Wireless Networks and Communications Centre

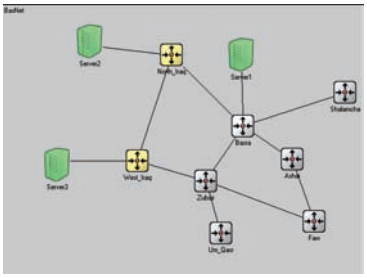
The mission of WNCC is to promote, support and carry out international quality, basic, strategic and applied in the following research areas: Wireless Communication Networks, Broadcast Communication Networks, Mobile Communication Networks, Radio over Fibre, Future Internet and applications of Networks for the communication of information, media and services within the media, energy and environment, security and defense, manufacturing and medical industries. The group currently consists of seven academics (Professor H. Al-Raweshidy, Professor J. Cosmas, Dr M. Hadjinicolaou, Dr R. Nilavalan, Dr Q. Ni, Dr K. Banitsas and several postdoctoral researchers and research students. The group is well funded by EU, EPSRC and Industry.

Current activities

Modeling of National Optical Networks

In order to help plan the inclusion of the whole Iraqi people digitally within a central computer communication network, a flow model representing the Basra region of Iraq was created using OMNet++ module, and is tested and reported in this paper against different possible types of data passing through it. Analysis was performed to the number of people within each Iraqi city in addition to the percentage of people using each sort of applications and their flows over that network aiming to have an idea about the potential congestions over the various links in this network. Ten applications were considered here, namely: web browsing; streaming audio; streaming video; IPTV; VoIP; video communication; interactive gaming; P2P file sharing; miscellaneous upload / download and finally a mix of all the above applications.

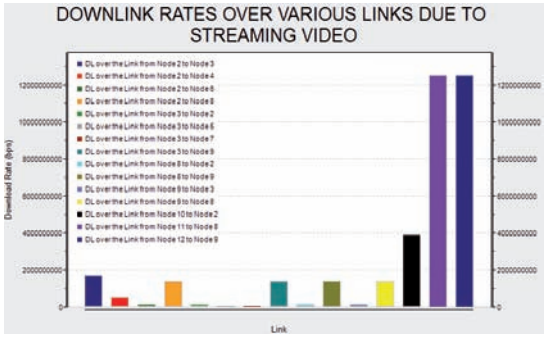
Fibre Map of Basra



Network Architecture of Basra

The current existing Iraqi fiber network was considered because it is envisaged that this will be the future backbone communication network of Iraq. Download and Upload data rates over each link in the network were recorded for different applications to obtain an idea of how these different types of applications can affect the loads over the network links.

Each region in Basra was represented by a single node with a particular number of users which was determined by the population of that region according to UN's Office for the Coordination of Humanitarian Affairs (OCHA) statistics. Messages of different types were passed through the network. Each message does not represent a single communication message but it instead carries flow parameters, such as download and upload rates coming into or going out of the whole sending region caused by certain type of applications. The type of the application was attached within the message to determine the traffic flow caused by a population of users using such an application type. The links between the various nodes represent the actual fiber cables that currently exist between these regions. The model is hierarchical at national, regional, city, district and street levels.

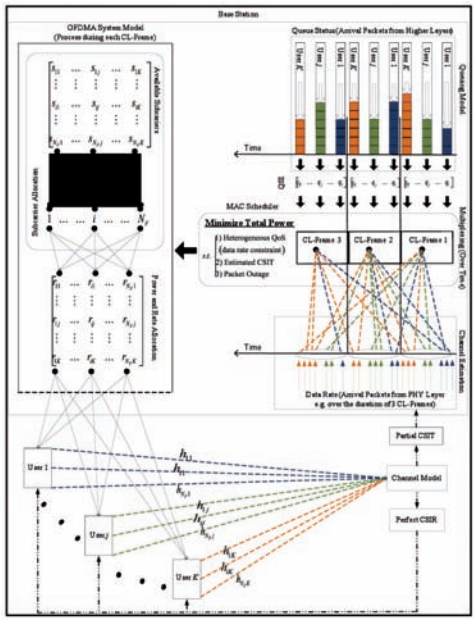


Download Rates Over Various Links Due to Streaming Video

Power Efficient Next-Generation Wireless

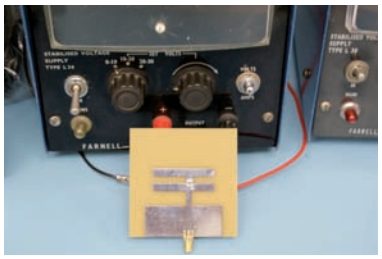
There is a growing demand that future networks should be ubiquitous, pervasive and multimedia-capable. This project seeks to explore effective solutions for managing radio and transmission power resources to guarantee the QoS performance as perceived by users with minimum transmission power consumption for emerging OFDMA-based broadband wireless access systems. We designed a new cross-layer optimization scheme, where subcarrier and power resources are optimally allocated by jointly considering the information from both physical and upper layers. Information theory and advanced queuing theory are combined together for modelling wireless system dynamics. Specifically, novel channel estimation methods are investigated for physical layer to estimate channel state information, and then to be utilized to formulate a robust power bit loading model. Meanwhile, an advanced queuing model is created for modelling QoS performance of upper layer heterogeneous multimedia applications. At the scheduler, a cross-layer multi-objective optimization is formulated and low-complexity algorithms are sought to search optimal solutions of joint subcarrier and power allocation. The outcomes of this project will make a significant contribution toward

acceleration of the rapid and ubiquitous deployment of emerging next-generation broadband wireless access systems in the UK and worldwide. The project is jointly funded by the UK Engineering and Physical Sciences Research Council (EPSRC) and Motorola Ltd.



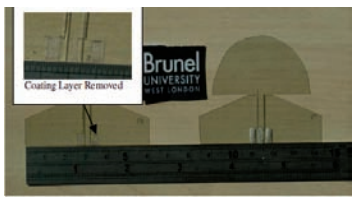
Microwave Systems

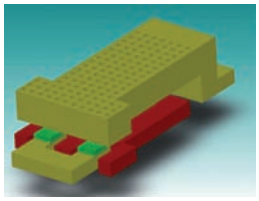
Microwave components are an essential part of efficient communication systems. The WNCC group is working on Antenna designs, electromagnetic modelling and RF-MEMS designs and control.



A low profile multi-band antenna.

Novel antenna designs are required to support future communication systems such as cognitive radio systems and broadcast systems involving hand held terminals. These antennas need to be simple and efficient while supporting multi-frequency and beam forming operations. The WNCC group is working on developing new designs with three, five and more band operations to meet these future demands. Reconfigurable multiband options are also being investigated. Furthermore, flexible and transparent designs and antennas for green radio technologies are also being considered.





A transparent Antenna Design *A proposed RF-MEMS Switch*

This group is also working on Radio Frequency Micro Electro-Mechanical Switches (RF-MEMS) for future antenna systems.

More reliable and efficient switches that can be employed in printed antenna designs are being developed. Control of these switches using tailored pulses has shown very good performance and optimisation of the tailored pulses are being carried out using Taguchi optimisation process.

Electromagnetic modelling based on Finite Difference Time Domain Techniques (FDTD) and Method of Moments (MOM) are extensively used by the group to model complex problems. In house built and commercial software are being employed to analyse antennas, RF-MEMS switches and other complex problems.

Digital TV Transmission

The advantages that can be achieved if Transmit Delay Diversity is applied to systems employing the DVB standard have been quantified. The techniques investigated can be applied to standard receiver equipment without modification. An extensive and carefully planned field trial was performed during the winter of 2007/2008 in Uxbridge (UK) to validate predictions from theoretical modeling and laboratory simulations. The transmissions were performed in the 730 MHz frequency band with a DVB-T/H transmitter and a mean power of 18.4 dBW. The impact of the transmit antenna separation and the MPE-FEC was also investigated. It is shown that transmit delay diversity significantly improves the quality of reception in fast fading mobile broadcasting applications.

The transmitter is located at Brunel University in Uxbridge, in the west outskirts of London, 1.2 km south of Uxbridge.

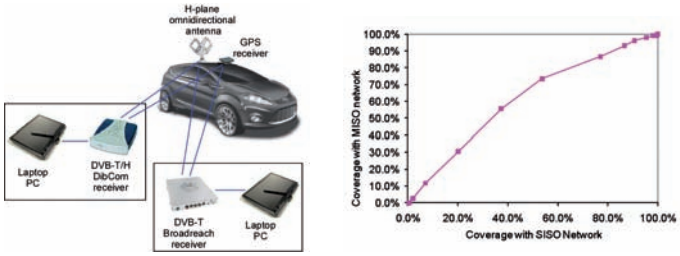
The broadcast transmitter setup *Route area classification*

The measurement area is relatively flat and representative of a typical suburban area. The field trial used two power amplifiers, rated at 100W, feeding a linear array of directive antennas. In the tests quality of reception in the measurement area when either all power was transmitted from a single antenna (Single Input system) or half power from each of two separate antennas (Multiple Input system) was compared.

The EIRP measured was 18.4 dBW for both the single transmitter and dual transmitter configurations on channel 53 which has a central frequency of 730 MHz and bandwidth of 8 MHz. A linear array of directive antennas was installed at the top of one of the university buildings (named Tower D), pointing towards the east. The antennas are horizontally polarized panels with a gain of 12 dB, a half-power beam-width of 53° degrees in the H plane and 24° degree in the V plane.

Mobile reception was measured using a purpose receiver which allowed measurement of uncorrectable Reed-Solomon blocks, Carrier to Noise Ratio (CNR), the Received Signal Strength Indication (RSSI) and delay spread all tagged with a GPS position, time and speed. From these measurements we would be able to derive the impact of diversity on other OFDM based broadcast standards.

Mobile reception was measured using a car equipped with receiver.

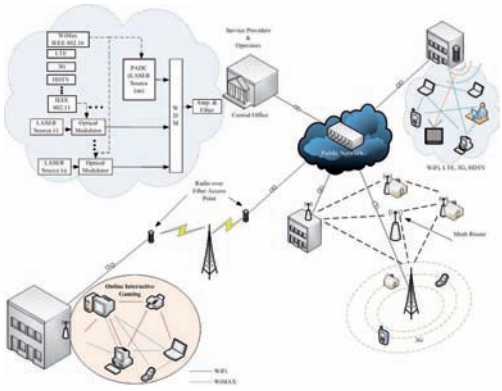


Results show that a coverage of network planning reference 95% and 70% (e.g. "good" and "acceptable" reception, respectively with MISO transmitter corresponds to 88% and 50% coverage respectively with SISO.

Converged Fiber and Wireless Technologies for Super-broadband Access Network

Deployment of optical and wireless access network infrastructure starts to proliferate throughout the world. When these heterogeneous access networks converge to a highly integrated network via a common optical feeder network, network operators can reap the benefits of lowering the operating cost of access networks and meeting the capital costs of future upgrades easily. In addition, the converged access network will facilitate greater sharing of common network infrastructure between multiple network operators. Radio or Wireless signals transportation over optical fiber (RoF or WoF) links will be a possible technology for simplifying the architecture of remote base stations (BSs). By relocating key functions of a conventional BS to a central location, BSs could be simplified into remote antenna units that could be inter-connected with the central office (CO) via high performance optical fiber feeder network.

RoF links employing analogue signal transport inherently suffer from inter-modulation distortions arising from the nonlinearity of both microwave and optical components that make up the link. Furthermore, it has been shown that the dynamic range of an analogue optical fiber link decreases linearly with increasing length of the optical fiber link due to the attenuation of the optical fiber. In addition, the bandwidth of the RoF links needs to be sufficiently larger than the highest microwave signal frequency regardless of the message bandwidth of that signal. On the other hand, an optical link employing digital RoF (DRoF) transport can maintain its dynamic range independent of the fiber distance up until where the received signal goes below the sensitivity of the link when error-free transmission is lost.

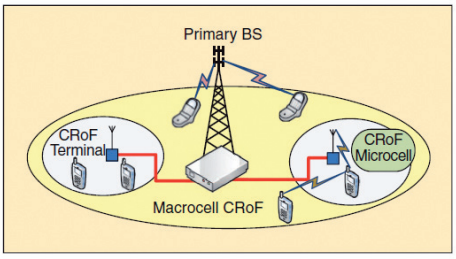


Integrated Fiber Optic and Wireless Technologies for Ubiquitous Wire and Wireless Services

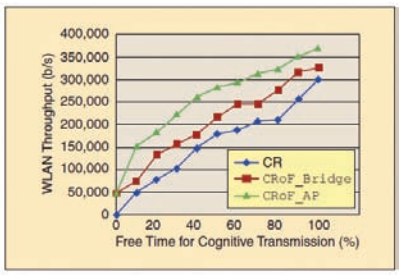
Cognitive Mesh Networks

Cognitive mesh networks (CMNs) are presented as a future solution for the near spectrum crunch. The spectrum availability is analyzed as the main barrier against the success of CMNs and huge data transmissions using cognitive communications. The cognitive solution for small enterprise microcells services in CMNs.

The CRoF architecture is based on using the radio over fiber (RoF) to connect cognitive radios (CRs). These CRoF stations are positioned inside the primary macrocell coverage area and in coexistence with the primary base stations (BSs). Accordingly, CRoF would be able to use local spectrum holes efficiently and provide higher throughput to secondary users. Opnet simulations show key savings in time delay and throughput increase using the CRoF subnet, compared with the traditional CR functioning.



Dependent CRoF system using terminals.



CRoF Throughput

The concept of CR can be applied to a wireless mesh network in which the mesh clients and routers can opportunistically access the channels that are licensed to a user. In this CMN, dynamic spectrum access is required for the mesh clients and routers to identify and access the channels that are not occupied by the licensed users. Networks of such radios are complex adaptive systems, the study of which is an emerging discipline concerned with the nonlinear behavior of large collections of adaptive entities that have complex interactions. In addition, the space-time models of the user, network, radio resources, and services personalize and enhance the consumer's experience.

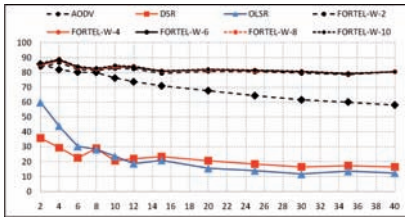
FORTEL (Forecasting Routing Technique using Location information)

FORTEL is a proactive position-based routing protocol designed to achieve high routing performance in Mobile Ad-hoc Networks (MANETs). FORTEL stores the location information of all the mobile nodes in a location table. A mobility prediction is applied to the location table to predict a future topology of the network, after which a route computation is performed. Routes to the desired destination are computed by constructing the Destination Connectivity Tree (DCT), which is a tree representation of the destination connections with its 1st, 2nd, 3d … nth hop neighbouring nodes. Once the DCT is constructed, an end-to-end route is extracted for data transmission. FORTEL responds to the nodes mobility by predicting the next topology state and constructing new routes, minimizing therefore, the probability of transmitting data through a disconnected path.

Moreover, to keep the location table up-to-date at each and every node with the newest location parameters (position, speed and deviation), FORTEL employs the window update

location scheme. According to the window update scheme, a location update packet is transmitted whenever a change occurs to the node's movement. In case no variation is been detected for a specific duration of time referred to as "update window", a location update packet must be broadcasted.

The figure below shows a comparison in terms of the delivery ratio (%) between Ad-hoc On Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Optimised Link State Routing (OLSR) and FORTEL protocol for different window update sizes.



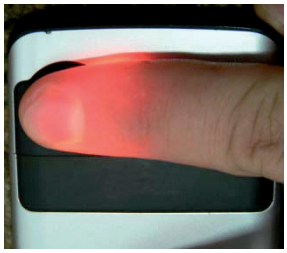
Real time telemedicine and e-health

Patients carried to the hospital by an ambulance are limited to the help that the paramedics can provide. By using newer high-speed mobile networks, a real-time videoconferencing link can be established between the moving ambulance and the hospital so that effective treatment of the patients can begin the moment they enter the ambulance. The recent addition of HSPA (HSDPA and HSUPA) into the UMTS suite provides the necessary higher bandwidth and reduced delays, making this choice ideal for such real-time telemedical applications.

In this research, we describe a set of scenarios that took place in a typical large city area, along with their equivalent results: a moving ambulance was linked with a consultation station using HSPA and several videoconferencing sessions were initiated. Best-case, worst-case and average scenarios were recorded. Furthermore, in areas where the UMTS reception was marginal, a repeater was placed on top of the ambulance to boost up the signal power and thus maintain the higher bandwidth. Finally, doctors were asked to evaluate the effectiveness of this system's outputs.

Heart Beat Rate Calculation using a Mobile Phone

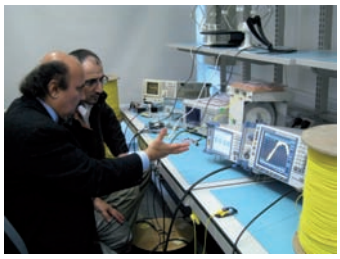
Heart Beat Rate calculation has traditionally been conducted using specialised hardware most commonly in the form of pulse oximeters or Electrocardiogram devices. Even though these methods offer high reliability, they require the users to have special sensor to measure their heart rate. In this research we developed a system capable of estimating heart beat rate using just a camera from a commercially available mobile phone. The advantage of this method is that the users do not need specialized hardware and they can take a measurement in virtually any place under almost any circumstances. Real time access to the heart rate brings advanced health coaching applications even closer to the users, aiming in enhancing their well being. The research has been conducted in collaboration with Health-Smart Ltd.



Facilities

WNCC is located in the new ECE Communications Lab environment which is a dedicated open space environment for sitting up to 40 researchers along with state of the art research Lab facilities consisting of configurable booth-type cells for research and showcasing activities. This occupies around 350 squared meters on the second floor of the new School of Engineering and Design research building: The Mike Sterling Building.

In addition to that, the centre benefits from the new DSP lab consisting of 20 FPGA boards and 20 DSP systems procured recently as well as other in-house equipment for network digital signal processing and analysis.



WNCC also uses the Broadcast Lab where there is laboratory space, radio transmission and TV Studio facilities.

WNCC is closely related to three MSc courses in ECE:
1. Data Communications, 2. Wireless Communications,
3. Advanced Multimedia Design and 3D Technologies.

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