# On-line Mobile Passenger Information System (OMPIS)

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**KEYWORDS**

Control Systems, Urban Sustainability, Transportation, Telecommunications, Distributed Processing, Mobile Computing.

**ABSTRACT**

This paper investigates the feasibility of delivering on-line traffic information to the users on the road through a mobile telephone connection. The On-line Mobile Passenger Information System (OMPIS) has been designed as an essential part of the urban traffic control and management systems based on the Distributed Memory Environment (DIME - [1], [7]) and makes use of two different ways of data delivering: a) using Pier to Pier Internet Protocol (PPP) over a mobile telephone data link and b) using the Short Message Service (SMS) facility provided within the GSM standard. The OMPIS has been implemented for lap-top computers (PC) and for hand-held computers (Psion) and makes use of the data collected by SCOOT ([3]) and processed by PADSIM ([5]).

## INTRODUCTION

With new roads becoming more and more difficult to build (for environmental and political reasons) and the number of cars constantly increasing, the emphasis of the development of the traffic control systems is to provide the individual drivers with up to date information about the traffic conditions and to try to persuade them to abandon their cars in favour of public transport. At the same time the essential uses of the car should be as efficient as possible in terms of the use of the road network, environmental impact and cost. This is only possible on the basis of accurate and up to date traffic information delivered to the individual user. In the same time the efforts to deliver the data will succeed only if the user can have it a) anywhere on demand (i.e. not only in his car), b) at any time of the day, c) the data contain accurate information about the traffic conditions and the public transport in the direction (s)he is going and d) it is easy and not prohibitively expensive to use.

The conditions a) and b) are easily satisfied with mobile telephone links. Anyone, having a mobile telephone, could request and receive traffic information anywhere anytime. The condition d) requires the usage of a computerised device, which the user will obtain for other than requesting travel information purposes, and which will allow the user to choose starting and finishing points of a journey and to request traffic information and travel time for specific, chosen in advance, route.

The attempts to deliver on-line information to date, however, concentrated on supplying WWW pages in the form of text data to the user ([2] and [8]). These systems tried to use one (telephone) device with limited computational functionality (Cellular phone or Personal Assistant - [8]) and inevitably had no graphical user screens. In contrast, OMPIS delivers route travel times and makes use of a cellular phone and a palm-top computer (or lap-top computer), thus using the full functionality of a general purpose computer power and computer screen flexibility.

The OMPIS has been designed and tested at The Nottingham Trent University, the Real-Time Telemetry Systems Group. It addresses the above mentioned conditions a), b) and d) while considering the presence of on-line up to date traffic and public transport information available through the traffic control system and within the DIME environment.

## DIME ENVIRONMENT AND OMPIS

The typical DIME environment is presented on Figure 1. Each user application code has an additional component linked to it, which provides the communication interface via DIME API with the shared memory system. The requests for reading/writing data from/to the shared memory (creating or removing areas) are transferred by the DIME library over the network to the memory manager task, where they are being processed and replies are sent back. There are two components of DIME: a) the shared memory manager (MM) task which owns the shared area and b) the communication DIME libraries which are linked to user applications and the memory manager in order to interface to the network.

In a typical traffic control system there are a number of applications running concurrently and exchanging information within DIME: the operational control real-time system (SCOOT in the case of this study), traffic simulation module (PADSIM), on-line Origin-Destination matrices estimation module (for the case of this research turning movements estimation module described in [5] and [7]), and other on-line modules like incident detection module, GIS for traffic information module etc. The OMPIS client within DIME is one of the traffic applications, which makes use of the data made available within the DIME environment by SCOOT (real-time measurements) and by PADSIM (prediction data, route travel time estimation and prediction).

The data delivery scheme in OMPIS is presented on Figure 2. On the road client using his mobile equipment (lap-top PC or hand held computer (PSION) and a mobile telephone) chooses his route and with the touch of a button requests the desired information. The OMPIS client part is connected constantly to the DIME system and listens for the incoming requests, which arrive through the radio link. According to the request, it performs access to the appropriate area of DIME and delivers the necessary information back to the user. The response from OMPIS contains sufficient amount

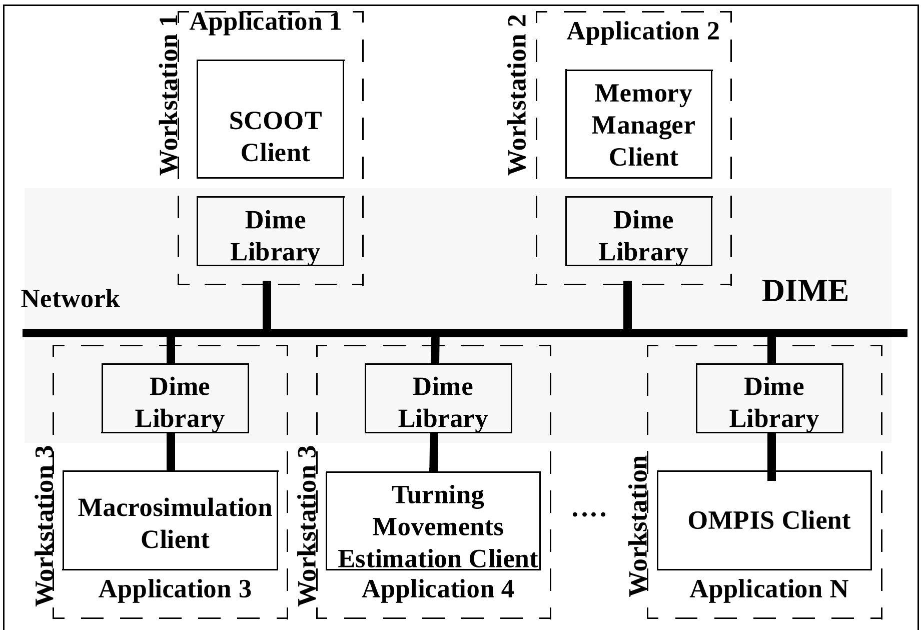



Figure 1. Using DIME and OMPIS for urban traffic simulation and control.

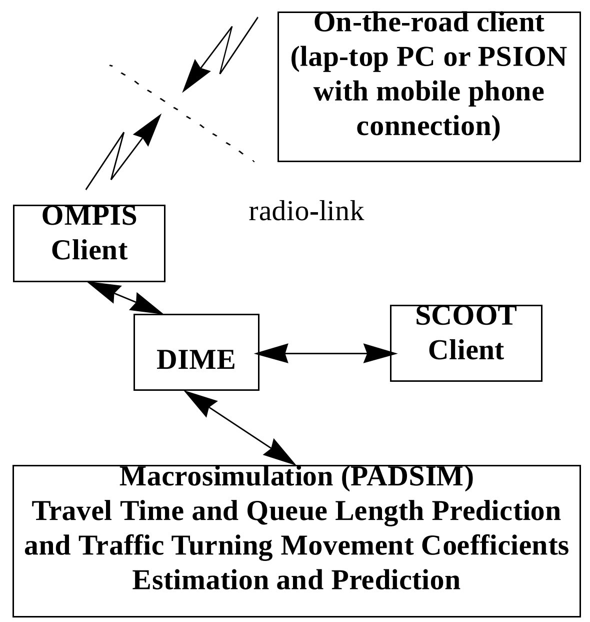



Figure 2. OMPIS - data delivery scheme.

of traffic and bus travel information for the user to be able to take the right decision regarding his/her means of travel.

## OMPIS IMPLEMENTATION

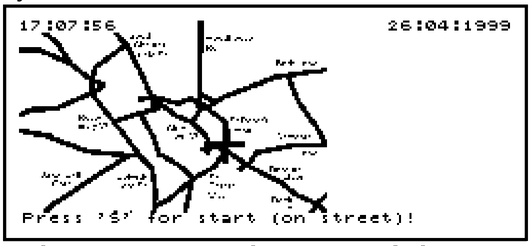
OMPIS has been implemented in two different communications frameworks:

- Synchronous communications - using the PPP facility of an Internet connection.
- Asynchronous communications - using the SMS facility of GSM connection.

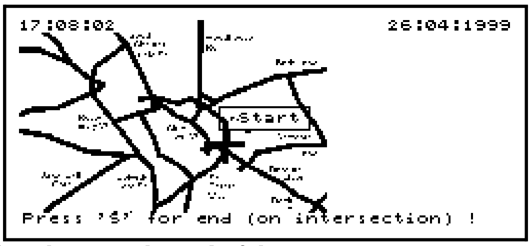
In the first case experiments have been performed with Intel 486 Windows based lap-top computer, Psion Workabout and Psion Series 3a. All these types of computers had Mansfield Traffic Network data pre-loaded on them. All routes and their starting and ending points have been pre-determined and pre-assigned. The connection to DIME environment in this case was established automatically with the start of the program on the mobile computer. The speed of data exchange had the limitation of the mobile link data connection of 9600 bytes/sec. This arrangement suffers from two substantial drawbacks if the computers stay permanently connected - a) the price of the connection is high and b) the mobile telephone remains engaged so it can not be used for other connections. If the mobile telephone is not connected permanently to the DIME system the initial negotiation is very slow (usually more than a minute), thus dramatically slowing down the data retrieving process.

In order to avoid the above mentioned drawbacks the communication part of the system has been designed to make use of the Short Message Service (SMS) facility. In this case a special protocol for requesting and delivering the data has been designed and implemented. The reason for this step is the limitation of 160 bytes for each SMS message. Thus keeping the message compact reduces the cost of the link between the programs (each SMS message costs approximately 10p). The protocol has been designed to deliver the response data within the limitations of a single message i.e. the response contains travel time data alongside the route chosen by the user together with information for alternative routes and their travel times packed in a message with length less than 160 bytes. Description of the protocol is given in Appendix A. The DIME OMPIS client, in this case, consisted of an Unix C++ program connected permanently to the DIME system.

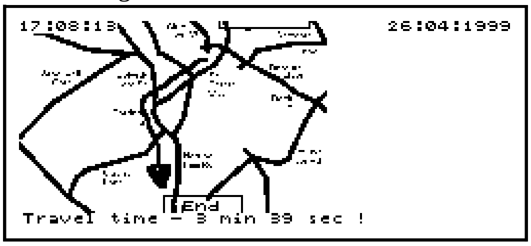
The communication data exchange using SMS message delivery protocol has been entirely hidden and the user needed to chose only a route and press a button to retrieve the latest traffic prediction and on-line data. This process is illustrated on a Psion Workabout computer. It begins with the start of a program which displays the initial Mansfield Traffic Network:



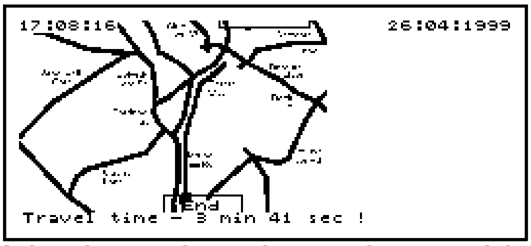

Next the user can move the cursor and chose start of a route:



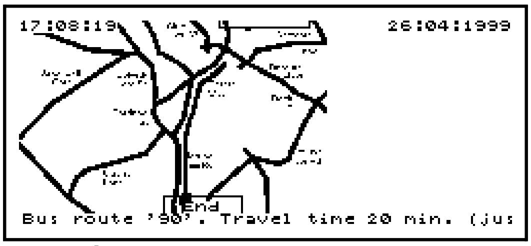

After choosing the end of the route




the program displays the appropriate route and is ready to request travel time information from the OMPIS DIME client. By pressing one button the user authorises the transaction and the Psion computer sends (through the mobile telephone) the SMS message requesting travel information. The response from the OMPIS DIME client contains information about alternative routes



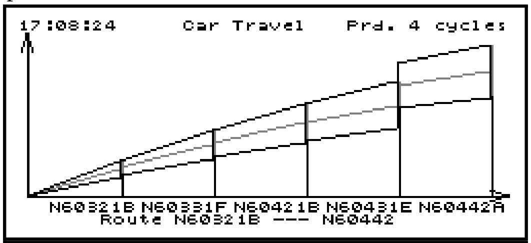

and about bus travel times between the start and the end

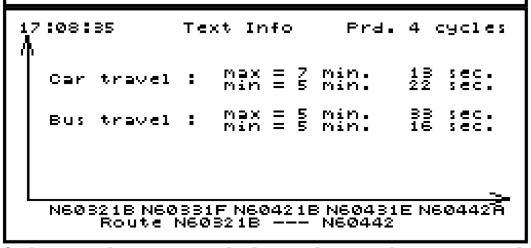



of the route chosen.

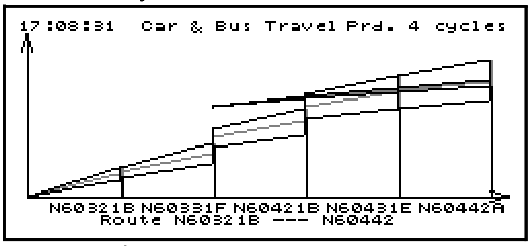
This illustrates the point that although, in the current implementation, no connection to the public transport on-line information data was available, a provision for delivering such type of data has been implemented and filled with some static values, which simulate the actual public transport data.

The predicted route travel time for an average, slow and fast driver can be seen on two more screens in graphic and text mode:




If the road user needed to choose between public transport and using the car, there was a graphical screen available allowing the comparison between the two alternatives. In this example the bus can be boarded after two intersections and after allowing time for the move. The bus goes faster than a car in the same direction with the assumptions it uses bus lanes and there is busy traffic in the desired direction.




Examples of user screens on a Windows I486 based computer providing the same functionality and with better screen facilities are presented in the Appendix B.

## EXPERIMENTAL RESULTS

The speed of data delivery required for delivering all raw SCOOT data for the Mansfield region is 800 bytes/sec. The speed of the communication over a telephone line (mobile telephone line, speed 9600 Bytes/sec) has been found to be sufficient to deliver all on-line raw data for the Mansfield region on a 4 second basis. Since the OMPIS environment, on the other hand, requires much smaller amount of data in comparison with the stream of raw data delivered by SCOOT, DIME can successfully deliver all route travel times and public transport information, necessary for the application, within the reasonable 2-5 sec. interval after the request in the case of PPP connection (depending on the network load).

However, since the connection can not be maintained on all the time (cost consideration), for a single transaction, including the negotiation of the connection, the interval can be as long as 1 1/2 minutes which is deemed to be unacceptable.

The alternative solution of using SMS connection reduces both the cost and the round-trip time of message delivery. Using the protocol described in Appendix A it is possible to achieve the request - delivery time of approximately 10 - 30 seconds. The time-line of SMS message delivery is presented in Figure 3. The GSM network latency was 4 - 13 sec., the latency of the UNIX client was approximately 3 sec. and the delays for data retrieval in the client program itself were less than 200 milliseconds. This time scale allows transmitting up to 20 user responses per minute.

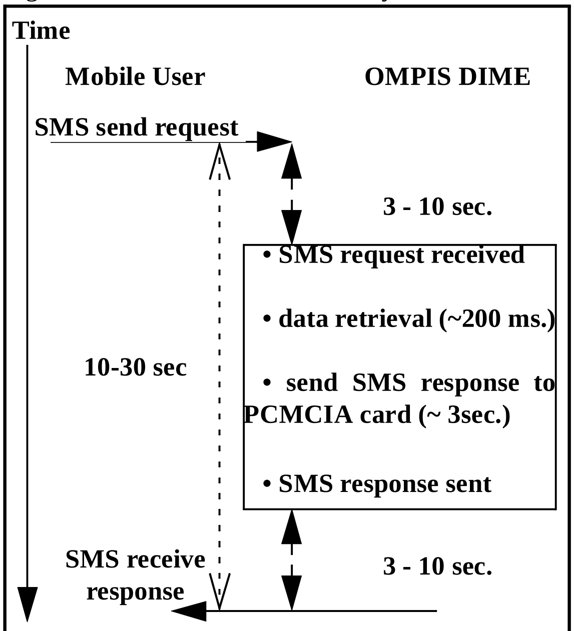



Figure 3. SMS message delivery scheme

In both implementations all map and route configuration data were preloaded on the respective computers.

**CONCLUSIONS**

A prototype of an on-line Mobile Passenger Information System (OMPIS) has been designed and implemented and the results from the field trials showed that:

• Such a system can be easily installed and used by the mobile passengers (in the car or outside the car).

• It requires hand-held computer and a mobile telephone set only, which is a combination that can be easily carried even outside the car. At the same time this equipment is obtained (very often) for other than collecting traffic and travel information purposes.

• The throughput of the system is sufficient to deliver route travel times and bus travel information on request over a radio link, but any change in the configuration of the traffic network requires ordinary wire cable connection because of the current speed and price of the radio link.

• The SMS facility is a convenient way of delivering limited amount of information (no need for dialling and negotiating a radio link data connection).

• With predetermined traffic network layout, the length of the SMS message is sufficient to include all data needed to deliver a request and its response in two single transactions.

• The SMS messages approach gives better scalability than PPP internet connection approach. With PPP connection every in-street user requires separate entry point to be able to connect to the DIME system. In contrast, the SMS approach allows several users to make use of a single entry point. The limitation in this case is the 3 sec. interval needed by the OMPIS UNIX DIME client to respond with a single message, thus reducing the number of users per entry point to 20 (assuming 1 min. as must-get-response time).

• OMPIS can be compared to GSMove [2] system and its objectives are the same as the objectives of the PROMISE TR1043 [8] project. In all cases the common technical background is using SMS messages to deliver travel information to a mobile user. The significant difference, however, is the use of on-line information available to OMPIS. The system utilises a connection to an on-line operational control system (like SCOOT) and uses the results of a prediction process capable of anticipating the development of the traffic in short term (5 - 30 min. - PADSIM). In contrast GSMove and PROMISE TR1043 use travel data available on the WWW pages. Consequently, OMPIS is able to deliver not only matter-of-fact on-line travel time information, but at the same time can anticipate how the traffic evolves and suggests alternative routes. These novelties in the contents of the information are reflected in the design of the communication protocol described in the appendices

Future research will concentrate on the investigation of the effectiveness of the user interfaces and on further improvement of the efficiency of the data delivery protocol.

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## APPENDIX A

Structure of the commands and the protocol:

• Command Number - every command starts with a pre-defined number showing the type of the request. At the same it carries information whether this is a request or respond to a previous request. In this way the same structure can be used for delivery of the requested data.

• Command tag - special number for message synchronisation.

• Command time - the exact time the command has been send.

• Map and Routes Tables revision - two numbers showing the revision of the map and routes tables in use. This is reserved for future use and it is set currently to 0.

• Command body - variable length information data, depending on the type of the specific command.

General format of the command body for request route travel time command:

• Route Number.

• [< Route Number >] - Optionally the body of the command can contain more than one route number.

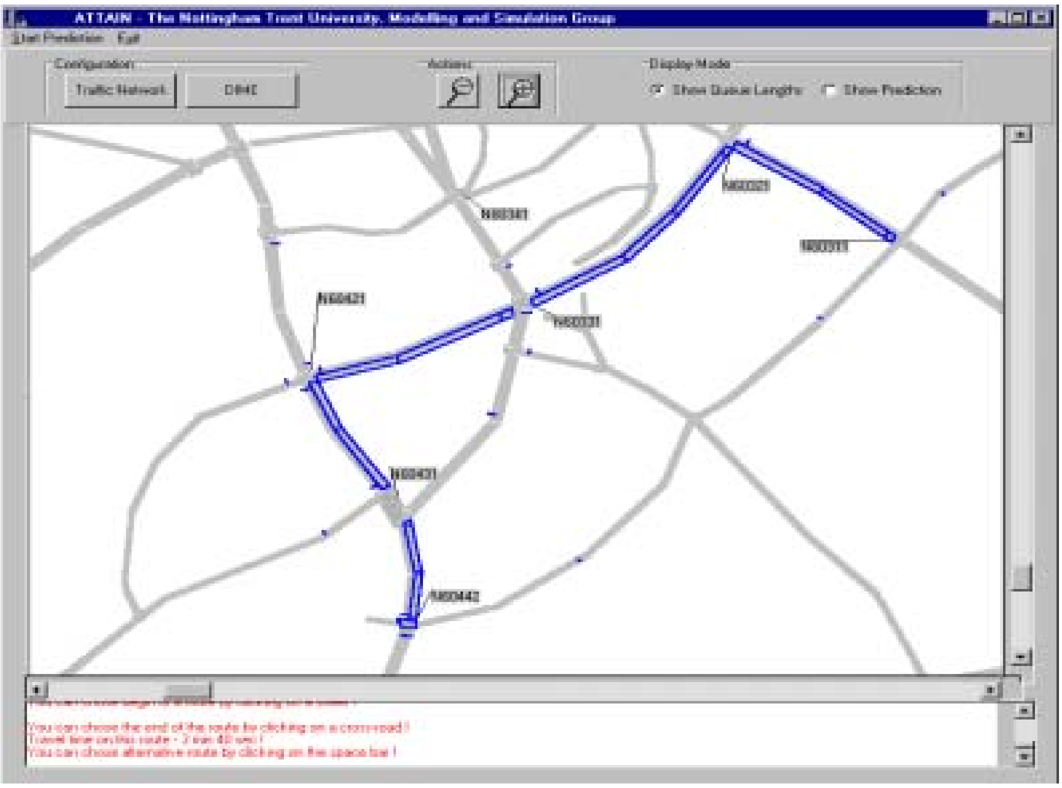
After receiving this request the OMPIS UNIX client retrieves the travel time data for the specified routes together with the travel times for all other routes with the same starting and ending point and sends back a response with command body data in the format:

• Route Number.

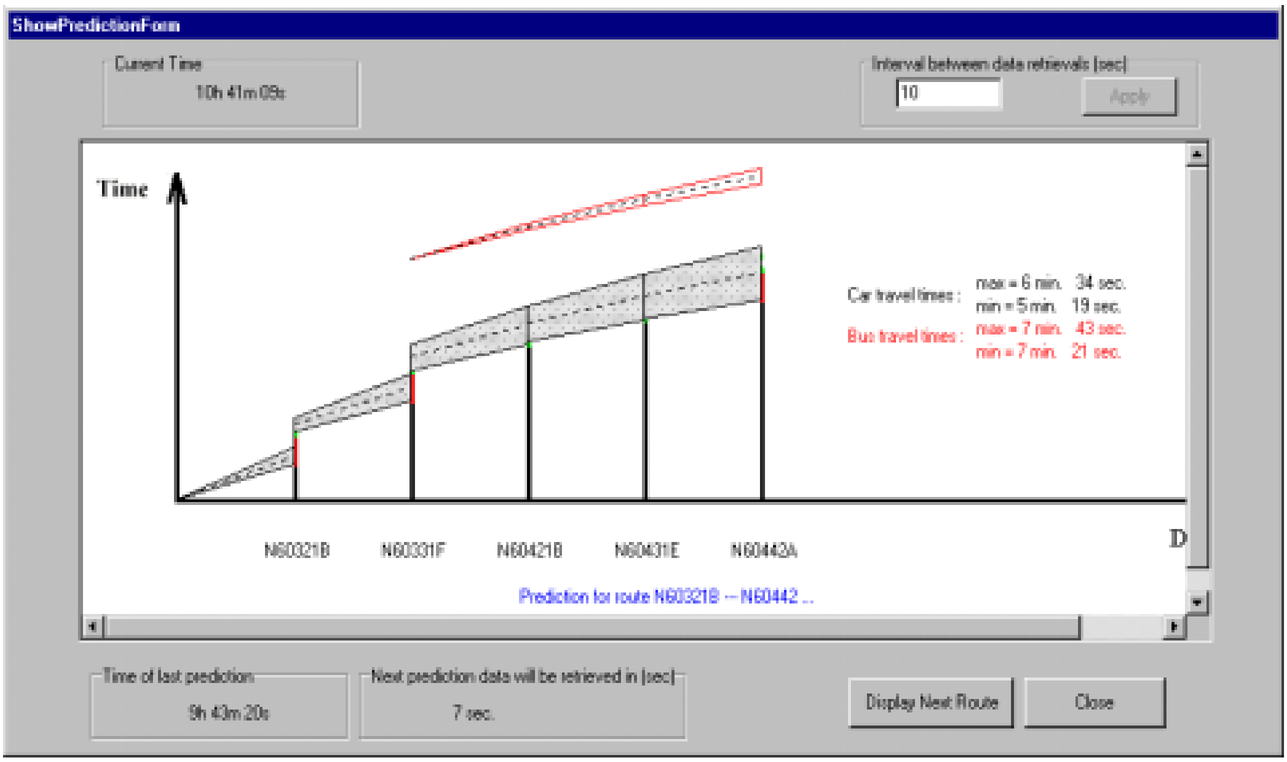
• Route Travel Time - representing the travel time for the specified number of the route in the routes table.

• [< Route Number >< Route Trav. Time >]- Optionally the body of the command can contain more than one route number and corresponding to the route number travel time.

**APPENDIX B**




Mansfield Traffic Network - route chosen and travel time alongside the route displayed.




Mansfield Traffic Network - travel time alongside the chosen route displayed for average, fast and slow driver (y - coordinate - time, x - coordinate distance) and compared with bus travel time for a bus starting in the middle of the route and using bus lane facility. The information is displayed in both graphical and alpha-numerical form.