

(21) Application No: 0319353.9
(22) Date of Filing: 18.08.2003
(30) Priority Data:
(31) 0301362 (32) 21.01.2003 (33) GB

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(51) INT CL⁷:
G08G 1/0968 , G01C 21/34 , G08G 1/123

(52) UK CL (Edition W):
G4Q QAJ

(56) Documents Cited:
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ADART - "Autonomous Dial-A-Ride Transit" -
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Administration Report No FTA-TRI10-99-1 - November
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"Real Time Ridesharing using wireless pocket phones
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ISBN 07803-3587-7 - Pg 486-492.

(58) Field of Search:
UK CL (Edition W) G4A, G4Q
INT CL⁷ G01C, G08G
Other: ONLINE: WPI, EPODOC, JAPIO, INSPEC,
ELSEVIER, TDB, Internet

(54) Abstract Title: **Intelligent grouping transportation - Autonomous dial-a-ride transit system**

(57) A mode of public transportation which uses computer systems, data communication systems, electronic positioning systems, and electronic street navigation systems in order to orchestrate a fleet of driver-controlled multi-passenger transit vehicles on the roads. To ride via this transport system, individual travellers must first submit their itinerary requirements to the computer system. Typically, travellers will do this by entering their itinerary data on their cellular telephone. The computer system scans all the submitted itinerary requirements that it receives, and then intelligently groups travellers with compatible itineraries onto the same, typically minibus-sized, transit vehicle. The computer system creates a customised road route for this transit vehicle so that each traveller thus grouped is picked up and conveyed exactly according to his itinerary, even though journeying simultaneously with other travellers on board. The computer system supplies street navigation instructions to the transit vehicle driver to direct him along this customised road route.

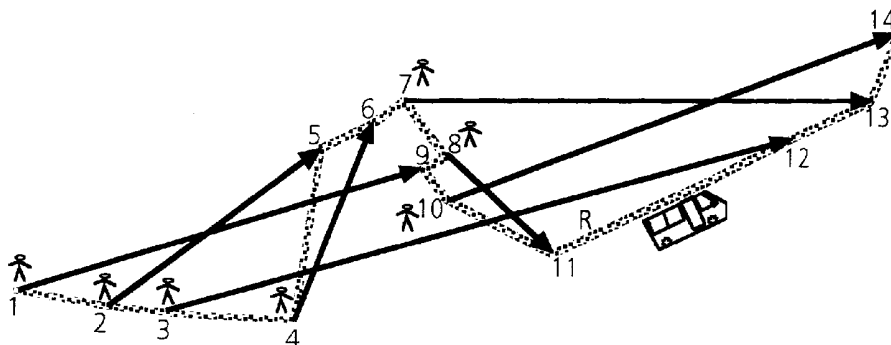


Figure 3

1 / 6

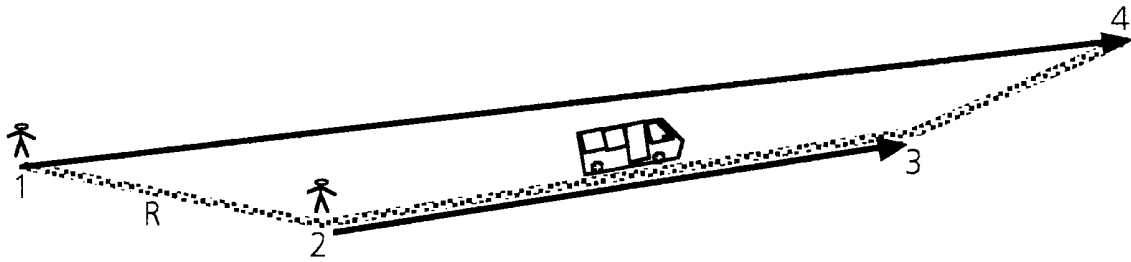


Figure 1

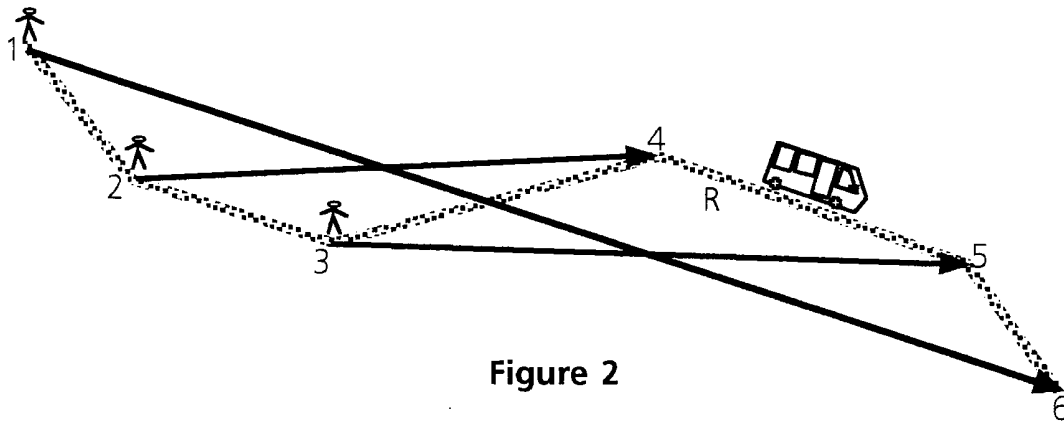


Figure 2

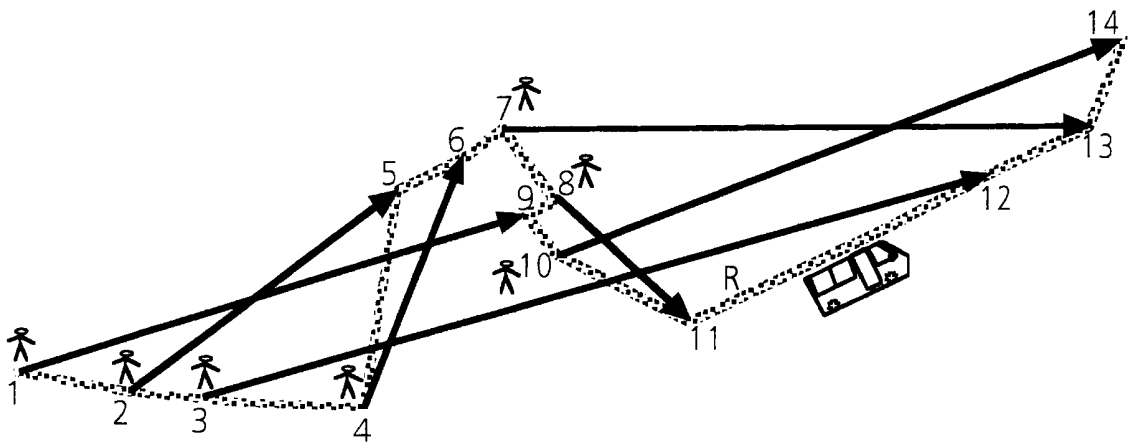


Figure 3

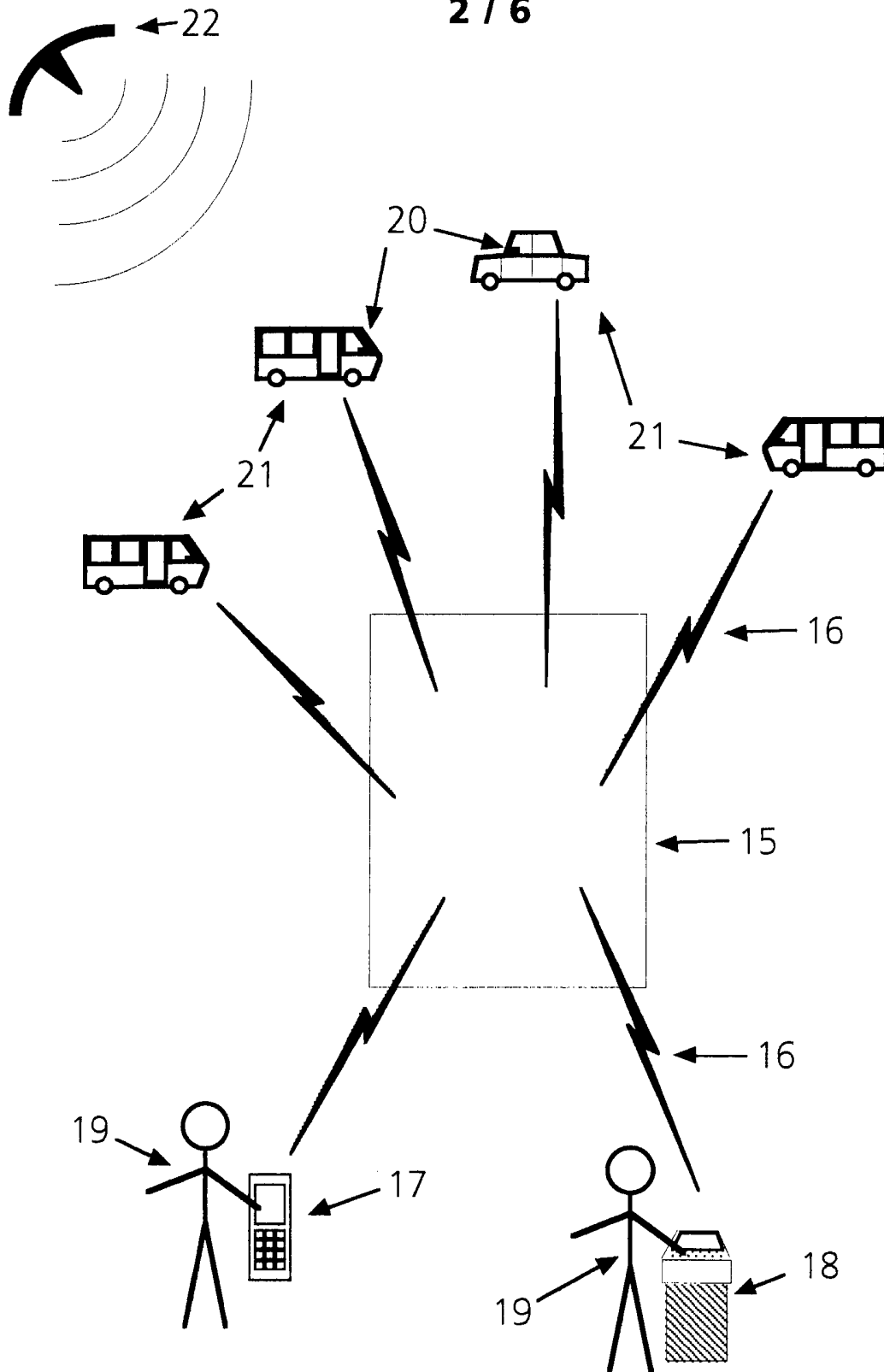


Figure 4

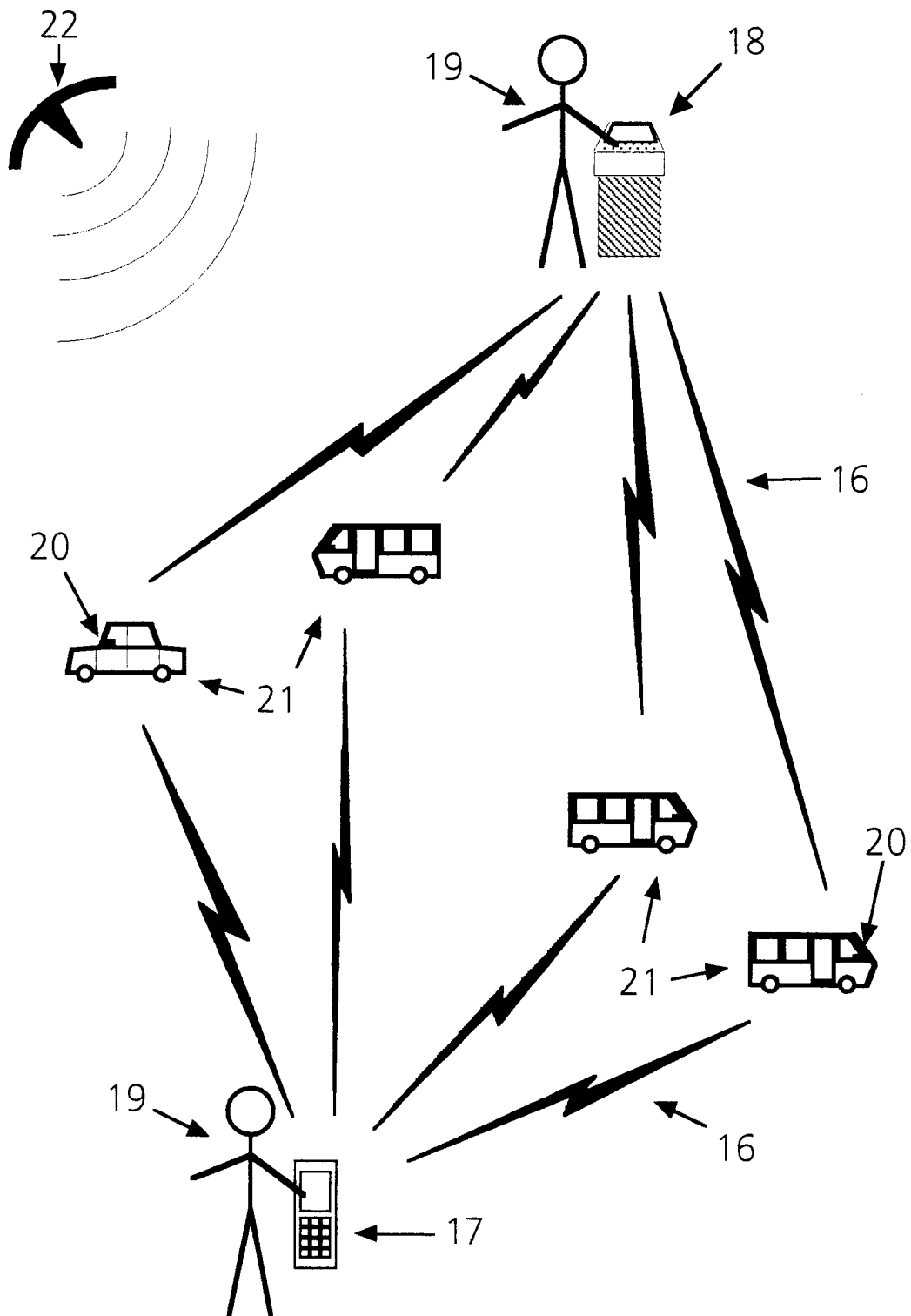


Figure 5

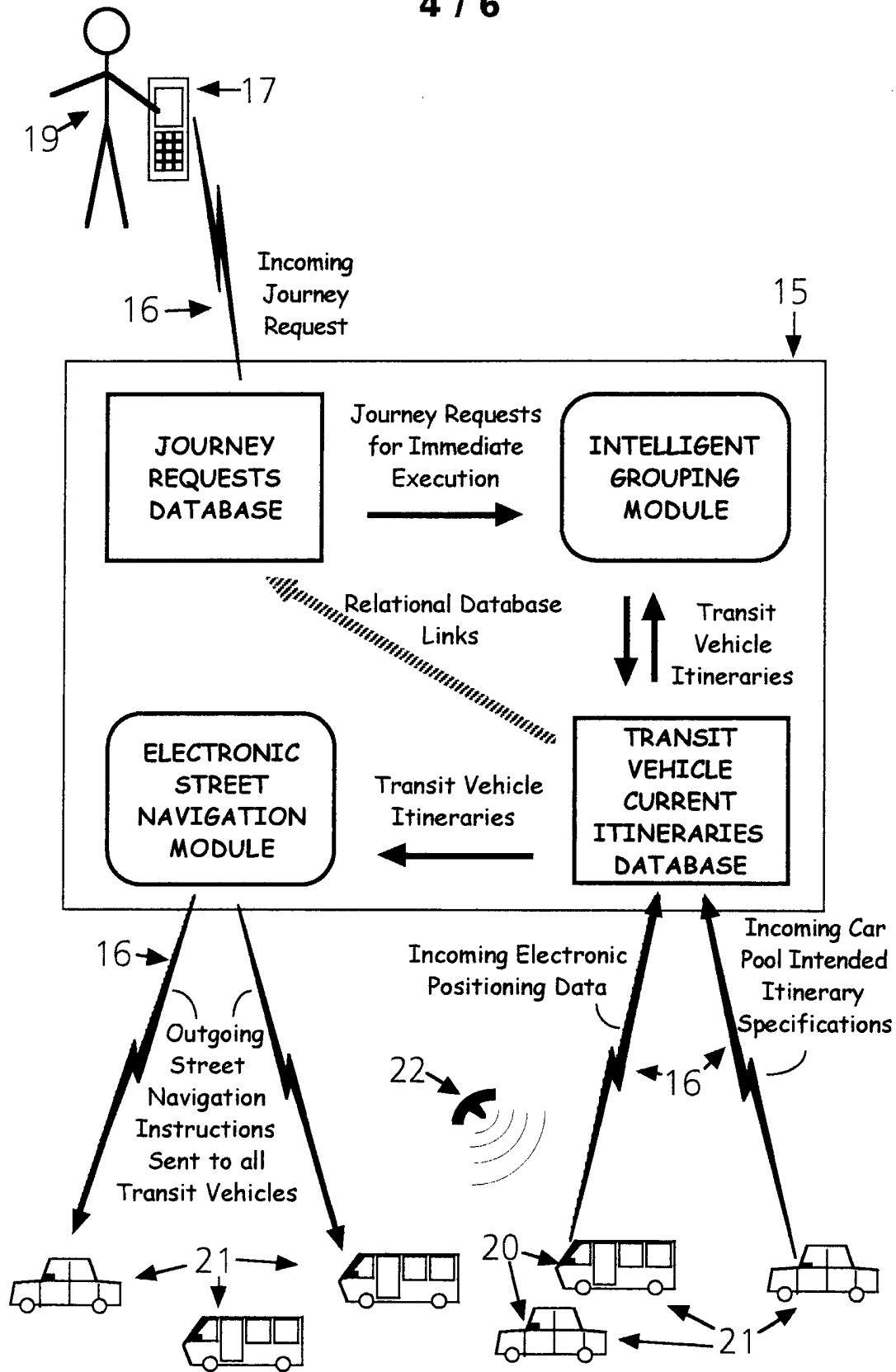


Figure 6

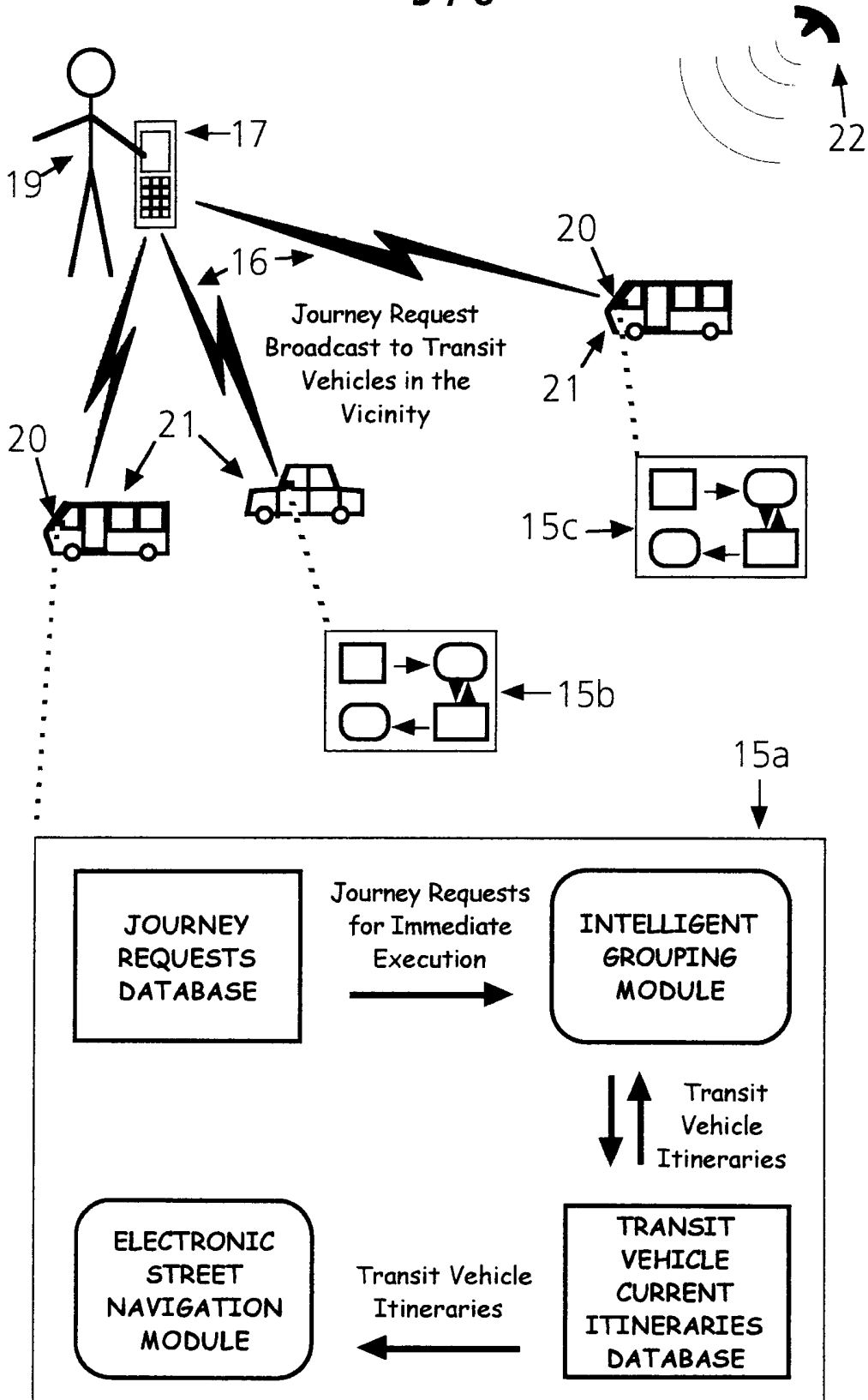


Figure 7

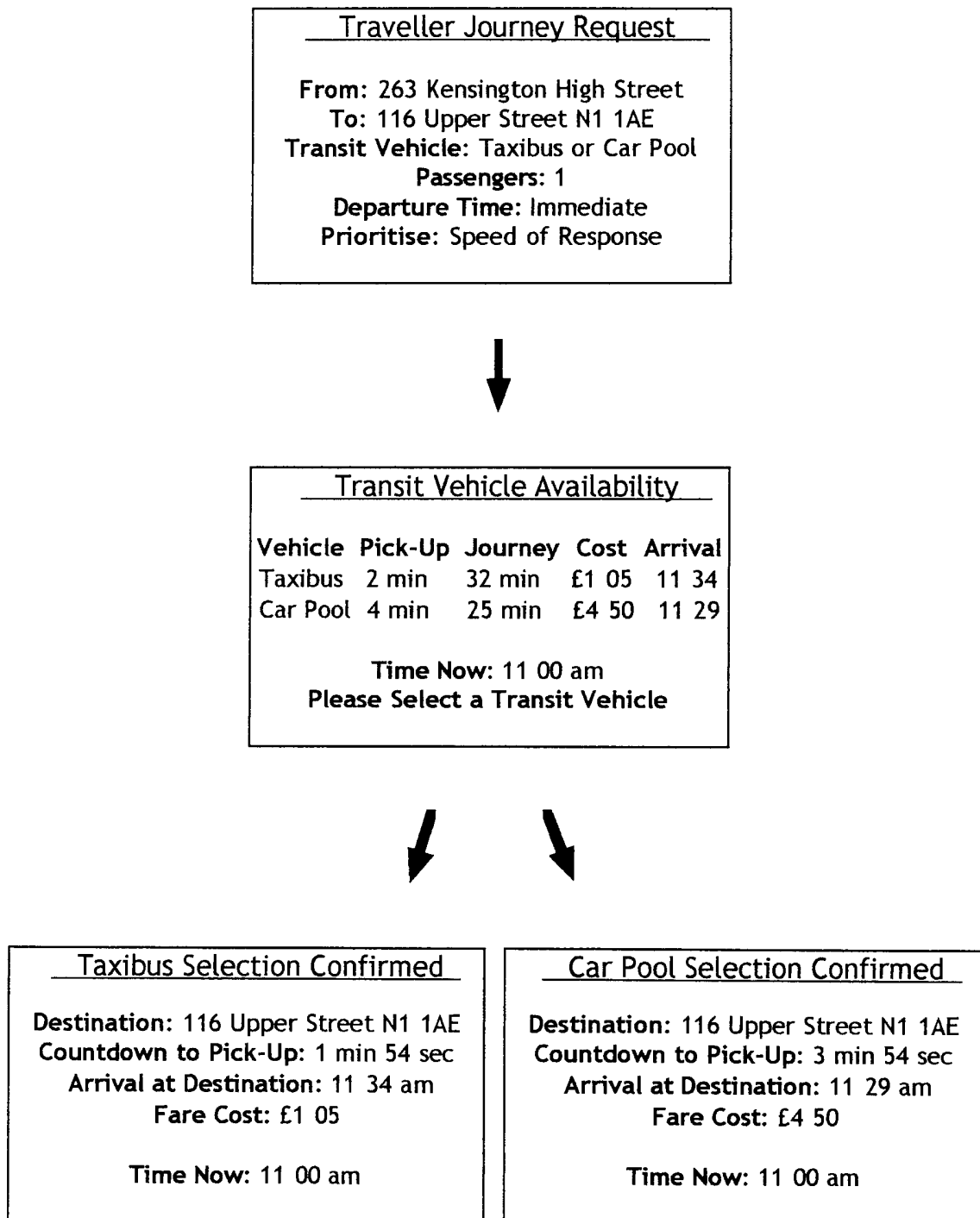


Figure 8

Intelligent Grouping Transportation

1 - TECHNICAL FIELD OF INVENTION

This invention relates to a public transportation system that operates on the roads.

2 - SYNOPSIS

This invention is an entirely new mode of public transport which uses computer and communication technology to group travellers with compatible itineraries onto the same (typically minibus-sized) transit vehicle, customising the road route of this transit vehicle so that it transports each traveller according to his or her itinerary, generally from door-to-door. Though conceptually simple, this idea provides an enormous range of economies and efficiencies. With individualised routing for each traveller, this form of travel can compete with the private car in terms of convenience and flexibility. The door-to-door service offers excellent personal security, protection from the weather, and conveys travellers considerably faster than conventional public transport. As a consequence of grouping many travellers into the same vehicle, this invention has the potential to substantially reduce the number of cars on the roads by as much as *fourfold*, and to end the proliferation of the private car. This invention thus has application in overcoming traffic congestion, parking congestion, toxic air pollution, noise pollution, and if implemented around the globe, will radically decrease greenhouse gas emissions.

3 - BACKGROUND OF THE INVENTION

Throughout the world, road traffic congestion is becoming a critical problem. Congested roads dramatically increase journey times, making travel often stupidly inefficient. Being caught in slow moving and dense traffic not only wastes time, but frequently puts drivers in aggressive moods. At the end of a car journey there is the added problem of parking: in many towns and cities finding a parking place can be very troublesome; too many vehicles compete for limited parking space. The huge amount of time lost through traffic and parking delays costs the United Kingdom an estimated £20 billion each year. There are also enormous costs for maintaining and expanding the road networks to support the increasing levels of traffic. Traffic congestion significantly degrades the quality of life for everyone - a fact not so easily quantified, but one which is directly perceived by most people in their daily lives without the need for figures or statistics.

Pollution is a further and very pressing problem of high traffic levels. Engines that run on fossil fuels (such as petrol or diesel) emit many toxic pollutants: carbon monoxide, nitrogen dioxide, sulphur dioxide, benzene, formaldehyde, polycyclic hydrocarbons, lead, and small particle matter. Some of these pollutants react together in warm sunshine to form the poisonous gas ozone, the chief component of summer smog. In London, these vehicle exhaust emissions are responsible for a staggering 90% of the air pollution.

Air pollution has grave health consequences. The Department of Health estimates that in the UK around 24 thousand people die each year as a result of vehicle exhaust gases and small particle pollutants, which cause heart and lung diseases. In particular, the soaring rise in asthma is very disturbing. Five million Britons suffer from asthma, with a very high incidence amongst children: one child in seven is now afflicted. The annual cost of asthma to the UK is estimated at £2 billion.

New research in the USA, funded by the California Air Resources Board, not only proves that asthma is aggravated by traffic pollution (a fact already accepted), but conclusively proves that traffic pollution causes this disease in the first place. Ozone is the culprit: breathing this gas damages lung tissue and can precipitate asthma.

Air pollution also causes cancer. New findings reported in the Journal of the American Medical Association in March 2002 show that the death rate from lung cancer is directly related to exposure to small particle pollution in the air. This large-scale study followed half a million people over 16 years. Particulate pollution arises from fossil fuel combustion and factory chimneys. The smaller-sized particles, those less than 2.5 microns in diameter, are the most dangerous: they are easily inhaled deep into the lungs where they can lodge for long periods causing persistent damage to lung tissue.

Another pollution problem is hayfever - a disease virtually unheard of before the industrial revolution. Hayfever is not life threatening, but is nevertheless an unpleasant allergic condition. In major cities there is a marked increase in people contracting this disease, and air pollution is thought to be the principal causal factor

in the development of hayfever (although this has not been rigourously proven).

Vehicle exhaust emissions are a substantial source of greenhouse gases. Fossil-fuel burning engines generate large quantities of carbon dioxide, a gas which though not toxic to human health, is the principal greenhouse gas implicated in global climate change. The Transport Studies Unit at Oxford University estimate that at least 25% of Britain's carbon dioxide emissions originate from transportation, and in the US the figure is closer to 33%. Road traffic may thus be detrimental to climate stability.

Traffic congestion, parking congestion, lost time and earnings, stressful journeys, road rage, degradation in the quality of life, noise pollution, air pollution, life threatening medical conditions, global warming potential: these are all problems of high traffic levels. How can traffic volumes be meaningfully reduced?

One obvious solution is to entice more of the populace to travel by public transport. Yet experience has shown that this approach often fails because the private car is much faster, more flexible and more convenient than public transport. The car will remain the preferred mode of travel unless public transport is radically improved.

Another approach to curbing car usage rests on vehicle restriction schemes, which aim to limit the quantity of vehicles on the roads. Though many different traffic restriction schemes have been contrived and implemented, they have not in general been very effective, and often introduce problems of their own.

A third method of cutting traffic levels involves car pooling schemes, in which commuters with similar itineraries organise themselves so that they can travel in a single vehicle driven by one of the commuters. Car pooling is a great idea in principle, but there are many logistical problems to be solved before such an approach becomes practicable and widely adopted.

In summary, no simple and effective system for dealing with the traffic congestion crisis has yet been found, even though virtually every nation in the world is in desperate need of a workable solution.

The present invention is the breakthrough solution to transport problems and traffic congestion. Its various modes of operation will radically reduce traffic levels, yet amazingly this invention requires no changes to road layouts, highway laws, existing public transport operation, or any transport infrastructures: it is a minimal-impact system, which easily coexists with other forms of transport, and other traffic control schemes. This solution places absolutely no restrictions or additional costs on motorists. In fact in one mode of functioning it actually helps drivers *recoup* the costs of running their vehicles. Most importantly, this invention decreases the number of vehicles on the roads, yet it does not decrease the total number of passenger journeys taking place, thus maintaining people-mobility.

4 - PROBLEMS OF EXISTING TRANSPORT SCHEMES

In order to appreciate the compelling logic of this invention we must first familiarise ourselves with the flaws and failures of existing modes of transport and existing means of traffic congestion control. We inspect three areas: public transport solutions, traffic restriction schemes, and car pooling.

4.1 - Public Transport Solutions

Improvement of conventional public transport facilities is frequently claimed to be the best approach for reducing traffic levels. Public transport is unarguably a vital mode of travel, and road traffic levels would certainly soar without it. However public transport, in its *existing* forms, can never compete with the private car. The car is at present unbeatable in terms of door-to-door convenience, all-weather comfort, flexibility of itinerary, the ease of carrying goods or luggage, personal security, and so forth.

Compared to the private car, travelling by public transport frequently requires complex pre-planning (consulting timetables, examining fare options, checking journey times, working out how to get to and from the train stations or bus stops). This planning becomes especially time consuming when travelling to new and unfamiliar destinations. For many people it will always seem easier to jump into the car. This fact is borne out by the Department for Transport's statistics: in the UK a massive 62% of all journeys take place by car, compared to only 6% by bus and a paltry 2% by train and underground railway. (Walking accounts for 26% of trips.)

These statistics further reveal that, for journeys of less than 25 miles, travelling by car is around *twice* as fast, on average, as the same journey by bus or train, when the overall door-to-door travel time is taken into account. Public travel takes so much longer than the car because of the necessary wait for the transport vehicle to arrive, and also because of the time consumed by trips to and from the station or bus stop, at either end of the journey.

Given these facts, it is not surprising that the car is the first choice for transport. Clearly if public travel is to be made more attractive so as to compete with the private car, the sources of this wasted time must be eliminated, as must the complex pre-planning process, the inflexibility of itinerary, and the many other problems of public transport. Furthermore, as we saw, the private car provides the bulk (62%) of the daily passenger journeys in the UK: the car cannot be replaced until another mode of transport is introduced to provide for this amount of passenger journeys.

4.2 - Traffic Restriction Schemes

Since it appears that the car is clearly favoured over public transport, in an effort to combat road traffic congestion, many cities are concentrating on traffic restriction

schemes. All these traffic restriction schemes have the same goal: to limit the volume of vehicles travelling within a controlled region. Many different traffic restriction systems have been tried; some were successful, others failed completely. All were complex and inconvenient, especially in terms of the constraints forced upon the motorist.

One type of restriction scheme is road pricing, which charges motorists for driving in designated areas in order to price out a certain percentage of road users. Road pricing schemes are controversial for many reasons, nevertheless, such a scheme will shortly begin operation in London.

A second class of scheme restricts traffic according to vehicle licence number. Although now discontinued, a system enforced in Mexico City during periods of extreme air pollution controlled car use on the basis of vehicle number plate. Vehicles with odd-numbered licence plates were prohibited from use on certain days in the week, and vehicles with even-numbered licence plates were prohibited on the alternate days. Although one would expect such a scheme to effectively halve the number of vehicles on the roads, only an 11% traffic reduction was actually observed. The scheme's disappointing performance was due to several factors. For example: necessary car journeys would just be deferred to a permitted driving day, meaning that overall vehicle usage was not decreased; and wealthier families would often buy a second car with a complementary licence number, allowing road use everyday. Ultimately this highly inconvenient scheme did little to reduce traffic congestion.

A third class of scheme, already adopted by Gothenburg in Sweden and Bremen in Germany, divides the city into several traffic cells. Vehicles can travel freely within one cell's locality, but in order to travel between cells, a ring road must be used. The exceptions are for bicycle and commercial vehicles, which are permitted to travel directly across cells. As a result of this scheme, traffic volumes were substantially lowered. Nevertheless, this method does have one big disadvantage, which is that it frequently forces vehicles to take a longer and more complicated trip than is necessary when travelling to an adjacent traffic cell. There may also be problems in scaling up the concept for use in larger cities, or when the particular layout of a city prevents expediently routed ring roads.

As well as their own specific problems, these congestion control schemes suffer from two problems common to all restriction methods: firstly the need to police the system, and secondly the abuse of exceptions. Continual monitoring of the system is necessary if it is to be enforced, thus taxing human resources and transport budgets. Even with good policing, however, the abuse of exceptions remains an unresolved problem. Many categories of vehicle (delivery vehicles, doctors, salespeople, and so forth) may be granted exemption for their legitimate business; but what is to prevent such drivers from enjoying this concession on non-legitimate journeys?

A further problem with vehicle restriction is the possible economic repercussions. If vehicle restriction results in less passenger journeys taking place, a proportional decrease in economic activity could result, as a certain percentage of trips to shopping centres, to the high street, to business clients, to city centre restaurants, to

night entertainment, and to tourist attractions are cancelled. Many sectors of the economy are critically dependant on transportation, and modern lifestyles are based around mobility. Traffic levels certainly need to be controlled, but ideally without decreasing the overall amount of passenger journeys daily taking place.

One final problem with vehicle restriction schemes is simply the fact that they are a restriction. Nobody wants extra constraints placed on their free movement. In a sense, introducing traffic restrictions is an admission of defeat. It would be so much better to develop a transportation scheme that liberated the roads in a positive way rather than impose harsh restriction methodologies on road users.

4.3 - Car Pooling Congestion Control Schemes

Car pooling is one such approach to a positive transportation scheme. Typically in car pooling schemes, suburban commuter travellers elect to leave their cars at home and journey to their destination in the vehicle of a fellow commuter. Clearly, were car pooling widely adopted, traffic levels would noticeably fall.

Many states in the USA have tried to encourage car pooling by marking out special 'diamond' lanes on the freeways, these lanes being reserved for vehicles carrying several passengers; drivers of such 'high occupancy vehicles' can cut their journey times and avoid traffic congestion by using the relatively traffic-free diamond lane. A ninety-minute freeway commute, as an example, can typically be cut down to just one hour using this diamond lane. In this way the diamond lane encourages drivers to fill the empty seats in their cars with passengers.

The intention behind car pooling is good. Even a casual examination of cars on the roads during the commuter rush hours reveals that most carry the driver only. This is clearly a wasteful and inefficient way of transporting people as most of these solo drivers will have three or more unused seats available in their vehicles, seats which in principle could carry passengers travelling to compatible destinations. Solo drivers are also travelling at a maximum 'pollution per person' level by having an entire exhaust emitting engine to themselves.

The fundamental difficulty in car pooling, however, is the logistics of matching passengers to vehicle drivers. In the American diamond lane scheme, no formal system of matching has been established: freeway commuters must arrange this themselves. Typically prospective passengers will congregate at freeway entrances, sometimes wielding cardboard signs bearing the name of their destination, waiting for a suitable vehicle to pick them up. There are also Internet web sites via which passengers can link up with suitable car pool drivers. Although the American experiment has had some success in stimulating car pooling amongst commuters, the diamond lanes often remain empty even when the other lanes on the freeway are heavily congested. Some US states are discontinuing the diamond lane scheme on the grounds that, having failed to stimulate car pooling to a sufficient degree, these relatively empty lanes waste valuable carriageway space.

Clearly the diamond lane idea has some serious weaknesses. Firstly, the informal manner of matching prospective passengers to drivers with compatible itineraries is not effective enough; the process of placing passengers into an appropriate vehicle needs to be much better organised. Secondly, if prospective passengers are in short supply, the diamond lane cannot be used and wastes valuable lane space on the freeway. Thirdly, the scheme requires diamond lanes to be set up and marked out: whilst this can be done on freeways, it becomes more difficult to do this in urban areas where roads are narrower, frequently cluttered with parked cars, and may only have one lane running in each direction. Fourthly, the diamond lane must be constantly policed to ensure only high occupancy vehicles use it. Finally, if the diamond lane were successful, then it would begin to fail, because these lanes would also become congested and therefore the incentive to carry passengers disappears.

In spite of the diamond lane method failing to stimulate car pooling to a sufficient degree, the intention and principle of car pooling remains an intelligent solution to road traffic congestion. All that is needed is a better way of encouraging drivers to carry passengers (preferably one that does not require road layout changes), and an effective way of matching passengers and drivers with compatible itineraries.

4.4 - Summary of Transport Problems

It is evident that certain formidable transport problems underlie road congestion. In summary:

The Private Car is generally the fastest and most flexible means of travel, yet for this very reason the car, in its burgeoning numbers, causes traffic congestion, parking congestion, air pollution, noise pollution, stress and road rage, greenhouse gas emissions, and many other problems besides.

Existing Modes of Public Transport cannot compete with the car since, on average, they take twice as long for journeys under 25 miles; they lack the 'jump in and go' immediacy of the car; they often demand complex pre-planning before travel; and they have no flexibility of itinerary. In addition, existing modes of public transport do not provide a door-to-door service, so personal security and protection from the weather is not complete, and carrying luggage or goods is made more difficult.

Traffic Restriction Methods place undesirable constraints on free movement, need constant policing, and are open to abuse of exceptions. They may decrease the number of journeys taking place, so there may be adverse economic repercussions. Restriction methods are a negative approach to solving traffic congestion problems; they should be used as temporary measures rather than as long term solutions.

Car Pooling Schemes are a great idea in principle, but existing methods of matching passengers to vehicle drivers are not sufficiently effective, and it is not easy to devise a car pooling system which provides an incentive for drivers to give rides.

5 - DEFINING FEATURES OF THE INVENTION

5.1 - Object and Applications of this Invention

The formidable transport problems described above are addressed and solved by the present road transportation invention. In particular:

This invention has an objective to provide a mode of public transport that operates on the roads and can supply a city with millions of passenger journeys daily, yet generating only a fraction of the road traffic that normally arises when this amount of passenger journeys are furnished by the private car mode of transport.

This invention has an objective to provide a mode of public transport that is quicker than existing public transport: for door-to-door journeys under 25 miles, existing public transport is on average a factor of 2 slower than the car; this invention aims to reduce this factor (preferably to a value of 1.6 or lower).

This invention has an objective of being able to provide a mode of public transport that, like the private car (and unlike existing mass public transport), has complete flexibility of itinerary, provides a door-to-door transport service, has a 'jump in and go' immediacy, and does not demand pre-planning before travel: these features allow this invention to compete with the car in terms of transport convenience.

This invention has an objective to provide a mode of public transport that is able to respond very rapidly to a prospective traveller's travel needs, aiming where possible to get a transit vehicle to collect traveller within a three minute timescale (or when the traveller is less pressed, within a fifteen minute timescale) from the moment the traveller submits his or her itinerary specification (see section 7.12).

This invention has an objective of decreasing road traffic levels without decreasing the total number of passenger journeys taking place on the roads (traffic restriction schemes lower traffic levels, but may decrease the amount of journeys taking place, which reduces people-mobility and may have adverse economic repercussions).

This invention has a long-term objective of reducing the number of private cars on the roads by a twofold factor (a 50% reduction) or more.

This invention has a long-term objective of abating parking congestion, which is a significant problem created by the proliferation of private car (see section 7.10).

This invention has the vitally important long-term objective of substantially reducing air pollution and greenhouse gas emissions wherever implemented, both in developed and developing nations.

To achieve these objectives, this invention has two main configurations: **electronic navigation taxibus** transport, and **car pooling** transport. This invention can run either of these configurations separately, or can run them both at the same time. Other transport configurations of this invention are also possible, such as the self-drive transit vehicle described in section 9.21.

The electronic navigation taxibus is a revolutionary and entirely new mode of public transport, perhaps destined to become the primary mode of travel in the 21st century. The taxibus is a road transport vehicle that generally conveys passengers from door-to-door, thus providing a transport service comparable to that of a taxi cab, yet one which may profitably operate with fare costs similar to those of a bus. The taxibus is the first mode of mass public transport that can not only equal the convenience of the private car, but as will become apparent, may even exceed it.

Analysis suggests that introducing a fleet of taxibus vehicles can massively reduce the quantity of traffic on the roads: a remarkable *fourfold reduction* in the number of cars on the roads is obtainable (see section 7.18). The taxibus can swiftly curtail traffic congestion, air pollution and greenhouse gas emissions with unparalleled efficacy; for these reasons it is anticipated that the taxibus will be rapidly adopted as the primary mode of public transport in towns and cities around the globe.

The car pooling configuration of this invention, though not quite as revolutionary as the taxibus, nevertheless manages to solve all the problems of car pooling described in section 4.3. In particular this car pooling configuration provides a very effective means of matching prospective passengers with car pool drivers having compatible itineraries, and can provide a monetary incentive to encourage drivers to give rides. Although car pooling, even in this present incarnation, is an informal mode of public transport, it can certainly help further decrease the quantity of cars on the roads.

In both taxibus and car pooling, the transportation capabilities of this invention are completely scalable: this invention can operate in a village where it might provide just a few hundred passenger journeys each day, or in a major city where it could comfortably handle 10 million or more daily passenger journeys (the ability of this invention to provide passenger journeys in the millions is proven in section 7.11).

Note that this invention is highly practicable, both technologically and financially. For the most part it uses existing and established technologies, most of which are already in place or already in operation; as a consequence this invention can be implemented remarkably cheaply, and without changing any of the physical or technological infrastructures of a town or city. The system of transportation of this invention is also cheap to run, and may quite easily be operated at a profit (a simple financial analysis of the transport operations of this invention is given in section 7.11). Financial viability is crucial to making this invention useful, and allows it to be implemented in both rich and developing nations throughout the globe.

5.2 - Basic Concepts - Adaptable Routing and Intelligent Grouping

The conceptual foundation of this invention rests on two transport methodologies which we shall refer to as **adaptable routing** and **intelligent grouping**.

Adaptable routing applies to vehicles whose route is completely flexible and can be modified at any time to accommodate a traveller's particular journey requirements. Adaptively-routed vehicles provide a transport service that collects a traveller from his starting point or address and conveys him to his destination point or address. This contrasts to fixed-route transport vehicles such as buses and trains which do not alter their routing to accommodate the traveller's itinerary. Ordinary taxi cabs use adaptable routing, as of course does the private car.

Intelligent grouping involves the placement of disparate travellers, who happen to have compatible itineraries, onto the same transport vehicle. Fixed-route vehicles such as buses and trains automatically use intelligent grouping; though obviously in these cases, no great intelligence is involved, as the conveyance of passengers with compatible itineraries is intrinsic to fixed-route transport vehicles.

In the case of adaptively-routed transport vehicles, however, intelligent grouping of travellers is by no means automatic and to achieve it requires precise orchestration of both travellers and transport vehicles. It is a very complex undertaking to operate transport vehicles that *simultaneously* use adaptable routing and intelligent grouping. Nevertheless, this is exactly what this invention does, as we shall see.

Adaptable routing is an important characteristic of this invention because it can provide travellers with door-to-door travel from their starting point or address to their destination point or address, thus creating a convenient and highly attractive mode of public transport.

Intelligent grouping is an equally important characteristic of this invention as it enables transport vehicles to carry many disparate travellers at once, which allows passenger fare costs to be kept low, and allows travellers to share the same transport vehicle.

The simultaneous union of adaptable routing and intelligent grouping achieved by this present invention is fundamental to reducing road traffic as it entices travellers who might have otherwise journeyed in their own individual cars to climb aboard an adaptively-routed transport vehicle and get exactly the same door-to-door service that their cars would have provided.

In adaptively-routed transport vehicles, a set of travellers are said to be intelligently grouped when the itinerary of any one traveller does not force the transport vehicle to significantly deviate from, and thus increase the journey times of, the itineraries of the other travellers aboard the vehicle. A set of travellers can only be intelligently grouped when they have reasonably compatible itineraries.

Generally, an individual traveller will want to be conveyed on the quickest route from his embarkation to his destination (such as he would take in his own private

car), rather than travel by a longer and more roundabout path in an adaptively-routed transport vehicle; the above definition states that when travellers are intelligently grouped in an adaptively-routed transport vehicle, each individual traveller's journey time from his embarkation to his destination point is not significantly increased in relation to this quickest route.

Note, however, that this definition of intelligent grouping, although succinct, does not quantitatively specify what is meant by 'significantly increased'. A quantitative definition of intelligent grouping which does is provided in section 5.7.

In section 5.7 we shall show that for each set of travellers intelligently grouped in an adaptively-routed transport vehicle, there exists an associated **optimal transit route** which represents the quickest way (or almost the quickest way) to convey the said travellers in accordance with their itineraries; we also introduce a parameter called the **Compatibility Index** which quantitatively measures intelligent grouping.

5.3 - Some Further Terminology

Having defined the terms **adaptable routing**, **intelligent grouping**, **optimal transit route**, and the **Compatibility Index**, we now introduce some further terminology.

Note that any terms introduced in bold type in this document are definitions that apply throughout the document.

In this document the term **traveller** is used to denote a person journeying on their own itinerary, which includes drivers journeying on their own itinerary. The term **passenger** denotes any person journeying on their own itinerary, excluding drivers. The term **driver** covers both drivers who are travellers (such as car pool drivers and drivers of the self-drive transit vehicle described in section 9.21, who are journeying on their own itinerary), as well as drivers who are not travellers (such as taxibus drivers, who have no itinerary of their own).

A traveller or passenger **itinerary** is defined as a data structure or a computer data format which specifies a traveller or passenger travel plan. In most forms of public transportation, the embarkation and disembarkation points are the most important aspects of a traveller itinerary, and many traveller itineraries are specified by just two items of data: the traveller's embarkation point and the traveller's destination point. This definition of itinerary, however, includes more complex travel plans, including travel plans with more than one destination point, and travel plans with specific routing requirements (such as itineraries required to avoid specified areas of town). Mathematically speaking, using the terminology of graph theory, most traveller or passenger itineraries can be encoded as a directed graph whose vertices are the embarkation and disembarkation points of the itinerary, and whose directed edges indicate the direction of travel.

A vehicle **itinerary** is defined as a data structure or a computer data format which specifies the travel plan of the vehicle. Typically, a vehicle itinerary will comprise a

set of prescribed geographic points or addresses to which the vehicle must navigate in a prescribed order. A vehicle itinerary may or may not include a specification of the road route that will enable the vehicle to reach the said geographic points or addresses. Typically these geographic points will be traveller embarkation and destination points. Mathematically speaking most vehicle itineraries can be encoded as a directed graph whose vertices are the said geographic points or addresses, and whose directed edges indicate the direction of travel between these geographic points or addresses.

A **journey request** is defined as a data structure or a computer data format which includes a specification of a traveller or passenger itinerary, and may also include a specification of any other travel requirements relating to this itinerary, such as the number of travellers to be conveyed on the said itinerary, the details of any luggage carried by the travellers, and the time and date at which conveyance of the travellers according to the said itinerary is to commence. The journey request may also specify certain travel preferences, such as whether the traveller prefers to avoid split journeys (section 9.2), or whether he wants to prioritise transit vehicle speed of response or speed of journey (section 7.12).

Car pool drivers are classed as travellers, but their itineraries are specified in a data structure or a computer data format which we call a **car pool intended itinerary specification**, rather than a journey request. A car pool intended itinerary specification will include details of the vehicle itinerary that the car pool driver intends to follow, and will usually include related information such as the number of available passenger seats in the car pool vehicle. Usually the driver's intended itinerary will simply comprise his current location point or address and his intended destination point or address; however if the car pool driver needs to make additional stops en route, then the location point or address of these stops must be included in the car pool intended itinerary specification.

The term **transport vehicle** is defined as a vehicle which is capable of carrying travellers. The term **adaptively-routed transport vehicle** is defined as a vehicle which is capable of carrying travellers and which is capable of being adaptively routed on the road networks. Adaptively-routed transport vehicles include, for example, the car, minibus, coach, the rickshaw, and the horse-drawn carriage.

A transport vehicle's current **itinerary commitments** are defined as the set of itineraries of the travellers currently being conveyed in the vehicle, plus the itineraries of any travellers that the vehicle is currently committed to picking up.

A **digitised street layout map** is defined as a data structure or a computer data format, typically a graph, which details the layout or connectivity of the road networks of the particular geographic regions in which this invention operates.

The term **data-processing instructions** is used to denote any computer instructions or computer programming code, including software, and including computer instructions or code encapsulated in hardware (such as firmware or purpose-designed integrated circuits). A **data-processing module** employs a set of data-processing instructions to perform a specific data-processing function. (Note: one

set of data-processing instructions may constitute more than one data-processing module; for example, the intelligent grouping module and the electronic street navigation module defined below may be embodied in the same set of data-processing instructions).

5.4 - Component Parts of the Invention

We now introduce and define a number of component parts used in this present invention. The components defined appear in bold type, and these definitions apply throughout this document.

A **transit vehicle** is defined as one which is capable of carrying travellers, which is capable of being adaptively-routed on the road networks, and which is participating (or is about to participate) in the transportation system of this invention, and whilst participating, forms a component part of this invention (in other words a transit vehicle is an adaptively-routed transport vehicle which is operating as part of this invention). We define a **taxibus** as a transit vehicle piloted by a driver who has no itinerary of his own; and define a **car pool vehicle** as a transit vehicle piloted by a driver who is currently travelling in this vehicle on his own itinerary.

A **controlling computer system** is defined as a data-processing system comprising one or more mainframe computer data-processing installations, or comprising a set of distributed (typically portable or mobile) computer processors, or comprising a combination of these last two setups, or comprising some other configuration of data-processing hardware; in this document the term controlling computer system not only refers to the data-processing hardware, but also encompasses the data-processing instructions (computer programming code) running on this hardware; in particular note that both the electronic street navigation module and the intelligent grouping module defined below are component parts of the controlling computer system; by definition a controlling computer system will have the ability to send and receive data over the data transmission system defined below.

A **data transmission system** is defined as one which facilitates transmission of data between the remotely-located (geographically distant) components in this invention. The data transmission system may comprise one or more transmission methods, including wireless electromagnetic transmission (for example radio, optical and microwave), land-line transmission (for example electric or fibre optic cable), and transmission over the Internet or other computer networks. The remotely-located components in this invention may include: the controlling computer system (and any geographically distributed computer processor elements thereof), the electronic positioning system (and any geographically distributed elements thereof), and the communicator devices (defined below) used by travellers and transit vehicle drivers. When remotely-located components need to exchange data, the data transmission system is used to transmit this data; components of this invention that are adjacently located (such as an computer processor element incorporated into a communicator device) may exchange data directly via a local data connection.

A **communicator device** is the generic name we shall give to the (typically portable and electronic) gadgets which allow people interacting with this transportation invention (passengers and drivers) to send and/or receive data over the data transmission system (typically to the controlling computer system). When a communicator device is locally connected to the controlling computer system (or a computer processor element thereof), then the sending and/or receiving of data may be performed via this local connection. Examples of communicator devices include the telephone, the cellular telephone, the wireless PDA (Personal Digital Assistant) and an Internet-connected personal computer.

An **electronic positioning system** is used in its commonly-understood meaning: an electronic or computerised system that allows its users to determine their geographic location. A satellite positioning system such as the American GPS (Global Positioning System) is an example of an electronic positioning system. An electronic positioning system may comprise one or more methods of providing positioning data (such as for example the methods described in section 9.22); using more than one method may be done in order to improve positioning accuracy, to widen the geographic coverage of the system, or for any other reason.

An **electronic street navigation module** is defined as a data-processing module that, given a vehicle itinerary, can provide navigational instructions which allow a transit vehicle driver to follow this vehicle itinerary; by definition the electronic street navigation module (both its data-processing hardware and its data-processing instructions) forms part of the controlling computer system. A basic form of electronic street navigation module might simply pass on the optimal transit route data generated by the intelligent grouping module (described below), thereby providing the driver with static navigational instructions for the optimal transit route itinerary; a more sophisticated electronic street navigation module would operate along the lines of the in-car satellite navigation systems that are now commonly available: in-car satellite navigation systems make use of a digitised street layout map, and make use of data from a satellite electronic positioning system, in order to provide the car driver with real-time navigation instructions which are based on, and dynamically respond to, the vehicle's current geographic location.

An **intelligent grouping module** is defined as a data-processing module which, on the basis of traveller journey requests, and on the basis of the transit vehicles available, intelligently groups the travellers associated with the journey requests into the said transit vehicles and devises optimal transit routes by which these transit vehicles can transport the said travellers in accordance with the itineraries specified in the said journey requests; by definition the intelligent grouping module (both its data-processing hardware and data-processing instructions) forms part of the controlling computer system. An intelligent grouping module may utilise a digitised street layout map with which to plan routes.

5.5 - Essential Features of the Invention

In accordance with the objectives described in section 5.1 the essential features of this present invention are described using the terminology defined in sections 5.2, 5.3 and 5.7 along with the components defined in section 5.4, and are as follows.

This invention provides a traveller transportation system operating on the roads in which travellers use communicator devices to send their journey requests, and any car pool vehicle drivers use communicator devices to send their car pool intended itinerary specifications, to a controlling computer system wherein:

an intelligent grouping module intelligently groups the said travellers into transit vehicles, and creates an optimal transit route for each of these transit vehicles to convey the said travellers in accordance with the itinerary and the other travel details specified in each of the said journey requests or car pool intended itinerary specifications;

the said intelligent grouping module operating with the aid of data from an electronic positioning system detailing the current geographic position of each of the said transit vehicles;

the drivers in each of the said transit vehicles being directed along the said optimal transit routes to convey the said travellers by means of navigational data supplied by an electronic street navigation module incorporated into the said controlling computer system;

the said navigational data being sent to the communicator device within each of the said transit vehicles, these communicator devices detailing the navigational data to the drivers of the said transit vehicles;

throughout the above-described operations, a data transmission system is used wherever data needs to be sent between the remotely-located components of the invention, these components including the controlling computer system (and any geographically distributed computer processor elements thereof), the electronic positioning system (and any geographically distributed elements thereof), and the communicator devices used by travellers and transit vehicle drivers.

Note: it follows from these essential features that: all transit vehicles are equipped with a communicator device; and that the electronic positioning system is able to locate the geographic position of all operational transit vehicles.

Note: it is advantageous for the electronic positioning system to be able to locate travellers as well as transit vehicles, but this is not a mandatory feature.

5.6 - Preferable Features of the Invention

Preferably the journey request will allow travellers to specify the number of traveller seats required on the journey, so that groups of people travelling together can be accommodated by this invention.

Preferably the journey request will allow travellers to specify their luggage requirements, so that travellers with luggage can be found a suitable transit vehicle.

Preferably this invention will have the ability to handle pre-order booking and regular order booking traveller journey requests: travellers who place a pre-order booking with the controlling computer system will have a transit vehicle arrive to collect them at the time they specify in the journey request, in order to convey them along the itinerary they specify in the journey request; a regular order booking is like a pre-order booking except that it is repeated on a regular basis specified in the journey request (for example: daily) until cancelled (see section 7.8).

Preferably this invention will operate with traveller itineraries that fall into the category of simple two-point itineraries which comprise the traveller's embarkation point and destination point: this makes the itineraries simple to specify on a communicator device and easy to process computationally.

Preferably this invention will operate with vehicle itineraries that comprise a set of defined geographic points or addresses to which the vehicle must navigate in a prescribed order, to pick up or drop off travellers.

Preferably the transit vehicles operated by this invention will be able to service the same sort of street addresses and locations as can a private car or taxi cab (in other words, like the car and taxi cab, these transit vehicles will be sufficiently small and manoeuvrable to be able to reach virtually all street addresses).

Preferably the transit vehicles operated by this invention will be piloted by a professional driver with no itinerary of his own (by definition, this is the electronic navigation taxibus configuration of this invention); **alternatively** these transit vehicles may be piloted by a driver who is travelling on an itinerary of his own, and who wishes to accommodate and transport passengers in his vehicle (by definition, this is the car pooling configuration of the invention); **alternatively** this invention may operate both taxibus and car pooling vehicles simultaneously.

Preferably the transit vehicles operated by this invention will include the self-drive transit vehicles described in section 9.21.

Preferably the data transmission system will use a cellular telephone network as a method of data transmission, and **preferably** this cellular network will use the 3G (third-generation) cellular network technology currently being introduced in the UK, or later generations thereof, which is particularly adept at text and graphic data transmission; **alternatively** this data transmission system may use a mesh network method of data transmission (mesh networks are described in section 8.4).

Preferably the data transmission system will be able to transmit data more or less

instantaneously, typically with the speed of an electromagnetic wave or the speed of a signal propagating along an electric land line, so that no burst of data will take longer than a few seconds to travel via the data transmission system. Such speed is necessary if this invention is to operate effectively in real time.

Preferably this invention will operate a door-to-door transport service, that is to say, run transit vehicles that convey each traveller in accordance with his itinerary right from his starting point or address to his destination point or address;

alternatively travellers may be conveyed almost door-to-door by being picked up and/or dropped off within a short walking distance of their starting and destination points or addresses (such as in the 'quasi door-to-door' taxibus in section 9.3).

Preferably this invention will employ communicator devices that are electronic gadgets capable of two-way transmission of information (able to send data and receive data via the data transmission system).

Preferably this invention will employ communicator devices that are portable so that users of this invention can carry a communicator device on their person.

Preferably this invention will employ communicator devices that possess a text and/or graphics display screen and some sort of keyboard or keypad, allowing a visual presentation of information to the user, and allowing users to type in information.

Preferably this invention will employ communicator devices that are of the cellular telephone or wireless PDA (Personal Digital Assistant) type and which operate with a cellular telephone network data transmission system (see section 7.2 for a more detailed description of such types of communicator device).

Preferably the electronic positioning system of this invention will be able to locate the geographic position of communicator devices carried by travellers, as well as locate the geographic position of transit vehicle communicator devices.

Preferably the electronic positioning system will be a satellite positioning system; **alternatively** the electronic positioning system will be based on cellular base station triangulation (both are described in detail in section 9.22); **alternatively** a combination of both satellite positioning and cellular base station triangulation.

Preferably the electronic positioning system will use a road coding system or a short range radio transmitter system as described in section 9.22 as an ancillary (or **alternatively** as the main) electronic positioning system.

Preferably the electronic positioning system will be capable of providing a locational accuracy to within 10 metres when operating at optimum performance, so that communicator devices equipped with electronic positioning functionality can be located to within this distance.

Preferably this invention will operate using pre-defined passenger pick-up (and optionally set down) points, each with a unique pick-up point reference code, in order to eliminate passenger pick-up point ambiguity (see section 9.16).

Preferably the electronic street navigation module would operate in a similar manner to the self-contained in-car satellite navigation system, providing the vehicle driver with real-time street-by-street navigation directions which are based on the vehicle's current geographic location. Such in-car navigation systems rely on a digitised street layout map, and use an electronic positioning system to provide current location data.

Preferably this invention will rapidly process incoming journey requests, so that when a prospective traveller submits a journey request on his communicator device, the controlling computer system will marshal a fast response that has a transit vehicle arrive to collect the traveller and convey him along his specified itinerary typically within minutes (section 7.12 explains why a fast response is important).

Preferably this invention will operate such that prospective travellers will generally have their transit vehicles arriving to collect them within three minutes of submitting their journey request (section 7.12 examines the importance and theoretical feasibility of a three minute response).

Preferably the intelligent grouping module will take into account transit vehicle proximity to the prospective traveller: this means that when trying to place a new traveller into a transit vehicle, not only will the intelligent grouping module seek a vehicle with a good itinerary compatibility to the traveller, the module will also try to find a transit vehicle that is currently located in the vicinity of that traveller, enabling the transit vehicle to get to the traveller's pick-up point quickly.

Preferably the intelligent grouping module will process traveller journey requests which specify an immediate departure time as follows. The intelligent grouping module will examine the current position and current itineraries of its transit vehicles en route (and any idle transit vehicles, if available), searching for a transit vehicle in the vicinity (a few minutes driving distance) of the traveller's pick-up point, and one into which the traveller can be intelligently grouped. When the intelligent grouping module finds such a transit vehicle for the traveller, this module revises the transit route of that vehicle so that it can pick up the traveller from the pick-up point specified in his journey request, and convey him and the other travellers on board the vehicle to their respective destinations. This method is useful when dealing with new journey requests in which travellers require immediate pick up and departure. **Alternatively** the intelligent grouping module may process journey requests some time in advance of the traveller's departure time, searching for a transit vehicle which will be in the vicinity of the traveller's pick-up point at (or close to) his departure time, and one into which the traveller can be intelligently grouped. This second method is useful when dealing with batches of pre-order and regular order journey requests. **Alternatively** the intelligent grouping module may operate both of these two methods. (These two methods respectively correspond to the processing of class C and class D journey requests described in section 7.1).

Preferably the intelligent grouping module will have the ability to split a traveller's journey into different legs using two or more different transit vehicles (the need for split journeys is explained in section 9.2).

Preferably the intelligent grouping module will have the ability to route, or, in the case of split journeys, partially route, a traveller itinerary via existing modes of public travel such as buses and trains as well as by taxibus or car pool transit vehicles. This will enable this invention to seamlessly integrate with existing public transport (multi-modal travel is described in section 7.17).

Preferably the intelligent grouping module will operate so as to aim to place at least 6 travellers into each transit vehicle. An objective of this invention is an ability to provide mass transportation of travellers without generating high levels of road traffic congestion: this objective depends on placing several travellers in each transit vehicle. Placing 6 passengers is certainly achievable with the taxibus. Section 7.11 details how traffic congestion is overcome, and section 7.18 details how this invention substantially lowers greenhouse gas emissions, when there are 6 to 8 travellers travelling in each transit vehicle. Obviously this preferable feature only applies to transit vehicles of sufficient size: those having 6 or more passenger seats. In particular we exclude car pool vehicles, most of which will not have sufficient seats to accommodate 6 passengers (and even if they had, the car pool driver would be unlikely to want to convey that many passengers in his vehicle).

Preferably the intelligent grouping module will intelligently group travellers so that the Compatibility Index (defined in section 5.7) of their itineraries is typically less than 1.6 (measured when there are at least 6 travellers in the transit vehicle). A low value for the Compatibility Index is important to achieving one of the objectives of this invention: to provide a mode of public transport that for the door-to-door journey is quicker than existing public transport.

Preferably the intelligent grouping module will intelligently group travellers so that the Compatibility Index of their itineraries is typically less than 2 (measured when there are at least 6 travellers in the transit vehicle). This invention still remains a very viable mass transportation system when the Compatibility Index is less than 2.

Preferably the intelligent grouping module will perform its intelligent grouping calculations using data that details the current traffic speed on each road - that is to say, using a traffic-speed travel-time metric as described in sections 5.7 and 9.1.

Preferably the intelligent grouping module in this invention will be employed in such a way that when a transit vehicle, for whatever reason, gets significantly displaced from its optimal transit route, or suffers a significant delay along this optimal transit route, the intelligent grouping module will be triggered to re-optimize the intelligent grouping and devise a new optimal transit route for that transit vehicle (see section 9.1).

Preferably the intelligent grouping module will incorporate all the features described in section 9.1

Preferably this invention will operate with a transit vehicle density of at least 10 vehicles per square mile in a large city. Such scales of operation vastly improve the efficiency of this invention (see section 5.8) which is important to all the objectives

of this invention stated in section 5.1.

Preferably this invention will be designed to take advantage of the transportation efficiencies that arise at large scales of operation (scales such as 10 or more transit vehicles per square mile). Three important transportation efficiencies materialise at a large scale of operation which enable this invention to function in a manner that is not possible at smaller scales (see section 5.8).

Preferably this invention will be designed to provide transportation coverage across a whole city. City-wide implementation is important for reducing city traffic congestion and air pollution.

Preferably this invention will be designed to provide transportation coverage to a whole state or nation - widescale implementation is important to the environmental objectives of this invention in reducing air pollution and greenhouse gas emissions.

Preferably this invention will pre-emptively marshal its transit vehicle fleet in order to geographically position the fleet in readiness to handle the expected traveller numbers arising from the morning and evening rush hours, from large-scale public events, and similar situations where it is known in advance that there will be high concentrations of new travellers requiring transportation (see section 7.9).

Preferably this invention will operate a system of automatic computer-calculated fare metering and charging for travellers using its transit vehicles: this will speed up journeys and will make travel more streamlined and convenient (see section 9.5).

Preferably in its ordinary handling of traveller journey requests and in the control and orchestration of its transit vehicles, this invention will work automatically without the need of human operators or assistance. When implemented in a large city this invention might operate tens of thousands of transit vehicles and receive thousands of journey requests each minute - far too many for human operators to handle, unless a huge number of operators are employed, which would be costly.

Preferably this invention will operate using a central controlling computer system as described in the preferred embodiment (see section 7), but will also have the capacity to operate using a distributed controlling computer system as described in the second embodiment (see section 8), such that in the event of a failure of the central controlling computer system, the distributed controlling computer system will be able to take over, thus keeping the transit vehicle fleet in operation.

Preferably the controlling computer system will, on request, provide electronic street navigation to its users (passengers and vehicle drivers) even when they are not travelling by means of this invention.

Preferably the controlling computer system of this invention will incorporate quantum computer hardware when quantum computer technology becomes available: quantum computers are especially good at handling the non-polynomial calculations that can arise during the process of intelligent grouping.

5.7 - Quantitative Definition of Intelligent Grouping

The provisional definition of intelligent grouping provided in section 5.2 was:

In adaptively-routed transport vehicles, a set of travellers are said to be intelligently grouped when the itinerary of any one traveller does not force the transport vehicle to significantly deviate from, and thus increase the journey times of, the itineraries of the other travellers aboard the vehicle.

This however was a qualitative definition: no quantitative meaning was given to the term 'significantly deviate'. In this section we are going to remedy this: we define a parameter and mathematical function called the **Compatibility Index** which, given any set of traveller itineraries, expresses the average increase in each traveller's journey time that results when these travellers are grouped together and conveyed (along one of the quickest routes) in an adaptively-routed transport vehicle; the said increase is in relation to the journey time that would result if each traveller were to travel on his itinerary via the most direct route (such as would normally be taken in a private car). The Compatibility Index thus measures the *degree* of compatibility of a set of traveller itineraries; it measures how well a given set of travellers can be intelligently grouped into an adaptively-routed transport vehicle.

The lower the value of the Compatibility Index, the more compatible are the itineraries of the set of travellers. Perfect intelligent grouping has a Compatibility Index of 1 and, for reasons that will shortly be explained, Compatibility Index values in the range of 1 to 1.3 represent excellent intelligent grouping, with values between 1.3 and 1.6 representing an acceptable level of intelligent grouping. A Compatibility Index approaching 2 or higher represents an increasingly inefficient and a generally unacceptable level of intelligent grouping.

We shall now focus on deriving the Compatibility Index.

For any set $\mathbf{S}$ of traveller itineraries, we shall define a Compatibility Index function which takes $\mathbf{S}$ as its argument and returns a real number which is the Compatibility Index value of the set $\mathbf{S}$. We assume that each traveller itinerary in $\mathbf{S}$ is expressed as a directed graph whose vertices encode the traveller's embarkation and destination points (and any other points), and whose directed edges indicate the direction of travel. We similarly assume that the itinerary of the adaptively-routed transport vehicle can be expressed as a directed graph whose vertices are the embarkation and destination points of the travellers on board (and any other points to which the vehicle must navigate), and whose directed edges indicate the direction of travel of the vehicle.

We will make reference to figures 1, 2 and 3 in the accompanying drawings, in which three example sets $\mathbf{S}$ of traveller itineraries are given (figure 1 is a set of two travellers, figure 2 is a set of three travellers and figure 3 is a set of seven travellers). Note: in these figures the travellers have simple two-point itineraries, but our analysis equally applies to more complex itineraries.

Each figure abstractly represents travellers making their way across a city in an

adaptively-routed transport vehicle (for clarity, the streets of the city are omitted from the figures). Each arrowed line represents a particular traveller and his itinerary: the start of the line denotes the current location of the traveller (which will be his embarkation point) and the arrowhead of the line marks the traveller's desired destination. The dotted path R (beginning at point 1 and proceeding sequentially to points 2, 3, 4, etc) shows the itinerary route of an adaptively-routed transport vehicle transporting these travellers.

Figure 1 for example shows a set **S** of two travellers, whose itineraries are indicated by the two arrowed lines, being conveyed along the vehicle itinerary R. Here the adaptively-routed transport vehicle picks up the first traveller at point 1, drives along to point 2 where the second traveller is picked up, proceeds to point 3 where the second traveller is dropped off, and finally drives to point 4 where the first traveller alights.

Notice for this vehicle itinerary R, both travellers get point-to-point transport, yet neither traveller is much inconvenienced by the other's travel requirements - this is the essence of intelligent grouping. The vehicle itinerary R which facilitates this efficient concurrent transport of travellers is called an **optimal transit route**.

We now provide a formal definition of what is meant by an **optimal transit route**. For any given set **S** of traveller itineraries (such as those in figures 1, 2 and 3), an optimal transit route is defined as the quickest road route, or one of the quicker road routes, by which an adaptively-routed transport vehicle can travel so as to pick up, convey, and drop off each traveller in the set **S** in accordance with his itinerary. As a data structure, an optimal transit route takes the form of a vehicle itinerary. There will usually be more than one optimal transit route by which a given set of travellers can be transported.

In order to determine the optimal transit routes for a given set **S** of traveller itineraries, we need to employ a **travel-time metric**. We define a travel-time metric as a mathematical method that allows us to calculate the journey time along any given vehicle itinerary - that is, it allows us to estimate the time it will take for an adaptively-routed transport vehicle to traverse this itinerary. For the moment we shall use a **direct-distance travel-time metric** which assumes that the journey time along any given vehicle itinerary is proportional to the distance as the crow flies between the various points (such as traveller embarkation and disembarkation points) on that route. Then by assuming a fixed vehicle speed along this vehicle itinerary (such as the average traffic speed in a city), we have ourselves a simple travel-time metric.

For example: in figures 1, 2 and 3 the points on the vehicle itinerary R are labelled 1, 2, 3, 4, and so forth. To apply a direct-distance travel-time metric to estimate the journey time along route R, we must first measure the total length of R as the crow flies, which is simply the length represented by the dotted path R, and then divided by the fixed vehicle speed, in order to calculate the journey time along route R. Later we examine two more travel-time metrics which are more complex but more accurate (they measure distance along the road route, rather than as the crow flies).

Once we have a travel-time metric, we can then calculate the optimal transit routes for any given set **S** of traveller itineraries by using an exhaustive search method (which is a standard method of graph theory). This exhaustive search finds optimal transit routes by first enumerating all the mathematically possible transit routes that pass through the embarkation and destination points (points 1, 2, 3, 4,... in the figures) of the traveller itineraries in set **S**, excluding any transit routes that arrive at a traveller's destination point before they get to his embarkation point, and then applying the travel-time metric to each of these possible transit routes to measure the journey time for each transit route. By definition, the quickest or the quicker of these possible transit routes, as measured by the travel-time metric, are the optimal transit routes for the set **S** of traveller itineraries.

(As a useful rule-of-thumb, we can define the quicker transit routes as those that are not more than a factor of 1.6 slower than the very quickest route).

So for example, in figure 1, assuming the transport vehicle starts at point 1 initially, there are six mathematically possible transit routes that pass through the travellers' embarkation points and destination points, namely the transit routes: **1-2-3-4**, **1-2-4-3**, **1-3-2-4**, **1-3-4-2**, **1-4-2-3** and **1-4-3-2**. Out of these six routes, the 3rd, the 4th and the 6th route are excluded on the grounds that in these, the transit vehicle will arrive at a traveller's destination point before it gets to his embarkation point. This leaves us three possible transit routes: the 1st, the 2nd and the 5th in the list. Applying our direct-distance travel-time metric (just by visual inspection) to these three routes, it becomes clear that the 1st and 2nd transit routes in this list are the optimal transit routes, with the 1st being the very quickest route; and the 2nd just a little bit longer; the 5th route is discounted due to its excessive length (visual inspection clearly indicates that the 5th route is more than 1.6 the length of the quickest 1st route).

Note: the exhaustive search method of finding optimal transit routes can consume considerable computer processing time when the number of travellers in the set increases. However, graph theory offers various standard heuristic techniques which can be usefully employed to reduce this calculation time.

Although an optimal transit route always represents one of the quickest ways to convey a set of travellers according to their itineraries, the effectiveness of an optimal transit route will obviously depend on the actual itinerary compatibility of the set of travellers in question: if we have a set **S** of traveller itineraries that are totally incompatible, then the optimal transit route for this set, although one of the quickest routes, will be hideously lengthy and inefficient. Only when traveller itineraries are compatible does the optimal transit route become efficient in terms of adaptively-routed transportation. This fact underpins how we are going to quantify itinerary compatibility: our Compatibility Index measure is based on calculating an optimal transit route for a set **S** of traveller itineraries, and then gauging this route's transportation efficiency. In order to do this, we would normally use the quickest out of the calculated optimal transit routes for the set **S** of traveller itineraries; however, as will be shortly explained, sometimes the quickest optimal transit route can actually be very slow for just one particularly traveller, and if this is the case,

one of the other quicker optimal transit routes should be used instead.

Gauging an optimal transit route's transportation efficiency is achieved as follows. Given the quickest (or a quicker) optimal transit route for a set **S** of traveller itineraries, we employ our travel-time metric to calculate for each individual traveller itinerary in the set **S**:

Firstly, the estimated journey time required to convey that particular traveller, in accordance with his itinerary, from his embarkation to destination point, travelling in the adaptively-routed transport vehicle along the given optimal transit route; we call this the Transit Time for that traveller itinerary.

Secondly, the estimated journey time required to convey that particular traveller, in accordance with his itinerary, from his embarkation to destination point, travelling by the quickest, or one the quicker, routes (such as the traveller would normally take in his own car); we call this time the Quickest Time for the traveller itinerary.

For example: in figure 3 imagine that route R is our given optimal transit route, and consider the traveller itinerary that begins at point 1 and ends at point 9. Using a direct-distance travel-time metric, the Quickest Time for this traveller is the length represented by the straight line 1-9, divided by the fixed vehicle speed; and the Transit Time is the length represented by the path 1-2-3-4-5-6-7-8-9 along route R, divided by the fixed vehicle speed.

Once we have calculated the Transit Times and Quickest Times, then for each traveller itinerary in the set **S**, we calculate the ratio:

$$\text{Efficiency Ratio} = \text{Transit Time} \div \text{Quickest Time}$$

For any given traveller, an Efficiency Ratio of 1 indicates that his journey is the most efficient possible: that the optimal transit route between the traveller's embarkation and destination points is as fast as (and probably identical to) the quickest route between these points. An Efficiency Ratio of say 1.3 indicates this optimal transit route journey will take 1.3 times as long the quickest route between the traveller's embarkation and destination points.

Having calculated the Efficiency Ratio value for each traveller itinerary in the set **S**, we add these values together, and divide the sum by the number of travellers in the set, in order to arrive at the average Efficiency Ratio (note that if there are two or more travellers in the set with identical itineraries, these itineraries are still counted as distinct). This brings us to our definition of the Compatibility Index:

$$\text{Compatibility Index of set } \mathbf{S} = \text{average Efficiency Ratio of the traveller itineraries in the set } \mathbf{S}$$

The Compatibility Index precisely measures intelligent grouping. A Compatibility Index of 1 obviously indicates a perfect intelligent grouping in which each traveller is conveyed by the quickest road route from his embarkation to destination point. By contrast, a set of travellers having a Compatibility Index as high as 2 would be conveyed fairly inefficiently, with the travellers' journeys taking twice as long, on

average, as going by the quickest road route.

Note that the Compatibility Index of any set **S** of traveller itineraries only applies if the travellers are transported in an adaptively-routed transport vehicle via the optimal transit route used to calculate that Compatibility Index. Note also that for a set **S** of traveller itineraries with a measured Compatibility Index, there is always an associated optimal transit route.

To provide an example of the Compatibility Index, we refer to figure 3 in which the seven travellers' Efficiency Ratios work out to 1.56, 1.39, 1.44, 1.10, 1.33, 1.30 and 1.15 when the Transit Time and Quickest Time are measured with a centimetre ruler (such measurement is a direct-distance travel-time metric). Taking the average of these values gives these seven travellers a Compatibility Index of 1.32.

In taxibus transportation we would aim to intelligently group a set of travellers with a Compatibility Index value somewhat lower than 2. The Department for Transport statistics mentioned in section 4.1 show that, for the average door-to-door journey under 25 miles, going by existing public transport takes twice as long as going by car. Therefore to better existing public transport and to compete with the speed of the car, the taxibus must operate with a Compatibility Index below 2. Aiming for a Compatibility Index of 1.3 or less is a good objective: this means that the average taxibus journey will take at most 30% longer than the direct journey by car, making the taxibus a very fast form of public transport. A Compatibility Index of 1.6 or less is an acceptable value: in this case the average taxibus door-to-door journey will take at most 60% longer than going by car. Compatibility Index values greater than 2 are generally undesirable, as the taxibus would then be slower than existing public transport for door-to-door journey under 25 miles. (Note however that in the long run, with a comprehensive taxibus fleet in operation, traffic levels will fall, road speeds will increase, and taxibus journeys will become quicker, in absolute terms).

Note: it is relatively easy to get a low Compatibility Index when grouping just two or three travellers, but more difficult when the number of travellers increases. In the case of car pooling, there will often be just two or three travellers (including the driver). However for the taxibus we will be looking to achieve intelligent grouping with higher numbers of travellers, typically with up to 6 or more travellers in a taxibus vehicle at the same time.

Note: as explained above, corresponding to a given set **S** of traveller itineraries, there will generally be several optimal transit routes; for transporting the travellers we would normally employ the quickest optimal transit route in order to calculate the Compatibility Index. However if one or more travellers have an unacceptably high Efficiency Ratio (say more than 1.6 say) on the quickest route, these individual travellers will suffer a long journey time, even though, overall, the optimal transit route is the quickest one. In this case we would normally use another optimal transit route of the set **S**, employing the quickest optimal transit route which does not cause any particular traveller to suffer an excessively long journey.

It is important to point out that optimal transit routes can be calculated to different degrees of accuracy, depending on what type of travel-time metric used. Thus far

we have assumed a **direct-distance travel-time metric** as the basis for calculating optimal transit routes. We now introduce two more metrics which are better: the **road-distance travel-time metric**, and the **traffic-speed travel-time metric**.

Our original direct-distance travel-time metric is based on distances 'as the crow flies' between the (embarkation or destination) points on the vehicle itinerary. This direct-distance travel-time metric generates an optimal transit route of reasonable quality, even though in reality the vehicle must travel from point to point by road and not 'as the crow flies'. For higher accuracy, we can use a **road-distance travel-time metric** which, like the direct-distance travel-time metric, operates by assuming an average vehicle speed, but calculates the distances between the points on the vehicle itinerary in relation to road distances, not 'crow' distances. In practical terms, such a calculation is best achieved with the aid of a digitised street layout map that details the layout and length of the roads. Using such a map, and operating on the assumption that the road routes shortest in length represent the best optimal transit routes, a more accurate calculation of the optimal transit route is made (the shortest road routes between two points on the digitised street layout map can be found by employing a standard graph theory method such as Dijkstra's algorithm).

Finally we come to the **traffic-speed travel-time metric**. This also operates with actual road distances, but rather than assuming an average speed for all roads, this metric takes into account the particular speed at which a vehicle can travel along each individual section of road on this route. Apart from being the most accurate, certain configurations of the **traffic-speed travel-time metric** have several other important advantages; these advantages are discussed in section 9.1.

Note: for the highest accuracy, a travel-time metric should account for the transport vehicle **stop time** at each traveller embarkation and disembarkation point (the stop time is defined as the duration between the moment a transport vehicle pulls over and stops to let travellers board or alight, to the moment this vehicle is ready to get going again; a fast stop time might be less than one minute). When estimating the journey time for a given vehicle itinerary, a travel-time metric should accrue the stop time on each occasion the transport vehicle pulls over. Not only does this make the travel-time metric more accurate, it also enables better intelligent grouping, because then travellers with identical embarkation or disembarkation points are more likely to be placed in the same adaptively-routed transport vehicle in order to minimise the total stop time accrued.

Note: it is clear that optimal transit routes calculated using the 'as the crow flies' direct-distance travel-time metric will comprise a vehicle itinerary whose data structure comprises a series of geographic points (traveller embarkation and destination points) to which the adaptively-routed transport vehicle must navigate in sequence. By contrast, optimal transit routes determined with the aid of a digitised street layout map will create a vehicle itinerary whose data structure is much more detailed - consisting of the entire route on a road-by-road basis. It thus follows that any intelligent grouping module utilising a road-distance travel-time metric or traffic-speed travel-time metric will output detailed road-by-road optimal transit routes, and therefore such an intelligent grouping module can be construed

as doing the work of the electronic street navigation module (whose function it is to provide detailed navigation directions to the transit vehicle drivers). In other words, the functionality of these two modules is provided by one set of data-processing instructions. (Note however that the electronic street navigation module used in the embodiments of this invention is specified as having the capability to dynamically adapt transport vehicle routing using real-time electronic positioning data, to allow for small routing deviations such as navigation mistakes made by the driver; thus on many journeys, the original road-by-road optimal transit route created by the intelligent grouping module may not be followed exactly).

Note: the above description is a mathematical definition of intelligent grouping; however it is clear that this definition can be used as a software specification for the intelligent grouping module (and in the embodiments of this invention, we indeed use this definition as a data-processing specification of the intelligent grouping module). However the intelligent grouping module does not necessarily have to be programmed along the lines of this definition: the fundamental essential feature of the intelligent grouping module is simply that it performs intelligent grouping - by any equivalent or near equivalent mathematical means. (There are also many desirable features that the intelligent grouping module might have in addition to this essential feature; some of these desirable features are discussed in section 9.1).

Finally, let us provide some further definitions and notes on terminology usage:

In terms of the Compatibility Index, **intelligent grouping** is defined as the process of selecting and matching traveller itineraries to create a set of travellers that has a calculated Compatibility Index which is minimised, or has an acceptably low value.

When dealing with large numbers of traveller itineraries (as for example when this invention covers a whole city), **intelligent grouping** may be defined as the process of dividing the traveller itineraries into small sets (each set to be allocated to an available adaptively-routed transport vehicle) such that the calculated Compatibility Index values of these sets, when averaged, is minimised, or has an acceptably low value.

The term **intelligent grouping** also covers any processes that are mathematically equivalent or mathematically similar to the two processes above which maximise the time-efficiency of concurrently conveying travellers according to their itineraries in an adaptively-routed transport vehicle.

We say that a set of travellers are **intelligently grouped** into an adaptively-routed transport vehicle when the calculated Compatibility Index of those travellers' itineraries is minimised or is of an acceptably low value.

We say that a traveller is **intelligently grouped** into an adaptively-routed transport vehicle when the overall calculated Compatibility Index of that traveller's itinerary, plus the itineraries of the other travellers already aboard the vehicle (and usually plus the itineraries of any travellers the vehicle is currently committed to picking up), is minimised or is of an acceptably low value.

5.8 - Efficiencies of Scale

In a large city such as London, assuming this invention is running a sizeable fleet of say 10 thousand transit vehicles, the intelligent grouping module will have anything up to 3 thousand new journey requests coming in from travellers every minute.

However a great virtue of this invention is that it becomes more efficient as the scale of its operation increases; that is to say, as the **passenger flux** (defined as the number of travellers requesting transit per unit area per unit time) increases, and the transit vehicle density (the number of vehicles per unit area) needed to handle these travellers is increased proportionately, the transportation efficiency of this invention is not only maintained, but is further increased.

This greater efficiency arises simply because the more numerous the journey requests, the greater the chance of having itineraries amongst these journey requests that are highly compatible. Consequently the intelligent grouping module becomes better able to intelligently group travellers; that is to say, better able to group travellers into transit vehicles at lower Compatibility Index values.

Two other efficiency of scale factors come into play when the number of transit vehicles per unit area increases: the first factor is a quicker response time (see section 7.12) to traveller journey requests, due to the larger number of transit vehicles in close proximity to the traveller; and the second factor is the greater ease of scheduling split journeys (see section 9.2) across two or more transit vehicles, again due to the larger number of transit vehicles available.

It is important, however, that the intelligent grouping module has an appropriate data-processing design to take advantage of these three efficiencies of scale, and that the controlling computer system has sufficiently fast and powerful hardware to be able to search through the larger numbers (thousands per minute in a large city) of journey requests to be able to seek out highly compatible itinerary matches.

Efficiencies of scale are vital to the success of this invention. The increased efficacy of this invention at high passenger fluxes helps make it a viable mass transportation system which can solve the problems of traffic congestion, air pollution, greenhouse gas emissions, and so forth. Operation at a large scale (and reaping the efficiencies that materialise at such scales by means of an suitably-designed intelligent grouping module and a sufficiently powerful computer with which to run it) constitute a preferable feature of this invention.

6 - OVERVIEW OF THE EMBODIMENTS

6.1 - Introduction to the Drawings

Two ways of embodying this invention are described in chapters 7 and 8 (with chapter 9 detailing some aspects that are common to both embodiments).

We now provide a brief overview of these two embodiments, with reference to the accompanying drawings in which:

Figures 1, 2 and 3 illustrate the principle of intelligent grouping which is fundamental to this invention (these figures were described in section 5.7).

Figure 4 shows a schematic diagram of the basic features of the preferred embodiment of the invention.

Figure 5 shows a schematic diagram of the basic features of the second embodiment of the invention.

Figure 6 shows a schematic diagram for the computer data-processing operation of the preferred embodiment of the invention (figure 6 is described in section 7.1).

Figure 7 shows a schematic diagram for the computer data-processing operation of the second embodiment of the invention (figure 7 is described in section 8.1).

Figure 8 shows part of the sequence of user-interface events on the text display screen of a communicator device when a passenger submits a journey request to the controlling computer system for taxibus transport, and for car pool transport (note: a passenger must choose either taxibus or car pool transport; the figure shows both selections just for completeness). This figure applies to both embodiments.

6.2 - Schematic Overview of the Two Embodiments

Figure 4 shows the preferred embodiment of the invention in which a central controlling computer system 15 has, by means of the data transmission system 16, a two-way communications connection with the communicator devices 17 and 18 of the prospective travellers 19, and a two-way communications connection with the communicator devices 20 of the transit vehicles 21 (in the figures, the communicator device of a transit vehicle is shown as a small black box on the vehicle dashboard). An electronic positioning system 22 provides the controlling computer system with data regarding the current geographic location of the transit vehicle communicator devices 20 and (optionally) some passenger communicator devices 17.

Figure 5 shows the second embodiment of the invention in which the controlling computer system (not shown explicitly) consists of a distributed series of computer processors which are incorporated into the communicator devices 20 of the transit vehicles 21. The data transmission system 16 provides two-way communications directly between the communicator devices of the prospective travellers 19 and the

communicator devices of the transit vehicles 21. An electronic positioning system 22 supplies the said computer processors with data detailing the current geographic location of the transit vehicle communicator devices 20 and (optionally) some passenger communicator devices 17.

In both the preferred and the second embodiment of the invention, the data transmitted over the data transmission system 16 will consist of such information as journey requests detailing the itinerary requirements of travellers, the controlling computer system's responses to these journey requests sent back to travellers, and other categories of information.

In the preferred embodiment shown in figures 4 and 6, the data transmission system 16 transmits car pool intended itinerary specifications from car pool vehicles to the central controlling computer system. The data transmission system 16 also transmits street navigation instructions, created by the electronic street navigation module that is run on the controlling computer system 15, to the communicator devices 20 in the transit vehicles 21; these instructions enable the drivers of these transit vehicles to follow the optimal transit routes devised by the intelligent grouping module that is run on the central controlling computer system 15.

A useful variation of the preferred embodiment shown in figures 4 and 6 has the electronic street navigation module relocated into computer processors incorporated in the communicator devices 20 of the transit vehicles 21, with a separate electronic street navigation module in each transit vehicle, but is otherwise the exactly same as the system shown in figure 6. Electronic street navigation is a fairly self-contained task which can easily be performed locally in the transit vehicles 21. In such a configuration, the appropriate transit vehicle itinerary, from the transit vehicle current itineraries database on the central controlling computer system 15, is sent over the data transmission system 16 to the said electronic street navigation module in the transit vehicles 21. This electronic street navigation module takes this transit vehicle itinerary as input (it also inputs transit vehicle current geographic location data from the electronic positioning system 22), and from this data alone provides street-by-street navigation instructions to the transit vehicle driver. This configuration has three advantages: firstly it eases the data-processing burden on the central controlling computer system; secondly it can reduce the amount of data travelling via the data transmission system 16, because a transit vehicle itinerary contains less data than do real-time street-by-street navigation instructions; thirdly it allows uninterrupted navigation even when the transit vehicle temporarily loses contact with the central computer system (such as when driving through a tunnel).

In the second embodiment of the invention shown in figures 5 and 7, in which there is no central computer system, all data-processing functions, including the electronic street navigation module and the intelligent grouping module, are performed on the computer processors incorporated into (or connected to) the communicator devices 20 of the transit vehicles 21.

Both embodiments of this invention are capable of running the invention's two main transport modes, namely the electronic navigation taxibus and car pooling.

7 - PREFERRED EMBODIMENT OF THE INVENTION

A preferred embodiment of the invention is now described with reference to figures 4, 6 and 8 in the accompanying drawings. In this embodiment, a single central controlling computer system 15 orchestrates all transit vehicles 21 and travellers 19. A data transmission system 16 comprising land lines, cellular telephone networks, and Internet transmission is used to provide a two-way data exchange between this centralised controlling computer system 15 and the communicator devices 17 and 20 (of the travellers 19 and transit vehicles 21 respectively).

The electronic positioning system 22 in this embodiment is a satellite positioning system such as the American GPS (Global Positioning System), the broadcast positioning signal of which is received by GPS receivers contained in the vehicle communicator devices (and optionally in passenger communicator devices). These GPS receivers transmit electronic positioning data to the controlling computer system via the data transmission system. Note: this embodiment may instead operate with one or more of the electronic positioning systems described in section 9.22.

In this embodiment, the electronic street navigation module will function in a manner similar to the existing in-car satellite navigation systems now commonplace in cars: that is to say, this module will use the said electronic positioning data to determine the current location of a transit vehicle, and by relating this current location to a digitised street layout map, will provide the vehicle driver with real-time navigation instructions based on this location to guide him street-by-street along the vehicle's itinerary.

To describe this embodiment of the invention, we begin in section 7.1 by detailing the software operation at a systems analysis level. Section 7.1 represents the data-processing core of this embodiment, and in itself, this section sufficiently describes a full working embodiment of this invention at the systems analysis level.

Subsequent sections of this embodiment describe the transportation operation of this invention from the perspective of the passengers and transit vehicle drivers that will utilise this transport system. These subsequent sections also detail certain communicator device user interface functions; these user interface functions are desirable features that help streamline the use of this invention but do not in themselves form part of this invention's core transportation operations and essential features. One example of a user interface function is the automatic passenger fare calculation described in section 9.5 (and elsewhere); another example is the allocation of a user name and password for registered users of this transportation described in section 9.7 (and elsewhere). Such user interface functionality is a standard part of software design, and rather than provide a description in terms of data-processing operations, we instead detail it from the user perspective - but with sufficient precision to allow any competent systems analyst to understand the data-processing requirements of each user interface function thus described.

7.1 - Computer Data-Processing Operations

Figure 6 in the accompanying drawings schematically illustrates the data-processing elements of the controlling computer system 15. The main elements are: the intelligent grouping module, the journey requests database, the transit vehicle current itineraries database, and the electronic street navigation module.

In figure 6 a prospective traveller 19 uses a communicator device 17 to formulate and send his journey request to a central controlling computer system 15 via the data transmission system 16 (travellers who are car pool vehicle drivers will use a communicator device to submit their car pool intended itinerary specification to the controlling computer system in a manner to be described below).

The data in each such incoming journey request is stored as a **journey request record** in the **journey requests database**. The format of the journey request record is such that it includes the six following data fields:

- (1) The specification of the itinerary of the traveller 19 (note that this traveller itinerary will include the current location or desired pick-up point for the traveller).
- (2) The number of travellers to be conveyed on the said itinerary.
- (3) The departure time (and date) at which the traveller requires conveyance in a transit vehicle according to the said itinerary. By default the departure time is set to the present moment for immediate travel unless a specific time (and date) is given. (For regular order journey requests, this data field will specify the regular times and dates at which conveyance is required).
- (4) A specification of whether the traveller wants to prioritise transit vehicle speed of response or transit vehicle speed of journey (see section 7.12). When speed of response is the priority, we would aim to pick up the traveller within 3 minutes of his specified departure time (and date); when speed of journey is the priority, then we have a window of 15 minutes after the specified departure time (and date) in which to pick up the traveller. We define the **latest acceptable pick-up time** of each journey request record as the latest possible time (and date) that a transit vehicle can arrive to pick up the traveller. We can calculate the latest acceptable pick-up time by adding either 3 or 15 minutes to the departure time (depending on whether the traveller has specified speed of response or speed of journey respectively). The aim is to pick up travellers in the time window between their specified departure time, and the latest acceptable pick-up time 3 or 15 minutes later.
- (5) A specification of the type of transit vehicle requested by the traveller (either a taxibus, a car pool vehicle, or an indication that either type is acceptable).
- (6) The current status of the journey request. Current status is defined as follows:

The current status of a journey request record will be one of five classes which are labelled A, B, C, D and E. These five classes indicate the stage that the traveller is at in the transportation process. The five current status classes are:

(Class A) These are journey request records for travellers who have been allocated a transit vehicle by the controlling computer system, and who are currently being transported in that transit vehicle.

(Class B) These are journey request records for travellers who have been allocated a transit vehicle and who are currently waiting for their allocated transit vehicle to collect them from their current location or pick-up point.

(Class C) These are journey request records for travellers who have NOT yet been allocated a transit vehicle and whose **latest acceptable pick-up time** is within the next three minutes (or has already passed). The Class C status is intended to flag journey request records that require urgent attention, that is, journey request records of travellers who must be found a transit vehicle quickly. The class C category will include journey requests that have just been submitted by travellers who require immediate travel and who have prioritised transit vehicle speed of response (meaning that the traveller should be picked up within 3 minutes).

(Class D) These are journey request records for travellers who have NOT yet been allocated a transit vehicle and whose **departure time** (and date) is within the next 20 minutes, but whose latest acceptable pick-up time is still more than 3 minutes away. The Class D status is intended to flag journey request records for which the traveller must be found a transit vehicle, but for which there is no pressing urgency as yet. Class D journey request records will include pre-order and regular order journey requests (see section 7.8) whose specified departure time (and date) falls within the next 20 minutes. Class D journey request records will also include newly submitted journey requests from travellers who require immediate travel, but who have prioritised transit vehicle speed of journey rather than transit vehicle speed of response (prioritising speed of journey implies the traveller is prepared to wait up to 15 minutes after his specified departure time for a transit vehicle to pick him up).

(Class E) These are journey request records for travellers who have NOT been allocated a transit vehicle and whose departure time (and date) is more than 20 minutes in the future. Class E journey request records will include pre-order and regular order journey requests which are to be executed in the future.

In the controlling computer system, the journey requests database is regularly maintained every few seconds by data-processing instructions that update the current status data field (6) to ensure that, with respect to the current time (the present moment), this data field contains the correct value. These data-processing instructions will search for any journey request records that have a current status of class E and a departure time (and date) within 20 minutes of the current time: any such records found will have their current status updated to class D. These data-processing instructions will also search for any journey request records that have a current status of class D and a latest acceptable pick-up time within the next three minutes (or a latest acceptable pick-up time that has already passed): any such records found will have their current status updated to class C.

A traveller's journey request record remains in the journey request database until that traveller has been transported according to the itinerary specified in the

journey request. Once travellers have been conveyed to their destination, their journey request records are deleted from the journey requests database (and may be archived elsewhere for reference). However regular order journey requests are not deleted from the journey requests database after travellers have been conveyed to their destination since such journey requests are regularly executed at specified dates and times; regular orders are only deleted from the journey requests database when cancelled by the user.

In addition to the journey requests database, the controlling computer system also maintains a **transit vehicle current itineraries database**. The transit vehicle current itineraries database contains a data record, which we shall call the **transit vehicle record**, for each currently operational transit vehicle. By a currently operational transit vehicle we mean a vehicle that is currently conveying travellers, or a vehicle that is currently empty but is ready to convey travellers.

The format of the transit vehicle record includes the following seven data fields:

- (1) The current geographic position of the transit vehicle (this data is obtained from the electronic positioning system).
- (2) The current vehicle itinerary of the transit vehicle (this is usually an optimal transit route that was earlier created by the intelligent grouping module).
- (3) The passenger capacity of the transit vehicle (excluding the driver); that is, the total number of designated passenger places (seated or standing) in the vehicle.
- (4) The number of passengers currently being conveyed in the transit vehicle (this data field is normally set to zero when a new transit vehicle record is created).
- (5) The type of transit vehicle (usually either car pool or taxibus).
- (6) The unique **vehicle identification number** of the transit vehicle. This number is painted on the outside of the transit vehicle so that travellers can unambiguously identify their vehicle - see section 7.7. For car pool vehicles this data field instead contains the vehicle license plate number, vehicle make, model and colour.
- (7) The itinerary commitments of the transit vehicle. This field contains relational database links pointing to the journey request records of all travellers currently being conveyed in that transit vehicle (class A journey request records), and any travellers that the transit vehicle is currently committed to picking up (class B journey request records). The relational database links in this field make it possible to obtain the journey request records of the travellers that constitute the current itinerary commitments of the transit vehicle.

The transit vehicle current itineraries database is regularly maintained by data-processing instructions which ensure the current geographic position data field (1) for each transit vehicle record is kept updated with the latest geographic position data for that transit vehicle, received from the electronic positioning system.

In these transit vehicle records, most current vehicle itinerary data fields (2) will

contain optimal transit routes created earlier by the intelligent grouping module. However some records in the transit vehicle current itineraries database will have a **null itinerary**. A null itinerary represents a transit vehicle that is currently empty (no travellers on board) and with no route to follow, but which is available for use.

When a driver of a car pool vehicle wants to make himself available for car pooling, he will use the communicator device in his vehicle to submit his **car pool intended itinerary specification**, via the data transmission system 16, to the controlling computer system 15, and these details are stored in the transit vehicle current itineraries database, in the same transit vehicle record format described above, the only difference being that the car pool driver's specified itinerary is also entered in the journey request database as a journey request record, with a relational link set up from this transit vehicle record to this journey request record. (A journey request record is created for the car pool driver because he is also a traveller, and his personal itinerary forms part of the itinerary commitments of his vehicle).

In this way, the transit vehicle current itineraries database will contain a record for each available taxibus and car pool transit vehicle, and each such transit vehicle record will have relational database type links in data field (7) pointing to the journey request records in the journey request database that form the itinerary commitments of the transit vehicle.

Transit vehicles that are not currently available for transporting travellers are not logged in the transit transit vehicle current itineraries database. Only when a transit vehicle becomes available does it get a corresponding transit vehicle record entered in this database (initially, new transit vehicle records for taxibuses will have a null itinerary in the current vehicle itinerary data field (2); new transit vehicle records for car pool vehicles will have the current vehicle itinerary set to that in the car pool intended itinerary specification - that is, to the personal itinerary of the driver).

Having described how data in the transit vehicle current itineraries database and the journey requests database is maintained in order keep tabs on the transit vehicles and the travellers, we now proceed to describe how the intelligent grouping module operates and how it utilises these two databases.

The intelligent grouping module constantly scans the journey requests database for journey request records whose current status is either class C or class D. As a matter of priority, the intelligent grouping module will deal with class C journey request records first. Class C journey request records relate to travellers whose latest acceptable pick-up time is less than 3 minutes in the future, and who have not yet been allocated a transit vehicle by the intelligent grouping module, and must therefore be found a transit vehicle with the utmost urgency.

Whenever it finds a journey request record of class C, the intelligent grouping module copies the data from this journey request record with the objective of intelligently grouping the traveller or travellers 19 to which the record relates into a transit vehicle or vehicles. In order to achieve this objective, the intelligent grouping module searches the transit vehicle current itineraries database for transit vehicle

records that satisfy the following three search criteria:

(1) The current geographic position of the transit vehicle is within the vicinity of the traveller's current location or embarkation pick-up point as specified in the journey request record. This vicinity is defined as a 3 minute driving distance radius around the traveller's current location. The 3 minute driving distance may be converted to miles or kilometres using the direct-distance travel-time metric. If no transit vehicles are currently found within this radius, the radius is repeatedly extended in size, up to a 20 minute radius (though clearly any transit vehicles found therein will not be able to get to the traveller's pick-up point before the latest acceptable pick-up time).

(2) The transit vehicle has a sufficient quantity of available passenger places for the number of travellers specified in this journey request; the number of available passenger places is found by subtracting the value in data field (4) from the value in data field (3). When no single vehicle can be found with sufficient passenger places for the quantity of travellers specified in the journey request, then it is necessary to find two or more transit vehicles to accommodate these travellers.

(3) The transit vehicle is of the type specified in this journey request (taxibus, car pool vehicle, or either).

If no transit vehicles are currently available that satisfy these three search criteria, the intelligent grouping module will wait a few minutes, and then search again, repeating until a suitable transit vehicle is found. (Other options open to handle this situation are: to make more transit vehicles available by taking currently idle transit vehicles out of their depots and onto the roads for use; or prompting the traveller try alternative forms of travel: if he requested a taxibus, then suggest car pooling).

Once one or more transit vehicle records satisfying these three search criteria are found (we would normally expect to find quite a few such records), the intelligent grouping module reads the current itinerary commitments of each such transit vehicle record (these are the traveller itineraries in the class A and B journey request records relationally linked to each transit vehicle record). Then for each transit vehicle, the intelligent grouping module must calculate the Compatibility Index for the set **S** of traveller itineraries comprising the current itinerary commitments of the transit vehicle plus the itinerary of the traveller or travellers 19.

This Compatibility Index calculation is performed using the exhaustive search procedure described in section 5.7 and this is done in the following steps:

For each of the transit vehicles satisfying the above three search criteria:

(Step 1) The set of itinerary commitments of the transit vehicle is combined with the desired itinerary of the traveller 19, and this combined **S** set of itineraries is examined in order to determine all the mathematically possible transit routes that can convey the travellers whose itineraries are in set **S** (these are the routes passing through the travellers' embarkation and disembarkation points, excluding routes that get to a traveller's destination point before they get to his embarkation point).

(Step 2) A travel-time metric (such as a simple direct-distance travel-time metric) is then employed in order to find the quickest and the quicker transit routes out of all these mathematically possible transit routes in set **S**. These quickest and quicker routes are of course the optimal transit routes for the set **S** of traveller itineraries (for the rule-of-thumb definition of 'quickest' and 'quicker' see section 5.7).

(Step 3) For each optimal transit route in turn, we calculate the Efficiency Ratios for all traveller itineraries in set **S** (if we are using the direct-distance travel-time metric, the Efficiency Ratio for any traveller itinerary is simply the distance along the optimal transit route from the traveller's embarkation point to destination point, divided by the direct distance between these two points).

(Step 4) We then select the quickest and quicker optimal transit routes in which no traveller itinerary has an Efficiency Ratio greater than 1.6 (or failing that, out of the quickest and quicker optimal transit routes available, select those which have the smallest values for the maximum Efficiency Ratio).

(Step 5) If the transit vehicle is currently committed to picking up travellers (such travellers will have class B journey request records), we really need ensure that each of these travellers can still be collected within the time window between their departure time and their latest acceptable pick-up time (the size of this time window being 3 or 15 minutes, depending on whether the traveller prioritised speed of response or speed of journey in his original journey request). For each optimal transit route, we can use the direct-distance travel-time metric to estimate the time the transit vehicle will arrive at these travellers' pick-up points. We would exclude optimal transit routes in which these travellers can no longer be picked up within their time windows.

(Step 6) Out of the optimal transit routes which satisfy the above steps (4) and (5), we calculate the Compatibility Index for each of these routes (by taking the average of each optimal transit route's Efficiency Ratios) and we finally select the optimal transit route whose Compatibility Index value is the lowest.

We repeat these six steps to calculate the Compatibility Index for each transit vehicle that satisfied our three search criteria.

Once we have a Compatibility Index value (and an optimal transit route) for each of these transit vehicles, we can choose the most appropriate vehicle or vehicles to convey the traveller or travellers 19. We would normally select the vehicle with the lowest Compatibility Index. If the lowest value corresponds to more than one transit vehicle, the vehicle positioned nearest to the traveller pick-up point is selected.

Note: in the case of journey requests for taxibus travel, the intelligent grouping module will select just one suitable transit vehicle; but in the case of journey requests for car pool travel, the intelligent grouping module will normally select one or more suitable transit vehicles to offer the prospective passenger.

When the intelligent grouping module has selected a suitable transit vehicle into which the traveller 19 can be intelligently grouped according to his journey request,

details of this transit vehicle are sent to the traveller's communicator device 17. These details include the estimated time for this transit vehicle to arrive at the traveller's pick-up point, and the estimated journey time in the vehicle to the traveller's destination (these details are calculated simply by applying the travel-time metric to the new optimal transit route). Should the traveller choose this transit vehicle offered, the traveller's communicator device will inform the controlling computer system of this choice. (In the case of pre-order and regular order journeys, however, details of these vehicle options are not sent to the traveller's communicator device: a suitable transit vehicle is automatically chosen to pick up and convey the traveller).

Once a transit vehicle is chosen, the intelligent grouping module will update its transit vehicle record in the transit vehicle current itineraries database so that the current vehicle itinerary data field (2) contains the new optimal transit route. The journey request record of the traveller 19 will have its current status updated to class B, indicating that the traveller has been allocated a transit vehicle and is now waiting for that vehicle to pick him up. A relational database pointer to this journey request record is added to the itinerary commitments data field (7) of the said transit vehicle record. (When the traveller 19 is picked up by the transit vehicle, this journey request record will have its current status updated to class A).

Once the transit vehicle record is thus updated with the new optimal transit route, the details of this revised route get passed on to the electronic street navigation module, whose function it is to send, via the data transmission system, navigational instructions to the communicator device in the said transit vehicle to guide the vehicle driver along this optimal transit route. From this point onwards, the electronic street navigation module alone takes care of the operation of guiding the transit vehicle along the optimal transit route. The electronic street navigation module provides real-time navigation instructions, based on the transit vehicle's current position, to guide the transit vehicle driver along the optimal transit route.

When the traveller 19 is delivered to his destination, his journey request record is deleted from the journey request database (unless it is a regular order record), and the pointer to this record in the itinerary commitments data field (7) is also deleted.

When all the journey request records with a current status of class C have been dealt with by the intelligent grouping module, this module can dedicate some time to dealing with class D journey request records - these are for travellers who must be picked up and conveyed within the next 20 minutes. Class D journey request records encompass pre-order and regular order travellers whose specified departure time is within the next 20 minutes; and also travellers whose specified departure time is immediate, but who have prioritised transit vehicle speed of journey.

For these class D journey request records, the intelligent grouping module searches the transit vehicle current itineraries database for transit vehicle records that satisfy the following three search criteria:

- (1) Transit vehicles that will be in the vicinity (3 minutes driving distance) of the traveller's pick-up point at time which falls in between his departure time, and the

latest acceptable pick-up time, all of which are specified in the journey request.

(2) Transit vehicles that have sufficient available seats for the number of travellers specified in this journey request.

(3) Transit vehicles that are of the type or types specified in this journey request (the type will usually be a taxibus, a car pool vehicle, or either).

Search criteria (2) and (3) are the same as the search criteria described above for class C journey request records. However search criterion (1) is different: it requires that we determine the geographic position of a transit vehicle up to 20 minutes into the future. This is achieved using our travel-time metric to estimate the future position of the transit vehicle along its current transit route, which is a straightforward calculation.

Once one or more transit vehicles that satisfy these three search criteria are found, the intelligent grouping module then proceeds exactly as described in the class C case: that is to say, for each transit vehicle, we calculate the Compatibility Index for the set **S** consisting of the vehicle's current itinerary commitments plus the specified itinerary of the traveller 19. We do this with the objective of placing the traveller in the transit vehicle which has the lowest Compatibility Index.

The only difference in this class D case is that, given we have up to 20 minutes to place the traveller, we can afford to be more exacting regarding finding him a transit vehicle with a low Compatibility Index. This means that out of the transit vehicles that currently satisfy the three search criteria, if a vehicle with a low Compatibility Index is not available, we can wait 5 minutes, and then search the transit vehicle current itineraries database again, in the hope of getting a low value. We might aim to find a transit vehicle with a Compatibility Index value of 1.3 or less, and reject transit vehicles whose Compatibility Index is higher. When the current time reaches a point within 3 minutes from the latest acceptable pick-up time of the traveller, if that traveller has not been found a transit vehicle, the class D journey request record is automatically changed to a class C journey request record and processed accordingly (that is, more urgently, and with less emphasis and concern about finding a good Compatibility Index value).

By dealing with class C and class D journey requests separately like this, the former can be handled with the necessary urgency that they require, whereas the latter are handled 'at leisure', and as a consequence, the traveller itineraries of class D journey requests will often be intelligently grouped with a better Compatibility Index value.

Having described the data-processing core of this invention, we now proceed to describe the operation of this invention from the perspective of the passengers and transit vehicle drivers that will use it.

7.2 - The Communicator Device

Passengers and transit vehicle drivers will use a communicator device to interact with the controlling computer system. This embodiment of the invention uses seven practicable types of communicator device, and these are described and listed below. Note that communicator devices 1 to 4 in the list are portable or mobile units, whereas communicator devices 5 to 7 are fixed-location units. Some communicator devices in the list are specifically designed to be operated by passengers, others are specifically designed to be operated by drivers. Communicator devices 1 and 2 in the list are designed to be used by both passengers and drivers: these devices will include functionality that allows switching between **passenger mode** and **driver mode** of operation (this is useful because the owner of the communicator device may at one time be a car pool driver, but later travel as a passenger himself in a taxibus or car pool vehicle).

(1) *For use by drivers and travellers:* cellular telephones make excellent communicator devices, since many of the latest models allow two-way transmission of text and graphical information, and the soon-to-be-launched 3G (third-generation) cellular telephones are particularly adept at text and graphical information transmission. When used in driver mode, drivers will need to mount their cellular telephone on the dashboard for easy viewing of information whilst on the move.

(2) *For use by drivers and travellers:* a wireless PDA (Personal Digital Assistant), the ubiquitous electronic agenda and mini computer, can transmit data over a cellular network. When used in driver mode, drivers will need to mount their wireless PDA on the dashboard for easy viewing of information whilst on the move.

(3) *For use by drivers only:* a **dashboard communicator device** is one specifically designed for use with this invention. It comprises a display screen and keyboard, and is intended to be permanently fitted on the dashboard of the transit vehicle, such that the driver can easily see its display screen and enter information on its keyboard. Dashboard communicator devices will be standard equipment in taxibuses, and are desirable in any car pool vehicle regularly participating in car pooling.

(4) *For use by passengers only:* an **on-board kiosk communicator device** unit is a communicator device that is located within a taxibus vehicle where it can be used by passengers. These kiosks comprise a display screen and keyboard (or a virtual touch-screen keyboard, which is more robust), and will be used by passengers for such purposes as cancelling or changing their journey request (see section 9.14) or used by passengers that board a taxibus by manual hailing to specify their journey request (see section 9.4).

(5) *For use by travellers only:* a **roadside kiosk communicator device** unit will comprise a display screen and keyboard (or a more robust virtual touch-screen keyboard), and these kiosks will be incorporated into bus stops or similar roadside structures. Kiosk communicator devices may be located both on high streets and on quieter residential streets.

(6) *For use by travellers only:* a **web browser communicator device** allows a personal computer with Internet access to act as a communicator device.

(7) *For use by travellers only:* regular land line or cellular telephones will offer audio communication with the controlling computer system by means of a voice recognition or touch-tone telephone interaction with the controlling computer system in a style similar to automated telephone banking. This is not the easiest way of interacting with the controlling computer system, but this method has the advantage of operating with any telephone. For people without a touch-tone phone, or for technophobes, human operator assistance could also be provided.

We use the term **vehicle communicator device** to denote communicator devices of type 1 or 2 used in driver mode, and communicator devices of type 3. We use the term **passenger communicator device** to denote a communicator devices of type 1 or 2 used in passenger mode, and to denote communicator devices of types 4 to 7.

The most popular communicator device is likely to be the cellular phone: it is anticipated that most users will use these to correspond with the controlling computer system. This is not just because cellular phones are small, portable and ubiquitous, and can send and receive text and graphics (and will have an enhanced ability to do so once the new 3G cellular networks are operational), but is also because in a few years, most cellular phones will have electronic positioning functionality built-in as standard. This is due to the American 911 mandate which requires that electronic positioning is fitted to all new cellular telephones to help emergency services locate a caller. The European Union is planning an equivalent law, the E112 mandate. In the meantime, there are cellular telephone replacement battery packs containing a satellite electronic positioning unit to upgrade existing phones. Thus the ordinary cellular telephone, that tiny gadget in everyone's pocket, becomes the perfect miniature communicator device for use with this invention.

7.3 - The Journey Request and the Car Pool Intended Itinerary Specification

To illustrate how passengers and vehicle drivers will use their communicator devices to interact with the controlling computer system, we start with car pooling, perhaps the simplest configuration of this invention, describing the sequence of events that takes place in a car pool trip from the perspective of passengers and car drivers. Once the operation of car pooling is understood, we shall, in section 7.7, proceed to explain the operation of the electronic navigation taxibus.

In order to allow different drivers to use the same vehicle for car pooling, a **user name** and **password** are allocated to every **registered user** (see section 9.7) of this transportation invention. The user name and password are first keyed into the vehicle communicator device to establish the identity of the driver.

At the journey start, a driver thus identified who wants to engage in car pooling must inform the controlling computer system of his intended itinerary (this is the first part of the car pool intended itinerary specification). The user interface of the

vehicle communicator device would be designed so as to let the driver easily specify the destination address (or addresses) on his itinerary simply by selecting this address from a list of **personal travel locations**: each registered user would maintain his own list of personal travel locations; this list is analogous to the list of personal telephone numbers that people save on regular cellular phones, except that personal travel locations are addresses rather than phone numbers, and personal travel locations are stored on the controlling computer system rather than on the user's communicator device. Most users will save the address locations of their home, office, friends houses, the sports centre, the local shopping centre and so forth in their personal travel locations.

When a driver's intended destination address is not in his list of personal travel locations, he must inform the controlling computer system of the exact address of the intended destination. This is most easily achieved by entering the house number/postcode combination of the destination address into the vehicle communicator device, from which the controlling computer system will determine the full address, returning the address details to the driver for validation. Should the driver only have partial knowledge of his intended destination, options are available to perform an address search, to examine an on-screen street atlas, or to speak to an operator assistant. Once an address is fully determined and validated, it may be saved as a personal travel location, for ease of selection next time.

Having declared his destination address (or addresses), the driver must next tell the controlling computer system how many passenger seats are available in his vehicle (in an ordinary saloon car this would usually be 3 or 4 seats, unless some seats are already taken by the driver's own passengers). The controlling computer system always knows the car pool vehicle's current location through data obtained from the electronic positioning system. Once the controlling computer system has been informed of the car pool vehicle's current location, its intended destination address (or addresses), and the number of passenger seats in the vehicle (these data items constitute the complete car pool intended itinerary specification), then the driver's vehicle is logged as available for car pooling, and the driver may now begin his journey. (As described in section 7.1, a vehicle is logged as for car pooling simply by creating a new **transit vehicle record** in the **transit vehicle current itineraries database** in the controlling computer system; this transit vehicle record details the car pool vehicle's real-time current location, the vehicle's intended itinerary, and the number of available passenger seats in the vehicle; the car pool driver's itinerary is also included in a new **journey request record** in the **journey request database**).

Let us turn our attention to the prospective passenger.

Most prospective passengers will typically carry a passenger communicator device in the form of their cellular telephone or wireless PDA; however any communicator device can be used by a passenger. The prospective passenger first enters his user name and password into the communicator device in order to identify himself to the controlling computer system; he then specifies his intended destination address (we assume here that the passenger has just one destination). Just like car pool drivers, passengers will have their personal travel locations detailed on the communicator

device that they are currently using, and simply need to select the appropriate destination from this set. When travelling to a destination address which is not one of these personal travel locations, the passenger must specify the exact address, just as the car pool driver does, as described above.

For passengers using communicator devices that have built-in electronic positioning functionality, the controlling computer system can automatically determine their current location address. However passengers using communicator devices that do not have built-in electronic positioning functionality must manually specify their current location address. Typically this address might be one of their personal travel locations, which makes things easy; otherwise they will have to specify the exact address (if the passenger is waiting in the street, they will need to supply the address of the nearest house or building). For fixed-location communicator devices such as roadside kiosks, however, the location address of the communicator device will be known to the controlling computer system and will not need to be supplied by the prospective passenger.

Having declared his desired itinerary, the passenger will specify how many people are travelling on this itinerary (if there is more than one), and whether he wishes to prioritise transit vehicle speed of response or speed of journey (see section 7.12). Once the controlling computer system has received this information, a new **journey request record** in the **journey request database** is created, as described in section 7.1. Assuming this journey request is for immediate travel, the intelligent grouping module will begin searching the transit vehicle current itineraries database for a suitable car pool vehicle, seeking one that is close to the passenger (a few minutes drive away), and with itinerary commitments that can easily accommodate the passenger's desired destination (that is to say, with itinerary commitments that are compatible with the passenger's itinerary).

As soon as a suitable car pool vehicle is found, the controlling computer system provides details to the passenger: the vehicle's distance from the passenger (in minutes), an estimate for the total car pool journey time (in minutes), and the cost of this car pool journey. Should the controlling computer system find more than one suitable car pool option, a list of the suitable vehicles will be detailed on the passenger's communicator device. The passenger then simply selects any vehicle from the list in order to proceed with the car pool trip. Figure 8 in the accompanying drawings illustrates how the user interface on the display screen of the passenger communicator device handles this selection process.

7.4 - Responding to the Car Pool Journey Request

As soon as the passenger selects a car pool vehicle from the list, the controlling computer system will send a message to that vehicle's communicator device, requesting the driver to convey this passenger. The driver can accept this journey request by pressing the appropriate key or button on his communicator device. If he does not respond to the request within a short time, the controlling computer system assumes that the driver has declined the request, and the passenger will be so

informed via his communicator device. The passenger may then try another car on the list. (Note: preferably this embodiment will be such that any additional suitable car pool vehicles newly arriving in the passenger's locality will automatically appear on the list detailed on his communicator device). As described in section 7.1, once the passenger finds a car pool driver who accepts his journey request, the intelligent grouping module will devise an optimal transit route which allows the car pool driver to pick up, convey and deliver this passenger, the **transit vehicle record** in the **transit vehicle current itineraries database** is then updated with this optimal transit route, and the current status of the passenger's journey request record is updated to class B. The street navigation module in the controlling computer system then proceeds to direct the vehicle driver along this route by means of real-time electronic street navigation instructions exhibited on his communicator device. These navigation instructions will be similar to those given by existing in-car satellite navigation systems: "take the next left", "take the third exit on the roundabout", and so forth. By using the electronic street navigation module and the electronic positioning system the controlling computer system can guide the vehicle driver to the waiting prospective passenger with pinpoint precision.

A real-time countdown to the estimated car pool vehicle arrival time is provided on the passenger's communicator device, informing the passenger of the estimated number of minutes to the car's arrival at the passenger pick-up point. This is useful in conditions of bad weather, where the passenger can remain under shelter or indoors, coming out into the street just before the car arrives.

As the car pool driver nears the passenger's pick-up point, his vehicle communicator device will give precise guidance to home in to the exact position of the passenger. The navigation instructions indicate "200 metres... 100m... 50m... 25m" and so forth until arrival at the passenger's location. At arrival, the driver is given identification details of his passenger: an indication of child or adult and an indication of male or female. Similarly, the waiting passenger communicator device gives identification details of the car pool vehicle: registration number, colour and model - making it easier for the passenger spot the car. The controlling computer system also gives both driver and passenger each other's user names. Should the passenger and driver not immediately spot each other, some form of identification etiquette (such as switching on the vehicle's hazard warning lights) might be necessary. If the passenger uses his cellular telephone as a communicator device, then it would be possible for the car pool driver to telephone the passenger in cases when the driver and passenger are unable to spot each other. Passengers that use a roadside kiosk communicator device to make their journey request are more easily spotted since the kiosk structure will be clearly visible from the road.

Once the passenger is spotted and enters the car pool vehicle, the journey can commence. A quick check on the passenger's user name ensures the car pool driver has picked up the correct person. A more sophisticated passenger user name check would have the passenger's and vehicle's communicator devices exchange data over a short-range wireless data link in order to establish that the correct person has been picked up, or would use a smart-card system as described in section 9.5. Once pick up is confirmed, the current status of the passenger's journey request record in

the journey request database is updated to class A, as described in section 7.1.

Electronic street navigation instructions are now sent to the vehicle communicator device to guide the driver to the passenger's destination. Once the passenger has been delivered, the controlling computer system will supply street navigation directions to guide the driver onwards to his own destination, should these be required.

Quite often, the car pool driver will not need the street navigation instructions: remember that the controlling computer system only groups passengers whose itineraries are very similar to the driver's, so the passenger's destination may well be familiar to the driver. Furthermore, as anyone who has used satellite electronic street navigation in their car knows, the driver can at any time insert his own navigation ideas or short-cuts into the routing, and afterwards, the satellite navigation system will continue guiding the driver from wherever he has got to; this is wonderful because it means the driver does not have to follow the navigation instructions verbatim, and may weave in his own routing preferences when he feels like it (even if only to take the scenic route). A great advantage of using electronic street navigation is that anyone can become car pool driver, even people with little or no knowledge of the roads.

7.5 - Alternative Vehicle Selection Logistics

In the scheme described in section 7.4, when a passenger makes a journey request, the controlling computer system provides a list of suitable car pool vehicles, which are detailed on the passenger communicator device, leaving it to the passenger to select a vehicle out of the options on the list. The reason for giving the prospective passenger more than one choice of several suitable car pool vehicles (when they are available) is because even when a particular car pool vehicle is selected, the driver of that vehicle may decline the journey request, and the passenger can then immediately select another car pool vehicle in the list.

However, an alternative logistic is this: when a passenger makes a journey request, the controlling computer system sends this request to all car pool vehicles that have itinerary commitments that are compatible to the itinerary of the passenger; the first driver to respond to this journey request - by pressing the appropriate key or button on his communicator device - gets the passenger.

Or perhaps an even better alternative: after sending the journey request to suitable vehicles, the controlling computer system will examine all the 'accept' responses received from car pool drivers, and out of these responses, select the vehicle that the controlling computer system calculates will most expediently convey the passenger to his destination. This last alternative makes car pooling even easier for the passenger as the controlling computer system automatically selects the car pool vehicle which will transport the passenger in the most rapid and efficient manner.

7.6 - The Incentive for Car Pooling

The principal incentive for a driver to participate in car pooling is monetary. For every car pool passenger carried, the driver receives a fee. For speed and simplicity, no money is exchanged in the vehicle: the controlling computer system handles all financial transactions automatically. Every person registered with the controlling computer system will have their own system-administered **monetary account** (see section 9.7), and after a car pool journey, the controlling computer system credits the driver's monetary account with his fee and debits the passenger's monetary account by an amount which represents the fare for his journey.

It is thought that car pool fares should be set at approximately two or three times the price of an equivalent bus ride, making car pooling a remarkably cheap form of door-to-door transport, yet from the driver's perspective, providing sufficient reward for carrying passengers. Note that when conveying more than one passenger, the fee received by the driver would be proportionally higher; a car driver can thus make a good profit from his journey by providing carriage to a series of passengers, or a group of passengers travelling together.

The fare charge to the passenger and the fee received by the driver is calculated by the controlling computer system. There is a minimum set fare for a car pool journey (just as there is in taxi cabs) after which the cost is primarily based on the distance travelled. The controlling computer system will use the distance between the passenger's starting and destination point to calculate the fare. The total fare cost, however, will also include an amount related to the additional time added on to the driver's own journey as a result of diverting to collect and deliver the passenger: this ensures that the driver receives fair recompense when a larger route deviation is required to convey a passenger. Methods for accurately computer metering passenger fares are discussed in section 9.5.

Many car pool drivers will not purely be interested in the financial reward; perhaps they also enjoy the company and conversation provided by passengers, or might just be curious as to whom they will meet. This may not be so true in countries such as the UK where public behaviour is generally more introverted, but this invention is conceived with global application in mind. In any culture, though, there are many sociological as well as technological considerations involved in the implementation of car pooling. Will private vehicle owners want to take strangers in their cars? The American experience of car pooling (described in section 4.3) indicates that it does work reasonably well: a passenger etiquette was even created to manage the social process. This etiquette included rules such as: don't talk unless the driver initiates the conversation; don't talk about religion, politics or sex; and don't complain about the heat or the choice of radio station. In the US it was found that car pool passengers came from a wide social spectrum: blue collar workers to company directors were happy to travel by this means.

Should legislation be introduced that allows car pool drivers to use bus lanes (as do taxi cabs) or have access to free city centre parking, or similar privileges, then the incentive to carry passengers becomes even stronger.

7.7 - The Electronic Navigation Taxibus

We now turn our attention to the electronic navigation taxibus.

The electronic navigation taxibus is an entirely new mode of public transportation facilitated by this invention. The taxibus vehicle (which is typically the size of a minibus) can travel door-to-door, picking up passengers from their current location and dropping them off precisely at their destination. Just as in car pooling, the taxibus transports passengers using the principles of intelligent grouping. Unlike car pooling, however, the taxibus driver is a paid professional with no itinerary of his own, so the process of intelligent grouping is applied only to the passengers travelling in the taxibus, not to the driver.

From the passenger perspective, riding a taxibus is just like travelling by car pool, but is even easier (and much cheaper). To make a taxibus journey, the prospective traveller sends his journey request to the controlling computer system using a communicator device such as his cellular phone. From the passenger perspective, the user interface operation is just like the car pooling operation described in section 7.3. The passenger must specify his desired itinerary (current location address and intended destination address), how many people are travelling on this itinerary (if there is more than one), and whether he wishes to prioritise transit vehicle speed of response or speed of journey. As with car pooling, once the controlling computer system has received this information, a new journey request record in the journey request database is created. Figure 8 in the accompanying drawings illustrates the operation of user interface on the passenger communicator device when submitting a journey request.

Just as in car pooling, when the time comes to execute this journey request (which will be straight away if the journey request is for immediate travel), the intelligent grouping module in the controlling computer system will search the transit vehicles current itineraries database in order to find a taxibus vehicle in the vicinity of the passenger that has an itinerary compatible to the passenger's destination. Out of the available taxibus vehicles, the intelligent grouping module will try to find the most efficient matching of passenger with taxibus; that is to say, to find a taxibus into which the passenger can be intelligently grouped with a good Compatibility Index.

When a suitable taxibus is found, its details will be displayed on the passenger communicator device. These details will include the estimated time for the taxibus to arrive at the passenger's pick-up point, details of the estimated journey time, and the calculated fare cost of the journey (these two time estimates are derived by applying the travel-time metric to the optimal transit route calculated by the intelligent grouping module). If the passenger confirms that he wishes to travel by this taxibus, the current itinerary in the appropriate transit vehicle record is updated to reflect the new optimal transit route. As per usual, the electronic street navigation module sends the driver navigation directions to the vehicle communicator device in order to guide the taxibus along the transit route. A real-time countdown to the estimated taxibus arrival time is provided on the passenger's communicator device. Note that since the taxibus is in the vicinity of the passenger, it will generally take just a

couple of minutes for this vehicle to arrive at the passenger's pick-up point.

Each taxibus has a unique **vehicle identification number** (or name) that is prominently exhibited at the front, on the sides, and at the rear of the vehicle. When a passenger makes a journey request, this identification number is detailed on the passenger's communicator device, to help him spot his taxibus when it appears. In addition, an electronically updatable **outside display screen** situated at the front of the taxibus will exhibit the principal destinations on the vehicle's itinerary. This display screen is controlled by the vehicle communicator device. Both the taxibus identification number and the outside display screen will be invaluable on busy high streets, where many passengers may be waiting for taxibuses, and where there may be several taxibuses simultaneously arriving and departing.

Just inside the entrance door of the taxibus, an electronically updatable **passenger display screen** (which is capable of displaying text and is which controlled via the vehicle communicator device) will clearly exhibit the user names of the passengers that are expected to board the taxibus at that point; as they board, passengers just need to glance at the passenger display screen to ensure that their user name is listed, thus confirming they have entered the correct taxibus vehicle.

The taxibus driver's communicator device will indicate the number of passengers that are expected to board or alight at any particular stop point (on most occasions it will just be one or two passengers that alights or boards). It is the driver's responsibility to ensure that he picks up and drops off the correct number of people.

A more robust method of verifying correct passenger-boarding in taxibus (and car pool) travel would employ **smart card** technology wherein each passenger would carry a personally-issued smart card, and this card would be remotely scanned (without needing to take the smart card out of one's wallet or bag) by a card reader in the taxibus vehicle communicator device as the passenger boards, thus confirming a correct passenger pick-up. Using such a system of smart cards, as each passenger boards the taxibus vehicle, both the taxibus driver and passenger will see a correct pick up confirmation sign appear next to the passenger's user name on the passenger display screen. Smart cards are further discussed in section 9.5.

Just as in car pooling, payment of taxibus fares is handled automatically by the controlling computer system, and the amount of the fare is debited from the user's system-administered monetary account. This allows passengers to board the taxibus without fumbling for coins or travel passes, thus minimising the vehicle's stop time. Various practicable methods for computer metering passenger fares are discussed in section 9.5.

Once on board, the passenger will typically share his trip with several other fellow travellers. Because it picks up and drops off other passengers en route, the taxibus is not quite as quick as the car. But taxibus travel is much quicker than an excursion on a regular bus. Bus journeys are lengthy because of the walk to and from the bus stops, the time spent waiting for the bus, and the time it takes for passengers to board and alight at each of the bus stops along the route. The door-to-door service of the taxibus operates with much greater rapidity and convenience. The controlling

computer system will ensure that all taxibuses follow a reasonably linear trajectory, pressing forwards towards their destinations at all times. The controlling computer system will allow a taxibus to pick up new passengers if they are located ahead on its itinerary, but generally not if the taxibus must double back in order to get them, as this would be inefficient (such passengers will be placed on another taxibus).

Passengers travelling on a taxibus are informed when their destination is imminent. Inside each taxibus, one or more large **interior display screens** capable of displaying textual information will be mounted so that they are visible to all passengers within the vehicle; these screens, which are controlled by the vehicle communicator device, will show the geographic name of the upcoming taxibus stop points (with a format such as 'NEXT STOP: Kensington High Street W8 6NA'). Additionally, these interior display screens will list the user name of the passenger or passengers who should alight at the displayed destination. Passengers who carry their own portable communicator device (such as a cellular phone) will have the general progress of their personal journey exhibited on this device, including advance notice of their upcoming destination.

Note that a passenger can ask the driver to stop the taxibus at anytime should he wish to disembark before his specified destination (see section 9.14 for details).

7.8 - Advantages of the Taxibus from the Passenger Perspective

The taxibus does something that even the private car often cannot: it delivers passengers exactly to their destination. In most cities, when a parking space is eventually found for a private car, it is often several minutes walk away from the intended destination. This is a problem in bad weather, in areas of high crime rate, and for single women late at night. Leaving a car unattended and out of view can also increase the risk of theft or vandalism. The door-to-door service of the taxibus has an inherent level of security that neither the car nor conventional public transport can beat. A taxibus can be used, for example, to safely transport children to school on a door-to-door basis, so that parents need not worry about the school run each morning (which in itself will clear a great deal of traffic from the roads in the UK: just before 9 am in urban areas, an astounding one car in every five is taking children to school).

The door-to-door service of the taxibus is also invaluable for the frail, elderly or disabled. Many towns in the UK have a 'dial-a-ride' service for people with a mobility impairment, which provides minibus door-to-door travel in the local district; typically these rides must be booked by telephone a day in advance. This invention can subsume the dial-a-ride service: the taxibus offers more efficient routing, and can be requested just *minutes* before required; the existing dial-a-ride minibus vehicles, which are specially designed for use by mobility-impaired people, can be incorporated straight into this invention as taxibuses simply by fixing a communicator device for the driver on the dashboard (and installing a passenger display screen, an interior display screen, and painting a vehicle identification

number (or name) on the outside of the minibus).

By default this invention will marshal a rapid response to passenger journey requests, providing a taxibus to pick up passengers within minutes; however it is also possible to submit a journey request that books a taxibus trip some time in advance, using **pre-order booking**. A pre-order booking is just like an ordinary journey request, except that the passenger must additionally specify the precise time in the future that she wishes the taxibus to come and collect her for the journey. It is also possible to organise a **regular order booking** for taxibus trips. A regular order booking is a journey request which is automatically executed at a specified time, and which is repeated on a specified regular basis. Regular order bookings are very useful for people who commute to and from work at the same hour each day. When commuters place a regular order booking with the controlling computer system, a taxibus will automatically collect them from their home on the days and the times they have specified for the journey to work, and likewise for the return journey if so requested. Regular order journeys have many other uses: for children travelling to and from school each day, for regular visits to the gym after work, and for any trip or journey that is routinely undertaken. Regular order bookings have advantages both for passengers, and for the taxibus system. For passengers, it saves them the trouble of ordering a taxibus every time; the taxibus will arrive automatically as specified. For the controlling computer system, foreknowledge of passenger journey requirements can allow for a more efficient routing of the taxibus fleet. Pre-order booking and regular order booking journey requests are stored in the journey requests database (see section 7.1).

It is anticipated that the taxibus will be more convivial and community-oriented than any other means of travel, because the controlling computer system will naturally tend to group like-minded passengers in the same vehicle. Football fans, theatre goers, concert crowds, conference attendees, tourist attraction visitors, and so forth, will all tend to be grouped with their own kind into the same taxibus, simply because this is the most efficient way of transporting people headed for the same destination. It would even be possible to program the controlling computer system to deliberately exaggerate this social grouping effect. This might be done not just for conviviality, but also for security: school children, for example, would benefit from being exclusively grouped together in one taxibus for safer travel.

The taxibus is an interesting way of travelling. Even for commuters going to the same destination every day, the taxibus will generally run a different route variation on each journey, depending on the itineraries of the other passengers on board. This means that on every journey the traveller may see something new: a street he has not been down before, or an area of the city he has never seen. Also, because the taxibus takes the most efficient route and because the system knows all the back streets, travelling by taxibus is a great way to learn new short cuts.

There are so many benefits to taxibus travel. There is the great feeling of freedom the taxibus gives: it takes you exactly where you want to go, and wherever you are, a taxibus is always available whenever needed. As a taxibus traveller, there is no need to carefully monitor the amount of alcohol you are drinking, as car drivers

must. This in itself may revolutionise the social lives of many people, but more importantly, a hidden benefit of introducing a comprehensive taxibus service might be a marked decrease in alcohol-related road accidents.

The taxibus is particularly fast and convenient for travel to an unfamiliar address: instead of pre-planing the trip using a street atlas, you simply submit a journey request for travel to this address, and the taxibus will drop you right outside.

The taxibus brings simplicity to public travel, offering an easy way of taking a trip. Ease and simplicity are partly why the private car remains so popular: with the car you just get in and go. The taxibus is equally uncomplicated: state your destination, and let the taxibus take you there. One must reflect for a moment to really appreciate the almost magical power of taxibus transportation. With nothing but a cellular phone, you press a couple of keys, and a taxibus appears just minutes later, ready to whisk you away to the destination you selected.

7.9 - The Taxibus Fleet

The taxibus fleet will contain a diversity of types and sizes of vehicle. Vehicle size brings advantages and disadvantages. Larger vehicles can transport more people (and using just one driver, so it is also more economic on personnel); but higher passenger numbers equate to longer journey times, as a result of the extra pick-ups and drop-offs en route. By contrast, smaller vehicles transport less people, but do so more rapidly. Larger vehicles are efficient at transporting passengers that have identical embarkation or destination points, for example, passengers travelling from an airport to city centre hotels, or passengers travelling to a large public event such as a music concert or football match. Larger vehicles may be more appropriate for inter-city travel. Smaller vehicles are better at driving down narrow residential streets, picking up and dropping off passengers from their homes. It is thought that taxibus fleets in cities should comprise mainly smaller-sized vehicles, in the range of 4 to 12 passenger seats (in other words, the size of a multi-purpose vehicle or people carrier, up to the size of a minibus).

The journey range of each taxibus vehicle may vary. Some vehicles might be restricted for use within specified suburban areas; other vehicles might cover the whole of a city; still others might run from city-to-city or cover an entire country.

Occasionally a passenger's journey may be split into two legs, using two different taxibus vehicles. Typically, passengers travelling city-to-city by taxibus may have their journey thus split: a local taxibus vehicle first collects the passenger from his address, and later the passenger is transferred to another (perhaps larger) taxibus vehicle for the inter-city portion of his journey. The controlling computer system will however always try to transport passengers on a single taxibus if possible. Split journeys are examined in more detail in section 9.2.

An enhancement to further improve the efficiency of this embodiment of the invention would involve the controlling computer system deploying its taxibus fleet

according to the time of day. During commuter rush hours the controlling computer system will tend to pull all its taxibus vehicles into operation; at quieter times such as during the night, many taxibuses will rest in their depots (small taxibuses might be parked outside the residence of the taxibus driver). In the morning rush hours, the controlling computer system will ensure that plenty of taxibuses are mustered around the suburban regions ready to take passengers into the city centre. In the evening rush hours, the controlling computer system will orchestrate the reverse. The controlling computer system will maintain a database of the statistically averaged passenger flux in all regions of the city, for all times of day, and for all days of the week. (The passenger flux from a given area is defined as the number of passengers per unit time requesting taxibus transport in that area). Using this passenger flux database, the controlling computer system will pre-emptively marshal its taxibus fleet so that the vehicles are fully prepared and positioned to meet temporal variations in travel demands (the controlling computer system will generally pre-emptively re-position taxibuses that are currently empty). The controlling computer system will also act on any notice that it is given of large public events, pre-emptively marshalling its fleet in order to handle the crowds.

Later in the evening and at night the controlling computer system will withdraw larger taxibus vehicles from the roads, keeping just the smaller taxibuses in operation. This will save fuel, keep noise levels down, and further decrease road congestion, as smaller vehicles take less space and cause less blockage when pulling over to pick up or drop off passengers. One of the problems with regular buses is that large vehicles are needed to deal with the peak hour passenger flux, but at other times these vehicles remain half empty. The taxibus fleet responds much more dynamically to variations in passenger flux.

Who would run the taxibus fleet? Many operators could be accommodated by franchising different organisations to run taxibuses. As long as each taxibus vehicle runs under the control of the controlling computer system, it does not matter who owns or drives the vehicle. Even an individual driver may purchase a taxibus vehicle and enter into a franchise; existing taxi cab or mini cab drivers might consider this (more of which in section 7.15). At the other end of the spectrum, large companies might operate a fleet comprising thousands of taxibus vehicles. This invention can accommodate all.

The controlling computer system may also accommodate specialist taxibuses: for example, large shopping centres or supermarkets might operate a small local fleet of taxibuses which would respond only to passengers headed for the shopping centre. Containing ample space for purchases, these taxibuses might even offer free rides to customers. Other types of specialist taxibuses could include ones designed for transporting particularly large or heavy items. There is even the possibility of including first class taxibus vehicles in the fleet. First class vehicles would levy higher fares, but would contain larger and more comfortable seats, and provide additional services such as for example airline style back-of-seat Internet access terminals. A first class taxibus vehicle might even be designed to comprise several small compartments which are separated or semi-separated from each other, thus providing greater privacy for passengers carried. In general, the greater the

diversity of taxibus vehicles operating, the better this invention is able to satisfy specific transport requirements.

Taxibus vehicles could advantageously be powered by hydrogen fuel cell engines. In certain configurations these engines are completely pollution-free: their exhaust product is actually pure water vapour. No pollutants or greenhouse gases are emitted. Hydrogen fuel cells create electricity which then drives an electric motor: vehicles with these engines thus run very silently. Large investments in developing hydrogen powered vehicles have been made, and they are fast becoming a viable technology. The main problem is the lack of fuelling stations. However, proponents for hydrogen fuel argue that at this initial stage, the rollout of fuel cell technology is ideally suited to public transport vehicles. Such vehicles are usually refuelled at their depots: this small number of depots can be equipped with hydrogen fuelling stations at minimal expenditure - thus providing an extremely cost effective way of cutting air pollution and greenhouse gas emissions.

7.10 - The Taxibus Combats Parking Congestion

We have seen that the inherent efficiency of the taxibus arises from adaptable routing and intelligent grouping, with each taxibus typically conveying several disparate passengers at once on a door-to-door basis. By contrast, the private car, which occupies pretty much the same road space, typically carries only the driver. Worse still, each solo driver has a whole exhaust emitting engine to himself, which pumps out pollutants and greenhouse gases. The private car is thus indicted on transportation inefficiency, and excessive emission of undesirable exhaust products.

However the private car harbours a third and equally disturbing inefficiency: the average automobile is only utilised 10% of the time, with the typical car driven for less than 1.5 hours each day.

The rest of the time, which is 90%, a private vehicle lies idle, parked, and taking up space. Considering this inefficiency it is not surprising that the kerbs on most main roads and residential streets are crammed with parked cars. If the usage efficiency of cars were 100% then clearly no parked or stationary vehicles would be seen anywhere, apart from when dropping off or picking up travellers or delivering goods. This is self-evident, but it is worth repeating this point because it is normally overlooked: the reason our streets are so overburdened with parked cars is not just a factor of the level of vehicle ownership, but also a factor of vehicle usage efficiency, which as stated is a meagre 10%. A simple equation describes parking congestion:

$$\begin{aligned} \text{Number of Parked Vehicles} = \\ \text{Number of Vehicles Owned} \times (100 - \text{Usage Efficiency}) \div 100 \end{aligned}$$

We have become so accustomed to seeing parked vehicles clogging up towns and cities that we assume this is an unavoidable consequence of enjoying the convenience of motor transport. But it is not: the above equation implies that if

vehicle usage efficiency is increased, the number of parked vehicles will decline proportionately, and that increasing the usage efficiency to 100% will actually result in having no parked vehicles in the streets whatsoever. A taxibus vehicle's usage efficiency generally tends towards a perfect 100%, because the controlling computer system tries to ensure that all of the taxibus's time is dedicated to active transportation. Once the taxibus delivers a passenger, it does not remain idle, but continues conveying other passengers. The private car, on the other hand, tends to be quite useless once the driver has departed.

In urban areas, the fact that the private car must be parked when it arrives at its destination can be considered a *design flaw* in this mode of transportation. Consider the amount of time that is lost looking for parking places, the parking fees that must be paid, and the inevitable parking fines, vehicle clamping and tow-away costs, the cost of building massive multi-level car parks, the running of controlled street parking, of buying parking area land for shopping centres and sports centres, and so forth. Still further expense results from salary costs for traffic wardens and other staff to regulate these parking zones.

Even when drivers are on the move, parking *still* affects their journey: in many cities, most smaller roads are now effectively reduced to one lane due to parked cars on both kerbs, and during any trip, drivers are frequently forced to pull over into a gap between these parked cars in order to let oncoming traffic squeeze past. Parked vehicles are cholesterol on the road arteries of our cities.

In a future where the electronic navigation taxibus has taken over from the car as the primary form of travel, and the number of privately owned vehicles has fallen, parking congestion will be of historical interest only, and free parking spaces will be abundant. Perhaps the streets will never quite revert to an era when they were largely clear of parked vehicle clutter, but with a comprehensive taxibus service in place, this epidemic of idle kerbside automobiles can be abated.

In such a future of streamlined taxibus transportation, the roadside parking meter would become redundant; parking meters could be advantageously converted into mini roadside kiosk communicator devices on which passengers can request taxibus rides, and by which they can wait for their taxibus to arrive.

7.11 - Greater London Case Study of the Electronic Navigation Taxibus

Let us examine how an electronic navigation taxibus fleet compares to existing forms of transport. We shall take Greater London as our case study. For each 24 hour period in central and outer London, around 25 million passenger journeys take place. These divide modally as follows.

9 million	Private Car (as Drivers)
6 million	Private Car (as Passengers in above)
4 million	Bus
2 million	London Underground
2 million	Walking
1 million	Train (Surface Rail)

Source: Department for Transport. Figures have been rounded.

Other modes of travel in Greater London (motorcycle, taxi cab, mini cab, bicycle) are fairly negligible in comparison. The relative importance of these transport modes is somewhat reversed as far as peak-hour travel to and from central London is concerned: morning peak hour (7 am to 10 am) passenger journeys into central London divide modally as follows.

0.5 million	Train (Surface Rail)
0.4 million	London Underground
0.1 million	Private Car (Either as Driver or Passenger)
0.05 million	Bus

Source: Department for Transport. Figures have been rounded.

How would a London-based electronic navigation taxibus fleet compare? Consider a taxibus fleet of just 10 thousand vehicles. Assume an average vehicle occupancy of 6 passengers and a typical passenger journey time of 20 minutes (average journey length in Greater London is 7 miles and the average suburban speed of 20 mph; this corresponds to a journey time of about 20 minutes when the Compatibility Index is low). A quick calculation shows that this taxibus fleet would complete 180 thousand passenger journeys every hour. In a 24 hour period, the fleet could in principle handle 4.3 million door-to-door passenger journeys, which is a formidable number.

We can compare this to London's 6 thousand buses, which carry 4 million passengers each day, mainly in double-decker vehicles having a capacity of around 80 passengers. Another point of reference is London's 20 thousand licensed taxi cabs which, throughout every 24 hour period, manage to transport 0.5 million passengers.

How will these 10 thousand taxibuses cope, theoretically at least, with the 7 am to 10 am rush hour commute to central London? Assuming, during these rush times, an average taxibus occupancy of 8 passengers and an average commuter journey length of say 40 minutes, then a simple calculation shows that the taxibus fleet will manage to transport over 0.36 million commuters during these three hours. This is a very impressive figure, almost equalling the performance of the entire London

Underground system during the same time period.

The incredible power of this invention becomes even more apparent if passenger journeys from car pooling are also taken into consideration. There are 9 million private car journeys made each day: if these drivers were to offer a car pool ride just once in every five journeys they make, this would add up to nearly 2 million car pool passenger journeys daily. Again for comparison, this is a figure equal to the daily total of passenger journeys on the London Underground.

What about the operating profit and the running costs of the taxibus fleet? The major running costs will arise from driver wages: this fleet of 10 thousand taxibuses will require around 30 thousand drivers working in 8 hour shifts to keep these vehicles on the road 24 hours a day, 7 days a week (based on only a reduced taxibus service running at night). Assume each driver costs a total of £25,000 per year for salary and other costs, then the wage bill will amount to £750 million annually. Fuel costs for this fleet can be calculated at £300 million a year (based on the fleet using diesel fuel, and each taxibus giving around 20 miles per gallon).

Further costs will be incurred from vehicle servicing and maintenance, and the expenditure of running the controlling computer system. Telecommunications costs should be minimal, since only low volumes of data are transmitted. Driver training costs will be low: a standard driver's licence will suffice since most of the taxibus vehicles will be not much larger than a regular multi-purpose vehicle or people carrier type of motorcar. Taxibus drivers will not need to have knowledge of the street layouts, as electronic street navigation is provided at all times.

What about the sales revenue generated? Setting the taxibus passenger fare at a modest 15 pence per mile, and assuming an average vehicle occupancy of 6 passengers, with an average vehicle speed of 20 miles per hour, then the daily (24 hour) revenue collected by the fleet will be £4.3 million. This adds up to nearly £1.6 billion a year, which should easily cover the running costs of the taxibus fleet.

Regarding the capital cost of introducing such a taxibus fleet: most of the investment will arise from buying taxibus vehicles; the computer technology that runs this invention is relatively cheap. Assume each taxibus vehicle costs £30,000, which is the typical current price of a multi-purpose vehicle or minibus: it will then require a capital investment of £300 million to purchase a fleet of 10 thousand taxibus vehicles. Not only is this a modest figure by transport budget standards, but this amount might even be accommodated within the annual profits generated by such a fleet.

It is interesting to examine the figures for a larger taxibus fleet. Suppose the fleet is increased to 30 thousand taxibuses. This requires a capital investment of £900 million to buy the vehicles, a team of 90 thousand drivers to keep them moving, £2.25 billion a year in driver salaries, and £900 million a year on fuel; such fleet will generate an annual revenue of £4.7 billion, and provide almost 13 million door-to-door passenger journeys each day - a figure that is close to the daily total of passenger journeys made by private car in London. Thus a fleet of 30 thousand taxibuses can do more or less the same job as London's 2.3 million privately-owned

cars. We could therefore dispense with many of these cars. This possibility is not just a utopian vision: it is a glimpse at what cities of the future will be like. The taxibus has the potential to transform urban life and the city landscape. Car manufacturers need not worry unduly about the prospect of a decline in private car sales: due to the high workload of taxibuses, which will be in operation 24 hours a day, it is expected that taxibus vehicles will wear out quickly, and will require frequent replacement.

Does it make economic sense for a Londoner to sell his car and travel primarily by taxibus? Ownership of the average car can be costed at around £10 a day inclusive of fuel, road tax, insurance, servicing, maintenance, and vehicle depreciation, but exclusive of parking. The average vehicle covers a distance of less than 30 miles each day with an average occupancy of 1.4 travellers: this equates to a cost of 24 pence per person per mile, excluding any parking fees. Comparing this to the 15 pence per mile taxibus cost, this analysis suggests that it does make good economic sense to sell the car and adopt the taxibus, although the precise economics will greatly depend on individual circumstances. Families with children may not be so keen to sell the car, since the car becomes more economically viable when there are more travellers. A special discount on taxibus fares might be offered to family groups in order to make the taxibus more financially appealing to families.

The ultimate objective of the taxibus is not to eliminate the private car, but to seduce people away from the car by providing a taxibus transportation network that the public will come to view as a much more convenient and convivial way to travel. The taxibus aims to compete with - and beat - the private car in terms of transport excellence; winning over clientele through its manifest superiority.

Note: the above transportation and financial performance analysis of the taxibus is based on an assumed average vehicle occupancy of just 6 passengers; if higher average vehicle occupancies are achieved, say 10 passengers per vehicle for example, then all the above performance figures will be proportionally improved.

7.12 - Taxibus Response Times

The success of the electronic navigation taxibus as an everyday means of transport will crucially depend on the time a prospective passenger has to wait for a taxibus to arrive. To compete with the 'jump in and go' immediacy of the private car, it is felt that a taxibus must appear *within three minutes* of a passenger making a journey request. Is such a rapid response feasible? Some simple analysis can answer this question. Again we shall take Greater London as our case study.

The total area of Greater London is around 610 square miles. Assuming we have a fleet of 10 thousand taxibuses more or less evenly spread across this area, this gives an average vehicle density of 16 taxibuses per square mile. Department for Transport statistics indicate that the average road speeds in the suburbs are around 20 mph, and 11 mph in the central London area. Thus in the suburbs, in order for the typical taxibus response time to be three minutes or less, the responding vehicle

must be situated no further than one mile away (since at the average suburban road speed of 20 mph, it takes three minutes to travel one mile). How many taxibuses are there within a one mile radius of any waiting passenger? The answer is simply the area of a one mile radius circle (which is 3.142 square miles) multiplied by the taxibus vehicle density per square mile. This gives $16 \times 3.142 = 50$ taxibuses. This is a fair number of vehicles, and since these 50 taxibuses will have a wide variety of itineraries, there is a high chance that one or more will be travelling in a direction compatible to the passenger's desired destination (this probability also depends on the closeness of the passenger's destination; the closer the destination, the higher the chance; note that the average journey length in London is just 7 miles).

In central London, the average speed is 11 miles per hour, so the three minute response time will encompass a smaller circle: one of just over half a mile in radius. This circle is smaller than the suburban one: its area is only 1 square mile - thus containing fewer taxibuses. However the controlling computer system could be configured to maintain central London taxibus densities at a higher level, and this greater abundance of vehicles will ensure that a three minute response time is attained, even if the road speeds are lower. Of course, if traffic congestion falls due to the ubiquitous success of the taxibus, then average road speeds will improve, and so speed up response times all round.

This simplified analysis is no substitute for a more in depth mathematical modelling of taxibus response times, but it does strongly suggest that a three-minute response is eminently feasible.

If we relax the constraints and allow the passenger's journey to be split into two legs on different taxibus vehicles (see section 9.2 for split journeys), then there is almost certainly going to be a suitable taxibus within three minute's proximity to run the first leg of the journey. If the taxibus fleet is increased from 10 thousand to 30 thousand vehicles, then the taxibus density increases proportionately, yielding a remarkable 150 taxibus vehicles within a three-minute radius of a passenger, thus making the desired response time still more feasible.

In certain travel circumstances, such a rapid response time might not be so critical. When a regular taxi cab or mini cab is ordered over the phone, for example, the taxi normally arrives around 10 or 15 minutes later; in many situations this time scale is perfectly adequate. In taxibus travel, there are advantages for passengers who are more flexible regarding the arrival time of their taxibus: such time flexibility gives the controlling computer system more opportunity to find a taxibus with a near-perfect itinerary match to the passenger. This means that although the passenger may have to wait a little longer for her taxibus to arrive, the journey on the taxibus itself will be quick and efficient, due to good itinerary matching.

When ordering a taxibus or car pool vehicle, passengers should be given the choice of prioritising the transit vehicle **speed of response** or the **speed of journey**. Perhaps most passengers will prioritise the speed of response, preferring to get aboard a vehicle as quickly as possible (which is desirable if the prospective passenger is waiting in the street). However passengers who prioritise the speed of journey will find that, once aboard their transit vehicle, they will be more speedily

delivered to their destination (perhaps this is a better option for prospective passengers waiting indoors). When speed of response is prioritised, the controlling computer system would aim to get a transit vehicle to pick up the traveller within 3 minutes of the departure time specified in the journey request; that is to say, the **latest acceptable pick-up time** for the traveller will be 3 minutes after this departure time, the total traveller pick up time window thus being 3 minutes. When speed of journey is prioritised, the traveller pick up time window is extended to 15 minutes, starting from the specified departure time.

7.13 - Car Pooling versus the Taxibus

Car pooling is an informal means of transportation provided by this invention. Car pooling enlists the help of private vehicle drivers to provide travellers with a door-to-door service similar to that supplied by the taxibus. It is hoped that the number of passenger journeys arising from car pooling will be a useful addition to the number of passenger journeys provided by the taxibus fleet, so that car pooling will further contribute to defeating traffic congestion.

It is thought that many car drivers will convey passengers now and then, according to their mood and schedule. Some drivers may want to give car pool rides because it helps top up their system-administered monetary account: by filling their monetary account in this way, such drivers effectively get their travel for free when they themselves are passengers in a taxibus or car pool vehicle. In other words 'what you give is what you get' and this is a great motivation for offering car pool rides.

7.14 - Testing the Taxibus Concept

The taxibus is an entirely new form of transport, and must initially be tested on a small scale, firstly to examine its overall functionality, and secondly to optimise certain design and operational parameters.

Implementing the car pooling mode of this invention is a simple and inexpensive way of testing the invention's general functioning: no vehicles need to be purchased, so the car pooling mode can be implemented at a very low cost. Once car pooling is up and running, it will yield valuable data on how this invention operates in reality. However, there are many differences between car pooling and the taxibus, and the taxibus transportation system needs to be tested separately.

Perhaps the cheapest way of testing the taxibus is by means of computer simulation of a city's travel networks. The software for such a simulation could be written without much difficulty, and would be extremely useful for observing the effects of adjusting various parameters, such as the number of taxibuses in the fleet, the passenger capacity of each taxibus, and the operational characteristics of the intelligent grouping module. By means of this simulation, optimum parameter values can be determined before setting up a real taxibus service.

Subsequent to computer simulation tests of the taxibus, the next step would be to implement a taxibus service on a small scale. This might best be accomplished in a city of less than half a million inhabitants, wherein a relatively modest fleet of taxibus vehicles can cover the whole town. It is very important to implement a **saturation level** of taxibus vehicles in any test. Saturation level is defined as the minimum taxibus vehicle density that can consistently provide a three minute response time to journey requests. If the taxibus density is below the saturation level, then the average response time to passenger journey requests becomes longer. Slow response times will put people off using the taxibus: nobody is going to find the taxibus quick and efficient if it takes 20 minutes for the vehicle to arrive. Thus this invention must be tested at saturation capacity in order to investigate how the general public take to the taxibus.

A small scale test is even possible in large cities. This is achieved by providing a saturation level, 24 hour taxibus fleet to a particular suburb in the city. Just a few hundred taxibus vehicles will be needed for saturation coverage. Travel on these taxibuses would be restricted to journeys within the selected suburban area, and journeys from the suburban area to the city centre and back. These limited transport options will not be able to accommodate all the travel demands of these people, but should encompass a good percentage of their normal journeys - enough to make the test meaningful.

Small scale testing in a large city may also be achieved by confining the taxibuses to the central area. The central London region, for example, bounded by the Inner Ring Road covers just eight square miles. A fleet of 200 vehicles constrained to this zone would yield a density of 25 taxibuses per square mile, which should be sufficient.

Note that the vehicles used for testing need not be specially designed or purchased. Large cars and minibuses can be employed. For testing purposes, the only essential modifications required are the fitting of a communicator device on the dashboard, and the displaying of a vehicle identification number (or name) on the outside of the taxibus. However, if the budget is available, a fleet of new, purpose-built vehicles will obviously make a better impression on the public.

7.15 - Including Regular Taxi Cabs into this Invention

Regular taxi cabs are readily included in this invention, and there are two ways a taxi driver can benefit. In the first, the taxi driver uses this invention just to acquire customers, in a manner similar to the existing 'radio taxi' passenger procurement system. In this mode of operation, when a passenger makes a journey request, his communicator device, in addition to detailing the currently available taxibus and car pool travel options in the passenger's vicinity, will also detail the taxi cab options available. Should the passenger select a taxi cab option, the controlling computer system will respond accordingly: the journey request will be detailed on the selected taxi driver's communicator device, and if the taxi driver accepts the journey request, the controlling computer system will guide him to the passenger, just as it does with

car pool drivers (this was described in section 7.4). This taxi mode of operation is not strictly speaking an application of this invention since it does not follow the principle of intelligent grouping; nevertheless this taxi mode can easily be provided by the controlling computer system, and will be helpful for both taxi drivers and their passengers.

The second way a taxi driver can benefit from this invention is to operate his vehicle as a taxibus. In this taxibus mode of operation, the passenger fares charged will be lower - being priced similar to car pool fares; however the taxi driver will be conveying perhaps three or four disparate passengers at once, so their concurrently metered fares will add up to an amount which is comparable to a normal taxi fare. It is entirely up to the taxi driver how he wants to operate: he can function in taxi cab mode or in taxibus mode. The mode of operation can be switched at any time; the taxi driver would select the mode in order to maximise his business and profit.

Even if taxi drivers prefer to remain as regular cabs, operating only in taxi cab mode, it is anticipated that this invention will deliver taxi drivers more custom. Many prospective passengers using this invention will want to take the first and fastest transport option available: this will always be the taxi cab. Why? Because with taxibus or car pool travel there are two requirements to satisfy: the transit vehicle must be in proximity to the passenger *and* the vehicle must have itinerary commitments compatible to the passenger's itinerary. With the taxi cab there is only one constraint to satisfy: proximity. Thus a taxi cab vehicle will generally be the first available, and because it does not pick up other passengers en route, it will generally be the fastest available. For these reasons it is believed that this invention will deliver more business to taxi cabs. Whether the taxi driver's fee is paid automatically into his system-administered monetary account, or paid in cash within the cab, is a question that needs further consideration.

One advantage this invention offers the taxi driver is the ability to accept or decline incoming journey requests on the basis of the passenger's specified itinerary - this itinerary will always be detailed on the taxi driver's communicator device. This is useful when the taxi driver is finishing his working day and is about to return home: in these circumstances he can select a passenger with a destination close to his home, and thus conveniently include one more fare before he ends his shift.

For mini cab drivers too, this invention holds promise. Instead of illegally soliciting business on the streets, mini cab drivers might find it much more rewarding to work as a professional taxibus driver. Though many mini cab drivers often have a less than complete knowledge of the road layouts, this does not present a problem since taxibus drivers just need to follow the electronic street navigation directions detailed on the vehicle communicator device.

7.16 - Including Existing Modes of Public Transport

Most of the difficulties and time wasted using existing modes of public transport arise from the trips to and from the transport departure and arrival points (train stations, bus stops, and so forth). It is anticipated that just by introducing a taxibus service - which can cheaply and efficiently provide these trips - the general public will start to make better use of existing public transport, especially the railways, which offer fast long distance travel.

However, it is thought that in the long term, existing public transport modes such as bus, train, tram, coach and metro may also be included in the controlling computer system of this invention. These existing modes of transport are not strictly speaking an application of this invention, since they are fixed route rather than adaptively-routed transport vehicles. Nevertheless these existing public transport modes can be advantageously incorporated into the controlling computer system of this invention, and in this section we outline how this can be done.

In order to operate with existing public transport, the controlling computer system of this invention must have real-time knowledge of the current location, routing, and destination of all participating public transport vehicles (this may require the installation of communicator devices in each transport vehicle, and/or linking up to any computer systems that help control these transport vehicles). With this information available, when a traveller submits a journey request, the controlling computer system of this invention will be able to provide the traveller with details of the various transport options that enable the traveller to get to his desired destination; the controlling computer system will detail these various transport possibilities on the traveller's communicator device.

Fixed-route transport vehicles such as bus, train, tram, coach and metro cannot divert in order to pick up or drop off passengers; so if a passenger opts to travel by these modes of transport, he will be provided with a walking route to the appropriate bus stop or train station. Passengers using a roadside kiosk communicator device will be shown a map of this walking route on the kiosk screen, and passengers that have a portable electronic positioning communicator device (such as a cellular phone) equipped with electronic positioning will be given electronic street navigation directions in real time as they walk to the station or bus stop. On arrival at the station or bus stop, the controlling computer system will inform the passenger what ticket to buy, and which transport vehicle to take. The controlling computer system will also inform the passenger at what point he or she must alight from the vehicle. Passengers carrying their own electronic positioning communicator device will even be prompted to alight from their transport vehicle just before their destination station or bus stop comes up (provided, of course, their communicator device is within range of a signal). After alighting, further walking directions from this disembarkation point to the destination address are available on the passenger's communicator device, if needed.

Note that the taxibus and car pooling configurations of this invention operate by means of a self-contained computer system which runs entirely independently, without any interface to the software systems of existing transport systems.

However if existing transport modes are included, this adds considerable complexity, since the controlling computer system of this invention will need to interface with the computer systems of these various forms of existing public transport. For this reason, it is thought that the integration of existing transport modes into the controlling computer system should be deferred, and not form part of the immediate implementation of this invention. In the long term, however, such an integration of transport modes will be enormously convenient to travellers, as the next section describes.

7.17 - An Integrated Multi-Modal Transport System

Should existing public transport modes such as bus, train, tram, coach and metro be incorporated as described above in section 7.16, then the controlling computer system of this invention will become an incredibly flexible transportation nerve centre, yet one which anyone can access using a communicator device such as a cellular telephone.

Once existing public travel modes are integrated into this controlling computer system, prospective passengers will have a comprehensive range of travel possibilities instantly at their disposal. For example, consider a passenger in London wishing to travel from Kensington to Islington. Having submitted his journey request to the controlling computer, the passenger might have the following travel options exhibited on his communicator device:

FROM: 263 Kensington High Street W8 6NA **TO:** 116 Upper Street N1 1AE

<u>Transport</u>	<u>Wait</u>	<u>Journey</u>	<u>Cost £</u>	<u>Arrival</u>
Taxibus	2 mins	32 mins	1.05	11:34 am
Car Pool	4 mins	25 mins	4.50	11:29 am
Bus	0+1 min walk	56 mins, 2 legs	2.00	11:57 am
Underground	6+7 min walk	30 mins, 2 legs	1.60	11:43 am
Taxi Cab	1 min	24 mins	14.00	11:25 am

Time Now: 11:00 am **Passengers:** 1 **Distance:** 7 miles

These detailed travel options are based on the passenger's current location, his desired destination, and the current availability of transport vehicles in his vicinity. These options detail the estimated wait before the transport reaches the passenger, the estimated journey time, the cost of the journey, and the estimated time of arrival at the destination. For taxibus, car pool and taxi cab modes of transport, the 'Wait' estimates the time it will take for the vehicle to get to the passenger (in this example the taxibus is estimated at two minutes away). For bus and Underground modes, the 'Wait' estimates the time it will take for the passenger to walk to the transport (in this example the Underground station is 6 minutes' walk away, and at the other end of the journey, there is a 7 minute walk from the Underground station to the final destination).

All travel options shown on the communicator device are available to the passenger. Should he select one, the controlling computer system will proceed with that choice, either organising a transport vehicle to collect him, or guiding the passenger to walk to the transport embarkation point. In car pooling, note that vehicle availability is unconfirmed until the driver accepts the fare: when a passenger selects car pooling, the passenger's journey request is sent to the car driver, who may or may not accept it; if he does not accept, the controlling computer system will try to find another car pool vehicle for the passenger. The same unconfirmed status applies to taxi cabs too, since the controlling computer system gives taxi drivers the choice of accepting or declining passenger journey requests. In reality, taxi drivers will generally accept passenger journey requests because these drivers earn their living from providing carriage.

As the figures indicate, carriage by car pool is more expensive than travel by taxibus. This is because adequate remuneration is needed to provide an incentive for car pool drivers to carry passengers, and also because car pooling is generally quicker than the taxibus: car pool vehicles carry fewer passengers (usually just one or two) so there are fewer pick-ups and drop-offs en route.

Like the taxibus, the cost of a car pool trip is calculated according to the distance travelled. However a second costing factor is also added to the car pool pricing equation, this factor based on the additional time the driver spends in picking up and dropping off his passenger. The additional time is called the "diversion time". If the diversion time is large, the passenger fare will increase correspondingly in order to fairly remunerate the driver for his trouble. Because of this diversion time factor, shorter car pool journeys often have a higher cost per mile compared to the taxibus. However long car pool journeys can be relatively inexpensive, approaching taxibus fares, because, for these lengthier trips, the diversion time factor will generally be less significant than the distance-travelled factor.

With the controlling computer system having real-time knowledge of the current location, routing, and destination of all participating public transport vehicles, it is possible to program the controlling computer system to respond to a traveller's journey request in a dynamic and flexible way, employing the most suitable travel options available at the time, and splitting a traveller's journey across different transport modes if this can expedite the trip (see section 9.2 for split journeys). For example: a traveller may submit a journey request specifying that she wishes to travel as rapidly as possible from a suburban address in London to an office in central London during the morning rush hours. The controlling computer system calculates that the quickest way of getting to central London at that time is by Underground, and thus arranges for a taxibus to collect the traveller from her address and drop her off at the appropriate Underground station, where she will catch a train into London.

7.18 - Greenhouse Gas Emissions - Can the Taxibus Save the Planet?

Although global warming studies are controversial, most predict that man-made emissions of greenhouse gases such as carbon dioxide will cause an increase in average global temperatures, and this in turn will precipitate more extreme weather phenomena such as flash flooding and hurricanes.

Transportation is a major source of greenhouse gases, accounting for as much as 33% of a nation's carbon dioxide emissions. What impact can this invention have in cutting this greenhouse gas output?

The taxibus has great potential for reducing greenhouse gas emissions. To elucidate this potential, let us again take Greater London as our example. Assuming that the average taxibus holds 8 passengers during the rush hours, and given that the typical occupancy of a car is 1.4 travellers, this equates to each taxibus vehicle having the capability of removing about 6 cars from the road (since $8 \div 1.4$ is roughly 6).

This analysis thus suggests that in major cities, for every 10 thousand taxibus vehicles introduced, up to 60 thousand cars can be removed from the roads - if car drivers can be persuaded to travel by taxibus. In terms of greenhouse gases, this equates to 60 thousand carbon dioxide emitting engines being reduced to just 10 thousand (or reduced to zero if the taxibuses are powered by hydrogen fuel). There are around a quarter of a million vehicles on the roads at any one time in Greater London, the majority of these are private cars; therefore, introducing a modest fleet of just 20 thousand taxibus vehicles could in theory remove 100 thousand private cars from London's roads - this roughly translates to a twofold reduction in road traffic. By doubling the size of this taxibus fleet, an incredible fourfold reduction in traffic can be achieved. Would this traffic reduction manifest in reality, though?

Turning theory into reality means enticing car drivers to leave their cars at home and travel by taxibus. Considerable efforts should be made to make taxibus travel as attractive as possible in order to seduce people away from their cars. However, should global warming, air pollution and traffic congestion start to become really critical problems, then more coercive means of getting car drivers to switch to the taxibus may be necessary. Such means may include running persuasive advertising campaigns, increasing road and fuel tax, providing corporate tax incentives for companies that champion taxibus usage, and so forth. It is believed that once the public have got into the habit of travelling by taxibus, the car will be considered as a little bit clumsy. Eventually no-one will want to return to their old driving habits, especially when they see how traffic-free the roads have become.

Note: introducing a taxibus fleet might initially *increase* the number of vehicles on the roads, because to start with, the taxibus may attract bus passengers rather than car drivers (the taxibus being viewed as a superior type of bus) and since taxibuses generally have smaller passenger capacities than buses, there may be a net increase in vehicles on the roads. However, even if the taxibus fleet were to entirely replace the bus service, this net increase in vehicles would be small: each day in Greater London there are 4 million passenger journeys provided by a fleet of 6 thousand buses; in order to accommodate these bus passengers a fleet of around 10 thousand

taxibus vehicles would be necessary (see section 7.11), equating to a net increase of 4 thousand vehicles. This is an insignificant number compared to the quarter million or so vehicles on the roads in Greater London at any one time; and once this surplus of 'converts' from buses and other public transport are accommodated, the taxibus fleet can begin its job of cutting the number of cars on the roads.

Altogether, it is believed that the taxibus, plus the car pooling configuration of this invention, will have tremendous impact in cutting carbon dioxide emissions, especially if this invention is implemented in thousands of cities around the world.

Indeed, world-wide implementation is the ultimate goal for this invention, and this prospect is much more feasible than one might initially think. Though this invention comprises a sophisticated transport system run by computer and communications technology, the beauty of this system is that all its intelligence and complexity is contained within the controlling computer software rather than in transportation hardware. Compared to the complex and costly physical infrastructures of railway and underground railway transport networks, for example, the physical infrastructure and hardware of this invention is very basic: it comprises just vehicles and roads.

Since the nucleus of this invention is data-processing, once the software is written, it becomes easy to implement around the world. Most countries already have the required cellular networks, and all countries are covered by satellite electronic positioning. With these infrastructures already in place, the computer software that runs this invention can be installed virtually anywhere. In developing countries, even old and existing transport vehicles can be used as taxibuses, just by fixing an inexpensive communicator device on the dashboard in front of the driver. This invention is therefore very 'third world friendly' and will operate with equal efficacy in London or Mexico City. Indeed the developing world's heavily polluted and traffic congested cities stand to benefit the most from this invention.

Once the initial writing of the software that runs this invention is complete, this invention can become the global solution to traffic congestion, parking congestion, noise pollution, toxic air pollution and climate instability; this invention will provide reliable rapid transport, improved business efficiency, better health, and a greatly enriched quality of life around the world.

8 - SECOND EMBODIMENT OF THE INVENTION

A second embodiment of the invention will now be described with reference to figures 5 and 7 in the accompanying drawings. In this embodiment, the controlling computer system 15 is decentralised and all data-processing is performed by computer processors located within, or directly connected to, transit vehicle communicator devices 20. In this embodiment, passenger communicator devices 17 and 18 also have some basic computer-processing capability.

In this embodiment, the data transmission system 16 comprises a radio transmission system, or alternatively, a cellular telephone network, and is used to provide a two-way data exchange between the communicator devices 17 and 18 of the travellers 19 and the communicator devices 20 of the transit vehicles 21 in which the computer processors of the controlling computer system reside.

The electronic positioning system 22 in this embodiment is a satellite positioning system such as the American GPS (Global Positioning System), the broadcast positioning signal of which is received by GPS receivers contained in the vehicle communicator devices (and optionally in passenger communicator devices). These GPS receivers pass on this positioning data to the computer processor in the communicator device. Note: this embodiment may alternatively operate with one or more of the electronic positioning systems described in section 9.22.

In this embodiment, the electronic street navigation module will function in a similar manner to the existing in-car satellite navigation systems now commonplace in cars: that is to say, it will use electronic positioning data to determine the current location of the transit vehicle, and by means of a digitised street layout map, will provide the vehicle driver with real-time navigation instructions based on this current location, in order to guide the driver along a given itinerary.

8.1 - Computer Data-Processing Operations

Figure 7 shows transit vehicles 21 whose communicator devices 20 contain computer processors labelled 15a, 15b and 15c. These computer processors run independently of each other, but perform the same data-processing tasks.

The data-processing performed by each computer processor is very similar to that already described in section 7.1 of the preferred embodiment of this invention, except for the following differences:

In each transit vehicle computer processor, the transit vehicle current itineraries database contains only the transit vehicle record relating to that particular transit vehicle.

In each transit vehicle computer processor, the journey request database only contains the journey request records of the travellers currently conveyed in that particular transit vehicle, and the journey request records of the travellers which

that transit vehicle is committed to picking up (in other words, journey request records relating to the itinerary commitments of that transit vehicle). Furthermore, this journey request database will only contain journey request records of class A, B and C, that is to say, journey requests for immediate travel (pre-order and regular order journey requests are instead stored within the traveller's communicator device, and simply executed and transmitted by that communicator device at the date and time that the journey is required).

8.2 - Broadcasting to Transit Vehicles in the Traveller's Local Area

In this embodiment, the operation of the user interface on passenger communicator devices and car pool driver communicator devices is just as the sequence of events described in section 7.3 of the preferred embodiment.

When a prospective traveller 19 submits the journey request formulated on communicator device 17, the journey request data is directly broadcast by this communicator device over the data transmission system 16, and is received by the communicator devices 20 in transit vehicles 21 in the local area surrounding the traveller (the journey request is received by transit vehicles that are within range of the signal broadcast from the traveller's communicator device). The received journey request data is passed on to the computer processors (labelled 15a, 15b, and 15c in figure 7) in the communicator devices 20 of the said transit vehicles.

Each transit vehicle computer processor will calculate whether the vehicle has itinerary commitments compatible to the itinerary specified in the traveller's journey request. This calculation is performed by an intelligent grouping module run on the transit vehicle's computer processor; the result of this calculation is a Compatibility Index value (plus, of course, the corresponding optimal transit route) measuring the compatibility of the traveller itinerary to the transit vehicle's current itinerary commitments. If this Compatibility Index is too large, it indicates insufficient compatibility, and in this case the traveller's journey request is simply ignored. When this Compatibility Index is small (say below 1.6) it indicates that there is good compatibility between the traveller itinerary and the transit vehicle's itinerary commitments. In this case, the transit vehicle's communicator device will respond by transmitting back to the traveller's communicator device (via the data transmission system) data regarding the estimated time it would take for the transit vehicle to arrive at the traveller's pick-up point, the estimated journey time aboard the transit vehicle to the traveller's destination, and the calculated passenger fare cost of this journey.

All transit vehicles that receive the traveller's broadcast journey request will respond in this way when their computer processors calculate that there is good compatibility between the traveller's desired itinerary and the vehicle's itinerary commitments. The vehicle drivers themselves are not involved or aware of this process; the computer processor in each transit vehicle does this calculation automatically. The traveller's communicator device collates the responses from the transit vehicles that received the broadcast journey request, and then details these

responses to the traveller. Based on these details, the traveller selects the most suitable transit vehicle in order to proceed with his journey.

Usually, the prospective traveller will select the transit vehicle that can most quickly arrive to collect him from his pick-up point, or the transit vehicle that can most rapidly deliver him to his destination.

Note: an alternative approach is to arrange for the computer processor in the traveller's communicator device to automatically pre-select the quickest transit vehicles, and only detail these transit vehicle options to the traveller.

Once the traveller selects a particular transit vehicle from the vehicle options detailed on his communicator device, the traveller's communicator device transmits his choice (over the data transmission system) to the appropriate transit vehicle.

If the vehicle selected was a taxibus, the computer processor of this taxibus will update the current itinerary of the transit vehicle (in the transit vehicle current itineraries database) to the already-calculated new optimal transit route which incorporates the traveller's itinerary. The electronic street navigation module in the computer processor of this taxibus will then provide the appropriate electronic street navigation instructions to the taxibus driver to direct him along this optimal transit route, thereby routing the taxibus to pick up and convey the traveller.

If the transit vehicle selected was a car pool vehicle, the computer processor of this vehicle will first detail the desired journey request to the car driver on the vehicle's communicator device. Remember in car pooling, the vehicle driver must be given the option to accept or decline any journey request. Should the driver accept this journey request (by pressing an appropriate key or button on his communicator device), this acceptance response will be transmitted (over the data transmission system) back to the traveller's communicator device in order to inform the traveller. The computer processor in the car pool vehicle will then run an intelligent grouping module to devise an optimal transit route which incorporates the traveller's itinerary into the itinerary of the vehicle. The electronic street navigation module in the car pool vehicle's computer processor will then provide the appropriate electronic street navigation instructions to the car driver to direct him along this optimal transit route, thereby routing the car pool vehicle to pick up and convey the traveller.

Note: a slight variation on the above-described embodiment has a computer processor incorporated into the traveller's communicator device to perform the itinerary-compatibility calculation. Another variation on the above-described embodiment has the itinerary compatibility calculations performed partly on the traveller's computer processor, and partly on the vehicle's computer processor. In fact it does not really matter where the computer processing is performed; the principal characteristic of this embodiment of the invention is that there is no central controlling computer system; all computational tasks are performed locally rather than centrally. One advantage of this decentralised configuration is robustness: in the first embodiment of the invention, should the central controlling computer system and its backup systems fail for any reason, then the whole transportation system of this invention would fall into disarray. In this decentralised

embodiment, any computer failure remains isolated and concerns only the traveller or transit vehicle whose computer equipment has broken down.

Note: in section 7.16 above we explained how the controlling computer system of the preferred embodiment of this invention could include existing public transport modes (although such fixed-route transport is not, strictly speaking, an application of this invention). This present embodiment of the invention can also work with existing public transport vehicles such as buses, trains or trams, if they are fitted with communicator devices and computer processors. When a prospective passenger broadcasts his journey request (over the data transmission system), fixed-route transport vehicles in the vicinity of the passenger will receive his broadcast journey request, and their computer processors will calculate whether the passenger's journey request is compatible with the itinerary of the transport vehicle. If it is not compatible, the journey request is ignored. When there is compatibility, the transport vehicle communicator device will transmit data (over the data transmission system) back to the passenger communicator device describing the travel possibilities of that transport vehicle (data that includes details of how to get to an appropriate embarkation point such as a bus stop in order to board the vehicle). This transport option is then detailed on the passenger's communicator device, and should the passenger select this option, his communicator device will provide directions to guide him to the embarkation point.

It would also be possible to incorporate fixed-location communicator devices in the embarkation points (bus stops and train stations) rather than in transport vehicles: each embarkation-point communicator device would respond to a passenger's broadcast journey request if a suitable transport option is available at that point.

8.3 - Semi-Direct Radio Transmission

We have seen that, in this embodiment of the invention, there is a *direct* transmission of data (over the data transmission system) between vehicle and traveller communicator devices. This contrasts to the first embodiment of the invention, in which there is only an indirect transmission of data between vehicle and passenger communicator devices, since in the first embodiment, all transmitted data is mediated via the central controlling computer system.

In this second embodiment, it is feasible and advantageous to use a *semi-direct* radio transmission between traveller and vehicle communicator devices. This semi-direct transmission would be performed by a cellular telephone network. The usefulness of this approach is that it allows travellers to use their regular cellular telephone as a communicator device, which is very convenient. Transit vehicle communicator devices would also operate by means of a cellular device.

A semi-direct cellular telephone data transmission system would operate as follows: when a prospective traveller makes a journey request using his cellular telephone or wireless PDA, the cellular network cell that received the journey request data from the traveller would re-broadcast his journey request in that network cell's local area

(this cell might also pass on the data to the adjacent network cells for re-broadcast as well). This re-broadcast is performed in order to contact all transit vehicles in the vicinity of the traveller: the communicator devices in such transit vehicles would pick up this cellular re-broadcast. Setting up such a semi-direct data transmission system would require the co-operation of the cellular telephone companies, but technically it would be reasonably easy to do.

Note: this second embodiment of the invention could serve well as a backup or ancillary system to the central controlling computer system described in the first embodiment. This would be particularly valuable for large taxibus fleets, to ensure that they continue to operate in the event of a central computer failure. Each taxibus would be equipped with an on-board computer that functions under the control of the central controlling computer system, but which also has the capacity to work autonomously should the central computer fail. This on-board computer could also help handle routine tasks such as providing electronic street navigation directions and navigation maps to the vehicle driver, thus decreasing the central computer's data-processing burden. Having the on-board computer autonomously manage certain tasks is also useful in situations when contact between the central controlling computer system and the vehicle is momentarily lost (when the vehicle enters a long tunnel for example).

8.4 - Mesh Networks

One communications technology for data communications and cellular telephony that may be introduced in the future is called a 'mesh network'. Mesh networks comprise countless short-range wireless transceivers that link to each other by radio to form a co-operating web of data transceiver nodes. Mesh networks are superior to the third-generation cellular networks that are currently being introduced, and may also alleviate concerns over the effect of cellular telephone microwave radiation on human health, since equipment connected to a mesh network broadcasts its radio signals at a much lower power than conventional cellular equipment. Such low power is feasible because mesh networks are formed from a web of locally-situated transceiver nodes, and each node can broadcast a very low power signal yet still contact its neighbours. Cellular phones, wireless PDAs, computers, and so forth, which are equipped with an appropriate transceiver can automatically join and self-configure to the local mesh network, and in addition, act to further extend the mesh (this is how mesh networks grow automatically). Even equipment on the move, such as cellular phones carried in vehicles, can self-configure on-the-fly into the local mesh network that the cellular phone is passing through. Mesh networks are an ideal data transmission system in both the central controlling computer embodiment of this invention, and in this decentralised controlling computer embodiment. In the decentralised setup in particular, mesh networks will allow good communication between prospective travellers and the vehicles in the local area. Furthermore, as we shall see in section 9.22, mesh networks can be used to help increase the electronic positioning system's accuracy and coverage.

9 - FURTHER ASPECTS OF THE EMBODIMENTS

Chapter 9 forms part of the description of the two embodiments above; the sections in this chapter include miscellaneous aspects that are common to both embodiments.

9.1 - The Intelligent Grouping Module

The intelligent grouping module is really the operational nucleus of this invention. This module will comprise a computer algorithm or heuristic that implements the process of intelligent grouping defined in section 5.7. Within the scope of this definition, there are many ways in which the intelligent grouping module can be mathematically crafted and programmed.

What follows is a general and somewhat intuitively-pitched description of certain desirable features that the intelligent grouping module might incorporate, and how this intelligent grouping module might handle certain important specific situations.

First of all, it must be understood that the intelligent grouping module will be performing an enormous amount of computational work during the normal operation of this invention. Consequently, it is crucially important to ensure that the mathematical programming of the intelligent grouping module is as computationally efficient as possible. In particular, the intelligent grouping module should be able to make rough estimates of itinerary compatibility with minimal computational effort: such an ability will enable the intelligent grouping module to rapidly scan for good itinerary matches, and only when a few good matches have been found would a more accurate itinerary compatibility calculation be applied to these good matches, in order to arrive at a precise Compatibility Index value, and in order to devise optimal transit routes.

The intelligent grouping module always seeks to produce the best intelligent grouping possible, ideally finding a transit vehicle that can incorporate a traveller's itinerary without adding any extra time costs *whatsoever* to the itineraries of the other travellers aboard. This ideal solution will often be possible: as anyone who drives a car knows, between any two locations there are usually several alternative routes that are more or less equally time efficient. Thus when faced with a new traveller journey request, the intelligent grouping module will first check if there are any transit vehicles that can accommodate the traveller simply by switching the vehicle to an alternative route; such a transit vehicle could convey the new traveller without incurring any delay to the journeys of existing on-board travellers. (Note that the process of intelligent grouping described in section 5.7 automatically achieves this.)

This is the ideal case: new travellers are accommodated by an intelligent choice of route, and no time is wasted. However this perfect situation will not always present itself, and in general there will be a time cost for picking up and transporting new passengers. The intelligent grouping module decides whether this extra time cost is acceptable or not, and this decision, though handled automatically, is carefully weighed up. A huge diversion with a large time cost to pick up just one single

passenger must be balanced by the inconvenience caused to the other travellers already on board the transit vehicle (and again the process of intelligent grouping described in section 5.7 automatically seeks this balance). The intelligent grouping module will need to be carefully fine-tuned in order to get this balance right, so as to maximise overall transportation efficiency.

The overall performance of the transit vehicle fleet is a key consideration: balancing the demands of routing efficiency against the need to pack as many travellers as possible into each transit vehicle. It must be understood that these two different demands can be in conflict, but may also be in harmony. The intelligent grouping module aims for harmony: it tries to place travellers with highly compatible itineraries into the same transit vehicle, so that good routing speed and efficiency are attained, even though many travellers are simultaneously transported. Itinerary compatibility typically occurs when the embarkation and disembarkation points for all travellers are reasonably aligned on a direct path, thus satisfying both the need for routing efficiency and the need to convey a sufficient quantity of travellers. Though complete accord between these two requirements will not always be possible, the intelligent grouping module always aims to achieve it.

In terms of the Compatibility Index and the Efficiency Ratios defined in section 5.7, good accord between routing efficiency and passenger packing means having a low value for this Compatibility Index (say less than 1.6), which indicates a good routing efficiency, but at the same time having many travellers (say six or more) on board a transit vehicle, which translates to good passenger packing. (Note that it is easy to obtain a low Compatibility Index for two or three people, but when we have of 6 or more travellers on board, it is not so easy, and will not always be attained).

When good accord between routing efficiency and passenger packing cannot be attained, the focus shifts to striking a balance between these two demands. This compromise will need to be carefully weighed up. It is important not to pack on too many travellers, as this may result in an excessively high value for the Compatibility Index of the transit vehicle, and a value greater than say 1.6 will not make these travellers very happy because their journeys will be quite elongated. If a new passenger would increase a transit vehicle's Compatibility Index to an unacceptably high value, then it may be better to place that passenger on another transit vehicle, if possible. On the other hand, it is important not to leave a passenger stranded: if there is only one transit vehicle currently in the vicinity of a new passenger, even though that transit vehicle would need to run a significant diversion to pick him up, it may be necessary to thus divert the vehicle in order not to leave this passenger waiting an unacceptably long time before the next suitable transit vehicle arrives. These sorts of situations will typically occur in the small hours of the night, or in smaller towns or rural areas, where there may not be so many transit vehicles available. During the day, and in major cities, there will be numerous transit vehicles, and the intelligent grouping module will rarely need to be concerned with keeping a passenger waiting.

As well as the routing efficiency and passenger packing balance, there is another important balance that the intelligent grouping module must always take into consideration: that between routing efficiency and vehicle proximity. The intelligent

grouping module aims to place new passengers in transit vehicles with the highest itinerary compatibility; however it also tries to find a transit vehicle that is in close proximity to the passenger, in order to have the transit vehicle arrive for pick up within three minutes of the passenger making the journey request. These two requirements may be in conflict. There may, for example, be a transit vehicle whose existing itinerary commitments can very easily accommodate the new passenger itinerary, but whose current location is six minutes away from the passenger; there may, however, be another transit vehicle whose itinerary commitments are not such a good match, but this vehicle is located just one minute away from the passenger. The intelligent grouping module must make a balanced choice between keeping the passenger waiting six minutes for the more compatible transit vehicle, or placing him on board a transit vehicle within one minute, and accepting the compromise in routing efficiency (and therefore journey time). This balanced choice will be affected by the passenger's own preferences: as described in section 7.12, each passenger may choose whether the controlling computer system prioritises transit vehicle speed of response (how quickly a vehicle arrives to pick him up) or transit vehicle speed of journey (how quickly the passenger is delivered to his destination once aboard the transit vehicle).

Another automatic yet balanced decision the intelligent grouping module must make is whether to convey a passenger on a single transit vehicle, or split a passenger's journey using two or more different transit vehicles. This is discussed in section 9.2.

There will be many other balances that the intelligent grouping module automatically takes into account. These various balances may have to be fined-tuned on a trial and error basis: adjusting a little, and observing the effect it has on overall transit vehicle fleet performance (this is where a computer simulation of the transit vehicle fleet becomes very useful).

Different routing techniques could be experimented with to see which best expedites the overall transportation process. For example, it is conceivable that the technique of location clustering might speed up certain journeys. Location clustering is the bunching of pick-up points and/or drop-off points within the same small area. This might work well for suburban commuting, where a transit vehicle will pick up passengers from a cluster of homes in a particular suburban region, run all the way into the centre of town on a main road without stopping, and deliver these passengers directly to their various places of work, these places again clustered in the same locale.

Another technique relates to travellers that have identical pick-up or drop-off points: if these travellers also have compatible itineraries, placing them on the same transit vehicle can further increase transit vehicle efficiency, because the vehicle will have less individual pick-up or drop-off points on its route. (The process of intelligent grouping described in section 5.7 will automatically orchestrate this, especially if transit vehicle stop time is taken into account in the travel-time metric).

In section 5.7 we saw that for the best results in calculating optimal transit routes, the intelligent grouping module must take into account not only the distance along a route, but also the speed at which a transit vehicle can traverse the various roads

that comprise the route. Although such a **traffic-speed travel-time metric** is more complicated to calculate, it yields many advantages. The complications come from the need to estimate the speed at which a transit vehicle can travel on each road.

A simple approach to estimating these speeds assumes that the transit vehicle will travel at the speed limit of each road traversed. Another simple approach - which would work quite well in traffic congested cities - assumes that on all roads, the transit vehicle will travel at the average traffic speed for that time of day (for example average traffic speeds in suburban London are around 20 mph for most of the day). A more sophisticated approach assumes the transit vehicle travels at the average traffic speed of each particular road, for the particular time of day, these average traffic speeds being calculated from previously recorded electronic positioning data received from transit vehicles in the fleet.

The most refined approach would use *real-time* electronic positioning data received from the transit vehicles fleet to provide an up-to-the-moment analysis of the current traffic speeds on all roads (see section 9.17 for more details). This last approach is the one recommended, not only because it provides the most accurate estimate of traffic speeds, but more importantly, because it allows the intelligent grouping module to *automatically* take any traffic jams into account when devising optimal transit routes: if the current estimated traffic speed on a particular road is very slow, then the intelligent grouping module would, by the definition of the optimal transit route, tend to avoid routing transit vehicles via that road until the traffic situation improves. This means that the transit vehicles of this invention will tend to pre-emptively avoid traffic jams.

Note that once the intelligent grouping module has grouped travellers in a transit vehicle and has devised a optimal transit route for that vehicle, the task of directing the transit vehicle driver along that route is delegated to the electronic street navigation module, which in the two embodiments of this invention, operates in a similar fashion to in-car satellite navigation systems that are familiar to many drivers. With the electronic street navigation module in control, should the vehicle driver want to change course slightly (in order to avoid a small traffic jam for example), or should the driver simply make a routing mistake, the electronic street navigation module will adapt to, and continue from, his new position and circumstances (such adaptability and flexibility is one of the useful features of in-car satellite navigation systems, as any driver that has used one knows).

However should there be, for whatever reason, a large change in circumstances such that the transit vehicle gets significantly displaced from the original optimal transit route, then, with respect to this transit vehicle's displaced current position, the original optimal transit route may no longer be the most efficient way of transporting the transit vehicle's passengers. So rather than letting the electronic street navigation module try to adapt to the highly displaced position, instead, the intelligent grouping module will momentarily step in to re-optimize the transit vehicle's route. After the intelligent grouping module has devised a new optimal transit route for the vehicle, based on its displaced position, the electronic street navigation module will proceed as normal, directing the transit vehicle along that

new optimal transit route.

This route re-optimisation would be set to kick-in automatically whenever a transit vehicle becomes significantly displaced from its intended route. Thus, provided a transit vehicle keeps close to the optimal transit route originally devised by the intelligent grouping module, transit vehicle navigation will remain under control of the electronic street navigation module; but should a transit vehicle, for whatever reason, significantly deviate from this optimal transit route, this will trigger the intelligent grouping module to step in and re-optimize that transit vehicle's route.

Such re-optimisation may mean, for example, that the transit vehicle will be given a new path to follow, and may also mean that it will be instructed to pick up and drop off its passengers in a different sequence. Re-optimisation might also entail that one or more passenger pick-ups planned for that transit vehicle are now cancelled, with those waiting passengers now collected by another transit vehicle, the intelligent grouping module having calculated that, under the present circumstances, this is the most efficient way to convey them.

Re-optimisation would also be set to trigger in other significant circumstances, such as when a transit vehicle gets delayed for a long time due to heavy traffic, or when the traffic congestion conditions (as determined by the real-time traffic speeds module described in section 9.17) have significantly deteriorated ahead along the current optimal transit route of the transit vehicle, now making that route less than optimal.

This complex juggling of circumstances is performed automatically in order to maximise the overall speed and efficiency of the transit vehicle fleet; transit vehicle drivers themselves are not involved (or aware of) this process. It is the controlling computer system that sweats; the transit vehicle drivers merely follow the resulting navigational instructions shown on their vehicle communicator device.

In summary: this section has considered some desirable features that the intelligent grouping module might have. However this is not an exhaustive survey, and further performance-enhancing features may be added. The beauty of this invention is that when performance improvements are made to the intelligent grouping module, these instantly alter the operation of the whole transit vehicle fleet. It is anticipated that the mathematical operation of the intelligent grouping module will be perfected over a period of many years. Each city in the world that implements this invention can employ mathematicians and software engineers to try to further increase the transportation efficiency of the intelligent grouping module: the great virtue of this invention is that any new performance-enhancing features devised can be easily implemented in other cities, just as a software upgrade.

9.2 - Split Journeys

Split journey are an optional addition to the basic functionality of the intelligent grouping module. Should this functionality be included, then when the intelligent grouping module cannot find a suitable transit vehicle for a given passenger itinerary, the module may divide the passenger's journey into two (or more) legs utilising whatever transit vehicles are available at the time.

In such a split journey, the controlling computer system will arrange for one transit vehicle to pick up the passenger and convey him along part of his itinerary, after which the passenger will be set down at a convenient transfer point, from where a second transit vehicle will collect him for the second leg of his journey to his destination.

The controlling computer system will actually be searching for the second transit vehicle whilst the passenger is still travelling on the first, thus on most occasions, passenger transfer will take place with minimal waiting time for the connecting vehicle, and on some occasions the first and second vehicle may even arrive at the transfer point more-or-less simultaneously.

The decision to divide a passenger's journey on separate transit vehicles is taken automatically by the intelligent grouping module. The intelligent grouping module tries to find a transit vehicle that can take the passenger directly to his destination, but if no such vehicle can be found in reasonable time, the journey may be split into two or more different legs. The general strategy is to get a transit vehicle to the passenger as soon as possible, both for reasons of transport speed, and so as not to keep the passenger waiting. Split journey will usually only occur on longer trips such as inter-city journeys; shorter journeys within a city will tend to be direct.

Travellers who dislike split journeys can be given the option to specify on their journey request that split journeys are to be avoided if possible, even if it means waiting longer to find a suitable transit vehicle.

Should this invention incorporate existing public transport (as described in section 7.17) so that the controlling computer system has real-time knowledge of the current location, routing, and destination of all participating existing public transport vehicles, then there is scope to split a passenger's journey across different travel modes; such an integrated system would rarely leave a prospective passenger waiting long.

9.3 - Quasi Door-to-Door Taxibus Service

Traditional public transport generally has its access points on main streets in the form of train stations and bus stops. However the taxibus is a unique form of mass transport which distributes its passenger pick-up and drop-off points more widely across smaller roads and residential areas as well as on main streets. This strategy, it is believed, will provide improved transportation efficiency, even if some time is lost

by taxibus vehicle excursions into the back-streets.

We present here some variations on this strategy that may help further streamline taxibus travel.

The taxibus conveys passengers on a door-to-door or point-to-point basis, and so a certain portion of its journey will be spent in excursions into residential or other back-street areas to pick up or drop off passengers. The intelligent grouping module always tries to streamline these excursions so that any diversion into the back-streets to pick up or drop off a passenger can also act as a short-cut or cut-through on the overall taxibus route. However, not all back-street excursions can be made to double up as short cuts, and some excursions will slow down the taxibus journey.

One way to eliminate this slow down, and to further streamline overall transportation efficiency, is by confining all taxibus routing to main roads and larger streets (just as with regular buses), with passenger drop-offs and pick-ups taking place exclusively on these main roads. This confinement to larger streets would be controlled by the intelligent grouping module, which would create optimal transit routes that avoided the back-streets. This quasi door-to-door taxibus is considerably more convenient and flexible than a regular bus service because it still allows complete customisation of travel route according to each passenger's personal itinerary; each main street would have several taxibus stops containing a kiosk communicator device into which passengers can enter their journey request, and at which they can wait for their requested taxibus to arrive; it just means that passengers must walk to a taxibus stop on the nearest main road to catch a taxibus, and on disembarkation, it means that passengers will typically need to walk the last few hundred metres to their destination. One clear advantage of such taxibus stops is that, with passengers congregated in the street at such points, the taxibus will perform less individual passenger pick-ups and drop offs, as there will tend to be several passengers boarding and alighting together. This will speed up the taxibus since there will be a reduced number of passenger stops en route. Furthermore, by tending to pick up passengers in such batches, it becomes feasible (and necessary) to use larger capacity taxibus vehicles, thus further increasing the fleet efficiency.

A hybrid between the quasi taxibus and the true taxibus service is also conceptually possible, and is indeed an excellent compromise between efficiency of the former and the convenience of the latter. In this hybrid system, the taxibus picks up passengers directly from their current location (such as the home or office) as usual, but drops off passengers on main streets, so that passengers may need to walk the final few hundred metres to their destination. This sensible compromise will be especially useful near one-way systems and cul-de-sacs, where a taxibus might otherwise have to make a large diversion in order to deliver a single passenger. Indeed this hybrid system might advantageously be set to operate only at such awkward destinations as one-way systems and cul-de-sacs.

9.4 - Manual Hailing of Taxibus Vehicles

It may be feasible to allow prospective passengers in the street to manually hail a taxibus, just like hailing a taxi cab, thus boarding the vehicle without having to use a communicator device. Since the outside display screen at the front of each taxibus exhibits the principal points on the vehicle's route, should a taxibus be spotted that is headed in the right direction, a passenger can flag it down and jump aboard. Once on board, this passenger will be able to enter his desired destination into an on-board kiosk communicator device located within the vehicle (an on-board kiosk communicator device must be installed in the taxibus if manual hailing passengers are to be accommodated). If his exact destination is compatible with the existing itinerary commitments of the taxibus, the controlling computer system will accept his request and the taxibus will deliver him to the door. If not, the taxibus will take him as close as possible to his destination, after which the controlling computer system can arrange for the passenger to be transferred to another taxibus for completion of his journey, or else the passenger can just walk the remaining distance if he prefers.

9.5 - Passenger Fare Metering and Calculation

Taxibus and car pool travel can be further streamlined by arranging for the controlling computer system to automatically calculate and levy the fare charge as passengers enter the vehicle. This means that neither passenger nor vehicle driver need be concerned with handling cash, issuing tickets or checking travel passes, thus facilitating rapid boarding of the transit vehicle, and making taxibus and car pool travel delightfully simple. For car pooling in particular, automatic fare charging is highly desirable, since the driver of a private car is unlikely to want to fumble around with coins and change.

A system of automatic fare charging requires some means of calculating and levying the fare, and there are several ways that the controlling computer system can do this. The simplest way uses data from the passenger's original journey request. This journey request includes all the relevant details: embarkation and destination points, the number of passengers travelling, and the amount of luggage carried. With this data, the controlling computer system can calculate the exact fare cost of the passenger's journey based on the distance between his embarkation and destination points, and charge this fare to the passenger's system-administered monetary account.

On its own, however, this system of calculating and levying fares is not foolproof: it is based on the passenger's journey request, but there needs to be some method of verifying that the passenger was actually picked up and conveyed in accordance with this request before the charge is levied on the passenger. This is particularly necessary in car pooling, otherwise a car pool driver could accept a passenger journey request, automatically receive payment for providing carriage, but not actually bother to pick up and deliver his passenger.

In car pooling, perhaps the easiest way of verifying that an accepted journey request has actually been carried out is by examining the electronic positioning data coming from the communicator device in the car pool vehicle. Using this data, the controlling computer system can determine whether the car pool vehicle did indeed travel to the passenger pick-up point and did indeed travel to the passenger destination point. This is ample evidence for verification. Remember: there is not much scope for dishonesty in this system since all drivers are registered on the controlling computer system, and should a driver engage in unreliable or deceitful practices, his passengers' complaints would rapidly expose him, and he would be banned from using the transportation system of this invention.

In taxibus travel, the concern is not so much whether the taxibus arrives to pick up the passenger, but whether at the pick-up point, some person other than the passenger climbs aboard, either in an attempt to gain a free ride, or simply just in error, and the taxibus departs with the actual fare-paying passenger left behind. However if this does happen, the passenger that was left behind can contact a human operator at the **control centre** of this invention and explain the situation: this operator would hastily arrange for another taxibus to pick up the stranded passenger, and the operator would also contact the driver of the first taxibus vehicle and ask him to investigate what has happened.

Another concern is that a group of passengers travelling together might try to enter a taxibus, when only one passenger is specified on the journey request, in order that the other members of the group can avoid paying for their travel. However, this situation should easily be spotted by the taxibus driver, whose is responsible for ensuring that the correct number of passengers board (and alight) the taxibus at any stop point.

A more robust method of verifying that the correct passengers have boarded a taxibus (or car pool) vehicle would employ the smart card technology mentioned in section 7.7. With such technology, the passenger would keep his personal smart card in his wallet or purse, and this card would be remotely scanned by a card reader in the vehicle communicator device as the passenger boards, thus confirming a correct pick-up, and therefore verifying that the fare charge could be levied on the passenger.

Another means of verifying passenger pick-up is possible when the passenger carries a cellular telephone or wireless PDA communicator device: it is quite feasible for this phone or PDA to automatically exchange data with the transit vehicle communicator device to establish that the passenger has boarded. This data exchange could be facilitated by an infrared or a short-range wireless data link (many cellular telephones and wireless PDAs have infrared or short-range wireless data link capabilities). This method of verification may not always work, however, because passengers may have their phones turned off, or their phones may have run out of battery power.

Automatic fare calculation can even be applied when a taxibus is hailed in the street: passengers that manually hail a taxibus will specify their journey request at an on-board kiosk communicator device located inside the taxibus vehicle; if the passenger

is a registered user, his system-administered monetary account will be debited in the normal way; if the passenger is not a registered user of this invention, he will specify his journey request at the on-board kiosk, and pay for the trip by swiping his credit or banker's card at this kiosk.

9.6 - Groups of Passengers Travelling Together

Group travel by taxibus or car pool is very straightforward when each person in the group is a registered user and carries his or her own communicator device: each person simply makes an individual journey request to the same destination at more or less the same time. On receiving these multiple requests arising from the same geographic location, the controlling computer system will automatically try to place these people on board the same transit vehicle or vehicles - simply because that is the most efficient way to transport them.

Another way that a group of registered users can travel is by nominating a group leader: all members of the group must enter the user name of the leader into their communicator devices to inform the controlling computer system that they are members of one group, and that their leader is the user specified. Should some group members not have communicator devices, this does not present a problem, since these people can borrow a communicator device from one of their fellow travellers, log into their own **system account** (see section 9.7) by entering their user name and password, and then, like everybody else, enter the user name of the group leader. Once the group is thus defined to the controlling computer system, the leader can enter a single journey request for the group, and the controlling computer system will send a transit vehicle to transport the whole ensemble.

Group travel can be arranged more simply by one user making a journey request which includes details of the number of passenger seats required. On receiving such a request, the controlling computer system will send a taxibus vehicle with sufficient capacity to transport this number of people. The controlling computer system will charge the entire group fare to the user who made the journey request, and thus this user may need to be reimbursed by the group. This method of group travel, however, introduces a security breach: when several passengers travel under one user's system account, although the identity of this user will be known to the controlling computer system, the identities of the other passengers will not. Car pool drivers that are concerned with security may prefer to avoid groups travelling under one system account.

Another form of group travel occurs when one passenger orders a taxibus journey to a specified destination, but would like his taxibus vehicle pick up a friend on the way, so that they can travel together to the same destination. It would be possible to include this sort of group travel option (but note that it would only be available to a passenger when the friend's address is located more or less on the way to the destination - the controlling computer system would reject the request otherwise). Of course this sort of group travel is more simply achieved by first taking a taxibus to the friend's address, alighting, and subsequently ordering a second taxibus to

convey both travellers to the desired destination.

In general, group travel is a very efficient use of the taxibus: groups tend to board or alight together, which means that the transit vehicle has less pick-up and drop-off points on its route to slow it down.

9.7 - Registering with the Controlling Computer System

To apply to become a **registered user** on the files of the controlling computer system and thus gain access to taxibus and car pool travel, some personal details must first be provided, such as the applicant's name, date of birth, sex, home address, driver's licence number, telephone number, email address, occupation, banking and credit details. For security reasons, this data will be validated to ensure that the details are correct. Once validated, the applicant will be set up with a **system account** (which includes a system-administered **monetary account**), and a **user name** and **password** that enables him or her to access this system account, and to make use of all the transport facilities of this invention. Users would usually need to transfer funds to their system-administered monetary account before they can travel as a passenger.

As well as travelling as a passenger in taxibus and car pool vehicles, the same system account will also allow the registered user to act as a car pool driver (provided he or she meets certain requirements which are discussed in section 9.9).

Note that since a registered user's system account incorporates a monetary account within it, there are certain security considerations that must be fully examined. Although the user name and password scheme just mentioned is reasonably secure, it may be deemed necessary to include additional security measures such as issuing each user with a unique smart card which is automatically read by the transit vehicle communicator device when the user begins a journey, and thus automatically identifies the passenger to the controlling computer system. Smart cards would also be helpful at roadside kiosk communicator devices: the smart card could be read by the kiosk, thus identifying the user to the controlling computer system without him needing to enter his user name. Smart cards are briefly discussed in sections 7.7 and 9.5.

9.8 - Security and Safety in Taxibus Travel

The electronic navigation taxibus is probably the safest means of public transport ever devised, offering more personal security than even the private car. This is because it provides a door-to-door service overseen by a professional driver, and because all details of all taxibus journeys are logged on the controlling computer system. These details include the identities of the driver and all fellow passengers, the exact route traversed by the taxibus, the place and time each passenger boarded and alighted, and for extra safety, video surveillance inside the taxibus.

In addition, the controlling computer system will keep a security file for each registered user. Any reported incidents of anti-social behaviour will be recorded on the user's file, and if any particular user is implicated too frequently in such incidents, he or she would be banned from using the transportation system of this invention for a certain number of months. Just the possibility of a ban should be an incentive to maintain proper personal conduct in the taxibus.

Some passengers may be a little worried by that fact that the taxibus (and a car pool vehicle) drops them off right outside their house, thereby indicating to fellow travellers where they live. However, there is a simple solution for this concern about privacy: instead of specifying their exact home address as their travel destination, such passengers can specify an address which is say just a hundred metres away from their home, perhaps in front of a local shop or similar location. The controlling computer system would then automatically direct the taxibus to drop the passenger off at the specified point.

9.9 - Security and Safety in Car Pool Travel

In car pooling the inherent security again arises from the fact that the identity of all passengers and drivers is always known to the controlling computer system. The controlling computer system will keep a log of all journeys and maintain a history of who has been travelling with whom. In a regular taxi cab or mini cab journey, neither the driver's nor the passenger's identity is known, nor is the journey logged, so car pooling is in many ways safer than a taxi ride.

Should it be considered necessary, there are various other practicable means of increasing security. For example, the controlling computer system could monitor car pool journeys in real time as they progress to their destinations. Any inexplicable deviation from the intended passenger destination will flag an alert to a human operator at the control centre of this invention. The operator might then phone the driver or passenger to find out why there was a deviation from the intended route, and could contact the police if any suspicious circumstances were encountered - the location of the passenger and driver will be known through the incoming electronic positioning data. As electronic equipment becomes cheaper, it may be feasible to incorporate a small audio and video surveillance camera within the communicator devices fitted in car pool vehicles. Though many people may feel that video surveillance during car pooling is too intrusive, it must be remembered that such surveillance systems are already in operational on most public transport in the UK.

Regarding security factors at passenger pick-up point: the car pool driver is always in his rights to decline providing carriage after spotting his passenger in the street. Perhaps the passenger has a demeanour that makes the driver feel apprehensive. In this case, the driver could keep his doors locked and drive away. The driver might wish to telephone an operator at the control centre to explain why he declined the pick-up; the operator may decide to telephone the passenger in question to assess the situation. Should there be a genuine cause for concern (say for example the prospective passenger sounded aggressively drunk when the operator called) the

operator could put a temporary bar (say for 6 hours) on that passenger's system account, allowing him access to taxibus and other public transport, but preventing further access to pool car travel during that time.

In relation to the personal safety of women travelling solo: both women car pool drivers, and women car pool passengers, will be able to indicate on their communicator devices that they only wish to travel with other women. This option need not always be used; it could be selected just at certain times such as, for example, late at night.

In cases of unpleasant incidents in car pooling, or even milder circumstances such as personality clashes or just plain irritation with a particular person, it will be possible for either party to request that the controlling computer system never groups them both together in the same vehicle in future.

Having mentioned all these issues in relation to security, evidence from the United States, which has been running car pooling on freeways for some time now, suggests that unpleasant incidents are actually very rare.

As for driving skills and road safety, to help ensure a good standard of driving, all car pool drivers would be required to have a reasonably clean drivers licence, a minimum age of 25, and minimum of 5 years driving experience. The controlling computer system itself will automatically monitor all drivers engaged car pooling: using real-time electronic positioning data it will calculate vehicle speeds, and will check for any excessive speeding. Any driver found to be consistently speeding whilst carrying car pool passengers might receive some warning regarding his dangerous driving, and would be banned from car pooling for a period of time if these warnings were not heeded.

In the case of lost property left in a car pool vehicle, since the controlling computer system logs all journeys and knows who has been travelling with whom, it would be possible to obtain the email address or telephone number of the appropriate driver or passenger in these situations. Similarly in taxibus travel, any lost property will be easily returned to its owner since most taxibus passengers will be registered users, with their journeys logged on the controlling computer system.

9.10 - Theft or Disclosure of a Registered User's Password and User Name

Theft or disclosure of a user name and password to a third party involves two security issues: one is that the third party will be able to travel using funds from this user's system-administered monetary account; and another is that the third party will be travelling under a false identity, thus breaching the inherent security of taxibus and car pool travel, which is based on knowing the identities of all travellers. It is therefore important for users to keep their passwords completely secret, and to change their password if they suspect someone else knows it.

In reality, though, it would be very difficult for a thief to make much use of a someone else's user name and password. Since the controlling computer system

monitors all journeys, the thief may manage a free ride on a taxibus - and then find the transport police waiting for him at his destination. Even if the thief evades the police on that occasion, all taxibus vehicles have video surveillance on board, and all journeys are logged on the controlling computer system, so it will not take long for the transport police to catch him. If you were a thief, would you feel comfortable travelling using a stolen user identity, knowing that your journeys will be logged and videoed, and that the controlling computer system will alert the transport police to your every movement? Such is the intrinsic security of this invention, that even when user identities are stolen, its safety and integrity are barely compromised.

9.11 - Passengers Carrying Luggage

In taxibus travel it is thought that there should be no extra charge for carrying goods or luggage - in keeping with most other forms of public transport. Most taxibus vehicles will contain enough space to accommodate passengers carrying a suitcase or several bags of supermarket shopping. However, smaller taxibus vehicles will possess only a limited amount of luggage space, and may not be able to accommodate a group of passengers if each is carrying bulky luggage. Nevertheless, if such a group of passengers indicate in their initial journey request that they have heavy luggage, the controlling computer system will automatically deploy a sufficiently spacious taxibus to transport them.

In car pooling, passengers with weighty luggage are charged a little extra, and the car pool driver will receive a slightly larger fee to compensate for his trouble. Passengers should indicate that they have luggage when the initial journey request is made, so that the controlling computer system can supply a car pool vehicle with sufficient space.

9.12 - Pick-up Delay Charge

Passengers who make a journey request for a car pool or taxibus vehicle, but who are not ready to leave when the vehicle arrives, will automatically be charged a small fine for every minute that they keep the transit vehicle waiting. The controlling computer system will know when the transit vehicle has arrived at the passenger pick-up point from the incoming electronic positioning data it receives from the communicator device on the vehicle. Once the vehicle arrives at the passenger's pick-up point, the controlling computer system begins the delay-charge timer. Any delay in boarding that is longer than one minute will incur a fine, levied on that passenger's monetary account (the controlling computer system will make the car pool driver or taxibus operator the direct benefactor of this fine). This fine will gently encourage passengers to be prompt for pick-up. Pick-up delays not only inconvenience the driver and other passengers, but they also equate to a waiting transit vehicle in the road that may be partially blocking the thoroughfare. Should a taxibus or car pool vehicle arrive at the pick-up point and find that the passenger is still not ready to go even after waiting a few minutes for him, the controlling

computer system will instruct the driver of the transit vehicle to leave without the passenger. That passenger will incur a fine equal to the minimum fare charge for travel in that transit vehicle, and will have to resubmit his journey request to the controlling computer system if he still requires transit. When a passenger frequently causes delays through his or her lack of punctuality, he or she may be barred from using taxibus and car pool transportation for a period of time.

Quick and efficient passenger pick-ups are important to the smooth functioning of this invention. The waiting passenger's communicator device will generally provide a countdown to the estimated time of arrival of his requested car pool or taxibus vehicle, so the passenger can have little excuse not to be ready.

9.13 - Cancelling a Journey Request before the Transit Vehicle Arrives

A prospective passenger can cancel any journey request he has made, even after the controlling computer system has already diverted a vehicle to collect him. However a small fine is automatically levied on that passenger to discourage this type of capricious behaviour; the charge being paid directly into the system-administered monetary account of the diverted car pool driver or taxibus operator by way of compensation. The amount of the fine would depend on how far the vehicle has already diverted at the time of cancellation; the maximum possible fine being equal to the minimum fare charge for that transit vehicle.

9.14 - Passenger en Route Cancels his Journey or Changes his Itinerary

A passenger may at any time ask a car pool or taxibus driver to stop and drop him off. The driver of the vehicle would submit a cancellation request on the vehicle's communicator device. On receiving this cancellation request the controlling computer system will cancel this passenger's journey request, and will update the routing of the transit vehicle (the transit vehicle will no longer need to navigate to that passenger's destination). The controlling computer system will only charge the passenger for the proportion of the journey travelled, or the minimum fare, whichever is larger. To determine the proportion of the journey travelled, the controlling computer system uses the current location of the transit vehicle at the time of cancellation (this location is derived from the electronic positioning system).

Should a passenger en route want to entirely change his destination, he can alight as described above and submit a new journey request on his communicator device.

Alternatively, and more conveniently, the passenger can submit the new journey request on his own communicator device whilst still on board the first transit vehicle, or using an on-board kiosk communicator device located within the vehicle. Since the controlling computer system knows that the passenger is currently journeying on board a transit vehicle, the controlling computer system will recognise that the passenger wants to cancel his current journey and change his

destination to that specified on the new journey request. The controlling computer system may keep the passenger on the first transit vehicle for a while until another transit vehicle is found to take the passenger to his new destination; at which point the controlling computer system will prompt the passenger to alight, and will instruct the passenger to wait for the other transit vehicle to arrive.

9.15 - Considerations to the Car Pool Driver

This invention operates in a way that is always very considerate to the car pool driver, making sure that he or she is not inconvenienced when conveying a passenger. The intelligent grouping module will only attempt to place a passenger in a car pool vehicle when the passenger's itinerary is highly compatible with the driver's existing itinerary; the driver will thus only need to make a small deviation from his own route in order to convey this passenger. The controlling computer system even calculates, and details on the vehicle's communicator device, the estimated extra time in minutes that will be added to the the driver's own journey if he decides to convey the passenger: this extra time is called the **estimated diversion time**. Using the estimated diversion time, the driver can decide whether giving carriage to the prospective passenger will fit into his time schedule. No pressure whatsoever is placed on car pool drivers to carry passengers; drivers may provide carriage according to their mood and schedule.

Whilst carrying a passenger, should a car pool driver have a sudden change of plan and thus become unable to take the passenger to his destination, that driver is fully within his rights to cancel the journey. On receiving such a cancellation the controlling computer system will instruct the driver to drop the passenger off at the next convenient point. The passenger will not be charged for this aborted journey and the controlling computer system will assign high priority to finding the passenger an alternative means of transport, perhaps in another car pool vehicle, or in a taxibus.

This courtesy and flexibility that the controlling computer system extends towards car pool drivers is designed to encourage them to convey passengers frequently.

9.16 - Ambiguous Passenger Position

Passenger communicator devices would advantageously be equipped with electronic positioning functionality so that the controlling computer system can automatically determine a prospective passenger's current address location without the passenger needing to specify it explicitly. This is a very useful feature which will function perfectly well on most occasions. For example, when a prospective passenger located on a street pavement makes a journey request on a communicator device equipped with electronic positioning, the controlling computer system will have no problem determining the nearest corresponding address location to that passenger.

However when such a journey request is made from within a house or office, an ambiguity in location may sometimes arise due to the fact that some buildings may straddle several streets. This ambiguity must be resolved, because the controlling computer system needs to know the street address to which the transit vehicle must be sent for passenger pick-up.

When there is an ambiguity in the address, the controlling computer system will detail on the passenger's communicator device the various street addresses that surround the building in which the passenger is located, and the passenger must select the right address. Alternatively the passenger can exit the building and submit his journey request at the precise spot in the street at which he wants to be picked up.

Should a passenger make a journey request from an inappropriate point (for example, from an off-road location that is inaccessible to ordinary vehicles) then the controlling computer system will deny the journey request, since no vehicle would be able reach that passenger. The controlling computer system will however advise the passenger where the nearest road is located, and once the passenger has relocated himself to such a road (by means of electronic navigation directions supplied by the controlling computer system, if necessary) then the passenger's journey request will be accepted.

One scheme that would eliminate passenger pick-up point ambiguity involves a series of pre-defined passenger pick-up (and optionally set-down) points placed throughout the region in which this invention operates. These pre-defined pick-up points would be closely spaced, say at 25 metre intervals along every road, and could be indicated by markings painted on the road or pavement, or painted on lampposts, with each such pre-defined point clearly displaying a unique **pick-up point reference code** (such as, for example, the house-number/postcode combination for that street location); when making a journey request, using this pick-up point reference code would eliminate pick-up point ambiguity. Note: a similar scheme called **road coding** is discussed in section 9.22.

9.17 - Real-Time Traffic Speed Module

Once a sufficient quantity of transit vehicles are in operation in a city or similar region, it will be possible to assess the current average vehicle speeds on all roads. This is achieved by a **real-time traffic speed module** which runs on the controlling computer system and examines incoming electronic positioning data from all transit vehicles in order to estimate current traffic speeds. This module has the ability to automatically detect any roads with traffic jams or traffic blockages because the transit vehicle speeds, as calculated from their electronic positioning data, would be slow or stationary on these roads.

The real-time traffic speed module operates using a digitised street layout map. Each time a transit vehicle traverses a stretch of road, the real-time traffic speed module will use incoming electronic positioning data from that vehicle to plot the

vehicle's progress; by noting the time the transit vehicle takes to cover a known length of road, the module can determine the transit vehicle's speed on that road. Working on the assumption that transit vehicles travel at the prevailing traffic speed (when not picking up or dropping off passengers), the real-time traffic speed module can estimate the prevailing traffic speed on each road in the city.

When a large fleet of transit vehicles are operating in a city, one would expect several transit vehicles to traverse a typical city street in each ten-minute period. For every stretch of road, the real-time traffic speed module averages the transit vehicle speed values it receives over this time period to provide a constantly updated road-by-road city-wide map of the prevailing traffic speeds.

For roads on which transit vehicles run only infrequently, the real-time traffic speed module would use other methods to estimate prevailing traffic speeds (for example, if a road only infrequently has transit vehicles running along it, then one might assume that this road has very little traffic in general, meaning that any vehicle on it will be able to travel at the speed limit of the road).

With this real-time traffic speed data at its disposal, the controlling computer system will be able to automatically re-route its vehicles away from blocked or heavily congested roads, thus avoiding delays, and also relieving the traffic burden at these already-congested points (see section 9.1 for details).

9.18 - Predictive Crowd Convergence

Occasionally, at large public events such as sports fixtures or music concerts, an unexpectedly huge crowd of people arrive, the sheer numbers of which place event organisers and the police under sudden strain. With existing transport systems, no advanced warning of such a rapid convergence of people is generally available. However with this invention, the controlling computer system can examine all traveller itineraries to create a numerical analysis of the passenger journeys being undertaken, from which it would be possible to predict any unusually large crowd convergence in a particular location. The controlling computer system could supply advanced warning of any large influxes of people to the police, who could promptly deploy more personnel to help cope with the crowds.

9.19 - Street Navigation Facility Always Available

In this invention, an electronic street navigation module is used to direct drivers of transit vehicles who are conveying passengers. However this electronic street navigation facility could also be made available at other times, so that any driver or pedestrian can use any communicator device equipped with electronic positioning to get precise street navigation directions to any address at any time. Since most cellular telephones will be equipped with electronic positioning in the future, this useful extra feature would be quite straightforward to implement.

9.20 - Current Location Address Sampling

To facilitate easy saving of address locations, it is thought that communicator devices with built-in electronic positioning should have a **grab current address** function. On activating this function, the controlling computer will work out the current location address, based on the electronic positioning data, and will store this address as a personal travel location. This is a very useful feature: for example, when visiting any given location, a user can effortlessly grab the address whilst there, and save it for future use.

9.21 - The Self-Drive Transit Vehicle

Here we present a way of cheaply extending the taxibus fleet, and obtaining transit vehicle drivers completely for free. This is achieved by introducing small capacity **self-drive transit vehicles**. The self-drive transit vehicle can be hired and driven by any registered user completely free of charge, provided that whilst using the vehicle, the driver agrees to convey any passengers that the controlling computer system instructs him to convey (as per usual, these passengers will have itineraries that closely match that of the driver). Using a self-drive transit vehicle is thus just like car pooling: the driver must follow the navigation instructions on the vehicle's communicator device in order to pick up and convey passengers. The difference is that the driver gets use of a vehicle at no expense; and the controlling computer system gets a driver for free. If the current driver of a self-drive transit vehicle wishes to carry his own passengers, this is entirely acceptable, but his passengers will have to pay the normal taxibus fare. Self-drive transit vehicles would be parked in the streets all over town; and these vehicles would be of a distinctive style and colour for easy visibility.

When a traveller makes a journey request on a communicator device, the controlling computer system will indicate if any self-drive transit vehicles are available in the vicinity - the location of all self-drive vehicles is known to the controlling computer system through electronic positioning. Self-drive transit vehicles are bookable only on a communicator device. This is to prevent the possible tussles that might ensue should two people simultaneously arrive at an available self-drive transit vehicle in the street that they both wish to use. Once booked, the registered user will enter the vehicle by keying in his user name and password via a keypad on the vehicle door; some other security checks may also be required.

Once a driver and his passengers finish the journey, the self-drive transit vehicle is parked, and immediately becomes available for the next registered user. In order to make the use of these vehicles as streamlined and efficient as possible, it is thought that the self-drive transit vehicle should be entitled to free parking on all public roads. It is anticipated that most self-drive transit vehicles will spend only minimal time parked before another registered user books them for a journey.

Vehicle theft is clearly a potential problem with the self-drive transit vehicle. However, since only registered users can operate such vehicles, and since the controlling computer system will be tracking all transit vehicles at all times by electronic positioning, this will tend to make theft difficult. Additional security measures might include embedding electronic tags in the vehicle that can locate the vehicle's position even if stolen and shipped to another part of the world. To stop self-drive transit vehicles being used by drivers under the influence of drink or drugs, some sort of human reaction response test could be built into the vehicle. If the potential driver's reactions were sluggish, he would not be allowed to drive, and the controlling computer system would find him some other means of transport.

The self-drive transit vehicle is a somewhat controversial concept. It may work, but there is a chance that many vehicles will end up being vandalised, abused or stolen. However with sufficient security measures, including on-board audio and video surveillance, the self-drive transit vehicle idea could be successful in certain towns, especially in the more socially-minded countries, such as Scandinavia, for example.

9.22 - Electronic Positioning Accuracy and Coverage

In order for this invention to operate properly and effectively, an electronic positioning system of sufficient accuracy and coverage is required. Accuracy is needed to determine the precise street location of transit vehicles (as well as prospective travellers): parallel roads may be just tens of metres apart, so the positioning resolution needs to be good enough to distinguish between such roads. Good coverage is needed, since electronic positioning is needed at all locations.

In terms of accuracy, excellent results are obtained from satellite positioning systems, such as the American GPS (Global Positioning System), the Russian GLONASS (Global Navigation Satellite System), or the soon to be launched European Galileo satellite positioning system, which will be superior to both GPS and GLONASS.

GPS is typically accurate to within 10 metres, but there are methods of improving this accuracy: a system called WAAS (Wide Area Augmentation System) improves the positioning accuracy of GPS to within 3 metres, and a technique called Differential GPS can be accurate to within 1 metre.

A European project called EGNOS is working to combine the GPS and GLONASS satellite signals to create a positioning system accurate to within 5 metres even before any improvement methods are applied. The EGNOS system will be operational in 2004.

When the European Galileo satellites are launched, and the system begins operation in 2006 (fully operational in 2008) it will be accurate to within 1 metre. Galileo will have a stronger signal than GPS, and is being designed to inter-operate with GPS and GLONASS to provide even greater positioning precision.

Although satellite positioning is very accurate, coverage can be a problem. Satellite

signals cannot penetrate inside buildings, and are often unavailable in the street valleys between high-rise blocks when the sky is predominantly obscured. Combining the signals from Galileo, GPS and GLONASS together will provide a slightly better coverage.

Other methods of electronic positioning may be used when the satellite signal is lost, such as cellular base station triangulation, which can locate a cellular phone to within 50 to 150 metres. Though not as precise as satellite positioning, base station triangulation has the great advantage of working with *any* cellular phone or wireless PDA, and it usually works inside buildings too. Ideally both cellular triangulation and satellite positioning could be used in conjunction to augment each other: the satellite system providing accuracy and cellular base station triangulation supplying coverage when the satellite signal is unattainable.

There are additionally some ad hoc means of electronic positioning that might be considered. For example, a city could be supplied with an radio positioning signal broadcast locally from radio masts planted around its perimeter. These masts would be situated on high ground, perhaps where existing television and radio signals are transmitted. These terrestrial positioning signals would have two advantages over satellite positioning signals. Firstly, the signal from these terrestrial transmitters can be broadcast at higher power levels in order to penetrate through buildings and thus provide a more complete coverage (GPS positioning satellites typically broadcast at a very feeble 50 Watts of power as the satellites rely on solar energy). Secondly, terrestrial transmitters may be more reliable: the satellite positioning signal could conceivably be switched off for security reasons during military conflicts (this is less likely with Galileo which is civil system, but GPS is owned by the US military).

Another unusual means of electronic positioning could be achieved by installing cheap short-range wireless transmitters (such as Bluetooth, Wi-Fi or UWB devices) into lampposts, traffic lights, and similar points on the roads. Each transmitter would digitally signal its own geographic address location to any receiving device in proximity, thereby facilitating an electronic positioning system. Since many new cellular phones and wireless PDA devices have short range transceivers built-in, this method is an entirely practicable solution. It would also be possible to place cheap short-range wireless transmitters into cat's eye reflectors in the road, powering the transmitters from solar cells running on daylight during the day and from vehicle headlights during the night.

Still another means of electronic positioning may be realised by means of a **road coding system** wherein geographic location is encapsulated into codes continuously painted onto each lane in the road. These painted codes need not necessarily be visible to the human eye, just detectable to a reader device. The painted codes could be based on a barcode, or based on some other coding system; the coding system would encode the geographic location where the code is painted on the tarmac. When a transit vehicle moves over these painted codes, a reader device fixed to the vehicle would scan them and thus obtain positioning information. If the painted code were visible, and of a form easily read by prospective travellers, this code could also be used to specify current location when a traveller makes a journey

request. It would be easy to develop a paint-spraying unit that, fixed beneath a truck, would continuously paint the roads with these codes as the truck moves along; the spraying unit could use a very accurate satellite positioning receiver in order to determine the exact location.

Road coding systems and short range radio transmitters are non-conventional methods of electronic positioning. However they might advantageously be used in conjunction with more standard electronic positioning techniques in order to improve coverage or accuracy. In underground railway systems, for example, where neither a satellite positioning nor cellular triangulation signal can penetrate, short range radio transmitters would make an excellent ancillary positioning system.

In the future 'mesh networks', which comprise a web of radio-transmission-linked transceiver nodes which will host equipment such as cellular telephones, wireless PDAs, computers, and other digital gadgets, may become the predominant means of data communications. The principle of mesh networking could allow locally situated communicator devices to confer with each other in order to corroborate electronic positioning data. This offers three advantages: firstly such corroboration would help improve the accuracy of the satellite positioning data using similar error reduction methods to those employed in Differential GPS; secondly, when a communicator device is beyond the reach of the satellite signal (such as when indoors, or in a tunnel), a communicator device could still get positional data by corroborating with nearby communicator devices that are within range of the satellite signal; thirdly, communicator devices that do not have built-in electronic positioning functionality can use this corroboration to obtain positioning data from nearby communicator devices that do. Such corroboration would work both for stationary communicator devices, and communicator devices in moving vehicles.

Note that mesh networks, and similar local electromagnetic broadcasting data transmission systems, may be set up to function as simple electronic positioning systems just in themselves. Given that such local broadcasts have limited range, whenever broadcast contact is made from one transceiver device to a second transceiver device, this automatically implies that these devices are situated within a given radius of each other (this radius equal to the maximum distance the electromagnetic signal can be broadcast by the transceiver devices). This provides rudimentary electronic positioning data. Such a rudimentary electronic positioning system could in principle be used in the second embodiment of this invention.

10 - IGT FROM THE PASSENGER'S PERSPECTIVE

The following description, in the form of a short story, illustrates the nature of IGT travel from the perspective of the journeying passenger.

It is 8:22 am in the London suburbs. Alex is taking a last sip of coffee before commencing his journey into work. He puts on his jacket and takes out his cellular telephone. From a list of pre-programmed addresses on his phone, Alex selects the destination address labelled Office followed by the embarkation address labelled Home. On the telephone's display screen, a validation message summarises the travel itinerary that he has just requested:-

Traveller Journey Request

Embarkation: Home > 56 Muswell Hill, N10 3ST
Destination: Office > 110 Charing Cross Rd, WC2H 0JP
Departure Time: Immediate
Transit Vehicle Type: Taxibus
Passengers: 1

This request for a journey is transmitted to the IGT central computer system. Alex waits a moment whilst the system responds to his journey request. He regularly travels to work by IGT and is completely familiar with this simple, efficient and relaxing way of commuting. A few seconds later, the IGT system details a nearby transit vehicle that is available to collect him. These details are displayed on Alex's cellular phone in the following format:-

Transit Vehicle Availability

Vehicle	Pick-Up	Journey	Cost	Arrival
Taxibus	2 mins	34 mins	£0.96	8:58pm

Please Confirm: YES | NO

These details tell Alex that there is a taxibus-type transit vehicle available that can pick him up in just two minutes, and which will deliver him to his office destination at the estimated time of 8:58pm. Alex hits the YES response to select the transit vehicle offered; his cellular phone subsequently displays some confirmatory details:-

Taxibus Selection Confirmed

Embarkation: Home
Destination: Office
Distance: 6.4 miles **Fare Cost:** £0.96
Vehicle Identification: Taxibus 4025
Countdown to Pick-Up: 1 min 50 sec

These confirmation details remain visible and provide a real-time countdown to pick-up. It is now just under two minutes to go before his transit vehicle arrives. Alex has just got enough time to check the house, making sure the doors and windows are closed. His umbrella and briefcase lie by the front door. He grabs the

briefcase, but leaves his umbrella behind; he rarely needs to use it since he started travelling by IGT.

Alex glances at his cellular phone: the countdown to pick-up now shows just under one minute. Alex should be in the street when the taxibus arrives, so he steps outside, locks the front door, and walks down to the roadside. A short while later, a taxibus turns into the road, with the identification 4025 marked on it. The taxibus pulls up at Alex's residence. The vehicle is small and compact: a sleek, narrow minibus with just 9 passenger seats. The passenger doors open, Alex climbs aboard, and the driver politely greets him good morning. No money is handed over, nor are any travel passes shown, since the fare for the journey is computer calculated and automatically charged to Alex's IGT user account. This makes boarding the vehicle fast and easy.

As the taxibus vehicle moves off, Alex walks down the small central aisle and finds himself a comfortable seat. There are already a few passengers on board. The journey to the office has been estimated at 34 minutes; Alex wonders which route the taxibus will take this morning. He knows that there will usually be additional passenger pick-ups along the way, and a few passenger drop-offs too. The IGT computer system provides real-time street navigation instructions on a dashboard display screen to guide the taxibus driver along the customised route. However the IGT system ensures that all pick-ups and drop-offs lie along a more-or-less direct trajectory, so Alex's own journey is not really that much lengthened by them

Half an hour later, Alex's taxibus is nearing his destination. An interior display screen, visible to all the passengers in the taxibus, shows the upcoming stop, and also indicates which passengers should alight at that stop. In this case it is only Alex, and so his IGT user name (which he has chosen as 'Alex-G') is displayed on this interior display screen:-

NEXT STOP: Charing Cross Rd, WC2

Arrival Time: 2 minutes

Passengers Alighting: Alex-G

The same information is also available on Alex's cellular telephone. Alex gets ready to alight. All taxibus passengers are made aware that they must board and alight reasonably quickly in order to keep taxibus travel fast and streamlined for everybody. Quick boarding and alighting are made possible by displaying on the passenger's cellular telephone a precise countdown to the time that their taxibus will arrive to pick them up, and by providing this advanced warning just before a passenger's destination is due. The fact that all passenger fares are automatically calculated by the IGT system - eliminating the need to buy tickets from the taxibus driver - also greatly helps to expedite the whole transport process. The taxibus arrives at Alex's destination and pulls up at the kerb. The driver announces "Arrival at Charing Cross Road" and opens the vehicle doors. As Alex steps out on to the pavement he observes that, as usual, the IGT system has guided the taxibus right up to the front door of his office. Which is good, because it had just started to rain.

CLAIMS

The terminology used in these claims is defined in sections 5.2, 5.3, 5.4 and 5.7.

1 A traveller transportation system operating on the roads in which travellers use communicator devices to send their journey requests, and any car pool vehicle drivers use communicator devices to send their car pool intended itinerary specifications, to a controlling computer system wherein:

an intelligent grouping module intelligently groups the said travellers into transit vehicles, and creates an optimal transit route for each of these transit vehicles to convey the said travellers in accordance with the itinerary and the other travel details specified in each of the said journey requests or car pool intended itinerary specifications;

the said intelligent grouping module operating with the aid of data from an electronic positioning system detailing the current geographic position of each of the said transit vehicles;

the drivers in each of the said transit vehicles being directed along the said optimal transit routes to convey the said travellers by means of navigational data supplied by an electronic street navigation module incorporated into the said controlling computer system;

the said navigational data being sent to the communicator device within each of the said transit vehicles, these communicator devices detailing the navigational data to the drivers of the said transit vehicles;

throughout the above-described operations, a data transmission system is used wherever data needs to be sent between the remotely-located components of this invention, these components including the controlling computer system (and any geographically distributed computer processor elements thereof), the electronic positioning system (and any geographically distributed elements thereof), and the communicator devices used by travellers and transit vehicle drivers.

2 A traveller transportation system as described in claim 1 in which the journey request format allows travellers to specify the number of traveller seats required on the journey, so that groups of people travelling together can be accommodated by this invention.

3 A traveller transportation system as described in claims 1 or 2 in which the journey request format allows travellers to specify their luggage requirements, so that travellers with luggage can be found a suitable transit vehicle.

4 A traveller transportation system as described in claims 1, 2 or 3 which has the ability to handle pre-order booking and regular order booking traveller journey requests: travellers who place a pre-order booking with the controlling computer system will have a transit vehicle arrive to collect them at the time they specify in

the journey request, in order to convey them along the itinerary they specify in the journey request; a regular order booking is like a pre-order booking except that it is repeated on a regular basis specified in the journey request (for example: daily) until cancelled (see section 7.8).

5 A traveller transportation system as described in claims 1 to 4 which operates with traveller itineraries that fall into the category of simple two-point itineraries which comprise the traveller's embarkation point and destination point: this makes the itineraries simple to specify on a communicator device and easy to process computationally.

6 A traveller transportation system as described in claims 1 to 5 which operates with vehicle itineraries that comprise a set of defined geographic points or addresses to which the vehicle must navigate in a prescribed order, to pick up or drop off travellers.

7 A traveller transportation system as described in claims 1 to 6 which operates with transit vehicles that are able to service the same sort of street addresses and locations as can a private car or taxi cab (in other words, like the car and taxi cab, these transit vehicles will be sufficiently small and manoeuvrable to be able to reach virtually all street addresses).

8 A traveller transportation system as described in claims 1 to 7 which operates exclusively with transit vehicles that are piloted by a professional driver with no itinerary of his own (by definition, this is the electronic navigation taxibus configuration of this invention).

9 A traveller transportation system as described in claims 1 to 7 which operates exclusively with transit vehicles that are piloted by a driver who is travelling on an itinerary of his own, and who wishes to accommodate and transport passengers in his vehicle (by definition, this is the car pooling configuration of the invention).

10 A traveller transportation system which combines the functionality described in claims 8 and 9 (that is to say, one that operates both taxibus and car pooling vehicles simultaneously).

11 A traveller transportation system as described in claims 1 to 10 which operates the self-drive transit vehicles described in section 9.21.

12 A traveller transportation system as described in claims 1 to 11 in which the data transmission system comprises a cellular telephone network as a method of data transmission.

13 A traveller transportation system as described in claim 12 where the data transmission system comprises a 3G (third-generation) cellular telephone network or later generations thereof.

- 14** A traveller transportation system as described in claims 1 to 13 where the data transmission system employs a mesh network method of data transmission (mesh networks are described in section 8.4).
- 15** A traveller transportation system as described in claims 1 to 14 in which the data transmission system is able to transmit data more-or-less instantaneously (typically with the speed of an electromagnetic wave or the speed of a signal propagating along an electric land line) so that no burst of data takes longer than a few seconds to travel via the data transmission system; such speed is necessary if this invention is to operate effectively in real time.
- 16** A traveller transportation system as described in claims 1 to 15 which provides a door-to-door transport service, that is to say, which runs transit vehicles that convey each traveller in accordance with his itinerary right from his starting point or address to his destination point or address.
- 17** A traveller transportation system as described in claims 1 to 15 in which travellers are conveyed almost door-to-door by being picked up and/or dropped off within a short walking distance of their starting and destination points or addresses (such as in the 'quasi door-to-door' taxibus in section 9.3).
- 18** A traveller transportation system as described in claims 1 to 17 which employs communicator devices that are electronic gadgets capable of two-way transmission of information (able to send data and receive data via the data transmission system).
- 19** A traveller transportation system as described in claims 1 to 18 which employs communicator devices that are portable so that users of this invention can carry a communicator device on their person.
- 20** A traveller transportation system as described in claims 1 to 19 which employs communicator devices that possess a text and/or graphics display screen and some sort of keyboard or keypad, allowing a visual presentation of information to the user, and allowing users to type in information.
- 21** A traveller transportation system as described in claims 1 to 20 which employs communicator devices that are of the cellular telephone or wireless PDA (Personal Digital Assistant) type and which operate with a cellular telephone network data transmission system (see section 7.2 for a more detailed description of such types of communicator device).
- 22** A traveller transportation system as described in claims 1 to 21 in which the electronic positioning system is able to locate the geographic position of communicator devices carried by travellers, as well as locate the geographic position of transit vehicle communicator devices.
- 23** A traveller transportation system as described in claims 1 to 22 in which the

electronic positioning system is a satellite positioning system.

24 A traveller transportation system as described in claims 1 to 22 in which the electronic positioning system is based on cellular base station triangulation.

25 A traveller transportation system as described in claims 1 to 22 in which the electronic positioning system uses a combination of both satellite positioning and cellular base station triangulation.

26 A traveller transportation system as described in claims 1 to 22 in which the electronic positioning system is exclusively based on road coding and/or short range radio transmitters (both are described in section 9.22).

27 A traveller transportation system as described in claims 1 to 26 in which road coding and/or short range radio transmitters (described in section 9.22) act as an ancillary electronic positioning system.

28 A traveller transportation system as described in claims 1 to 27 in which the electronic positioning system is capable of providing a locational accuracy to within 10 metres when operating at optimum performance, so that communicator devices equipped with electronic positioning functionality can be located to within this distance.

29 A traveller transportation system as described in claims 1 to 28 which operates using pre-defined passenger pick-up (and optionally set down) points, each with a unique pick-up point reference code, in order to eliminate passenger pick-up point ambiguity (see section 9.16).

30 A traveller transportation system as described in claims 1 to 29 in which the electronic street navigation module operates in a similar manner to the self-contained in-car satellite navigation system, providing the vehicle driver with real-time street-by-street navigation directions which are based on the vehicle's current geographic location; such in-car navigation systems rely on a digitised street layout map, and use an electronic positioning system to provide current location data.

31 A traveller transportation system as described in claims 1 to 30 which rapidly processes incoming journey requests, so that when a prospective traveller submits a journey request on his communicator device, the controlling computer system marshals a fast response, organising a transit vehicle to collect the traveller typically within a time-scale of minutes in order to convey him along his specified itinerary (section 7.12 explains why a fast response is important).

32 A traveller transportation system as described in claims 1 to 31 which operates such that prospective travellers generally have their transit vehicles arriving to collect them within three minutes of submitting their journey request (section 7.12 examines the importance and theoretical feasibility of a three minute response).

33 A traveller transportation system as described in claims 1 to 32 in which the intelligent grouping module takes into account transit vehicle proximity to the prospective traveller: this means that when trying to place a new traveller into a transit vehicle, not only does the intelligent grouping module seek a vehicle with a good itinerary compatibility to the traveller, the module also tries to find a transit vehicle that is currently located in the vicinity of that traveller, enabling the transit vehicle to get to the traveller's pick-up point quickly.

34 A traveller transportation system as described in claims 1 to 33 in which the intelligent grouping module processes traveller journey requests which specify an immediate departure time as follows: the intelligent grouping module examines the current position and current itineraries of its transit vehicles en route (and any idle transit vehicles, if available), searching for a transit vehicle in the vicinity (a few minutes driving distance) of the traveller's pick-up point, and one into which the traveller can be intelligently grouped; when the intelligent grouping module finds such a transit vehicle for the traveller, this module revises the transit route of that vehicle so that it can pick up the traveller from the pick-up point specified in his journey request, and convey him and the other travellers on board the vehicle to their respective destinations (this method is useful when dealing with new journey requests in which travellers require immediate pick up and departure, and corresponds to the processing of class C journey requests described in section 7.1)

35 A traveller transportation system as described in claims 1 to 33 in which the intelligent grouping module may process journey requests some time in advance of the traveller's departure time, searching for a transit vehicle which *will be* in the vicinity of the traveller's pick-up point at (or close to) his departure time, and one into which the traveller can be intelligently grouped (this method is useful when dealing with batches of pre-order and regular order journey requests, and corresponds to the processing of class D journey requests described in section 7.1).

36 A traveller transportation system which combines the functionality described in claims 34 and 35, such that the intelligent grouping module has the facility to operate either of the two methods of processing journey requests described in these above two claims.

37 A traveller transportation system as described in claims 1 to 36 in which the intelligent grouping module has the ability to split a traveller's journey into different legs using two or more different transit vehicles (the need for split journeys is explained in section 9.2).

38 A traveller transportation system as described in claims 1 to 37 in which the intelligent grouping module has the ability to route, or, in the case of split journeys, partially route, a traveller itinerary via existing modes of public travel such as buses and trains as well as by taxibus or car pool transit vehicles; this enables this invention to seamlessly integrate with existing public transport (multi-modal travel is described in section 7.17).

39 A traveller transportation system as described in claims 1 to 38 in which the intelligent grouping module operates so as to aim to place at least 6 travellers into each transit vehicle: an objective of this invention is an ability to provide mass transportation of travellers without generating high levels of road traffic congestion: this objective depends on placing several travellers in each transit vehicle (obviously this only applies to transit vehicles of sufficient size, having 6 or more passenger seats; in particular we exclude car pool vehicles, most of which do not have sufficient seats to accommodate 6 passengers).

40 A traveller transportation system as described in claims 1 to 39 in which the intelligent grouping module intelligently groups travellers so that the Compatibility Index (defined in section 5.7) of their itineraries is typically less than 1.6 (measured when there are at least 6 travellers in the transit vehicle); a low value for the Compatibility Index is important to achieving one of the objectives of this invention: to provide a mode of public transport that for the door-to-door journey is quicker than existing public transport.

41 A traveller transportation system as described in claims 1 to 40 in which the intelligent grouping module intelligently groups travellers so that the Compatibility Index of their itineraries is typically less than 2 (measured when there are at least 6 travellers in the transit vehicle); this invention remains a very viable mass transportation system when the Compatibility Index is less than 2.

42 A traveller transportation system as described in claims 1 to 41 in which the intelligent grouping module performs its intelligent grouping calculations taking into account details of the current traffic speed on each road - that is to say, using a traffic-speed travel-time metric as described in sections 5.7 and 9.1.

43 A traveller transportation system as described in claims 1 to 42 wherein the intelligent grouping module operates in such a way that when a transit vehicle, for whatever reason, gets significantly displaced from its optimal transit route, or suffers a significant delay along this optimal transit route, the intelligent grouping module will be triggered to re-optimize the intelligent grouping in order to devise a new optimal transit route for that transit vehicle (see section 9.1).

44 A traveller transportation system as described in claims 1 to 43 in which the intelligent grouping module incorporates all the features described in section 9.1

45 A traveller transportation system as described in claims 1 to 44 which operates with a transit vehicle density of at least 10 vehicles per square mile in a large city; such scales of operation vastly improve the efficiency of this invention (see section 5.8) which is important to all the objectives of this invention stated in section 5.1.

46 A traveller transportation system as described in claims 1 to 45 which is designed to take advantage of the transportation efficiencies that arise at large scales of operation (scales such as 10 or more transit vehicles per square mile); three important transportation efficiencies materialise at a large scale of operation which

enable this invention to function in a manner that is not possible at smaller scales (see section 5.8).

47 A traveller transportation system as described in claims 1 to 46 which is designed to provide transportation coverage across a whole city; city-wide implementation is important for reducing city traffic congestion and air pollution.

48 A traveller transportation system as described in claims 1 to 47 which is designed to provide transportation coverage to a whole state or nation - widescale implementation is important to the environmental objectives of this invention in reducing air pollution and greenhouse gas emissions.

49 A traveller transportation system as described in claims 1 to 48 which preemptively marshals its transit vehicle fleet in order to geographically position the fleet in readiness to handle the expected traveller numbers arising from the morning and evening rush hours, from large-scale public events, and from similar situations where it is known in advance that there will be high concentrations of new travellers requiring transportation (see section 7.9).

50 A traveller transportation system as described in claims 1 to 49 which operates a system of automatic computer-calculated fare metering and charging for travellers using its transit vehicles: this speeds up journeys and makes travel more streamlined and convenient (see section 9.5).

51 A traveller transportation system as described in claims 1 to 50 wherein during its ordinary handling of traveller journey requests and in the control and orchestration of its transit vehicles, this invention works automatically without the need of human operators or assistance (when implemented in a large city this invention might operate tens of thousands of transit vehicles and receive thousands of journey requests each minute - far too many for human operators to handle, unless a huge number of operators are employed, which would be costly).

52 A traveller transportation system as described in claims 1 to 51 which operates using a central controlling computer system as described in the preferred embodiment (see section 7), but which also has the capacity to operate using a distributed controlling computer system as described in the second embodiment (see section 8), such that in the event of a failure of the central controlling computer system, the distributed controlling computer system will be able to take over, thus keeping the transit vehicle fleet in operation.

53 A traveller transportation system as described in claims 1 to 52 in which the controlling computer system will, on request, provide electronic street navigation to its users (passengers and vehicle drivers) even when they are not travelling by means of this transportation system.

54 A traveller transportation system as described in claims 1 to 53 in which the controlling computer system incorporates quantum computer hardware when

quantum computer technology becomes available: quantum computers are especially good at handling the non-polynomial calculations that can arise during the process of intelligent grouping.

55 A traveller transportation system substantially according to any embodiment hereinbefore described.

56 A traveller transportation system substantially according to any embodiment hereinbefore described with reference to the accompanying drawings.



INVESTOR IN PEOPLE

Application No: GB 0319353.9
Claims searched: 1-54

Examiner: Nigel Hanley
Date of search: 13 February 2004

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X,Y	1 at least	EP 0859346 A1 LUCENT - See whole document. Note use of customer and vehicle terminals in coordinated transit system.
X,Y	1 at least	US 5168451 A BOLGER - See whole document . Note the use of terminals in vehicles and for customer use and matching system.
Y	1 at least	US 4360875 A BEHNKE - See whole document. Note matching of requests to offered rides and billing mechanisms.
Y	1 at least	GB 2341708 A IBM - See whole document. Note method of matching traveller with a route in a car pool system.
Y	1 at least	DE 10033341 A DAIMLER - See Abstract- Note route/traveller matching using parameters including a comfort parameter.
X,Y	1 at least	ADART - "Autonomous Dial-A-Ride Transit" - Technical Overview - US Federal Transit Administration Report No FTA-TRI10-99-1- Nov 1998. <i>Note concept and consideration of technologies in providing an Autonomous Dial a Ride system.</i>
Y	1 at least	WALBRIDGE - "Real Time Ridesharing using wireless pocket phones to access the ride matching computer" - Pacific Rim Trans Tech Conference 1995 - ISBN 07803-3587-7 - PG 486-492 - <i>Note use of wireless communication devices in a cooperative transit system.</i>

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^W:

G4Q; G4A

Worldwide search of patent documents classified in the following areas of the IPC⁷:

G08G, G01C

The following online and other databases have been used in the preparation of this search report:

Online: WPI, EPODOC, JAPIO, INSPEC, ELSEVIER, TDB, Internet