Overview

John S. Baras

Industry Advisory Board Meeting
February 17, 1999
Outline

- CSHCN Structure and Partners
- Highlights of Major Accomplishments
- Technical Theme and Vision
- Collaboration with NASA and Support of NASA Missions
- Collaboration with Industry
- Education and Outreach
- Financial Summary
Hybrid Networks
Center for Satellite & Hybrid Communication Networks

University of Maryland, College Park
College of Engineering
• Institute for Systems Research
• Engineering Research Center
• Electrical Engineering Department
• Computer Science Department
• College of Business and Management

University of Colorado, Boulder
College of Engineering and Applied Science
• Optoelectronics Center (NSF)
• Telecommunications Lab
• ECE Lab

Johns Hopkins University
Applied Physics Lab (APL)
Whiting School of Engineering
• Electrical Engineering Department

Industry Partners

• AT&T
• Bell Atlantic
• Bellcore
• Boeing
• COMSAT Laboratories
• FORE Systems
• GTE
• Hughes Network Systems
• Hughes Space & Communications
• IBM
• Lockheed Martin Corporation
• Lockheed Martin Telecommunications
• Motorola
• Orbital Sciences Corporation
• Philips
• Sanders, A Lockheed Martin Corporation
• Space Systems Loral
• Superconducting Core Technologies, Inc.
• Tektron
• Telesystems
• TRW
• U.S. Sprint
Center for Satellite & Hybrid Communication Networks

Industry Advisory Board (1998)

Mr. Jim Bagwell  
Manager, Commercial Space Communications  
NASA Lewis Research Center

Dr. Thomas A. Brackey  
Director, Technical Operations  
 Hughes Space & Communications

Dr. Prakash Chitre  
Vice President, Technology Development  
COMSAT Laboratories

Dr. Leonard Golding  
Vice President, Systems Engineering  
Hughes Network Systems

Mr. Burt Liebowitz  
Chief Technical Officer  
Loral Orion

Dr. Ron Paulson  
Vice President, Engineering and Technology  
Lockheed Martin Space & Strategic Missiles

Dr. Robert Bonometti  
President  
Strategic Technology Decision

Dr. Joseph Bravman  
Senior Vice President  
Orbital Sciences Corporation

Dr. Luis Figueroa  
Manager, Strategy & Analysis  
The Boeing Company

Dr. Milton Halem  
Chief, Space Data and Computing Division  
NASA Goddard Space Flight Center

Mr. Roger Mancuso  
Vice President, Technical Operations  
Lockheed Martin Telecommunications

Mr. Rocky Roccanova  
Vice President  
TRW Telecom Group
Faculty

- Dr. Michael Ball (BMGT/ISR)
- Dr. John Baras (EE/ISR)
- Dr. Frank Barnes (University of Colorado)
- Dr. Scott Corson (ISR)
- Dr. Anthony Ephremides (EE/ISR)
- Dr. Evaggelos Geraniotis (EE/ISR)
- Dr. Nariman Farvardin (EE/ISR)
- Dr. Armand Makowski (EE/ISR)
- Dr. Prakash Narayan (EE/ISR)
- Dr. Catherine Plaisant (UMIACS)
- Dr. Nicholas Roussopoulos (CS/UMIACS)
- Dr. Ben Shneiderman (CS/ISR)
- Dr. Leandros Tassiulas (EE/ISR)
- Dr. Roger Westgate (John Hopkins University)

Research Staff

- Dr. Michael Hadjitheosodiou (ISR)
- Dr. George Mykoniotis (ISR)
- Mr. Steve Kelly (UMIACS)
- Mr. Spyro Papademetriou (ISR)
History at a Glance

- Initiated emphasis on hybrid networks
- Commercial successes in Hybrid Internet, Multiple access and modulation schemes, Multicasting, Network Management
- Research funding from NASA, DoD and industry has created a unique expertise
- More recent activity: bring this expertise to support high priority NASA missions:
  - Broadband communication to the ISS
  - Efficient distribution of NASA and space data
  - Support the move of NASA networks, spacecraft and instruments on the Internet
Outline

• CSHCN Structure and Partners
• Highlights of Major Accomplishments
• Technical Theme and Vision
• Collaboration with NASA and Support of NASA Missions
• Collaboration with Industry
• Education and Outreach
• Financial Summary
Highlights of Major Accomplishments

- **CONGRATULATIONS TO ALL FOR THE EXCELLENT PEER REVIEW REPORT!**
- **Presence/participation in national forums**
  - National Board on Computer Science and Telecommunications
  - IETF, ATM Forum, Network Management Forum
  - Continued Participation in satellite industry work (TIA, Technical Committees, Alliance)
- **Continued influence on DoD telecommunications (ARL-ATIRP, DARPA workshops, Space Architect office, HLA office)**
- **Frequent brainstorming with industry partners, NASA and DoD on future long term network research problems**
Highlights of Major Accomplishments

- Emphasized and increased efforts on manpower education (short courses, industrial internships, workshops)
  - CSHCN has graduated in the period 1991-98: 29 PhDs, 62 MS, 24 BS (98% to US Industry)
  - Last three years 15 to 24 interns with US Industry, each summer
- Closer and expanded collaboration with industry
- Continued technical emphasis on: hybrid networks, asymmetric Internet, interoperability, cost issues
- Focusing intensely on:
  - High-data rate satellite networks, modeling, design and performance evaluation
  - Hybrid fast Internet over broadband hybrid networks (in particular future $K_a$-band systems)
  - Network interoperability
    - broadband satellite/terrestrial wireless (LMDS, MMDS)
    - mobile satellite/terrestrial wireless
    - broadband satellite/terrestrial wireline (HFC, fiber)
Hybrid Networks Laboratory
First Phase Completed

- Fully meshed ATM network with OC3/12 connections
- HP Broadband Test equipment with DS3, OC3, and OC12 modules
- ADTECH delay channel simulator with DS3, OC3 interfaces (will procure OC12 when available from manufacturer)
- Comsat Fast Packet switch
- Fully meshed mobile network using multiple wireless interfaces
- Hybrid Host Router capable of redistributing unicast, broadcast and multicast traffic streams
- Developed a system to study the effects of jitter on real time applications on ATM networks. This system can generate both bursty and constant bit-rate traffic
High-Data Rate Experiments and Demonstrations

• **Joint with NASA LeRC and industry**
  – Invite industry partners to declare interest in participating: make available satellite and/or terrestrial resources

• **Fast Internet over high-data-rate satellites**
  – SACK, RED, spoofing, caching, buffers, queue management, TCP improvements, new flow control
  – ATM, TCP/IP over ATM over high data rate satellites

• **Reliable, large scale multicasting**
  – Advantage of Hybrid Internet Access
  – High-data rate satellite adds reliability
  – Multicast delivery of bulky “information objects”: movies, books, software, maps

• **Interoperability between high-data rate Ka-band satellites and LMDS systems**
  – What we gain by using the same frequency band? ($K_a$, 28 GHz)
  – Video delivery, and Fast Internet services
Outline

• CSHCN Structure and Partners
• Highlights of Major Accomplishments
• Technical Theme and Vision
• Collaboration with NASA and Support of NASA Missions
• Collaboration with Industry
• Education and Outreach
• Financial Summary
New Business Paradigm

- The “New Data”: Internet / Intranet / Extranet applications
  Digital, compressed voice, audio and video

- Paradigm shifts:
  - Data applications require flexible connectivity
  - Applications require much larger capacities and “bandwidth-on-demand”
  - Subscribers require low-cost, high capacity access
  - Enterprise networks require in addition scalability, dependable performance, simple network management, controlled costs
The “Last Mile” is Key

- **Local Access options:**
  - Fiber to anywhere (FTTN, FTTC, FTTH, SDV)
  - Copper twisted pair wire (ADSL, VDSL, … HDSL)
  - Cable Television (CATV), coaxial cable (HFC)
  - Multichannel Multipoint Distribution Service (MMDS)
  - Local Multipoint Distribution Service (LMDS)
  - Broadband Satellites

- **Not a technology issue**
- **Economic and marketing issue**
- **Time of deployment & market penetration**
Many advantages of wireless infrastructures:
- Instant deployment
- Flexible asset reuse and resource allocation
- Ideal multi-service platform: voice, data, video
- Access comparable to wireline access in price and performance
- Lower initial investment & faster initiation of revenue

**MMDS:** 2.5 GHz with 200 MHz, 40 miles

**LMDS:** 28 or 38 GHz with 1.5 Ghz, 3 miles
• **DBS major success**

• **New remarkable satellite constellations**
  – FSS or Mobile, LEO or MEO
  – From 8kbps to 1 Gbps and higher; *on demand*
  – Competition to fiber (“faster than light”)
  – On-board processing, spot beams, hoping beams, autonomy
  – Globalstar, Iridium, Teledesic, Spaceway, CyberStar, PanAmSat, Astrolink, ...
  – Newest EHF satellites: OrbLink, Lockheed Martin, ...
Vision: The “New Space-Time” plus “Smart Space”

**Fact:** The Internet will be the Information Superhighway: it will carry video, voice, broadband data worldwide

**Evolution (architecture) controlled:**
- **Now:** backbone
- **Future:** “last-mile”

**Problems:** Data Smog; World-Wide Wait
Drivers for success: Economics and “customer psychology”
- Low, low price (terminals, nets, satellites, power)
- Availability and reliability
- Security
- Information “follows” the user
Architectures

Economics of Broadband
Economics of Last Mile

Imply: Intelligent hierarchies in architecture
Hybrid Networks Architectures: High-Data-Rate Ka-band SatCom and Wireless or Wire-line Terrestrial
Hybrid Networks Architectures:
High-Data-Rate SatCom, Fiber and LMDS
Hybrid Networks Architectures:
DBS, Wireless Terrestrial
Efficient Broadband Services not just a Bandwidth Issue

- **Challenge:** Exponential growth in demand workloads cannot be met by traditional data services with scalability growth linear in network bandwidth and server capacity
- Traditional unicast (point-to-point) connection-oriented data services uneconomical and wasteful
- Utilize distributed caching, smart prefetching, dynamic bandwidth allocation, reliable multicast, adaptive hybrid data delivery
- **Need to broadcast the right set of data: highly in demand**
  - Balance data delivery modes to match user’s request
  - Broadcast the right amount of the hottest data and provide the rest on demand
The “Last Mile”

- There will be no winner-take-all in the “last mile”
- LMDS will be widely deployed over the next 3-5 years
- MMDS will continue modest deployment in rural areas and outside the USA
- HFC broadband services will be deployed fast over the next 3-5 years, where CATV already exists
- Fiber to the CO and xDSL will deploy slowly over next 5-10 years
- Broadband satellites and wireless will be deployed extensively, especially outside the USA
Key Technical Challenges

- Design of smaller satellites with on-board processing, autonomy
- Energy and cost efficient small end-user terminals
- Access equipment: PC cards and set-up boxes
- Local intelligence to “hide” heterogeneity: end-to-end simplicity
- Protocol re-design and integration, interoperability
- Hybrid network planning and design methodologies, tools
- Dynamic, adaptive routing, congestion and flow control
- Automated network management of hybrid networks:
  - Databases, MIBS, Fault management, Configuration management, Performance management, Security management, Self-managed networks
  - Service pricing, cost and business models
- Efficient information distribution and broadband services
CSHCN STRATEGIC PLAN

- TCP/IP and ATM over Satellite and Wireless
- Modulation, Signaling, Access
- Internet over Hybrid Networks including Hybrid Data Delivery
- Switching and Routing
- Multicasting including security
- Network Management and Control
- Interoperability
- NOC design
- Next Generation Hybrid Network Architectures including Mobility
- Network Systems Engineering Tools including Performance Evaluation
- Universal Interfaces and Subscriber Equipment

1999 2000 2001 2002 2003
Current CSHCN Projects

Internet over Broadband Hybrid Networks
  Baras, Corson, Roussopoulos, Tassiulas

High Data Rate Satellite Networks and NASA Missions
  Baras, Geraniotis, Hadjitheodosiou

Modulation, Coding and Interference Cancellation in Satellite and Hybrid Networks
  Ephremides, Geraniotis, Hadjitheodosiou

Hybrid Network Control
  Ephremides, Tassiulas

Satellite Traffic Modeling and On-Board Switch Design
  Makowski, Narayan

Modeling, Simulation and Performance Evaluation of Hybrid Networks
  Baras, Corson, Geraniotis

Automated Monitoring and Management of Hybrid Broadband Networks
  Baras, Mykoniatis, Roussopoulos
Current and Future Technical Topics Emphasized

- Multicasting techniques for hybrid networks
- Internet-based high data rate communications from space to the users
- Next-Generation network architecture development tools
- Modulation and coding
- ATM-based on-board switching
- In-space wireless network/hybrid network interoperability
- Advanced hybrid networks research (modeling, simulation, performance evaluation, network management)
Outline

- CSHCN Structure and Partners
- Highlights of Major Accomplishments
- Technical Theme and Vision
- Collaboration with NASA and Support of NASA Missions
- Collaboration with Industry
- Education and Outreach
- Financial Summary
High Data Rate Communications from Spacecraft and Space-Missions

• Commercial Space needs high data rate and high quality communications
  – Experiments with Shuttle
  – Experiments with ISS
  – Spacecraft linkage
  – Future space habitats and planetary missions

• NASA networks, spacecraft, instruments on the Internet

• Needed:
  – Efficient and cost effective communications from spacecraft to commercial satellite constellations
  – Experiments to validate such systems
HDR Commercial Communication
Services to the ISS

- Initiated interactive modeling and simulation of HDR telecomm services between the ISS and future HDR satellite constellations
- Special session in the ISS Utilization Conference, February 1999
Close Collaboration with NASA Centers

• Close and intensive collaboration with NASA Lewis RC
  – joint projects
  – student internships
  – faculty monthly visits (lecture, interactions)
  – joint experiments and demonstrations

• Collaboration with NASA Goddard on ATM over HDB hybrid networks; interoperability
  – take advantage of ATD Net and ACTS
Outline

- CSHCN Structure and Partners
- Highlights of Major Accomplishments
- Technical Theme and Vision
- Collaboration with NASA and Support of NASA Missions
- Collaboration with Industry
- Education and Outreach
- Financial Summary
CSHCN Partnership

• Initiate and perform research and development in areas of strategic significance to industry. Facilitate effective commercialization.

• Be a catalyst in industry-university, industry-industry, industry-university-government collaboration

• Attract, educate and promote to industry and government expertly educated and trained professionals
  – Undergraduate researchers and interns
  – Graduate researchers and interns

• Develop and deliver timely, leading-edge education and training to industry/government

• Influence and guide national policy and national goal setting in technology R&D
Outline

• CSHCN Structure and Partners
• Highlights of Major Accomplishments
• Technical Theme and Vision
• Collaboration with NASA and Support of NASA Mission
• Collaboration with Industry
• Education and Outreach
• Financial Summary
Education and Outreach

- Attract “best brains” in these technical areas
- Cross-disciplinary education to graduate and undergraduate students, coupled to industry and government internships
- Annual Review Conference
- Advanced Networks Colloquium (distinguished lecturers, videotapes)
- New educational initiatives and paradigms
- Reach to user groups: telemedicine, distance learning
Outline

• CSHCN Structure and Partners
• Highlights of Major Accomplishments
• Technical Theme and Vision
• Collaboration with NASA and Support of NASA Mission
• Collaboration with Industry
• Education and Outreach
Education, Manpower and Outreach

John S. Baras

Industry Advisory Board Meeting
February 17, 1999
Education, Manpower and Outreach

From the CSHCN Partnership Strategy Chart:

• Attract, educate and promote to industry and government expertly educated and trained professionals
  – Undergraduate researchers and interns
  – Graduate researchers and interns

• Develop and deliver timely, leading-edge education and training to industry/government
Education, Manpower and Outreach

• Critical shortage of well-educated and trained personnel in the technical areas represented in the CSHCN program

• Graduate and undergraduate students from Electrical Engineering, Computer Science and Business and Management

• Two special programs:
  - MS in Systems Engineering
  - MS in Telecommunications

• Create opportunities for “bright” undergraduates to participate in engineering design projects early on, often with industry collaboration
  - Research Experience for Undergraduates (REU)
  - Undergraduate Research Participation Awards (URPA)
Education, Manpower and Outreach: Strategic Initiatives

- Web-based interactive courses (ATM, Satellite Networks, Hybrid Internet)
- Initiated planning for new educational paradigm in telecommunication and information technologies (accelerated M.S. program modeled after Institute Eurecom)
- CSHCN monthly faculty visits and lectures at Government and Industry Partners
- CSHCN Advanced Networks Colloquium Series
- Rich web page on all aspects of CSHCN program; Private part for Partners
EXAMPLE: CSHCN Lectures at NASA LeRC

10/21/97  Novel Information Distribution Architectures and Methodologies Based on Broadcast Delivery *(Tassiulas)*

12/17/97  Rate-based Transmission Scheduling for Asymmetric, Satellite-based Reliable Multicast *(Corson)*

1/27/98  Hybrid Asymmetric Internet Services: Performance Enhancements, Extensions and Network Operations *(Baras)*

3/6/98  Statistical Tools For Fast Performance Evaluation and Optimization of High Data Rate Satellite Networks *(Geraniotis)*

3/10/98  Connection-Oriented Traffic Management over Hybrid Mobile Networks *(Ephremides)*


11/5/98  OSI, TMN and CORBA for Network and Service Management *(Mykoniatis)*
Education, Manpower and Outreach

• Advanced Network Colloquium Series; Soon to be broadcast

  – Graduate Student Participation
    ➢ Four graduate students determine list of potential speaker

  – Speaker Visits
    ➢ Lecture (every Friday, 11:00 a.m. - 12:00 p.m.)
    ➢ Lunch
    ➢ Roundtable Discussions
## CSHCN ADVANCED NETWORK COLLOQUIUM SERIES
### LIST OF SPEAKERS
#### 1997 - 1998

<table>
<thead>
<tr>
<th>SPEAKER</th>
<th>AFFILIATE</th>
<th>DATE</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prakash Chitre</td>
<td>COMSAT Labs</td>
<td>11/21/97</td>
<td>New Development in ATM Over Satellite</td>
</tr>
<tr>
<td>C.J. Su</td>
<td>UMCP</td>
<td>02/13/98</td>
<td>Information Distribution Through Broadcast Delivery</td>
</tr>
<tr>
<td>Raj Jain</td>
<td>Ohio State University</td>
<td>02/27/98</td>
<td>Traffic Management of ATM Over Satellite Links</td>
</tr>
<tr>
<td>Balaji Prabhakar</td>
<td>MIT</td>
<td>03/06/98</td>
<td>Towards High-Speed, High Performance Data Switches</td>
</tr>
<tr>
<td>Tennis Ott</td>
<td>Bellcore</td>
<td>03/13/98</td>
<td>The Square-Root Formula for TCP Window Behavior and Stabilized RED</td>
</tr>
<tr>
<td>David McElroy</td>
<td>MIT</td>
<td>03/20/98</td>
<td>Key Technologies for Future Satellite communications Systems</td>
</tr>
<tr>
<td>Pierre Humblet</td>
<td>Eurocom Institute</td>
<td>04/03/98</td>
<td>Communication Over Fading Channels</td>
</tr>
<tr>
<td>Ioannis Paschalidis</td>
<td>Boston University</td>
<td>04/10/98</td>
<td>Providing Statistical QoS in Multimedia Networks (Effective Bandwidths and Beyond)</td>
</tr>
<tr>
<td>Richard Delanoy</td>
<td>MIT-Lincoln Lab</td>
<td>04/24/98</td>
<td>Toolkit for Image Mining: User-Trainable tools for Data Search, Image Analysis, and Algorithm construction</td>
</tr>
<tr>
<td>Samuel Dwyer</td>
<td>University of Virginia</td>
<td>05/01/98</td>
<td>Acquisition, Transmission, Display, Networks, and Archiving</td>
</tr>
<tr>
<td>David Forney</td>
<td>Motorola</td>
<td>05/08/98</td>
<td>On Iterative Decoding and the Forward-Backward Algorithm</td>
</tr>
<tr>
<td>John Baras</td>
<td>UMCP</td>
<td>09/11/98</td>
<td>The ‘Last Mile’, Hybrid Networks and Broadband Internet</td>
</tr>
<tr>
<td>Joseph Macker</td>
<td>NRL</td>
<td>09/25/98</td>
<td>The Multicast Dissemination Protocol</td>
</tr>
<tr>
<td>Rajiv Laroia</td>
<td>Lucent Technologies</td>
<td>10/02/98</td>
<td>Overview of High-Speed Access Over Existing Telephone Infrastructure</td>
</tr>
<tr>
<td>Walter Willinger</td>
<td>AT&amp;T</td>
<td>10/09/98</td>
<td>The Fractal Nature of Data Traffic</td>
</tr>
<tr>
<td>Scott Corson</td>
<td>UMCP</td>
<td>10/16/98</td>
<td>Mobile Ad hoc Networking</td>
</tr>
<tr>
<td>David Tennenhouse</td>
<td>DARPA</td>
<td>10/23/98</td>
<td>From Internet to Active Net</td>
</tr>
</tbody>
</table>
Anjum, Farooq  
Arora, Anubhav  
Barrett, Bradley  
Bharadwaj, Vijay  
Birmani, Vineet  
ElGamal, Hesham  
Gu, Junfeng  
Han, Zhu  
Kar, Koushik  
Karir, Manish  
Khairy, Mohamed  
Koutsopoulos, Iordanis  
Li, Hongjun  
Luo, Wei  
Parulekar, Minothi  
Payne, Stephen  
Ramakrishnan, Arvindha  
Ramakrishnan, Pradeep  
Ramaswamy, Sreenivas  
Sarkar, Saswati  
Stamatelos, Dimitrios  
Tabatabaei, Vahid  
Tripathi, Rohit  
Vaidyanathan, Ravichander  
Bellcore  
Lockheed Martin Telecommunications  
Howard University  
Lockheed Martin Telecommunications  
Hughes Network Systems  
Hughes Network Systems  
LNK Corporation  
Hughes Network Systems  
Lucent Technologies  
Hughes Research Labs  
Orbital Sciences  
Hughes Network Systems  
MCI  
Hughes Network Systems  
Hughes Network Systems  
Army Research Laboratory  
Bellcore  
Yurie Systems (Lucent)  
Comsat Labs  
IBM  
Schafer Corporation  
Yurie Systems (Lucent)  
Lockheed Martin Telecommunications  
Bellcore
<table>
<thead>
<tr>
<th>CSHCN Employers</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADVANTIS</td>
</tr>
<tr>
<td>AIMS, Inc.</td>
</tr>
<tr>
<td>Arthur Anderson</td>
</tr>
<tr>
<td>AT&amp;T Bell Laboratories</td>
</tr>
<tr>
<td>BDM</td>
</tr>
<tr>
<td>Bell South</td>
</tr>
<tr>
<td>Bellcore, Inc.</td>
</tr>
<tr>
<td>Berkeley.Nets</td>
</tr>
<tr>
<td>Booz Allen</td>
</tr>
<tr>
<td>CENA</td>
</tr>
<tr>
<td>Cisco</td>
</tr>
<tr>
<td>Computer Science Corporation</td>
</tr>
<tr>
<td>COMSAT Labs</td>
</tr>
<tr>
<td>Comsearch, Inc.</td>
</tr>
<tr>
<td>FORE Systems</td>
</tr>
<tr>
<td>GEISCO</td>
</tr>
<tr>
<td>GTE Lab</td>
</tr>
<tr>
<td>Hi-Tech Resources, Inc.</td>
</tr>
<tr>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Hyundai Electronics America</td>
</tr>
<tr>
<td>IBM Watson Labs</td>
</tr>
<tr>
<td>InterWave, Inc.</td>
</tr>
<tr>
<td>Intracom S.A.</td>
</tr>
<tr>
<td>Iterated Systems, Inc.</td>
</tr>
<tr>
<td>JP Morgan</td>
</tr>
<tr>
<td>Lucent Technologies</td>
</tr>
<tr>
<td>Microsoft</td>
</tr>
<tr>
<td>MIT Lincoln Labs</td>
</tr>
<tr>
<td>MITRE</td>
</tr>
<tr>
<td>MITRE Technical systems</td>
</tr>
<tr>
<td>Motorola</td>
</tr>
<tr>
<td>National Institute of Health</td>
</tr>
<tr>
<td>Northern Telecom</td>
</tr>
<tr>
<td>Performance Eng. Corp.</td>
</tr>
<tr>
<td>Qualcomm</td>
</tr>
<tr>
<td>Raytheon</td>
</tr>
<tr>
<td>Stanford Telecommunications</td>
</tr>
<tr>
<td>Telegy Networks, Inc.</td>
</tr>
<tr>
<td>Texas Instruments</td>
</tr>
<tr>
<td>Texas Instruments Research Labs</td>
</tr>
<tr>
<td>TRW</td>
</tr>
<tr>
<td>U.S. Sprint, Inc.</td>
</tr>
<tr>
<td>United Airlines</td>
</tr>
<tr>
<td>Visix Corp.</td>
</tr>
<tr>
<td>VLSI Technologies, Inc.</td>
</tr>
<tr>
<td>Yurie Systems</td>
</tr>
</tbody>
</table>
### Ph.D. STUDENTS

<table>
<thead>
<tr>
<th>NAME</th>
<th>ADVISOR</th>
<th>DEPT</th>
<th>YEAR</th>
<th>FIRST/CURRENT AFFILIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ayyagari, Deepak</td>
<td>Ephremides</td>
<td>EE</td>
<td>1998</td>
<td>GTE Labs – Cambridge, MA</td>
</tr>
<tr>
<td>Banego, Lionel</td>
<td>Makowski</td>
<td>EE</td>
<td>1996</td>
<td>CENA</td>
</tr>
<tr>
<td>Chang, Yu-Wen</td>
<td>Geraniotis</td>
<td>EE</td>
<td>1996</td>
<td>InterWave, Inc.</td>
</tr>
<tr>
<td>Chen, Shihwei</td>
<td>Baras</td>
<td>EE</td>
<td>1994</td>
<td>Yurie Systems</td>
</tr>
<tr>
<td>Chou, Chih-Hsien</td>
<td></td>
<td>EE</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Corson, Scott</td>
<td>Ephremides</td>
<td>EE</td>
<td>1993</td>
<td>University of Illinois, Chicago</td>
</tr>
<tr>
<td>Datta, Anindya</td>
<td>Ball</td>
<td>BGMT</td>
<td>1994</td>
<td>University of Arizona</td>
</tr>
<tr>
<td>Delis, Alex</td>
<td>Roussopoulos</td>
<td>CS</td>
<td>1993</td>
<td>Unknown</td>
</tr>
<tr>
<td>Frantzeskakis, Emmanuil</td>
<td>Baras</td>
<td>EE</td>
<td>1993</td>
<td>Intracom S.A. (Greece)</td>
</tr>
<tr>
<td>Issac, David</td>
<td>Roussopoulos</td>
<td>SE</td>
<td>1994</td>
<td>MITRE</td>
</tr>
<tr>
<td>Kanlis, Angelos</td>
<td>Narayan</td>
<td>EE</td>
<td>1997</td>
<td>The University of Crete, Greece</td>
</tr>
<tr>
<td>Kao, Yu-Hung</td>
<td>Baras</td>
<td>EE</td>
<td>1992</td>
<td>Texas Instruments Research Labs</td>
</tr>
<tr>
<td>Khudanpur, Sanjeev</td>
<td>Narayan</td>
<td>EE</td>
<td>1997</td>
<td>The Johns Hopkins University</td>
</tr>
<tr>
<td>Kim, Young B.</td>
<td>Makowski</td>
<td>EE</td>
<td>1996</td>
<td>Telogy &amp; Hyundai Electronics America</td>
</tr>
<tr>
<td>Kuang, Lei</td>
<td>Makowski</td>
<td>EE</td>
<td>1992</td>
<td>ADVANTIS (Currently at IBM Networks)</td>
</tr>
<tr>
<td>Lambadaris, Ioannis</td>
<td>Narayan</td>
<td>EE</td>
<td>1992</td>
<td>Unknown</td>
</tr>
<tr>
<td>Li, Jerry</td>
<td>Geraniotis</td>
<td>EE</td>
<td>1997</td>
<td>GTE Lab, Waltham, MA</td>
</tr>
<tr>
<td>Lin, Feng Lee</td>
<td>Ball</td>
<td>BGMT</td>
<td>1992</td>
<td>National Sun Yatsen University</td>
</tr>
<tr>
<td>Lin, Ie-Hong</td>
<td>Geraniotis</td>
<td>EE</td>
<td>1994</td>
<td>Comsearch, Inc.</td>
</tr>
<tr>
<td>Liu, Shang-Chien</td>
<td>Geraniotis</td>
<td>EE</td>
<td>1998</td>
<td>Lucent Technologies</td>
</tr>
<tr>
<td>Modiano, Eytan</td>
<td>Ephremides</td>
<td>EE</td>
<td>1992</td>
<td>MIT Lincoln Labs</td>
</tr>
<tr>
<td>Peris, Vinod</td>
<td>Makowski</td>
<td>EE</td>
<td>1997</td>
<td>IBM Watson Labs</td>
</tr>
<tr>
<td>Rananand, Nol</td>
<td>Narayan</td>
<td>EE</td>
<td>1995</td>
<td>FORE Systems (Currently at COMSAT)</td>
</tr>
<tr>
<td>Rezaifar, Ramin</td>
<td>Makowski</td>
<td>EE</td>
<td>1996</td>
<td>Qualcomm</td>
</tr>
<tr>
<td>Tassiulas, Leandros</td>
<td>Ephremides</td>
<td>EE</td>
<td>1992</td>
<td>Polytech Institute of NY</td>
</tr>
<tr>
<td>Vakhutinsky, Andrew</td>
<td>Ball</td>
<td>BGMT</td>
<td>1996</td>
<td>United Airlines</td>
</tr>
<tr>
<td>Wu, Tsing-Hsien</td>
<td>Geraniotis</td>
<td>EE</td>
<td>1994</td>
<td>Bell South</td>
</tr>
<tr>
<td>Yang, Wen-Bin</td>
<td>Geraniotis</td>
<td>EE</td>
<td>1993</td>
<td>Comsearch, Inc.</td>
</tr>
<tr>
<td>Yao, Shee</td>
<td>Geraniotis</td>
<td>EE</td>
<td>1997</td>
<td>VLSI Technologies, Inc.</td>
</tr>
</tbody>
</table>
# CSHCN Student Alumni List

## 1991-1998

(Through Fall 1998 Semester)

### M.S. STUDENTS

<table>
<thead>
<tr>
<th>Name</th>
<th>Advisor</th>
<th>Dept.</th>
<th>Year</th>
<th>First/Current Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agarwal, Manoj</td>
<td>Ephremides</td>
<td>EE</td>
<td>1993</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>Almeida, Fernando</td>
<td>Baras</td>
<td>EE</td>
<td>1995</td>
<td>Computer Science Corporation</td>
</tr>
<tr>
<td>Anjum, Farooq M.</td>
<td>Tassiulas</td>
<td>EE</td>
<td>1997</td>
<td>Graduate – Working towards PhD</td>
</tr>
<tr>
<td>Arora, Anubhav</td>
<td>Baras</td>
<td>EE</td>
<td>1998</td>
<td>Graduate – Working towards PhD</td>
</tr>
<tr>
<td>Arora, Vivek</td>
<td>Baras</td>
<td>CS</td>
<td>1995</td>
<td>AT&amp;T Bell Laboratories</td>
</tr>
<tr>
<td>Ayyagari, Deepak</td>
<td>Ephremides</td>
<td>EE</td>
<td>1996</td>
<td>Graduate - Working towards PhD</td>
</tr>
<tr>
<td>Bisain, Abhijeet</td>
<td>Baras</td>
<td>EE</td>
<td>1998</td>
<td>Qualcomm</td>
</tr>
<tr>
<td>Chan, Wai-Chung</td>
<td>Geraniotis</td>
<td>EE</td>
<td>1995</td>
<td>Graduate - Working towards PhD</td>
</tr>
<tr>
<td>Charleston, Giles</td>
<td>Makowski</td>
<td>SE</td>
<td>1997</td>
<td>MITRETEK</td>
</tr>
<tr>
<td>Chen, Bin</td>
<td>Baras</td>
<td>EE</td>
<td>1998</td>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Chen, Chao-Hwa</td>
<td>Fuja</td>
<td>EE</td>
<td>1995</td>
<td>Graduate - Working towards PhD</td>
</tr>
<tr>
<td>Das, Arnab</td>
<td>Narayan</td>
<td>EE</td>
<td>1996</td>
<td>Graduate - Working towards PhD</td>
</tr>
<tr>
<td>Delancy, Sandra</td>
<td>Baras</td>
<td>SE</td>
<td>1993</td>
<td>BDM</td>
</tr>
<tr>
<td>Dogu, Talat Mert</td>
<td>Ephremides</td>
<td>EE</td>
<td>1998</td>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Dorsey, Molly Bryson</td>
<td>Baras</td>
<td>SE</td>
<td>1993</td>
<td>AT&amp;T</td>
</tr>
<tr>
<td>Ercetin, Ozgur</td>
<td>Tassiulas</td>
<td>EE</td>
<td>1998</td>
<td>Graduate – Working towards PhD</td>
</tr>
<tr>
<td>Falk, Aaron</td>
<td>Baras</td>
<td>SE</td>
<td>1994</td>
<td>TRW</td>
</tr>
<tr>
<td>Friedman, Daniel</td>
<td>Ephremides</td>
<td>EE</td>
<td>1995</td>
<td>Graduate - Working towards PhD</td>
</tr>
<tr>
<td>Fruth, Frank</td>
<td>Geraniotis</td>
<td>EE</td>
<td>1998</td>
<td>Telogy Networks, Inc.</td>
</tr>
<tr>
<td>Goli, Stravan</td>
<td>Roussopoulos</td>
<td>CS</td>
<td>1994</td>
<td>Microsoft</td>
</tr>
<tr>
<td>Gupta, Sandeep</td>
<td>Baras</td>
<td>CS</td>
<td>1996</td>
<td>Berkeley.Nets</td>
</tr>
<tr>
<td>Gupta, Sonjai</td>
<td>Ephremides</td>
<td>EE</td>
<td>1996</td>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Jiang, Yimin</td>
<td>Baras</td>
<td>EE</td>
<td>1998</td>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Jog, Ninad</td>
<td>Shneiderman</td>
<td>EE</td>
<td>1995</td>
<td>Visix Corp.</td>
</tr>
<tr>
<td>Johnson, Brian</td>
<td>Farvardin</td>
<td>EE</td>
<td>1995</td>
<td>GRA @ UMC (Currently @ HNS)</td>
</tr>
<tr>
<td>Kamal, Ahmad</td>
<td>Geraniotis</td>
<td>EE</td>
<td>1993</td>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Kant, Nishi</td>
<td>JaJa</td>
<td>EE</td>
<td>1994</td>
<td>Northern Telecom</td>
</tr>
<tr>
<td>Kawle, Mandar</td>
<td>Ball</td>
<td>RE</td>
<td>1994</td>
<td>Unknown</td>
</tr>
<tr>
<td>Khan, Khursheedul</td>
<td>Ephremides</td>
<td>EE</td>
<td>1996</td>
<td>Comsearch</td>
</tr>
<tr>
<td>Khairy, Mohamed</td>
<td>Geraniotis</td>
<td>EE</td>
<td>1997</td>
<td>Graduate – Working towards PhD</td>
</tr>
<tr>
<td>Kumar, Harsha P.</td>
<td>Shneiderman</td>
<td>SE</td>
<td>1994</td>
<td>Bellcore, Inc.</td>
</tr>
<tr>
<td>Liu, Mingyan</td>
<td>Baras</td>
<td>SE</td>
<td>1997</td>
<td>Research Staff UMCP-Wrkg towards PhD</td>
</tr>
<tr>
<td>Luo, Wei</td>
<td>Ephremides</td>
<td>EE</td>
<td>1997</td>
<td>Graduate – Working towards PhD</td>
</tr>
</tbody>
</table>
### M.S. STUDENTS (Continued)

<table>
<thead>
<tr>
<th>NAME</th>
<th>ADVISOR</th>
<th>DEPT.</th>
<th>YEAR</th>
<th>FIRST/CURRENT AFFILIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michail, Anastassios</td>
<td>Ephremides</td>
<td>EE</td>
<td>1997</td>
<td>Graduate – Working towards PhD</td>
</tr>
<tr>
<td>Misra, Archan</td>
<td>Baras</td>
<td>EE</td>
<td>1996</td>
<td>Bellcore &amp; PT PhD program at UMCP</td>
</tr>
<tr>
<td>Murad, Ahsun</td>
<td>Fuja</td>
<td>EE</td>
<td>1992</td>
<td>COMSAT Labs/PhD program @ UMCP</td>
</tr>
<tr>
<td>Olariu, Gabriel</td>
<td>Baras</td>
<td>SE</td>
<td>1997</td>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Pang, Xiaozhong</td>
<td>Baras</td>
<td>EE</td>
<td>1998</td>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Paranjape, Deepak</td>
<td>Ephremides</td>
<td>EE</td>
<td>1992</td>
<td>Unknown</td>
</tr>
<tr>
<td>Qui, Chencheng</td>
<td>Shneiderman</td>
<td>CS</td>
<td>1995</td>
<td>Graduate – Working towards PhD</td>
</tr>
<tr>
<td>Ramaswamy, Venkateshwaran</td>
<td>Baras</td>
<td>EE</td>
<td>1998</td>
<td>Qualcomm</td>
</tr>
<tr>
<td>Rao, Sanjeeep</td>
<td>Narayan</td>
<td>EE</td>
<td>1997</td>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Seeka, Isatou</td>
<td>Baras</td>
<td>SE</td>
<td>1997</td>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Shah, Parthiv</td>
<td>Baras</td>
<td>SE</td>
<td>1996</td>
<td>Motorola</td>
</tr>
<tr>
<td>Singh, Gagan</td>
<td>Baras</td>
<td>EE</td>
<td>1997</td>
<td>JP Morgan</td>
</tr>
<tr>
<td>Sivarajan, Rajesh</td>
<td>Narayan</td>
<td>EE</td>
<td>1994</td>
<td>TRW (Currently @ HNS)</td>
</tr>
<tr>
<td>Srinivasarao, Mulugu</td>
<td>Ball</td>
<td>BGMT</td>
<td>1994</td>
<td>U.S. Sprint, Inc.</td>
</tr>
<tr>
<td>Stagarescu, Marian</td>
<td>Baras</td>
<td>EE</td>
<td>1998</td>
<td>Raytheon</td>
</tr>
<tr>
<td>Stamatelos, Dimitrios</td>
<td>Ephremides</td>
<td>EE</td>
<td>1995</td>
<td>Graduate – Working towards PhD</td>
</tr>
<tr>
<td>Statthatos, Konstantinos</td>
<td>Baras</td>
<td>CS</td>
<td>1994</td>
<td>Graduate – Working towards PhD</td>
</tr>
<tr>
<td>Taj, Azhar Paul</td>
<td>Ball</td>
<td>SE</td>
<td>1994</td>
<td>Hi-Tech Resources, Inc.</td>
</tr>
<tr>
<td>Tatake, Sachin</td>
<td>Baras</td>
<td>EE</td>
<td>1998</td>
<td>Stanford Telecommunications</td>
</tr>
<tr>
<td>Tan, Michael</td>
<td>Roussopoulos</td>
<td>CS</td>
<td>1993</td>
<td>Graduate – Working towards PhD</td>
</tr>
<tr>
<td>Tran Luu, Tung-PHung</td>
<td>Ephremides</td>
<td>EE</td>
<td>1995</td>
<td>Unknown</td>
</tr>
<tr>
<td>Tsoukatos, Konstantinos</td>
<td>Makowski</td>
<td>EE</td>
<td>1994</td>
<td>Graduate – Working towards PhD</td>
</tr>
<tr>
<td>Tunpan, Apinun</td>
<td>Corson</td>
<td>CS</td>
<td>1997</td>
<td>Graduate – Working towards PhD</td>
</tr>
<tr>
<td>Turo, David</td>
<td>Shneiderman</td>
<td>CS</td>
<td>1993</td>
<td>GEISCO</td>
</tr>
<tr>
<td>Valluri, Jaibharat</td>
<td>Baras</td>
<td>EE</td>
<td>1996</td>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Viswanathan, Prem</td>
<td>Baras</td>
<td>EE</td>
<td>1996</td>
<td>U.S. Sprint, Inc.</td>
</tr>
<tr>
<td>Wu, Shiyi</td>
<td>Baras</td>
<td>EE</td>
<td>1996</td>
<td>Telogy Networks, MD</td>
</tr>
</tbody>
</table>
## B.S. STUDENTS

<table>
<thead>
<tr>
<th>NAME</th>
<th>ADVISOR</th>
<th>DEPT.</th>
<th>YEAR</th>
<th>FIRST/CURRENT AFFILIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abu, Muritala</td>
<td>Baras</td>
<td>EE</td>
<td>1997</td>
<td>MITRE Technical Systems</td>
</tr>
<tr>
<td>Aylay, Adam</td>
<td>Baras</td>
<td>EE</td>
<td>1997</td>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Bakshi, Karun</td>
<td>Baras/Corson</td>
<td>EE</td>
<td>1996</td>
<td>Comsat/Working towards MS Degree</td>
</tr>
<tr>
<td>Charuhas, George</td>
<td>Baras</td>
<td>BGMT</td>
<td>1994</td>
<td>Booz Allen</td>
</tr>
<tr>
<td>Goldman, Judy</td>
<td>Baras</td>
<td>EE</td>
<td>1995</td>
<td>Research Asst-University of Illinois</td>
</tr>
<tr>
<td>Gupta, Rajarshi</td>
<td>Narayan</td>
<td>EE</td>
<td>1997</td>
<td>GRA, University of CA, Berkeley</td>
</tr>
<tr>
<td>Holleman, Keith</td>
<td>Baras</td>
<td>CS</td>
<td>1998</td>
<td>Cisco</td>
</tr>
<tr>
<td>Hsu, Kevin</td>
<td>Baras</td>
<td>CS</td>
<td>1996</td>
<td>Unknown</td>
</tr>
<tr>
<td>Jen, Ting-Juin</td>
<td>Baras</td>
<td>EE</td>
<td>1998</td>
<td>Unknown</td>
</tr>
<tr>
<td>Karir, Manish</td>
<td>Baras</td>
<td>EE</td>
<td>1996</td>
<td>Graduate - Working towards MS</td>
</tr>
<tr>
<td>Kurichh, Rishi</td>
<td>Baras</td>
<td>EE</td>
<td>1997</td>
<td>NIH – Working towards MS, part time</td>
</tr>
<tr>
<td>Nguenkam, Pascal</td>
<td>Baras</td>
<td>EE</td>
<td>1997</td>
<td>Unknown</td>
</tr>
<tr>
<td>Pal, Fouzan</td>
<td>Narayan</td>
<td>EE</td>
<td>1993</td>
<td>Arthur Anderson</td>
</tr>
<tr>
<td>Peters, Steven</td>
<td>Baras</td>
<td>EE</td>
<td>1996</td>
<td>AIMS, Inc.</td>
</tr>
<tr>
<td>Pluemphitiwiyawej, Charanchai</td>
<td>Baras</td>
<td>EE</td>
<td>1995</td>
<td>Unknown</td>
</tr>
<tr>
<td>Rempas, Rommy</td>
<td>Baras</td>
<td>EE</td>
<td>1996</td>
<td>Unknown</td>
</tr>
<tr>
<td>Sabnis, Arun</td>
<td>Baras</td>
<td>EE</td>
<td>1996</td>
<td>Hughes Network Systems</td>
</tr>
<tr>
<td>Suphasindhu, Narin</td>
<td>Baras</td>
<td>SE\EE</td>
<td>1996</td>
<td>Fore Systems</td>
</tr>
<tr>
<td>Suri, Shikha</td>
<td>Baras</td>
<td>EE</td>
<td>1996</td>
<td>Unknown</td>
</tr>
<tr>
<td>Tso, Stanley</td>
<td>Baras</td>
<td>CS</td>
<td>1995</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
Industrial Affiliates Program for the CSHCN

John S. Baras

Industry Advisory Board Meeting
February 17, 1999
Industry, University, Government Partnership

• CSHCN Partnership: MISSION

Lead the research and development, demonstration, education and commercialization of hybrid network technologies and promote an efficient and economic global information infrastructure

• Agreement and structure finalized with the University of Maryland
CSHCN Partnership: STRATEGY

- Initiate and perform research and development in areas of strategic significance to industry. Facilitate effective commercialization.
- Initiate and perform research and development of critical importance to Government (NASA, DOD, NSA)
- Be a catalyst in industry-university, industry-industry, industry-university-government collaboration
- Attract, educate and promote to industry and government experts educated and trained professionals
- Develop and deliver timely, leading-edge education and training to industry/government
- Influence and guide national policy and national goal setting in technology R&D
CSHCN Partnership: BENEFITS

- Partnership Agreement will entitle Partners to a set of valuable broad and specific benefits.
- $25K per year Partner contribution. Three years
  - Partners are expected to have major involvement with CSHCN through additional directed and proprietary funded projects, student internships and joint contract work for the government
  - Consulting remuneration to faculty and research staff not included (private agreement between Partner and consultant).
- Position on CSHCN Industry Advisory Board: Influence direction and execution of CSHCN programs
- Affiliates of CSHCN (as a group) are provided first opportunity to negotiate exclusive license of R&D results from CSHCN programs, (those resulting from general funds, not those resulting from directed or proprietary funding)
CSHCN Partnership: BENEFITS (cont.)

- Dedicated program review days at CSHCN (2 days per partner per year)
  - total program or a portion of it

- Dedicated and targeted recruitment of CSHCN students for Partner
  - Screening of students
  - Holding dedicated to Partner recruitment events
  - Provide special opportunities for Partner to enhance Partner visibility and appreciation among student body

- One “stop” referral of CSHCN faculty, research staff and students for consulting services (one “phone call away”, or one “e-mail away” help)
  - Maintain current profiles of researchers
  - Match people to requests; follow-up to facilitate engagement
CSHCN Partnership: BENEFITS (cont.)

• Development and delivery of topical short courses requested by Partners
  – On Partner site
  – Electronically or via video conference
  – Here at the CSHCN for small groups of Partner personnel
  – 1 week; 1 day a week

• On-demand intensive custom workshops (two per year, 2-3 days each)
  – Single Partner
  – Multiple Partner

• Faculty and research staff visits (short: 1-2 days) to Partner site
  – give detailed seminar on current work
  – participate on-site in topical discussions with Partner personnel
  – help in recruiting students
CSHCN Partnership: BENEFITS (cont.)

- Free participation to CSHCN Software Library and Club
  - Offer for R&D purposes CSHCN software
  - Priority in licensing of CSHCN software
- Priority response to requests for research work and consulting support
- Extensive and advanced information dissemination of CSHCN R&D results via a web page for Partners only
- Cooperative programs, including the placement of visiting industry scientists or engineers at the CSHCN
- Option for free membership in ISR Industrial Affiliates Program