Physical Layer DVB Transmission Optimisation

The Physical Layer DVB Transmission Optimisation (PLUTO) project will research novel techniques for broadcast transmitter networks that will optimise the use of spectrum and minimise the performance demands on end user equipment.

At A Glance: *PLUTO*

Project Coordinator

Prof. John Cosmas

Brunel University, Uxbridge, Middlesex UB8 3PH
Tel: +44 (0) 1895 266756
Fax: +44 (0) 1895 258728
John.cosmas@brunel.ac.uk
http://www.brunel.ac.uk/pluto/

Partners: *Brunel University, UK; Broadreach Systems Ltd, UK; Dibcom SA, France; Deutsches Zentrum Fur Luft und Raumfahrt E.V, Germany; Digital TV Group, UK; SIRADEL, France; Tampere University of Technology, Finland; Telediffusion De France, France; Ortikon Interactive Ltd, Finland.*

Duration: *01/2006 – 7/2008*
Total Cost: *€2,912m*
EC Contribution*: €2,0m*

MAIN OBJECTIVES

DVB-T, DVB-H, DAB are key radio broadcast technologies which are expected to complement emerging standards such as WiMAX and derivatives in future 4G networks. These technologies all use Orthogonal Frequency Division Multiplexing (OFDM); a technique that distributes data over a large number of carriers spaced at precise frequencies providing frequency diversity.

Complexity and power consumption of personal receiving devices can be optimised by improving the transmission of signals in non line of sight cluttered environments using Transmit Diversity and Low Cost Repeaters. Transmit Diversity exploits the statistical nature of fading due to multipaths and reduces the likelihood of deep fading by providing a diversity of signals; multiple signals are transmitted in such a way as to ensure that several signals reach the receiver each with uncorrelated fading. Resultant digital broadcast networks would have fewer transmitter sites and thus be more cost-effective with less environmental impact. Transmit Diversity is more universal than Receive Diversity due to the difficulty of locating two receive antennas far enough apart in a small mobile device.

Currently in-fill transmitters using different polarisations and frequency channels to the main transmitters are used to illuminate “black holes” where network broadcast signals cannot penetrate. An alternative low cost on-frequency transmitter, although technically demanding could provide a better way of illuminating “black holes” with minimal complexity and conserving valuable spectrum.

TECHNICAL APPROACH

The program will be addressed in 3 phases each taking approximately 9 months;

- **Modelling**; Candidate schemes and architectures will be investigated using mathematical models and the most promising techniques identified for further investigation.
- **Signal Simulation**; Experimental equipment will be assembled and tested in simulated environments to verify performance predicted by the models.
- **Pilot trials and Demonstrations**; Experimental equipment will be evaluated in full scale trials in representative service delivery scenarios.

Transmit Diversity is a technique that is applied to most digital wireless transmission systems except for broadcast. The relative benefits of different schemes will be evaluated during the 3-phase program and the most promising schemes realized in experimental equipments. Different transmit diversity techniques that comply with existing broadcast standards will be examined in representative service delivery scenarios such as rural, urban and indoors. Effectiveness can only be determined after detailed analysis and experimentation in the field where sensitivity to antenna separation can be explored. It will be necessary to define new measurement metrics that can be used to indicate the likelihood of a receiver to successfully deliver useable services. A prime outcome will be the antenna physical separation required to deliver uncorrelated signals.

User Terminals implementing the DVB-H standard will be modified for diversity reception and performance evaluated when combined with transmitter diversity in the various service delivery scenarios.

Statistical Analysis of test results will determine which combinations of transmit and receive diversity would be most effective in each scenario.

Mini On-Channel Echo Cancellers for Repeaters: A mini on-Channel repeater is a low TX power stand-alone subsystem that could be placed anywhere in a network to illuminate a 'black hole'. The system would receive signals off-air, pass them through an echo canceller to remove unwanted feedback from the repeater's transmit antenna and then re-transmit the signal. Of key importance is the system's ability to discriminate between wanted and unwanted signals and remove the unwanted signal with minimal impact on the quality of the retransmitted signal.

Multi Channel Power Amplification (MCPA): Broadcast sites transmit several channels using separate transmit chains for each channel leading to complex and expensive installations. A repeater would also use several receive and transmit chains and with diversity this complexity would be doubled. MCPAs allow multiple RF channels to use a single amplifier. Combining an MCPA with a multichannel echo canceller would provide cost, complexity and size advantages and since splitting and combining degrades carrier to noise, an integrated architecture could provide performance advantages. It is only due to recent advances in DSP technology that this can be realised.

Network Modeling: Once the effects of these techniques have been evaluated their impact on network design and cost of network roll-out will be evaluated. Example networks will be designed using both the traditional broadcast model of few large high power transmitters and the cellular model of many small lower power transmitters with and without diversity and repeaters. Networks will be designed for a variety of scenarios including extreme rural, mountainous and urban regions. Relative cost and complexity of each design will be investigated and published for reference.

Network Management and Service Creation: Potential enhancements to a service management system will be investigated to improve effectiveness of handover of mobile broadcast multimedia services between technologies such as 3G and DVB and between transmitters. It is postulated for this project that the decision of a terminal to select a particular broadcast service over a particular access medium depends on not just current network connectivity but also on estimated robustness for a particular type of mobility and reception scenario.

EXPECTED IMPACT

Broadcast is an important part of broadband service delivery, a multitude of applications requiring high downlink bandwidths can be provided to mobile terminals, coupled with the uplink bandwidth delivered over 2G, 3G or 4G technologies enabling full interaction. Traditional broadcast networks were not designed for indoor or mobile reception and coverage was improved by increasing the transmit power or deploying in-fill transmitters.

This project will encourage co-operation between Cellular telecoms and broadcast industries which have historically designed networks with different objectives, on the one hand cellular networks are designed to provide a relatively low grade of universal service using transmitters with small footprints whereas broadcast networks have been designed using large transmitters with huge coverage for reception by rooftop antennas. In the future these two diverse industries must be encouraged to converge to deliver ubiquitous services from common or interconnected networks to the advantage of business cases and environmental impact. The rules and tools used to design the networks, and technology used to deliver them will be brought together and a new understanding of how best to use the complementary technologies and common infrastructure will be developed.

Transmit diversity is expected to provide a gain of up to 5dB in non-line of sight situations leading to a potential reduction in basestations of nearly 4 times in areas of poor reception. Mini on-channel repeaters will also improve efficiency of use of spectrum by eliminating the need for traditional in-fill transmitters using additional frequency channels or polarizations. Both of these techniques will enable simpler and lower cost receivers thereby providing affordable broadband content for all.

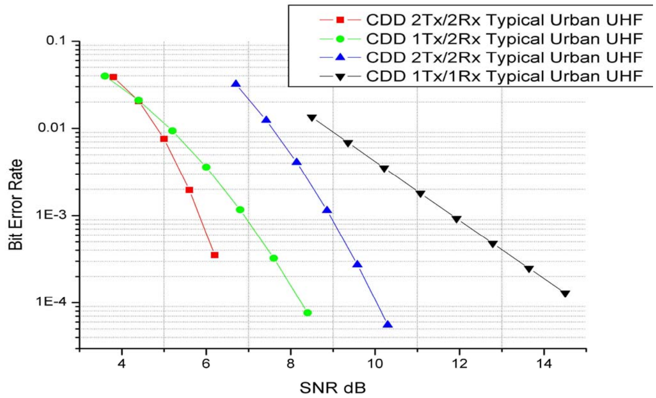

Figure 1 BER vs. SNR with Cyclic Delay Diversity