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A Connected World

In the past couple of years' research focused on developing new tools for the management and control of the transport network have emerged under the guise of Intelligent Transport Systems (ITS). Here we are utilising emerging products, systems and services that are the result of applying new computing and communications to transport. Earlier this year the Office of Science and Technology published the findings Foresight Intelligent Infrastructure Study (IIS) which investigated how technology may evolve over the next 50 years to deliver a robust, sustainable and safe transport infrastructure in the future (www.foresight.gov.uk). Among the many recommendations and predictions on how the technology may deliver more intelligence into infrastructural systems was the view that pervasive wireless systems will have a significant future role in transport.

Recently the use of RFID (radio frequency identification) for transport applications has begun to emerge as a key technology, particularly for use in the freight and logistics sector for tracking containers, palletised and individual products, for car-parking, ticketing and possibly for future road user charging. However Foresight recognized that RFID is just the starting point for a raft of more exciting possibilities with future wireless mobile ad-hoc networks, with much more capability and 'intelligence' than current RFID and thus moving towards a more 'all-seeing, all-knowing' network.

Research is currently focused on filling in the knowledge and technology gaps in pervasive, mobile adhoc wireless systems for a range of transport applications. Mobile wireless systems are beginning to be proven as a future tool that will enable the joining up of vehicles, individuals and infrastructure into a single 'connected' intelligent infrastructure system. Embedding this technology in infrastructure (such as environmental sensors in lampposts, embedded in vehicles and infrastructure, in goods, and even connecting To individuals through their PDAs, mobile phones, or even bespoke wearable wireless interfaces offer potential for a more all-seeing, all knowing ITS infrastructure. If for example, vehicles are continually in wireless communication with the infrastructure (through small wireless sensors embedded in the infrastructure), new paradigms for traffic monitoring and control could be considered, road space allocated more efficiently and incidents dealt with in an optimum way. If vulnerable users have such wireless devices, the infrastructure could warn vehicles to slow down and the drivers be more vigilant – indeed wireless devices attached to children could for example warn drivers that children are playing out on the street, just around the corner so reduce speed now. Such devices could help with security and safety of individuals, be used on airline boarding cards and other tickets, and even be used to verify HOV (high occupancy vehicles) or blue badge entitlement. When such a system is also connected to say, a vehicles CAN-bus, then information on driving style, strange driving behavior (say where there is a badly maintained stretch of road or object in the road, could be detected from the CAN data – them mitigating and maintenance actions could be automatically triggered) .

Many of these devices can carry payloads such as sensors and the idea of monitoring pollution, with these devices in a pervasive way is beginning to be researched in the university in the MESSAGE project (with pervasive wireless environmental sensors being attached to lampposts). However if these devices become small and cheap enough (as is the future vision for Smartdust) then one could image that we each carry our personal exposure meter. Moreover with

'extreme' sensor design, wireless pollution sensors could be fitted in engine manifolds and exhaust pipes to the actual pollution generated by a vehicle is measured and maybe adjustments to driving style or engine management systems are advised or made to mitigate some of the pollution effects (early prototypes are being developed at the university at the moment. If future 'carbon allowances' are to be considered the connected car and the pollution a driver generates will need to be measured and monitored – as proposed in the Smart Market Protocols project where auction and trading-based carbon allowances have been considered.

Wireless interfaces on individuals whether through PDAs or mobile phones, or dedicated devices (such as motes integrated into jewelry – a research project currently in its early stages at Newcastle University) enable individuals to be connected and interact with the infrastructure. This thrust of research will finally provide the missing link in delivering the vision of future pervasive information delivery, whereby context specific and bespoke traveler information can be delivered to the individual on the move, through embedded screens in infrastructure, on mobile devices and for example on 'terminator' glasses where one is able to display traveller information on the lens of specially adapted spectacles (seen as particularly beneficial for mobility impaired users who are unable to interact readily with mobile phones and PDA's or other ICT systems). A key element of the connected environment is future pervasive traveler information (FPTI) whereby pervasive, bespoke information delivery may have a role in influencing travel behavior and travel choices and hopefully could help affect a modal shift towards public transport, particularly if the cost and carbon costs of the alternatives can be readily compared. Moreover such pervasive information may also be a driver in making more effective use of DRT (Demand Responsive Transport) and flexible transport services.

Significant research is required to fully realise the potential of such wireless systems, not just on the transport application side, but challenges to reduce the size of these devices from 'smart-lumps' to 'smartdust' is critical as size and cost of these devices will dictate whether the devices will become pervasive in the transport domain. This requires detailed work on antennae design, an investigation as to which is the most appropriate communications frequency, 802.11xx, the influence of CALM (a range of connected communications standards), WiFi and probably the most important challenge being battery power requirements (using power scavenging or other techniques). The final key area of research which is still embryonic is in low-cost and robust sensor design – much work is on-going but uncoordinated in the transport domain. Finally the robustness and dependability of mobile sensor devices and suitable communications protocols and e-science techniques to deal with the data are crucial. As is the issue of privacy, data protection in a potentially all-seeing, all-knowing connected world and how much information do we want, need and the level of intrusion.

A final element of the connected world the smartcards. There has been a great deal of investment in public transport smartcards. New generations of smartcards are likely to offer longer range wireless interfaces as an option (be it RFID, NFC or smardust ad-hoc capabilities) which will offer new possibilities for the connected traveler and their interaction with the infrastructure, transport services and info-mobility services. Examining and using the data generated by public transport smartcard systems could potentially deliver a wealth of new data on how the cards are used, where individuals, board, alight and interchange for their destinations and whether there is variation in time of travel due to other factors such as weather. Early research at Newcastle in spatially analyzing such data has provided some intriguing results, however much more is needed to be investigated here (this was

research supported by the DfT with a data set provided by Nottinghamshire CC – who have offered to provide more extensive data for future studies). To analyse this data in a systematic way and possibly follow it up with surveys of operators and users could provide invaluable operational data used to better configure transport provision to meet the needs of the travelers. This may indeed tip the business case for investment in ITSO, the UK's National Interoperable Smartcard Specification, in a positive way.

The above hopefully provides a glimpse of what wireless ITS may deliver the transport sector in the near future. Concerted research, demonstrations and evaluations are underway, much of what is described above was demonstrated in one way or another at the recent ITS World Congress at the Excel centre in London. We have the opportunity to bring these technologies to bare to help meet the challenges of congestion, logistics, climate change and sustainability, as eloquently outline recently in the Stern Report and Eddington Review

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