CSHCN upLINK

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Center for Satellite & Hybrid Communication Networks • A NASA Center for the Commercial Development of Space
Institute for Sytems Research, A. James Clark School of Engineering, University of Maryland at College Park

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A.V. Williams Building (#115)
University of Maryland
College Park, MD 20742

301-405-2000
FAX: 301-314-8586
E-Mail: skirch@isr.umd.edu
URL address: http://www.isr.umd.edu/CCDS/homepage.html

CSHCN Collaborates with Hughes to Win 1994 UMCP Invention of the Year

And the award goes to ...

CSHCN team members for "A System for Hybrid Network Data Communications Terminal Using Asymmetric TCP/IP to Support Internet Applications."

The award was presented April 20 at a ceremony hosted by the University of Maryland's Office of Technology Liaison.

Pictured at the event are (front, from left) Dr. John Baras, CSHCN Director; Douglas Dillon, Hughes Network Systems Advisory Engineer; Dr. Anthony Ephremides, CSHCN faculty member and electrical engineering professor; Narin Suphasindhu, CSHCN undergraduate student; (back, from left) Vivek Arora, graduate student; Daniel Friedman, graduate student; Timothy Kirkwood,

CSHCN Assistant Director for Commercialization; Brian Johnson, graduate student; and Aaron Falk, former graduate student.

The winning invention is featured in the article on page 3.

CSHCN Develops Prototype Hybrid Network Testbed Using ACTS and T1 VSAT

The CSHCN, in collaboration with Comsat Labs and the University of Colorado, is conducting a series of experiments in hybrid networking that utilize the on-board processing technologies of the NASA Advanced Communications Technology Satellite (ACTS).

The experiments are designed to test advanced concepts that will permit commercial use of such hybrid networks. ACTS was launched by NASA in September 1993. It is an experimental geostationary satellite; the first non-defense satellite to have on-board processing capabilities.

Earlier commercial satellites served as signal relay stations, simply reflecting back to the Earth the communications signals pointed at them, according to Dr. Anthony Ephremides, CSHCN faculty member and electrical engineering professor, who is directing the CSHCN ACTS experiments. However, ACTS is capable of performing on-board processing, such as bandwidth assignment on demand and remodulating and re-encoding signals. Its switchable spot beams concentrate power in relatively small areas on the Earth, and thus achieve bandwidth and power efficiency on a demand basis.

see **Acts**, *pg. 4*

CSHCN Advisory Board Identifies Technology Areas

The CSHCN invited advisory board recommendations for future technology directions at its February 16 semiannual advisory board meeting.

Dr. John Baras, CSHCN director, introduced an interactive facilitation technique similar to that used at Sematech to solicit board member input.

The information from the board members provides the CSHCN with a list of tangible technology directions that may ultimately lead to commercial products. Based upon the positive result of the meeting, Baras is planning future interactive meetings with the advisory board and other industry participants.

The participants first identified six major topics for hybrid communications research and development: gateways and interfaces; satellite communication payload; hybrid network architecture; earth terminals; network management and control; and transmission issues. Advisory board members and CSHCN faculty members responded with suggested specific technology directions with potential for commercialization. The proposed technology directions were then rated by the board members based upon their determined commercial support and significance.

The rating exercise produced a short list of technology directions for each of the six major topics. The CSHCN will determine which technology directions will be ratified based on the enabling technology, potential collaborators and suppliers, and dependencies.

For more information, contact Tim Kirkwood at 301-405-7904; e-mail: timk@isr.umd.edu.

Directors' Message

Dr. John Baras

When the Center for Satellite & Hybrid Communication Networks (CSHCN) was established in 1991, it began with a vision of the convergence of various modes of communication—telephone, cable, wireless and satellite. Since then, the CSHCN has worked with engineers and strategists from both industry and government to develop research and development projects to achieve that vision. Hybrid networks, as we predicted, are rapidly being established as the only economically and technologically feasible evolution path towards the National and Global Information Infrastructures (NII/GII).

Last summer a Peer Review of the CSHCN was conducted, offering praise and encouragement for the accomplishments and progress achieved over our first three years. After having reached a desired level of maturity, a decision was made to simplify our management structure to a single directorship. Dr. Anthony Ephremides served as a founding co-director of the CSHCN and we are all grateful for his many contributions toward meeting the demands and challenges of the first three years. He will continue his enthusiastic efforts as a participating faculty member as we strive for further excellence and growth.

The CSHCN has had many successes, some of which you will read about in this first edition of our newsletter. These successes are, in large part, due to the talents of CSHCN participating faculty, the contributions made by our industrial partners and co-workers, an outstanding technical and administrative staff and our graduate students who are forging ahead with new approaches to tackling difficult problems. I would like to thank all of the CSHCN faculty and staff, and the faculty and staff of the Institute for Systems Research, our parent organization, for their contributions toward the establishment of the Center for Satellite & Hybrid Communication Networks. A special word of gratitude goes to the members of our Industry Advisory Board who have offered their advice and helped us to focus our program to achieve the success and recognition that we enjoy today.

Now that the center has been established and successful partnerships with industry have been demonstrated, it is time to strengthen those existing partnerships and build new ones to achieve a stronger alliance and utilize leveraged resources to the benefit of all of our members. I look forward to this time of increased growth and opportunity and I welcome the change and new ideas that will result over the months to come.

— Dr. John Baras
Director

1994 Tech Report Abstracts Available

The CSHCN Technical Report Abstracts have been compiled and are available from the Center.

The *CSHCN TR Abstracts* report contains the abstracts of reports for the third year of the Center's operation. It also includes abstracts of theses reports contributed by CSHCN students.

Technical reports are a critical means by which the Center accomplishes its mandate for technology transfer. They provide immediate access to research results, eliminating the often lengthy delay prior to journal publication.

Single copies of Technical Reports are free to Center Industry Advisory Board members, participating Center faculty members and students, and interested representatives of academic institutions. CSHCN theses reports are available for $12 per copy.

To obtain a copy of the *CSHCN TR Abstracts* report, contact Suzanne Kirchhoff at 301-405-7903, or send your request to skirch@isr.umd.edu.

CSHCN Device Driver Deployed in Hughes' DirecPC™

Researchers at the CSHCN have collaborated with Hughes Network Systems engineers to develop a low-cost hybrid (terrestrial and satellite) network service that can deliver data from the Internet to the user at much faster rates.

Hughes announced the commercial availability of the technology in November of 1994, and have begun to market their new line of products, DirecPC™, to businesses and computer enthusiasts.

Satellite technology makes it possible for DirecPC™ to provide nationwide service immediately, eliminating the need for incremental upgrades to the cable or telephone plants in each locality. According to Hughes representatives, users equipped with a 9,600 bps modem could experience a 40-fold increase in speed in receiving material using DirecPC™.

DirecPC™ is a hybrid system consisting of a receive-only satellite dish coupled with a special SLIP telephone/modem connection. Increasing the rate at which users can receive information is desirable because most computer users, especially those in a home environment, want to consume much more information than they generate. A receive-only satellite terminal is considerably less expensive to manufacture and much easier to install than one that can also transmit. Internet protocol encapsulation manipulates the transmission control protocol/internet protocol (TCP/IP) to route packets away from and back to the user asymmetrically.

"Our joint effort to develop inexpensive hybrid terminals that can provide a variety of services to the user and to foster hybrid communications is the most promising path to the National Information Infrastructure, both technically and financially" said Dr. John Baras, CSHCN director. "As the most direct demonstration of these capabilities we are developing a variety of tools that can extend Internet services through satellite broadcasting, while at the same time providing the end user with higher quality service."

From left, Bob Costello, Dr. Steven Marcus, Dr. John Baras, and Narin Suphasindhu look on as Aaron Falk demonstrates the advantages of broadcast internet access.

DirecPC™ uses a device driver developed at the CSHCN that breaks the network link into two physical channels: the terrestrial dial-up that carries data from the terminal into the Internet and a receive-only satellite link that carries information from the Internet to the user. This system is aimed at supporting bandwidth-hungry Internet applications such as Mosaic and FTP and it works with the Internet without any modifications. In addition, it is compatible with any Intel 80386/486 or Pentium PC.

A market analysis conducted prior to the development of the system imposed four design requirements for the commercial success of the product. The system must reduce delay responding to requests for large data files using a modem; work with any commercial TCP/IP package and any commercial SLIP service provider; access any Internet host; and support Internet initiated connections.

A wireless broadcast mode of communication offers extraordinary efficiencies compared to wireline communications, even where the wireline service employs sophisticated packet switching techniques. Traditional radio and TV broadcasting have exploited the efficiencies of the broadcast mode for years using terrestrial radio frequencies. Newer satellites offer TV and radio broadcasts from the vantage of a geosynchronous orbit in space. Hughes currently markets a satellite dish and television set top box called DirecTV™ designed on this basis. DirecTV™ provides 150 channels of digital television.

DirecPC™ expands the scope of the evolution from terrestrial to satellite broadcast beyond radio and TV to data services delivered to the remote personal computer. The Internet and numerous commercial online data services, such as Reuters New Media, America Online™, Compuserve™ and Prodigy™, could benefit from this enhancement to satellite-based broadcasting.

see **DirecPC**, *pg. 8*

ACTS Employed to Test Three Hybrid Network Experiments

(continued from page 1)

The CSHCN ACTS experiments are investigating dynamic bandwidth allocation algorithms, error control schemes for use in satellite and hybrid networks, and are comparing frame relay and X.25 protocols by using LAN-to-LAN interconnection and multimedia database access in a hybrid network environment.

Experiment I — Dynamic Bandwidth Allocation for Voice and Data Traffic

The first experiment addresses the economics of bandwidth allocation by testing a number of different algorithms for voice and data traffic. These algorithms manage the amount of total bandwidth, as well as the division of bandwidth between voice and data traffic. This requires a balance between voice and data so that the data queues do not grow too large, while maintaining adequate bandwidth for service of the incoming voice call requests at as good a level as possible. This experiment is monitored by Sonjai Gupta, an electrical engineering graduate student.

Hybrid networks integrate the technologies of satellite networks and terrestrial networks. The CSHCN experiments utilize for their terrestrial network components the Public Switched Network and the Internet, and will exploit the advantages of Frame Relay, which is an important protocol widely used in terrestrial networks but still relatively untested over satellite links. The experiments are based on a hybrid network architecture whereby a node may use both satellite and terrestrial links in obtaining a service from the network.

These experiments go beyond traditional applications, which typically utilize satellite and terrestrial links as separate entities rather than as a single integrated system, according to Dr. Ephremides. In the hybrid network, low-rate control and link management messages, application commands, and high-rate transport services are routed via the satellite or the terrestrial link according to specialized algorithms. These algorithms are designed to exploit the inherent advantages of either the satellite or terrestrial link for optimal performance.

In addition to delay mitigation, a hybrid network also allows the use of a receive-only satellite station at the destination. Such a terminal is significantly less expensive than a two-way (receive and transmit) satellite station, so significant cost savings may be achieved by adopting the hybrid architecture.

The CSHCN experiments were prepared over the course of the past year by a team led by Dr. Ephremides, and including ISR visiting faculty member Dr. Apostolos Traganitis, CSHCN Assistant Director Timothy Kirkwood, and Faculty Research Assistant Ioannis Konstantopoulos. Several graduate, undergraduate, and exchange students are participating in each experiment. NASA has provided the research team with use of a specialized T1-VSAT terminal for several months. The $250,000 equip-

Pictured with the T1-VSAT terminal are (left to right) Dr. Anthony Ephremides, Dr. Apostolos Traganitis, Sonjai Gupta, Ioannis Konstantopoulos, and Changuo Zhang. The terminal was installed at the ISR in July for three months of testing.

Experiment II—Error Control Schemes for Satellite and Hybrid Networks

Satellite communications systems are often used for high-speed transfer of information. A penalty typically incurred in the use of satellites is the round trip propagation delay. Thus, error control schemes that are ARQ-based perform poorly since a large number of unacknowledged packets are in transit at any given time. By providing a terrestrial path for reply or retransmission messages, the performance of such schemes can be significantly enhanced.

The aim of this experiment is to compare forward error-control and ARQ schemes using a hybrid configuration. Various specific FEC codes and ARQ variants are being tested to determine how to best take advantage of a hybrid network. The experiment is monitored by Daniel Friedman, an electrical engineering graduate student.

ment was installed at the CSHCN on July 5, 1994. In addition, the Department of Commerce's National Telecommunications and Information Administration has provided T1-VSAT access to the University of Colorado. An important portion of the preparation was the development of the Frame Relay Access and Control Switch (FRACS), which was built by Comsat Labs.

"We believe we are conducting the most forward-looking and sophisticated experiments using this satellite," Ephremides said. "They will help the design and operation of future hybrid networks and we are grateful to NASA and the Department of Commerce for the opportunity to use the terminals and the satellite."

The experiments are to be conducted on a hybrid network testbed which consists of two ACTS T1-VSATs complemented by terrestrial network services. "The equipment will allow us to evaluate the unique capability of the ACTS on-board baseband processor," Dr. Ephremides added. "In addition, it will allow us to establish a hybrid network testbed to support investigations into the bandwidth management challenges that will confront future commercial and military network service providers as they try to meet demands from the market and mission requirements for multimedia network services."

"The team at the University of Maryland CCDS has performed an outstanding set of far-reaching experiments," said Mike Smith, ACTS Experiments Program Manager at NASA Headquarters. "They quantify and calibrate the capabilities of advanced technologies in future communication satellites and will help to define the role of communication satellites in the hybrid National/Global Information Infrastructure."

The CSHCN experiments have been underway since July 1994 and results will be generated in early Fall 1995. For more information on these experiments, contact Dr. Anthony Ephremides at (301) 405-3641 or via e-mail: tony@src.umd.edu, or Timothy Kirkwood at (301) 405-7904 or via e-mail: timk@src.umd.edu.

Experiment III—Comparison between Frame Relay and X.25 Protocols in Satellite and Hybrid Networks

The third experiment consists of two parts. The first focuses on multimedia database remote access via a hybrid network; the second part compares inter-networking protocol performance in a LAN-to-LAN interconnection environment. Chuanguo Zhang, an electrical engineering graduate student, is monitoring the experiment.

Annual CCDS Conference Conducted in Albuquerque

CSHCN researchers contributed 10 papers at the first annual NASA Conference for the Centers for Commercial Development of Space (CCDS). The event took place in January in Albuquerque.

The CCDS program was designed by NASA to increase private sector investment and interest in commercial space-related activities while stimulating advances in promising areas of research and development. This conference provided a forum for the centers to share accomplishments, compare strategies, and formulate synergistic approaches to common space exploration and technology development goals.

A highlight of the conference was an introduction of Hughes Network System's latest product, DirecPC™. Hughes developed the terrestrial and satellite network service in collaboration with CSHCN researchers. DirecPC™ delivers data from the user to the Internet, and vice versa, faster and more efficiently than conventional methods (see page 3).

CSHCN papers presented at NASA's 1995 CCDS conference are listed below:

Cell Loss Probabilities in Input Queuing Crossbar Switches Via Light Traffic Derivatives
– Young B. Kim and Armand M. Makowski

Dynamic Routing in Hybrid Networks with Integrated Voice and Data Traffic
– John S. Baras and Shihwei Chen

Enhancement of Cellular Service Via the Use of Satellite Capacity
– Deepak Ayyagari and Anthony Ephremides

Faster than Fiber: Advantages and Challenges of LEO Communication Satellite Systems
– S. Joseph Campanella and Timothy J. Kirkwood

Hybrid Internet Access
– Vivek Arora, John S. Baras, Douglas Dillon, Aaron Falk and Narin Suphasindhu

Hybrid Network Architectures: A Framework for Comparative Analysis
– John S. Baras, S. Joseph Campanella and Timothy J. Kirkwood

Innovative Networking Concepts Tested on the Advanced Communications Technology Satellite
– Daniel Friedman, Sonjai Gupta, Chuanguo Zhang and Anthony Ephremides

Next Generation Network Management Technology
– John S. Baras, George C. Atallah, Mike Ball, David Whitefield, Shravan Goli, Ramesh K. Karne, Steve Kelley, Harsha Kumar, Catherine Plaisant, Nick Roussopoulos, Ben Shneiderman, Muligu Srinivasaran, Kostas Stathatos, Marko Teittinen

Optimal Strategies for Admitting Voice and Data Traffic in Networks of Leo Satellites Using CDMA
– Evaggelos Geraniotis, Yu-Wen Chang and Wen-Bin Yang

Satellites in the National Information Infrastructure
– Timothy J. Kirkwood and S. Joseph Campanella

For a copy of any of the papers listed above, contact Tim Kirkwood at 301-405-7904; e-mail: timk@isr.umd.edu.

CSHCN/Colorado's New Class of Phased Array Antennas

A group in the Electrical and Computer Engineering Department at the University of Colorado and Superconducting Core Technologies of Golden, Colorado, are developing a new class of thin film ferroelectric phase shifters that can be integrated into phased array antennas.

The development of phase shifters that can be rapidly tuned presents an exciting opportunity to generate small beams from a fixed antenna that can be electronically scanned to maintain communications with moving targets.

Currently the cost of phased array antenna systems is too high to allow them to be used in many commercial systems. The development of an integrated phased array system that could be fabricated on a single wafer should reduce the cost of phased arrays so that they can be used on commercial systems, as well as with military and satellite systems.

For example, a base station for a cellular communications system using a single antenna array system could generate multiple spot beams, each of which could track cars moving through their area of coverage. The addition of space diversity and the ability to track the moving cars electronically with a well-defined beam will increase the number of customers that can be served by a single base station, thus reducing the cost of operating a cellular phone system in high traffic areas where the cost of property for locating base stations may be very high.

A second potential application is between a moving vehicle and a low orbit satellite. The ability to generate a small beam that can be scanned makes it possible to radiate less power for the same received signal levels. Since the amount of radiated power dictates the size of the solar cell array on satellites and the size of the batteries that are required in hand-held transceivers, reductions in the requirements for radiated power lead to reductions in cost and weight.

Two graduate students and a post doctoral fellow are being funded to develop these new ferroelectric microwave components. This support is from NASA, through the University of Maryland CSHCN, and from Superconducting Core Technologies. The approach that is being taken is to use eximer lasers to ablate thin films of BaSrTiO3 onto a LaAlO3 substrate. These films are patterned using photolithography. Thin metal films are evaporated onto the wafer and patterned to form voltage tunable delay lines or phase shifters. Both the phase shifter and small antennas can be fabricated on the same substrate using a single sequence of processing steps. This greatly reduces the cost of fabricating an array of phase shifters and antennas over the present approach that requires the assembly of a large number of parts.

The ferroelectric BaSrTiO3 films change their dielectric constant and thus the time required for an electrical signal to propagate along the line when a large electric field is applied between the two conductors of the transmission line. Thus far, changes in delay time of about 30 picoseconds have been obtained on transmission lines that are less than a centimeter long and the insertion losses are less then 6 dB at 2GHz. Work is now underway to reduce the insertion loss and increase the delays.

Three different types of planar antennas have been fabricated as a part of the development of antenna elements that can be evaporated onto a wafer and integrated with the phase shifters. Tests are underway on the radiation patterns and the efficiency with which they can be driven from a coplanar line.

University of Colorado Update

This has been a very productive period for the CSHCN group at the University of Colorado.

"We constructed our first group of phase shifters operating at room temperature. To our knowledge, these phase shifters are the best that have been made anywhere," said Dr. Frank Barnes. "We have achieved variations in time delays of more than 30 ps on a 1.8 cm coplanar line and our best insertion losses are now less that 7 dB at 10 GHz. We believe we will be able to reduce this to less than 4 dB." Rapid progress is also being made in understanding the source of the losses and Dr. Barnes predicts that the group can eliminate about half of them without a major breakthrough. "We are excited about our results as we feel we are getting close to being able to fabricate a phase shifter that could be used in antenna systems," he said.

Dr. Barnes authored a paper, "Some microwave applications of BaSrTiO3 and high temperature superconductors," with John Price, Allen Hermann, Zhihang Zhang, Huey-Daw Wu, David Galt, Ali Naziripour. The paper was presented at the International Ferroelectrics Conference last year, and has now appeared in *Integrated Ferroelectrics*, vol. 8, no. 1-2, pp. 171-184. (1995).

Dr. Barnes was also invited to present a lecture May 20 in St. Petersburg, Russia, on the CSHCN/University of Colorado work. The lecture is part of the IEEE Electron Device Societies Distinguished Lecturer Series.

CSHCN Hosts Telecommunications Industry Workshop

Attendees of the April '95 meeting of the Satellite Industry Task Force, which was hosted by the CSHCN.

The CSHCN is hosting a series of workshops for the Satellite Industry Task Force. The first meeting was held in July 1994 and the meetings are ongoing.

The task force was organized by the Communications Division of NASA's Office of Space Access and Technology. It was set up to determine the direction of NASA's communications program and to assess how the program fits into the National Information Infrastructure/Global Information Infrastructure.

NASA's objectives for the workshops include the following: to identify and define communication services for the next 15 years; to determine what role satellites will play in future communication services and their service requirements; to examine architectures for an information infrastructure; to identify technology, policy, standards, and regulatory concerns; and to identify industry-government roles and potential areas of collaboration for addressing key issues.

NASA has encouraged the industry task force to take a cooperative and collaborative approach and to base their results on market forces and indicators. The findings of the task force will be presented to NASA headquarters and to the White House Office of Science and Technology Policy.

The companies that participated in the workshop include AT&T, American Mobile Satellite Corporation, Ball Aerospace, COMSAT, CTA INC., GLOBALSTAR, Hughes, Lockheed Martin, Loral, Motorola and TRW.

Alumni Transfer CSHCN Know-How to Industry

Many of the CSHCN graduates go on to work in industry.

These graduates help facilitate the transfer of technology to business and industry. The following is a list of graduates and the companies where they were employed after graduation.

Manoj Agarwal, '93	Texas Instruments
Molly Bryson, '93	AT&T
Kadett Chan, '94	Lockheed Martin
George Charuhas, '94	Booz Allen
Shiwei Chen, '94	TELOGY
Sandra Delaney, '93	BDM
Aaron Falk, '94	TRW
Pal Fouzan, '94	Arthur Anderson
Shravan Goli, '94	Hughes Network Systems (HNS)
Brian Johnson, '95	HNS
Ahmed Kamal, '93	HNS
Yu-Hung Kao, '92	Texas Instruments
Lei Kuang, '93	ADVANTIS
Harsha Kumar, '94	Bellcore, Inc.
Ie-Hong Lin, '94	Comsearch, Inc.
Michael Lynch, '92	IBM
Eytan Modiano, '92	MITRE
David Patton, '93	Superconducting Core Technolgies (SCT)
Raj Sivarajan, '94	TRW
Mulugu Srinivasarao, '94	US Sprint
Daniel Stotz, '95	Hewlett Packard
David Turo, '93	GEISCO
Tsing-Hsien Wu, '94	Comsearch, Inc.
Wen-Bin Yang, '93	LCC, Inc.
Zhihang Zhang, '94	SCT

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Center for Satellite & Hybrid Communication Networks
University of Maryland
A.V. Williams Building (#115)
College Park, MD 20742-3311

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Hughes & CSHCN Collaborate on DirecPC™

(continued from page 3)

The system and resulting products can now be used to provide high performance, affordable services in several areas, including linking elementary and high schools to digital libraries (with images), providing telemedicine and cooperative diagnosis systems, and linking news and business services.

Participants in this work were Douglas Dillon, Ilya Faenson and William Stanton, of Hughes Network Systems, and Dr. John Baras and Dr. Anthony Ephremides, Vivek Arora, Aaron Falk, Daniel Friedman, Narin Suphasindhu, and Tim Kirkwood, of the CSHCN. It was supported by NASA, the Institute for Systems Research, Hughes Network Systems, and the state of Maryland, under a cooperative industry-University contract from Maryland Industrial Partnerships.

For more information about this project and the results and products, contact Dr. Baras at 301-405-6606; e-mail: baras@isr.umd.edu or Timothy Kirkwood at 301-405-7904; e-mail: timk@isr.umd.edu.