Towards a World of Ubiquitous Sensors and Actuators

After Dinner Talk
AFOSR Program Review – Nanoelectronics, Negative Index Materials, and Superconducting Electronics
July 26, 2005
Birch Aquarium, UCSD

Dr. Larry Smarr

Director, California Institute for Telecommunications and Information Technologies

Harry E. Gruber Professor,

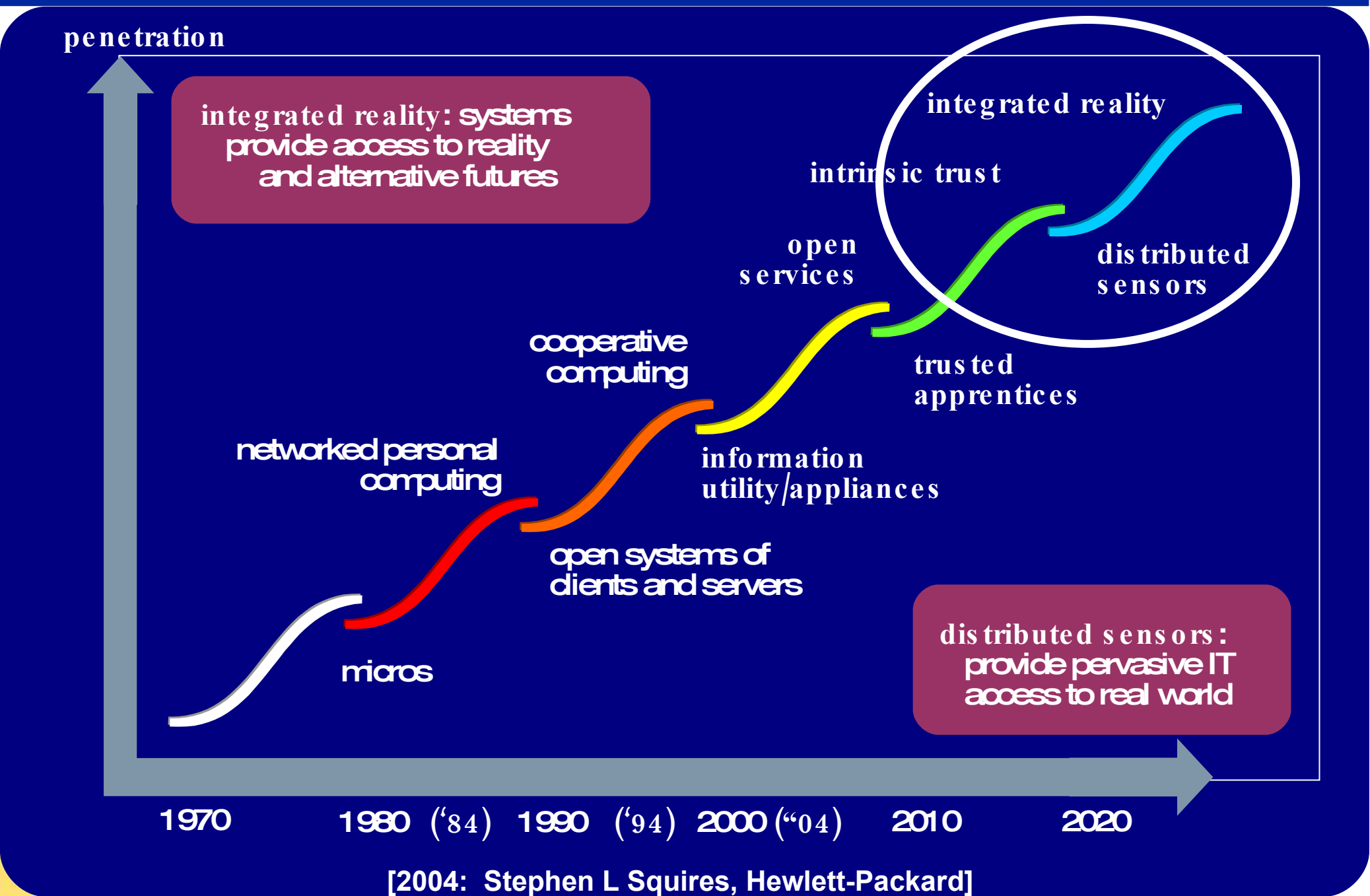
Dept. of Computer Science and Engineering

Jacobs School of Engineering, UCSD

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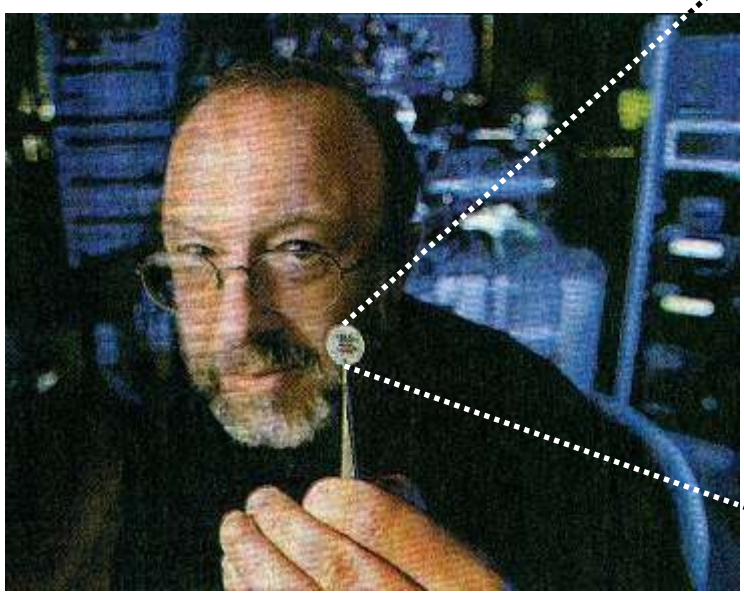
From Critical & Pervasive Trusted Information Systems Toward Integrated Reality



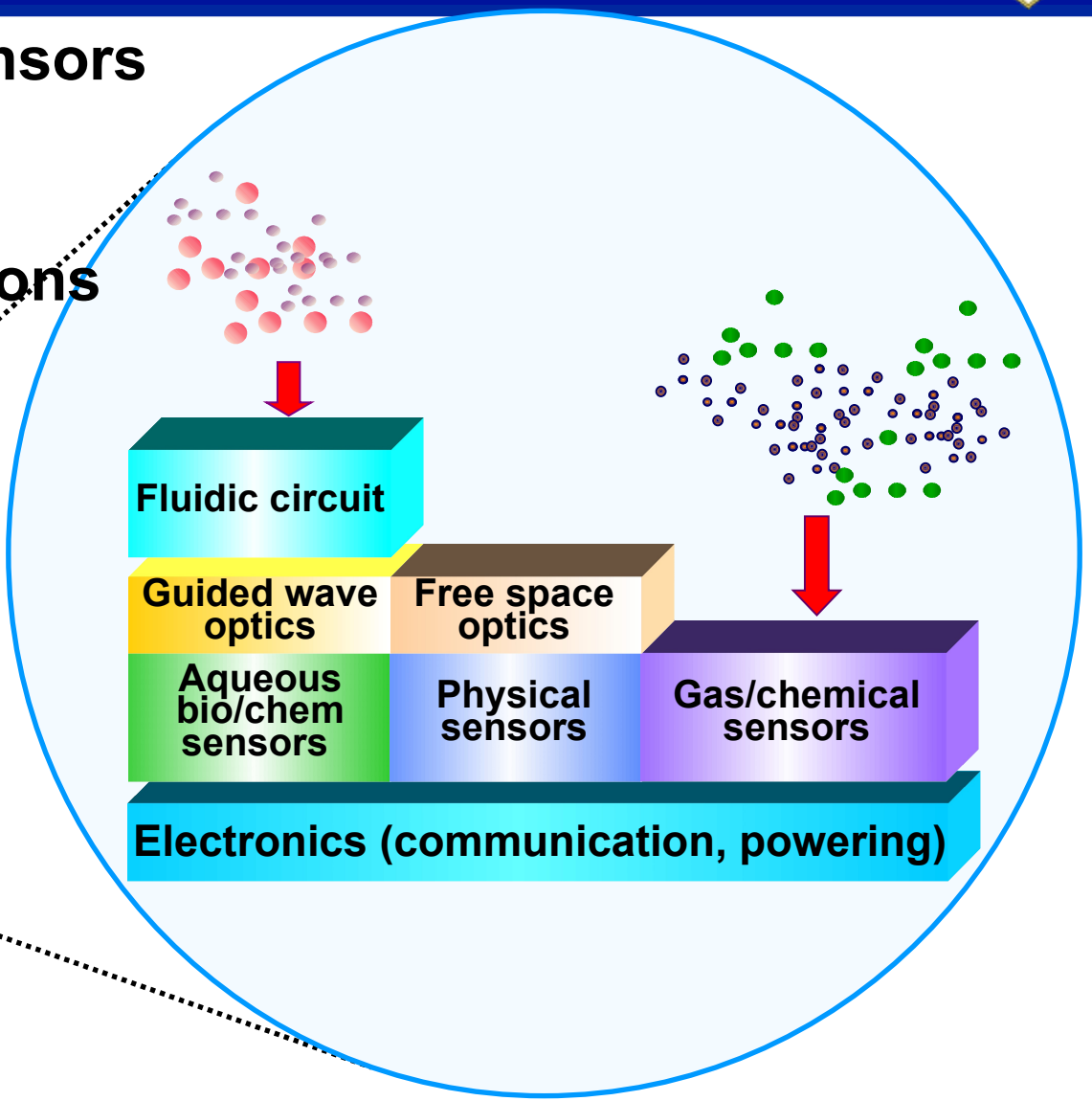
[2004: Stephen L Squires, Hewlett-Packard]

A World of Distributed Sensors Starts with Integrated Nanosensors

Developing Multiple Nanosensors on a Single Chip, with Local Processing and Wireless Communications



I. K. Schuller holding the first prototype



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I. K. Schuller, A. Kummel, M. Sailor, W. Trogler, Y-H Lo

What is Needed Beyond the Integrated Sensor to Create a Ubiquitous Distributed SensorNet?

- **Sensors**
  - Physical, Chemical, Biological, Imaging,…
- **Sensor Platform**
  - Computing, Power, Storage, Radios, …
- **Sensor Arrays**
  - Homogeneous, Inhomogeneous, Ad Hoc, …
- **Telecommunications Infrastructure**
  - Wired, Wireless, Internet, …
- **Layered Software**
- **Backend Data Systems**
- **Advanced Visualization and Analysis Facilities**

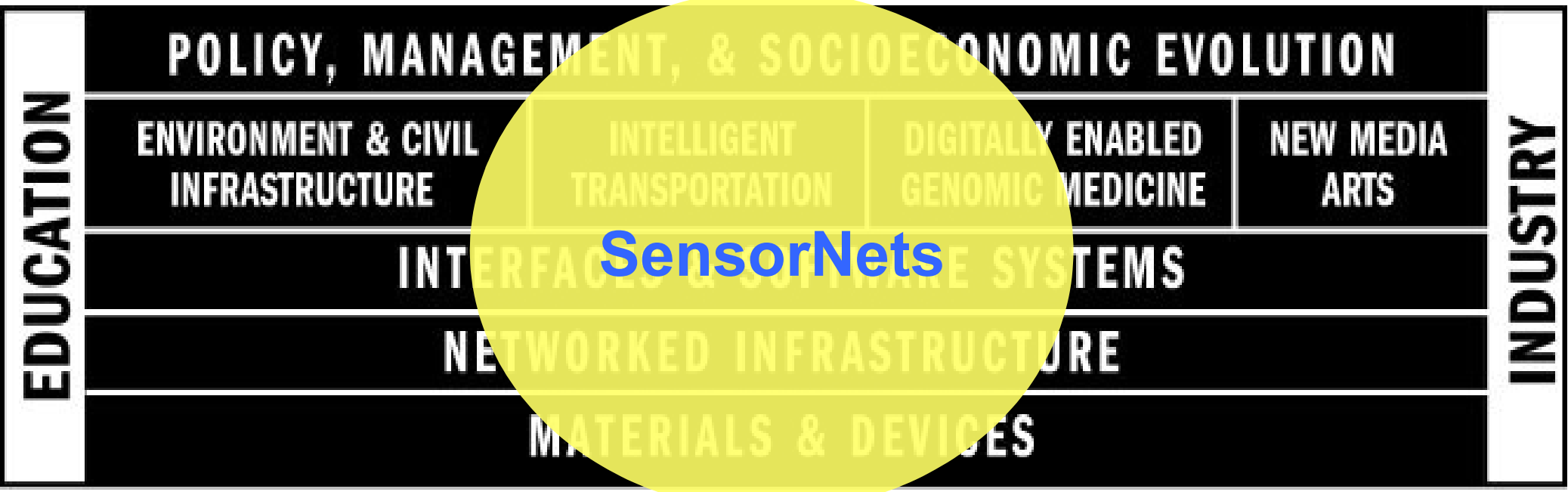
Calit2 Has Spent Five Years
Pulling Together
Leaders in All These Areas

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Calit2 -- Research and Living Laboratories on the Future of the Internet

UC San Diego & UC Irvine Faculty
Working in Multidisciplinary Teams
With Students, Industry, and the Community



www.calit2.net



Two New Calit2 Buildings Will Provide a Persistent Collaboration "Living Laboratory"



- **Over 1000 Researchers in Two Buildings**
  - Linked via Dedicated Optical Networks
  - International Conferences and Testbeds
- **New Laboratory Facilities**
  - Virtual Reality, Digital Cinema, HDTV, Synthesis
  - Nanotech, BioMEMS, Chips, Radio, Photonics, Grid, Data, Applications

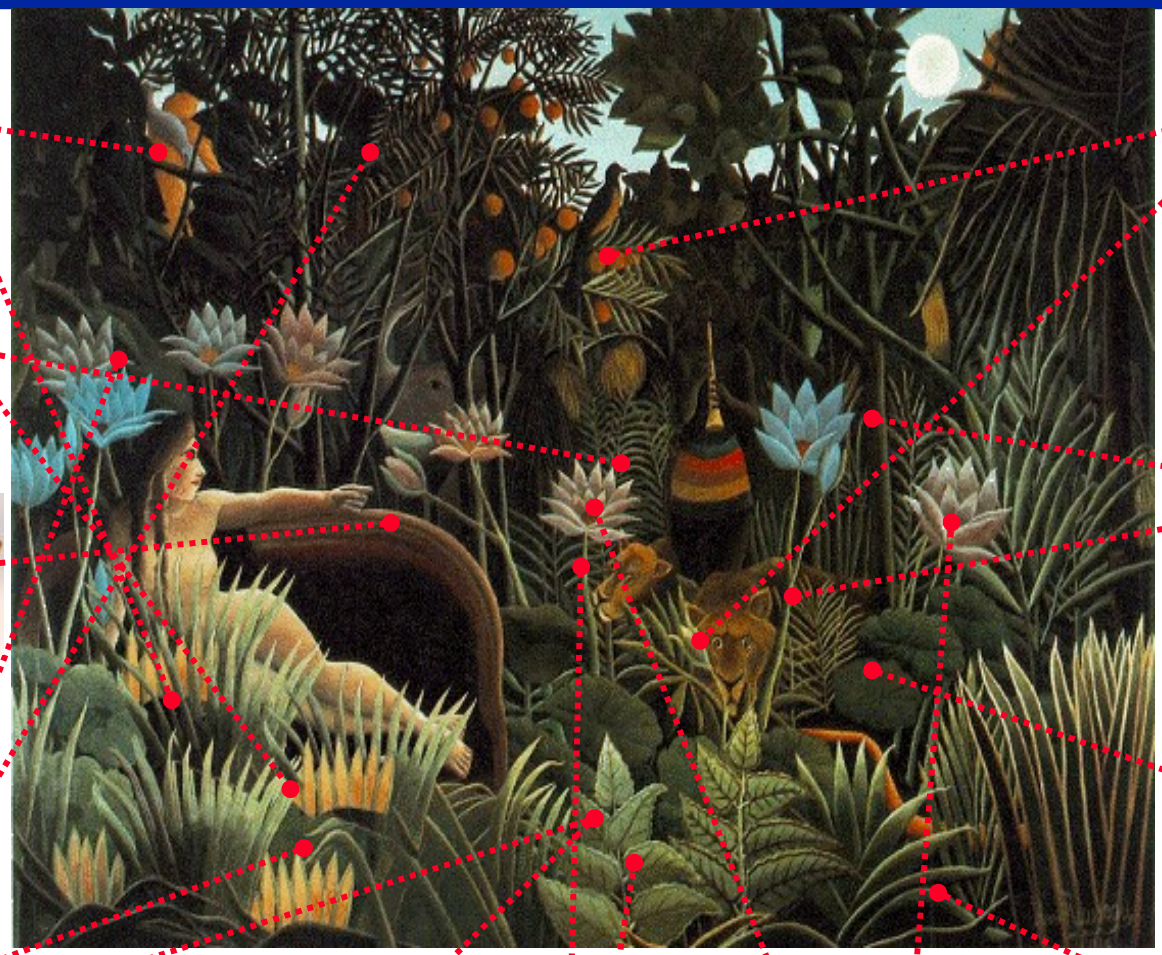


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California Provided $100M for Buildings
Industry Partners $85M, Federal Grants $250M

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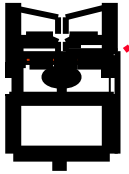
Distributed Sensors Can Read Out the Micro-States of the Macro-Environment



Sensor Web



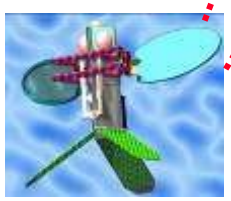
Micromet Station



Chem-Lab on a Chip



Artificial Insect



Multi-Analysis Soil Probe

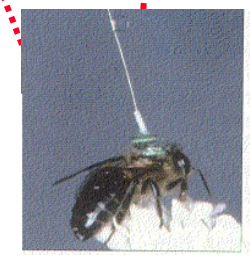




Electronic Tongue



Electronic Nose



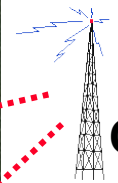
Micro-Telemetry



Automated Minirhizotron



Sap Flow Sensor



Radio Frequency Communication

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Source: Gregory Bonito, LTER

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Wireless Sensors Will Allow Instrumentation of Critical Civil Infrastructure





Calit2 Will Develop and Install Wireless Sensor Arrays Linked to Crisis Management Control Rooms



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Source: UCSD Structural Engineering Dept.

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Major Progress on Wireless Internet Information System for Medical Response in Disasters

Working Closely with the First Responder Community

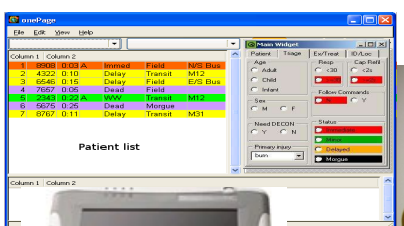
WISARD





First Tier





Mid Tier



802.11 pulse ox



Triage







Reality Flythrough
Mobile Video



Wireless Networks



Command Center

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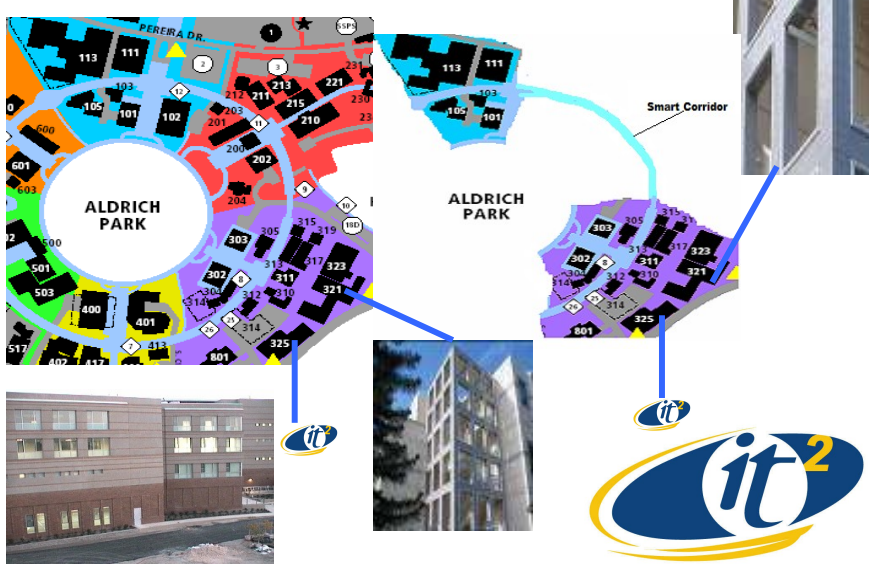
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New NSF Infrastructure Grant Establishes Calit2 Project Rescue Testbeds in Irvine and in San Diego

- **Localized Site-Specific Disasters Via Crisis Response Drills**
- **Large Scale Regional Disasters Via Simulations**
- **Transportation (Simulation) – ImageCat**
  - **Test & Validate IT and Social Science Research Within the Context of Regional Crisis Response**
- **CAMAS (*Crisis Assessment, Mitigation, And Analysis*) – UCI Campus**
  - **Field-Test and Refine Research on Information Collection, Analysis, Sharing, and Dissemination in Controlled yet Realistic Settings**
- **GLQ (*Gaslamp Quarter*, San Diego/UCSD)**
  - **Ubiquitous Wireless Coverage in Downtown San Diego**
  - **Test Network Architecture Enhancement and New Applications**







bren:school information and computer sciences

responsphere

UCSD UCIrvine

PI: Magda El Zarki, ICS, UCI
www.responsphere.org

Over the Next Decade
Vast SensorNets Will Feed Optical Core

- **The Small**
  - Pervasive Self-Powered Micro- and Nano-Sensors
- **The Cheap**
  - One-Cent Radios
- **The Smart**
  - System-on-Chip Integration of Computers with Sensors
- **The Big**
  - Terabit Optical Internet Core
  - Gigabit Wireless Streams

"The all optical fibersphere in the center finds its complement in the wireless ethersphere on the edge of the network."
– George Gilder

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Source: Rajesh Gupta, UCI Center for Embedded Computer Systems

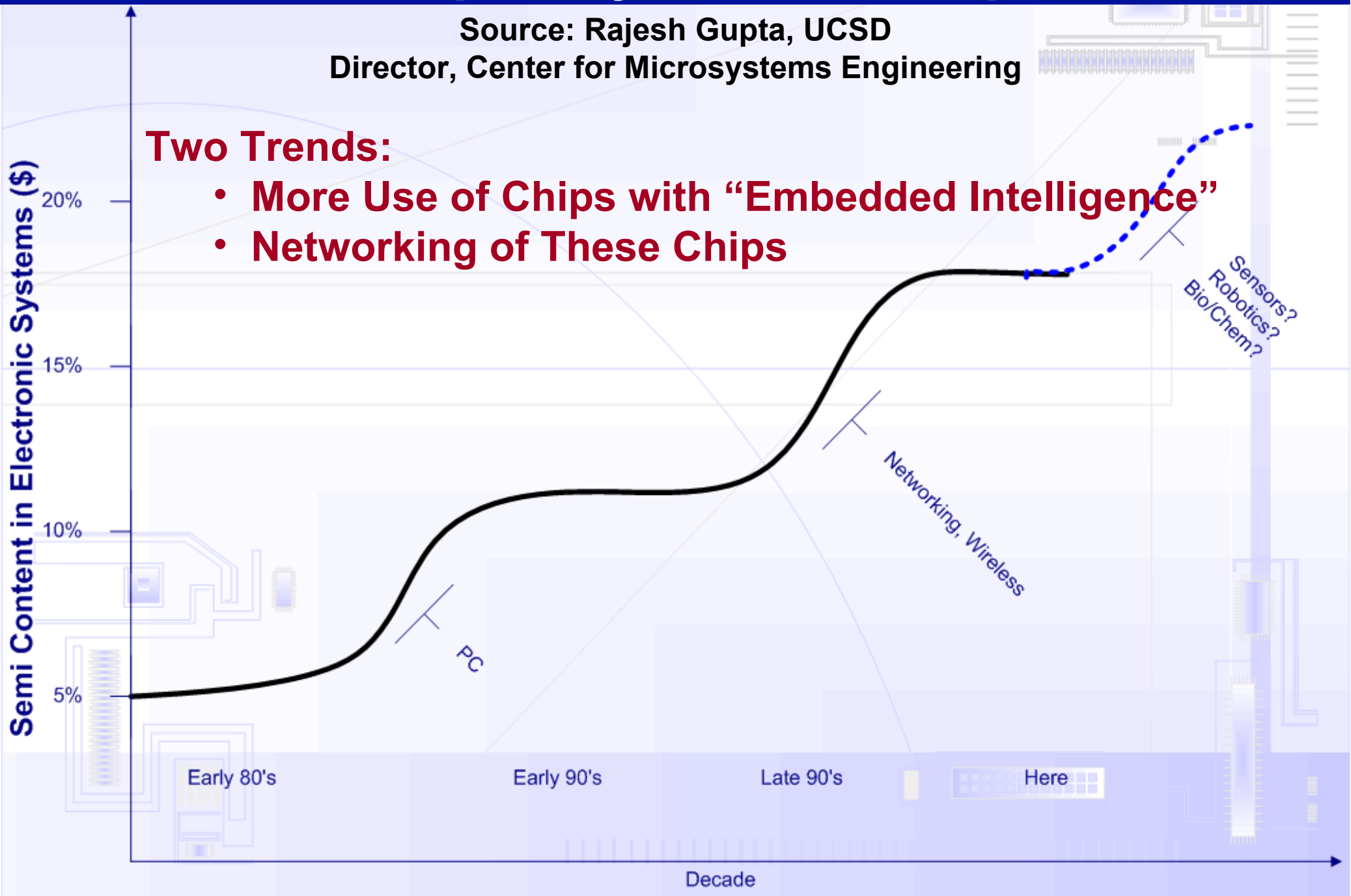
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Network Endpoints Are Becoming Complex Systems-on-Chip

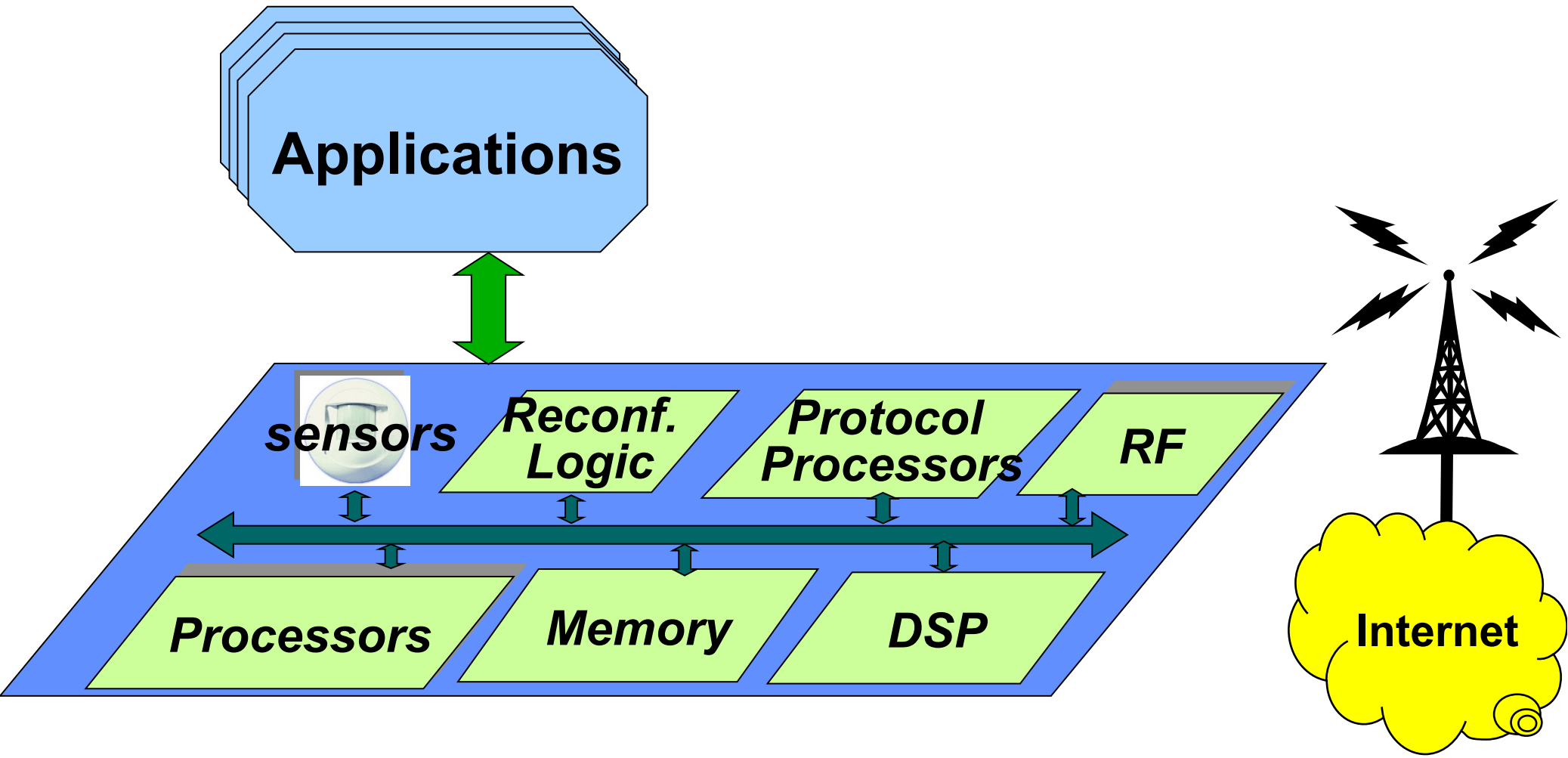
Source: Rajesh Gupta, UCSD
Director, Center for Microsystems Engineering

Two Trends:

- More Use of Chips with "Embedded Intelligence"
- Networking of These Chips



Adding Brilliance to Wireless Sensors With Systems-on-Chip



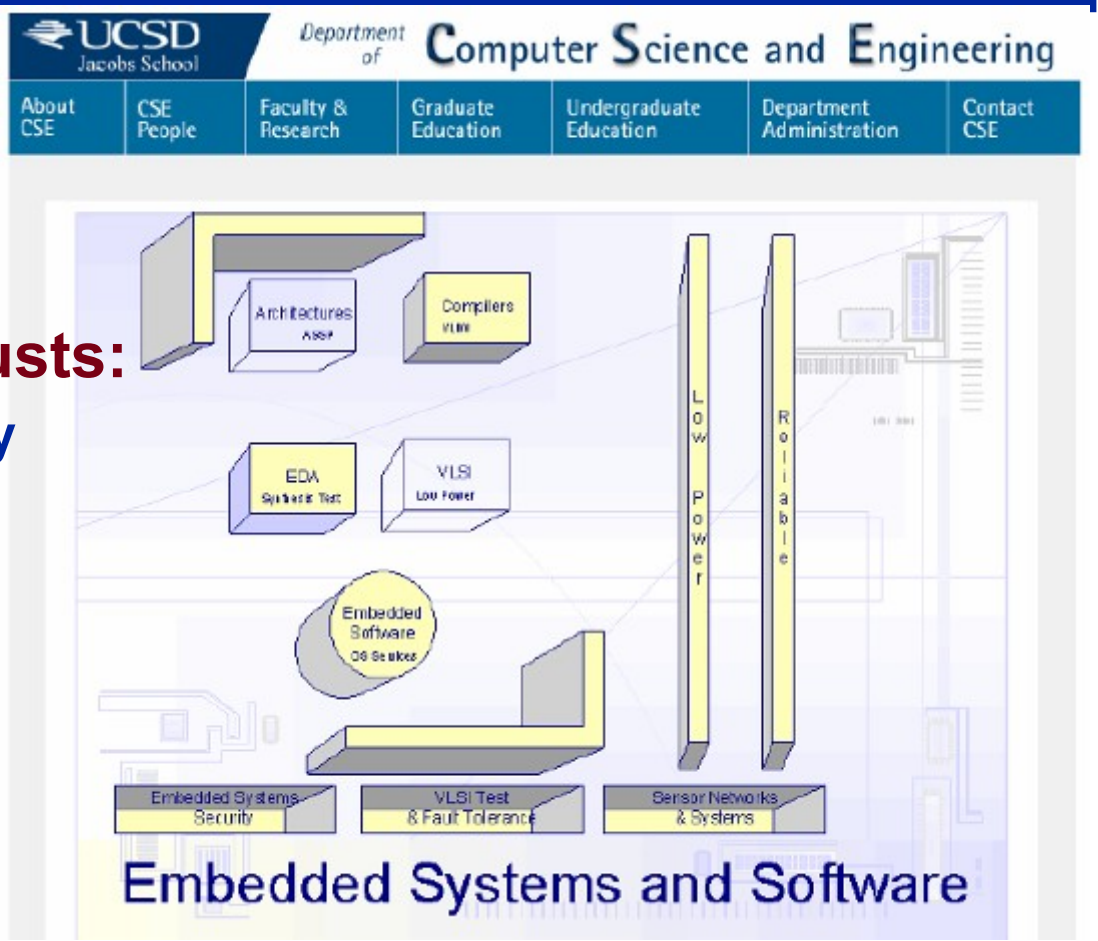
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Source: Sujit Dey, UCSD ECE

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The UCSD Program in Embedded Systems & Software

- **Confluence of:**
  - Architecture, Compilers
  - VLSI, CAD, Test
  - Embedded Software
- **Cross-Cutting Research Thrusts:**
  - Low Power, Reliability, Security
  - Sensor Networks
- **Affiliated Laboratories:**
  - High Performance Processor Architecture and Compiler
  - Microelectronic Systems Lab VLSI/CAD Lab
  - Reliable System Synthesis Lab



http://mesl.ucsd.edu/gupta/ess/

CalRadio 1.0 – A Calit2 Academic-Industrial Platform Launches Open Source Software Defined Radio

- **Developed with Industrial Partners**
  - Symbol Technologies—RF Module
  - Texas Instruments—Development System
- **Being Used in Calit2 Projects**
  - ResponseSphere, RESCUE, WIISARD



Calit2 principal development engineer Doug Palmer

- **Allows Researchers to Test Out New Algorithms and New Techniques for Wireless Communications**
- **Teaching Tool for Graduate and Undergraduate Researchers**
- **Won Best Demo Award at Information Processing in Sensor Networks (IPSN'05)**

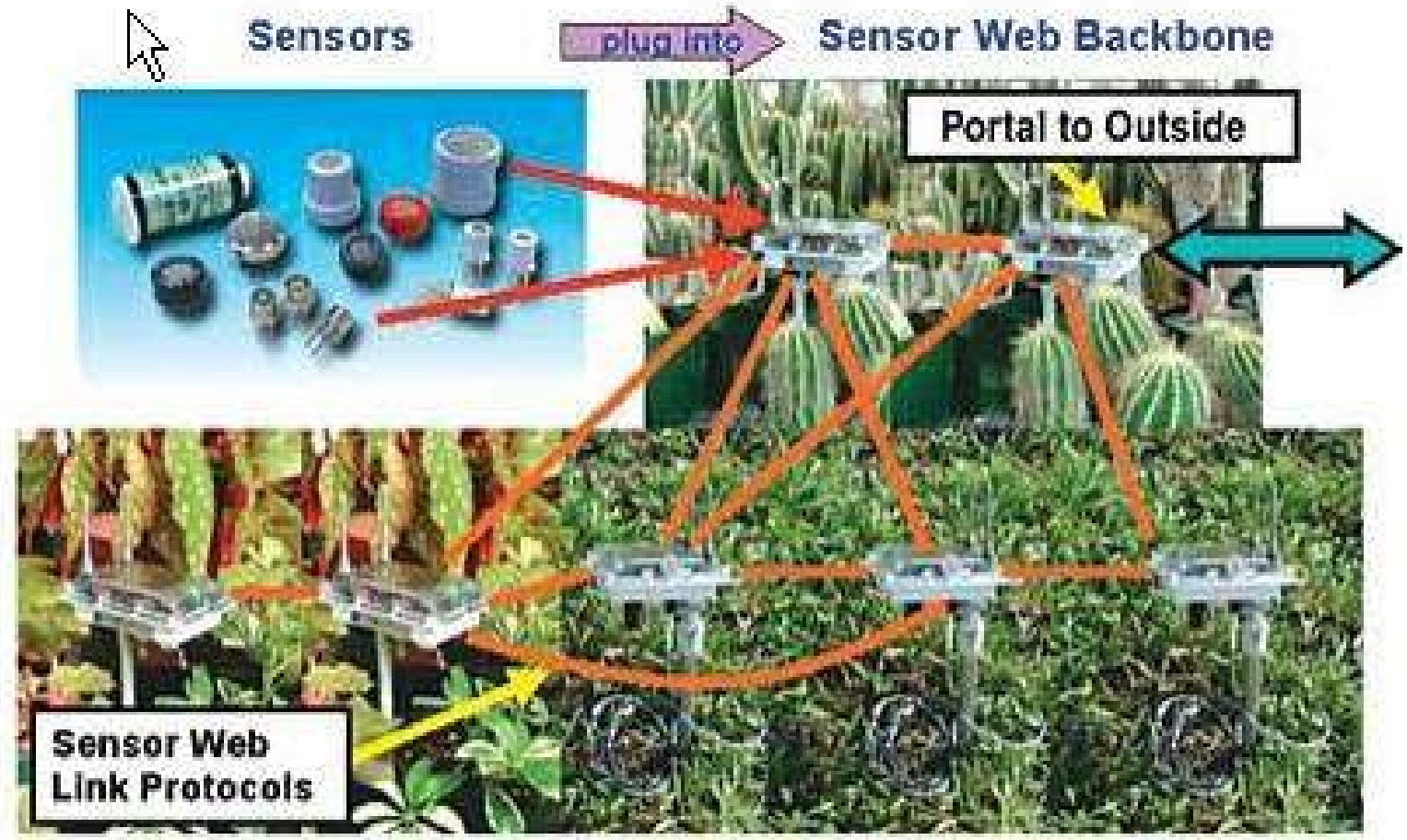
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Souce: Doug Palmer, Calit2

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Sensors + Platforms Plug Into Sensor Webs





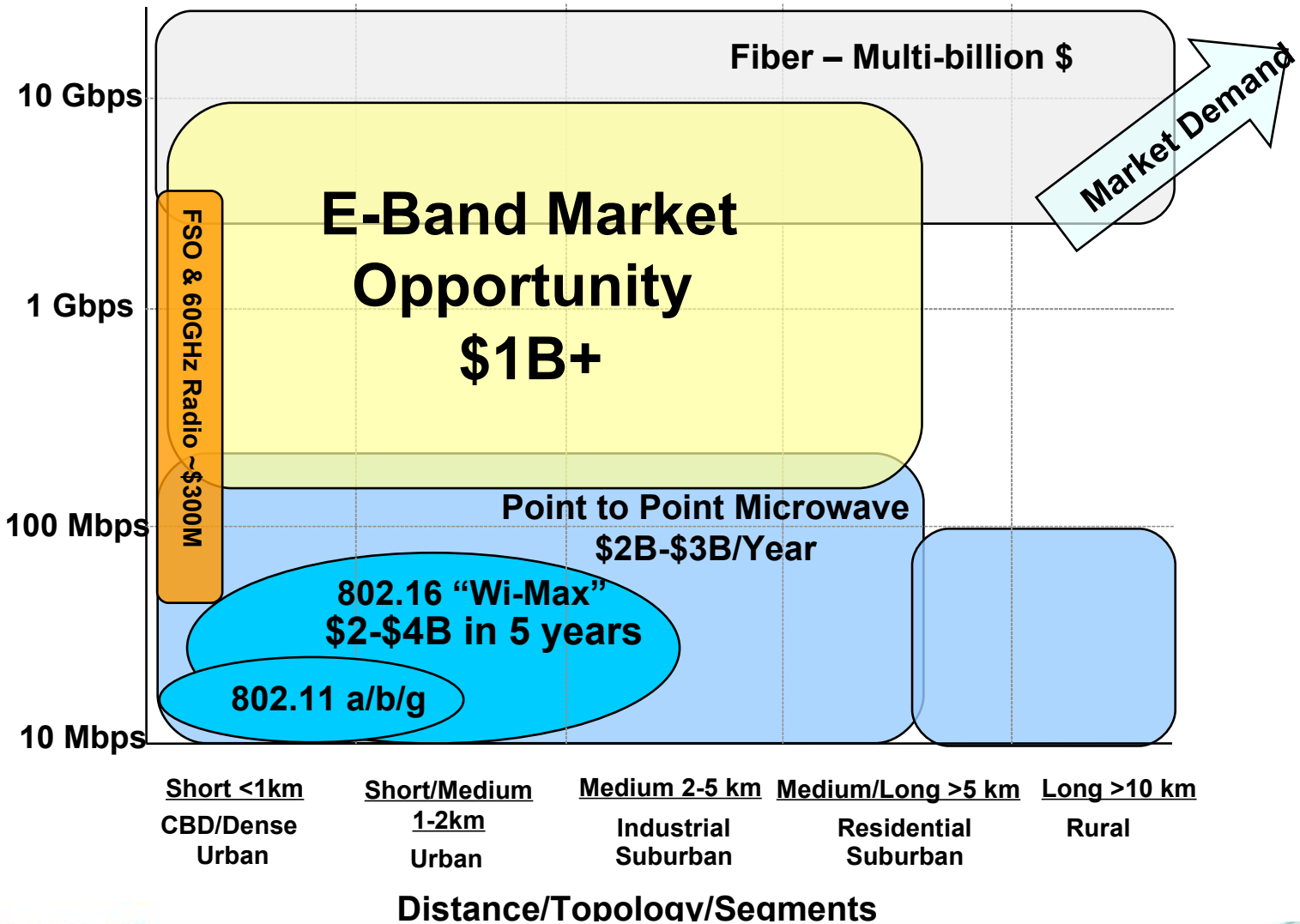
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Source: NASA/JPL Sensor Webs Project
http://sensorwebs.jpl.nasa.gov/

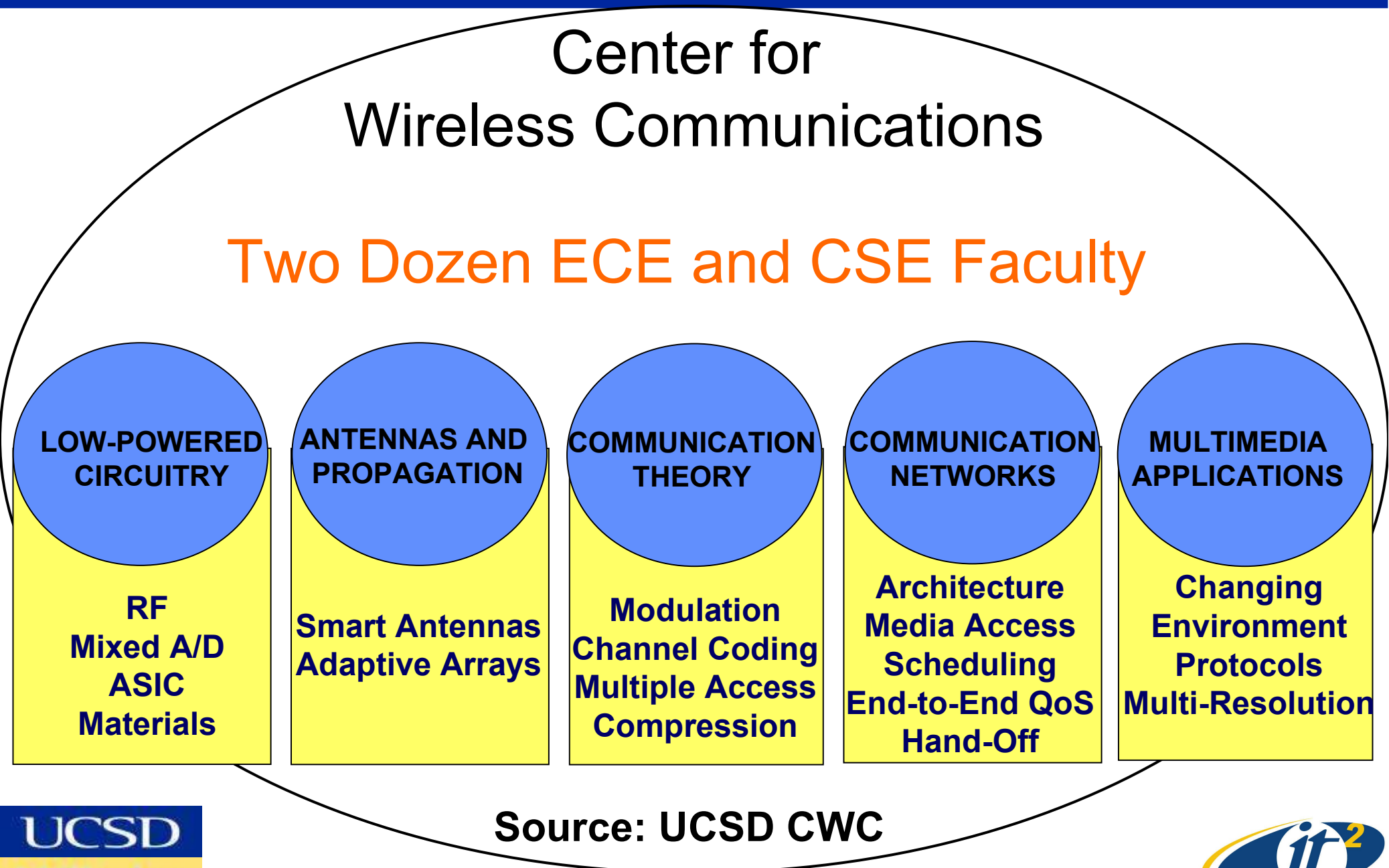
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An Explosion in Wireless Internet Connectivity is Occuring

Broadband Cellular Internet Plus…



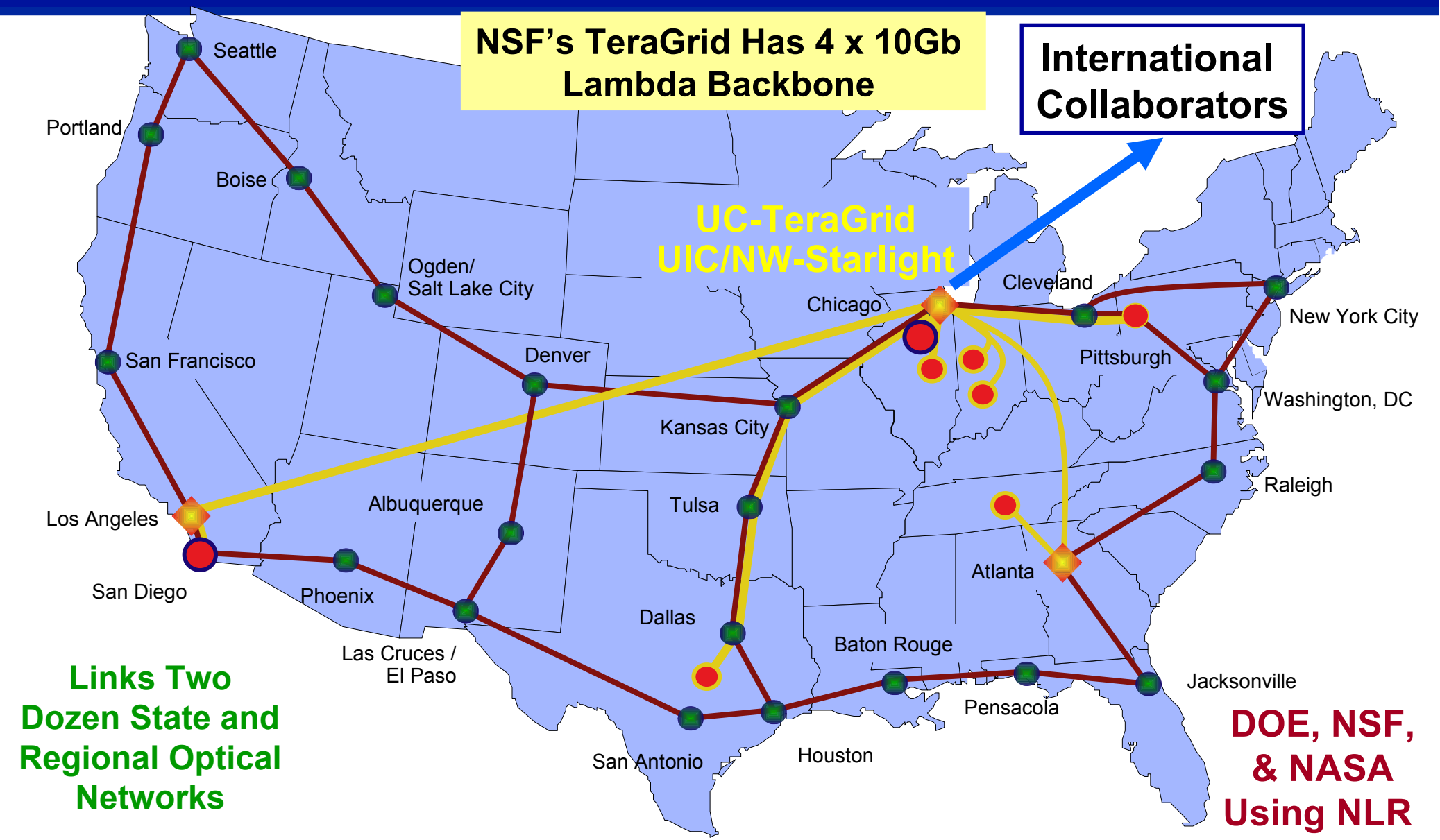
The CWC Provides Calit2 With Deep Research in Many Component Areas



Source: UCSD CWC

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National Lambda Rail (NLR) and TeraGrid Provides Researchers a Cyberinfrastructure Backbone



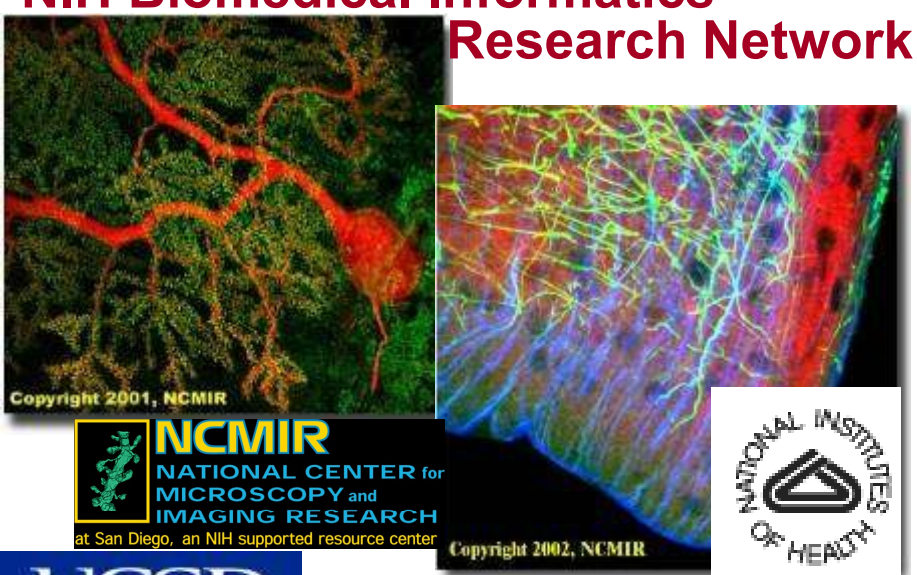
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The OptIPuter: From the Grid to the LambdaGrid
A New Optical Architecture for Analyzing Sensor Data Products

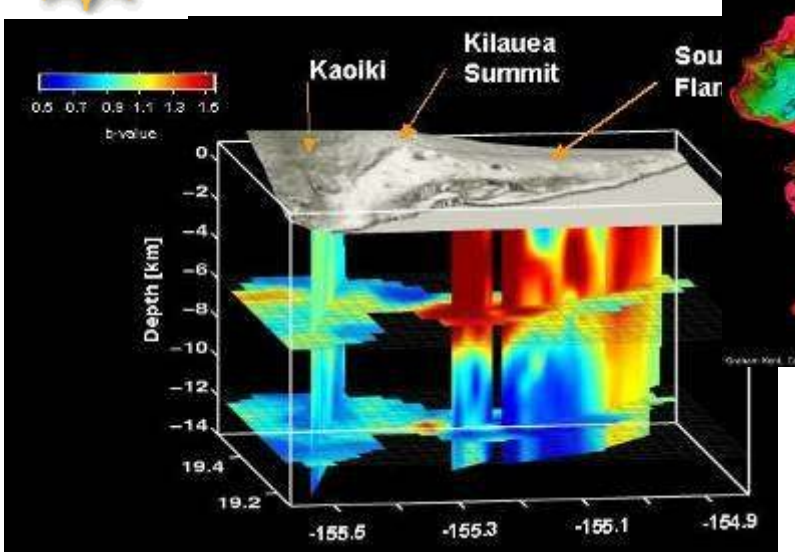
- **NSF Large Information Technology Research Proposal**
  - Calit2 (UCSD, UCI) and UIC Lead Campuses—Larry Smarr PI
  - Partnering Campuses:
    - USC, SDSU, NW, TA&M, UvA, SARA, NASA,KISTI, AIST
- **Industrial Partners**
  - IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent
- **$13.5 Million Over Five Years**
- **Connecting Researcher's Linux Clusters to Remote Data**

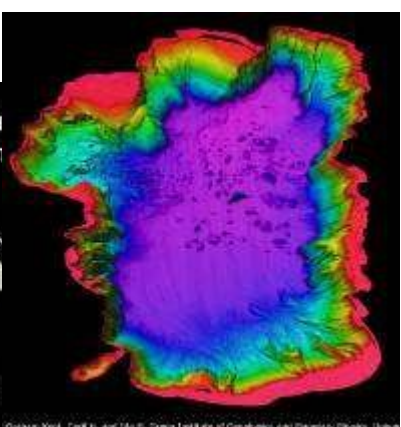
NIH Biomedical Informatics Research Network



http://ncmir.ucsd.edu/gallery.html

NSF EarthScope and ORION





siovizcenter.ucsd.edu/library/gallery/shoot1/index.shtml

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High Resolution Portals to Global Science Data -- 200 Million Pixels of Viewing Real Estate!



it² Center of GRAVITY
Center of Graphics, Visualization and Imaging Technology

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Source: Falko Kuester, Calit2@UCI
NSF Infrastructure Grant

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The Upcoming World Jamboree of LambdaGrids

Maxine Brown, Tom DeFanti, Co-Organizers



iGrid 2005

THE GLOBAL LAMBDA INTEGRATED FACILITY

www.startap.net/igrid2005/



September 26-30, 2005

Calit2 @ University of California, San Diego

California Institute for Telecommunications and Information Technology

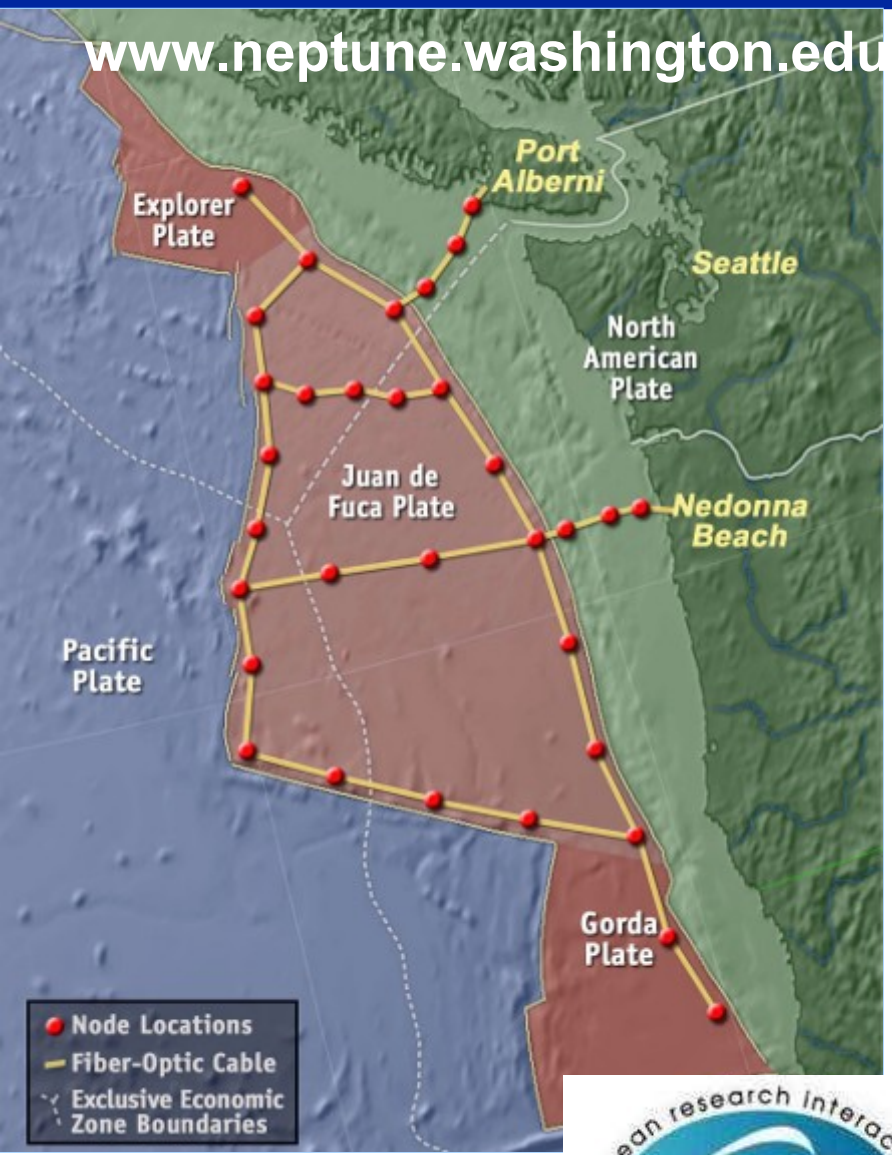
21 Countries Driving 100 Gbps to Calit2@UCSD Building Sept 2005-- A Number of Projects are SensorNets

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http://sc05.supercomp.org

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Adding Web and Grid Services to Lambdas to Provide Real Time Control of Ocean Observatories



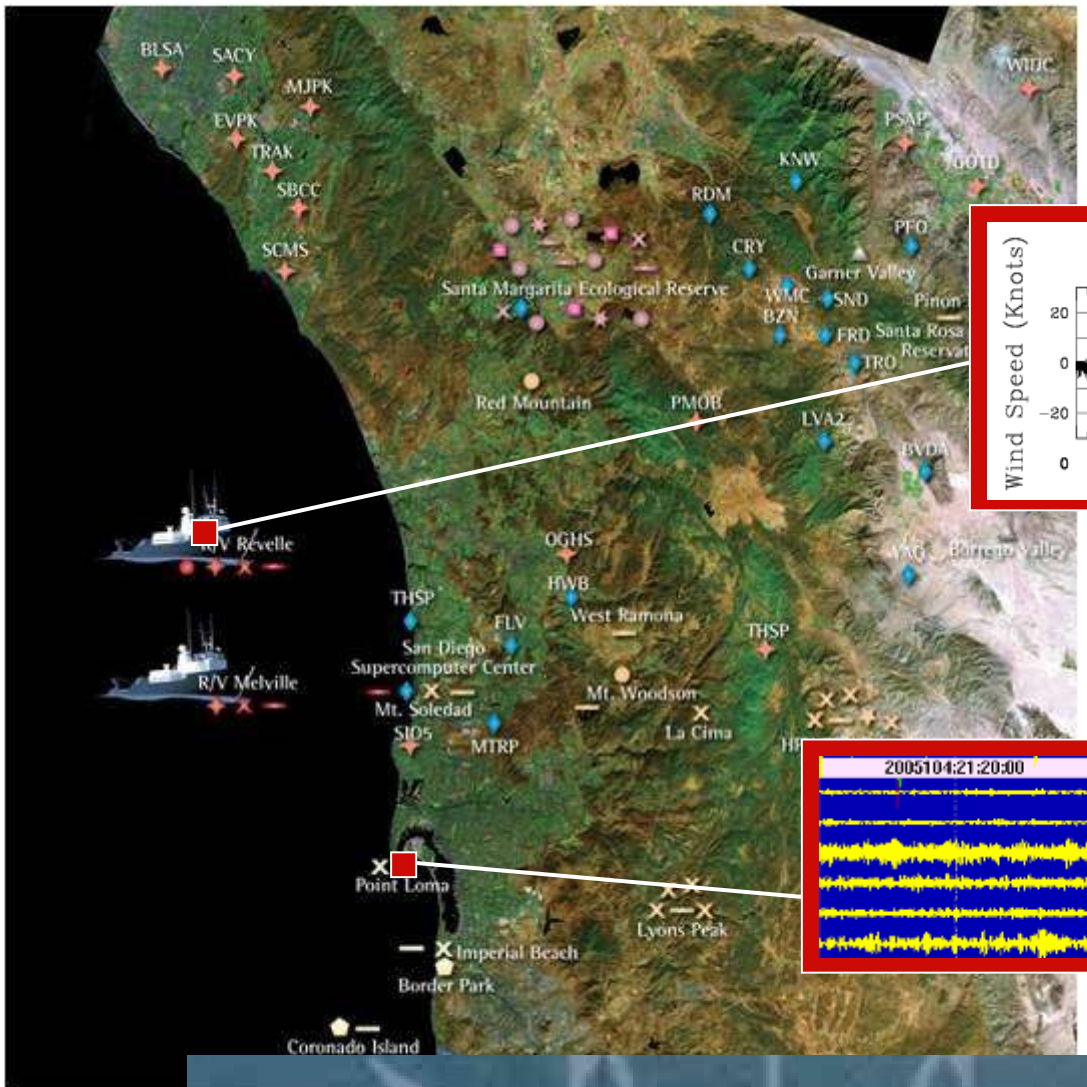
LOOKING:
(Laboratory for the Ocean Observatory Knowledge Integration Grid)

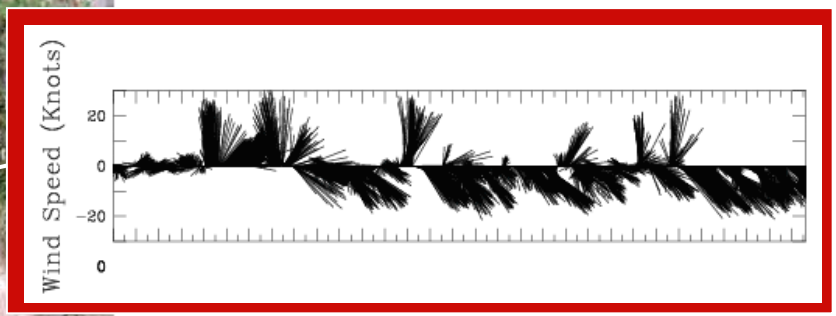
http://lookingtosea.ucsd.edu/

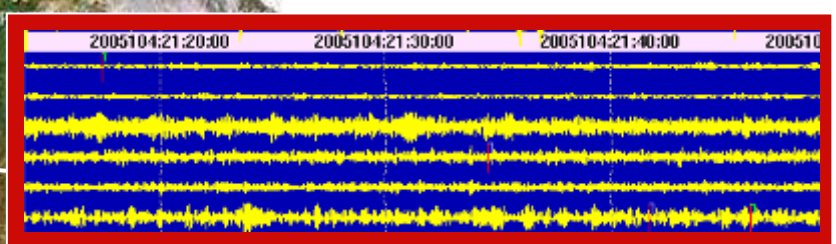
- **Goal:**
  - Prototype Cyberinfrastructure for NSF's Ocean Research Interactive Observatory Networks (ORION) Building on OptIPuter
- **LOOKING NSF ITR with PIs:**
  - John Orcutt & Larry Smarr - UCSD
  - John Delaney & Ed Lazowska –UW
  - Mark Abbott – OSU
- **Collaborators at:**
  - MBARI, WHOI, NCSA, UIC, CalPoly, UVic, CANARIE, Microsoft, NEPTUNE-Canarie

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NSF
ocean research interactive ORION observatory networks
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LOOKING will Build on the NSF ROADNet Project: Observing Data Streams in Real-Time









BRINGING THE INFORMATION SUPERHIGHWAY TO THE DIRT ROAD AND THE HIGH SEAS

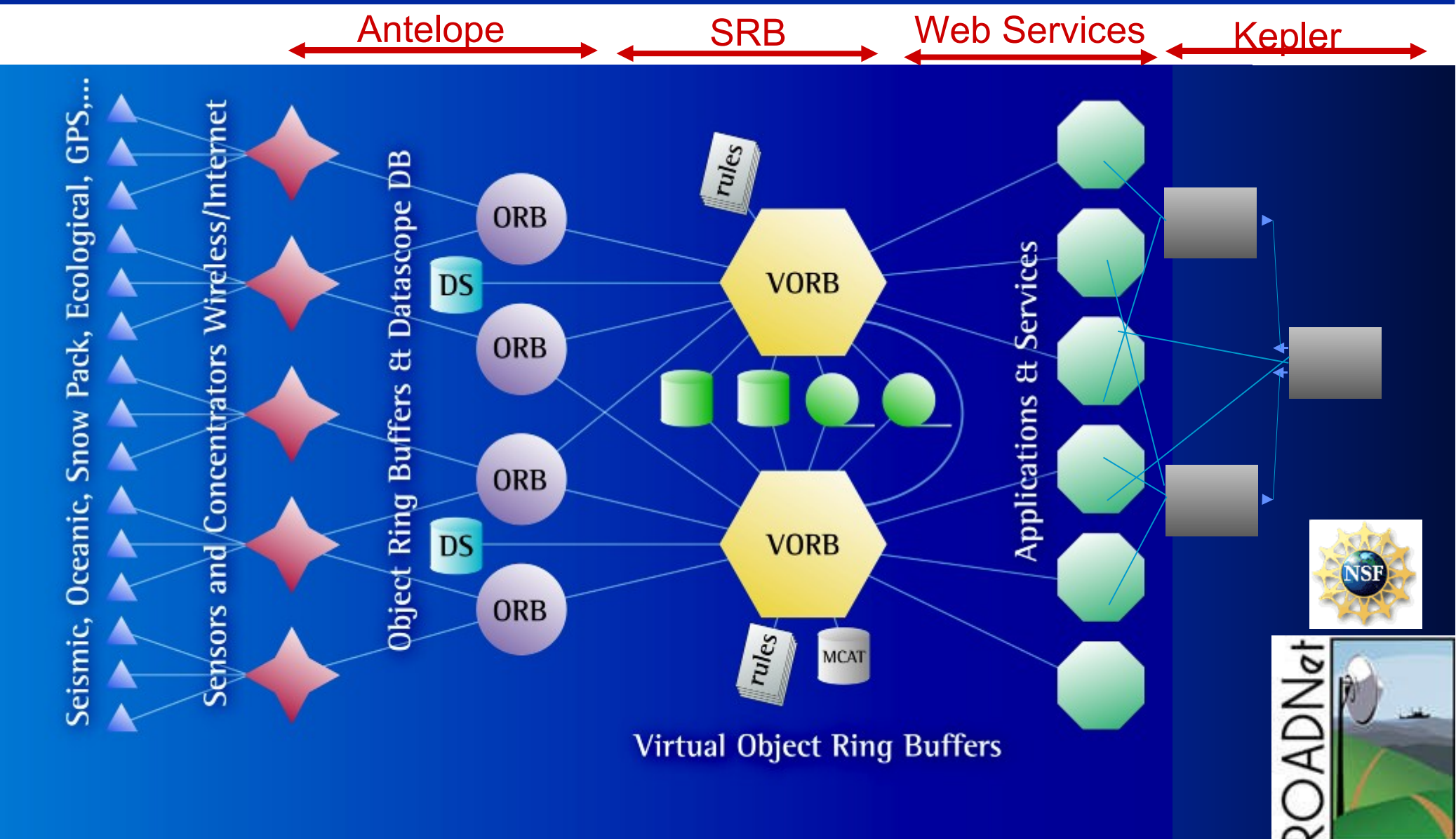
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http://roadnet.ucsd.edu/

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ROADNet Architecture:

SensorNets, Storage Research Broker, Web Services, Work Flow



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Frank Vernon, SIO; Tony Fountain, Ilkay Altintas, SDSC

Goal – From Expedition to Cable Observatories with Streaming Stereo HDTV Robotic Cameras

http://disney.go.com/disneypictures/aliensofthedeep/alienseduguide.pdf

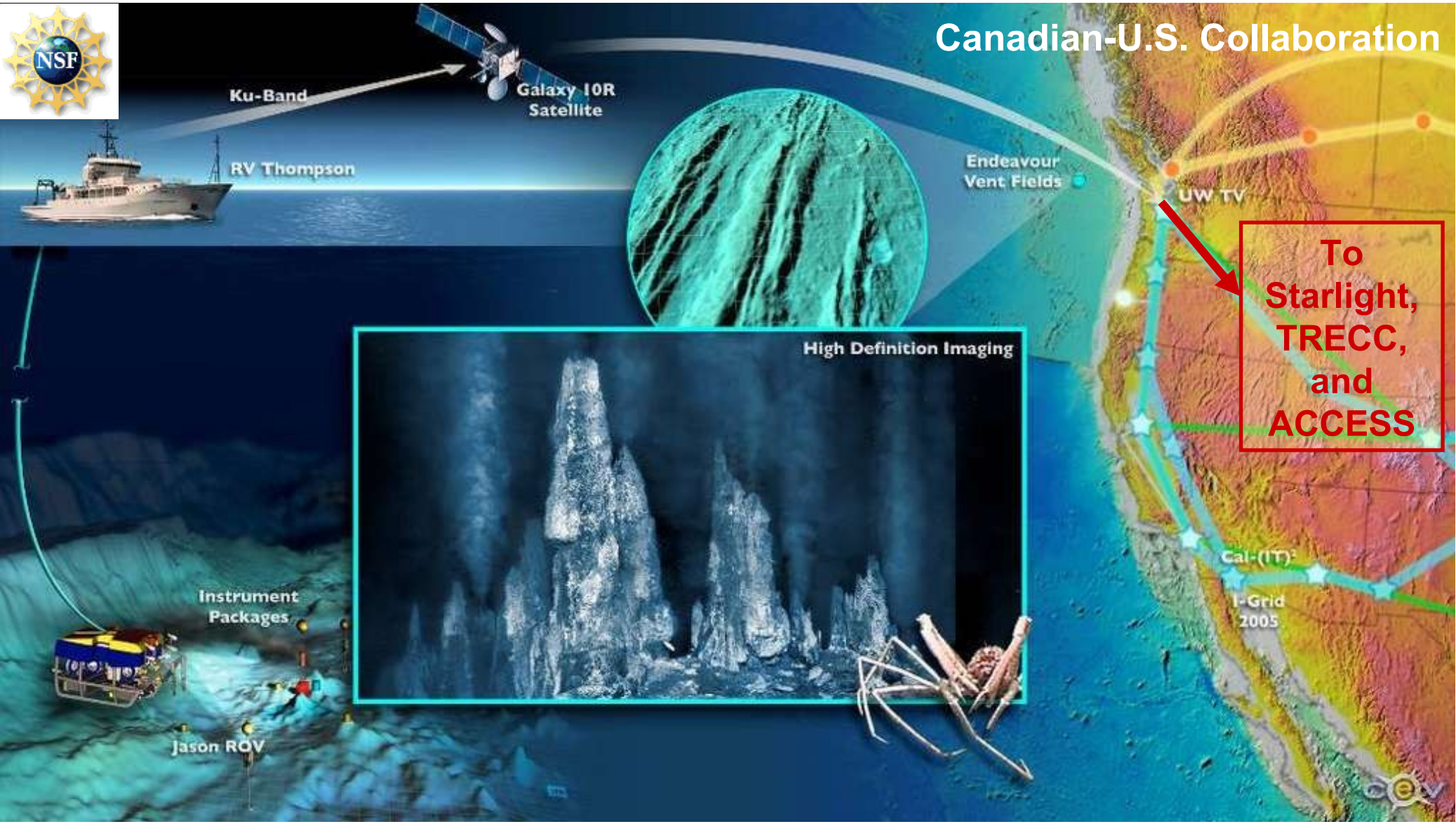


Scenes from The Aliens of the Deep, Directed by James Cameron & Steven Quale



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Proposed UW/Calit2 Experiment for iGrid 2005 – Remote Interactive HD Imaging of Deep Sea Vent

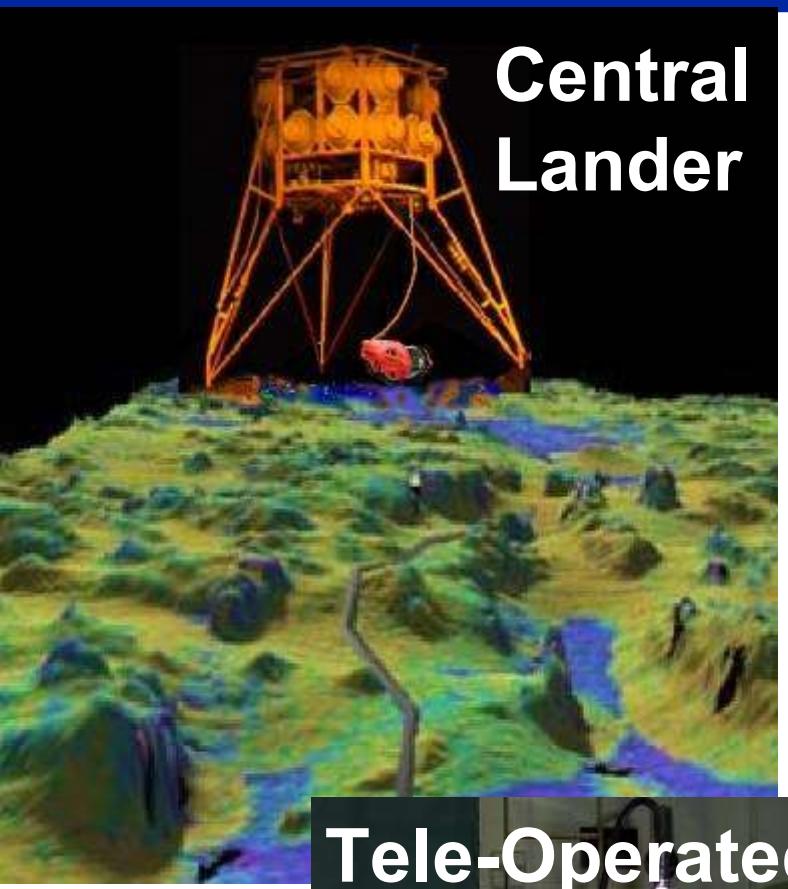


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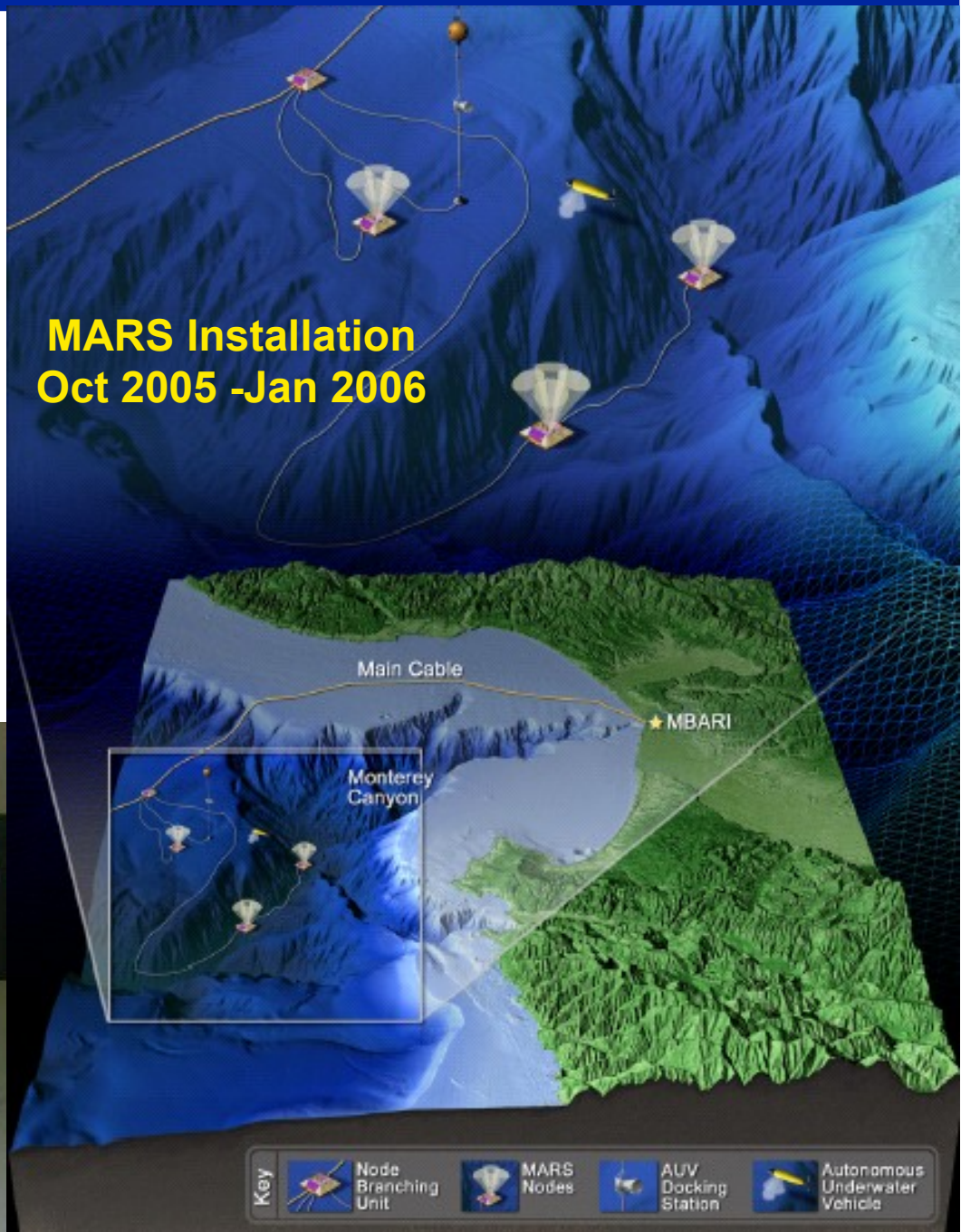
NEPTUNE

Source John Delaney & Deborah Kelley, UWash

MARS Cable Observatory Testbed – LOOKING Living Laboratory







Source: Jim Bellingham, MBARI

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