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Combining Mobile Data Transport and Mobile Data Recharging to Address Public Transport Information Maintenance Problems in Rural and Remote Australia

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Abstract

Connecting geographically dispersed communities, public transport plays an important role in rural and remote areas. As bus service frequency tends to be lower than in metropolitan areas, availability of reliable scheduling information is a prerequisite to successfully using public transport services. A persistent issue associated with providing scheduling information at bus stops is the need to maintain up-to-date information at geographically dispersed locations. Printed timetables are easy to handle and to produce but have shown to be difficult to maintain as replacing them requires the maintainer's physical presence. Electronic timetables, updated over the Internet or other communication networks, solve the update issue given that bus stops are located within network coverage. In large and sparsely populated countries like Australia, however, this prerequisite is not necessarily met. In this paper, we discuss Mobile Data Transport (MDT) as a solution to covering bus stops at locations lacking suitable network coverage. MDT can also be used in countries, such as Austria or Switzerland, facing network coverage gaps in their sparsely populated mountain areas. We also highlight how the approach could be expanded for providing other information services, such as news propagation or tourist information.

1 Introduction

A persistent information management and maintenance issue associated with bus stops in rural and remote areas is the need to maintain up-to-date scheduling information at geographically dispersed locations.

Public transport is often seen as the ecologically and economically most effective way of transporting large numbers of people. Benefits to the environment include less pollution and less need to occupy and pave land for roads and parking spaces. Public transport is also an alternative means of transport for those who do not drive a car because of age, disability, income or inclination. Other reason for using public transport include potentially lower costs than driving, a lower risk of being involved in an accident, being able to relax (such as by reading a book) and the potential for enriching social contact [New Zealand Ministry for the Environment].

The traditional approach to providing schedule information is to print the information on paper or other suitable material and display these respective documents at bus stops (see below for examples). This approach, however, has its clear shortcomings in terms of maintenance overhead and reliability. It is a common experience among riders that schedules published at bus stops do not provide the most recent scheduling information. The overhead associated with maintaining printed timetables at geographically dispersed locations appears to be a contributing factor.

“Virtualizing” timetable information allows updating the information via the Internet or other communication networks, such as CDMA or GSM, and qualifies as a promising way to address maintenance problems associated with printed timetables. Furthermore, electronic timetables could be downloaded wirelessly (e.g., via Bluetooth or WiFi connections) by riders carrying suitable mobile information systems, such as mobile phones or personal digital assistants (PDA). Downloading timetables at bus stops relates to the concept of Mobile Data Recharging [Cherniack et al. 01]. Timetables could also be displayed on screens attached to selected bus stops to meet the requirements of those not carrying mobile information systems because of age, disability, income or inclination.

A prerequisite to addressing the timetable maintenance problem by virtualizing timetables is that bus stop locations are covered by communication networks. Large and sparsely populated areas in countries like Australia, however, are only partly covered by such communication services (see [Telstra Coverage] for information about coverage of Australia’s Northern Territory of which Darwin is the capital).

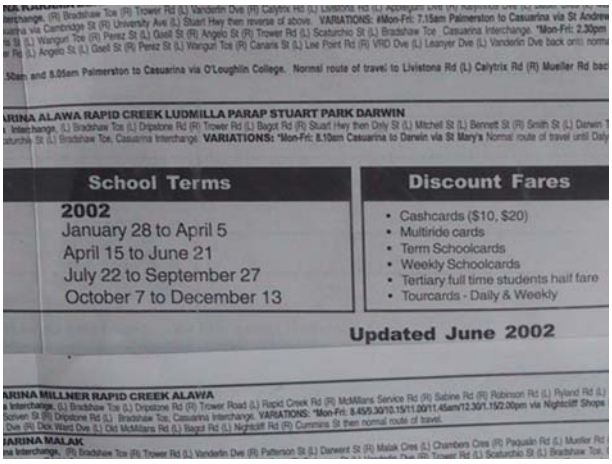
In this paper, we focus on ways to expand the concept of updating electronic timetables via communication networks (and mobile data recharging utilizing the information) to areas that are *not* covered by such communication networks. We will illustrate that the concept of Mobile Data Transport (MDT) allows limited Mobile Data Recharging at locations that would not normally be covered by communication networks. We will also motivate that the concept’s applicability is not limited to public transport in large and sparsely populated countries. Public transport or post bus services connecting remote communities in the Swiss Alps, for example, could be used as transport medium as well. Last but not least the concept could be used to implement a limited notion of dynamically adjusted timetables in the sense that timetables provide information about relevant events in the near future, such as road works expected to impact traffic conditions.

2 Maintenance Problems Associated With Printed Timetables

In this section we briefly summarize the drawbacks of providing timetables as printed matter which is the standard way of providing scheduling information. By printed matter we mean that timetables are printed on paper or similar material which is then displayed at bus stops. We illustrate the shortcomings by example of bus stops located in Darwin, a regional city of about 100,000 citizens situated at Australia’s tropical top end. Public transport in Darwin is based on regular bus services and, more recently, railway services connecting Darwin to the rest of Australia. Darwin’s bus services appear to be well accepted, especially those linking the city's major suburbs to the CBD and those providing services to and from the only university in the Northern Territory seem to be quite popular. Problems associated with printed timetables include but are not limited to:

2.1 No Timetable Information Provided

A number of smaller bus stops in Darwin do not provide any timetable information.



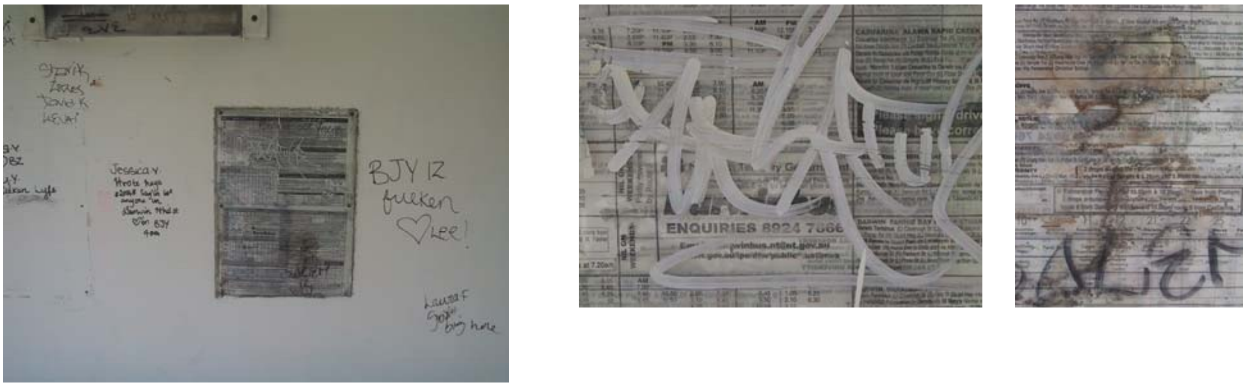
2.2 Outdated Information Provided

We found a number of bus stops displaying outdated timetables. The timetable at the university bus stop (see pictures 1, 2), for example, had not been updated for almost two years.

2.3 Time Tables Virtually Unusable

A number of timetables we looked at had been subject to vandalism, especially graffitis sprayed onto them. Such timetables may be of little value even *if* they are up-to-date as in the case of the timetable featured below (a. the timetable at the bus stop; b., c. details of the timetable). Fading may occur due to the harsh sunlight in the tropics.

a b c



3 Pros and Cons of Virtualizing Timetables

The main advantage of virtualizing timetables is that instead of being required to physically attend at bus stops in order to replace printed matter, staff situated at the central bus depot could organize the uploading of timetables.
Furthermore, electronic timetables provided in an open, well-defined format based on XML other similar standards would allow riders to download timetables to their personal devices, thus allowing them to personalize how they want timetable information be presented on their personal devices. Additional services, such as reminders, graphical visualizations or even location-oriented services could be used to enhance the browsing experience.

At the current stage of mobile technology adoption, it cannot be assumed that all mobile devices are capable of receiving and displaying information via

Bluetooth or other wireless protocols. However, it is reasonable to assume that in the near future, most mobile devices will feature these capabilities. Some public transport users may still be excluded from using electronic timetable information, as they do not carry suitable mobile devices (for financial or lifestyle reasons). This means that at the current, still relatively early stage of mobile technology adoption, electronically available timetables may not completely replace but complement printed timetables. As a service to those not carrying mobile devices, bus stops could be fitted with displays providing the latest timetable information. Compared to static printed timetables, these displays could enhance dynamic features, such as to-be-expected delays likely caused by road construction. See [Smart Bus Technology] for an example of an advanced type of dynamic information display trialed in Melbourne, Australia.

4 Data Formats Used by Public Transport Providers

As mentioned before, electronic timetables provided in an open, well-defined format based on XML other similar standards would allow riders to download timetables to their personal devices, thus allowing them to personalize how they want timetable information be presented on their personal devices. Quite a few public transport companies provide electronic timetable information but they only provide the information on their web sites (see below for examples). This means the information is not available at bus stops *unless* the user has wireless mobile access which is not necessarily the case in the areas we are interested in. Further complicating matters is our observation that all public transport companies we looked at were using their own, apparently proprietary data format. We looked at a number of public transport web sites in different cities and found a range of proprietary and unspecified formats. We found different document formats (e.g., Adobe's PDF, HTML) and different web site set-ups (page and link structure). We did not find computer-readable information revealing how to parse the information provided. Three examples from different cities will be used to illustrate the situation:

4.1 Bus Stop "NT University" in Darwin, Australia

The local transport provider DarwinTransport provides online schedule information as HTML page containing one or more table structures. There was no information provided regarding the data format used. Departure times are given in absolute time, e.g., the first bus in the morning leaves at 6:38am. Time is based on the 12h clock which is the standard in Australia. AM/PM

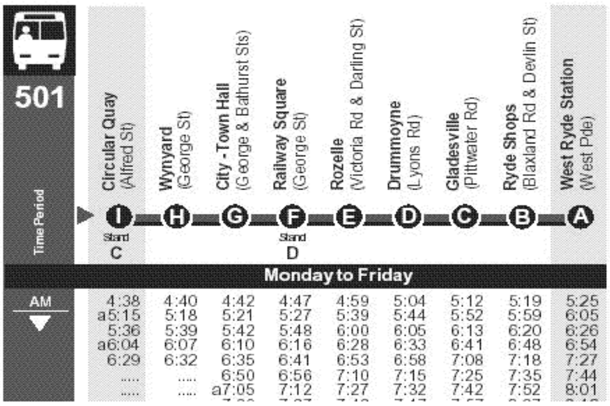
Monday to Friday	Route 4: via Alawa, Rapid Creek, Nightcliff and Fannie Bay							
Depart	am	am	am	am	School Days	School Holidays	School Days	School Holidays
Casuarina Interchange	6:35	7:00	7:15	7:30	7:45	7:45	8:00	8:00
NT University	6:38	7:03	7:18	7:33	7:48	7:48	8:03	8:03
1st stop Ryland Rd	6:43	7:09	7:25	7:39	7:55	7:54	8:10	8:09
Essington School	–	–	–	–	7:57	–	–	–
Nightcliff Shops	6:49	7:15	7:33	7:45	8:03	8:00	8:18	8:15

has to be inferred from a separate row in the table. Location information is in the left-most column.

Picture 6: Example of a bus schedule used in Darwin, Australia.

4.2 Bus stop "University of Technology" in Sydney, Australia

The local transport provider StateTransit provides online schedule information. There was no information provided regarding the data format used in the electronic version. Time is based on the 12h clock which is the standard in Australia. AM/PM has to be inferred from a separate row in the table. Location information is in the upper-most row.

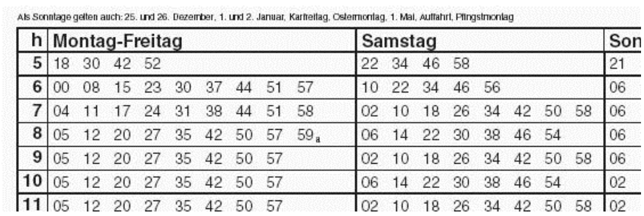


501 Time Period	Circular Quay (Alfred St) I Stand C	Wynyard (George St) H	City - Town Hall (George & Bathurst Sts) G	Railway Square (George St) F Stand D	Rozelle (Victoria Rd & Darling St) E	Drummoyne (Lyons Rd) D	Gladesville (Pittwater Rd) C	Ryde Shops (Blaxland Rd & Devlin St) B	West Ryde Station (West Pde) A
Monday to Friday									
AM	4:38	4:40	4:42	4:47	4:59	5:04	5:12	5:19	5:25
	a5:15	5:18	5:21	5:27	5:39	5:44	5:52	5:59	6:05
	5:36	5:39	5:42	5:48	6:00	6:05	6:13	6:20	6:26
	a6:04	6:07	6:10	6:16	6:28	6:33	6:41	6:48	6:54
	6:29	6:32	6:35	6:41	6:53	6:58	7:08	7:18	7:27
	.....	.....	6:50	6:56	7:10	7:15	7:25	7:35	7:44
	.....	.....	a7:05	7:12	7:27	7:32	7:42	7:52	8:01

Picture 7: Example of a bus schedule used in Darwin, Australia.

4.3 Tram stop "Freihofstrasse" in Zurich, Switzerland

The local transport provider Verkehrsbetriebe Zürich (VBZ) provides online schedule information split into two separate data files (one for each of the two directions). The file format is Adobe's Portable Document Format (PDF) which is handy if the timetable is to be printed on paper or displayed on a screen. However, parsing the timetable requires extracting the information required. There was no information provided regarding the data format used.



Als Sonntage gelten auch: 25. und 26. Dezember, 1. und 2. Januar, Karfreitag, Ostermontag, 1. Mai, Auffahrt, Pfingstmontag

h	Montag-Freitag	Samstag	Son
5	18 30 42 52	22 34 46 58	21
6	00 08 15 23 30 37 44 51 57	10 22 34 46 56	06
7	04 11 17 24 31 38 44 51 58	02 10 18 26 34 42 50 58	06
8	05 12 20 27 35 42 50 57 59a	06 14 22 30 38 46 54	06
9	05 12 20 27 35 42 50 57	02 10 18 26 34 42 50 58	06
10	05 12 20 27 35 42 50 57	06 14 22 30 38 46 54	02
11	05 12 20 27 35 42 50 57	02 10 18 26 34 42 50 58	02

Picture 8: Example of a tram schedule used in Zurich, Switzerland.

Departure times are given relative to the hour, e.g., "08" in the "6" row ("h" column") means departure at 6:08. Time is based on the 24h clock which is the standard in Switzerland and most other European countries.

This brief overview already indicates that a provider-independent approach to downloading and parsing public transport schedules (as the very idea of mobile data recharging suggests) would be quite a challenge because of the different formats use by public transport providers. Even implementing a solution supporting recharging from a specific public transport provider would be labor-intense at this stage because due to the lack of documentation, information extraction procedures might need to be adjusted whenever the schedule structure changes.

The research group has started exploring generic timetable formats based on XML and other standards that would be provided as web services. Web services are "software applications identified by a URI, whose interfaces and bindings are capable of being defined, described, and discovered as XML artifacts" [Ferris and Farrell 03]. Work by the Swiss Railway SBB on providing schedules via SMS and WAP will be considered too.

5 MDT Enabling Limited MDR at Rural/Remote Bus Stops

Due to sparse population and enormous distances (in Australia’s Northern Territory, for example, distances of a few hundred kilometers between towns are not unusual), bus stops in rural or remote areas may not be covered by communication networks. Mobile phone network coverage (except mobile satellite services) typically ceases a few kilometers outside town boundaries. Installing mobile satellite services is technically possible even at the remotest locations (see [Telstra Mobile Satellite]) but can generally be assumed too expensive.

We propose addressing the problem of providing rural and remote bus stops with the latest timetable information by implementing what we termed Mobile Data Transport (MDT). Roughly, MDT is about having data packages “travel” on those buses approaching bus stops during their regular tours. In a way, we are reviving a tradition of physical data transport that was omnipresent before high-speed network connections became financially viable. A major technical difference is that we are using wireless connectivity for easy data transfer between bus depot (maintaining the master timetable), buses, bus stops and, if applicable, mobile information systems carried by riders. Our research suggests that technical requirements for a sound and easy-to-use solution are reasonable (see below). [D’Monte 03] actually describes how a similar concept is used to transport emails on a bicycle to remote locations. [Heinemann et al. 03] explore peer-to-peer applications of what we would call physical data transport on mobile devices.

MDT enables a limited notion of Mobile Data Recharging at bus stops. “Mobile data recharging" has emerged as a topic of interest among researchers investigating mobile technology. According to [Cherniack et al. 01], data recharging is about “developing a service and corresponding infrastructure that permits a mobile device of any kind to plug into the Internet at any location for any amount of time and as a result, end up with more useful data than it had before.” Another related concept is “information clouds” that could be accessed using wireless mobile devices (see [Heinemann et al. 03] for details).

Due to technical constraints, mobile data recharging at rural and remote bus stops would be limited to downloading timetable information and possibly other useful information, such as scheduled modifications to timetables, road construction in the near future or information relating to the bus stop’s physical location (nearby attractions, etc.).

In our mobile timetable recharging project, we are looking at three different types of inter-connected components:

- The stationary “base station” installed at the bus depot (one per depot).
- Mobile “data packages” installed on buses (one per bus).
- Stationary “recharge stations” built into or attached to bus stop infrastructures, such as poles or shelters (one per bus stop). The devices used are self-managed, support external and internal power supply and provide wireless remote administration and configuration.

Data “travel” is organized as follows:
The “base station” located at the bus depot maintains the most recent version of the timetable (e.g., regularly updated from public transport back office servers).

Upon departure, buses download the most recent version of “their” timetable onto the “data packages” they carry. Buses and associated timetables are easily identified by route number. The data is transferred to the data package via WLAN 802.11b, installed at the bus depot. The data will be filtered on the basis of mobile device profiles. Recharge data is available for download to riders traveling on the bus.

Upon arrival at a participating bus stop, the recharge data is uploaded using wireless data connections to the bus stop's “recharge station”.

It is important to note that unlike updating printed timetables, updating electronic timetables is fully automated and does not require any human intervention.

Prospective riders interested in the latest timetable can recharge their mobile devices at any participating bus stop or while riding the bus simply by downloading the data using

- A Bluetooth-enabled device, e.g. mobile phones
- A device with WLAN (IEEE 802.11b), e.g., high end PDAs and laptops
- A device with IrDA (Infra Red Connection), e.g., low end PDAs and laptops

Data management issues will be discussed below.

The hardware requirements for the mobile timetable recharge project are as follows.

Base station:

- Central Server (Optional)
- 3x WLAN 802.11b Hub (new generation Bluetooth possible as well)

Each Bus and Bus stop:

- PX30 on each bus and each participating bus stop. The PX30 is based on a single-board computer (SBC) with an Intel XScale PXA255 processor running at 300MHz. It boots from a 32MB internal Flash disk, and includes 64MB of RAM. It comes with open source Linux Platform supported by Developer Zone. The PX30 supports a broad range of communication protocols, including WLAN (802.11b), Bluetooth Class 1, Ethernet, IrDA, and GPRS (by installing a GPRS CompactFlash Card). PX30 does not have any moving parts, thus making it an appropriate device to be attached to a vehicle. The software can be updated and managed from a central location outside the premises of the physical installation. It can be powered by using any 5v DC, 2.4A adapter or Rechargeable Li-Ion battery: 3.7V 1200mAh.
- Rechargable Li-Ion battery: 3.7V 1200mAh for PX30 installed at the bus stop (solar recharging typically possible in the tropics)
- 802.11b external antennas for longer range at the bus stop

Wireless access points embedded in bus stops could not only beacon timetable information but also their coordinates and other helpful information, such as information regarding nearby attractions. Such additional information could be used to contribute to grassroots mobile infrastructure projects like the PlaceLab initiative [Schilit et al. 03] or Smart Guiding [Lueg 04].

6 Conclusions and Future Research

In this paper, we discussed virtualizing public transport timetables as a way to address representation-related information management and maintenance issues. Furthermore, virtual timetables would give riders a number of mobile data recharging options, including personalization and visualization of timetable information. In this context we also looked at timetable formats used by different public transport providers and found a lack of machine-parseable information. This problem could be addressed by providing timetable information in well-defined formats, such as XML, via web services.

The main contribution of this paper is that we introduced Mobile Data Transport as a way to enable Mobile Data Recharging at bus stop locations that would not normally be covered by (standard) communication networks. This means this research is addressing important issues for sparsely covered areas in countries like Australia or other geographically constrained areas, such as mountain areas in Switzerland. Furthermore, we have shown that the technology requirements are reasonable.

We are working on implementing a proof-of-concept version of the Mobile Data Transport concept and we are exploring collaborations with local public transport providers. We are also considering conducting surveys to deepen our understanding of some of our observations regarding information management in public transport and mobile technology adoption among riders (see [Carroll et al. 03] for related work).

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8 Web Resources

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