Table of Contents

Welcome

Dear Guests,

It is our distinct pleasure to welcome you to Alabama and the Samuel Ginn College of Engineering at Auburn University. We look forward to the opportunity to showcase our University, our college and our programs – especially our recently accredited undergraduate program in wireless engineering – and to learn from each other.

The impact of the Vodafone Fellows Initiative at our institution has been significant. We expect the same can be said for the program at our two partner institutions – the University of California, Berkeley and the University of Illinois at Urbana-Champaign.

We are honored to host this symposium in the Vodafone Fellows series and hope that you will enjoy this opportunity to celebrate Vodafone's commitment to education and to hear from leading academics in the field of wireless research, executives from the wireless industry, and some of the best and brightest students in the field.

Larry Benefield
Dean, Samuel Ginn College of Engineering

Prathima Agrawal
Samuel Ginn Distinguished Professor of Electrical Engineering
Director, Wireless Engineering Research and Education Center

Kai Chang
Department Chair, Department of Computer Science and Software Engineering

Dave Irwin
Department Head, Department of Electrical and Computer Engineering

History of the Vodafone-US Fellows Initiative

The AirTouch Communications Foundation was created in 1994 with the vision of making a positive and enduring impact on the communities in the area. Following the successful merger of AirTouch with the Vodafone Group, to form Vodafone Americas Inc., the foundation's name was changed to the Vodafone-US Foundation.

In August 2003, the Foundation awarded $12 million in grants, shared among Auburn University, the University of California, Berkeley and the University of Illinois at Urbana-Champaign, to establish and maintain a new program – the Vodafone Fellows Initiative – aimed at providing support for academics in the advancement of wireless technology. This initiative was the first major foundation effort involving higher educational institutions and wireless technology.

In addition to providing both tuition and full support for undergraduate scholarships and graduate fellowships in wireless engineering, the grants also support curriculum and research development in wireless engineering and provide a pool of funds for interscholastic seminars, web casts and symposiums.

This conference is one of a series designed to bring together Vodafone-US Foundation Fellows with other top international academic and industry professionals to share knowledge and create a community of scholars dedicated to the advancement of wireless technology.

Vodafone Americas Inc. is a wholly owned subsidiary of Vodafone Group, Plc. which is headquartered in the United Kingdom and is the world's largest mobile telecommunications network company, with operations in 26 countries and more than 151 million customers worldwide.

Symposium Planning Committee

Chair

Prathima Agrawal - Wireless Engineering Research and Education Center (WEREC)
Electrical and Computer Engineering

Administration and Travel

Shelia Collis - Wireless Engineering Research and Education Center

Panel Discussion

Richard Jaeger - Electrical and Computer Engineering

Posters

Thad Roppel - Electrical and Computer Engineering
David Umphress - Computer Science and Software Engineering

Breakout Sessions

Richard Chapman - Computer Science and Software Engineering

Publicity

Cheryl Cobb - Samuel Ginn College of Engineering
Sanjeev Bhaskiyar - Computer Science and Software Engineering

Local Arrangements

Kori Caldwell - Samuel Ginn College of Engineering

Vodafone Foundation Liasions

June Sugiyama - Vodafone
Tracy Bow - Vodafone
Dara Kloss - Samuel Ginn College of Engineering

Publications/Website/Registration

Cheryl Cobb - Samuel Ginn College of Engineering
Michael Stone - Samuel Ginn College of Engineering

Audio Visual Arrangements

Kori Caldwell - Samuel Ginn College of Engineering

Student Assistants

Santosh Pandey - Electrical and Computer Engineering
Pratap Simha Prasad - Electrical and Computer Engineering

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SAMUEL GINN
COLLEGE OF ENGINEERING

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Wireless service is available throughout the Auburn University Hotel and Dixon Conference Center.

The user name is: Auburn
The password is: Hotel

2007 Vodafone Symposium at Auburn University
Program

Friday, 23 March

2:00-4:00 pm National Center for Asphalt Technology Tour for UIUC
Buzz Powell, Track Manager, NCAT
Zeb Whitehead, Info Tech Specialist, Samuel Ginn College of Engineering
(Depart by charter bus from AUHCC[1])

5:00-6:00 pm Check-in and Registration (AUHCC Ballroom B)

Opening Session: (AUHCC Ballroom B)

6:00-6:15 pm Welcoming Remarks and Speaker Introduction
Larry Benefield
Dean, Samuel Ginn College of Engineering
Auburn University

6:15-7:00 pm Guest Speaker: Samuel Ginn
Wireless Innovation in the Future Economy
Retired Chairman, Vodafone AirTouch

7:00-8:30 pm Reception and Cocktail Buffet (Prefunction Foyer)
AU Student Poster Session

Saturday, 24 March

8:00-8:45 am Breakfast (AUHCC Ballroom A-left)

Morning Session: (AUHCC Ballroom B)

8:45-8:55 am Welcoming Remarks and Speaker Introduction
Prathima Agrawal
Samuel Ginn Professor, Electrical and Computer Engineering
Director, WEREC
Auburn University

[1] **All buses will pick up and drop off at circle drive at the front of the hotel.**

8:45-9:40 am Wireless Technology
Peters Suh
President, Vodafone Americas Inc.
and Vodafone Ventures Ltd.

9:40-10:20 am The Global Positioning System and Its Use for Control of Ground Vehicles
Dave Bevly
Asst. Professor, Mechanical Engineering
Auburn University

10:20-10:40 am Break

10:40-11:20 am The Brave New World of Wireless Communication
Ali Niknejad
Assoc. Professor, Electrical Engineering and Computer Science
University of California, Berkeley

11:20-12:00 pm System-Theoretic Foundations for Wireless Sensor Networks
Venu Veeravalli
Professor, Research Professor, Electrical and Computer Engineering
Coordinated Science Lab
University of Illinois at Urbana-Champaign

Lunch Session: (AUHCC Ballroom A-left)

12:00-1:30 pm Lunch and Round Table Discussions
Chair: Richard Chapman
Assoc. Professor, Computer Science and Software Engineering
Auburn University

- Beyond 3G
- Business Issues
- Industry/Academia Collaboration Issues
- Low Power Design
- MEMS Design of RF Components
- Mobile Phone/WLAN Convergence

- Multimedia over Wireless
- RFIC Design
- Security Issues
- Wireless Educational Issues
- Wireless Sensor Nets

Afternoon Poster Sessions: Exhibit Rooms E, F, G

1:30-2:45 pm UCB Student Poster Session

2:45-3:00 pm Break

3:00-4:15 pm UIUC Student Poster Session

Afternoon Session: AUHCC Auditorium

4:15-4:45pm Wireless Internet and VOIP Service for a Remote Orphanage in Honduras
Charles Ellis
Director, Microelectronics Lab
Auburn University

4:45-6:00 pm Panel Discussion — Wireless Without Borders
Chair: Richard Jaeger
Distinguished Univ. Prof., Auburn University

- Dan Bochneak, Sentinel Strategies
- Richard Chapman, Auburn University
- David Famolari, Telecordia
- Marion Lineberry, Texas Instruments
- Adrian Nemchek, Motorola

Dinner : Pavillion at Ag Heritage Park

6:30-9:30 pm Shuttle bus transport to and from AUHCC to Ag Heritage Park [1]

7:00-9:00 pm Introduction
Prathima Agrawal

Keynote Speaker: Anil Kripalani
Broadband Wireless – Realizing a World Without Borders

[1] **All buses will pick up and drop off at circle drive at the front of the hotel.**

Corporate Senior VP, Global Technology Affairs,
Qualcomm Inc.
Entertainment: The Village Squares

Sunday, 25 March

Breakfast and Closing Session: (AUHCC Ballroom A-left)

8:00-9: 00 am	Breakfast
9:00-9:30 am	Poster Awards Closing Remarks Prathima Agrawal Presenting Awards June Sugiyama
9:30-9:45 am	Overview and Final Remarks June Sugiyama Director, Vodafone Foundation
9:45-11:15 am	National Center for Asphalt Technology Tour for UCB Jennifer Still Lab Technician, NCAT Zeb Whitehead Info Tech Specialist, Samuel Ginn College of Engineering ***(Depart by charter bus from AUHCC[1])***
10:00-12:00 pm	Distribute Box Lunches and Hotel Check-out (Prefunction Foyer)
10:30 am	(***Departure to the Airport - UIUC[1]***)
2:00 pm	(***Departure to the Airport - UCB[1]***)

[1] **All buses will pick up and drop off at circle drive at the front of the hotel.**

Speaker Biographies/Abstracts

Wireless Innovation in the Future Economy
Samuel Ginn
Retired Chairman, Vodafone AirTouch Plc

Biography

Samuel Ginn is a distinguished Alabama native and graduate of Auburn University's College of Engineering recognized as a pioneer in the world of wireless technology and communication. His generous support to the College of Engineering funded the nation's first wireless engineering program; in 2001 the college was renamed as the Samuel Ginn College of Engineering. He continues to demonstrate his commitment to Auburn University and to higher education as a member of the university's board of trustees.

Ginn began his 42-year career in the telecommunications industry in 1960 as a student engineer with AT&T in Cincinnati, Ohio. He was appointed vice president of network operation for AT&T Long Lines in 1977. He joined the Pacific Telephone Group in 1978 as vice president in the Los Angeles area, became president and chief operating officer of Pacific Telephone and in 1988 was appointed chairman and chief executive officer of Pacific Telesis Group.

In April 1994, AirTouch Communications spun off Pacific with Ginn as its chairman and CEO. At AirTouch, Ginn created nearly $1 billion a month in shareholder gain and added more than $2-billion value for the company's employee stockholders. In June 1999, AirTouch completed a $62-billion merger with Vodafone and Ginn assumed the company chairmanship. He retired from Vodafone in May 2000.

Ginn has also served as chairman of the California Business-Higher Education Forum, the California Business Roundtable, and the Committee on Jobs. He has served as a member of several corporate boards including CH2M Hill, First Interstate Bank, Pacific Telesis Group, Safeway Inc., Transamerica Corporation, Vodafone PLC, AirTouch Communications, Hewlett Packard and Fremont Group, LLC.

He is a Sloan fellow at Stanford University's School of Business and is currently an overseer at the Hoover Institute in Palo Alto, California.

Wireless Technology
Peters Suh
President, Vodafone Americas Inc. and Vodafone Ventures Ltd.

Biography

Peters Suh is currently the president of Vodafone Ventures Ltd. Prior to joining Vodafone, he was a managing director for Fremont Communications a $250-million private equity fund focusing on telecommunication investments. Peters was previously vice president, chief technical officer for Vodafone's Global Internet Services group and he has also held a number of positions with AirTouch, including vice president of Internet Services and vice president of Management Information Services. Peters is a director of Mirapoint, Inc. a privately held messaging company and the Vodafone-US Foundation. Peters holds a B.A. and M.B.A., both from the University of California, Los Angeles.

The Global Positioning System and its Use for Control of UGVs
David M. Bevly
Asst. Professor, Mechanical Engineering
Auburn University

Abstract

The Global Positioning System (GPS) has provided the ability to determine a body's position, velocity, and attitude anywhere on the surface of the globe, which has led to many advances in land, marine, and air navigation systems. With the absence of Selective Availability (SA), a GPS receiver can provide three-dimensional velocity measurements with accuracies of 3 cm/s (1σ, horizontal) and attitude measurements with an accuracy of 0.4 degrees. Furthermore, GPS can be augmented with inertial sensors in order to decrease GPS errors and provide measurements between GPS outputs as well as during loss of GPS signals. This talk will cover the origins of GPS, the various measurements possible using GPS, as well as the measurement limitations and new applications of GPS. One such application of GPS is autonomous control of unmanned ground vehicles (UGVs). Both military and commercial applications of UGVs will be discussed with examples from the DARPA Grand Challenge and John Deere's Autosteer tractors.

Biography

David Bevly received his bachelors from Texas A&M University in 1995, master's from Massachusetts Institute of Technology in 1997, and doctorate from Stanford University in 2001, in mechanical engineering. He joined the faculty of the Department of Mechanical Engineering at Auburn University in 2001 as an assistant professor. Dr. Bevly's research focuses on vehicle dynamics as well as modeling and control of vehicle systems. Specifically, Dr. Bevly has developed algorithms for control of off-road vehicles and methods for identifying critical vehicle parameters using GPS and inertial sensors. He has received two Young Investigator Proposals from the Office of Naval Research and the Army Research Office, and was recognized by the College of Engineering with the Alumni Engineering Council Outstanding Faculty Award and Alumni Engineering Council Junior faculty Research Award.

The Brave New World of Wireless Communication

Ali Niknejad
Assoc. Professor, Electrical and Computer Engineering
University of California, Berkeley

Abstract

Wireless communication has become an integral part of our lives. We rely on several wireless technologies to provide voice and data at home and on the road. Today there are various competing and complementary standards for voice and data, and new products with wireless capability appear every day. The radio front-end circuitry is a key component in such systems, converting electromagnetic energy incident on the device to bits of data processed by the baseband circuitry. The design and manufacturing of these radios is currently time-consuming and expensive. This talk will review three new ways of utilizing spectrum, UWB, 60 GHz, and Cognitive Radios. We will demonstrate that a CMOS radio with multiple antennas can utilize the 60 GHz spectrum for Gb/s wireless LAN/PAN connectivity. We will also discuss a potential radio architecture for multi-standard and multi-mode applications, the Cognitive Universal Radio (COGUR), which is more amenable to mass production, integration, and multi-standard operability.

Biography

Ali M. Niknejad received his bachelor's in electrical engineering from the University of California, Los Angeles, in 1994, and master's and doctoral degrees in electrical

engineering from the University of California, Berkeley, in 1997 and 2000. From 2000-2002 he worked at Silicon Laboratories in Austin, TX, where he was involved with the design and research of CMOS RF power amplifiers for wireless communication applications. Presently he is an associate professor in the EECS department at UC Berkeley. He is a co-director of the Berkeley Wireless Research Center (BWRC) and the BSIM Research Group. He served as an associate editor of the IEEE Journal of Solid-State Circuits and is currently serving on the TPC for CICC and ISSCC. His current research interests lie within the area of analog integrated circuits, particularly as applied to wireless and broadband communication circuits. His interests also include device modeling and numerical techniques in electromagnetics.

System-Theoretic Foundations for Wireless Sensor Networks

Venu Veeravalli
Professor, Electrical and Computer Engineering
Research Professor, Coordinated Science Lab
University of Illinois at Urbana-Champaign

Abstract

Networks of distributed wireless sensors capable of collecting, storing, and disseminating a variety of environmental data have the potential to enable the next revolution in information technology. Research to date on such sensor networks has largely been focused on techniques for building the sensors, and on self-configuring protocols for establishing communication between them. However, in order to fully exploit their potential, a core system-theoretic framework for the design, analysis and application of sensor networks is needed. This presentation will describe recent efforts towards the development of such system-theoretic foundations, and outline some open problems and challenges that lie ahead.

Biography

Venugopal V. Veeravalli received his doctorate degree in 1992 from the University of Illinois at Urbana-Champaign. He is currently a professor in the department of Electrical and Computer Engineering, and a research professor in the Coordinated Science Laboratory at the University of Illinois at Urbana-Champaign. He served as a program director for communications research at the U.S. National Science Foundation in Arlington, Va. from 2003 to 2005, and has held academic positions

at Harvard University, Rice University and Cornell University.

His research interests include distributed sensor systems and networks, wireless communications, detection and estimation theory, and information theory. He is a Fellow of the IEEE and currently on the Board of Governors of the IEEE Information Theory Society. Among the awards he has received for research and teaching are the IEEE Browder J. Thompson Best Paper Award in 1996, the National Science Foundation CAREER Award in 1998, and the Presidential Early Career Award for Scientists and Engineers (PECASE) in 1999.

Wireless Internet and VOIP Service for a Remote Orphanage in Honduras

Charles Ellis
Director, Micro-Electronics Lab
Auburn University

Abstract

Orphanage Emmanuel is located outside of the remote city of Guaimaca, Honduras and is managed by David and Lydia Martinez along with a staff of up to 15 volunteers. It has been in operation for 17 years and now takes care of over 420 children. It is entirely supported by donations from individuals across the US and Denmark. This Orphanage has never turned away a child, regardless of health or emotional issues.

In order to provide adequate phone and internet service for the Orphanage, a team of Auburn Engineers initially decided to set up a satellite dish along with some wired internet connections. The wired connections proved inadequate, and given that the Orphanage encompasses over 1000 acres it was determined that a wireless system was needed. This presentation will discuss the implementation of a wireless internet (WiFi) system which provides internet and VOIP/PBX service to a medical clinic, internet café, administrative offices, school offices, a computer laboratory, six residences, a volunteer dorm, and farm training center. This system has been operational for over two years and has proven very reliable and useable.

Biography

Charles D. Ellis was born in Charleston, SC, on January 19, 1958. He received his bachelor's degree in Electrical Engineering in 1980 and master's of electrical engineering in 1988 – both from Auburn University. He recently completed all coursework and qualifications for a doctorate in electrical engineering which will be awarded in the spring of 2007.

He has worked as a lead IC process engineer for Texas Instruments, Dallas Texas, in charge of the Dielectrically Isolated, Advanced Digital Bipolar MX missile components. He also worked at Insouth Microsystems as IC fabrication manager, setting up a new CMOS fab line which fabricated Silicon accelerometers, gate arrays, and custom IC's. He has worked at Honeywell Solid State Electronic Division, Colorado Springs, Co., in charge of implementing the Diffusion/Ion Implant areas for a new 6" VHSIC Fabrication facility. He then took charge of four process technologies at Honeywell which included radiation hardened IC MOS (RICMOS), Dual-Poly Pwell Analog CMOS, CCD, and a baselined Metal-Gate CMOS process. He developed a process for achieving a sub 0.2 nA/CM2 dark current for the CCD process for which he was awarded the 1986 Divisional Outstanding Achievement Award. He is presently the director of the Microelectronics Laboratory at Auburn University where he is responsible for all ECE microelectronics research facilities and also principle investigator for various contracts.

Broadband Wireless – Realizing a World Without Borders

Anil Kripalani
QUALCOMM Corporate Senior Vice President,
Global Technology Affairs

Abstract

Cellular technology has come a long way, from first concepts at Bell Laboratories in the late 1940s, working systems designed during the'70s, leading to commercial analog cellular systems in the early '80s, followed by 2G systems in the '90s and global 3G rollouts currently ongoing. Subscriber acceptance has been an eye-opener for market analysts. A high-profile McKinsey/AT&T study in 1986 famously predicted no more than a million wireless subscribers in the U.S. by the turn of the century, citing several 'insurmountable' barriers to market growth. Contrast that with today's reality nearing 2.5 billion subscribers across the globe who are using digital wireless technologies for voice, email, internet access, music and video services. While the McKinsey study 'predicted' that wireless voice would remain a luxury, we now know that hundreds of millions across the developing world clearly see it as a necessity and have used cell phones to make their first call and remain in touch, whether at home or on the move, across town, country and continent. New spectrally efficient technologies are enabling innovative and economical services for broadband wireless access, supporting an ever growing variety of highly-

integrated semiconductor devices supporting tiered capabilities and feature rich applications, including high quality imaging, mobile television, interactive mobile games, videoconferencing and social networking. Wireless Wide Area Network operators are provisioning cost-effective All-IP communication facilities and supporting service architectures around the world, connecting communities that have thus far had limited or no telecommunications access. Costs for network equipment and handsets have plummeted in large part due to fierce global competition from Asian vendors.

Anil Kripalani will take a look back at where we have been over the past two decades in the global world of wireless. After setting the foundation by listing key enabling technologies, he will elaborate on the future capabilities of mobile devices, illustrating the convergence with consumer electronics, as well as the benefits and innovative services/applications such devices will offer device manufacturers, operators, content providers, application developers and end users. He will then venture a perspective on what seems to be the most critical question in the communications industry today: what's coming next in mobile communications?

Biography

Anil Kripalani is corporate senior vice president for Global Technology Affairs at QUALCOMM Incorporated based in San Diego, Calif. Kripalani actively promotes the global adoption and deployment of current broadband standards, and positions next-generation wireless air interface and network technologies that enable wireless multimedia services. In the past, his responsibilities have included global standards planning, technology marketing, network applications engineering and international administration.

Prior to joining QUALCOMM in 1994, Kripalani spent more than 18 years at AT&T Bell Laboratories, AT&T Network Wireless Systems and AT&T Information Systems and last served as a department head for Wireless Systems and Local Access Architecture in AT&T's Chief Architects Division. He was also responsible for cellular base station system software development and cross-functional project management.

Kripalani has been associated with the wireless industry for 22 years and has been active for 16 of those years in the area of wireless standards development. He serves on the Executive Committee of the Telecommunications Industry Association board of directors as chair of TIA Standards. He has previously served on the board of governors of the IEEE Vehicular Technology Society. He currently serves on the board of directors of the Open Mobile Alliance and is chairman of the board

of the Center for Telecom Management at USC's Marshall School of Business. He serves on the Advisory Board of the WINMEC Center at UCLA. He is affiliated with the TiE entrepreneurial organization (The Indus Entrepreneurs) as a charter member and has recently joined their board of directors for the TiE Wireless SIG (Special Interest Group). He serves on the Executive Council of the International Engineering Council and on the board of directors of the San Diego Symphony.

Kripalani holds a bachelor's degree in electrical engineering from the Indian Institute of Technology in New Delhi, India and a master's degree in computer science from the University of California, Los Angeles. He holds a patent in signaling networks.

Poster Abstracts

Auburn University (22)

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Electrical Engineering

An Efficient Power Estimation Tool for CMOS Circuits

We have developed a gate-level (total) power estimation tool forCMOS circuits. Average, maximum and minimum values of each component of power, namely, dynamic (separate logic and glitch), short circuit, and leakage are determined. Such a tool has useful applications because, in circuit design, the objective is total power optimization and methods to reduce any one component affecting others.

■ ■ ■

Lei Chen
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Doctorate
Computer Science

Secure Media Streaming with Path Diversity in Mobile Ad Hoc Networks (MANETs)

Media streaming in Mobile Ad Hoc Networks is quite challenging because of the limited bandwidth, signal loss and signal interference. Securing the huge amount of data in media communication makes this task even more difficult to complete. In our research, we try to increase the bandwidth and reduce delay by utilizing Path Diversity, or making use of multiple paths between the source and destination nodes. For security purpose, we propose a smart data distribution mechanism; to balance the traffic in MANETs without draining any node, a selective encryption/decryption mechanism is also applied.

■ ■ ■

E. Vincent Cross II
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Doctorate
Department of Computer Science and Software Engineering

Prime III

Prime III is a voting system that delivers the requisite system security, integrity, and user satisfaction safeguards in a user friendly, secure, electronic voting system. Moreover, Prime III incorporates the current voting process that the voter is accustomed to using and significantly improves upon it. This approach allows the voter to remain comfortable and confident while using an enhanced voting system. The design goal was to develop a robust multimodal application through user centered design principles that combines security with user interaction to create a usable security system that facilitates user interaction with the application, through multiple means (i.e. text-to-speech, speech-to-text, touch). This multimodal approach permits voters to hear and/or see the candidate names while they cast their votes (via voice and/or touch).

■ ■ ■

Shuangchi He
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Electrical Engineering

Direct FIR Linear Equalization of Doubly Selective Channels Based on Superimposed Training

Design of doubly-selective linear equalizers for single user frequency selective time-varying channels is considered using superimposed training and without first estimating the underlying channel response. Both the time-varying channel as well as the linear equalizers are assumed to be described by a complex exponential basis expansion model (CE-BEM). A periodic (non-random) training sequence is arithmetically added (superimposed) to the information sequence at the transmitter before modulation and transmission. There is no loss in information rate. Knowledge of the superimposed training is exploited to design the FIR linear equalizer. An illustrative simulation example is presented.

■ ■ ■

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Electrical Engineerinig

A Single-Chip Programmable RF MEMS Filter for SDR Cellular Pico BTS

The RF front end circuitry makes up more than 60% of the cost of a base transceiver station (BTS, also referred as Node B in 3G networks). Included in this cost is that of the Power Amplifier unit, RF filters, and the GPS unit for clock recovery and synchronization. Depending on the architecture complexity, number of supported sectors, power range specification, and wireless network standards supported, a base transceiver station can cost between $10,000 to $40,000. RF MEMS (microelectromechanical systems) is a technology that has the potential to not only solve the BTS cost and logistic issues, but to also complement SDR architectures by providing a true low cost, high performance, programmable RF Front End filter. The authors are researching the possibility of implementing a Single-Chip Programmable RF MEMS Filter for SDR Cellular Pico BTS for commercialization by 2010 or earlier, with particular attention to possible solutions to the issue of maximum switching speed limitation of RF MEMS.

■ ■ ■

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Undergraduate
Wireless Engineering

Mote Channel Selection in Noisy 2.4 GHz Enviroments

In environments where motes are deployed, several 802.11b/g access points frequently overlap a single area; more than three access points in an area limit the available frequencies because of the overlapping umbrellas associated with each 802.11 channel, limiting motes' operating quality. Motes attempting to operate in these noisy channels will experience high packet loss due to corruption from interference. The motes cannot compete with access points due to power requirements for transmission power levels. Motes allow setting the channel to a value within the 2.4Ghz spectrum, but only a small fraction of the available spectrum exists outside

of the predominant 802.11 b/g channels (beyond channel 11). Using this small area of spectrum exclusively for motes will eventually result in increased mote-mote interference. Experimenting with channel selections and power levels for the motes will provide data indicating the sensitivity to surrounding 2.4Ghz noises.

■ ■ ■

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Computer Science

A High-Throughput And Low-Delay Protocol for Sensor Networks

This paper presents a compound metric, Cost, which combines both throughput and delay in wireless sensor networks. We employ ETX (expected transmission count) metric for each link and we propose a new way to compute ETX for a path, which doesn't exaggerate the effect of interference among the successive links of a path. We put forward a self-defined equation to compute the Cost for a path, based on which a proper path is reinforced locally. This paper describes the design and simulation of Cost for directed diffusion. We get the results from emulation on 20 computers connected by wired network that the metric Cost improves throughput with a factor of two or more and keeps the roughly satisfactory delay value.

■ ■ ■

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Computer Science

P2PGS: A Distributed Grid Scheduler Adopting P2P Resource Discovery Strategy Y

In a grid computing environment, dynamicity and geographically distributed sites, make task scheduling problems challenging to solve. It is hard for a local site to obtain precise real-time information about other sites given that specific information on a site such as load and computing resources may change rapidly. Moreover, in data grid environment, large scale data intensive applications make schedul-

ing problems even more challenging since both computational and data storage resources must be taken into consideration. In this paper we propose an innovative peer-to-peer scheduler to solve these problems. This scheduler is distributed and scalable. We used simulation to evaluate the performance of the scheduler under different circumstances, such as different number of hops to search suitable sites and different number of incoming tasks. Results show that our scheduler can successfully schedule around 75% of incoming tasks within their deadlines in average. For computation-intensive tasks, it can successfully schedule more than 90% of incoming tasks.

■ ■ ■

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Doctorate
Electrical Engineering

Statistical Leakage Optimization for Submicron Process Variation

A mixed integer linear programming method is proposed for dual-threshold design that minimizes the leakage power and circuit delay in a statistical sense such that the impact of process variation on the leakage and timing yields are minimized. Results show up to 30% greater leakage reduction than the deterministic approach.

■ ■ ■

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Software Engineering

The Top Ten Smart Phones

Smart phones have transformed cell phones into mobile, networked computers. This technology unites an assortment of electronic devices — cell phones, handheld computers, MP3 players, cameras — into a single platform that has more capabilities than computers of a half-decade ago. As versatile as these devices are, they have not caught the imagination of the consumer market as well as manufacturers predicted. There are a myriad of reasons for this, but complexity is the

predominate factor. Smart phone software development requires the skill of a desktop computer software engineer as well as the attention to detail of an embedded systems programmer. An examination of the top ten smart phones on the market today reveals the intricacies of cell phone software engineering: operating system alternatives, service-level APIs, battery power management, user interface models, carrier relations, and business model support.

■ ■ ■

Raghu Kisore Neelisetti
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Computer Science and Engineering

Wireless Acoustic Sensor Networks for Target Tracking

Target tracking involves estimating various trajectory parameters, such as position, slope of the trajectory and velocity. We are designing and implementing a method for estimating these parameters using CPA (Closest Point of Approach) measurements from a group of four (minimum) wireless acoustic sensors. The tracking algorithm based on CPA measurements requires an uneven distribution of sensors deployed on either side of the target trajectory, with a reference node on one side of the target trajectory and the other three nodes on the other side. However, given a random deployment it is not easy to choose the right set of four nodes that can successfully track a target trajectory. But if we can group together five nodes instead of four, then irrespective of the target's trajectory we will always have three nodes on one side of the target trajectory and two nodes on the other side. We have implemented a simple algorithm (in Ns-2) that will dynamically group the deployed nodes into groups of five. The algorithm further provides desired level of efficiency and redundancy.

■ ■ ■

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Wireless Software Engineering

Wireless Scoring System for Fencing Tournaments

The project involves the design of an automated, wireless scoring system for fencing tournaments. Sensors in the weapons detect scoring events during a match. This information is to be transmitted wirelessly to a "box" on the scorer's table that will signal events, and tabulate and display scores in real time for both of the fencing weapons (foil and epee). We will be using a microcontroller developed and built by Cypress Semiconductor Corp. in conjunction with their WirelessUSBTM solution. WirelessUSB is designed for short range multipoint to point wireless connectivity, while offering the benefits of low cost and low power.

■ ■ ■

Santosh Pandey
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Electrical Engineering

Sophisticated Node Placement Algorithms in Hierarchical Networks

In this work, we address the problem of node placement in a hierarchical heterogeneous wireless sensor network. We consider a two-tiered wireless sensor network where the resource constrained Lite Nodes (LNs) are used for sensing the environment and high-end Sophisticated Nodes (SNs) are added to aggregate and forward data. We intend to place minimum number of SNs to handle the traffic generated by LNs and ensure that the SNs form a connected network. We formulate the node placement problem as an optimization problem and use three different algorithms to solve it; namely, Binary Integer Linear Programming (BILP), Greedy algorithm (GREEDY) and Genetic Algorithm (GA). We also propose a hybrid approach (HYBRID) combining BILP, GREEDY and GA to improve results. It was found through simulations that GA performed better for random LN deployment. However, using HYBRID, results comparable to original GA could be obtained in only 11.46% of the time required for the original GA. We support the results with statistical tests.

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JME - The Mobile Platform

The average cell phone user may not realize it, but they are using a small computer. In fact, they may be carrying one that they can program. Over 80% of the cell phone handset models on the US market today are programmable in the Java programming language, making Java one of the most widely accessible languages of all time. The version of Java that runs on cell phones — Java Platform, Micro Edition (JME) — is the same language as used on desktop computers, but that is where the similarity stops. JME software development requires radically more attention to detail. An examination of the specifics of engineering software in JME shows that the developer must be adept at implementing applications that involve event loops, moderate computing capability, constrained user interfaces, limited power consumption, intermittent network connectivity, and increased robustness. Moreover, JME programmers must contend with extra-software issues such as over-the-air provisioning, cell phone carrier constraints on content, and cost models.

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FPGA-Based Analog Functional Measurements for Adaptive Control in Mixed-Signal Systems

A Field Programmable Gate Array (FPGA)-based Built-In Self-Test (BIST) approach used for adaptive control in mixed-signal systems is presented. It provides the capability to perform accurate analog functional measurements of critical parameters such as the 3rd order intercept point (IP3), frequency amplitude and phase responses and noise figure (NF). The results of these measurements can then be used to adaptively control the analog circuitry for calibration and com-

pensation. The BIST circuitry consists of a direct digital synthesizer (DDS) based test pattern generator (TPG) and a multiplier/accumulator based output response analyzer (ORA). The BIST approach has been implemented in an FPGA-based mixed-signal system and used for actual analog functional measurements. The BIST measurements agree quite well with the results obtained with the traditional analog test equipment. The proposed BIST circuitry provides a unique means for high-performance adaptive control in mixed-signal systems.

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Mobile Cell Phone Booth

The principle of noise cancellation is applied to speaker's speech. With the goal of providing the privacy of a phone booth to a cell phone user on the move, a digital signal processor feeds the speech signal in opposite phase to a loudspeaker with similar directional characteristics as the human speaker.

■ ■ ■

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Emerging Trends in Wireless Technology

Software development has come what seems like a full circle. Programming in the early days of computers required a careful marriage of hardware and software. Programmers had to have an intimate knowledge of the hardware with which they were working in order to make the software fit, both functionally and physically. As programming languages became more high-level, developers were able to ignore to a large extent the underlying hardware when implementing software applications. Mobile devices have returned software engineers to their original roots — designing and writing software for these platforms require careful attention to

a host of low-level details, such as program size, system speed, power consumption, network bandwidth, and user interaction all of which are typically tightly constrained. We examine emerging trends in software engineering technology based on cutting-edge features available on mobile devices today, and forecast what is required of software developers to keep pace with those trends.

■ ■ ■

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Cache Interconnection Architecture for Chip Multiprocessors

There is a growing trend to put multiple cores on the die. The interconnects among the cores on the same chip are quite different from those well understood for connecting chips, multi-chip modules, and board-level nodes because they share common limited resources, such as power, area. Our goal is to design the best cache to memory and cache to cache (in multi-core) interconnection architecture to maximize on-chip service and minimize off-chip misses for best performance and fault tolerance. Possible interconnection architectures are shared bus, wireless, point-to-point, or crossbar. Power, area, latency, and bandwidth are all design constraints. Using the design constraints, we assess different interconnects. Our cache to memory design uses a secondary channel to commit write backs while the main bus is busy with I/O operations. The parallelization of I/O with memory traffic improves performance significantly.

■ ■ ■

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An Improved On-chip 4-port Parasitics De-embedding Method with Application to RF CMOS

For on-wafer 2-port measurement, the measured test structure includes not only

the desired internal device, but also probing pads and interconnects. These parasitics can be significant at high frequencies, and must be deembedded. The on-chip parasitics between the two measurement ports and the two device ports can be viewed as a 4-port. We presents an improved algorithm to solve the general 4-port parasitics de-embedding problem. Experimental results on 0.13 μm RF CMOS device are presented. The reciprocity and symmetry of the 4-port parasitics are also examined.

■ ■ ■

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Wireless Communication for Collaborative Search and Rescue

Collaborative map building for search and rescue missions requires wireless communication. This communication must be optimized with respect to a number of parameters including the amount of data to be exchanged, security requirements, number of entities involved, available power, and the communication interval. Previous work has investigated these tradeoffs in simulation. Presently, a laboratory-scale hardware demonstration is under construction which uses collaborating mobile robots equipped with WiFi transceivers configured as a mobile ad-hoc network. Theoretical and practical aspects of the communication system's design will be presented.

■ ■ ■

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Multi-Interface Multi-Channel Mobile Terminals

We propose a multiple interface and multiple channel architecture for wireless terminals. With such architecture, each wireless terminal is configured with multiple interfaces, each of which operates on a different wireless channel to associate

with a different neighboring access point. Such wireless terminal architecture can work either as active-standby or load-balance mode. It can significantly improve throughput, enhance user response and enable seamless handoff. Moreover, this architecture explores the potential capacity of the existing wireless network infrastructure deployed ubiquitously today. Our measurement from real experiments confirms these benefits.

■ ■ ■

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Connection-based Routing Protocol for Vehicular Networks

A connection-based routing protocol is proposed for the vehicular network. Due to the high mobility feature, the end-to-end connection in such networks will become more fragile. Different from other works, we focus on establishing route paths which have the highest probability of full connection. Connectivity model for vehicles on street and intersection is invented from the information of the road density and average velocity of traffic flow.

University of California – Berkeley (8)

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A Data Oriented (and Beyond) Network Architecture

The Internet has evolved greatly from its original incarnation. For instance, the vast majority of current Internet usage is data retrieval and service access, whereas the architecture was designed around host-to-host applications such as telnet and

ftp. In addition, the proliferation of mobile devices in today's networking environment has made everything increasingly wireless and dynamic. To adapt to these changes, we propose the Data-Oriented Network Architecture (DONA), which allows wireless/mobile devices to seamlessly access data and services, leading to a ubiquitous user experience. DONA restructures naming and name resolution to provide a seamless and ubiquitous user experience. DONA is built around a route-by-name paradigm where we do anycast on the names of the data items, which are flat, semantic-free and hence help in maintaining ubiquitous availability. The concept of name-based routing is useful for resource discovery as well. For example, the basic primitives underlying SIP, RSS, Multicast and new technologies like Delay Tolerant Networks(DTNs) are easily supported by DONA.

■ ■ ■

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CMOS Power Amplifier for Modern Digital Communication Systems

The need for ubiquitous wireless communication systems has been a key driver in the development of high frequency integrated circuit building blocks. The design of efficient CMOS RF power amplifiers is particularly challenging. The introduction of wireless standards that utilize variable envelope modulation techniques pose several challenges to the PA design. In addition, technological constraints such as low breakdown voltage in deep submicron process necessitate design innovation. In the first phase of our work, we have designed a linear power amplifier in a 90 nm digital CMOS process that has a peak output power of 24.3 dBm with 27% efficiency. We have employed a novel on-chip transformer topology to combine the power output of 4 push-pull PAs. A big advantage of this topology is its scalability and the option to turn off some of the stages to have higher average efficiency. The stability of the power amplifier is always a big concern. In this project, we have developed a comprehensive mathematical model that helps us to predict any possible instability of the amplifier.

■ ■ ■

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The Design and Fabrication of Micropower Systems Tailored for Wireless Sensor Devices

Next generation wireless sensors are being developed with the goals of miniaturizing the sensors to millimeter dimensions while integrating a self-sufficient power supply to last the lifetime of the device. One of the challenges with the integration of an adequate power supply is the physical limitations imposed on power components as the sensors are miniaturized. A proposed micropower system combines vibrational energy harvesting and an energy storage system that couples a lithium ion polymer microbattery with a carbon capacitor. My research includes the characterization of the piezoelectric and electrochemical materials for the micropower components, and the design and fabrication of the energy scavenging and storage devices using pneumatic printing. Direct write printing techniques are being recognized as viable fabrication tools that are low cost, environmentally less wasteful, and will optimize materials properties through patterning structures and chemistries not possible or difficult with traditional fabrication equipment. The implementation of an integrated micropower system will enable wireless sensors to become truly ubiquitous, and with it improve the way people interact with information made available through technology.

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Utility Maximization in Single-Channel and Multi-Channel Wireless Networks

In a wireless network (e.g., cellular network, Wireless LAN, etc), when different users with various bit rates share the same spectrum, there is a fundamental tradeoff between fairness and spectrum efficiency. Allocating the same "throughput" to ev-

ery user is "fair", but may result in very low efficiency; while allocating the spectrum entirely to the user with the maximum bit rates achieves the best efficiency but the worst fairness. This work investigates the use of "utility maximization", particularly, "proportional fairness" (PF) to balance fairness and efficiency. In an earlier work, we have shown that for the single-channel case, PF leads to equal "time allocation" to individual users. This physical interpretation makes PF easy to implement. Recently, PF is further applied to multi-channel multi-rate wireless networks, where PF leads to equal "equivalent time allocation". Applications of the study include (1) Access Point (AP) association and transmission scheduling in large-scale multi-channel 802.11 networks; (2) sub-carrier assignment and scheduling in orthogonal frequency division multiplexing (OFDM) cellular networks. Simple algorithms are provided to make the allocation converge to optimum.

■ ■ ■

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Physical Activity Monitoring for Assisted Living at Home

We propose a methodology to determine the occurrence of falls from among other common human movements. The source data is collected by wearable and mobile platforms based on three-axis accelerometers to measure subject kinematics. Our signal processing consists of preprocessing, pattern recognition and classification. One problem with data acquisition is the extensive variation in the morphology of acceleration signals of different patients and under various conditions. We explore several effective features that can be used for classification of physical movements. Our objective is to enhance the accuracy of movement recognition. We employ classifiers based on neural networks and k-nearest neighbors. Our experimental results exhibit an average of 85% accuracy in movement tracking for four activities over several test subjects.

■ ■ ■

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Ultra-Low Voltage Logic Design

As supply voltages scale with technology, device threshold voltages are forced to decrease in order to achieve the required performance gain due to scaling. However, lowering device threshold voltage increases the leakage or standby current of the overall system. Thus, the minimum device threshold voltage is limited by the amount of standby energy the system can tolerate. This project explores the possibility of using a logic structure based on long chains of pass transistor. Using pass transistor-based logic reduces the number of supply and ground connections in the circuit, thus reducing the amount of leakage current incurred as the device threshold voltages are scaled down. Reducing the device threshold voltage recovers the increased delay associated with long chains of pass transistors. Thus aggressive supply voltage scaling below 500 mV can be achieved while maintaining decent circuit performance. The initial phase of this project involves the design and fabrication of test structures for logic block characterization, as well as larger design building blocks such as adders and multipliers in 90 nm CMOS.

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A Beam-former Architecture for Antenna Arrays Using General Purpose Hardware

Our group, the Center for Astronomy Signal Processing and Electronics Research (CASPER), seeks to speed the development of radio astronomy signal processing instrumentation by designing and demonstrating a scalable, upgradeable, FPGA-based computing platform and software design methodology that targets a range of real-time radio telescope signal processing applications. This project relies on a

small number of modular, connectible hardware components and open-source signal processing libraries which can be reused and scaled as hardware capabilities expand. In this particular poster we demonstrate an architecture for phased array processing of multiple beams with the Allen Telescope Array using a general purpose hardware platform called the Berkeley Emulation Engine (BEE2). The design is fully scalable in number of antennas, beams and signal bandwidth.

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On-Chip Digital Controller for Analog Testability

Analog testing requires many different bias voltages and currents that are traditionally set using instruments. Large designs require many pads for testing purposes. Reducing pad count and allowing digital configuration of the analog circuits make the testing process simpler and more efficient. An on-chip digital control block would replace the large number of pads and off-chip control lines with a 3-wire SPI serial interface. The digital control block was implemented and successfully tested on a 90nm CMOS research radio chip.

University of Illinois at Urbana-Champaign (22)

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Post-processed S-Parameter Measurements for Webpage Database

This open-source project involves performing scattering parameter measurements of passive microwave devices and post-processing the measured data. One of Professor Schutt-Aine's activities is measuring assorted 2-port and 4-port microwave

devices and sharing the results with researchers from other universities. These devices need to be characterized to provide a reference that can be used for verification of other measurements, but more importantly for verification of various modeling and simulation results. To make access and sharing of information easier, one of this project's goals is to create a webpage database, which would make easy global accessibility. My task consisted of post-processing the data for the purpose of creating a database, as well as making an associated user interface, in order to enable global access and sharing of information. Measured devices included transmission lines, reference standards, microwave filters, branchline couplers and other microstrip devices. The data, obtained through Vector Network Analyzer S-parameter measurements, and the physical outlook, schematics, layout, and various data plots, are provided to database users via a web interface.

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Connectivity and Capacity of Multi-channel Wireless Networks with Channel Switching Constraints

It is often assumed that nodes in a multi-channel wireless network are capable of switching on all available channels. This assumption may be challenged by emerging paradigms in wireless networking, such as envisioned large-scale deployment of extremely inexpensive wireless devices embedded in the environment, and dynamic spectrum access via cognitive radio. Hence there is need to study multi-channel network performance in the presence of constraints on channel-switching, both in terms of determining how asymptotic transport capacity is affected by the constraints, and designing protocols for efficient channel-coordination, and data-transfer. In this work, we make an attempt to address some aspects of this issue by introducing some models for constrained channel assignment, and exploring issues of connectivity and transport capacity for two of these models, viz., adjacent (c, f) assignment, and random (c, f) assignment. The proposed models are capable of capturing many of the constraints that may be encountered due to hardware or other limitations.

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Distributed Link Scheduling with Constant Overhead

This paper proposes a new class of simple, distributed algorithms for scheduling in wireless networks. The algorithms generate new schedules in a distributed manner via simple local changes to existing schedules. The class is parameterized by integers $k \geq 1$. We show that algorithm k of our class achieves $k/(k+2)$ of the capacity region, for every $k \geq 1$. Our class of distributed wireless scheduling algorithms are the first ones guaranteed to achieve any fixed fraction of the capacity region while using small and constant overheads that do not scale with network size. The parameter k explicitly captures the tradeoff between control overhead and scheduler throughput performance and provides a tuning knob protocol designers can use to harness this trade-off in practice.

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Cluster-Based Forwarding for Reliable End-to-End Delivery in Wireless Sensor Networks

Providing efficient and reliable communication in wireless sensor networks is a challenging problem. To recover from corrupted packets, previous approaches have tried to use retransmissions and FEC mechanisms. The energy efficiency of these mechanisms, however, is very sensitive to unreliable links. In this paper, we present cluster-based forwarding, where each node forms a cluster such that any node in the next-hop's cluster can take forwarding responsibility. This architecture, designed specifically for wireless sensor networks, achieves better energy efficiency by reducing retransmissions. Cluster-based forwarding is not a routing protocol. Rather, it is designed as an extension layer that can augment existing routing protocols. We demonstrate that cluster-based forwarding is effective in improving both end-to-end energy efficiency and latency of current routing protocols.

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Decentralized Detection Schemes in Cognitive Radio

A cognitive radio network is one in which if a primary user (who has purchased bandwidth) is not present, secondary users (who have not purchased bandwidth) can utilize that unused spectra to communicate. The detection problem occurs when the primary user re-enters the network's span and the secondary users can no longer communicate on the primary bandwidth. By taking advantage of the correlation between the sensors, detection schemes can improve the statistics compared to treating all the sensors as uncorrelated. A few different decentralized detection schemes were tested through Matlab. Statistical modeling of the noise in these networks was required to simulate an environment and test the probability of success in the schemes. By using the optimal linear decision rule, improved statistics were achieved.

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Sensing Techniques for Future Cognitive Radios

Although Federal Communications Commission (FCC) has allocated all frequency bands up to 60GHz to various primary users, it is often rarely used and is available to be utilized for other secondary users such as cognitive radio devices for higher efficiency of spectral usage. The channel availability for unlicensed users is projected to become more substantial as analog TV is switched to digital TV, which will become required by law for TV broadcast stations in 2009. The purpose of this research is to develop sensing schemes for cognitive radio (CR) technology, which will enable unlicensed users to use these vacant frequency spectra. It is essential for cognitive radio to sense the presence of existing and/or incoming primary users in order to avoid interfering with them by adapting its parameters (e.g. carrier

frequency, power, modulation). The research focuses on the cognitive radio operation in TV broadcast band, and specifically targets three primary users: analog TV signals, digital TV signals, and wireless microphones.

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Rate-Adaptive Framing for Interfered Wireless Networks

The majority of existing wireless rate controls are based on the implicit assumption that frames are corrupted due to the random, arbitrary environmental and thermal noises. They generally reduce the channel rate on frame losses, trading lower efficiency in frequency band utilization for more robust modulation so that the current noise level may be tolerable. In highly interfered wireless networks where frames are lost mainly due to interference from other wireless transceivers, simply reducing the channel rate prolongs the frame transmission time and therefore aggravates frame loss ratio. In this paper we present RAF, the rate-adaptive framing that jointly controls the channel rate and frame size according to the observed interference patterns and noise level at the receiver. Based on the inputs from physical layer carrier sense, the receiver derives the optimal channel rate and frame size that maximize throughput, and informs the transmitter of such optimal configuration in a few bits in the per-frame acknowledgement. Through intensive simulations we show that RAF consistently outperforms ARF, RBAR, and OAR in all simulated scenarios.

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Frequency Reconfigurable Antenna for WiFi and WiMax Bands

This poster presents the development of a frequency-reconfigurable antenna us-

ing RF MEMS (Radio Frequency Microelectromechanical Systems) switches. This antenna has the ability to operate in bands. The first band lies at 2.4 GHz, used by IEEE 802.11b/g (WiFi) wireless local area networks (WLANs) and Bluetooth. The second band is at 3.5 GHz, which is used by IEEE 802.16 (WiMAX). The third band is the IEEE 802.11a band at 5 GHz to provide complete WiFi compatibility with today's WLAN standards. There are several advantages of using a reconfigurable antenna as opposed to a fixed broadband antenna. By tuning the antenna to specific frequency bands, high gain can be realized with a narrow instantaneous operating bandwidth while keeping the antenna physically small. Because only one antenna is used, there will not be crosstalk associated with multiple antennas dedicated to each band. Noise and intermodulation distortion are reduced because the antenna selectively tunes into the frequencies of interest, effectively acting as a prefilter. All of this translates into high bit rates and low bit error rates. Results shown are for the antenna geometry with hard-wired connections rather than RF MEMS switches. Future work will involve adding RF MEMS switches and testing noise filtering and bit error rate.

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Smart Sleeping Strategies for Object Tracking in Sensor Networks

We study a tracking problem in sensor networks, in which the object being tracked moves along a random path through the network and the sensors switch between active and sleep states to conserve energy. It is assumed that a sensor that is asleep cannot be communicated with, and hence the sleep duration must be determined at the time the sensor goes to sleep based on all the information available in the network. We consider the design of smart sleeping policies that optimize the tradeoff between the resulting energy savings and tracking performance. Design of optimal policies is easily seen to be infeasible, even with simplistic models for the movement of the object and the observations made by the sensors. However, reasonable suboptimal policies can be designed and in some cases these suboptimal policies can be proved to be near-optimal. We describe these suboptimal policies and provide simulation results that characterize their performance.

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PDA: Privacy-preserving Data Aggregation in Wireless Sensor Networks

Providing efficient data aggregation while preserving data privacy is a challenging problem in wireless sensor networks research. In this poster, we present two privacy-preserving data aggregation schemes for additive aggregation functions. The first scheme — Cluster-based Private Data Aggregation (CPDA) — leverages clustering protocol and algebraic properties of polynomials. It has the advantage of incurring less communication overhead. The second scheme — Slice-Mix-AggReGaTe (SMART) — builds on slicing techniques and the associative property of addition. It has the advantage of incurring less computation overhead. The goal of our work is to bridge the gap between collaborative data collection by wireless sensor networks and data privacy-preservation. We assess the two schemes by privacy-preservation efficacy, communication overhead, and data aggregation accuracy. We present simulation results of our schemes and compare their performance to a typical data aggregation scheme — TAG, where no data privacy protection is provided. Results show the efficacy and efficiency of our schemes. To the best of our knowledge, this paper is among the first on privacy-preserving data aggregation in wireless sensor networks.

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A Limited Feedback Scheme for Linear Dispersion Codes over Correlated MIMO Channels

With partial Channel State Information (CSI) at the transmitter, the design of space-time codes for frequency flat, spatially correlated MIMO fading channels is considered. The focus of the work is on the class of space-time block codes known as Linear Dispersion (LD) codes, introduced by Hassibi and Hochwald.

For perfect CSI at the transmitter, the LD codes are optimized with respect to the instantaneous mutual information between the inputs to the space-time encoder and the output of the channel. An equivalent optimization problem is proposed and can be solved by standard convex optimization algorithms. It is then conjectured that the LD codes obtained by maximizing the instantaneous mutual information converge to that obtained from maximizing the averaged mutual information in the large antenna asymptote. Based on the insights drawn from the conjecture, a limited feedback scheme for LD codes is proposed assuming a common codebook at the transmitter and receiver. Numerical results for two scattering environments suggests that the proposed feedback scheme achieves high performance at low complexity.

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An Interpolatory Spectral Element Method Using Curl-Conforming Vector Basis Functions on Tetrahedra

The Nedelec basis functions are commonly used in the finite element solution of electromagnetic field problems. Higher-order Nedelec-type of basis functions are constructed to be either hierarchical or interpolatory. Due to a lack of an explicit expression for interpolation functions through an arbitrary set of nodes on a tetrahedron, equispaced nodes, for which explicit expressions do exist, are commonly used in the finite element formulation. The poor interpolation properties of those functions make the finite element matrices poorly conditioned for higher orders. Here we use the Vandermonde matrix to express the interpolatory vector basis on an arbitrary set of nodes in terms of a hierarchical basis utilizing orthonormal polynomials on a tetrahedron. In an effort to increase efficiency, integration and differentiation operations are developed using matrix-matrix multiplications. Numerical results are given which verify the efficacy of the approach.

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EnviroSuite: An Environmentally-Immersive Programming Framework for EnviroSuite: An Environmentally-Immersive Programming Framework for Sensor Networks

This poster describes EnviroSuite: a sensor-network programming framework that introduces a new paradigm, called environmentally-immersive programming (EIP), to significantly simplify the development of environmental monitoring and tracking applications. Traditional distributed computing paradigms are geared towards abstracting distributed communication. In contrast, in sensor networks, it is desired to abstract distributed interaction with the physical world. EnviroSuite creates a logical address space in which individual addressable entities can be either logical objects, developed by the application programmer or (representations of) physical elements in the external environment. The two types are seamlessly integrated, can communicate, and are able to invoke each other's methods. They allow the programmers to think directly in terms of physical objects and environmental events of interests rather than individual behaviors of network nodes. Several sample applications built upon EnviroSuite are evaluated. Experimental results demonstrate the efficiency and flexibility of the framework.

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Articulatory Speech Synthesis from 3D MRIs

The human speech mechanism is very complex and is not yet completely understood. For this reason, speech is typically synthesized by concatenating prerecorded words together. This generates highly intelligible speech but does not lend itself to expressive or tonal speech. Articulatory speech synthesis can easily generate varied speech, because it produces speech by simulating the physical act of speech generation. This presentation describes how I used 3D MRIs of sustained phonemes (sounds) to synthesize continuous speech.

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Real-Time Chains for Multi-Hop Wireless Ad-Hoc Networks

Prioritized MAC protocols are needed to enable soft real-time communication in wireless networks. We have developed real-time chain, a new prioritized MAC protocol that supports data flows in multi-hop ad-hoc networks. By avoiding packet collisions and limiting the effect of priority inversions, real-time chain is able to provide soft real-time and bandwidth guarantees. Furthermore, the use of multiple channels enables high spatial reuse and transmission rates. Finally, it can achieve compatibility with IEEE 802.15.4 after a minor modification to the standard. We have fully implemented the protocol on Crossbow MICAz motes and we have validated its performance with a large set of both indoor and outdoor experiments.

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Real-Time Scheduling for Wireless Systems with Losses

We study a real-time scheduling problem for collocated wireless networks serving users with diverse real-time requirements and loss patterns. Traffic is assumed periodic, with deadline equal to period. Wireless channel conditions are modelled Bernoulli. We prove that the optimal policy that minimizes the expected number of deadline misses only switches between users on arrivals, successful completions or deadline expiry. When users have similar periods, {em this optimal policy is a linear switching curve characterized by a single number}. Our result {em explicitly captures the trade-off between the real-time tendency to schedule users in earliest-deadline-first (EDF) order, and the wireless tendency to exploit multi-user diversity by scheduling users with good channel conditions first.} When users have

similar channels, we establish the optimality of EDF. {em Our results reduce the search space for optimal wireless real-time scheduling policies by an exponential order of magnitude}, and establish optimality of "virtual-deadline-first" policies, where each user's deadline is modified to take channel quality into account. Policies in this class are easy to implement in distributed fashion.

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Civil Engineering

Structural Health Monitoring Using Intel's Imote2 Wireless Sensor Platform

The ability to continuously monitor the integrity of civil infrastructure in real-time reduces maintenance and inspection costs, while providing for increased safety to the public. Structural health monitoring (SHM) has emerged as an effective tool to aid in the operation and maintenance of the civil infrastructure. Parallel and decentralized computing as well as data aggregation provide for adaptable smart sensors which allow for dense sensor deployment with the potential to detect local damage. Intel has recently developed an open-interface platform, the Intel Mote2 (Imote2), built around a low power XScale processor. The Imote2 provides enhanced computation and communication resources that allow demanding sensor network applications, such as SHM of civil infrastructure, to be supported, while low-power operation and small physical size are still considered. This study explores the potential of the Imote2 for SHM applications and the design of an accelerometer sensor board which meets the demands of structural monitoring is presented. The components of the accelerometer board have been carefully selected to allow for low-noise and high resolution data acquisition that is necessary to successfully implement SHM algorithms.

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Energy-Friendly Recovery in Ad Hoc Networks

Effective communication in ad hoc networks requires resilience to frequent link failures, especially in mobile environments. Handling such failures becomes more challenging in energy-saving networks, where only a subset of nodes are active at any given time instant, while the rest are in sleep. To support energy conservation, recovery should cause minimum interference with underlying power-save protocol that schedules node sleep and active times. To this end, we first explore performance of current local recovery mechanisms, which repair routes based on local knowledge about network connectivity. We show that encouraging results can be obtained by reducing both the overhead from proactive link-state collection and redundant packet transmission. However, recovery success, not surprisingly, relies on the quality of connectivity information. Therefore, we next investigate how to maintain up-to-date connectivity without disrupting energy-saving nodes using cues about network topology, sleep and traffic patterns.

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Model Checking of Wireless Network Protocols Using Simulation Code and Protocol-Specific Heuristics

One deficiency of traditional network simulators is that they only evaluate the performance of a network protocol in scenarios provided by the protocol designer but can not exhaustively analyze possible scenarios for correctness. To address this problem, we have extended J-Sim — a component-based network simulator — with a model checking capability that explores the state space created by a network protocol up to a (configurable) maximum depth in order to find an execution that violates a safety invariant (e.g., absence of routing loops in a routing

protocol). We demonstrate the usefulness of the model checking framework in J-Sim by analyzing two widely used network protocols: AODV routing for wireless ad hoc networks and directed diffusion for wireless sensor networks. To enable the analysis of these fairly complex protocols, we needed to develop protocol-specific search heuristics that guide state space exploration. An important question is how to determine a good search heuristic for a specific network protocol. We report our findings on discovering good search heuristics for network protocols similar to AODV and directed diffusion.

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Real-time Wireless Tracking and Analysis of Construction Workers, Materials, and Equipment

The construction industry with annual sales of $750 billion in the U.S. is perhaps among the most underserved industries in terms of technology utilization. Traditionally, analyzing construction operations is time-consuming and labor-expensive if a continuous stream of data for a long period needs to be collected. Recording required operation data is often done manually. Consequently, construction engineers are greatly limited in their means for analyzing construction operations and improving productivity, cost, time, and safety. The evolution of wireless technology has made possible solutions to collect and analyze construction operations, such as RFID and RTLS technologies. A construction project in Champaign as a proof of concept to track the real-time resource flows will be conducted and stored in a database to support construction operational analysis and improvement. The expected results include new approaches for construction operational analysis, frameworks for deployment of new wireless technologies to the construction industry, improvement in cost, productivity, time, and safety, and identification of challenges and opportunities for wireless and communication developers to improve the design and service for the construction industry.

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Coding Achieves the Optimal Throughput-Delay Tradeoff in Mobile Ad Hoc Networks

It is now well-known that mobility can be used to increase the throughput of mobile ad hoc networks (MANETs). The key idea is to relay packets between nodes only when they are close to each other. However, one may have to incur long delays while waiting for a packet to get sufficiently close to its destination. In this talk, we will investigate the maximum throughput that can be achieved in MANET when packets are subjected to strict delay deadlines. We present novel techniques to obtain an upper bound on the maximum throughput, and design a joint coding and scheduling strategy to achieve the upper bound. The upper bound is achieved by viewing the network as an erasure channel, thus allowing the use of rate-less codes to obtain the maximum throughput. The ideas presented in this talk are motivated by applications to the emerging fields of delay-tolerant networks and mobile sensor networks.

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Broadband Antenna for Software Defined Radio

This work presents the design and analysis of a broadband antenna that is capable of achieving an instantaneous 3:1 VSWR bandwidth and omni-directional radiation coverage spanning a bandwidth greater than 10:1. The antenna is designed to accommodate the very large bandwidth requirements of software-defined radios and to minimize the effective volume of the overall design. The antenna is composed of a vertical radiating element over a ground plane, and utilizes a tuning strap to improve the impedance bandwidth over the frequency range in which the antenna is considered electrically small. Measurements demonstrate a 3:1 VSWR impedance

bandwidth from 30 MHz to 6 GHz while maintaining a relatively omni-directional radiation pattern over the majority of this bandwidth. A model of the tuning mechanism is also analyzed along with a discussion of the antenna's efficiency.

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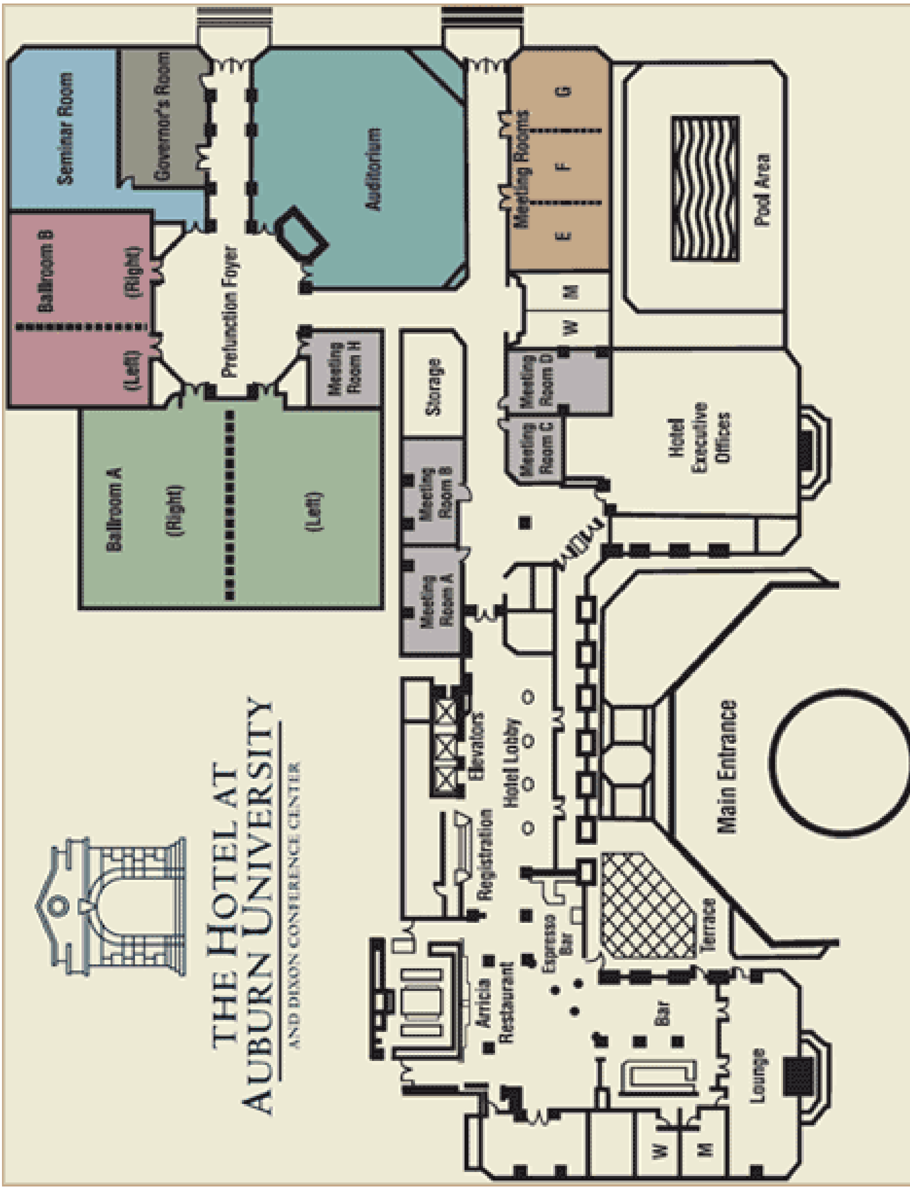
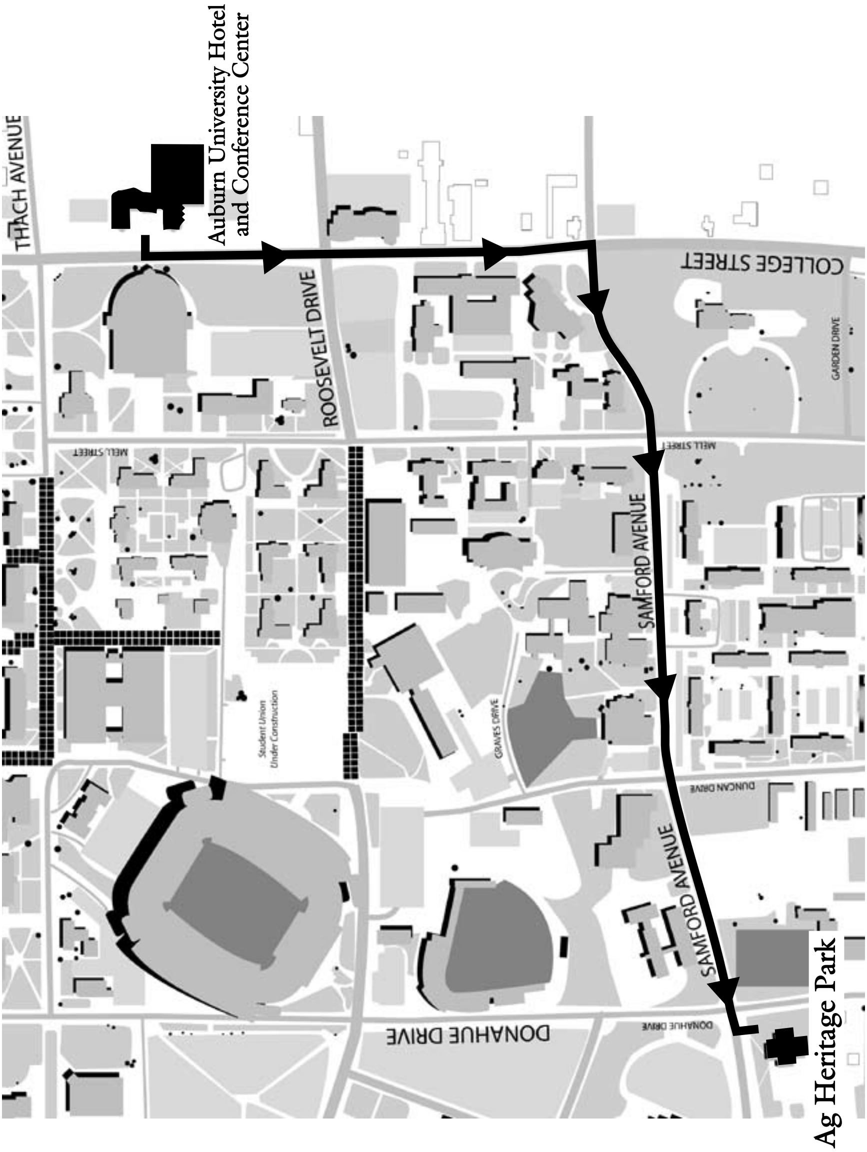

THE HOTEL AT
AUBURN UNIVERSITY
AND DIXON CONFERENCE CENTER
Seminar Room
Governor's Room
Auditorium
Meeting Rooms
E
F
G
Pool Area
Ballroom B
(Right)
(Left)
Prefunction Foyer
Meeting Room H
Storage
W
M
Meeting Room D
Meeting Room C
Hotel Executive Offices
Ballroom A
(Right)
(Left)
Meeting Room B
Meeting Room A
Elevators
Hotel Lobby
Registration
Main Entrance
Espresso Bar
Terrace
Aricia Restaurant
Bar
Lounge
W
M

Directions to Ag Heritage Park



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Web Resources

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Samuel Ginn College of Engineering
www.eng.auburn.edu

Wireless Engineering Research and Education Center
www.eng.auburn.edu/werec

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Department of Computer Science and Software Engineering
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Alabama Microelectronics, Science and Technology Center
http://spider.eng.auburn.edu/amstc/main/

National Center for Asphalt Technology
www.ncat.us

History of the Samuel Ginn College of Engineering

HISTORY

Auburn University is the oldest four-year, coeducational school in the state of Alabama, and second oldest in the Southeast. It is chartered as a land-grant institution.

The university has always been known as Auburn, a name taken by the Lee County community from the Oliver Goldsmith poem, "The Deserted Village." The poem includes the line, "Sweet Auburn, loveliest village of the plain." However, the institution has had four official names: East Alabama Male College, Agricultural and Mechanical College, Alabama Polytechnic Institute, and presently, Auburn University.

Engineering has long been an important part of Auburn. In October, 1872 the Agricultural and Mechanical College of Alabama awarded its first degrees, including four bachelor's, two master's and one professional degree in civil engineering awarded to W.E. Horne – one of the first engineering degrees to be awarded by a Southern institution.

Today, the college offers the state's largest engineering program, and is home to nine departments, offering 15 majors, and 12 research centers. It is responsible for approximately half of the university's annual research expenditures.

Auburn University consistently ranks in the nation's top 20 engineering programs in the number of students we graduate. Our undergraduate enrollment for fall 2006 was 2,815 and graduate enrollment 670. The 2006 U.S. News & World Report ranked Auburn's undergraduate engineering program 33rd and the graduate program 46th among the nation's public universities. Auburn Engineering ranks 17th nationally in number of bachelor's degrees awarded to African-Americans.

The university offers the nation's first and only bachelor's degree in wireless engineering, graduating the first students in 2004. It is the first program in the Southeast to offer bachelor's and master's degrees in software engineering.

Auburn Engineering students comprise approximately 25 percent of those who graduate with honors university-wide and 80 percent of co-op students. Beyond the classroom, students gain hands-on, real-world experience on student competition teams for Formula SAE race cars, SAE Mini Baja all-terrain vehicles, and SAE Aero Design unmanned aerial vehicles.

Research areas include transportation technology, food safety, materials processing, information technology, wireless engineering, aerospace engineering, bioprocess/environmental engineering, highway/asphalt technology, microelectronics, vehicle electronics, fiber technology, pulp and paper, occupational safety and ergonomics, and technology management. This research powers the local, state, regional and national economies. Employers tell us that our emphasis on fundamentals, hands-on engineering and a strong work ethic sets Auburn engineering graduates apart as leaders in the workplace and the community. In 2001, the college was renamed the Samuel Ginn College of Engineering, in honor of Samuel Ginn's $25 million gift to College of Engineering

The college recently completed renovations of two historic buildings: Ross Hall and Wilmore Laboratories. Construction of the new $108 M Sen. Richard C. and Dr. Annette N. Shelby Center for Engineering Technology is well under way. Phase I is slated for completion in Fall 2007, and Phase II in Fall 2010.

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