

**Center for Advanced TeleSysMatics (CAT):
Next-generation Network-centric Systems (NNS)**

Salim Hariri

Director

The University of Arizona

Tucson, Arizona, AZ 85750

hariri@ece.arizona.edu

www.ece.arizona.edu/~hpdc

Tel: (520) 621- 4378

Fax: (520) 621- 8076

Presentation Outline

- CAT Mission
- Motivation and Funding Opportunities
- CAT Organization Structure
- Collaboration with Industry
- Focused Research Areas
- University of Arizona Facilities
- ACTION PLAN
- Discussion

CAT Mission

- Focus Research and Education on Network-Centric Systems
 - Telecommunications and Advanced Networks
 - Distributed Computing Environments
 - Information System Engineering Theory
 - Information Technology Transfer
- Arizona Technology Development Partnership (ATDP)
 - Foster Multidisciplinary Research Program with industry in Arizona
- Support the Development, Deployment of Network-centric Systems
 - Develop Enabling Technology
 - Integrated Information Services

Integrated Information Services

Table 1. The potential market growth in telecommunication services.

Market Type	1998		1999		2000	
	Hardware	Service	Hardware	Service	Hardware	Service
Telecommunications	200 B	800 B	220 B	920 B	240 B	950 B
Commercial Remote Sensing	1.8 Billions		2.0 Billions		2.5 Billions	
Commercial Navigation	4.8 Billions		6.4 Billions		8.47 Billions	

CAT MOTIVATION - Research

- Challenging Research and Engineering Problems
 - Explosive growth in network-centric applications and information services
 - We build information systems and their services in ad-hoc approach
 - Modeling, analysis, control and management of interactive networked information systems
 - mathematical models are vague or may not exist
 - There no information system engineering science to design, analyze, control, manage and optimize large scale distributed information systems and their applications

CAT MOTIVATION - Government

- President's Information Technology Advisory Committee (26 members from CS, industry)
 - U.S. government must boost spending on information technology by \$1 billion over 5 years (2.5 billion total)
 - Emphasize large, long term projects on
 - robust software
 - faster supercomputers
 - scalable communications networks
 - Develop specific funding proposals for FY 2000

CAT MOTIVATION - DoD

- Information Superiority - a new organization being proposed to stimulate national interest in Info. Sup.
 - degree of dominance in information domain that permits the conduct of operations without effective opposition
- Network-Centric Warfare
 - a fundamental shift from platform-centric warfare
- Red-team vulnerability assessments of new technologies and ensure high confidence services
- Technology for Affordability
 - integrated product and process development
 - advanced modeling and distributed simulation
 - use of advanced information technology

CAT MOTIVATION - Industry

- Industry needs skilled graduates in emerging technologies
 - Advanced Networks and Telecommunications
 - Distributed Computing Environments
 - Information System Engineering
 - modeling, analysis, control, management
 - Software tools
- Technology Development Partnership
 - Facilitate the transfer of ready-to-market inform
 - continuous education and training
 - collaborative research projects

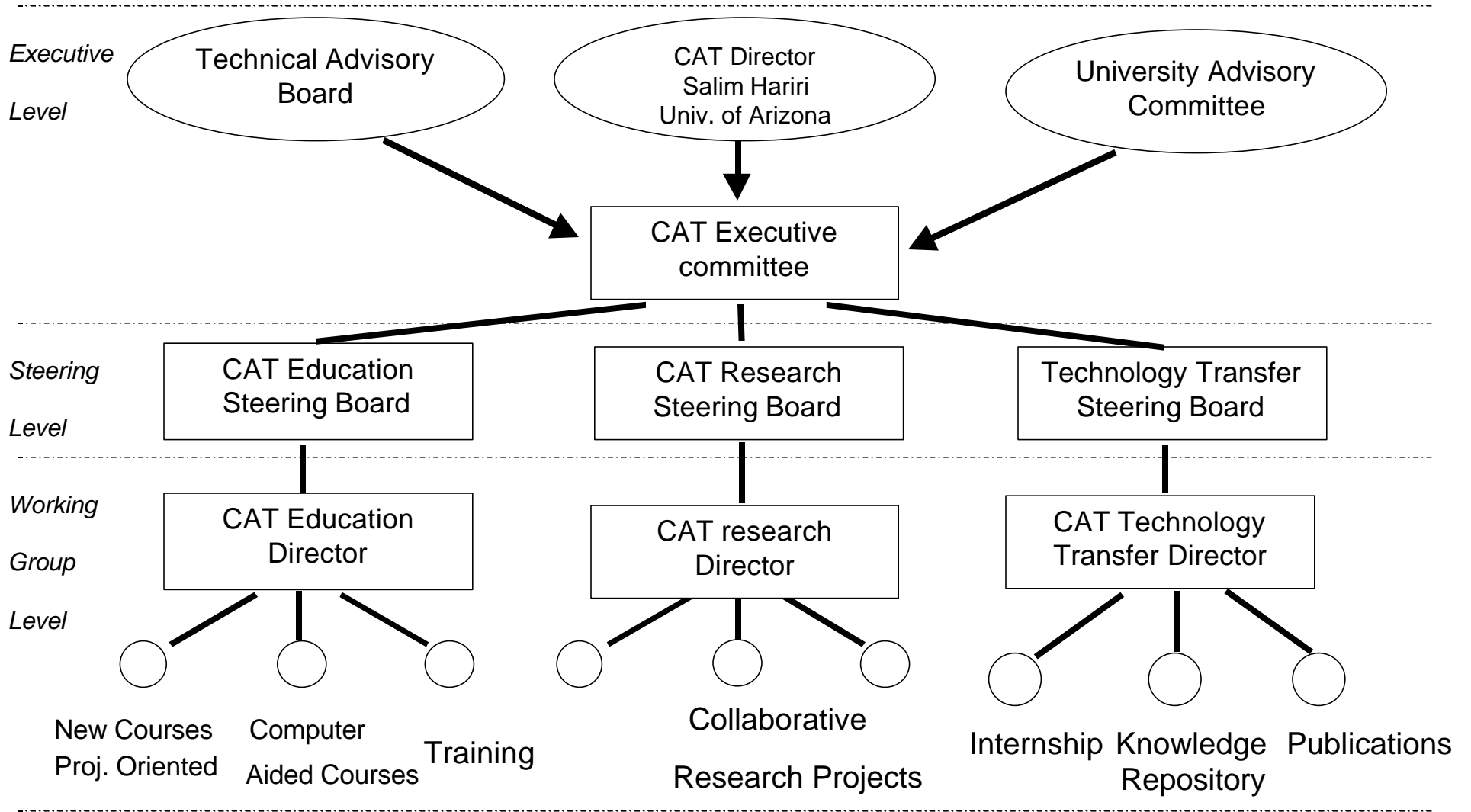
CAT MOTIVATION - State

- Explosive growth in immediate demands for high speed data communication
- State wants to increase services and reduce costs by installing modern technology
 - telemedicine, virtual schools, virtual community
- Arizona Technology Development Partnership
 - average high tech jobs (45+) >> private jobs (20+)
 - support start-up information technology companies
- Arizona Research Alliance (ARA) Collaborative Research Program
 - brings industry and government partners together with Arizona university researchers, leading to innovations in advanced telecommunications and information technologies

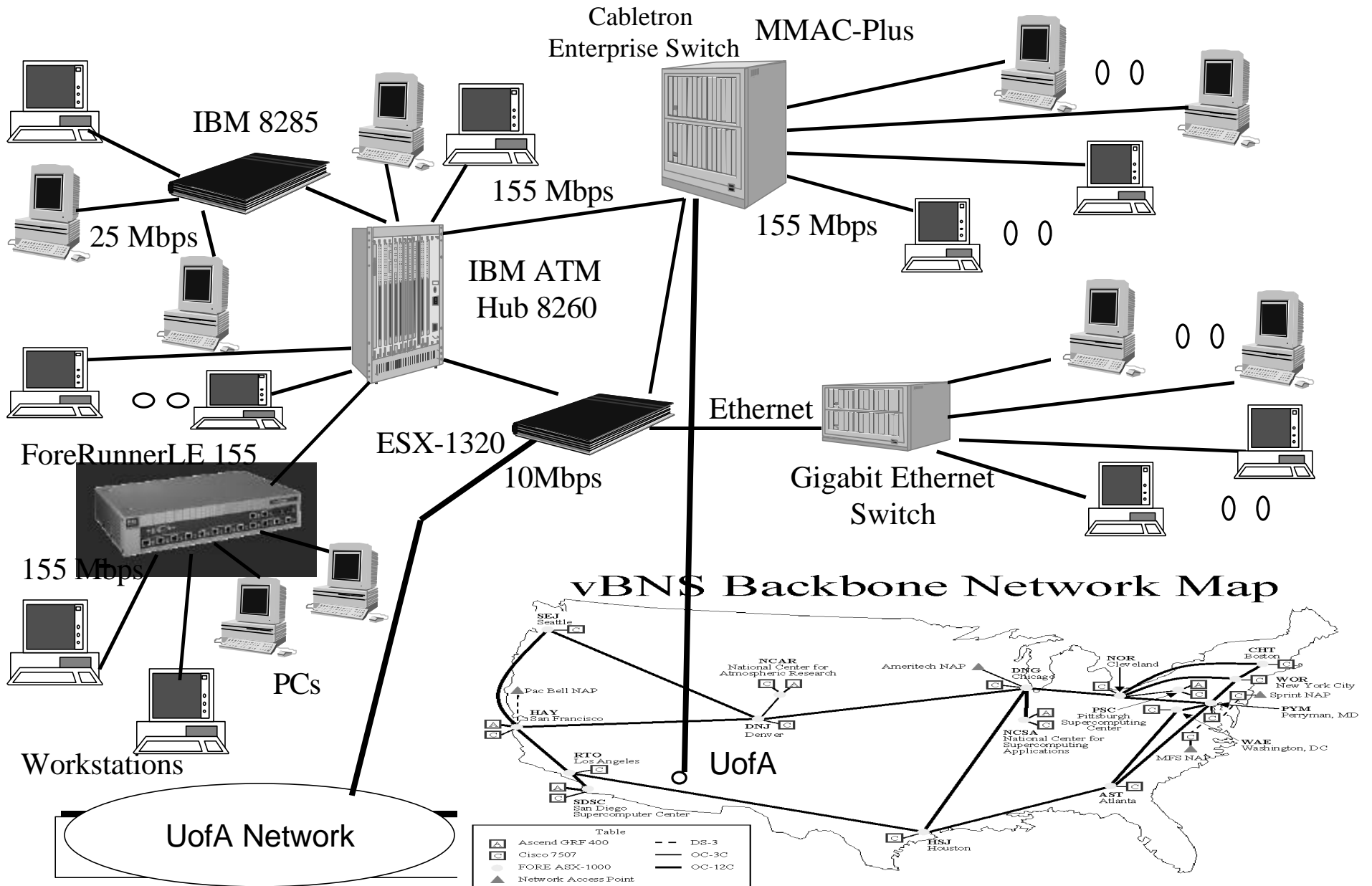
CAT Organization Structure

- CAT Staff
 - Director, Associate Director, Executive Assistant, Secretary, and Lab technician
- Center Advisory Board
 - industry, government, and research laboratories
- Technical Program Committee
 - Area/program leaders from UofA
- University Steering Committee
 - ECE, CS, MIS, etc.

CAT Organization Structure



High Performance Distributed Computing (HPDC) Laboratory



CAT Funding Opportunities

- NSF Experimental Activities Program
 - Experimental Partnership, November 1
- NSF Information Technology Research (ITR) - NSF99-167
- NSF Exploratory Research on Scalable Enterprise Systems
 - NSF 99-149, Due December 15, 1999
- NSF Engineering Research Center (ERC)
- DARPA Next Generation Internet (NGI)
- Major Industry Participation

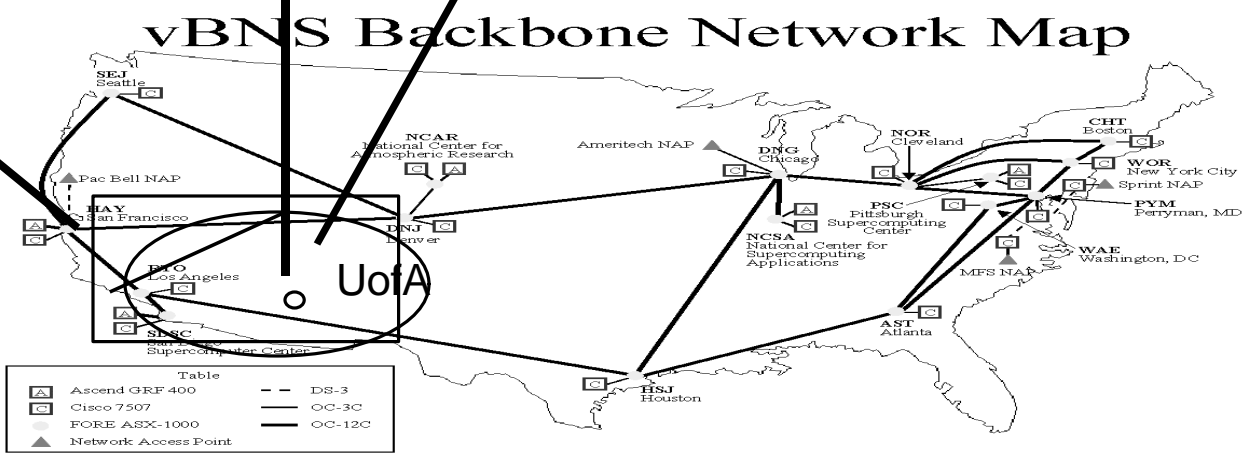
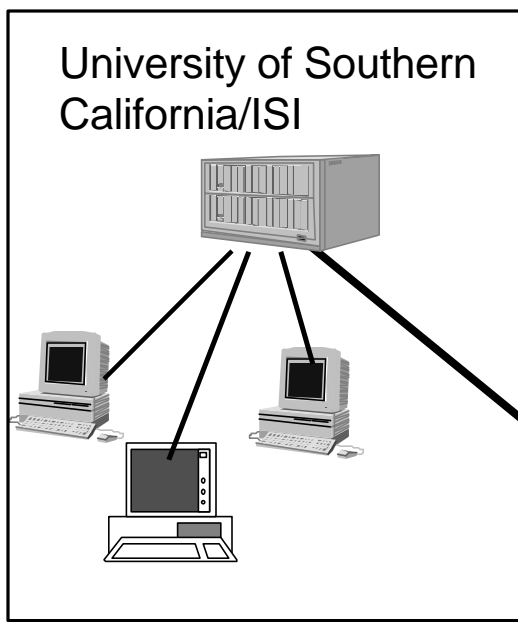
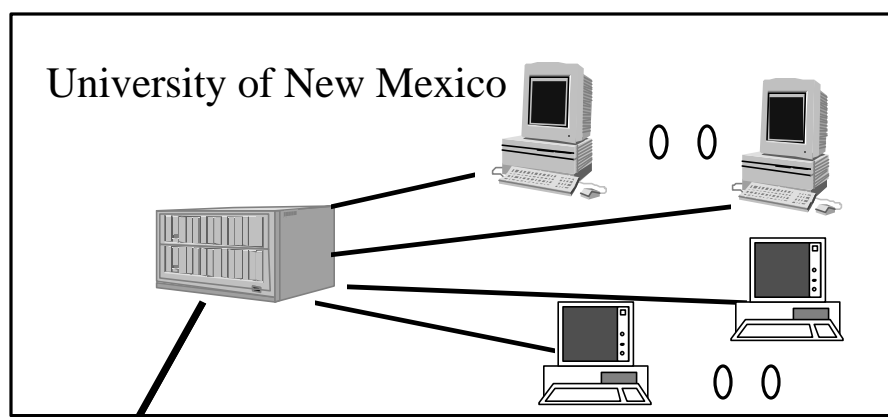
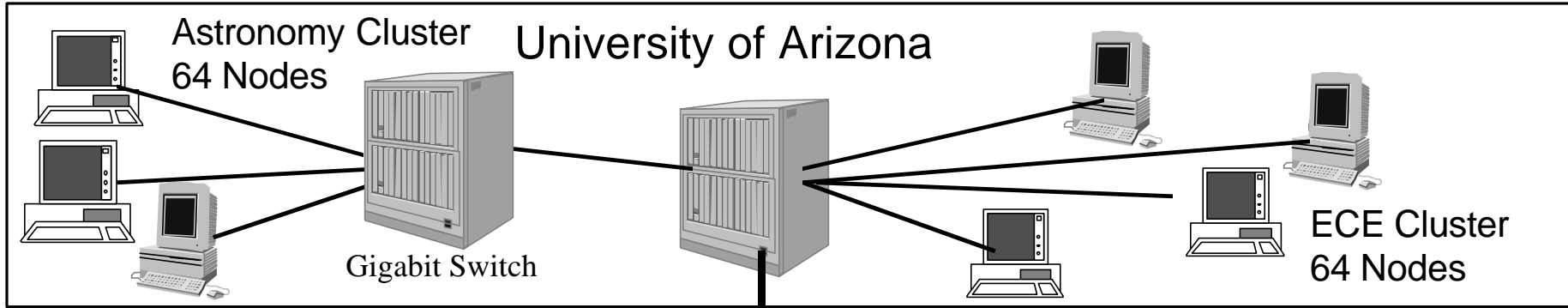
NSF Experimental Activities Program- Experimental Partnership

- Proposals with Budgets \$500K, for up to 5 years
 - Due Nov. 1 of each year
- Problem Solving Environment for Astrophysical Simulations
 - letter of intent: January 5, 2000
 - Full proposals: February 14, 2000
- NSF Multidisciplinary Program
 - William Decker, NSF Director of Advanced Information and Network Infrastructure
 - Darleen Fischer, NSF Special Network Projects

Southwest GRID Testbed: Problem Solving Environment for Astrophysical Simulations

- University of Arizona
 - Salim Hariri, TBD (ECE)
 - Phil Pinto, David Arnett, Adam Burrows, Matthias Steinmetz (Astronomy)
 - CS, TBD
- University of Mexico
 - David A. Bader, Chaouki Abdallah
- University of Southern California
 - C. S. Raghavendra

Southwest GRID TESTBED



CAT: HPDC Laboratory

Table	
▲	Ascend GRF 400
□	Cisco 7507
○	FORE ASX-1000
▲	Network Access Point
---	DS-3
---	OC-3C
---	OC-12C



NSF Information Technology Research (ITR)

- Proposals with Budgets over \$500K
 - letter of intent: November 15, 1999
 - Pre-Proposals: January 5, 2000
 - Full Proposals: April 17, 2000
- Proposals less than 500K
 - letter of intent: January 5, 2000
 - Full proposals: February 14, 2000

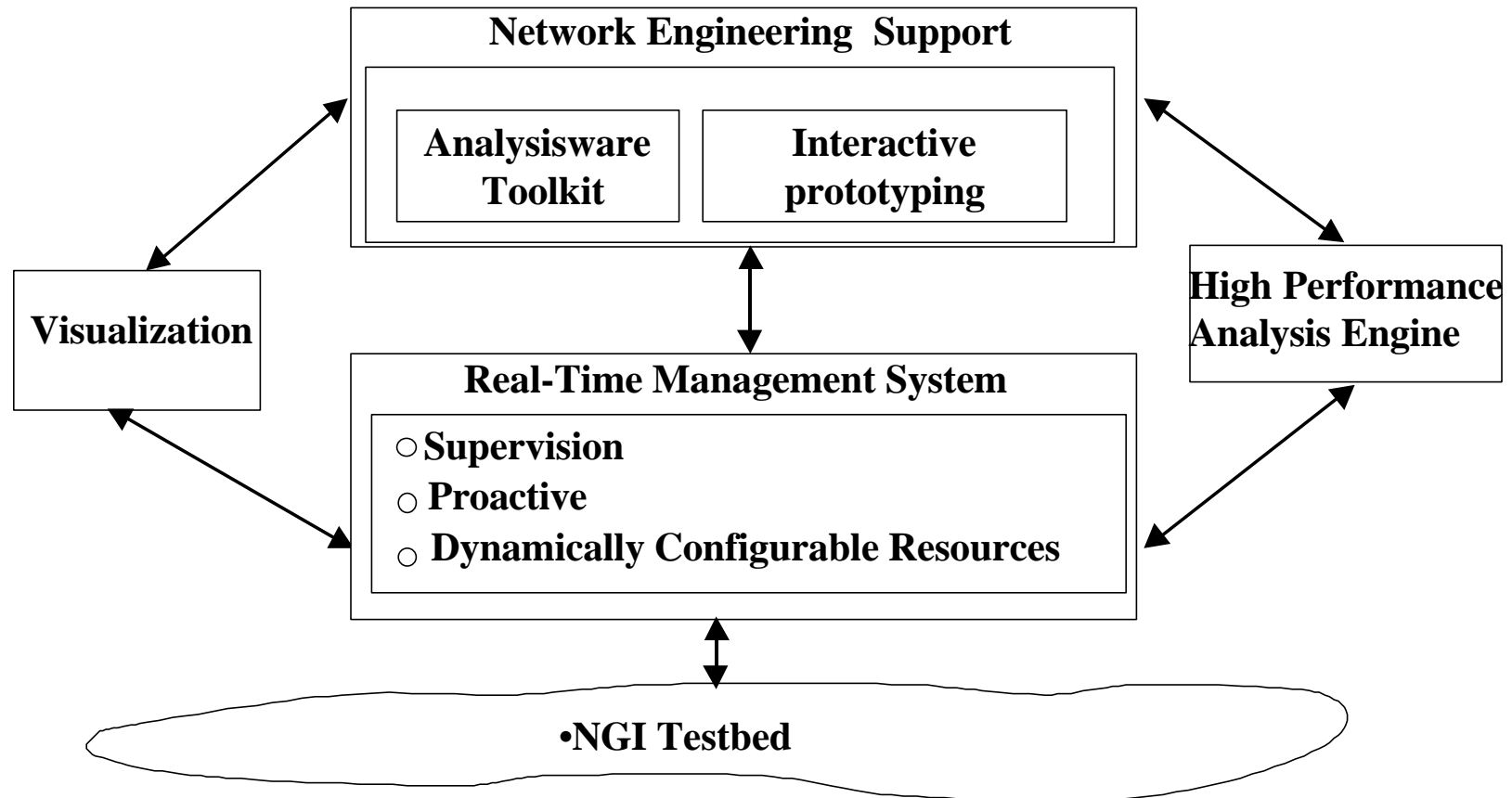
DARPA - Framework to Design and Manage Large Scale Network Systems

- University of Arizona
 - Salim Hariri, TBD
- University of Missouri-Kansas City
 - Khosrow Sohraby
 - Deep Medhi
- University of Southern California
 - C.S. Raghavendra

NSF ERC: Center for Proactive Network Management Systems

- University of Arizona
 - Salim Hariri, TBD
- University of Missouri-Kansas City
 - Khosrow Sohraby
 - Deep Medhi
- University of Southern California
 - C.S. Raghavendra
- Columbia University
 - Y. Yimini
 - Danilo Florissi

Engineering Network Management Services Framework



Real-time Network Management Task Objectives

- Develop An Intelligent Network Management Framework with the following features:
 - Proactive
 - Intelligent
 - Application Centric
 - Delegated Agents Based
- Develop a Proactive Application Management System
 - Use the system to manage proactively the performance, security, and fault of a set of large scale network centric applications

Analysisware Research Objectives

- Develop a Hierarchical Analysis Approach
 - Application Level Analysis
 - Protocol Level Analysis
 - Network Level Analysis
- Develop analytical models and algorithms to evaluate important performance metrics for each level of analysis.
- Validate and/or modify the analytical models and algorithms using simulation and/or measurement.
- Develop a design & analysis tool (Analysisware)

Hierarchical Analysis

System Description Phase

Platforms	Rings	Buses	Routers	Bridges	Switches
-----------	-------	-------	---------	---------	----------

Protocol Description Phase

Standard Protocols			
Synthesized Protocols			
Flow Control	Error Control	Segmentation	Signalling

Application Description Phase

Computing Primitives	Communication Primitives
----------------------	--------------------------

Redesign for optimal configuration

Integrated Analysis Phase

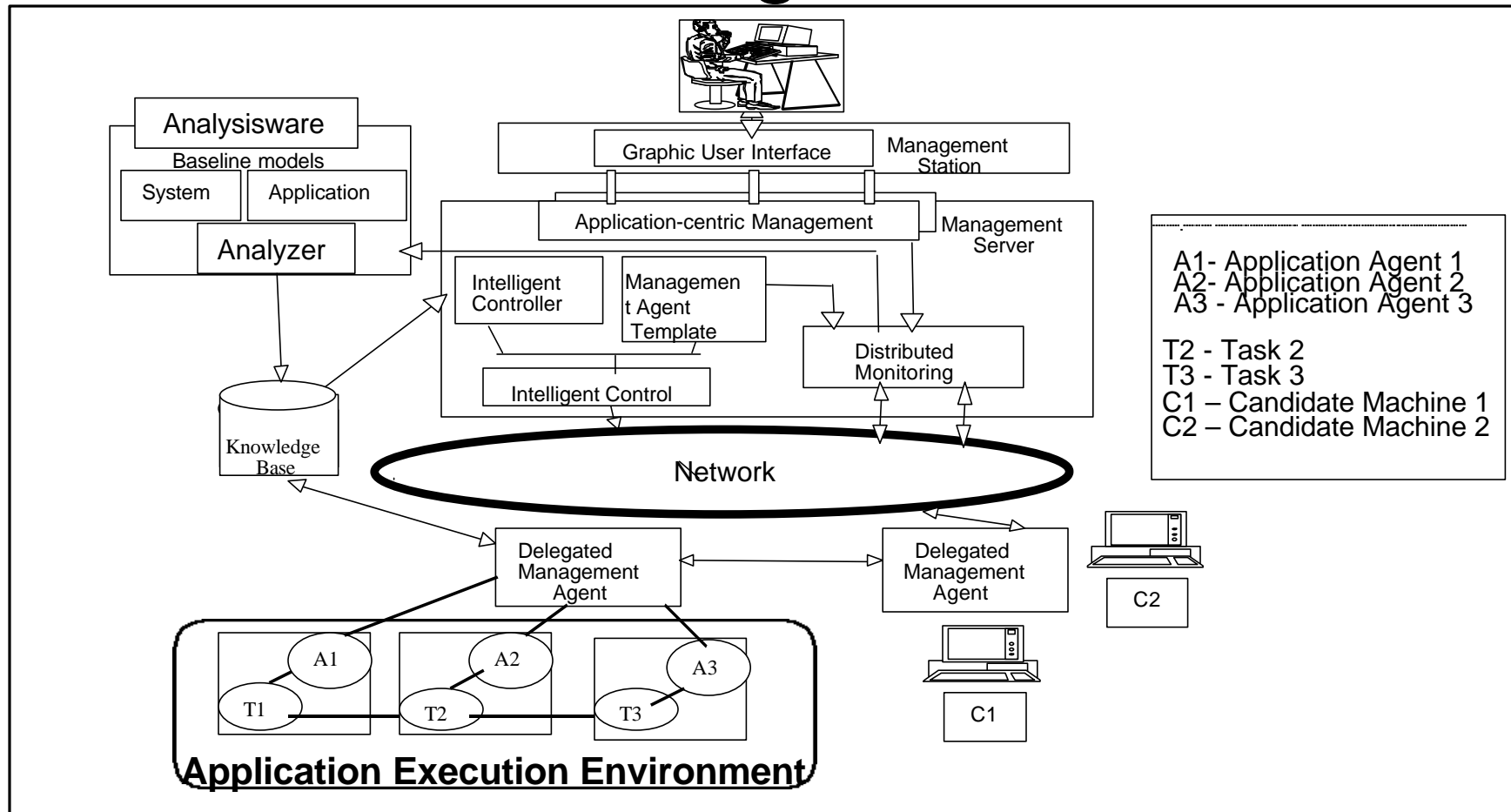
Analysis Levels

1. Application Level Analysis (ALA)
2. Protocol Level Analysis (PLA)
3. Network Level Analysis (NLA)

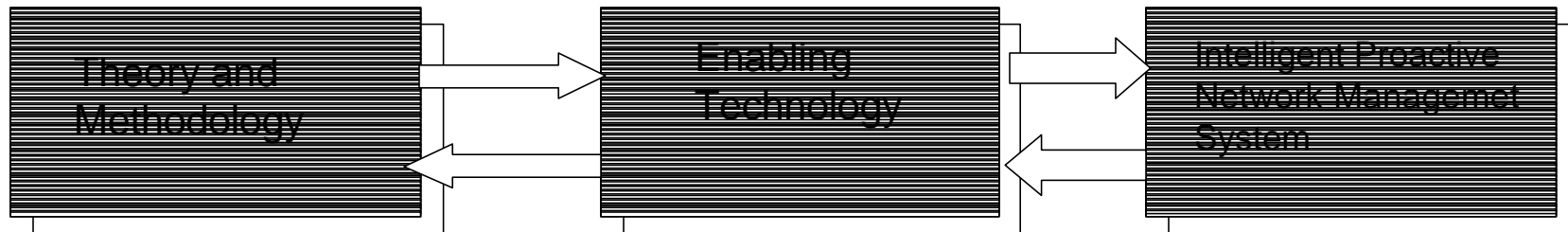
Analysis Models

1. Heuristic
2. accurate
3. Simulation

Intelligent Proactive Network Management



ERC/CAT Proposed Projects



- A1: Deterministic and Stochastic Modeling and Analysis (UMK, USC)
- A2: Information Transfer Functions (UofA)
- Computational Techniques and Large Scale Simulation (UofA)

- B1: Baseline models (UMK, UofA)
- B2: Global Resource Scheduling/Management (UofA, USC, Columbia Univ)
- On-line Diagnosis and Monitoring (U ofA, Columbia Univ)
- Intelligent Proactive Network Management (UofA, Columbia Univ)

- Smart Network Community (UofA)
- SouthWest Regional Testbed

DARPA/ITO BAA 97-04 AON F316

(June 1997-June 2000)

Combined Real-Time Modeling and Performance Analysis for Complex Networks

Benjamin Melamed

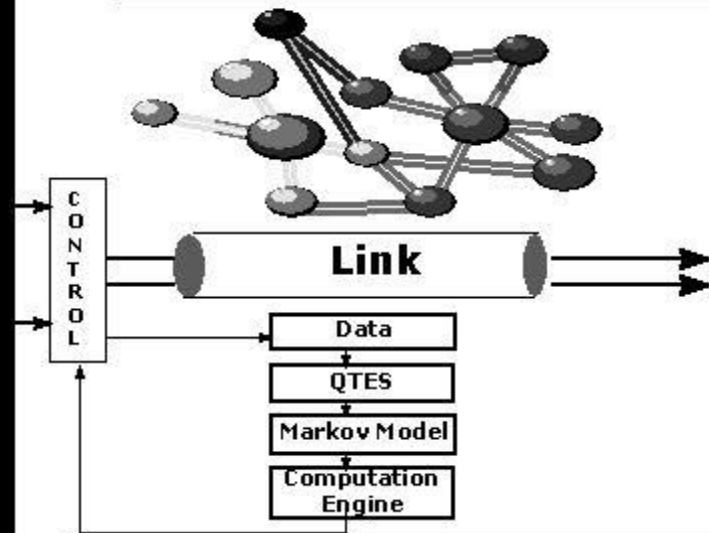
Rutgers University
Faculty of Management
Dept. of MSIS
94 Rockafeller Rd.
Piscataway, NJ 08854

Khosrow Sohraby

Computer Science
Telecommunications
University of Missouri-Kansas City
5100 Rockhill Rd.
Kansas City, MO 64110

PROJECT SUMMARY

Combined Real-Time Modeling and Performance Analysis for Complex Networks



New Ideas

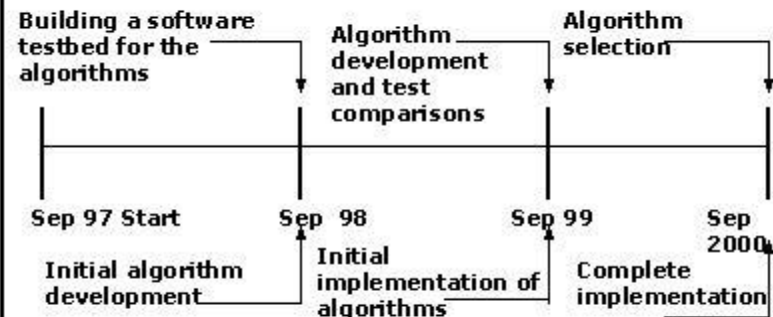
- Linkage between classical Control Theory and Teletraffic Theory
- Accurate modeling of teletraffic processes characterized by high burstiness (autocorrelation), using QTES processes
- Fast and accurate solution of large-scale teletraffic models using parallelizable algorithms
- Integrated end-to-end methodology (from field measurements to model building, and then to numerical solutions) for the analysis of models driven by complex teletraffic streams.

Impact

•A unified and efficient approach to modeling, analysis and computational solution of probabilistic models motivated by teletraffic models arising in many complex systems, including modern telecommunication networks

•Real-time model construction and computational solutions of large-scale teletraffic models leading to efficient design, engineering, management and real-time control of complex networks.

Schedule

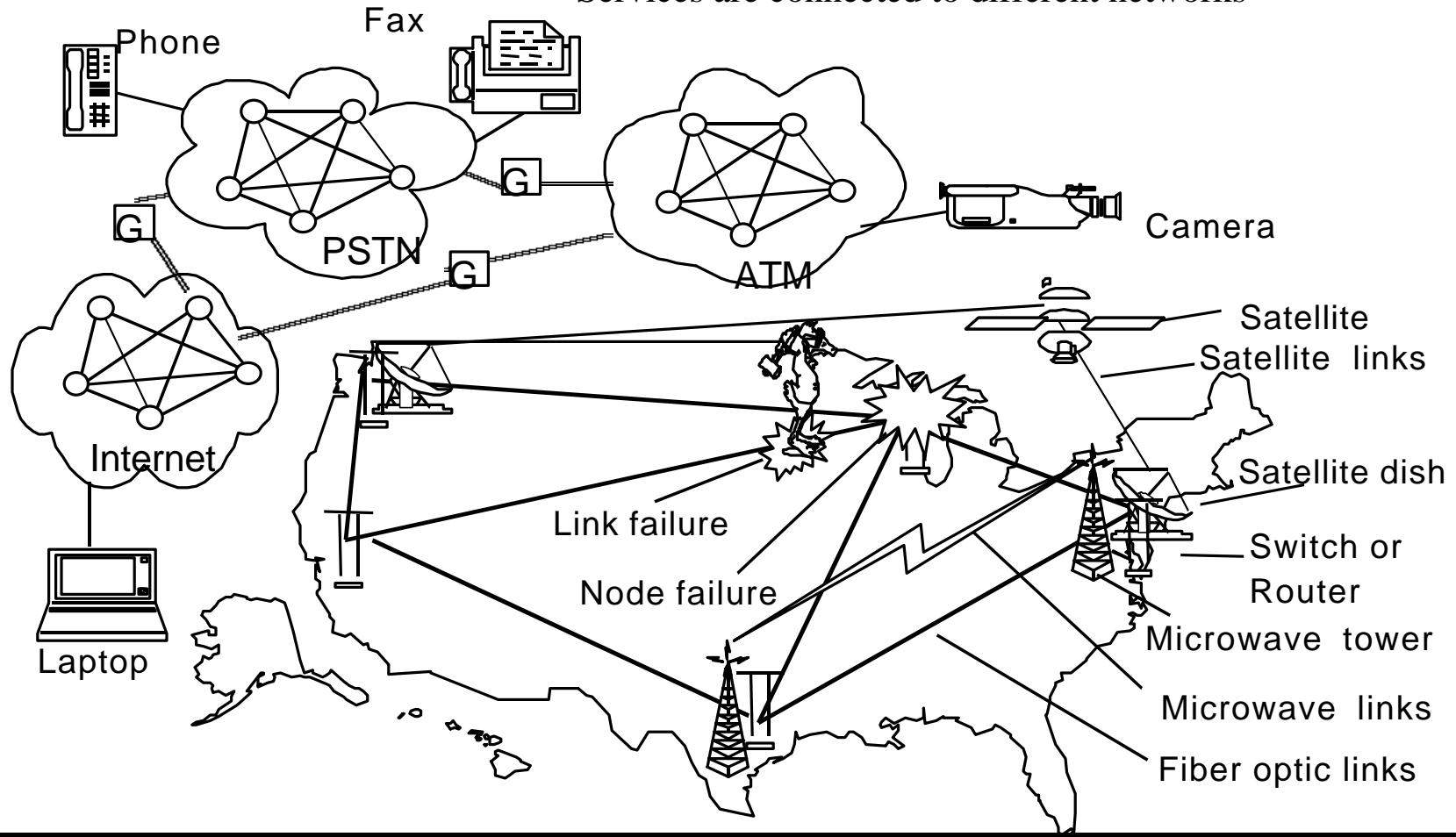


Deep Medhi's Darpa Project

- Multi-Networks approach to Network Survivability
- Development of models/algorithms
- Analysis of Transient network behavior under an attack or a failure
- Multi-level Network Management and Control approach to reduce impact of an attack/failure
- Development of Network Fault Management Architecture and Prototype Implementation for multi-networks

Multi-Networks under a failure/attack

Services are connected to different networks



ERC/CAT Industrial/Government Support

- IBM, Motorola, Honeywell, Raytheon
- 3COM, New Bridge, CISCO, Packetengine, Xylan
- USWest, RESNET
- US Air Force, Los Alamos National Laboratory
- Odyssey Research Associates
- Aerospace Corporation
- ERC University Collaborators
 - Columbia University
 - University of Missouri-Kansas City
 - University of Southern California

CAT On-Going Projects

- Telecommunications and Advanced Networks
 - Adaptive Communication System (ACS)
 - EXNet: An Intelligent Network Management System
- Distributed Computing Environments
 - ADVICE: Adaptive Distributed Virtual Computing Environment
 - VRE: U.S. Army Virtual Radiology Environment Project
- Information System Engineering Theory
 - Net_HPCC Toolkit
 - Performance Analysis and Characterization of Information Servers
- Information Technology Transfer
 - Arizona Information Infrastructure
 - RESENET: Rural Educational System Network