Communications

Emergency Cognitive Radio: A new cognitive radio developed by Christian Rieser (Ph.D. '04) and Thomas Rondeau (Ph.D. '07) can provide robust communications in changing and unanticipated emergency situations. Quality of service is maintained even in the presence of jamming and interference. The radio's novel algorithms are modeled on human learning and incorporate logic, randomness, and adaptive memory. Inset: Rieser exhibits the system's prototype channel sounder.

The department's wide range of communications research activities can be broadly classified in three major areas: wireless communications, digital signal processing, and fiber optic communications. The research is inherently interdisciplinary, and not only cuts across these areas, but is also coupled with related device, circuit and networking technologies. It is common for faculty interests to span multiple areas, and for multidisciplinary teams to form to address major topics.

In general, communications research is directed towards understanding the basic limitations on communication system performance; analyzing, modeling, and characterizing performance; devising, implementing and evaluating new techniques for improving performance; and contributing to a broad range of communications applications.

Wireless Communications

The largest research activity is in wireless communications. This has progressed from a long-standing involvement in radio technology to fundamental propagation and antenna studies for satellite communications, to wireless networking across distances and applications. Wireless researchers today model mobile communications channels, develop multiuser modulation and detection techniques to improve performance in interference environments, and devise communications techniques and applications for new spectral bands and, indeed, across spectral bands. New efforts involve developing ultra wideband techniques and cognitive radio systems.

Closely related and contributing to wireless communications is research on antennas, RF integrated circuits, digital integrated circuits, and wireless networking protocols.

Digital Signal Processing

Today, digital signal processing is an important component of wireless research in implementing communications functions in DSP chips, thereby achieving greater efficiency and functionality. However, DSP research reaches well beyond software radios, and covers fundamental understanding of efficient signal representation, compression, and interference cancellation, whether the application is for X-ray images, speech or speaker recognition, sonar detection, electro-encephalogram analysis, or spatial beamforming. New efforts in this area are applying signal processing to microscope signals in biomedical research.

Fiber Optic Communications

Communications is one aspect of a broad departmental fiber optics research activity in fiber fabrication, fiber-based devices, and sensors as well as telecommunication applications. Research in fiber communications centers on the interrelation between technology, system architecture, and applications. Recent activities have included new modulation techniques to counter the effects of dispersion and non-linearity in long distance systems, subcarrier multiplexing and coding techniques for extending the bit rate limitations of multimode fiber systems, and architectures for survivable communications. Of current interest are issues involving broadband access and interfaces between wireless and fiber systems.

Associated Groups and Laboratories

Wireless Microsystems Laboratory
See page 27

Virginia Tech Antenna Group
See page 24

Bluetooth Laboratory
Develops bluetooth software and applications and performs analysis, measurement, and testing of devices. Equipment includes a Bluetooth Internet access point, Bluetooth-enabled PDAs and computers, more than two dozen Bluetooth radios, proprietary interface software, and CSR and Ericsson development kits.

Digital Signal Processing & Communications Laboratory
www.ece.vt.edu/fac_support/DSPCL/
Conducting research in the general areas of signal processing, image processing, wavelets, and digital communications. Director: Amy Bell

Mobile & Portable Radio Research Group
www.mprg.org
Investigating the interplay of propagation, receiver design, signal processing, networking, and applications. The work has applications in cellular phones, personal communications, land-mobile radio, wireless data networks, and high-speed data links. Director: William Tranter

Radio based on human learning developed for emergency situations

Researchers have developed a cognitive radio that uses algorithms modeling human learning to automatically optimize communications across wireless channels in unanticipated situations. The radio formalism is expected to be of particular use in emergency response situations and in military applications. Commercial applications may also benefit from the dynamic utilization of the spectrum.

The team, led by Charles Bostian, has implemented the formalism in a working broadband wireless cognitive radio testbed.The system uses smart transmitters and smart receivers embedded with a distributed cognitive engine based on a multi-tiered architecture. A broadband channel sounder senses and a Wireless Channel Genetic Algorithm (WCGA) models wireless channels at the waveform or symbol level. A Wireless System Genetic Algorithm (WSGA) performs on-the-fly evolution of the radio's operational parameters, while a Cognitive System Monitor (CSM) handles the cognitive functions, short- and long-term memory and control.

The team is testing and improving the system and plans to extend the techniques to build a network testbed and apply the genetic algorithm approach to the MAC/Data Link Layer.

Game theory & wireless networks

Wireless networks are growing increasingly less structured, adopting many of the characteristics of ad-hoc networks. However, the dynamic interactions arising in these networks make it difficult to analyze and predict performance, inhibiting the development of wireless technologies.

A collaborative team consisting of Jeffrey Reed, Luiz DaSilva, Allen MacKenzie, Annamalai Annamalai, and Rob Gilles (Economics) is exploring the application of game theory to the analysis of these adaptive networks, particularly in relation to distributed power control, adaptive interference avoidance, adaptive MAC strategies, network formation, and node participation. This research has produced techniques for identifying when broad classes of algorithms will have a steady state and the conditions under which convergent behavior can be expected. The work is sponsored by the Office of Naval Research, Motorola, the IREAN program, and MPRG affiliates.

Hardware abstraction of middleware

MPRG researchers have developed a software abstraction of a hardware switch matrix (or any other hardware interface structure) that greatly improves the efficiency of software radios that meet the military standard software communications architecture (SCA).

In typical SCA implementation, data channels are directed through the system's general purpose processor. When two different resources in this type of architecture are connected, regardless of what platform they are implemented on, the processors must receive, process, and retransmit all data passed between different resources. This process places high demand on the computing platform.

The new approach reduces the middleware bottleneck by enabling different hardware components of the radio to communicate directly. The hardware abstraction of middleware is expected to enable lightweight, or low power, receivers that are fully compliant with the SCA.

Center for Wireless Telecommunications
www.cwt.vt.edu
A university center, involving four colleges, that develops technology and designs and builds hardware and software for wireless applications. CWT specializes in fully tested and operational prototypes, which are ready for production. Director: George Morgan (Finance)

UWB lab created

ECE's ultra wideband (UWB) research laboratory draws on expertise from communications, electromagnetics, and computer engineering. The measurement, analysis, and computation equipment supports research in the use of UWB for wireless communications and sensing. The laboratory's multidisciplinary research includes development of channel models for indoor and outdoor environments, and development of UWB antennas and hardware transceiver prototypes, designs, and techniques. In 2003, the group hosted the second annual IEEE Conference of Ultra Wide-band Systems and Technologies (UWBST), in Reston, VA.

Faculty

Wireless Communications

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Related Areas

Wireless Networks

Luiz daSilva

Nathaniel Davis

Thomas Hou

Yao Liang

Scott Midkiff

Amitabh Mishra

Jung-Min Park

RF, Antennas, Propagation

Gary Brown

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