Institution: Nottingham Trent University

Unit of Assessment: B11 Computer Science and Informatics

Title of case study: Wireless and Mobile Computing for Sustainable Urban Mobility and Social Inclusion

1. Summary of the impact

The impact described in this case study is the more efficient use of transport infrastructure through the application of our research into the use of wireless components and wireless communication devices. This gives passengers reduced travel times, better business performance for operators, and, for everyone, reduced pollution (including CO_2) and a more pleasant urban environment as a result of reduced congestion. The impact has benefitted transport systems throughout Europe, including Nottingham and Coventry in the UK, Gouda in the Netherlands, Leuven in Belgium and Sofia in Bulgaria.

2. Underpinning research

The Intelligent Simulation, Modelling and Networking Group (ISMNG) in the Computer Science and Informatics (CSI) Unit has conducted the research described here. The Group consists of 6 lecturers, 2 Research Fellows and 6 research students and is led by Dr Evtim Peytchev, Reader in Wireless, Mobile and Pervasive Computing.

The main insights described in this study relate to the employment of novel wireless and mobile communications technology in the field of transportation. In particular it has been found that these systems are more effective when they make use of peer-to-peer communications between vehicles and bi-directional communication with the control centre as opposed to traditional structures where roadside infrastructure devices send information to the centre.

1993 – ISMNG research has its first outpost in the field. Data collection started - server machine installed in the Nottingham Traffic Control Centre (NTCC) for on-line traffic control data collection.
1996 – First downstream deployment of the research results to the Traffic Control Centre (NTCC) – displaying traffic camera images on the NTCC web site.
2003 – First major funding (the TSB Traffimatics project) obtained for research into the use of wireless technologies into the Intelligent Transport System (ITS). This resulted in insights into the use of ad-hoc networking, mobile phone application solutions, mobile networking, and between cars (peer-to-peer) communication for collaborative knowledge generation. The project shed light on the future developments in the area of node-to-node mobile and wireless networking. This project advanced the current state-of-the-art in telecommunication platforms by providing a coherent Telematics platform for the provision of low-cost Telematics solutions to end-users.
2008-2010 - Extension of the research to telematics applications for public transport in Nottingham resulted in insights into the use of Bluetooth application on a mobile phone for indoor navigation (3 locally funded projects).
2009 – 2010 – Formulated new design of wireless communication architecture for ITS underpinned by the wireless networking research and reported in several keynote lectures and invited papers and illustrating the growing impact of the first suite of algorithms to cover the generation of traffic knowledge through collaborative and ad-hoc wireless frameworks.
2011 – Major EU FP7 funding obtained - Nottingham Trent University's transport networking project (MODUM – Models for Optimising Dynamic Urban Mobility). The research in this project identified a new approach for building simulation models, which incorporate wireless communication traffic data gathering and generation in urban conditions algorithms, and the wireless peer-to-peer communication architecture reported in earlier work. It provided evaluation of the usefulness of the approach and its effectiveness for the real-time control of traffic in cities. The research results have been applied to several European cities.

The research in wireless and mobile networking is also influencing other scientific areas in the same Unit e.g. application development for mobile devices for disabled people, in another two EU funded projects – RECALL and GOET led by Professor David Brown. This has been possible through utilising the peer-to-peer and client server wireless communication algorithms and approaches developed by the Unit.

3. References to the research (indicative maximum of six references)
Most representative references:

1.Y. Li, S. Papanastasiou, J. Akhlaghinia, E. Peytchev, "TMDA: A Broadcast-Based Message Delivery Algorithm For VANETs", International Journal On Advances In Telecommunications, Vol.: 6, Issue: (1, 2), Pages 34-44, ISBN/ISSN: 1942-2601, 2013.
The algorithm presented in this peer reviewed paper is a significant outcome from the work of the EU FP7 funded MODUM project. It shows how traffic route information can be blended and used into wireless message delivery architecture for building a new generation of Intelligent Transportation Systems.

2. E. Agafonov, A. Bargiela, E. Burke and E. Peytchev, "Mathematical Justification Of A Heuristic For Statistical Correlation Of Real-Life Time Series", European Journal Of Operational Research, Vol.: 198, Issue: (1), Pages 275-286, 2009. DOI: http://dx.doi.org/10.1016/j.ejor.2008.06.040
The algorithm proposed in this peer reviewed paper has been validated in Nottingham and included for EU wide distribution in the technical architecture of the EU FP7 funded MODUM project deliverable 3.1.1.

3. V. Charissis, S. Papanastasiou, W. Chan, E. Peytchev, "Evolution of a full-windshield HUD designed for current VANET communication standards", Proceedings of the 16th International IEEE Annual Conference on Intelligent Transportation Systems (ITSC 2013), The Hague, The Netherlands, October 6-9, 2013, ISBN: 978-1-4799-2914-613, pp 1637 – 1643, 2013.
This peer reviewed paper presents results obtained in the EU FP7 funded MODUM project and demonstrates how the achievements of the project diversify and affect other areas of Intelligent Transportation Systems – in this case the quality and type of images displayed on the windscreen of the car to help the driver.

Additional references:

4. Ø. Risan, E. Peytchev, "A Vehicle-To-Vehicle Communication Protocol For Collaborative Identification Of Urban Traffic Conditions", Springer Lecture Notes Of The Institute For Computer Sciences, Social Informatics And Telecommunications Engineering, Vol: 1, Pages 482-494, ISBN/ISSN: 978-3-642-17994-5, DOI: http://dx.doi.org/10.1007/978-3-642-17994-5_33, 2010

5. G Bilchev, D Marston, N Hristov, E Peytchev and N Wall, "Traffimatics - Intelligent Co-Operative Vehicle Highway Systems", BT Technology Journal, Vol.: 22, Issue: (3), Pages: 73-83, ISBN/ISSN: 1358-3948, DOI: http://dx.doi.org/10.1023/B:BTTJ.0000047122.78621.6f, July 2004.

6. M. Tomas, E. Peytchev, D. Al-Dabass, "Auto-Sensing And Distribution Of Traffic Information In Vehicular Ad Hoc Networks", International Journal Of Simulation", Vol.: 5 Issue: (3), Pages/Art.: 59-63, ISBN/ISSN: 1473-804X, 2004

Peer Reviewed Research Funding

MODUM project, EU FP7, Overall funding - 2,350,000 Euro, grant for NTU €403,000
01 October 2011 - 30 September 2014, Nottingham Trent University Principal Investigator Dr Evtim Peytchev, 9 partners from 5 countries, Consortium Coordinator Transport Mobility Leuven, Nottingham is test site for the experiments and tests in the project and for demonstration of the achievements of the project.

Traffimatics project, Department of Trade and Industry (DTI), The overall funding is £1,080,000 of which £145,000 for NTU, 01 March 2003 to 30 Sept 2005, Principal Investigator Dr Evtim Peytchev, Leading partner British Telecom, partners Shadow Creek Consulting and Influx Omitec, Nottingham is the test site for staging real-life experiments in the area of ad-hoc networking.

EPSRC project "Integration of heterogeneous traffic and travel information through a combined Internet and mobile communications" – Principal Investigator Prof. A. Bargiela GR/R32468/01 - £62,000 - 01 January 2004 - 31 December 2005, co-investigator Dr Evtim Peytchev.

Peer Reviewed Regional Research Funding *(Principal Investigator Dr. Evtim Peytchev)**:***
Public Transport Bus Cam control, East Midlands Development Agency, Overall is funding £10,000, 01 September 2006 - 30 August 2007.

Public Transport Bus Internet Access, East Midlands Development Agency
Overall funding £10,000, 01 December 2006 - 30 November 2007.

NHS hospital journey planner based on Bluetooth, East Midlands Development Agency
Overall funding £10,000, 01 December 2006 - 30 November 2007.

4. Details of the impact (indicative maximum 750 words)

Although as a society we have only recently started talking about Sustainable Mobility, efforts to reduce travel times, improve business performance and help protect the environment have always been the key aims of research for the improvement of urban and inter-urban transport control.
The research presented in this case study in the CSI Unit has been dealing with these issues since 1995 and the impact from these studies is evident in the number of applications developed and implemented by local businesses and also in the number of policies implemented in the regional traffic control centres (East Midlands). These achievements have been recently extended (2011) further afield, to influence European-wide decision-making and are considered as Europe-leading in the area of car-to-car communication for traffic data gathering, traffic knowledge generation and traffic control. Evidence for this is clearly visible in the text of the support letters from 4 different EU member countries (2013) e.g. "*the budgetary saving proved to be significant, while the amount of data gathering increased substantially*"– (after adopting the Unit's wireless approach to infrastructure in their centre, Sources to corroborate, 2).
The main indicator of the impact of this research into the design and implementation of next generation Intelligent Transport System is the degree of penetration of the Unit's wireless and mobile networking technologies and algorithms in the design of the architecture of the new ITS across Europe. This is emphasised in the support letter from the Nottingham Traffic Control Centre – "*The most sizeable influence however is the move to mostly wireless environment for real-time traffic control. This shift in paradigm has been possible only under influence and the information provided by the NTU's wireless research group*". (Sources to corroborate, 1)
The transfer of knowledge from the wireless and mobile arenas into mainstream traffic control systems started with the CSI Unit helping to create the Nottingham Traffic Control Centre's (NTCC) presence on the web - first implementation went live in 1999, modernised in 2009.
The widespread adoption of mobile phone technology led to the design of an SMS messaging service with a prototype implementation first developed in the CSI Unit. A local company - Infohub Ltd - furthered these ideas and developed a website for journey planning which is essential today (since 2009). The product is based on combining the SMS service with journey planning software development. This won "The Innovation Prize for the Bus Transport Industry" award in 2005. Subsequently the company developed their flagship website "Triptimes" in 2009, and has been a valuable source of traffic origin-destination data and wireless devices support for the Unit's research (Sources to corroborate, 6).
The next impact has been the creation of new solutions for building a new generation of Intelligent Transportation Systems, based on wireless, mobile and pervasive networking in 2010 – recognised and funded by the European Commission – the £3M MODUM project (288205).
NTCC and Coventry Traffic Control Centre (CTCC) implemented wireless systems in 2013 as a result of the Unit's research, and the current control is delivered through wireless devices mounted in traffic lights. The degree of incorporation of wireless devices in the NTCC's infrastructure is underlined by the merger of the Unit's own wireless test bed infrastructure with the NTCC's traffic control infrastructure. One of the NTU's tallest buildings (the Newton building - due to its strategic location), has been used by NTCC to mount antennas on its roof for delivering essential NTCC control services.
As a result of the expertise gained during research on Intelligent Transportation Systems, members of the Unit's research groups have been invited to participate in the strategic planning processes for the following public bodies: The Big Wheel consortium, the Greater Nottingham Transport Partnership (GNTP) and the NTCC Strategic Decision Board.

In 2010 the impact of the growing number of wireless applications for traffic information gathering, processing and control resulted in the award of the £3M FP7 EU MODUM project (288205). This is recognised in the support letters from the Netherlands, Belgium, UK and Bulgaria. For all these countries it is envisaged that the potential impact of the MODUM project will be even greater in the future. Preparations are under way to feed the real-time data collected in the MODUM project into Intelligent Transportation Systems (November – December 2013): including bus real-time GPS data, crowd (smart phone) sourced data, infrastructure collected data (non-SCOOT infrastructure – SCOOT is the current traffic control system using inductive loops for car counting – Split, Cycle and Offset Optimisation Technique - SCOOT), and car-to-car communication data.

5. Sources to corroborate the impact (indicative maximum of 10 references)

1. Nottingham City Council Traffic safety manager – evidence of long standing partnership with the research group, testimony for the deployment of the results of the Intelligent Simulation, Modelling and Networking Group's research in Nottingham and of the deployment of the wireless technology in the Nottingham Traffic Control process 1995 - 2013.

2. Coventry City Council traffic control centre manager - evidence of the deployment of the wireless technology in the Coventry Traffic Control process – 2012-2013.

3. Chief Scientists, Technolution, Netherlands – Corroborating European impact and Europe-wide influence of the wireless research and car-to-car communication algorithms for enhancing EU standing in the modern Intelligent Transportation Systems development 2008-2013.

4. Transport & Mobility Leuven, Data Enrichment Group – European Partner in The MODUM project, evidence of the influence of the wireless research as an essential strand for research within the EU funded MODUM project – 2011-2014.

5. Manager of Sofia Mobility Centre - evidence of long standing partnership with the research group, testimony for the deployment of the results of the Intelligent Simulation, Modelling and Networking Group's research in Sofia, Bulgaria and of the deployment of the wireless technology in Sofia's Traffic Control process 1990-2013.

6. Web site: http://www.triptimes.co.uk - web site developed following the Unit's research involving journey planning software and SMS message delivery since 2009 - evidence of downstream commercial implementation activity following initial research at Nottingham Trent University and the Intelligent Simulation, Modelling and Networking Group.

7. Web-site: http://www.itsnottingham.info/cctv/ - traffic camera's display initially developed by the Intelligent Simulation, Modelling and Networking Group, evidence of downstream commercial implementation activity following initial research within the Unit.

8. Traffimatics - BT Exact Martlesham Heath - Transportation Research Board, http://trid.trb.org/view.aspx?id=883584, Springer - http://link.springer.com/article/10.1023/B:BTTJ.0000047122.78621.6f
Evidence of the quality of the UK-wide research winning funding after a peer reviewed process.

9. MODUM - http://modum-project.eu - Evidence of the Europe-wide quality of the research winning funding after a peer reviewed process – only the top 5% of the proposals in the relevant category for the MODUM project won funding 2011-2014.