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INTRODUCTION

The Centre for Communication Systems Research was set up as an autonomous Research Centre in 1996, within the School of Electronic Engineering, IT and Mathematics and now houses:

- 10 Academics
- 20 Research assistants
- 37 PhD Research students
- 6 Support staff

Our research is sub-divided into three research areas as follows:

Mobile Communications
led by Dr Rahim Tafazolli

Multimedia Systems
led by Professor Ahmet Kondoz

Communication Networks
led by Dr Zhili Sun pending arrival of Professor George Pavlou in 1998.

Our research concentrates on future communication systems for the next millennium. We are unique in our coverage of:

- Mobile and wireless communications
- Satellite communication systems
- Integration of communication systems
- Telecommunication management systems (TMN, CORBA, Java)
- Core network technologies (ATM, IP, Software telecommunications)
- Multimedia services and signals (speech, video and service)
- Networking (protocols, software, security)
- Enabling technologies (modulation, coding, signal processing, channel characterisation)

Overall, CCSR has over £4 million of ongoing specialised research, funded in approximately equal ratios from the European Union (ACTS, ESPRIT), the EPSRC (a major research council in the United Kingdom), and industry.

CCSR is a major player in the European Union, with fifteen ACTS and ESPRIT projects running from 1998. These range from satellite systems, mobile communications, multimedia, IP and ATM telecommunications management to new chips. Our European partners number around forty companies and universities.

In the UK, CCSR is a member of the two Virtual Centres of Excellence, in Mobile and Personal Communications and Multimedia Broadcasting. In addition we have major funding from EPSRC managed (ROPA, LINK, JREI) programmes and responsive mode Grants. On the industrial front, we now have twelve industrially-funded projects which cover UK, European, Japanese and US industries.

CCSR is the UK's largest and best known research centre covering Mobile and Satellite Communication Systems, Multimedia and Networking. On an annual basis we award several scholarships to study for a PhD and almost constantly have vacancies for Research Assistants to work on our various contracts.

In addition to our research, CCSR is a major contributor to the Electronic Engineering School's one-year Masters courses in Satellite Communication Engineering, Mobile and Satellite Systems and Telematics. We also contribute one-week courses to the continuing education programme in the areas of Satellite Communications, Mobile Communications and Telecommunications.

We are progressively becoming more involved in technology transfer and consultancy to industry, by spinning off our intellectual property rights and technology and we are always willing to talk to potential collaborators.

This Annual Report gives a summary of our research as it was in 1997. Almost by definition things will have moved on by the time you are reading this and it is worth checking our Web pages for updates. (http://www.ee.surrey.ac.uk/CCSR/)

Professor Barry G Evans
Director, CCSR
December, 1997
PRESTIGIOUS HIGHLIGHTS OF 1997

- Presentation of the Queen’s Anniversary Prize for Higher and Further Education 1996 for “Excellence in Satellite Communications & Engineering - Research & Teaching”.

- Being the first UK university to become one of the four finalists for the Royal Academy of Engineering’s Premier MacRobert Award 1997 for Engineering Excellence in Satellite Communications and Engineering.

- Commencement of the Mobile VCE Programme with £0.75M award to Surrey, supporting 4 RAs, and 2 studentships over three years.

- Award of two EPSRC ROPA grants based on collaboration with industry and Surrey’s only special equipment grant for a Multimedia Performance Test Bed.

- Award of one of the first Space-Foresight contracts with Matra Marconi Space to study Air Interface Aspects of Multimedia Satellite Systems.

- Award of a Technology Transfer contract with Toshiba (Japan) for Speech Storage Technology.

- Involvement in sixteen bids for the EU third call for ACTS and the start of the first ESPRIT contract awarded with Siemens for ISDN chip architectures.

- Selected by the Cadence Group along with Berkeley, USA and Nan Yang University, Singapore in an International VCE for Communication Systems

- Appointment of new Racal Chair in Communication Network Management to Professor G Pavlou.

- Award of INMARSAT Chairman’s Prize to Dr Wei Zhao for work on “Terminal Location and Positioning in a Dynamic Satellite Constellation”, representing the most outstanding research in an area commensurate with INMARSAT’s business.
Industrial Partners

- VCE (Virtual Centre of Excellence) in:
  Mobile and Personal Communications: 5 Universities and 22 Industrial Companies
  Digital Broadcast and Multimedia Technology: 6 Universities and
  12 Companies
- Acorn
- Airtel
- Alcatel Espace
- Alenia Spazio
- Algotel
- Aurigae SA
- BBC
- BT
- Cadence Design Group
- Cable & Wireless
- CET
- CISCO
- CNET France Telecom
- CRL
- CELT
- Cellnet
- Dassault Electronique
- DLR
- Dolphin Communications
- Ericsson
- Ericsson OMC
- European Partnership Contracts
- ACTS: SECOMS, SINUS, THESEUS
- ESPRIT: COPARIS
- Fundacion Airtel
- Fujitsu
- Hitachi
- Hewlett Packard
- Hughes Network Systems
- IBM
- Italtel
- INMARSAT
- ICO Global
- Intracom
- Iona Technologies
- Laben Spa
- Lucent Technologies
- L3S Conseil
- Société de la Bourse Français
- Matra Marconi Space (France)
- Matra Marconi Space (UK)
- Matsushita
- Mitsubishi
- Mobile Systems International
- Motorola
- NDS
- NERA
- Nokia
- Nortel
- Nova Telespazio
- NTT
- NTL Cable Telecoms
- One2One
- Orange
- Philips
- Quotient
- Racal
- Roke Manor Research
- Samsung
- Siemens AG
- Simoco
- Sintef T & I
- Société de la Bourse de Valeurs Mobilières de Bruxelles
- Space Bel
- Space Engineering Spa
- Space Helas
- Symbionics
- Telenor
- Texas Instruments
- TNO
- Toshiba
- Vodafone
Current Grants/Contracts

EPSRC
- Source and Channel Coding for Mobile Multimedia
- Wireless ATM LAN
- User Terminal Positioning in Non-GEO Satellite Systems
- Migration to 3rd Generation Personal Communication Systems
- Variable Bit Rate Time Envelope Vocoder Using Source Dependent Rate Switching
- Study of Scintillation Applicable to Design of Satellite Communication Systems
- Global Integrated Personal Satellite Environment
- Multimedia Testbed for Audio Visual Communications
- Low Complexity Soft Decision Trellis Decoding of Block Codes
- Call Admission Control for Multimedia CDMA
- Multilayer Scaleable Audio & Speech Coding for 3rd Generation Systems
- GSM Network Optimisation

EUROPEAN
- SECOMS-Satellite EHF Communications for Mobile Multimedia Services-EU ACTS 2
- SINUS-Satellite Integration into Network for UMTS-EU ACTS 2
- ASSET-Advanced Satellite Switching End-end Trials-EU ACTS 3
- ACCORD-Advanced Satellite Switching End-end Trials and Demonstrations-EU ACTS 3
- SUMO-Satellite UMTS Multimedia service trials Over integrated Testbeds- EU ACTS 3
- WISDOM-Wideband Satellite Demonstration Of Multimedia-EU ACTS 3
- SORT-Software Radio Technology-EU ACTS 3
- FlowThru ACTS 3
- IACI-Internet and ATM Convergence and Integration of Ipv6 with resource reservation of ATM
- MIAMI-Management of the Information Infrastructure
- VITAL-Validation of Integrated Telecommunication Architectures for the Long-term
- REFORM-Resource and Fault restORation and Management close integration of control and management.
- COPARIS - Common Physical Access for ISDN Systems
- THESEUS - Terminal at High Speed for European Stock Exchange Users

INDUSTRIAL
- Indoor Propagation Factors at 17-20 GHz and 60 GHz
- High Quality Speech Codecs for Premium Communications Services
- VCE in Mobile & Personal Communications
- Satellite Wideband Air-Interface Design (SWAID)
- Ad-Hoc Computer Networking
- Software Radio
- Indoor Propagation Measurements at 17 & 60 GHz
Current Research Topics

**MOBILE COMMUNICATION SYSTEMS**
- Terrestrial and Satellite Mobile Systems
- Narrow band and broad band systems
- Networking, services, terminals, antennas & propagation
- Wireless LAN/cordless/mobile/satellite
- CDMA - Multi-user detectors, call admission control, power control, synchronisation, coded-CDMA, overlapped CDMA
- TDMA - equalisation
- Ad-hoc networking
- Genetic algorithm
- Integration cellular/cordless/satellite systems
- Traffic modelling for multimedia
- Integration cellular/cordless/satellite systems
- Packet communication in mobile networks - GPRS etc
- Band sharing CDMA/TDMA
- Satellite constellation studies and QoS
- Mobile satellite - mobility management and networking - resource management
- Satellite air-interface TDMA studies
- Mobile satellite channel modelling and simulators
- On-Board processing architectures
- Broadband satellite - ATM/IP networking
- Antennas - Intelligent base station and handhelds - Dual mode satellite/cellular
- Propagation - Indoor up to 60 GHz, Satellite up to 30 GHz, macro + micro cells deterministic and physical statistical modelling, cell planning tools
- Intelligent micro/pico cells

**MULTIMEDIA & DSP**
- Speech coding
- Joint speech and channel coding
- Image coding and compression
- Error resilient coding for images
- Performance analysis for speech and multimedia systems
- RS/Trellis/Soft decoding and turbo coding
- Cryptography for Multimedia Communications
- Higher level modulation and joint modulation/coding
- DSP applications and implementations
- On-Board Satellite DSP and Processing

**COMMUNICATION NETWORKS**
- Broadband service/traffic characterisation
- Performance assessment of Multimedia over ATM
- ATM over satellite and satellite networking
- IP over GEO Satellite and LEO/MEO Satellite Constellations
- Traffic management and congestion control in ATM
- Optimisation of TCP/IP over ATM
- Integrated services in INTERNE - Multimedia and Multicasting
- Network & Service Management using object, orientation, TMN and TINA
- Multimedia service control using IN and TINA
- Future integrated Telecom Architectures
- Network security
MOBILE COMMUNICATIONS RESEARCH GROUP

Aims
To research Global Universal Multimedia Personal Communication Systems integrated with cordless, cellular and satellite mobile components. To develop novel and practical techniques for the establishment and enhancement of personal communication networks and services for future public and private systems.

Achievements
- Breakthrough in Blind Search Algorithms-Genetic Algorithm
- Fast, Adaptive, low complexity MultiUser Detector for CDMA
- Fast, Frequency Planning Optimisation Algorithm
- Network Dimensioning Technique for Multimedia mobile Systems
- Mobility Management Technique for Wireless ATM
- Novel Media Access Technique for Wireless ATM
- Quality of Service Provisioning for Wireless ATM
- Novel CDMA Multiple Access Scheme for UMTS
- New code Synchronisation and tracking Technique for packet CDMA
- New Mobility Management Technique for GSM
- New Satellite Constellation Design
- New Handover for HCS algorithms
- Novel Mobility Management Technique for Satellite-PCS
- Four Novel Multiple access protocols for integrated DATA+Voice in GSM/GPRS
- New adaptive and predictive power control technique for CDMA
- New call admission control for load balancing in CDMA
- New mobile terminal positioning technique for satellite systems
- New in-call handover scheme between satellite and cellular systems
- Full network integration between cordless and cellular systems
- Novel call-handling and routing in non-Geostationary satellite mobile systems
- Novel intelligent (terrestrial-satellite) mobile terminal antenna
- New physical statistical propagation models for terrestrial and satellite coverage prediction
- High capacity indoor-outdoor radio architectures using intelligent antennas

Description

1 Satellite Mobile Communications

1.1 Network architecture and signalling investigation for GSM and satellite integration

This work concerns research into the possibility of integrating GSM networks into dynamic constellation mobile satellite networks. The satellite constellation considered representative MEO (e.g., ICO), LEO (such as Iridium and Globalstar).

The work has been divided into several areas
- Design satellite radio link frame structure and logical channels
- Identify various inter-connection schemes between GSM network entities (MSC, VLR, HLR and GMSC) and satellite network entities (GMSSC, MSSC, LES and SVLR). The inter-connection reuses as much as possible of already existing GSM signalling interface (A, B, C, D, E and G interface).
- Design signalling procedures between dual-mode terminal and network (GSM or satellite) for various services in the integrated system.
1.2 Satellite Integration into Networks for UMTS Services

A laboratory test-bed has been set up for performance experiments in satellite-UMTS environment and the laboratory demonstration will be performed in the test-bed. Entities being produced in the project: S-UMTS dual-mode terminal, satellite FES, satellite constellation+satellite propagation channel emulator, terrestrial radio link simulator, fixed network (only a switch) and a test-bed controller.

1.3 Non-GEO Mobility Management and Resource Management

The aim of this work was to determine the optimum location area definition and size for a given S-PCN system that would produce the minimum mobility related signalling on the air interface. This involved analysing layer two paging and location update signalling.

Key outcomes:

1. Intelligent Paging Strategies and new Location area definitions which result in minimisation of in-call handovers between FES (Gateways) and optimum call routing.

2. Handover solution between satellite and terrestrial cellular system. The techniques resulting from this work have been tested and optimised for ICO, Iridium and Globalstar Constellations.

1.4 S-PCN satellite availability in urban areas

Satellite blockage caused by buildings will result in a loss of service from an S-PCN system. Some of the 1st generation systems employ satellite diversity to overcome blockage. To evaluate the behaviour of the two satellite channels fish eye images of typical urban areas were taken. The images were transformed to obtain shadowing statistics.

The fish-eye images can also reveal how similar the two satellite channels behave based on the elevation and azimuth angles difference between the two satellites.
The figures below show how the correlation of blockage coefficient varies with different satellite elevation and azimuth angle differences and how it can be predicted using a theoretical approach.

1.5 Non-GEO Stationary Satellite Constellation Design

The aim of this work was to design a non-GEO satellite constellation as the satellite component of UMTS. Several demands and restrictions where initially placed on the constellation structure and coverage properties. Firstly to be competitive the orbit had to have fewer satellites than current 1st generation S-PCN proposals. At the time this limit was 66 satellites (Iridium). In order to minimise delay and power requirements the use of a LEO orbit was preferred, while avoiding the Van Allen radiation belts. In order to increase the availability of service and quality of service the constellation should provide dual satellite visibility at a minimum elevation angle of 15 degrees. The dual satellite diversity was restricted to the latitude range of +/- 70 degrees.

The requirements from the constellation lead to the use of an inclined LEO orbit. An altitude of 1626km was selected. This orbit height provides a repetitive ground track by compensating the altitude to account for the precession of the Right Angle of the Ascending Node due to the earth bulge effect. An inclination angle of 54 degrees was found to provide a good trade off between double coverage at the equator and coverage at higher latitudes. The number of satellites used was 64. The satellites are arranged in 8 planes with 8 satellites in each. A phasing angle between each plane of 39.375 degrees resulted in the best dual satellite visibility. Given that the orbit provides continuous dual satellite visibility the constellation was called Deligo which is Latin for ‘I Choose’.

1.6 Band Sharing between Non-Geostationary Satellite-PCNs

The first generation satellite PCNs are to operate at L-band for uplink and S-band for downlink to provide world wide services. However, the scarcity of free spectrum, together with the bandwidth requirements means that S-PCNs will have to share these bands with each other. In order to evaluate this complex sharing scenario, an Interference Simulation Program has been developed to model the dynamic satellite constellations (DSC) and to evaluate interference between such non-geostationary MSS and investigate techniques/criteria to make such bandsharing possible.
1.7 Multiple Access Schemes

TDMA and CDMA and various hybrids are currently being investigated. Among these, the packet switched protocols for support of mixed services are also being investigated. We are also researching on the suitability of GPRS (General Packet Radio Services) and in particular the optimisation of the following schemes for packet S-PCN:

- Stand-by state (Handover, Diversity, synchronisation and time advance mechanisms)
- Error correction and re-transmission strategies
- Optimisation of frame structure for packet switching
- Power control
- Random access protocol design

1.8 UMTS Satellite Channel Emulation

Bringing together a number of the threads of the research is an EU ACTS project SINUS, which is investigating the air-interface of the satellite part of the UMTS as well as producing a demonstrator air-interface system and a satellite channel emulator. The latter is a project within Surrey and uses the channel data at L/S band from the propagation campaign that has been converted to models for any elevation angle and environment. Also built into the channel emulation are the orbit dynamics of LEO/MEO and the interface paths for satellites and mobile users from the system. The emulation will allow a simulation of any run for LEO/MEO/GEOs and allow the prototype air interface to be tested and evaluated.

1.9 Antennas and Propagation

1.9.1 Propagation Measurements and Analysis include:

- Satellite PCN measurements, narrow-band and wide-band at L,S,X bands simultaneously, forthcoming narrow-band at 20 and 30GHz. Measurements made in 5 environments and elevation angles from 30 to 80 degrees using helicopters.

- Physical-statistical models of Satellite PCN, providing attenuation statistics and time-series generation based on statistical measures of the building environment and deterministic knowledge of satellite constellations.

- Analysis, simulation and modelling of scintillation effects for fixed satellite systems at 12.5, 20 and 30 GHz. Includes diurnal variations, time series generation and scintillation countermeasures using adaptive modulation schemes.

*Physical-statistical model of mobile satellite propagation in built-up areas*
1.9.2 Antennas:
- Design of Wire quadrifilar helix antennas. Compact fractional-turn designs for S-PCN handsets.
- Printed quadrifilar helix antennas for easy manufacture, small size and robustness. Analysis package created using Integral Equation / Method of Moments.
- Intelligent handset antennas for multiband, multimode operation in terrestrial and satellite systems. Incorporates adaptive matching and polarisation and pattern diversity. Such antennas are a key component of future software radio technology.
- Noise calculations for satellite PCN handsets. Includes the effects of sky and building noise, together with shadowing and satellite constellation statistics. Leads to calculation of effective statistical G/T, and permits specification and optimisation of antenna radiation patterns.
- Rapid electromagnetic simulation for both antenna and propagation modeling using Finite Difference Time Domain simulators. Rapid, simple 2D simulator and efficient parallel 3D simulators produced. Used to calculate the interaction of S-PCN antennas and the human body.

Prediction of radiation from a satellite-mobile handset in close proximity to the human head

2.0 Other research areas related to broadband satellite communications are as follows:

A number of projects are being undertaken in the Broadband Multimedia Satellite area. These are concerned with Multimedia Services above the 64-144 kb/s region dealt with in UMTS studies and reach up to 2-100 Mb/s. An EU ACTS project, SECOMS, forms much of the effort and this is looking at delivery of Multimedia to lap-top, and palm-top terminals at Ka-band and ehf respectively from a GEO satellite. Another project, GIPSE, is looking at new and hybrid constellations for such delivery. The work involves both air-interface studies in which synchronous CDMA is a feature together with advanced modulation and channel coding as well as networking issues such as ATM modification for both the satellite traffic and control planes, resource and bandwidth management and congestion control. In addition work on on-board-processing including on-board ATM switching and switch management as well as efficient digital implementation of on-board equipment. Particular topics are:

- Advanced CDMA Receiver Architectures for Satellite Multimedia Communication
- Call Handling for ATM Over Satellite
- Congestion Control Techniques
- ATM on-board satellite
- Resource management and bandwidth reservation mechanisms
- Channel Coding Schemes
- Network optimisation
- Propagation measurements and channel characterisations for all the environment categories at Ka band
3.0 Terrestrial Mobile Communications

3.1 Optimization of GSM network

The work has concentrated on reduction of signalling traffic and database transactions within the GSM network. A novel location tracking method has been proposed and evaluated both analytically and through simulations. The proposed technique has resulted in substantial reductions in DB access and a reduction of total network signalling load under most operating conditions.

A distributed mobility management scheme is also proposed that can also result in significant reductions in signalling traffic compared with the existing GSM scheme. Evaluation and application of optimization algorithms (NN, GA and SA) to the problem of optimal location area partitioning within cellular networks have been extensively researched. The aim is to reduce the signalling traffic over the air-interface through optimal design of LAs and support of “personal location areas” concept.

3.2 Cordless-Cellular interworking in the context of migration to UMTS

Identification of an alternative registration method in the combined system according to the similarity and dissimilarity of air-interface and network and also the level of integration or interworking. This will consider the deployments of new technologies such as IN concept in the system.
3.3 Software Telecommunication

This aims to investigate the applications of new software technologies such as Mobile and Intelligent Agents JAVA and CORBA for realisation of future software telecommunications scenarios. Such techniques could change the conventional management mechanism and offer more intelligence, flexibility and robustness, contributing to a suitable platform for open communication system infrastructure.

In particular we are investigating design and specification of software radio based terminals and base stations. The resulting flexibility and re-configurability of a software based communication system will enhance service provision, help realise VHE concepts and bring about capacity and coverage improvements. Other benefits include:

- network independence
- seamless roaming
- capacity
- upgradeability

3.4 Packet Communications

The following areas are being extensively investigated:

- General analysis
- Statistical upper bound study
- Performance comparison of 15 RRA protocols against each other
- Performance optimisation through dynamic contention mechanisms
- Guidelines for RRA protocols in cellular design
- Link quality control procedures

3.4.1 Reservation Random Access (RRA) Protocols

- Three different hybrid multi-access protocols based on TDMA/CDMA, DTDMA/CDMA, PRMA/CDMA
- Link quality control procedures

3.4.2 Hybrid Multiple Access Protocols Communications

- Systems Dimensioning

An aggregate source model is proposed by which the whole multi-service queuing system can be modelled with a mono-service M/G/c/N/FCFS queuing system.

3.5 Frequency Planning

We have developed an automatic frequency planning & optimisation tool, based on the Genetic Algorithm.

The novelty of this work lies in optimisation of Initialisation and Objective Function which together makes the GA convergence rate extremely fast so that the algorithm can also be used on the fly in an operating system for fast Dynamic Channel Allocation (DCA). Another aspect of this tool is the enhanced stability for GA, a feature which makes GA now suitable for such applications.

3.6 Multi-User Detection for CDMA

The work on Genetic algorithms is now extended and optimised for joint-detection for both S-CDMA and A-CDMA. The technique has been compared with Convention Detector (Single User Detector) as well as Multi-Stage Detectors (MSD) with 10 stages.

The single user bound is achievable and because of fast convergence rate, it is highly adaptable to fast channel changes due to fading and channel loading. The current work on GA is reduction of the implementation complexity whilst keeping the performance. In parallel we are also investigating Neural Network based Joint Detectors for CDMA.
Acquisition and Tracking particularly for packet CDMA
- Interference Analysis CDMA
- Cellular System Modelling currently configured for GSM and can be changed for CDMA
- OFDM/MC-CDMA/Call Admission Control
- Predictive and adaptive power control schemes
- Channel Estimation Techniques
- Amplifiers for UMTS
- End-to-end modelling and performance of UTRA
- Advanced RAKE receivers
- Interference cancellation in CDMA / TDMA overlay
- Overlapped carrier CDMA

3.7 Propagation

1. Multiple Edge Diffraction: Fast, accurate calculation of multiple edge and multiple cylinder diffraction, using deterministic numerical techniques. Applications: Urban / suburban area coverage and reuse prediction, terrain diffraction for point-to-point links.

2. Modelling and measurement of spatial and angular shadowing correlation for macrocells and picocells. Application to sectorisation, adaptive antennas, power control etc.

3. Measurement and statistical modelling of time-variant fading for line-of-sight links. Rapid time variant fading occurs due to vehicle and foliage motion combined with multiple scattering effects, as well as atmospheric and precipitation effects. These can lead to very rapid fading, having significant impact on performance and optimum system design. Applications include wireless local loop, MVDS and BRAN systems. Models allow prediction and simulation of time-variant effects for performance prediction and modem design.

4. Path loss models for direct mode mobile communications, such as TETRA. Physical-statistical models for picocell prediction, combining semi-deterministic path loss prediction with statistical prediction of spatially correlated shadowing effects.

5. Intelligent picocells, using intelligent antenna technology to provide high capacity indoor coverage solutions with distributed processing for plug-and-play, modular operation. Incorporates aspects of distributed antennas, diversity, optimum combining / beamforming, dynamic channel allocation and equalisation.

Measurement and predictions of Field Strength in an Indoor Environment at 17GHz - colours indicate path loss values in decibels
4.0 Wireless LAN

New challenges associated with the mobile stations that are being addressed, such as location management, registration (including authentication and network security) and handover implementation.

4.1 Mobility management and Call control in a wireless ATM LAN

Investigation of suitable MAC and DLC layers is being taken place. The HIPERLAN and IEEE 802.11 MAC layers have been tested using both an analytical and a simulation model. Delay and throughput deficiencies led to the development of a novel TDMA based MAC layer with better performance characteristics.

4.2 Ad-Hoc Computer Networking

Most of the work, in wireless LAN has been concentrated on star topology configurations. This research is on distributed wireless computer networking, researching on Dynamic Routing algorithms for a wide range of mobility for the terminals, and implications on TCP layer and mobile IP, as well as multiple access techniques for guaranteeing QoS.

- an extension of HIPERLAN specifications to support optimally ATM traffic,
- the definition of an ATDMA based multiple access, introducing traffic policing on the air-interface
- a technique for modifying NNI specifications to support mobility in a wide area ATM network with wireless access points
- the design of an OFDM based transmission path for the ATM WLAN with variable channel coding rate.

4.3 Antenna & Propagation

1. Space-time channel modelling for adaptive antenna systems operated in indoor/outdoor environments at 2 and 5GHz. Four-channel measurement system under construction to measure correlations in space and time.


3. Simultaneous Propagation Measurements at 17 & 60 GHz using a remote controlled mobile platform. Measurements in a variety of buildings from the Victorian-era to modern day, including indoor to outdoor and building to building scenarios. Leading to accurate physical-statistical prediction techniques.

4. Intelligent picocells, using intelligent antenna technology to provide high capacity indoor coverage solutions with distributed processing for plug-and-play, modular operation. Incorporates aspects of distributed antennas, diversity, optimum combining / beamforming, dynamic channel allocation and equalisation. Rapid electromagnetic simulation for both antenna and propagation modelling using Finite Difference Time Domain simulators. Rapid, simple 2D simulator and efficient parallel 3D simulators produced.

5. CCSR has a modern specially equipped Radio Frequency Laboratory, featuring the following key test and measurement capabilities:

- Vector Network Analyser up to 26.5 GHz
- Spectrum Analyser up to 75 GHz
- Power Meter up to 40 GHz
- Signal Generator up to 75 GHz
- Digital Storage Oscilloscope with 500 MHz bandwidth
MULTIMEDIA SYSTEMS RESEARCH GROUP

Aims

The main research activities of the group are in the area of low and very low bit rate speech and video compression algorithms with improved error robustness and efficient channel coding, encryption and watermarking techniques as well as new modulation and coding schemes and the DSP and ASIC implementation of satellite OBP.

Achievements

- Development and implementation of the AUDETEL codec which is currently undergoing acceptance tests being conducted by the ITC.
- Development of two new speech codec algorithms
- Pulsed Residual Linear coding for bit rates of 4.8 kbit/s and over
- Time Envelope Vocoding for rates from 1.2 to 2.4 kbit/s
- Development of a novel lossy multiplexing technique for thin route telephony
- Demonstration of the novel concept of source-aided channel decoding for increased error control performance for speech codecs
- Improvements to the error robustness and lost information recovery of ITU H.261 and H.263 video codecs.
- Development and performance study of an error resilience algorithm for H.263 and its comparison with other techniques found in the literature such as EREC
- Two-way decodable entropy coding for MPEG-4.
- Adaptation of MPEG-4 applications for satellite and terrestrial (indoor/outdoor) environments.
- New Turbo code implementations
- New applications and implementations of RS codes
- Reduced complexity on board satellite VLSI demultiplexers

Description

1 Low Bit Rate Speech and Audio Coding

1.1 Split-Band LPC Vocoder

The aim of this project is to develop a new type of low bit rate speech coder. By assuming that the spectrum of the speech is voiced for the low frequencies and unvoiced for the high frequencies, this coder gives a very high quality even at very low bit rates. Different versions, at 2.4 kbit/s, 4.0 kbit/s, 5.5 kbit/s and 6.2 kbit/s, have been developed. They give better speech quality than the full-rate GSM standard, which makes them suitable for mobile applications.

1.2 Wideband SB-LPC Vocoder

An advantage of a wideband speech (sampled at 16 KHz) over a narrowband speech (sampled at 8 KHz) is that it sounds more natural and pleasant to human ear. This is due to the better preservation of the speech dynamics during the higher sampling process. Therefore, the ultimate goal of this project is to develop a wideband LPC vocoder which, when quantised, should operate at the rate of around 8.5 kbit/s. This coder uses a split-band voicing technique which has proved successful at very low bit rates. Current results promise a high-quality speech coder ready to compete in the market with other wideband coders.
1.3 Low Bit Rate Speech Coder Based on CELP Coder

The coder is applied to encode the narrow band speech signal (4 KHz) and decode the wideband speech signal (8 KHz) at the receiving end. This will enhance hi-fidelity and the naturalness of the speech. The ultimate aim is to achieve the decoded speech signal which sounds more pleasant than the original one.

1.4 Low Bit Rate Audio Coding

Applications involving digital transmission and/or storage of high quality audio signals, such as Digital Audio Broadcasting and Multimedia, require low bit rates. The research area of digital audio coding is currently developing a time-domain scheme which achieves 1 bit/sample compression. The overall bit rate will of course depend on the sampling frequency of the analog audio. Our present work has been concentrated on the sampling rate of 16 KHz producing a very interesting bit rate of 16 kbit/s. The project employs CELP (Code Excited Linear Prediction) coding algorithm and noise masking techniques so as to achieve good quality at the low bit rate. The audio quality produced at 16 kbit/s is very acceptable for low bit rate applications and has already created significant interest from the industry.

2 Image and Video Coding

2.1 Reduced Resolution Updating

For fixed-rate video coding, a sudden increase in the amount of bits generated by the codec, caused by short-term changes in the video content, is undesirable as this will increase the time delay. By reducing the resolution in each dimension by half, the amount of bits spent on coding the motion-compensated difference signal will be reduced greatly. Fixed bit-rate variable frame-rate controller will be used.

2.2 Object Detection and Rate/Quality Optimisation in MPEG-4 Video coder

To take advantage of the content-based functionalities provided by MPEG-4, the scene must be searched for the contour of the enclosed VOPs. MPEG-4 does not explicitly specify any technique for the detection of objects in the video scene. The door is left open for researchers to combine their efforts in order to incorporate an efficient object detection algorithm for the alpha plane encoding. This project aims at providing an algorithm for an efficient and low-complexity detection of the object borders. On the other hand, the project examines the efficiency of binary shape coding defined by MPEG-4 and aims at optimising the quality against the bit rate generated by the alpha plane encoder.

2.3 Source and Channel Coding for Mobile Multimedia Communications

In this project, the performance and robustness of H.263 and H.261 were compared and focus has been made on the study of the error sensitivity of various video parameters in H.263. Furthermore, the error resilience aspects of the coder were examined and a set of several error resilience techniques have been implemented on H.263 to enhance its performance in error-prone environments. A novel error resilience algorithm has been developed and its performance was compared to that of the techniques found in the literature such as EREC. Two-way decoding and RVLC were applied on H.263 to mitigate the effect of channel errors on the video quality.

*Quality Improvement with an Error/Rate Control Mechanism Using Feedback*
2.4 Video Coding Algorithm for Wireless ATM Networks

This project aims at improving the transport of video intended for video conferencing applications. The H.263 low bit rate algorithm is to be modified for transport over wireless ATM channels. The project involves modification of the syntax of H.263 in order to adapt it to the mobile environment. Modifications include both source and channel level with prospects of channel assisted decoding.

3 Channel Coding

3.1 Trellis Decoding of Cyclic Block Codes

This project extends previous work in which it was found that Reed Solomon codes could use soft decisions from the demodulator to give performance and complexity comparable with convolutional codes on the AWGN channel. Methods being investigated include representation of the codes as binary codes, development of sequential decoding methods and trellis re-ordering techniques. Appropriate metrics for a range of channel conditions will also be investigated.

3.2 Algebraic Decoding of Cyclic Block Codes

Methods using the algebraic properties of block codes have speed advantages and can be adapted for soft decision decoding. Investigation of an algorithm proposed by Dorsch showed that it was more suited to binary than to multilevel codes, however other methods investigated have produced impressive results. An extension of the Kasami algorithm is shown to have significant computational advantages over Minimum Weight Decoding and a novel method based on re-ordering and error trapping provides low complexity decoding of Reed Solomon codes.

3.3 Cryptography for Images and Video

A range of issues are being investigated to resolve specific requirements of applications involving images and video. Achievements include:

- Definition of a method for certifying images from digital cameras.
- Development of a low-complexity method for encryption of compressed images and video.
- Development of source key distribution schemes for subscription broadcast services using smart card controlled set top boxes.
- Development of methods for hiding cipher text.
4  Modulation and Coding

4.1  Turbo Coded Modulation for Fading Channels

We are aiming at creating error robust coded modulation schemes for fading channels using the turbo coding scheme. In particular, we are investigating the characteristics and suitability of various constituent encoders in the appropriate channel conditions.

![Performance of our low-complexity Turbo Coding Scheme](image)

4.2  Ground-Satellite Optical Communications

We are studying system design/analysis of ground-satellite optical communication links, aimed at deriving well-defined guidelines with necessary tools in the form of graphs, tables, algorithms, simulation models etc. We have been concentrating on the issues which are not common with optical intersatellite links, namely atmospheric propagation. Atmospheric turbulence causes fluctuations in amplitude and phase of an optical beam propagating through it. We are planning to conduct optical turbulence measurements based on the analysis of bi-dimensional spatiotemporal spectra of stellar light in collaboration with the Communications Research Laboratory in Japan.

4.3  Robust Coded Modulations

The objective of this project was to develop bandwidth-efficient coded modulations that would be robust across a range of channel conditions. Achievements include:

- Development of a combination of set partitioning techniques, a novel expanded rotated detector and a multistage decoding method allowing Reed Solomon codes to be applied with hard decision demodulation.
- Development of techniques for reduction of peak-to-mean power ratio in OFDM.
- Development of concatenated RS-RS coding schemes for multilevel modulations on OFDM.
- Performance across a range of channel conditions comparable with, or better than, other trellis coded and block coded modulations.

4.4  Development of Algorithms for ASIC Implementation of DVB.0QPSK Demodulator

This project has been undertaken in conjunction with industry, in order to develop synchronisation algorithms for a QPSK demodulator for the reception of signals conforming to the ETSI DVB-S standard, Digital Video Broadcasting via satellite. The DVB standards renders the symbol rate completely unspecified, and hence imposes tremendous difficulties in terms of aliasing-avoidance in the sampling process due to the variable bandwidth, symbol rate and automatic frequency control.
COMMUNICATION NETWORKS RESEARCH GROUP

Aims

- To study ATM and INTERNET for satellite and terrestrial systems supporting broadband communications and multimedia services.
- To study Network and Service Management using Object-Oriented TMN and TINA principles.

Achievements

- Design and implementation of protocols stacks with security solutions for accessing to Paris and Brussels Stock Exchanges.
- Study and Development of “system-on-chip” solution for future ISDN switch and internetworking technology.
- Validation of Integrated Architectures based on the emerging CORBA/TINA framework for integrated multimedia services and network management.
- Study of Mobile Intelligent Agents Management and examines applicability of MIAs to TMN / TINA.
- Investigation of Internet and ATM Convergence and Integration IPv6 with resource reservation over ATM, pan-European trials.
- Developed and refined an integrated voice and data multiple access scheme for a VSAT satellite network.
- Developed a new and efficient traffic control mechanism for ATM.
- Demonstrated and tested the interconnection of LANs via an ATM satellite link.

Description

1.0 ATM and Broadband Communications

1.1 THESEUS (Terminal at High Speed for European Stock Exchange Users)

The objective of this project is to develop a terminal that will be a key component of an open system and able to meet the telecommunication needs of the future European capital market. The project aims to develop a universal terminal that will use low-level ATM properties to encapsulate data units, whatever the application layers maybe, and to display information exchanged between several stock exchanges on a single screen, through appropriate multi-windowing software. A representative sample of European stock exchanges are co-operating actively on the project from project definition through to the validation and analysis of the demonstration results.

1.2 TCP/IP over ATM

TCP/IP is the most widely used protocol in the computer communications area. Although it has been used globally in LAN/MAN/WAN environments for years, it is not optimised for high-speed networks such as ATM. The Communication Networks Research Group is carrying out experiments to test the performance of TCP/IP over ATM and to find ways to optimise it so that current applications can make use of the high-speed networks such as ATM.
1.3 Security Systems for ATM Networks

We have research in security system requirements to protect user, control and management planes in ATM networks. Specific areas of interest are:

- **User plane**: To provide end-to-end security services where the ATM network passes the user information (ATM cell payload) without any security processing
- **Control and management planes**: To protect signalling and management messages using public-key systems and timestamps
- **Public-key distribution**: Between end systems and network nodes as well as between network nodes
- **Parallel ciphering**: To provide fast encryption techniques suitable for ATM high data rate services

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2.0 Network and Service Management

2.1 VITAL

This project concerns Validation of Integrated Telecommunication Architectures for the Long-term and Validation of the emerging TINA framework for integrated multimedia services and service/network management. We are mainly involved in ATM resource configuration and connection control through the management plane.

2.2 REFORM

It is to study Resource and Fault restORation and Management Close integration of control and management, ATM-F PNNI signalling integrates VPC recovery, ATM network management based on CORBA/TINA principles. Our involvement is in ATM VPC configuration, planning activities and algorithms for dynamic bandwidth (re-distribution).

2.3 FlowThru

This project is a Trial Integration of the results of the VITAL, REFORM and PROSPECT projects integrated TINA-based multimedia service management with both TMN and TINA-based ATM network management. This work is mainly relevant to the VITAL, REFORM project plus ATM accounting management issues.
2.4 MIAMI

Concerns Mobile Intelligent Agents in the Management of the Information Infrastructure and Examines applicability of MIAs to TMN / TINA. It uses the OMG CORBA emerging mobile code solution involvement in ATM QoS management issues.

3.0 Network Access and Interworking

3.1 COPARIS (Common Physical Access Chip for ISDN Systems)

In order to stimulate the growth in the ISDN market, the ESPRIT COPARIS project will develop an application-specific embedded processor capable of implementing a large subset of the existing ISDN line interface standards. This will be the forerunner of a generation of advanced telecommunications processors using OMI subsystems that can be extended into a range of future applications. As an example, it will allow the production of ISDN home PBXs with a cost of about 50% compared to today’s equivalent products.

![Internal COPARIS Architecture](image)

3.2 IthACI

Will study Internet and ATM Convergence and Integration IPv6 with resource reservation over ATM, pan-European trials. CISCO is involved in the development of IP/ATM QoS management.

3.3 Integrated Service VSAT Satellite Access Protocol

There is an increasing demand for VSAT networks that can provide integrated voice and data services. This explores and develops VSAT protocols that can best meet these requirements. Using analytical and simulation methods, we have studied the performance of a variety of candidate access schemes that could be used in this scenario such as Reservation Aloha, Selective-Reject Aloha, Selective-Reject Aloha FCFS with Reservations, and Multiple Channel CRA. We have looked at the problems that the introduction of packetised speech introduces to the system and ways to deal with them. We have looked at voice/data integration at two levels: Firstly, by using a combination of voice channels and data channels and optimising the way we allocate these with respect to the available traffic, and secondly, by taking advantage of the silences in the voice channels and transmitting data packets during the longer silence intervals.
4.0 Internet and ATM over Satellites

4.1 CATALYST

The CATALYST project tested satellite technology in relation to the terrestrial Integrated Broadband Communications (IBC) network. We analysed end-to-end system communications for client-to-server architectures across Asynchronous Transfer Mode (ATM) links and satellite relays, interconnecting Ethernet, DQDB and FDDI networks. The project demonstrated the world’s first ATM connection via satellite at Nanteer, in Paris. This showed the capability of ATM via satellite to support interactive images, joint viewing, multimedia communications and network file systems.

4.2 Internet and B-ISDN via Satellite

The aim of this project is to investigate efficiency of the ATM and Internet protocols including the next generation of IP (IPv6) that would enable communication satellites to offer Internet and B-ISDN services. The research concerns satellite network architectures, protocol performance and optimisation and simulation prototype and validation.

4.3 Satellite Constellations

Low-earth orbiting (LEO) satellite constellations offer the possibility of full world-wide wireless networking, better support for high latitudes than provided by Geo-stationary Earth Orbit (GEO) satellites, and with decreased time delay over GEO. Ensuring seamless interworking with existing ground-based networks raises complex networking issues, as does attempting to model the performance of a network based on a rapidly-changing LEO satellite constellation or considering guaranteed-quality multimedia services over such a constellation. We are researching network topologies and simulation techniques to better understand these problems.
4.4 Security Systems for Satellite Networks

Security system requirements to improve the data and voice services provided by satellite networks. Specific areas of interest are:

- Security protocol efficiency to prevent long delays and bandwidth consumption.
- Mutual and unilateral authentication between the satellite-user and satellite network using public-key cryptosystems.
- Data encryption using a secret-key algorithm.
- Access control
CCSR STAFF

- **Director**
  Professor Barry G Evans, BSc, PhD (Leeds), FEng, FIIEEE, SMIEEE, FRSA

- **Deputy Director**
  Professor Ahmet M Kondoz, BSc (Birm), MSc (Essex), PhD (Sur), CEng, MIEEE, MIEEE, (Head of Multimedia Systems Research Group)

- **Academic Staff**
  Ms Frances Coakley, BSc, MSc (Manc), C.Eng, MIEEE, MIEEE, (Senior Lecturer)
  Mr Tony Jeans, MA (Camb), MSc (S'ton), (Senior Lecturer)
  Dr Abdul H. Sadka, BSc (AUB), MSc (METU), PhD (Surrey), (Lecturer)
  Dr Simon Saunders, BSc (Brunel), PhD (Brunel) AMIEEE, MIEEE (Lecturer)
  Dr Zhili Sun, BSc(China) PhD (Lanc), (Lecturer, Acting Head of Communication Networks Research Group)
  Dr Peter Sweeney, MA (Oxon), PhD (Camb), (Senior Lecturer)
  Dr Rahim Tafazolli, BSc (Bath), MSc (Lond), PhD (Surrey), MIEEE, MIEEE, (Reader) Head of Mobile Communications Research Group

- **Technical & Financial Administrator**
  Mr David Brock (MSc Surrey, C. Eng, MIEEE)

- **Computing Officers**
  Mr John Hibbitt
  Mr Adam Kirby

- **Technician**
  Mr Terry Roberts

- **PA to Director/Centre Secretary**
  Mrs Moira Cook

- **Financial Assistant**
  Mrs Stephanie Evans

- **Secretary to Research Groups**
  Mrs Lakshmi Chennell

- **Research Fellows/Assistants**
  *(PhD subjects where applicable)*

  - Mr Andreas-Albertos Agius
    (Dual mode antenna for SPCN handheld terminals)
  - Mr Costas Apostolos
    (Study for multiple access schemes for ATM wireless LANs)
  - Dr Bachir Belloul
  - Dr Haitham Cruickshank
  - Mr Shahram Ghaferi Niri
    (Integration between cordless and cellular systems)
  - Mr Cheng Jinwu
  - Mr Chris Meenan
    (Mobility management in SPCN)
  - Mr Ioannis Mertzanis
    (Networking aspects & QoS provisioning for mobile satellite multimedia services)
  - Mr Tolga Ors
    (Traffic management and control over ATM via satellite networks)
  - Mr Heng Pan
    (Satellite communications management)
  - Dr Martin Parks
  - Dr Haidar Radi
  - Mr Tony Sammut
    (Resource management for satellite SPCN)
  - Dr Riaz Suddle
  - Mr Payam Taaghol
    (Power control for CDMA)
  - Mr Pouya Taaghol
    (Wireless packet communications)
  - Mr Seiamak Vahid
    (Optimisation of GSM networks)
  - Mr Cyril Valadon
    (Advanced CDMA receivers for satellite multimedia communication systems)
  - Miss Greet Verelst
    (Satellite on-board processing for multimedia communications)
  - Mr Stephane Villette
    (High quality low bit rate speech coding)
  - Dr Stephan Wesemeyer
Research Students (PhD subjects)

Mr Saied Abedi
(Multi-user Detection)

Mr Dionisis Adamopoulos
(Design and management of telematic services - the case for Greece)

Mr George Aggelou
(Ad Hoc wireless networking)

Mr Bilal Ahmed
(Ka Band channel for satellite mobile multimedia services)

Mr Thumrongrat Amornraksa
(Cryptography for multimedia communications)

Mr Ilias Andrikopoulos
(Optimising TCP/IP over ATM networks)

Mr Mehrdad Ardebilipour
(Code Synchronisation for pocket CDMA)

Mr M. Hafeez Aziz
(Band sharing between CDMA based CDMA)

Mr Damon Birch
(CDMA for satellite broadband communications)

Mr Yotsapak Chotikapong
(TCP/IP over ATM via satellite constellations)

Mr David Cooper
(Communications using Mains for transmission)

Mr Nikolaos Dimitriou
(CDMA for multimedia)

Mr Kjetil Fagervik
(Interactive decoding techniques)

Ms Bin Fan
(Call handling for ATM via satellite)

Miss Maria Farrugia
(Audio and speech signalling)

Mr Mauro Fiasco
(Intelligent picocells using optimum combining)

Mr Hai Pang Ho
(Soft decision decoding of Reed-Solomon codes)

Mr Jong-Ok Joo
(Optimisation of ATM switch on-board satellite for multimedia)

Mr Stephen Leach
(Optimum control of hand portable terminal antennas for mobile communications)

Mr Teck Hock Kweh
(Improved Quality Block-Based Low Bit Rate Video Coding)

Mr Klaus Moessner
(Software radio)

Mr K Narenthiran
(Mobile satellite communications)

Mr Min-Seok Oh
(Binary Reed-Solomon decoder for multi-channels)

Mr John Paffett
(Interference avoidance techniques)

Mr Philip Psiloinis
(Video conferencing for wireless ATM networks)

Mr George Sfikas
(Call handling and mobility management for satellite SPCN)

Mr Chana Sriratanaban
(Low bit rate speech coding)

Mr Milos Stefanovic
(Low bit rate speech coding)

Mr Stavros Stavrou
(The accuracy of mobile propagation measurements)

Mr Rajan Thiruvathirai
(Interaction of satellite mobile hand-held with human body)

Mr Lloyd Wood
(Multicast over satellite constellations)

Mr Len Woodhead
(Coded modulations)

Mr Yusuf Yenice
(System design/analysis of ground-satellite optical communications)
Visiting Students

Mr Adrian Cortier
Mr Safak Dogan

Awarded PhDs

**Chronological list of awarded PhDs in CCSR over the last 3 years:**

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**Sadka Abdul H,**

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“Robust Reed Solomon Coded MPSK Modulation”, November 1997.

**Lee Joohee,**
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