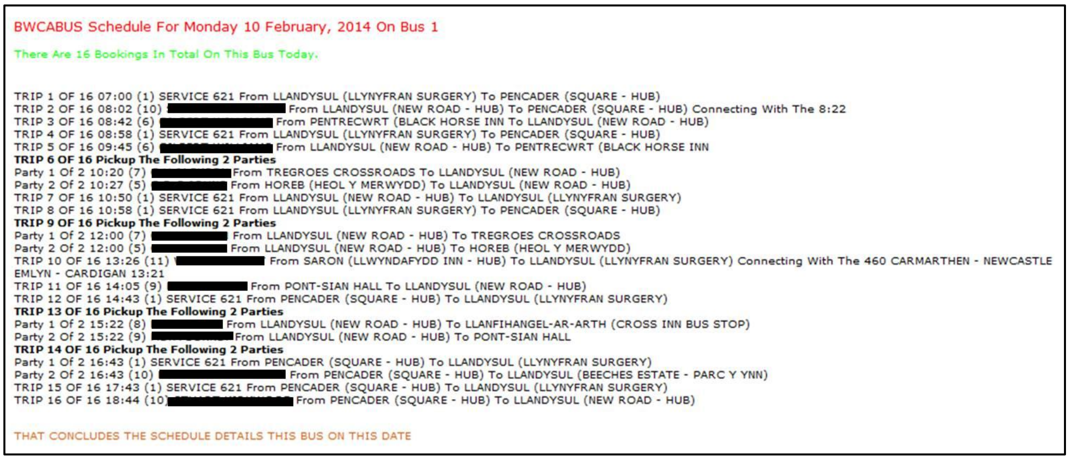
(West Wales) the system enables the modification of existing bookings, such as swapping the bus a booking takes place on, or the time, location and number of people travelling. Call centre users (located in North Wales) who take requests for bookings from end users face a wizard based interface as shown in Figure 1.

Figure 1 – Call Centre User Interface



Details of the journeys a bus is required to make can also be viewed via a web page, as shown in Figure 2. Mobile communication technologies are used to send the details of the schedule directly to each bus twice a day.

Figure 2 – Schedule Web View



Results

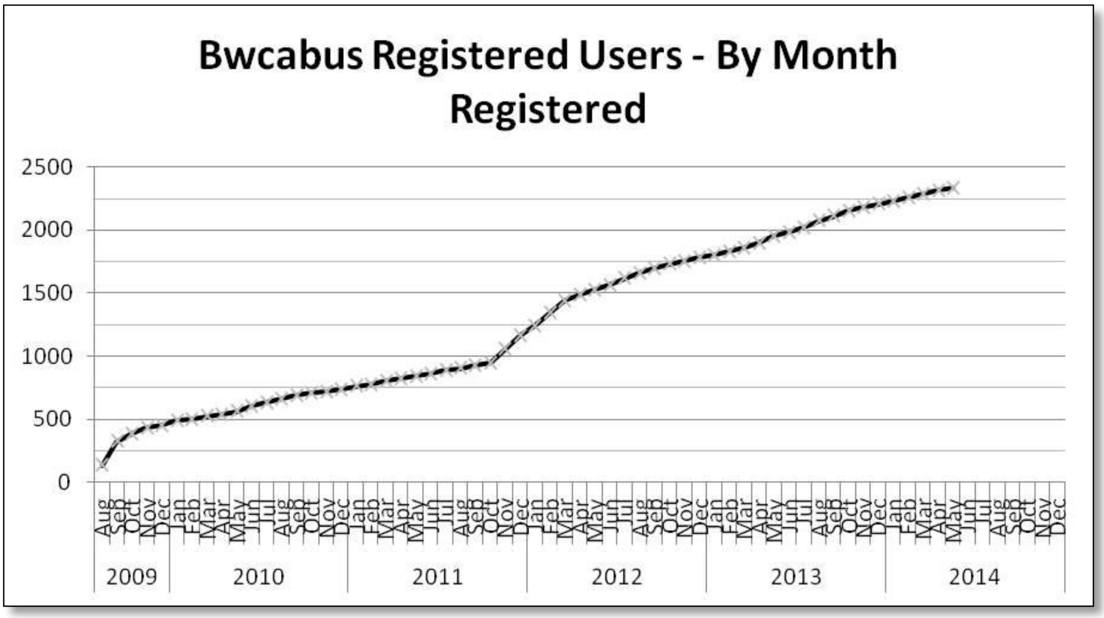
Over 2300 members have registered to use Bwcabus since August 2009. Table 1 presents a breakdown of the membership profile and highlights the popularity of the scheme with users under 25 years of age and users over 60 years old.

Table 1 – Bwcabus Registered members Profile

	Number	*Percentage of Total Membership*
Total Registered Users	2334	
Active Users in last 12 months	528	23%
Members who have never used the service	1052	45%
Female members	1548	66%
Male Members	786	34%
Members under 25	511	22%
Members 25-44	414	18%
Members 45-59	349	15%
Members 60 or over	1060	45%
Members with a mobility impairment	168	7%

Figure 3 shows that Bwcabus membership levels are continuing to increase despite the maturity of the scheme. On average 32 new members register each month (2013-14 figures).

Figure 3 – Growth of Registered Bwcabus members from August 2009 – May 2014



*The service area and number of vehicles was doubled in December 2011

In total 90,118 passenger journeys have been completed. Table 2 shows the yearly breakdown of passenger numbers. 2013 was a record year for the Bwcabus service, with 26,947 passenger journeys completed. 2014 data indicates a continued growth in passenger journeys, an 11.5% increase recorded from January – April 2014 as compared to the same period in 2013.

Table 2 – Bwcabus Passenger Journeys by Year of Operation (December 2009 – April 2014)

Year	*Passenger Journeys*	*Number of Operating Days*	*Average number of passengers per day*
2009	4,544	109	41
2010	12,586	301	42
2011	13,246	304	44
2012	23,771	309	77
2013	26,947	306	88
2014**	9,024	101	89
Total	**90,118**	**1405**	**63**

*The service area and number of vehicles was doubled in December 2011

**Data for January to April 2014 only

The booking system performance is measured by the number of referrals generated for manual scheduling as a proportion of the total number of demand responsive bookings made. A referral is generated by the system, when it cannot offer the passenger a time and a manual scheduler takes over to see if the journey can be accommodated. Table 3 shows the system performance between1st May 2013 – 30th April 2014.

Table 3 – Bwcabus Booking System Performance: Booking Referrals by Month (1st May 2013 – 30th April 2014)

Month	*Number of Referrals*	*Booking Rate (%)*
May	285	77.63
June	194	83.12
July	210	81.01
Aug	283	78.47
Sep	202	85.11
Oct	194	85.48
Nov	225	86.13
Dec	176	84.87
Jan	208	82.51
Feb	243	82.25
Mar	362	77.69
Apr	213	83.24
Average	**233**	**82.29**

A survey of 100 Bwcabus passengers undertaken in July 2013 highlighted:

- 70% either agreed or strongly agreed that they are now making trips that they would not have been able to make prior to the Bwcabus
- 74% of respondents agreed or agreed strongly that the Bwcabus has provided them with better opportunities to access travel
- 42% either agreed or strongly agreed that they have reduced the number of trips made by car since using the Bwcabus

Conclusions

The Bwcabus system overcomes a number of design challenges:

- Optimisation: how the system would optimise journeys to form the schedule vs. the demands of passengers, who expect the bus to be available when they want to travel.
- Manual Intervention: coping with manual [human] input which can introduce journeys onto the schedule that break system rules and would result in the system being unable to make logical sense of the journey ordering.
- Operational Efficiency: joining up similar journeys (based on origin, destination, direction of travel, journey time), so that passengers travel together on a fewer number of bus trips, with constraints to ensure maximum detour values (a factor of the original journey time) are not exceeded.

The implementation of the Bwcabus scheduling system demonstrates a solution to providing 'dynamic' demand responsive transport scheduling in rural areas. This approach has proven that providing rural communities with an integrated rural public transport network can increase the frequency of public transport use, improve accessible by public transport, and encourage a reduction in car use.

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