An Overview of the Communications and Information Technology Research Center (CICTR) at Pennsylvania State University

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History

The Center for Information and Communications Technology Research (CICTR) at the Pennsylvania State University started its operations in 1997. The focus of the on-going work at CICTR is design of fiber-based communications networks with wireless, twisted-pair copper and/or coaxial cable access ports enabling telecommunications companies to offer many new broadband services such as multimedia to business and residential users.

Research Objectives and Directions

The goal of the CICTR is to team with industrial partners to generate solutions to current and future technical challenges in the transmission, storage, transformation, switching and networking of digital information. These solutions most likely involve the amalgamation of commercial off-the-shelf technology, advanced prototype technology, and basic information & communications technology research. Some technological challenges on the horizon are broadband access, optical networking, interfacing RF/optical and digital radio components, miniaturization of wireless communication transceivers, broadband wireless access, mobile multimedia access & networking, quality-of-service IP routing, differentiated services for Internet, network management, next-generation-Internet and telepresence. CICTR activities include feasibility studies, applied research, software development, hardware prototype development, and education and training. CICTR's Mission is to enhance Telecommunication Research and Education through Government/University/Industry partnerships in focused and shared pre competitive research programs.

Projects

Broadband Access Networks and System

Our efforts in this area center around solving the broadband subscriber access problems, for example, the problems associated with deploying hybrid fiber / twisted-pair, hybrid fiber / coax and hybrid fiber / wireless networks evolution. These networks are planned to be transparent on the optical side, so far as advancement in the public communications networking is concerned by migrating towards IP or IPOA over Dense-Wavelength Division Multiplexing (D-WDM) where SONET layer appears to be redundant. Local access technologies (fiber, coax, ISM, UNNI bands and mm-wave bands) are becoming widely available at affordable costs to all potential service providers: LECs, cable-television operators, alternate-access providers, electric utilities, and wireless-communications companies. All access products are relatively similar in cost, and offer comparable operations savings. Important differentiators are service and product reliability and service. Our research activities focus on all these factors as they relate to hybrid fiber / coax (HFC), HFC overlaid with FTTC, FTTC (or HFC) integrated with PCS, fixed and / or mobile broadband wireless access, MMDS, LMDS and new broadband customer-premises networks using a diversity of media. We consider single access-networks solutions. A major thrust is our examination of possible synergy between wired access platforms and wireless technologies.

Sensor Networks

A number of applications exist for sensor networks. Commercial, transportation and agriculture sectors can benefit greatly from increased surveillance. Personal and institutional security can also apply this research directly to their sectors of activity. Other possible applications exist in radiology, medicine, and manufacturing. National defense relies on accurate Intelligence, Surveillance and Reconnaissance (ISR). Using a large number of small inexpensive sensors increases the dependability of ISR systems at a reasonable cost. Large numbers of redundant sensors decrease the vulnerability of the system to failure. On the other hand, the ability to combine information becomes important. Otherwise, the network will not have sufficient bandwidth and human decision makers will not be able to make timely decisions. To coordinate work in a distributed sensor network, an ac-

tive network of mobile code is being constructed. The system uses resource bounded optimization to adapt dynamically to a chaotic environment. This 3-year research effort started in July 1999. Users make demands for information. Placing them at the center of an active network. Sensors are present at multiple locations in the environment. The network forages for information, like ants forage for food.

Mobile Multimedia Networking

With information access becoming part of everyday life, mobile computing environments are increasingly essential to cater to the needs of mobile users. Present-day information access invariably involves multimedia data in some form or other. Hence, mobile multimedia networks are becoming popular. There is a need for efficient mapping of the requirements of multimedia systems onto mobile networking environments. This involves developing network protocol features that can handle widespread mobility of the clients as well as the fluctuating network characteristics. Mobile communication systems might have to dynamically re-route set of multimedia information flows associated with a mobile client, from one base station to another in a timely manner, without significant interruption and change in the Quality-of -Service (QoS). Also, multimedia systems have to become adaptive or scalable, with respect to the fluctuating network environments. This project focuses on the issues concerning mobile networking environments for multimedia systems. Some topics we are exploring include:

- QoS issues in mobile and fixed wireless networks
- Fixed Wireless and Mobile network architectures
- Mobile multimedia network protocols
- Admission control, resource management in mobile networks
- QoS adaptive transport layer issues
- Network management, resource control methodologies for mobile computing
- Wireless access to ATM or IPOA-based network support for multimedia applications
- Adaptive/scalable multimedia applications for mobile computing environments
- Mobile multimedia applications: Issues, Systems designs, Performance

Personal, Portable or Mobile Communication Systems

Current CDMA technology for wireless voice communications is perhaps the best air interface available today for a voice-dominant traffic, as we "also" had anticipated in early 80's (See US patent # 4,672,658). As we enter the Multimedia Age, traffic nature becomes highly bursty and data-like. Thus, it is not at all clear whether CDMA is still the correct approach. New reasons and logic must be sought to justify its usage. Old justifications only pertained to voice transmission. We are working on Robust and error-resilient multimedia transmission over 3G and beyond wireless fading channels and on Simulation and analysis of next generation broadband mobile based on Wideband - CDMA

Research staff and students

Faculty

- Dr. G. Cao , Assistant Prof. of Computer Science & Eng., Penn State
- Dr. H. Che , Assistant Prof. of Electrical Engineering, Penn State
- Dr. J. Doherty, Associate Prof. of Electrical Engineering, Penn State
- Dr. A. Ferraro, Retired Prof. of Electrical Engineering, Penn State
- Dr. N. Gautam , Assistant Prof. of Industrial & Manufacturing Eng., Penn State
- Dr. D. L. Hall , Prof. and Associate Director for Communication and Information at Applied Research Lab (ARL), Penn State
- Dr. A. Hurson , Prof. of Computer Science & Eng., Penn State
- Dr. M. Kavehrad , CICTR Director and Weiss Chair Prof. of Electrical Engineering, Penn State
- Dr. J. J. Metzner , Prof. of Computer Science & Engineering, Penn State
- Dr. D. J. Miller , Assistant Professor of Electrical Engineering, Penn State
- Dr. R. Mittra , Prof. and Senior Scientist at Applied Research Lab (ARL), Penn State

- Dr. Sh. Phoha , Prof. and Head of Information Science and Technology at Applied Research Lab (ARL), Penn State
- Dr. R. Van Dyck , Assistant Prof. of Electrical Engineering, Penn State
- Dr. S. Yin , Assistant Prof. of Electrical Engineering, Penn State Research Partners
- Mr. S. Thompson, President and Co-founder, Anntron Inc. Research Associates & Engineers
- Dr. R. Brooks, Research Associate, Applied Research Lab(ARL), Penn State
- Dr. Svetla Jivkova , Postdoctoral Fellow, Penn State

Student Number: 65

Sample list of publications

1. K. Muhonen , M. Kavehrad, "Amplifier Linearization,"Paper reprinted in Wireless Multimedia Network Technologies, Kluwer Academic Publishers, 1999.
2. D. Zaccarin, M. Kavehrad, "An Optical CDMA System Based on Spectral Encoding of LED," IEEE/LEOS Photonics Tech. Lett. Journal, Vol. 5, No. 6, April 1993.
3. G. Yun, M. Kavehrad, " Indoor Infrared Wireless Communications Using Spot Diffusing and Fly-Eye Receivers," Canadian Jour. on Elect & Comp. Eng., Vol. 18, No. 4, October 1993 and Wireless Communications Conference Proceedings, Vancouver, June 1992.
4. C. Chehadeh, A. Hurson and M. Kavehrad, "Object Organization on a Single Broadcast Channel in a Mobile Computing Environment,"Journal of Multimedia Tools and Applications, special issue on Mobile Computing Environment for Multimedia Systems, Kluwer Academic Publishers, July 1999.
5. M. Kavehrad, G.E. Bodeep, "Design and Experimental Results for a Direct-Sequence Spread-Spectrum Radio using Differential Phase Shift Keying Modulation for Indoor, Wireless Communications," IEEE Journal on Selected Areas in Communications, June 1987, pp. 815- 823.
6. M. Kavehrad, M. Tabiani, "A Selective-Broadcast Passive Star Coupler for Self-Routing Dense Wavelength Division Multiplexed Optical Networks," IEEE/OSA of Lightwave Technology, Vol. 9, No. 10, October 1991, pp. 1278-1288.
7. M. Kavehrad, "Wavelength-Division Multiplexed Systems and Networks," IEEE/LEOS'93, Annual Meeting, San Jose, Nov. 1993 - "INVITED PAPER".
8. I. Habbab, M. Kavehrad and C-E. Sundberg, " ALOHA with Capture Over Slow and Fast Fading Radio Channels with Coding and Diversity," IEEE Journal on Selected Areas in Communications, Vol. 7, No. 1, pp. 79-88, January 1989.

Facilities

CICTR computing facilities are equipped with modern scientific software packages for computer simulation needs. In addition, there is a CICTR hardware development laboratory. CICTR web at: http://cictr.ee.psu.edu/ provides a summary on some of the current research efforts.

Sponsoring organizations

The research activities at CICTR are sponsored by the following organizations:

- Ameritech
- Anntron Inc
- ARL
- ARO
- Ben Franklin
- IBM
- Lockheed martin
- Lucent technologies
- NSF
- ONR
- Penn State University
- Raytheon
- Telebeam Inc.

Statement on Impact

The community benefits of CICTR are many. For example, the high-tech industry benefits from having access to a top-notch research facility where they can sponsor and carry out product related research and development in a low-cost environment. The center provides technical training to its members via courses and seminars from leading researchers. Graduates who study here are trained in the multi-disciplinary field of Information and Communication Technology. These engineers then go on to work on networks and systems that currently in planning stages. Through CICTR, industry gets ready access to the latest research. Our projects are geared towards creating a climate in which longer term studies may be pursued. The results of these studies are then transferred to the industry. In addition to the industry, the CICTR activities help keep Penn State at the forefront of the information and communications technology research and development. As stated earlier, the center fosters the creation of multi-discipline research teams. Students are trained with practical considerations in mind and get a much better educational experience. Our projects encourage regular interaction with other US research teams, and with laboratories and universities around the world. The center's laboratory is equipped with modern hardware/software tools providing students access to the latest technology. All this translates to better employment opportunities for graduates, helping the overall economy of the country.