TOWARDS A FUTURE INTERNET PUBLIC PRIVATE PARTNERSHIP

SECOND USAGE AREA WORKSHOP, 21-22 JUNE 2010, BRUSSELS, BELGIUM

Transport, Mobility and Logistics usage area

Position Paper on issues and open questions to be addressed during the workshop on the **usage area of transport, mobility and logistics,** input from the research center IBBT.

(Q1) *What use case and scenario in your area would you consider the most appropriate and representative one for large-scale experimentation with the Future Internet platform to be built starting from 2013?*

In the European Union, traffic injuries are a major health problem. Each year, they are responsible for 40.000 fatalities and 2.000.000 injuries, at a cost of 160 billion euro. One of the means to tackle this problem are Intelligent Transport Systems, or ITS. These systems combine (wired and wireless) communication systems, innovative applications and services, integrated electronics and numerous other technologies in a single platform. In the ITS domain, Cooperative Systems are innovative applications that rely on vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication to increase the "time horizon", the quality and reliability of information available to the drivers about the road conditions and other vehicles and road users in their immediate environment. When approaching dangerous situations such as the tail of a traffic jam, an obstacle on the road or a ghost driver, ITS systems make it possible to warn drivers in time to avoid collision. Detected hazardous road conditions such as black ice or an oil trail can be automatically communicated to other drivers. Navigation systems can receive detailed real-time updates about the current traffic situation and can take this into account when calculating their routes. When a traffic distortion occurs, traffic centres can immediately take action and can actively influence the way that the traffic will be diverted. This is just a small selection from the large number of applications that are made possible because of ITS systems, but it is obvious that they have an important social relevance, both on the level of the environment, mobility and traffic safety.

(Q2) *What innovative Internet functionality and technologies would you consider important for your suggested use case and scenario (e.g. context awareness, sensor networks, advanced real time processing capabilities handling huge volume of data, ad hoc service composition and mash-up, managed broadband connectivity and services, embedded media support for interfaces easing the interpretation of processed contextual data, etc.)?*

To realise ITS systems on a large scale, the following technologies and functionalities are indispensable:

- Vehicular Ad-Hoc Networks (VANET) are specific ad-hoc networking protocols that interconnect vehicles and road side infrastructure equipped with local wireless communication technology (such as the IEEE 802.11p standard). These VANET protocols have to meet some specific challenges such as the rapid topology changes, frequent fragmentation and limited redundancy possibilities. They have to be able to cope with high network densities under limited bandwidth constraints, and should consume energy efficiently when using mobile devices for vulnerable road users. They have to support both broadcast and unicast data traffic, and should also enable addressing of network nodes on a geographic basis. In all these circumstances, the VANET protocols have to guarantee that they can meet the stringent requirements of cooperative safety applications regarding delay, reliability, security and privacy.

- Complete IPv6 support in the mobile data networks. When targeting a large-scale introduction of vehicular internet connectivity, an enormous amount of extra IP addresses is required. Therefore it is essential that current and future mobile data networks provide IPv6 support to the end users.
- Distributed real time safety applications can process the information received from other vehicles and road side infrastructure, assess possible hazardous situations, and take appropriate measures such as warning the driver, applying the brakes, etcetera. Critical performance parameters of these applications are reliability and timeliness.
- Advanced real time processing capabilities handling huge volumes of data. Vehicles equipped with Internet connectivity can provide data to central services for further processing. Because of the high number of vehicles, this can lead to huge volumes of data, requiring both adequate network and processing capabilities. Examples of such services are traffic control centers, which automatically build a complete view on current traffic conditions, detect distortions, define appropriate measures and communicate them directly to the proper roadside infrastructure or vehicles. Other examples of such services are advanced routing engines such as multimodal transport planners or probabilistic routing engines.

(Q3) *Which of the identified functionalities would you expect the Future Internet core technology platform to deliver to support your and other usage area scenarios?*

The core technology platform should provide the following functionality:

- End-to-end IPv6 support
- Flexible networking approach that provides researches the mechanisms to easily deploy and experiment with new (VANET) networking protocols.
- Standardized onboard and roadside unit, with cost-optimized installation procedures.
- Application provisioning service to provide new applications on the onboard and roadside units.

(Q4) *What kind of experimentation environment would you consider necessary for broad large scale testing of the platform to be developed in your use area? What would be needed to experiment new services and applications cutting across use areas (services and application mash-up) and building a new services and application ecosystem around the prototype implementations of the platform?*

Large-scale testbeds and Field Operational Test environments are indispensable for the validation of the ITS developments. In a large-scale testbed, both specific components and entire solutions can be tested in a realistic environment, but in a controlled and repeatable manner. It consists of a large number of fixed nodes, mimicking roadside units, and mobile nodes acting as on board units. The mobility of the nodes should be controllable, and could be implemented using mobile robots, miniature trains, etcetera. Preferably, this testbed should consist of a few hundred nodes. These should be complemented with the infrastructure to test centralized services operating on floating car data.
Field Operational Tests (FOT) are also vital for the validation of ITS solutions. During these tests, onboard units are installed in the vehicles of test persons. These can be their own

vehicles, in which case attention to a non-intrusive installation procedure is critical, or vehicles belonging to the project that are provided to the users for the duration of the test. Tests typically span a period of several weeks or months, and provide not only feedback regarding the technical functionality in the most realistic conditions, but also the perception of the application by the users. FOTs can be performed on a small scale for pure functional testing of the developed solutions. However, they are most useful when organized on a much larger scale, incorporating several hundreds of vehicles, combined with roadside unit coverage of large areas such as an entire city. Only such large-scale field trials can provide profound insights in both the technical and user-oriented aspects of novel ITS solutions.

(Q5) *How do you see the potential role of your organisation in the FI-PPP, in the context of Usage areas taking a prominent role in the Initiative, to ensure an appropriate application driven approach.*

IBBT (Interdisciplinary Institute for Broadband Technology) is engaged since its beginning in 2005 in user-centred inter-disciplinary research. The research projects initiate explicitly from the user needs and the analysis of the user's expectations. Effort is being made at the kick off of the projects, in order to make all non-technical issues explicit in the research track, such as: user-centric design, usability, legal issues, value network analysis, techno-economical issues, potential factors inhibiting future valorisation. Close collaboration in-between technical research groups, non-technical research groups, industry and user communities are built-in into the IBBT GBO and ICON project structure. IBBT has built-up valuable knowledge in the area of inter-disciplinary research methodologies.

In the domain of Intelligent Transport Systems, these competences can contribute to further research of several of the identified required functionalities, technology and experimentation environments. In the VANET domain, IBBT has built up expertise during the IBBT Next Generation ITS project. Solutions were implemented and tested on simulators, a large-scale indoor testbed with fixed nodes and a small-scale vehicular testbed. Based on this experience, IBBT can conduct further research to design and validate VANET protocols that meet all the imposed requirements. In the domain of distributed real time safety applications, IBBT can rely on an extensive track record regarding the research of distributed software in domains not related to ITS. Regarding advanced real time processing capabilities handling huge volumes of data, the expertise of IBBT can be mainly situated in the domain of advanced routing engines. In several IBBT projects, both multimodal transport planners and high-performance historical route planners have been successfully developed.

IBBT has also gained valuable experience in the development of experimentation environments. The IBBT iLab.t is an advanced testing infrastructure enabling technical evaluation of a large variety of ICT innovations. Two of the most important components of the lab are the Wireless Lab and the Virtual Wall. The Wireless Lab is an extensive facility that consists of 400 802.11 wireless mesh network nodes, and 200 sensor nodes, installed at 200 fixed locations at IBBT office premises. These nodes are centrally managed and can be easily configured. The IBBT iLab.t Wireless Lab could be used as a basis for the development of the required large scale ITS testbed as described in Q4. The other component, the Virtual Wall, is a generic test environment for advanced network, distributed software and service evaluation. It provides the capacities to test applications on a large scale in realistic network topologies. It consists of 100 high-performance nodes interconnected via a non-blocking Ethernet switch. The Virtual Wall features Full Automatic Install for fast context switching, as well as remote access. The Virtual Wall could be used as a basis for the required large scale testbed functionalities targeting the centralised services operating on the floating car data, as described in Q4.

Another relevant lab within IBBT is iLab.o, which designs, coaches and supports living labs. It has profound knowledge regarding procedures to setup a community of test users, manage them and perform rapid prototyping of envisaged applications. These competences could be utilized for the organisation of ITS Field Operational Tests.

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APPENDIX: TRANSPORT, MOBILITY & LOGISTICS RESEARCH AT IBBT

Increasing traffic volume, ever growing traffic jams, optimal use of infrastructure, traffic safety, eco-friendliness, traffic management, interactive – intelligent – intermodal travellers, sustainability... Each and all elements in which innovation in logistics and mobility plays an important role. IBBT wants to help to keep our society on the move by stimulating research into smarter transport and detection systems, integrated logistics chains and ICT innovations. IBBT has taken up the challenge of working with the public and private sector to investigate and develop fundamental innovations in the broad field of mobility and logistics. Two of the most remarkable innovations are further discussed in this document: Advanced Traffic Routing, and Intelligent Transport Systems (ITS).

Advanced Traffic Routing

IBBT has a strong interest in research areas related to Advanced Traffic Routing. Within this domain, IBBT has gained profound expertise in the following applications: multimodal routing and probabilistic routing.

A multimodal routing engine combines several transportation networks (road transport, rail transport, inland shipping, etcetera) when calculating the optimal route to transport goods to a given destination. The algorithms do not only take travel times into account, but also other factors such as transfer times when goods are transferred from one means of transport onto another, operating hours of inland shipping locks, available temporarily storage sheds, real time availability information of different transport modi, cost of transportation, and so on. In the MultiTr@ns project, IBBT developed a fully functional prototype of such a multimodal router. This router was connected to a specific developed agent platform that in real time gathers information regarding availability of different transport modi, the location of tracked goods, etcetera. Using this information, in combination with the different applicable transportation networks, enabled the calculation of highly efficient multimodal routes for the transport of goods in a fully integrated supply chain.

A probabilistic routing engine does not use fixed travel times per road segment, in contradiction to current routing engines. These current engines start from the principle that it always takes the same amount of time to travel a given road segment, in all different circumstances. They store these travel times in a static database, meaning that they only very rarely change (e.g. in case of special circumstances such as road works). The probabilistic routing engine on the other hand uses real time traffic flow data, in combination with historical data regarding past traffic flow behaviour. This enables the calculation in real time of more realistic travel times per road segment. Besides, the algorithms do not longer calculate a single travel time, but they output several travel times following a certain distribution of probability. For instance, they can state that there is a 25% chance that it will take less than 5 minutes to travel a given trajectory, 50% chance that it will take less than 7 minutes, 75% that it will take less than 10 minutes, and so on. Based on this principle, the probabilistic routing engine can be utilized to provide different kinds output:

- Probabilistic route planning: the user selects a start and finish location on a map, and the routing engine suggests the route that has the highest probability to reach the destination quickly. Alternatives can be offered to the users to give them the choice between routes that are more reliable but have a higher travel time, or routes that are faster but are more sensitive to traffic jams, and so on.
- Probabilistic day charts: if the user wants to determine when the best time is to commence the journey to a given destination, the probabilistic routing engine can predict the best routes for an entire day. The result is a chart as displayed below, that clearly indicates the best times of the day to travel a given route. In the example, it

can be seen that the ideal departure hours are before 07.30h, or between 08.30h and 13.00h.

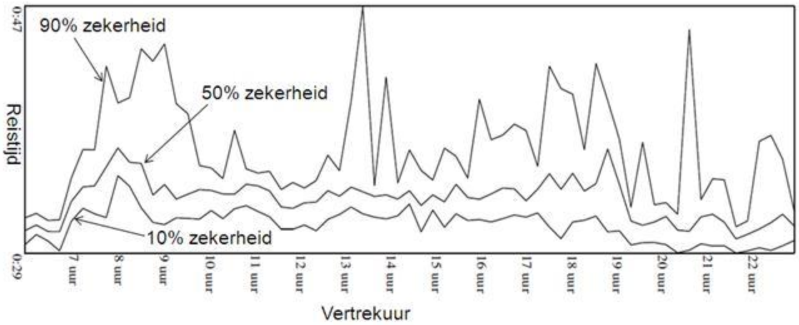

Figure 1: Probabilistic day charts

- Probabilistic reachability maps: the probabilistic routing engine can also calculate how far one could travel given travel time and start location. Output maps are similar to the example below, which illustrate the reachable destinations for 15, 30 and 45 minutes of travel time, starting in the city of Ghent (Belgium). These calculations all took actual traffic flow data and the proper distribution of probability into account.

Figure 2: Probabilistic reachability maps (15, 30, 45 minutes)

Reference Publications

- Demeyer S., Audenaert P., Slock B., Pickavet M., Demeester P., Multimodal transport planning in a dynamic environment, Proceedings of IPTS2008, the Conference on Intelligent Public Transport Systems, pp. 155-167, Amsterdam, 2008.
- Demeyer S, Goedgebeur J, Audenaert P. et al., 2009. Speeding up exact multiple objective shortest path algorithms. Submitted to European Journal of Operational Research.
- Demeyer S, Audenaert P. et al., 2010, Practical Dynamic and Stochastic Routing with Historical Measurements of Travel Times. Submitted to Transportation Research Part B.
- Demeyer S, Goedgebeur J., Audenaert P. et al., 2010, The predecessor and the accounting algorithm speeds up shortest path calculations in traffic routing applications. Submitted to ITSC 2010.

Intelligent Transport Systems – Cooperative Systems

Intelligent Transport Systems (ITS) are ICT systems that enable a more efficient and safer traffic through the use of a wide range of diverse technologies. ITS systems combine (wired and wireless) communication systems, innovative applications and services, integrated electronics and numerous other technologies in a single platform. In the ITS domain, Cooperative Systems are innovative applications that rely on vehicle-to-vehicle (V2V) and local vehicle-to-infrastructure (V2I) communication to increase the "time horizon", the quality and reliability of information available to the drivers about the road conditions and other vehicles and road users in their immediate environment. The mobile ad-hoc network enabling such local communication between vehicles and roadside infrastructure is called a Vehicular Ad-Hoc Network, or VANET.

The entire ITS spectrum enables a large number of applications with an important social relevance, both on the level of the environment, mobility and traffic safety. When approaching dangerous situations such as the tail of a traffic jam, an obstacle on the road or a ghost driver, ITS systems make it possible to warn drivers in time to avoid collision. Detected hazardous road conditions such as black ice or an oil trail can be automatically communicated to other drivers. Drivers can be notified well in advance about approaching emergency vehicles, and can be directed to yield way in a uniform manner. This is just a small selection from the large number of applications that are made possible because of ITS systems.

The research of IBBT in this domain mainly focuses on Cooperative Systems, more specifically on the research challenges related to VANETs. These VANET protocols have to meet some specific challenges such as the rapid topology changes, frequent fragmentation and limited redundancy possibilities. They have to support both broadcast and unicast data traffic, and should also enable addressing of network nodes on a geographic basis. In all these circumstances, the VANET protocols have to guarantee that they can meet the stringent requirements of cooperative safety applications regarding delay and reliability. They also have to be able to cope with high network densities under limited bandwidth constraints. This is also called the VANET scalability problem, indicating that in the case of high vehicle density, the IEEE 802.11p communication standard used in VANETs cannot meet the stringent requirements regarding delay and reliability. They main drivers behind this problem can be situated on all layers of the OSI networking stack. IBBT researches techniques that provide solid solutions for the VANET scalability problem, combining optimization techniques on all these different layers.

Another IBBT research centre point in this domain is power efficiency in VANETs. At first sight, VANETs should not be designed in an energy-efficient manner, since the can always rely on the high-performance vehicular batteries. However, when extending the ITS ecosystem towards vulnerable road users such as cyclists or pedestrians, this becomes a very important requirement since those users will rely on mobile devices such as smartphones for their ITS applications. To introduce energy-efficiency in the VANET domain, IBBT is researching which techniques used in the domain of sensor networks could be successfully transferred to the very dynamic VANET environment.

To support the research activities regarding VANET scalability and energy-efficiency issues, IBBT has developed a specific research environment. A software platform based on the Click Modular Router enables fast development of new VANET algorithms. Using exactly the same codebase, these solutions can be tested on the simulator environment, on the IBBT iLab.t Wireless Lab, and on a small scale (10 nodes) vehicular wireless testbed. This combination of simulation and testing on real hardware is one of the key properties of the research platform, enabling detailed testing of all different aspects of VANET networking. Another important quality of the research platform is the flexibility of development, making it possible to implement, test and combine multiple algorithms in a very time-efficient manner.

The applied simulation environment incorporates both vehicle movement and the wireless networking environment typical for VANETs. Realistic vehicular movements are an important building block of VANET simulations. These are modelled using SUMO (Simulation of Urban Mobility), an open source, highly portable, microscopic road traffic simulation package designed to handle large road networks. The output of SUMO contains information of realistic vehicle movements which can be immediately used by the NS-2 network simulation tool. The scalability of the proposed solutions can be expressed in terms of performance metrics such as the reliability of the communication (i.e. packet loss rate) and the end-to-end delay of messages (in particular for time critical applications). These measures can be evaluated for changing vehicle speed, vehicle density, communication range, road scenario (e.g. multiple traffic flows, congestion, accident), road structures (roundabout, highway, junction with traffic lights), etcetera.

The IBBT iLab.t Wireless Lab is an extensive facility, including wireless mesh and sensor network infrastructure, that has been rolled out on 3 floors of the IBBT office premises. The network consists of 400 802.11 wireless mesh network nodes, and 200 sensor nodes, installed at 200 fixed locations at IBBT office premises. These nodes are centrally managed for control and monitoring purposes and remote access, and can be easily configured, including installation of new software, protocols, middleware components, etcetera.

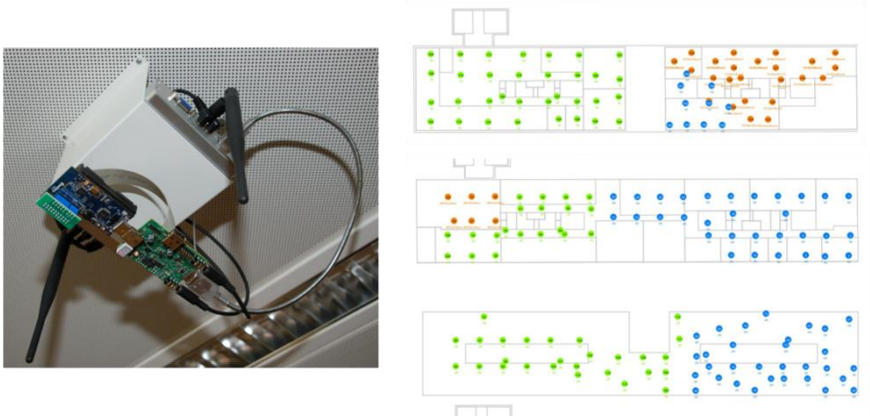

Figure 3: IBBT iLab.t Wireless Lab

The small scale vehicular wireless test bed is designed around a few basic cost-lowering principles: it does not use dedicated fixed road side units (but mobile units or stationary vehicles), it consists of of-the-shelve equipment and it does not use dedicated vehicles. Instead, it should be able to install the entire setup in the cars of volunteers within minutes. These requirements lead to the following design: the heart of the onboard unit is the Alix embedded PC, produced by PC Engines. It is provided with two 802.11a wireless interfaces, one is connected to a fixed antenna and is configured as in-vehicle wireless LAN access point, the other is connected to an external antenna with a magnetic base, which is placed on the roof of the vehicle. This interface is used for the VANET communication. The setup is complemented with an USB external GPS receiver (also placed on the roof), a standard USB 3G modem for the internet uplink, and a TFT touchscreen. This design is both cost-efficient and flexible to support development and testing of both VANET protocols and cooperative applications in real life circumstances.

Figure 4: Small scale vehicular testbed

Reference Publications

- W. Vandenberghe, D. Carels, J. Bergs, E. Van de Velde. “Development of Vehicular Ad Hoc Network Routing Protocols using the Click Modular Router”, Symposium on Click Modular Router, Ghent, Belgium, 23 November – 24 November 2009.
- W. Vandenberghe, J. Bergs, D. Carels, N. Van den Wijngaert, E. Van de Velde, C. Blondia, I. Moerman, P. Demeester. “Impact of introducing road charging on supporting mobile data networks”, 9th International Conference on ITS Telecommunications, Lille, France, 20 October 2009 – 22 October 2009
- D. Carels, W. Vandenberghe, J. Bergs, H. Cappelle, E. Van de Velde, N. Van den Wijngaert, L. Van der Perre, I. Moerman, C. Blondia, P. Demeester. “Architecture and scalable testbed for Cooperative Systems in the NextGenITS project”, ITS World Congress 2009, Stockholm, Sweden, 21 September – 25 September 2009
- W. Vandenberghe, P. Leroux, I. Moerman, F. De Turck, P. Demeester. "Design of a scalable ITS architecture based on IP datacast over DVB-H/SH", International Conference on Intelligent Transport System Telecommunications (ITST),978-1-4244-2858-8, Thailand, Phuket, 2008-10-24

References

National Reference Projects

- IBBT GBO SPAMM (Solutions Platform for Advanced Mobile Mesh): development of a mobile mesh wireless network interconnecting public transport busses.
- IBBT GBO MultiTr@ns (Multimodal Transport): development of a multimodal routing engine.
- IBBT GBO NextGenITS (Next Generation ITS): development of VANET research environment and routing protocols[1].
- IBBT ICON MobiRoute (Mobility & routing): development of probabilistic routing engine
- Policy Research Centre Mobility & Public Works, track Traffic Safety: literature studies regarding ITS, focus on policy supporting information.

European Reference Projects:

- FP6-STREP WIDENS (Wireless Deployable Network System): development of ad-hoc communication system for public safety, emergency and disaster applications.
- FP6-Integrail (Intelligent integration of Railway Systems): work on ontology based management systems for a.o. cooperation, coordination and safety.
- FP7-STREP ITS Test Beds: integration of IBBT iLab.t Wireless Lab and Virtual Wall in a generic European ITS test bed.

National Reference Partners

- Be-Mobile: provider of traffic information based on floating car data.
- IMEC: independent research centre in nano-electronics and nano-technology.
- Belgacom group: network operator.
- NXP Semiconductors: leading semiconductor company.
- Tele Atlas: producer of digital map data (now TomTom).
- Alcatel-Lucent: provides solutions to deliver voice, data and video communication services to end-users.
- Flemish traffic centre: Flemish road operator.
- ITS Belgium: member organisation that stimulates ICT- and Internet-based innovation in the transport and mobility domain.

[1] http://www.youtube.com/watch?v=cSP9xlTDY3o&fmt=22

European Reference Partners

- TNO: Dutch research institute, performs impact assessment of ITS applications.
- DLR: German research institute, researches solutions for automotive and railway systems, as well as for traffic management.
- SINTEF: Scandinavian research organisation, tests ITS applications in driving simulators and an ITS test track in Trondheim, Norway.
- Q-Free: supplier of solutions for road user charging and traffic surveillance, also develops prototypes of future ITS onboard units.
- Siemens: provides IT solutions and services in a broad range of markets.
- Alstom Transport S.A.: global specialist in energy and transport infrastructure.
- Televic: designs and produces electronic end products for different niche markets, one of them being railway electronics.
- Bombardier: leader in the rail equipment manufacturing and servicing industry.
- Nortel Networks: provides networking and communication services and infrastructure to service providers and enterprises.

About IBBT

The IBBT (Interdisciplinary Institute for Broadband Technology) is an independent research institute for ICT innovation in Flanders, Belgium. It has over 600 researchers dealing with the technological, economic, legal and social dimensions of the development and exploitation of broadband services. The IBBT-IBCN (INTEC Broadband Communication Networks) research group counts around 100 members, specialised in various technology aspects of both fixed and wireless networks, the related services and supporting software and the techno-economic evaluation of the future internet.

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