Multimodality for people and goods in urban areas

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WP2.3 – Instant Mobility recommended infrastructures for pilots

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Instant Mobility WP2.3
D2.5 – Recommended infrastructures for pilots

WP23	Recommended infrastructures for pilots
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Deliverable Abstract

This report identifies required infrastructures to prepare pilots instantiation aiming to speed up the roll out of trials by an early identification of infrastructure requirements. Instant Mobility pilots will be experiments to provide quantitative proof that the system has potential to succeed on a full scale basis. They will be run during Phase II of the FI-PPP programme in real settlements with some geographical, technical and demographic limitations and with not commercial bias.

The document is organized around the 3 development scenarios defined by WP3: Travel companion, Smart city logistics and Transport Infrastructure as a Service. It presents the required infrastructures as regards data gathering infrastructures, data providers, communication networks, data management and computing infrastructures, service delivery infrastructures, terminals and in-vehicle equipment, Instant Mobility domain specific enablers, Future Internet generic enablers and other requirements.

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1. Introduction

1.1 Objectives of this document

WP2 objectives in Instant Mobility

The "Program Collaboration" work package aims at organizing the exchanges between the Instant Mobility project and the other projects of the FI-PPP programme. More specifically, this work package dedicates efforts to:

1. Organise the collection of Core Platform (FI-WARE) requirements regarding Generic Future Internet enablers.
2. Assume and identify common issues and challenges with the other Usages Area projects.
3. Identify, with Capacity Building and Infrastructure Support project (INFINITY), target infrastructures to prepare pilots in phase II.

Objectives of Deliverable D2.5

D2.5 "Instant Mobility recommended infrastructures for pilots" identifies required infrastructures to prepare pilots instantiation in phase II. The results presented are a consequence of WP3, WP4, T6.2 results as well as the relationship maintained with the Capacity Building and Infrastructure Support project (Infinity) fostering a faster and better adoption of pilots' results.

Experimental infrastructures

Instant Mobility pilots will be experiments to provide quantitative proof that the system has potential to succeed on a full scale basis. They will be run during Phase II of the FI-PPP programme in real settlements but with some limitations. These limitations will be geographical sometimes, other will be derived from the FI-PPP schedule, and in all cases pilots will not have commercial bias.

In the scope of INFINITY project, infrastructures refer to available testing sites across Europe that have been catalogued in XiPi [XiPi] exposing their components, target business scenario when limited and constrains for using the experimental infrastructure.

Impact on the other Workpackages

This deliverable aims to speed up the roll out of phase II trials by an early identification of infrastructure requirements.

1.2 Document structure and content

The document is organized around the 3 development scenarios defined by WP3 [IMD33]:

- Chapter 2 identifies the infrastructure requirements that a city must fulfil when aiming to deploy the "Travel companion" scenario.
- Chapter 3 identifies the infrastructure requirements that a city must fulfil when aiming to deploy the "Smart city logistics" scenario.
- Chapter 3.3.1 identifies the infrastructure requirements that a city must fulfil when aiming to deploy the "Transport Infrastructure as a Service" scenario.

Each chapter starts by summarizing the purpose of the scenario, continues by describing a typical deployment and follows by identifying all the required infrastructures organized around the following categories:

- Data gathering infrastructures
- Data providers
- Communication Networks
- Data Management and computing infrastructures
- Service delivery infrastructures
- Terminals and in-vehicle equipment
- Instant Mobility Domain Specific enablers
- Future Internet Generic Enablers
- Other requirements

In some cases, it must be taken into account that this report is being written 6 months before the end of the project and before the proof of concepts. Hence, some equipment has been selected provisionally and may be subject of variation. In those cases, the reader is warned.

Finally, chapter 5 presents the conclusions and outlines how this work would be continued when deploying a pilot.

1.3 Abbreviations

6LoWPAN	IPv6 layer over Low-power Wireless Personal Area Networks
A-GPS	Assisted Global Positioning System
API	Application Programming Interface
B2B	Business to Business
CCTV	Closed Circuit TeleVision
CEP	Complex Event Processing
DATEX	DATa Exchange
DBMS	DataBase Management System
DDS	Data Distribution Service
DSRC	Dedicated Short Range Communication
FI-PPP	Future Internet Public Private Partnership
GMLC	Gateway Mobile Location Centre
HSDPA	High Speed Data Packet Access
HTTP	Hyper Text Transfer Protocol
HTTPS	Secure Hyper Text Transfer Protocol
IaaS	Infrastructure as a Service
ICT	Information and Communication Technologies
IEEE	Institute of Electrical and Electronics Engineers
IM	Instant Mobility
IoT	Internet of Things

IPsec	Secure Internet Protocol
IPv6	Internet Protocol version 6
ITS	Intelligent Transportation Systems
KPI	Key Performance Indicator
LTE	Long Term Evolution
NFC	Near Field Communication
NoSQL	Not only SQL
OBU	On Board Unit
PTO	Public Transport Operator
REST	REpresentational State Transfer
RFID	Radio Frequency IDentification
SIRI	Service Interface for Real Time Information
SPAT	Signal Phase And Timing
SQL	Structured Query Language
TCP	Transmission Control Protocol
TOPO	TOPOgraphical maps
TPEG	Transport Protocol Experts Group
VM	Virtual Machine
XML	EXtensible Markup Language

2. Infrastructures for a Travel Companion Pilot

2.1 Summary of the scenario

The personal travel companion offers services for transport operators and human traveller's to provide and receive up-to-date information and to be guided in consequence. The scenario is aimed at multi-modal travel, mainly in urban and inter-urban areas. Long distances journey are also taken into account but as a more straightforward case. Travellers, drivers and transport operators will benefit from dynamic planning and follow-up during multimodal journeys:

- Travellers will be able plan and adjust in real time a multi-modal journey from door to door;
- Vehicle drivers will be able to easily book and execute ride sharing on their way to their own destination;
- Transport operators will get the complete information necessary to initiate demand driven transportation.

The specific services are:

- Dynamic multi-modal journey;
- Dynamic ride sharing;
- Optimized public transport usage.

2.2 Description of a typical deployment of the scenario

This section describes the typical deployment of the IM system in a Pilot city as far as the scenario 1 is concerned. Assuming that the cloud infrastructure is provided by Infinity (or its successor), there is little in term of hardware required by the city or the users themselves. It is assumed that users/travellers/drivers have a smartphone either Android or iPhone with 3G connectivity and GPS capabilities. On-Board Units for private drivers are not necessary, smartphones with windshield mounts can be used as a replacement.

The deployment will require first the selection of the population for the limited scale trial. A target of few thousands users a day seems reasonable and should not require significant processing power from the infrastructure (2 or 3 multi-cores servers). The selection of the population will be done in concert with the city. Some cities may have specific constraints with regards to the population selected (e.g. only civil servant for Istanbul). Also, the reward (if any) for private drivers taking up travellers has to be decided jointly with the city.

The second important step is the configuration of the system using data such as maps, transport timetables, etc. They are provided by the city, the transport operators or both. It should be noted that although Transport Operators or Traffic Management Systems may interface with IM for "live" updates, it is in no way required. Indeed, traffic flow and current timetable for Public Transport can be derived from the current travellers' location and speed.

With regards to ticketing and payment, these systems are typically the property of PTO and unless there can be a specific agreement with them to integrate IM with their system, it is assumed that ticketing and payments are managed separately (still IM should be able to give an estimate of the total travel cost).

2.3 Identified infrastructures

2.3.1 Data gathering infrastructures

Personal Travel Companion takes data about traffic and flows from external web services, like those designed in scenario 3. So in our perspective there are no specific requirements about this topic, beside those that are already identified by scenario 3.

2.3.2 Data providers

Open data (web services) that provide traffic flows info and related events is required. Data must be provided in a standard way, like XML and TPEG.

Open data (web services) that provide static and real time timetables and transport means arrival time. Also they should provide transport means real time position (to "look" where the transport mean actually is). Data must be provided in a standard way, like XML.

Finally, in order to support different transport infrastructures or traffic management systems, a standard interface to these systems is required.

For public transport operators, this interface is defined by the SIRI standard [SIRI]. For traffic management systems the interface is defined by the DATEX2 standard [DATEX].

Whereas DATEX2 interface is optional (since Instant Mobility can derive traffic information from travelers' locations and speeds), the SIRI "Production Timetables" service is required to receive information about the expected operation of the transport network for any specified day in the near future.

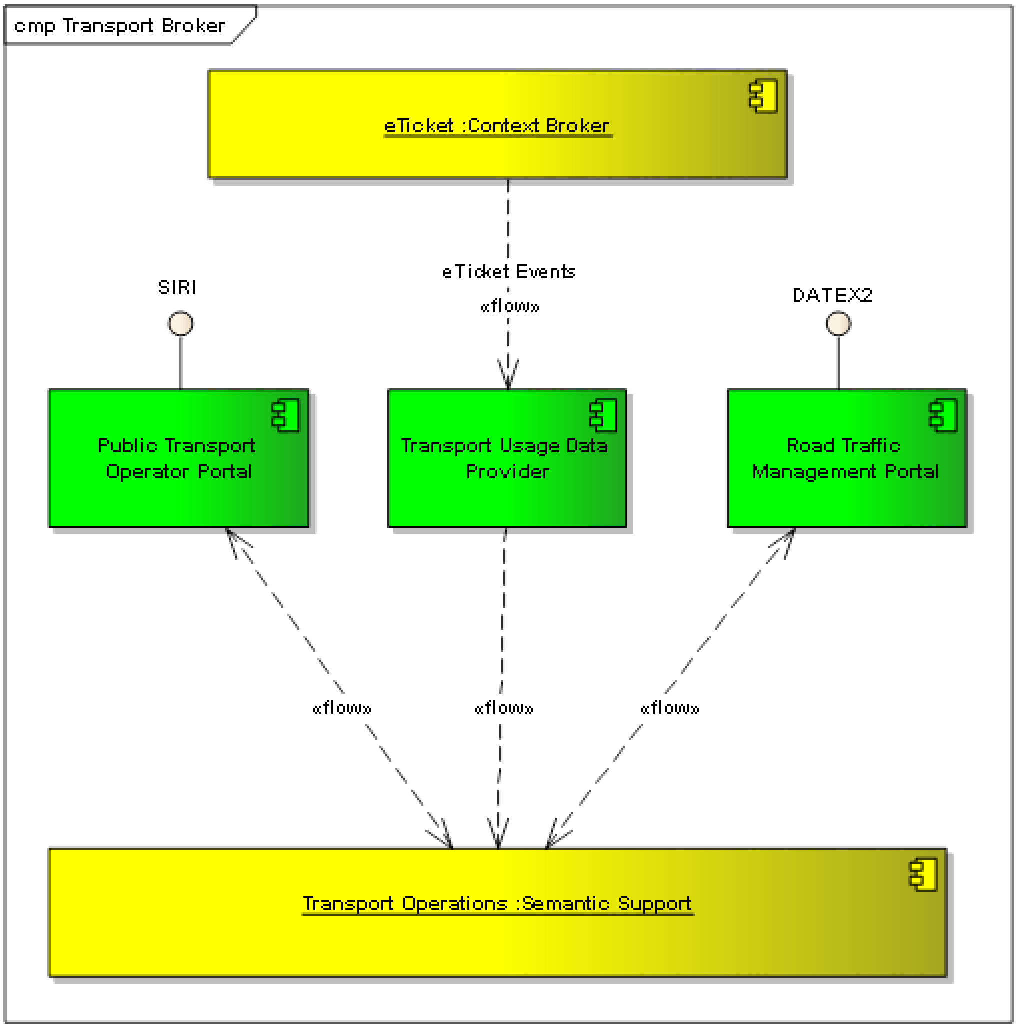

Figure 1: Instant Mobility Transport Broker

Figure 1:

2.3.3 Transport and Mobility Infrastructures

Personal Travel Companion takes data about traffic and flows from external web services, like those designed in scenario 3. So in our perspective there are no specific requirements about this topic, beside those that are already identified by scenario 3.

2.3.4 Communication Networks

The key communication network for a real deployment of the Personal Travel Companion scenario is the cellular network, being necessary HSDPA (or LTE where already present). Since pilots should be carried on in urban area we expect that this requirement should be easily satisfied.

Additionally, the presence of Wi-Fi networks is needed in areas where mobile network is not present, for instance subway station.

It is not expected that domain specific communication technologies, as for instance vehicle-to-x communication, will be used for Personal Travel Companion.

Finally, the scenario does not pose any special IP requirements.

2.3.5 Data Management and computing infrastructures

The platform should be grounded on a cloud computing infrastructure. Each different service composing the platform should provide patterns of distribution of their processing, together with the subsets of data that should be hosted closely to these computations. An intuitive sharding pattern would be geographical clustering. Other more sophisticated patterns should also be proposed. The current model for this scenario allows for a natural distribution of the platform over at least five nodes.

The exchange of information between services together with the synchronization of their parallel treatments should rely on REST Web services and should be DDS-compliant. An alternative would be to use an API allowing for the easy adaptation of single VM applications to multi-VM, such as Terracotta.

The data management can rely on one of the new NoSQL DBMS such as OrientDB, which allows to directly manipulating objects. It exhibits good scalability performances and access speeds up to 150.000 records per second.

2.3.6 Service delivery infrastructures

The service should be delivered in two ways. There should be a web portal to plan trips, and REST interfaces to access services. The server must be hosted in a suitable data center that can communicate with external services (e.g. public transport and traffic data web server). TCP port openness must be taken in account.

2.3.7 Terminals and in-vehicle equipment

End users willing to join the Personal Travel Companion scenario will need a Smart Phone equipped with 3G, Wi-Fi, and Bluetooth. At this stage of the project, only Android OS is supported and Nexus phone is recommended. In case of ride sharing, the Smart Phone will have also NFC support for authentication. In case of willing to use OBUs, Mirrorlink is also required. Tablets may replace smartphone, as long as they support the same feature listed above.

Regarding vehicle equipment, on board units (OBUs) are not mandatory; if present they must support MirrorLink, to display smartphone contents on OBU screen. In-vehicle map and navy system are not needed, the smartphone is used instead. Vehicle data may be used for ride sharing, so a proper mean to transfer data from vehicle to smartphone is needed.

2.3.8 Instant Mobility Domain Specific enablers

The Travel Companion Scenario consists of Instant Mobility domain specific enablers from the following sets of enablers:

- Multi-Modal Mobility subsystem should be installed in a proper data center with the capabilities described above.
- Personal Travel Companion subsystem will be used. Requirements derived from these enablers are reflected in Terminals and in-vehicle equipment requirements.
- Payment subsystem, in conjunction with PTO ticketing systems.

2.3.9 Future Internet Generic Enablers

2.3.10Other requirements

None has been identified.

3. Infrastructures for a Smart city logistics Pilot

3.1 Summary of the scenario

Smart city logistics are aimed improving city logistics operations with respect to safety, efficiency, environmental performance, and quality of service. It considers pick-up and distribution operations mainly relying on the use of trucks or delivery vans. The smart city logistics scenario considers the optimising of vehicle utilization, increasing consignee convenience by for instance flexible good drop off and eco-optimised driving.

The specific services are:

- Load sharing and optimising;
- Dynamic time/place drop point;
- Itinerary booking and real-time optimized route navigation;
- Eco-optimised driving, vehicle and driveline control.

3.2 Description of a typical deployment of the scenario

This section will focus on a potential implementation and deployment of the Smart city logistics scenario specifications that have been developed in the IM project. Due to the nature of the FI-PPP program that stipulates collaboration amongst usage area projects and is open for new consortia, the description of typical Smart city logistics aspects relies on the focussed vision of IM and especially this scenario.

This scenario will consider four specific services (see above) that will be operated in a consolidated way. This means that the services will be commissioned and operated in the same technical environment (e.g. cloud domain) that allows these services to also use parts of a different service. This will appear as a coherent single service to a user. E.g. a delivery van driver will experience that a parcel is dropped off at the customers desired location while the route to the customer is computed by the system automatically and the driving is assisted to be eco-friendly.

To translate this vision into deployment plan for early trials of the phase II or even the large scale trials of phase 3 of the FI-PPP program, there are some additional considerations to make:

IM is delivering a full architecture for an operational system which is established 4+1 views paradigm (See D4.1) [IMD41].

The Physical View on the system is relevant to understand the mapping of the functionality of this scenario onto different systems (e.g. mobile devices, backend servers). A potential implementation and deployment of this scenario needs to represent this. The following section (Identified Infrastructures) will explain these components in more detail.

A phase II deployment will present this scenario with a limited scope to some users. Although it will need to demonstrate that the chosen approach scales to a vaster user group in the following phase. This means that physical deployment of components needs to find a trade-off between challenging (resource intensive) and isolated installations and a broad deployment that brings Smart city logistic aspects to a full city.

In the IM project there are some cities and project partners involved that could form a good basis for a deployment of this scenario. To narrow down the choice of partners and cities it seems helpful to map the required infrastructure and services (see Identified Infrastructures section) to specific roles of these partners. This leads to key roles in a potential deployment:

There needs to be an operating consortium, team or partner that supplies the functional backend system to partners. As IM is delivering specifications and a limited amount of specific enablers this party will need to implement the specifications.

There needs to be a shipping operator that is willing to adapt the Smart city logistics services into existing business process. This partner also needs to agree to supply necessary data to the backend in return for the services. This partner will also need to cover the pragmatic steps to offer these services. E.g. advertise individual drop-off points as a service on the company's web site.

There is a need to consider specific hardware for this scenario. The mobile terminals (see 3.3.7) could be established by using the on board devices that have been developed in other EC-funded projects, such as PRE-DRIVE and DRIVE. A light weight alternative might be the use of smart phones. An embedding of the functionality in proprietary mobile terminals of the shipping operator seems also plausible. The hard- and software needs to be provided by partners. This could be a system integrator or a vehicle OEM.

There are additional roles (e.g. telecommunication operators) which are required, but those are "of-the-shelf" services and not specific for this scenario.

If IM would be continued for Phase II with the same partners (including cities), the following example could be a realistic vision for a typical deployment of the Smart city logistics scenario:

> DHL in the Madrid area functions as the shipping operator for the nearby city of Toledo. DHL agrees to provide the individual shipping data (destination etc.) to the IM system instance that is hosted by Telefonica. In return DHL is equipping the staff in the last mile delivery with android based smart phones that e.g. help to locate the individual drop off point for each parcel. Smart terminals on-board of the delivery vehicle could be installed by VOLVO and VALEO to provide eco-driving and online routing.

Other partners might be involved in different cities.

3.3 Identified infrastructures

3.3.1 Data gathering infrastructures

For the "Smart City Logistics"-scenario no data gathering infrastructure, like inductive loops, CCTV, automatic number plate recognition systems are foreseen.

Goods tracking systems are however likely to be used. Today, RFID remains state-of-the art, meaning that RFID-readers will be part of the goods sensing infrastructure. In the high end logistics segment, IP-based Internet-of-Things technologies are making an entrance. IEEE 802.15.4 is a standard radio technology for low-power, low data rate applications designed to enable transceivers of low complexity and low cost, which makes it relevant to intelligent goods applications. If these technologies are used in the field trial, routers with 802.15.4 will be used to gather information from the goods.

3.3.2 Data providers

Geographical information systems are used both in the vehicles, in the form of a navigation system fully integrated with the transport management system and at the back-office for route planning and transport itinerary processing purposes.

3.3.3 Transport and Mobility Infrastructures

One of the ideas of the "Eco-Optimized Driving"-application is to give eco-driving advice based on information about traffic light signal phase timings (SPAT) and intersection geometries (TOPO). The traffic light signal phase timings can be received either from physical road side units, over the 802.11p protocol or from virtual road side units in the cloud.

3.3.4 Communication Networks

Several communication technologies are used in the "Smart City Logistics"-scenario. The "Eco Optimized Driving"-application can use 802.11p to receive information about intersection topologies and traffic light signal phase and timing in order to give eco-drive advice when approaching traffic light. It can also use

802.11p to receive cooperative awareness messages from other vehicles to give eco-drive advice when approaching congestions.

Cellular communication technologies, such as 3G or LTE are used by the in-vehicle system to exchange information with services deployed in the cloud.

To support intelligent goods technologies, IPv6 will be needed. IPv6 features foreseen are neighbour discovery protocol, auto configuration and IPSec. The radio technology most likely to be used is IEEE 802.15.4. 6LoWPAN will likely be used to provide IPv6 over 802.15.4.

3.3.5 Data Management and computing infrastructures

For data management a document oriented database was considered a good fit. MongoDB was selected because of it auto-sharding features, which provides seamless scaling to 1000 nodes and automatic failover without any single point of failure. The number of nodes needed will, of course, depend of the size of the pilot. Data generated by a smaller pilot may very well fit into a single MongoDB node.

The cloud computing infrastructure will also be used to deploy the application logic and the web-servers serving the web portals. The number of virtual machines of course again depends on the scale of the pilot. A minimum deployment could be one virtual machine for the transport exchange services and one virtual machine for the eco-drive services. Next step up would be to have the web front ends and database instances on separate virtual machines (six VMs total). Next step up again would be to have separate instances for the business processes based on geographical regions. The software stack is Linux/Java/Tomcat.

3.3.6 Service delivery infrastructures

The services in the “Smart City Logistics”-scenario will be delivered through a combination of smartphone application marketplaces (such as Google Play) for the mobile applications, such as the consignee smartphone application and web portal for web applications such as the transport exchange portal and eco-drive portals.

3.3.7 Terminals and in-vehicle equipment

The in-vehicle installation consists of CAN-gateways to supply vehicle sensor data to the in-vehicle terminal unit. The terminal unit used depends on the vehicles selected for the pilot and whether all functionality or a subset is selected. A smartphone or tablet equipped with the latest available Android is a flexible solution with a limited effort needed for installation.

The consignee in the “dynamic drop point” application preferably also uses a smartphone application to select the drop-point time and location. For this application one or two of the leading smartphone platforms can be targeted, depending on the size of the pilot.

In order to access the transport exchange portal and the eco-drive portal, the only requirement is that the terminal supports a recent standard compliant web browser.

3.3.8 Instant Mobility Domain Specific enablers

The “Smart City Logistics”-scenario consists of Instant Mobility domain specific enablers from the following sets of enablers:

- multi-modal journey optimization enabler: for route planning
- vehicle and handheld devices enabler set: interfacing with in-vehicle network, consignee’s smartphone application
- goods transport operators’ enabler set: transport exchange portal, eco-drive portal, in-vehicle transport management service
- traffic management enabler set: interfacing with traffic infrastructure, virtual road side units etc.

3.3.9 Future Internet Generic Enablers

During work package 4, FI-WARE enablers of relevance for Instant Mobility were identified. For the "Smart City Logistics"-scenario the following FI-WARE enablers were considered to be of special interest:

- Big Data Analysis: Provides MongoDB instances
- Identity Management: Authentication and authorization of web applications and RESTful web services
- Location Platform: For retrieval of location of mobile terminals
- Internet-of-Things Gateway Data Handling: For collection of eco-drive data from the vehicles

3.3.10Other requirements

In order to be able to operate the cloud based services from within a corporate network with restrictive IT security policies, the cloud management tools must be accessible on standard ports for HTTP or HTTPS (80 or 443).

4. Infrastructures for a Transport Infrastructure as a service Pilot

4.1 Summary of the scenario

The transport infrastructure as a service provides online traffic and infrastructure management. Dynamic traffic management and integrated urban space management will be virtualized and based on Future Internet technologies such as cloud data storage, cloud computing and virtualization or services-in-the-cloud. Transport infrastructure as a service defines the online traffic and urban management generic enablers to improve the levels of mobility on the roads by acting as B2B services (e.g., provision of accurate real-time traffic information for mobility services such as routing information).

The services contain both information collection and exchange and service provision:

- Real-time traffic and route information;
- Floating passenger data collection;
- Virtualized intersection intelligence;
- Cooperative traffic signal control;
- Area wide optimization strategies.

4.2 Description of a typical deployment of the scenario

This scenario consists of five services (or applications) as shown above. Some of these five services may be implemented individually. Some of them can only be implemented after other services are available. However, a consortium can also choose to group some of the five services together for implementation.

Few options can be suggested:

- Implementing floating passenger data collection only;
- Implementing virtualized intersection intelligence only;
- Implementing real-time traffic and route information + virtualized intersection intelligence + cooperative traffic signal control;
- Implementing real-time traffic and route information + virtualized intersection intelligence + cooperative traffic signal control + area wide optimization strategies;
- Implementing all five services.

4.2.1 Implementing floating passenger data collection only

Floating passenger data collection is a new concept. It is similar to floating car data collection. While floating car data collection was enabled by in-vehicle tracking systems and low cost of wireless communication. One of the key benefits of floating vehicle data is that the data collection does not require cooperation with road operators. Floating passenger data is enabled by increasing usage of smart phones. There are two options for floating passenger data collection:

- Based on mobile phone data only (based on mobile phone location technologies);
- Based on mobile phone data and in-vehicle reading devices (e.g. Bluetooth reader)

Floating passenger data collection can be implemented as an independent service in any cities with any specific requirements for infrastructure. If the floating passenger data collection is based on mobile phone only, a consortium to implement this service must include:

- A mobile phone operator
- An organization who has expertise to handle huge data and is able to carry out data mining

The mobile phone operator may collect its users' location information in a city, identify who are public transport users by analyzing the behaviors, then future analyze those users' location data to extract floating passenger information. This can only be applied to surface transport only. The accuracy may not be ideal. This scenario does not require any additional hardware installation.

Implementing Floating Passenger Data Collection (choice 1)
A Typical Deployment Scenario is: The mobile phone operator authorizes a data processing company to use its user location data. Key technical requirements are: - Able to locate a user based on mobile phone data; able to from the location data to extract movement of the user; - Able to distinguish public transport users from car drivers, pedestrians and cyclists by using the mobile location data; Information required are: - Market penetration rate of the mobile phone operator; - Percentage of the public transport users who hold a mobile phone from the mobile phone operator The consortium analyses user's location data and identify public transport users. Based on such data, it is possible to estimate number of passengers and their usage of the public transport systems (e.g. O-D, interchanges etc.)

If the floating passenger data collection is based on mobile phone data and in-vehicle reading devices, a consortium to implement this service must consist of:

- A public transport operator owning a public transport vehicle fleet (bus, tram, metro, train, etc.);
- An organization who has expertise in software development (e.g. for mobile devices) and hardware installation;
- An organization who has expertise to handle huge data and is able to carry out data mining

This scenario will include hardware installation. The public transport operator should equip a number or all of its fleet with an in-vehicle reading device to be able to read all passengers' smart phone data, thus collecting floating passenger data.

Implementing Floating Passenger Data Collection (choice 2)
A Typical Deployment Scenario is: The public transport operator should equip a number or all of its fleet with an in-vehicle reading device to be able to read all passengers' smart phone data, thus collecting floating passenger data. Key technical requirements are: - In-vehicle reading device should be able to read all smart phone, thus identify a passenger entering the vehicle and leaving the vehicle; Key information required is: - Percentage of passengers who have smart phones This scenario, although involving with hardware installation (therefore, the cost may be higher), may give a better estimation of floating passenger. However, since cooperation with public transport operator is essential, it may have only limited applications.

4.2.2 Implementing virtualized intersection intelligence only

Implementing virtualized intersection intelligence will require cooperation from a city authority who is the owner of traffic control system. Deployment of this service does not require any additional roadside equipment to be installed. However, it will require in-vehicle systems which may be a handset device. Therefore, a consortium should have experts for in-vehicle system (or for handset device) and for traffic control and management.

Implementing virtualized intersection intelligence
A Typical Deployment Scenario is: The local authority should agree to switch off a number of traffic lights at selected intersections. The consortium should equip vehicles that pass those intersections with on-board unit. The on-board unit can be a handset device, i.e. smart phone. The handset device will act as virtual traffic light to inform drivers how to cross an intersection. Key technical requirements are: - On-board unit should be able to provide virtualized traffic signal to a driver; - On-board unit should be able to provide two-way communication with back-office - Back-office should be able to process all data sent from vehicles and then give them instruction how to cross an intersection.

4.2.3 Implementing real-time traffic and route information + virtualized intersection intelligence + cooperative traffic signal control

Implementing real-time traffic and route information + virtualized intersection intelligence + cooperative traffic signal control will be an excellent approach to demonstrate future internet to make transport infrastructure as a service. This implementation may be even easier than implementation of virtualized intersection intelligence alone since this implementation will not require a large number of vehicles, i.e. the consortium can choose to install a number of vehicles, and choose to keep traffic light running. The deployment will include install roadside equipment for cooperative traffic signal control and set up a back office. The consortium must have an approval from city authority and/or operator of traffic control system of a city. The consortium should also have expertise for traffic management and control, traffic signal systems, cooperative communication (short-range communication) and real-time traffic information and navigation.

Implementing real-time traffic and route information + virtualized intersection intelligence + cooperative traffic signal control
A Typical Deployment Scenario is: The local authority or operator of traffic control system should agree to allow the consortium to work with some traffic lights of the city network. Roadside requirements may be installed to be used for computing and short range communication with on-board units. This, however, can also be done through central computing or long range communication. The consortium can decide which technologies to choose. The on-board unit will provide the following functions: • To provide real-time traffic and route information; • To guide the vehicle to pass an intersection; • To inform driver traffic signal setting and may provide recommended driver speed (optional)

Key technical requirements are:

- On-board unit should be able to provide the above functions;
- Roadside equipment for communication and computing for traffic signal control;
- Back-office should be able to process all data sent from vehicles and/or roadside equipment, then calculate traffic light setting and disseminate such information

The deployment process may be illustrated by the following figure:

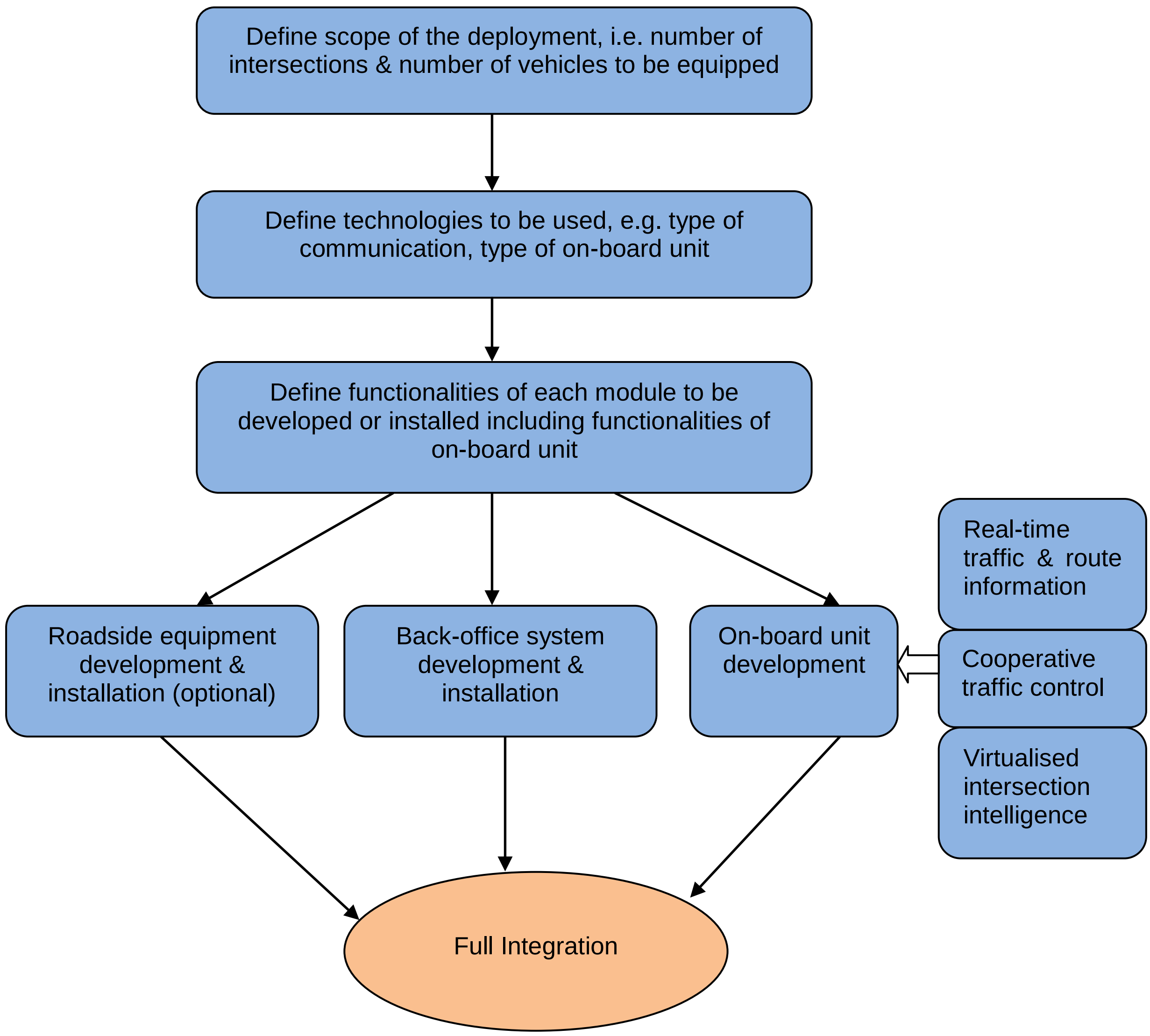

Figure 2: Deployment for real-time traffic and route information + virtualized intersection intelligence + cooperative traffic signal control

4.2.4 Implementing real-time traffic and route information + virtualized intersection intelligence + cooperative traffic signal control + area wide optimization strategies

Implementing real-time traffic and route information + virtualized intersection intelligence + cooperative traffic signal control + area wide optimization strategies will be a complex deployment. It will have to cover the whole network of an area and all vehicles in the area. The area wide optimization strategies must be supported by installations of real-time traffic and route information and can be enhanced by virtualized intersection intelligence and cooperative traffic signal control.

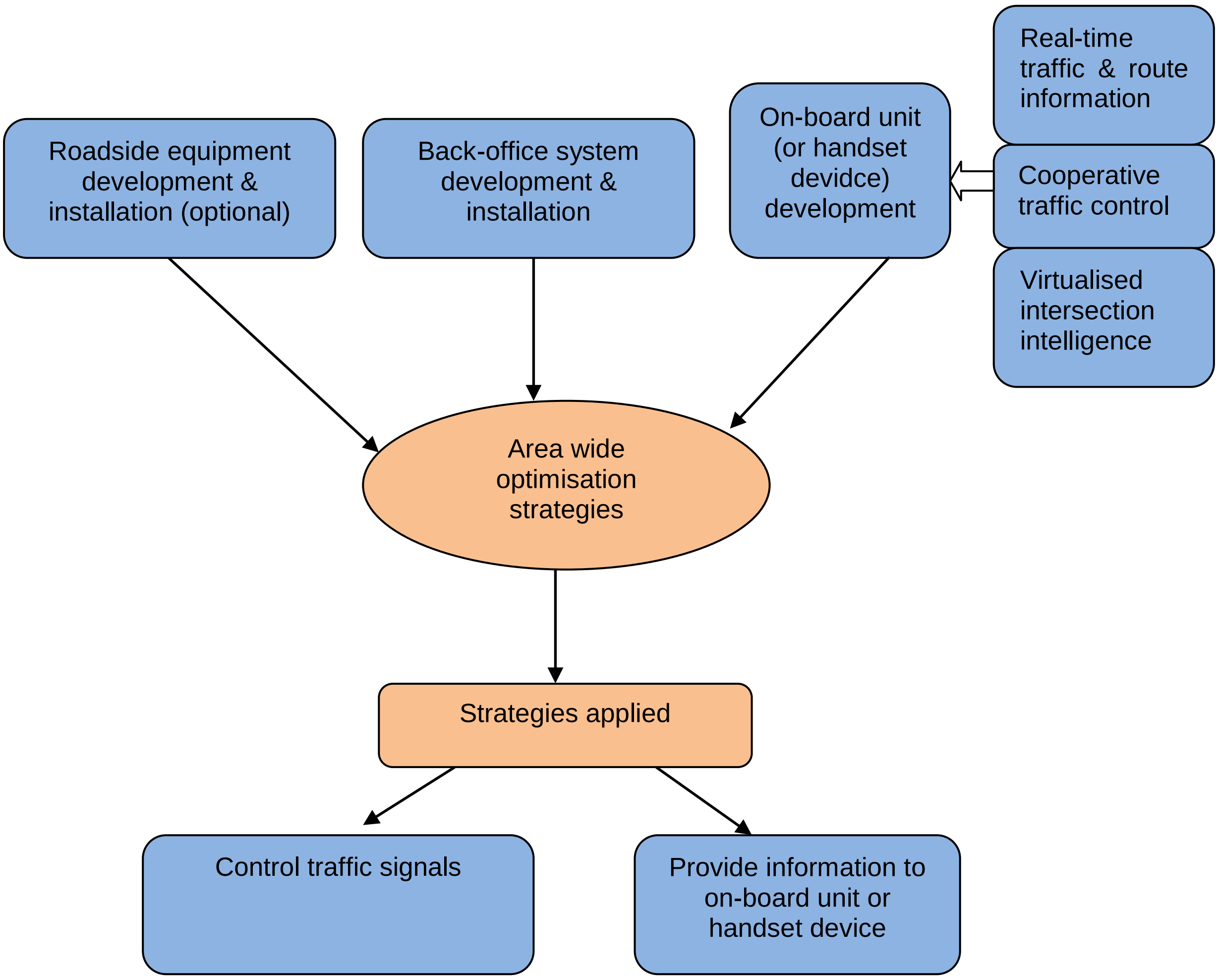

Figure 3: Deployment for real-time traffic and route information + virtualized intersection intelligence + cooperative traffic signal control + area wide optimization strategies

4.2.5 *Implementing all five services*

Note that the above implementation scenarios separate public transport and car traffic. However, it is possible to integrate all traffic by implementing all the five services. That will make a fundamental difference by enabling the following functions:

- Dynamic bus priorities based on number of passengers. For example, if a bus is rather empty, although the bus is behind schedule, a priority may not be given or only a lower priority will be given.
- Dynamic information to travellers (including car drivers) on situation of public transport operation such as estimated travel time, departure/arrival time, and number of empty seats or level of services.

To implement all the five specific services, a consortium must have all expertises mentioned above and cooperation with public authorities and public transport operators are essential. A consortium may include:

- City authority (owner of a traffic control system) and/or operator of traffic control system;
- Public transport operator (owner of public transport vehicles);
- Companies who have expertise on traffic control system;
- Companies who have expertise on communication, on-board unit (or handset device);

- Companies who can handle a large set of real-time data;
- Companies who can equip hardware (on-board unit and roadside equipment)

The overall deployment may be illustrated as below:

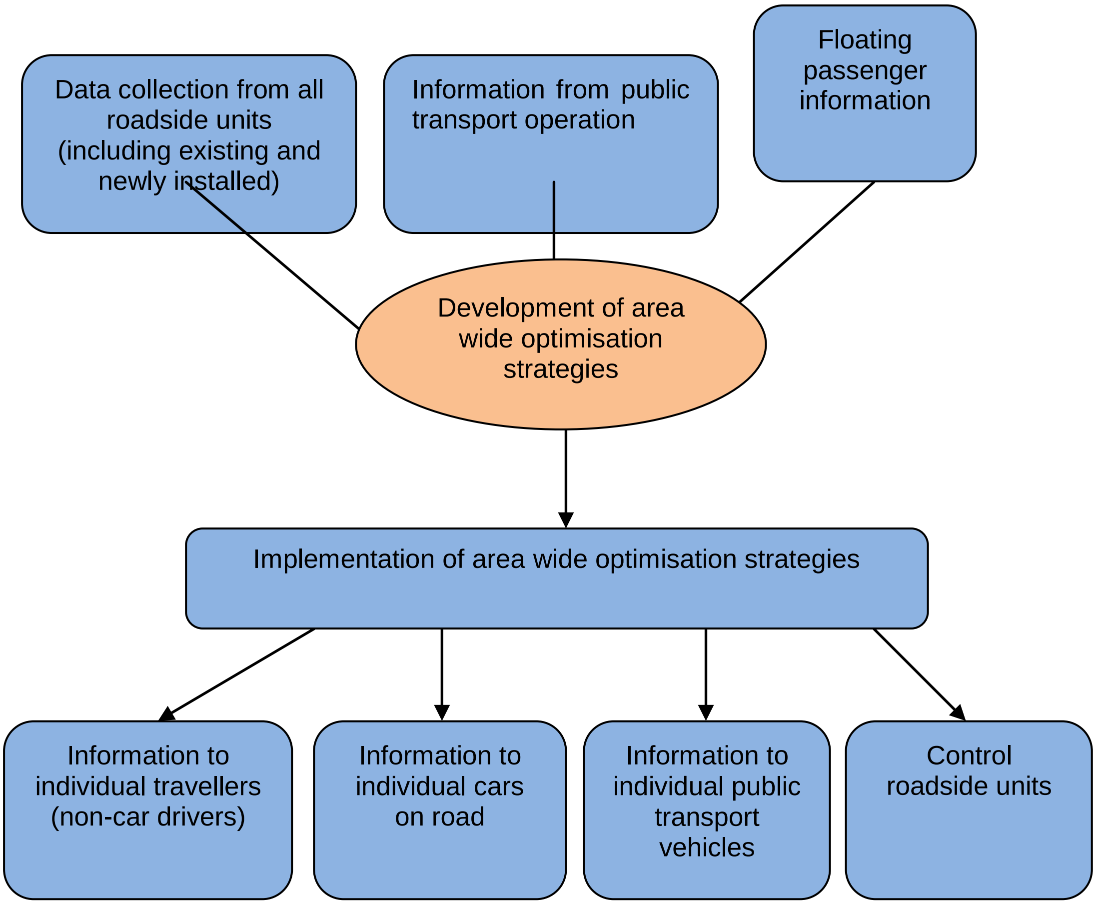

Figure 4: Deployment for all the five services

4.3 Identified infrastructures

4.3.1 Data gathering infrastructures

There are two approaches to implement the floating passenger data collection. The first one requires that public transport passengers are equipped with mobile phones and that the mobile network operator is equipped with a localization platform (e.g. GMLC). The other one is that passengers' mobile phones as well as public transport vehicles are equipped with Bluetooth.

In parallel, it is expected that Public Transport operators continue using in-vehicle tracking systems to collect data from their fleets and that public authorities continue using domain specific technologies such as inductive loops, DSRC beacon-based technologies and CCTV. However none of these infrastructures is strictly required by Instant Mobility system.

4.3.2 Data providers

The scenario requires the integration of open GIS (OSM) to traffic management's platform.

4.3.3 Transport and Mobility Infrastructures

Virtualized intersection intelligence service uses the existing traffic control system and does not requires additional road side units.

For cooperative traffic signal, a special road side unit connected to the back office (through mobile network for instance) and connected to OBUs (through short range communications) is needed.

4.3.4 Communication Networks

Mobile networks, such as 3G or LTE, will be used for information diffusion enabled by scenario 3 mainly. LTE will enable fast inter-cell communication and therefore the extension to safety applications. Mobile communication networks will be used by OBUs, smartphones replacing OBUs, passenger's mobile or smartphones used to localize people, and road side units.

Wi-Fi networks may also be used in some cases.

Regarding Vehicle-to-X communications, ETSI 802.11 p (DSRC) or IoT replacement has still to be evaluated.

4.3.5 Data Management and computing infrastructures

For deploying virtualized intersection intelligence and cooperative traffic signal control, a back-office able to process all data sent from vehicles and/or roadside equipment, then calculate traffic light setting and disseminate such information is needed. For data storing, a document oriented NoSQL database possibly complemented with a relational database such as PostgreSQL (commonalities and foreseen collaboration with Scenario 2 - to be evaluated) is necessary.

For floating passenger data collection an organization, e.g. a mobile operator or a big data provider, able to handle huge amounts of data and perform data mining is needed to distinguish Public Transport usrs and analyze behaviours.

Finally, the cloud computing infrastructure is required. Each VM can run multiple virtual road-side units. In the case of simulation (prototype) the simulation environment could run on a separated VM.

4.3.6 Service delivery infrastructures

Services delivery could be done through an ad-hoc B2B marketplace, defined in accordance to envisioned business models and to the functionalities of the FI traffic control center.

4.3.7 Terminals an in-vehicle equipment

For floating passenger data collection, passengers have to be equipped with a mobile or smartphone. In case of choosing to gather passengers information through Bluetooth instead of mobile network localization service, dedicated hardware must be installed in public transport vehicles.

For the real time traffic information, virtualized intersection intelligence and cooperative traffic signal control an OBU or smartphone is required. The OBU or smartphone will guide the driver how to pass the intersection without attending traffic light. OBU or smartphone must be able to send and receive data from backoffice through the mobile communication network. The project is currently evaluating the possibility to integrate data from most OS for SmartPhones/Tablets with 3G connection. We are still working with scenario 1 in order to evaluate all the possibilities about nomadic devices and their interaction with scenario 3 data exchange functionalities.

4.3.8 Instant Mobility Domain Specific enablers

The key block for this scenario is the Traffic Manager subsystem (Traffic Management enabler set). Besides, data collection and information provision need the following Instant Mobility enablers:

- Multi-Modal Mobility subsystem (Multimodal Journey optimisation enabler set).
- Personal Travel Companion subsystem (Driver & traveller enabler set).

- Public Transport subsystem (Public transport operators' enabler set).

The integration of Goods Transport Manager Subsystem with traffic management is being investigated.

4.3.9 Future Internet Generic Enablers

During work package 4, FI-WARE enablers of relevance for Instant Mobility were identified. For the "Transport infrastructure as a service" Scenario the following FI-WARE enablers were considered to be of special interest:

- BigData Analysis GE. This enabler is used to process huge amounts of data, which have been previously stored or can be continuous unbounded and large streams of data that extract relevant insights on the go;
- Complex Event Processing GE. Is the analysis of event data in real-time to generate immediate insight and enable instant response to changing conditions. The technology and implementations of CEP provide means to expressively and flexibly define and maintain the event processing logic of the application.
- Publish / Subscribe GE. It enables the publication of events by entities, referred as Event Producers, so that published events become available to other entities, referred as Event Consumers, which are interested in processing the published events.
- Location GE. Targets any application, GEs in FI-WARE or any complementary platform enabler that aims to retrieve mobile device positions and Location area events. This GE is based on various positioning techniques such as A-GPS, WiFi and Cell-id whilst taking into account the end-user privacy.
- IaaS Service Manager. This GE is key component to provide an automated control solution over Virtual Machines through scaling up/down and in/out in an automated manner and helps to save valuable time/resources by automating management of failure tasks that need to be done repeatedly.

4.3.10Other requirements

Key requirements for Scenario 3 infrastructure are represented by communication network latency and QoS, which has to be defined according to the critical parameters of each application (e.g. traffic control).

5. Conclusion and Future Work

Two main conclusions can be extracted from this report.

First of all, it clearly identifies the set of requirements that experimental infrastructures must fulfill for a potential deployment of any of IM scenarios through chapters 2.3, 3.3 and 4.3. The report provides a holistic vision, including not only ordinary ICT equipment and networks but also ITS equipment, Instant Mobility components and Future Internet Generic Enablers. On one hand this work enables a potential tester as service provider to quickly set up an experimentation site and to select the best infrastructure among Instant Mobility cities or among those that are published in INFINITY catalogue [XiPi]. On the other hand, it may be used by a city willing to be considered as experimental infrastructure to asses it suitability or required investment to reach the necessary state.

Secondly, this report explains how each scenario, and its services, should be operated in a consolidated way. This means that the services will be commissioned and operated in the same technical environment (e.g. cloud domain) that allows these services to also use parts of a different service. This will appear as a coherent single service to a user.

These results will be the starting point when setting up pilots during Phase II of the FI-PPP. The aim of the pilots will be to test the performance and operation of the Instant Mobility system from both technological and standard operation aspects in real environments.

Next steps, to be carried out for each pilot during phase II, are:

1. Selection of use cases and cities.
2. Elaboration of a deployment plan that includes use case implementation (who, what, when, how); infrastructures deployment including a pre-selection work and ensuring availability as well as compatibility; and testing of the infrastructure and the services.
3. Elaboration of an evaluation plan including KPIs, test procedures (preconditions, test sequence, and measures to be taken) that allows to assess Instant Mobility system.

6. References

[XiPi] Infinity database http://www.xipi.eu/home, last access on October 10th, 2012.

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