“The History and Possible Futures of the Internet”

A Game-Changing Lecture

Center for Advanced Study in the Behavioral Sciences

Stanford University

March 28, 2013

Dr. Larry Smarr

Director, California Institute for Telecommunications and Information Technology

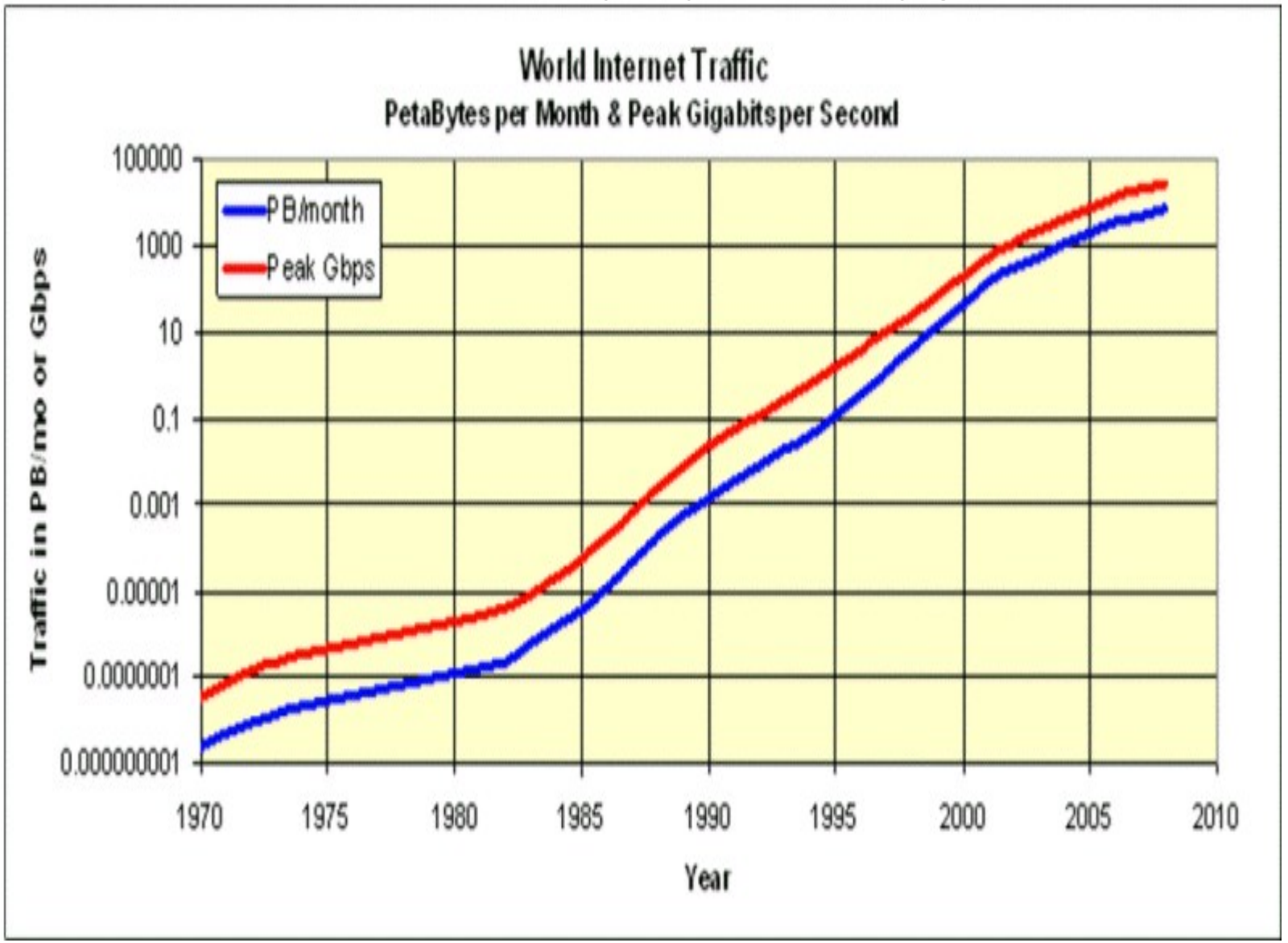
Harry E. Gruber Professor,

Dept. of Computer Science and Engineering

Jacobs School of Engineering, UCSD

The Forty Year Exponential Growth in Traffic on the Internet

Data Collected by Larry Roberts Copyright 2009 L.G. Roberts



One Trillion Fold Increase!

www.packet.cc/Traffic.html

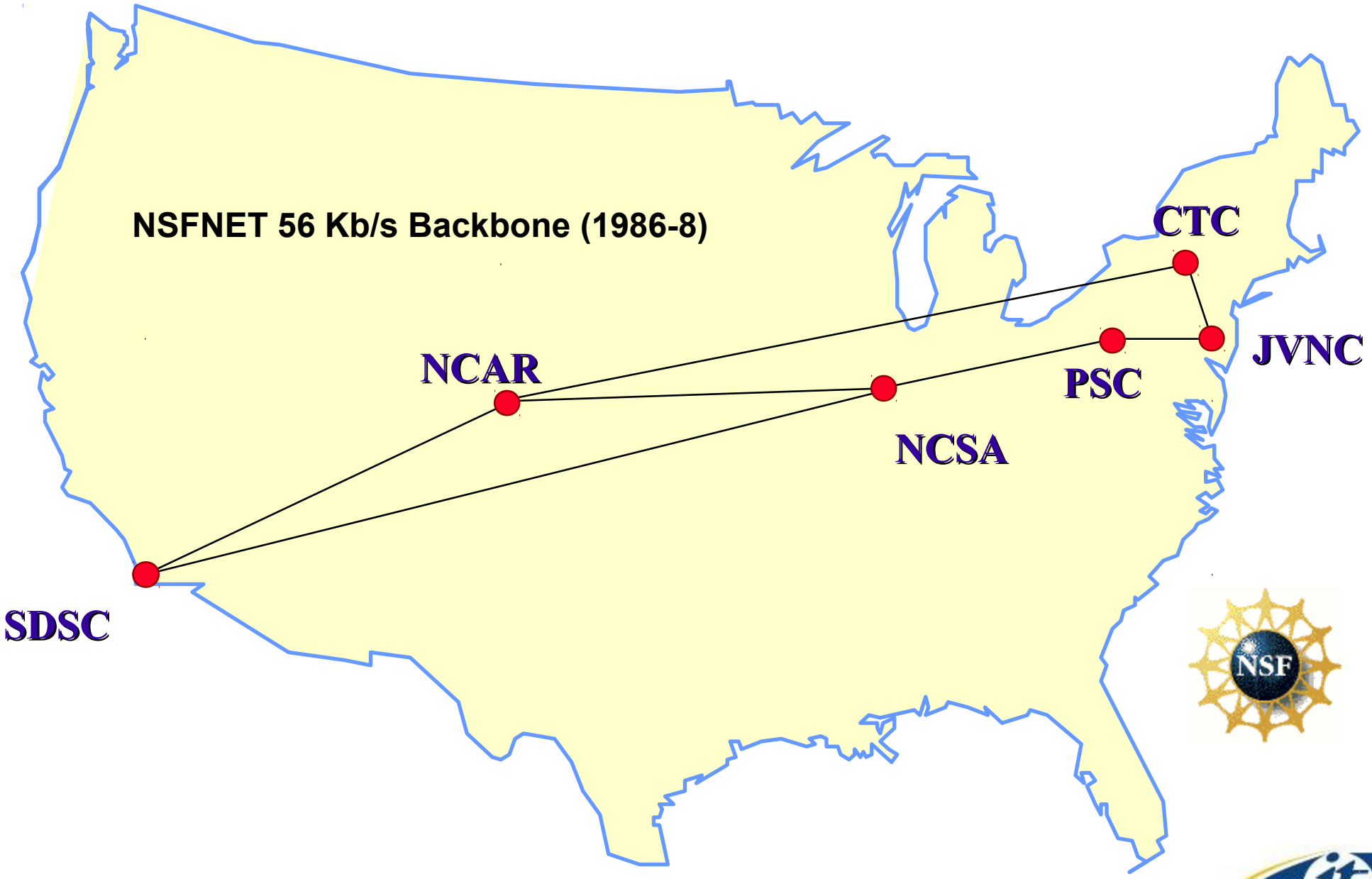
Birth of the Internet in Early 1970s Led to Forty Years of Exponential Growth



Vint Cerf, Robert Kahn, Len Kleinrock, Larry Roberts

http://www.uclabruin.com/30anniv.htm

The First NSFnet Backbone:
The National Shared Bandwidth = a Dial-Up Modem!



Slides from 1994 © CSC Vanguard Meeting with Larry Smarr.

NCSA Mosaic Home Page





Eric Bina (left) and Marc Andreessen (right)

***NCSA Mosaic* of Marc Andreessen and Eric Bina**

NCSA Mosaic Home Page

NCSA Mosaic Home

URL : http://www.ncsa.uiuc.edu/SDG/Software/Mosaic/NCSAMosaicHome.html

N C S A

MOSAIC

X Window System • Microsoft Windows • Macintosh

Welcome to NCSA Mosaic, an Internet information browser and World Wide Web client. NCSA Mosaic was developed at the National Center for Supercomputing Applications at the University of Illinois in Urbana-Champaign .

Each highlighted phrase (in color or underlined) is a hyperlink to another document or information resource somewhere on the Internet. *Single click* on any highlighted phrase to follow the link.

The following resources are available to help introduce you to cyberspace and keep track of its growth:

- What's New with NCSA Mosaic and the Internet
- Internet Resources Meta-Index at NCSA

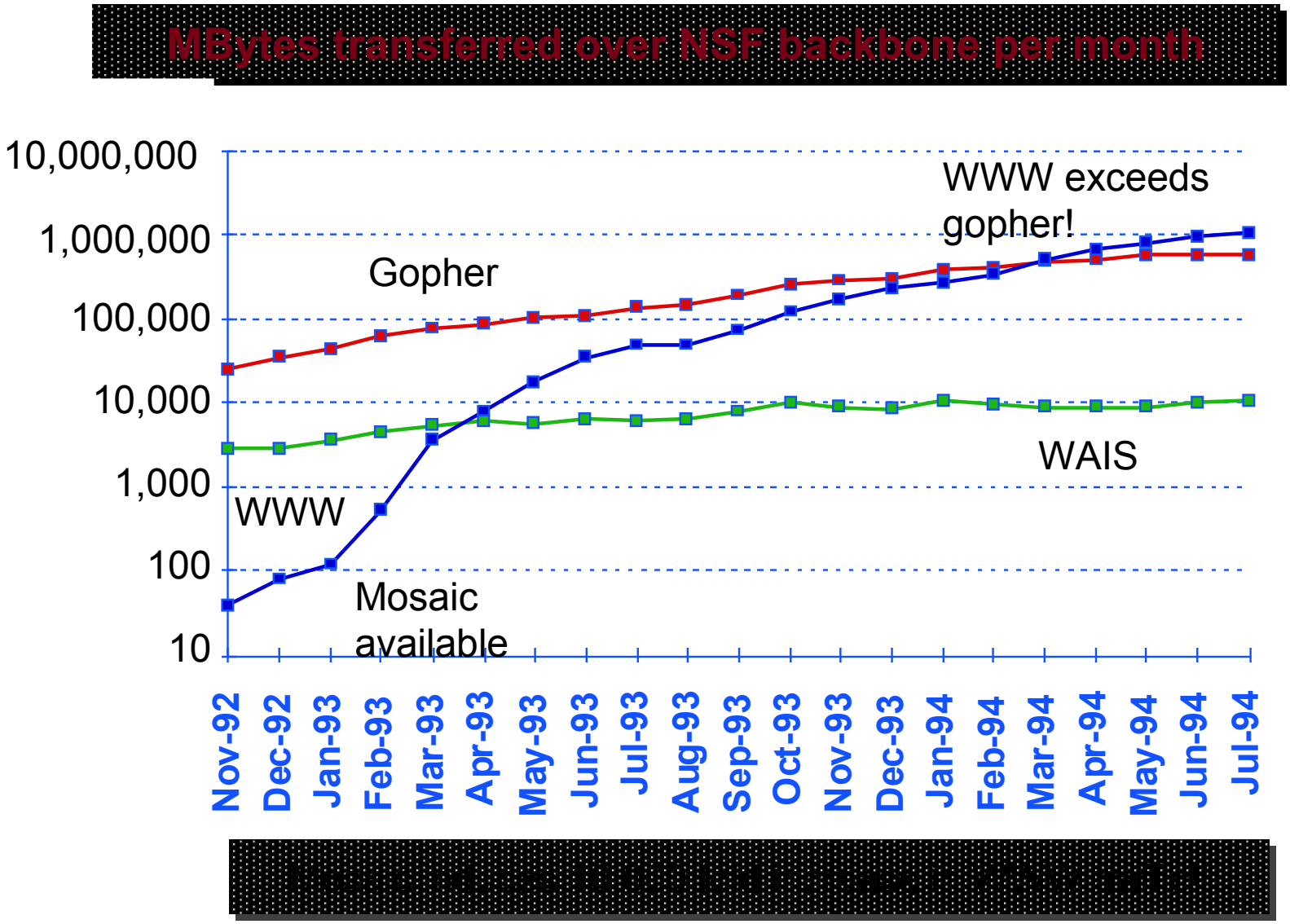
Slides from 1994 © CSC Vanguard Meeting with Larry Smarr.

NCSA Mosaic
A Client for All Servers

- Gopher
- Usenet
- Wide-Area Information Server (WAIS)
- Anonymous File Transfer Protocol (FTP)
- World Wide Web (WWW)

Slides from 1994 © CSC Vanguard Meeting with Larry Smarr.

Exponential Growth of Clients Coupling to Servers



Source: Data from Merit; Graph by Larry Smarr

Slides from 1994 © CSC Vanguard Meeting with Larry Smarr.

NCSA Mosaic Drove the WWW Into Exponential Growth

"A few weeks ago, in reviewing the "metrics" of the Internet at the Society, we found that all measures of the network and its use continued to scale inexorably: ever more connected countries, gateways, networks, hosts, users, services and traffic.

A network analyst recently noted that if one of those services – the World Wide Web – continues its traffic increase at present rates, it will exceed the world's digitized voice traffic in three years. We are now watching a global internetworking revolution scale in near real-time. Every thirty minutes, another network connects."

– Anthony M. Rutkowski
Executive Director, Internet Society
Interop 94 keynote
http://info.isoc.org/interop-tokyo.html

Slides from 1994 © CSC Vanguard Meeting with Larry Smarr.

NCSA Mosaic
Led to the Modern Web World



Licensing

SPYGLASS

100 Commercial Licensees

NCSA Programmers





1993

NCSA Collage

1992

CERN 1990

The world's largest particle physics laboratory ... where the web was born!

NCSA HTTPd

Open Source



Mac OS X Server

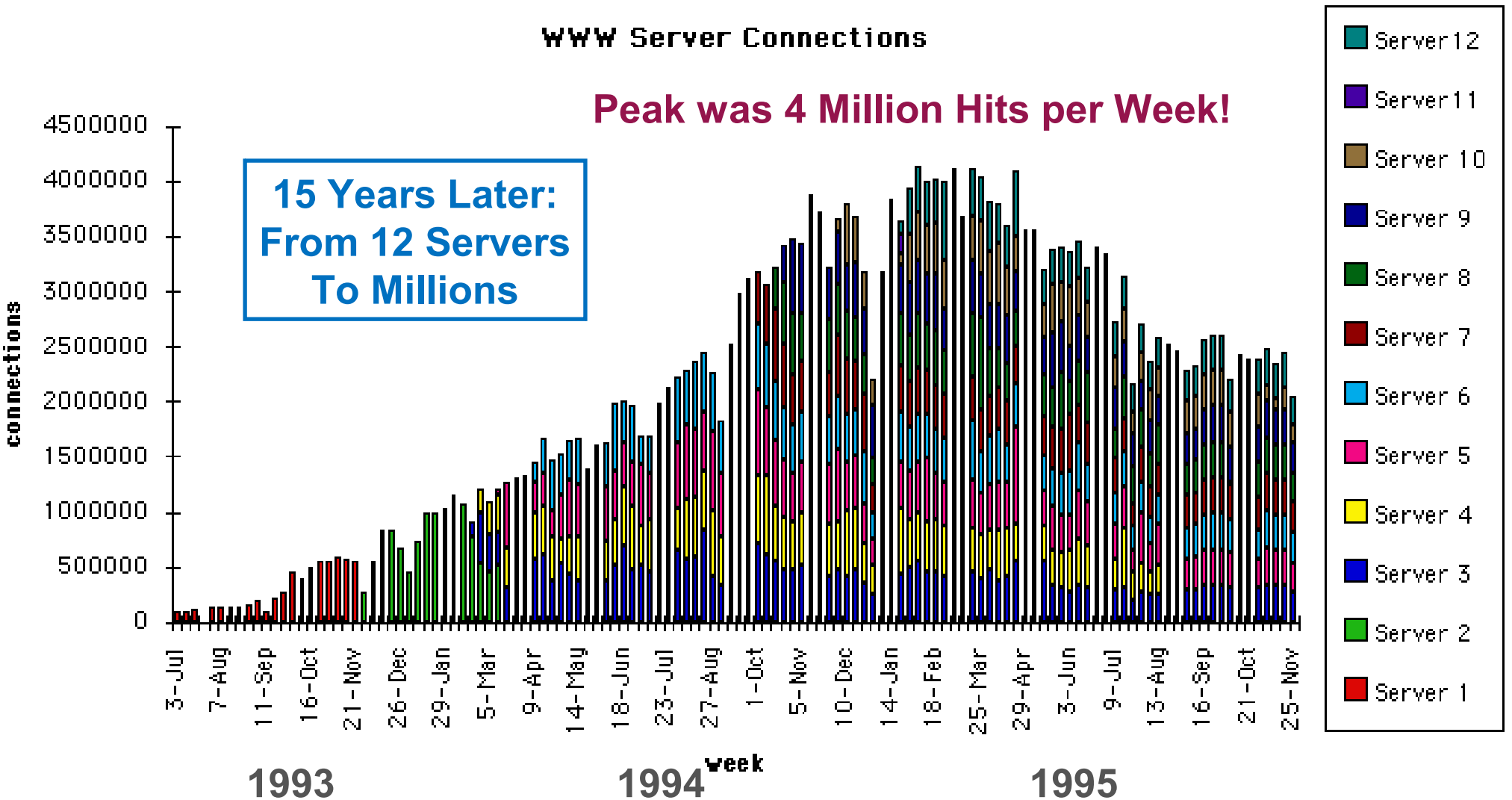


IBM WebSphere Software



Source: Larry Smarr

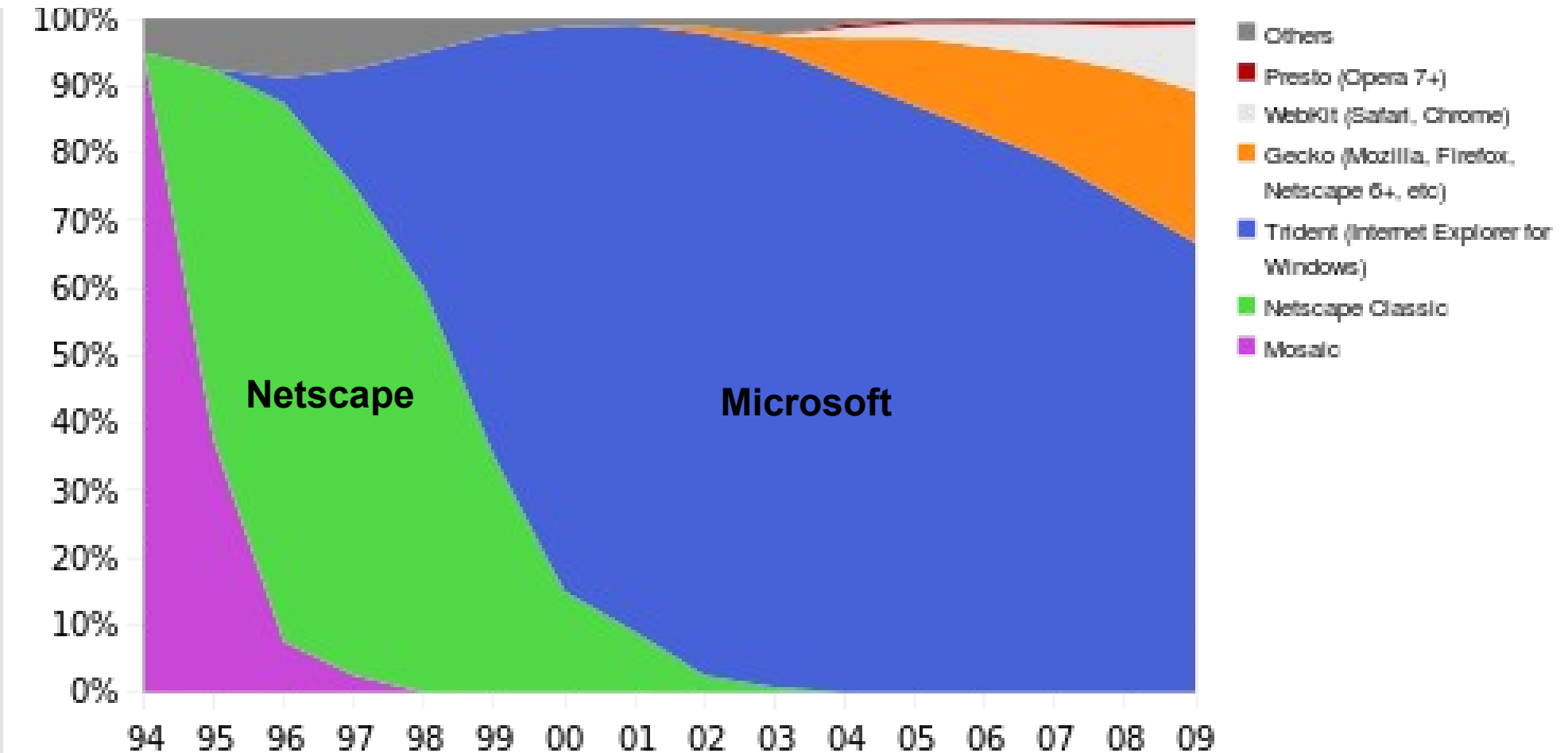
NCSA Web Server Traffic Increase Led to NCSA Creating the First Parallel Web Server



Data Source: Software Development Group, NCSA,
Graph: Larry Smarr

The 1990s Browser Wars

Chart showing history of web browser market share



NSFnet Upgraded Backbone Bandwidth: 1.5 -> 45 Mb/s Backbone (1988-94)

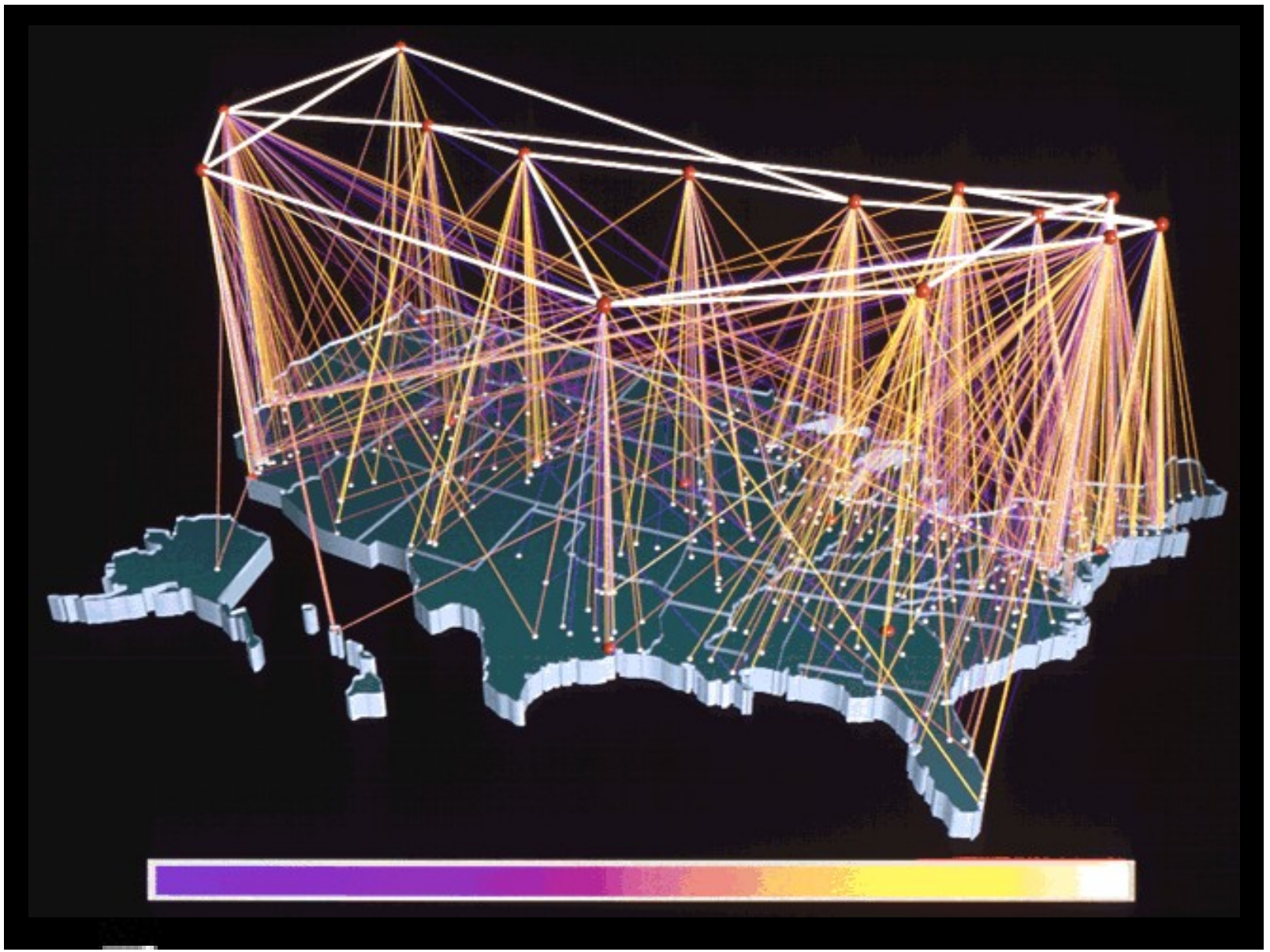


Image: Cox, Patterson, NCSA

Fifteen Years from Bleeding Edge Research to Mass Consumer Market

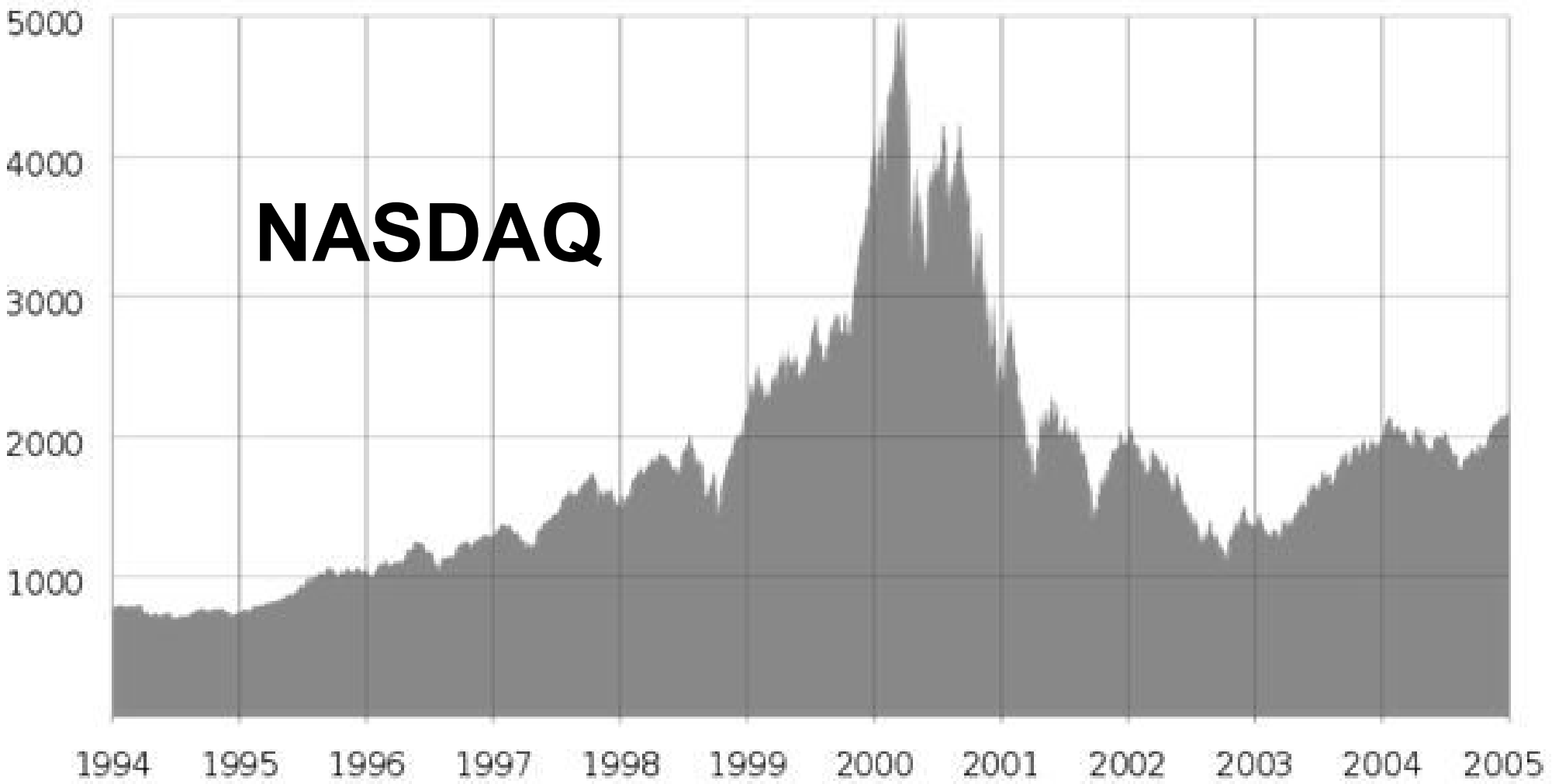
- 1990 Leading Edge University Research Center-NCSA
  - Supercomputer GigaFLOPS Cray Y-MP ($15M)
  - Megabit/s NSFnet Backbone
- 2005 Mass Consumer Market
  - PCs are Multi-Gigahertz ($1.5k)
  - Megabit/s Home DSL or Cable Modem



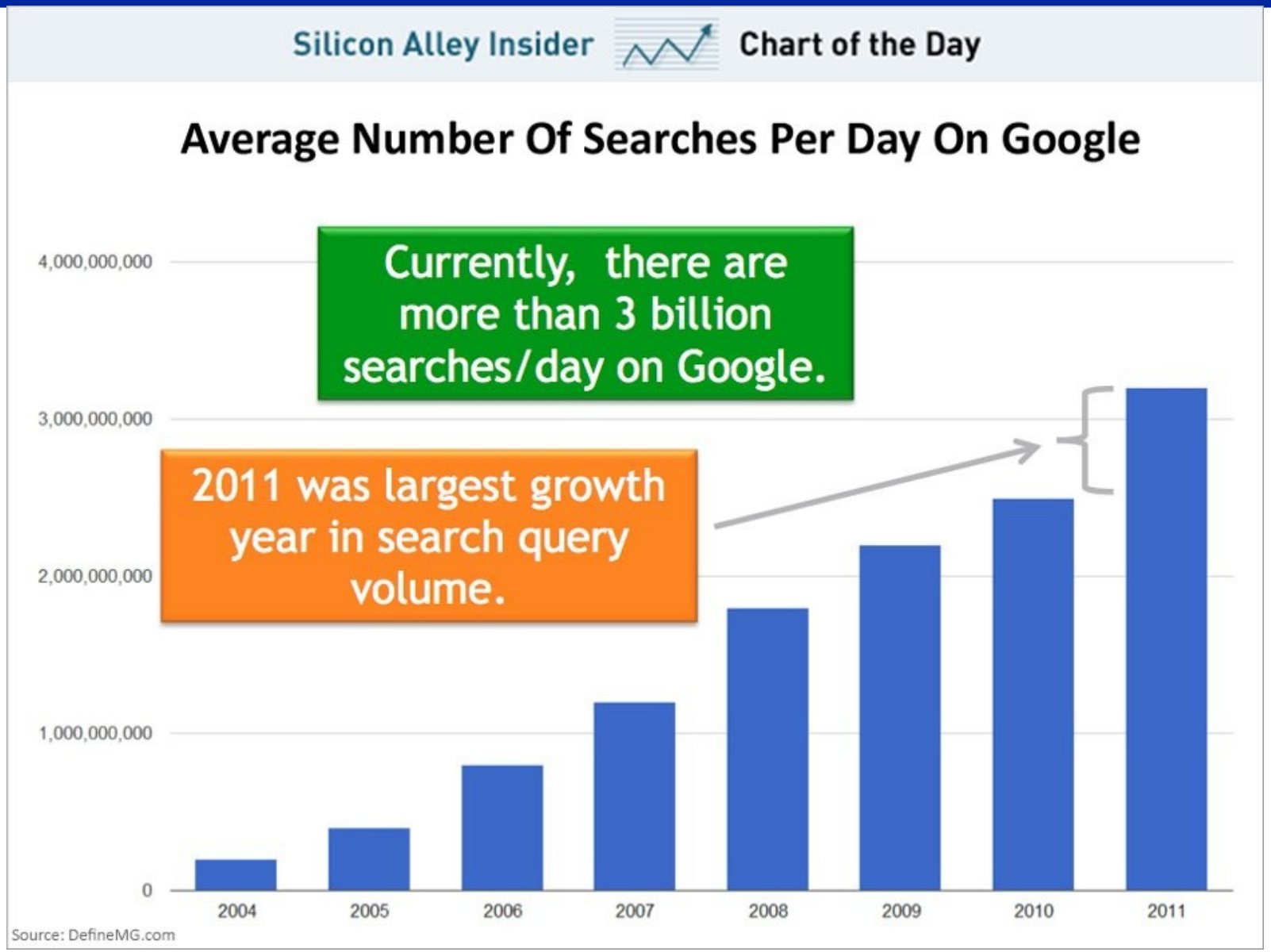
NCSA's Blue Waters Petascale Supercomputer (2012)
Is Over 1 Million Times Faster than Cray Y-MP (1990)!
Enormous Growth in Parallelism
Processors: Y-MP 4, Blue Waters ~400,000

www.ncsa.uiuc.edu/BlueWaters/system.html

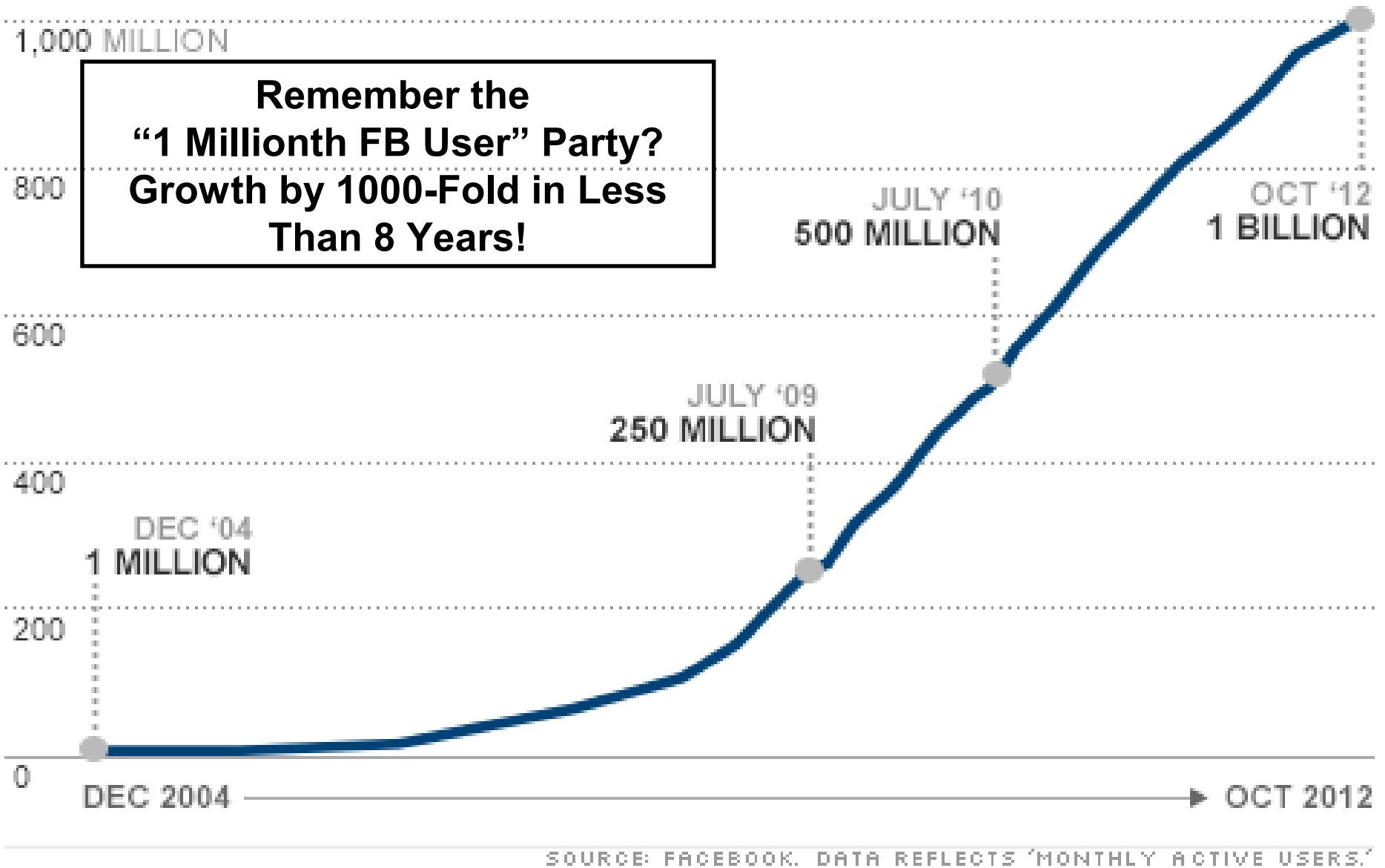
Then Came the Dot-Com Crash - Creative Destruction of Capitalism



Out of the Rubble
Google Brings Search to the Web



Over the Same Period
Facebook Leads the Rise of the Social Web



The Scale of the Web Today: "You Know What's Cool?-a Billion"

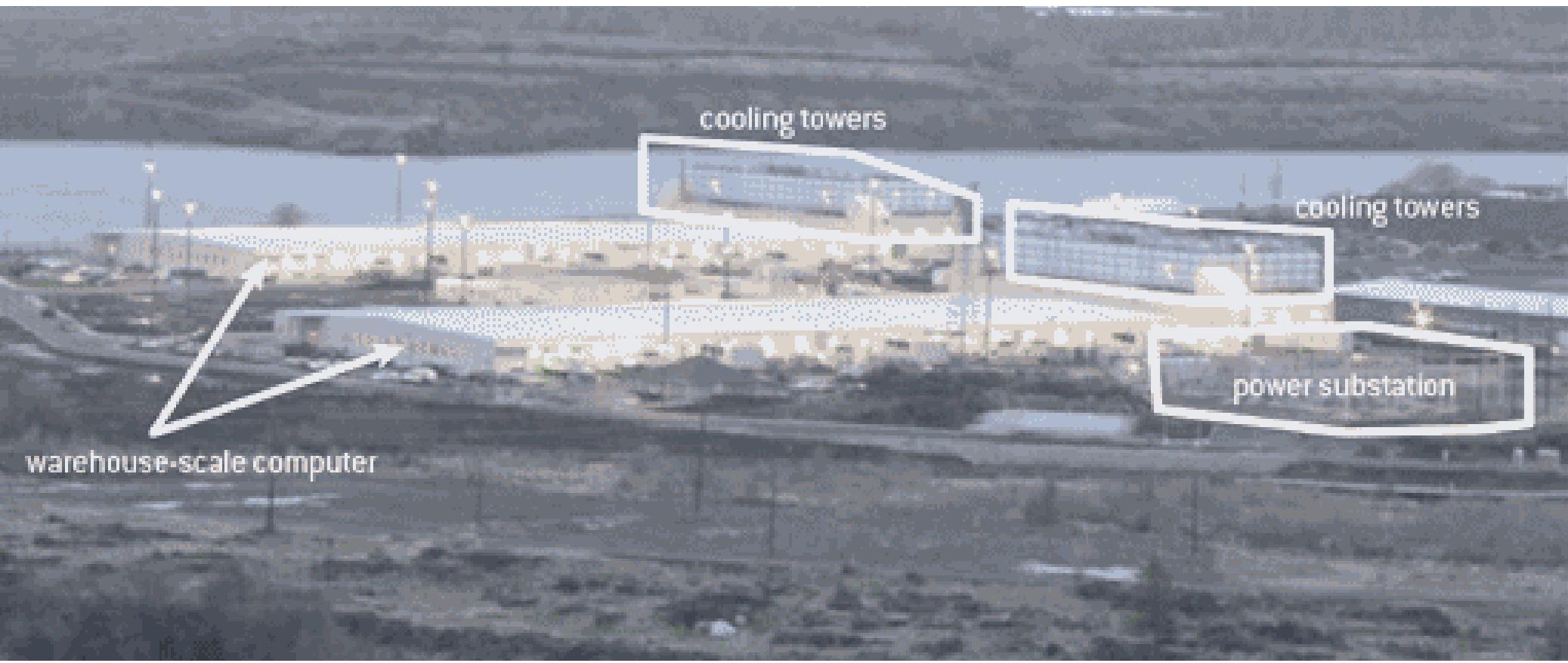
- **Facebook**
  - One Billion Active Users
- **YouTube**
  - 4 Billion Hours of Video Watched Each Month
- **Google**
  - Over One Billion Searches Every Day
- **Apple**
  - 15 Billion Apps Downloaded Per Year
- **Smartphones**
  - 1 Billion Active Users

The Unrelenting Computing Exponential

The Computing Power to Make a Single Google Search Is More Than Was Used In Space & On Earth For the 11 Year, 17 Flight Apollo Program!

http://insidesearch.blogspot.com/2012/08/the-power-of-apollo-missions-in-single.html

Warehouse-Scale Data Centers-
The Planetary Computer That Powers the Internet and Web



Source: A Guided Tour through Data-center Networking
Dennis Abts, Bob Felderman, Google

Inside Google's First Container Data Center



Each Google Container is a Data Center

www.youtube.com/watch?v=zRwPSFpLX8I&feature=player_embedded

Densely Packed Computers on an Aisle of Microsoft's Chicago Data Center



www.informationweek.com/news/infrastructure/remote_access/220300620

Four Trends of the Future Web

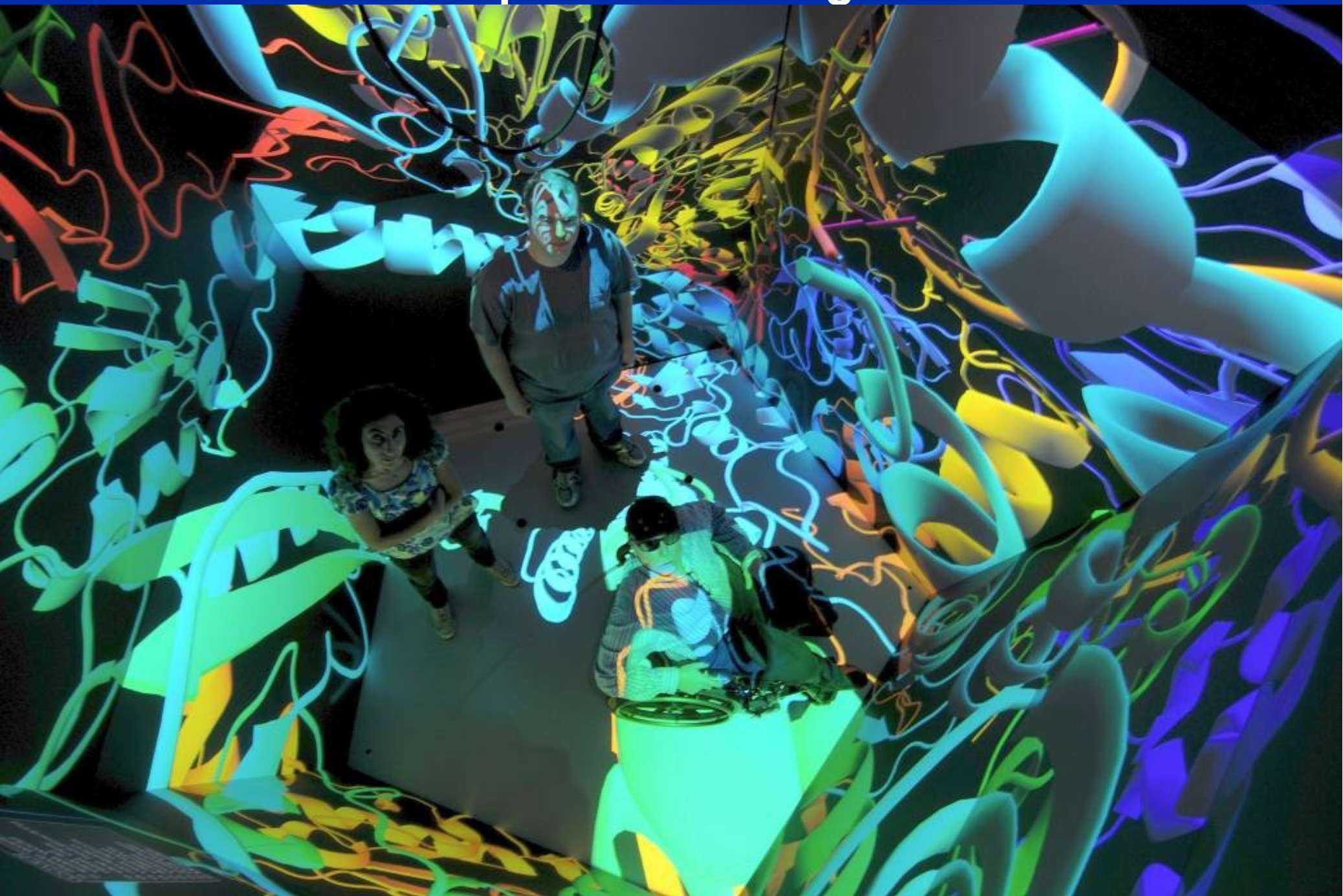
- Virtual Rooms
- Being There
- Telepresence
- Know Thyself
- Beyond the Earth

Towards Digital Wallpaper

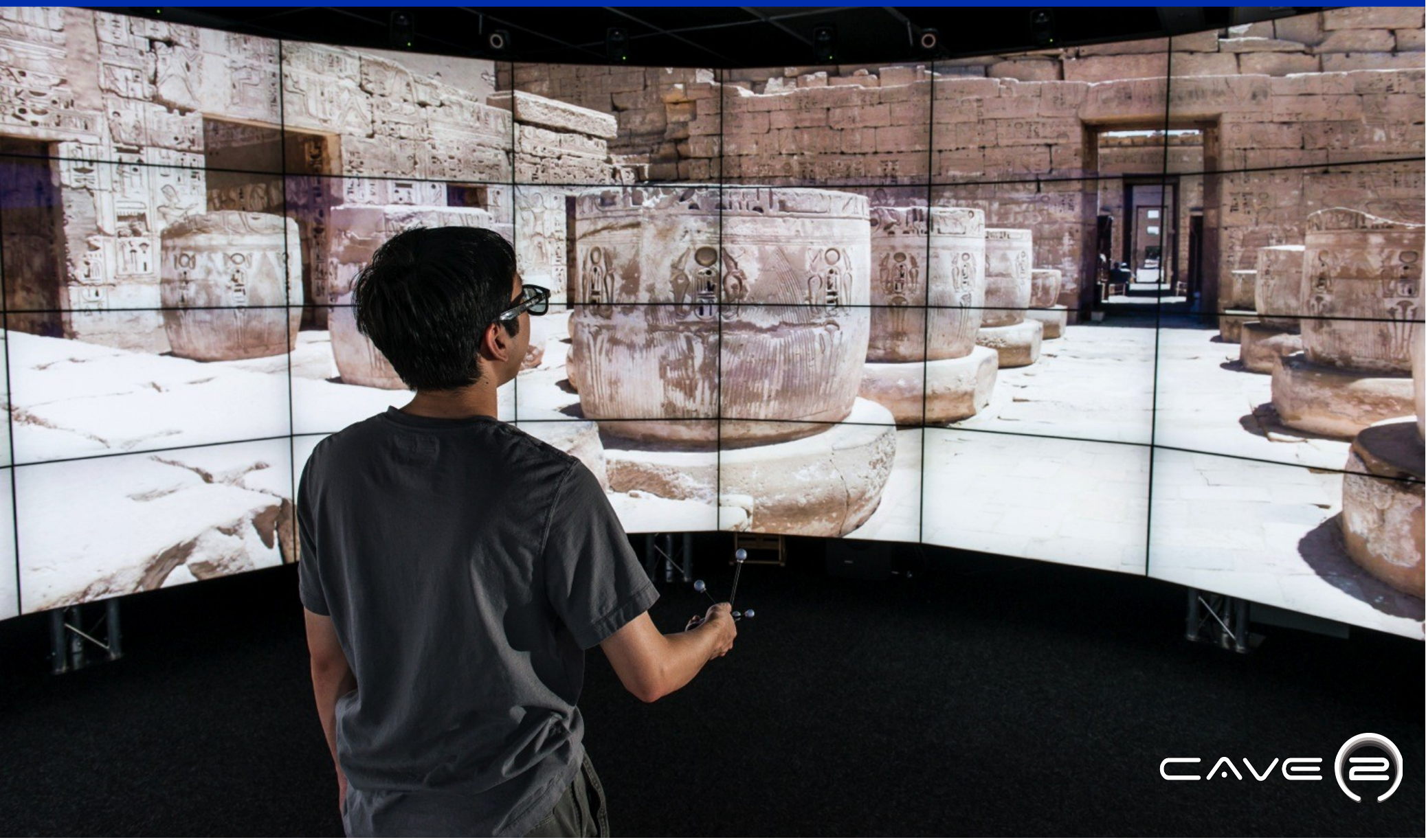


Hubble Space Telescope Collage of 48 Frames (30,000x 14,000 pixels) on Calit2's Vroom

Calit2 3D Immersive StarCAVE: Enables Exploration of Digital Worlds



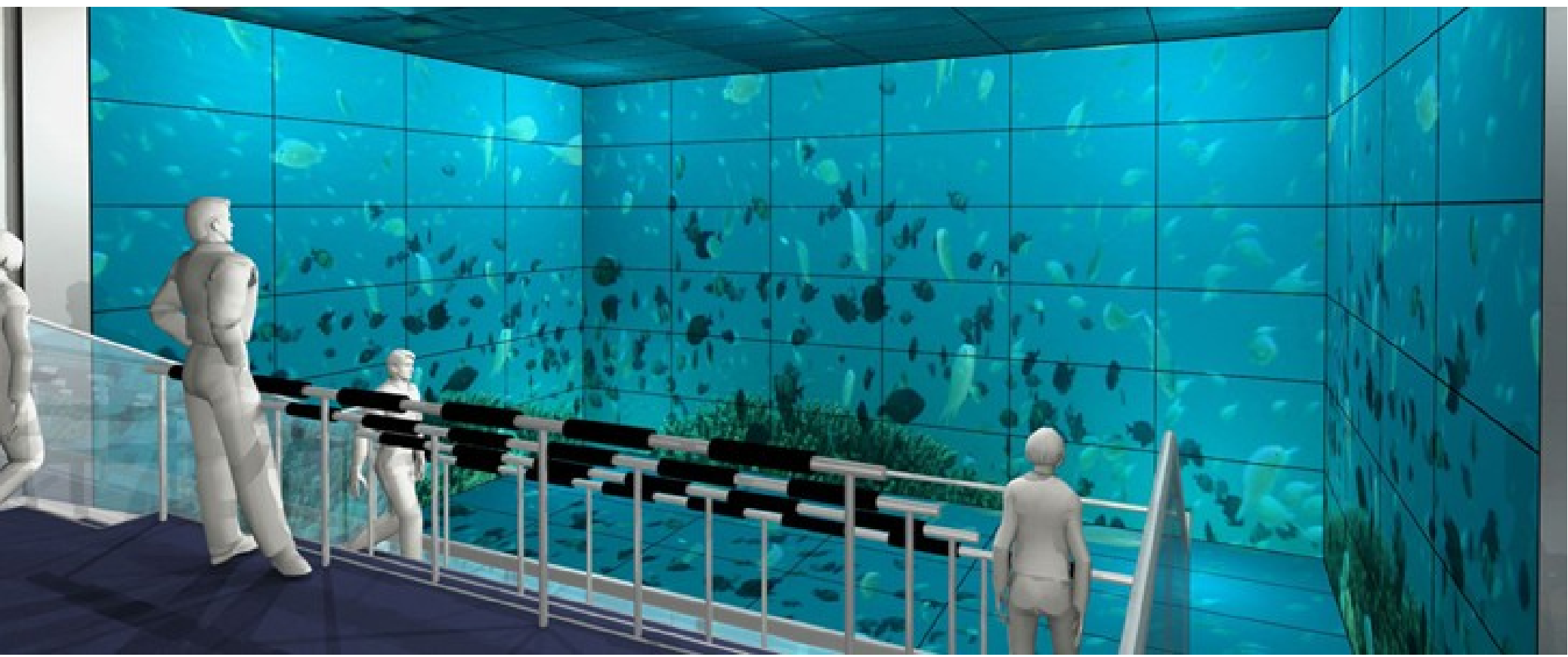
Cultural Heritage Visualization in Chicago's Electronic Visualization Lab's CAVE2



Displayed is a 3D panorama of Luxor in Egypt-
Images were Created at Calit2 by Tom DeFanti and Dan Sandin

The Beginning of Virtual Rooms

Sharp Corp's 156 60"LCDs for the 5D Miracle Tour at the Hui Ten Bosch Theme Park in Nagasaki Opened April 29, 2011



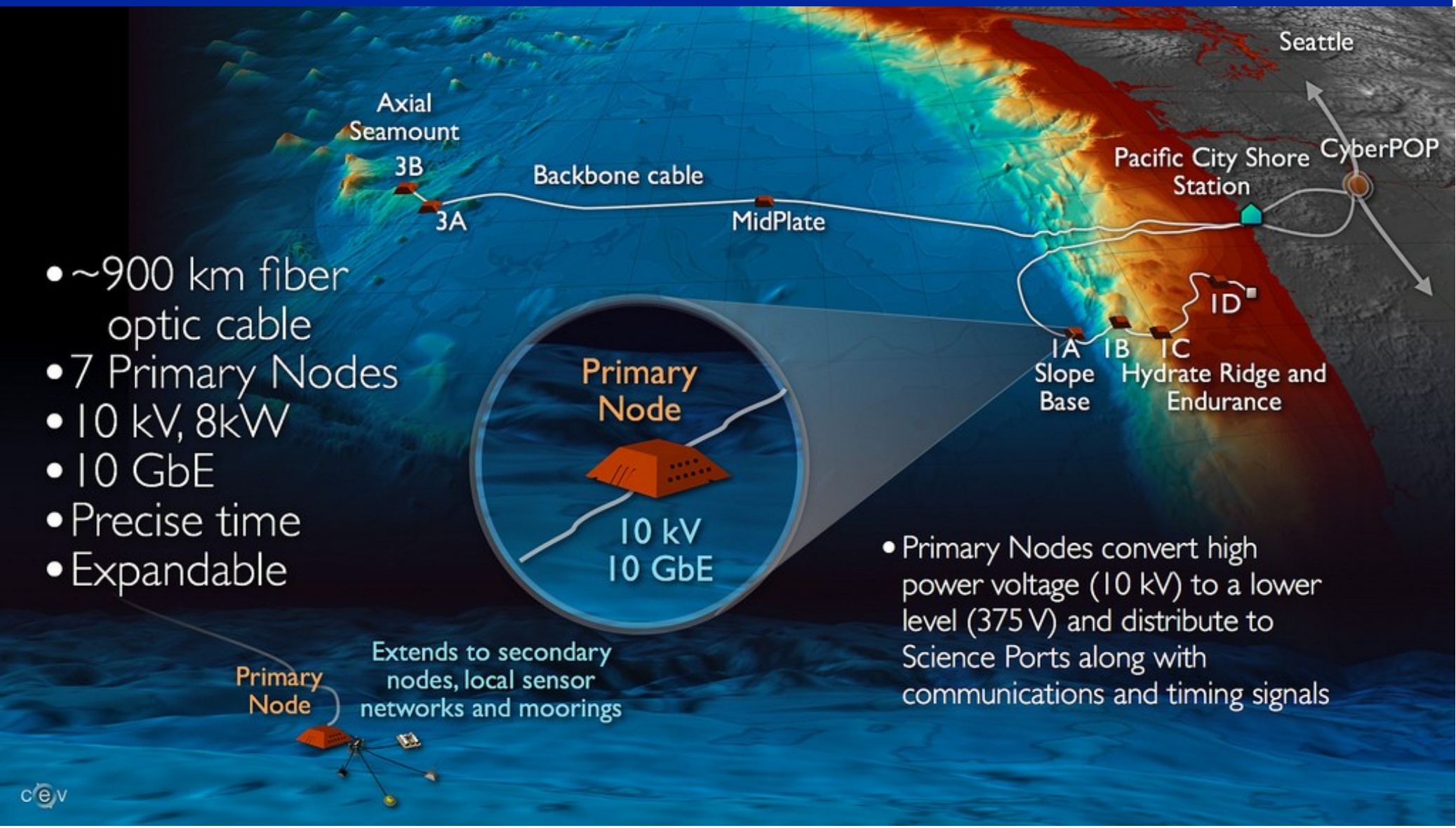
http://sharp-world.com/corporate/news/110426.html

Being There - Remote Interactive High Definition Video of Deep Sea Hydrothermal Vents



Source John Delaney & Deborah Kelley, UWash

NSF's Ocean Observatory Initiative Has Funded Fiber Optic Sensornets on Seafloor Off Washington



OOI NSF Ocean Leadership OSU Oregon State RUTGERS UCSD UNIVERSITY of WASHINGTON it2

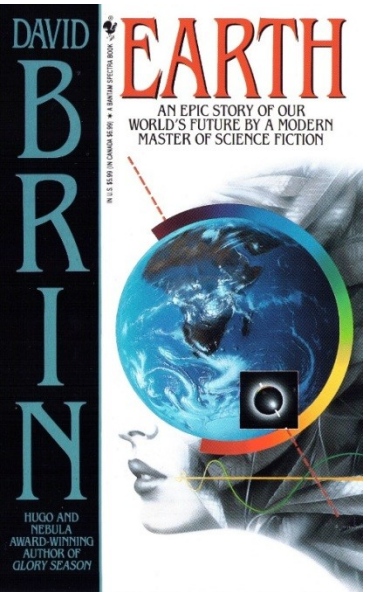

A Near Future
Fiber Optic Cable Observatory
Lights
Robotic Arm
Imaging Sonar
HD Stereo Cameras
Chemistry/Biology Lab
Fiber Optic Cable
Source John Delaney, UWash

David Brin's *Earth* in 2038: Video Cams on Glasses Watch Everyone

"Watching, all the time watching... goggle-eye geeks..."

"The old woman laid her wire-knitting aside and fixed them with the bug-eyed, opaque gape of her True-Vu lenses..."

"Just once I'd like to catch some google geek alone, with fritzed sensors and no come-go record.
Then I'd teach him 'em its *not polite to stare*."



-*Earth*, David Brin (1990)

The Mobile Internet Experience Will Overlay Physical Reality



Google Project Glass

Wikitude 3D Augmented Reality Browser



Glass Has Arrived

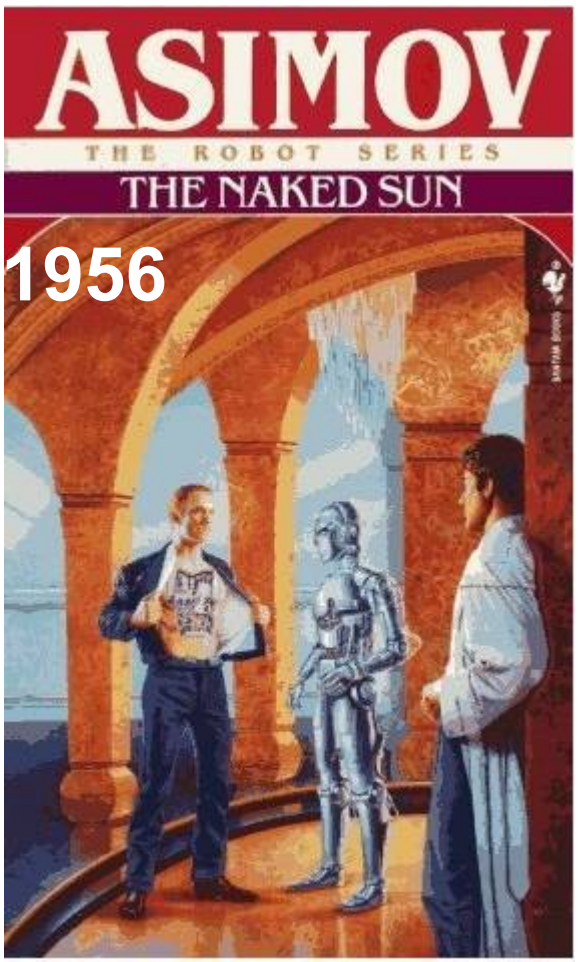


View from Glass
in Back of the Lecture Room



Joseph Streamed Glass Onto My Laptop
Which Was Displayed on the Screen In Front of the Room.
Photo Courtesy of Joseph Smarr From Glass

Over Fifty Years Ago, Asimov Described a World of Remote Viewing

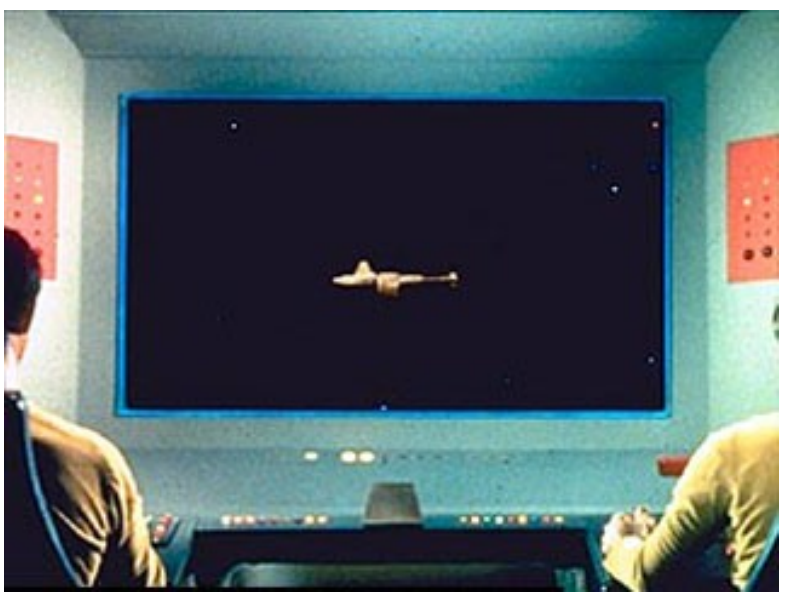


A policeman from Earth, where the population all lives underground in close quarters, is called in to investigate a murder on a distant world. This world is populated by very few humans, rarely if ever, coming into physical proximity of each other. Instead the people "View" each other with trimensional “holographic” images.

TV and Movies of 40 Years Ago Envisioned Telepresence Displays









Source: Star Trek 1966-68; Barbarella 1968

The Bellcore VideoWindow -- A Working Telepresence Experiment



(1989)

“Imagine sitting in your work place lounge having coffee with some colleagues. Now imagine that you and your colleagues are still in the same room, but are separated by a large sheet of glass that does not interfere with your ability to carry on a clear, two-way conversation. Finally, imagine that you have split the room into two parts and moved one part 50 miles down the road, without impairing the quality of your interaction with your friends.”

Source: Fish, Kraut, and Chalfonte-CSCW 1990 Proceedings

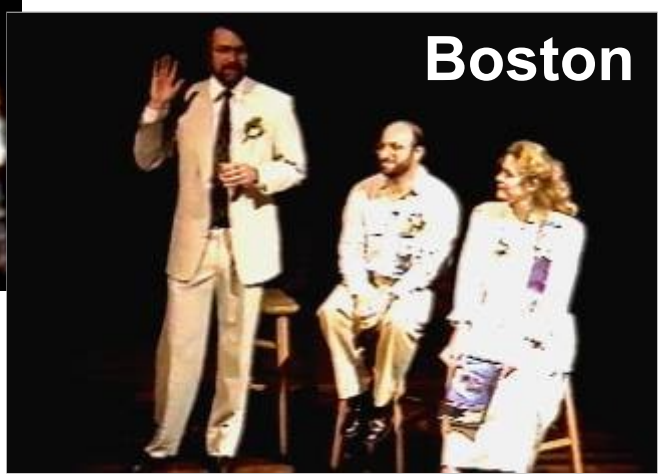
A Simulation of Shared Physical/Virtual Collaboration:

Using Analog Communications to Prototype the Digital Future

"What we really have to do is eliminate distance between individuals who want to interact with other people and with other computers."
— Larry Smarr, Director, NCSA

- **Televisualization:**
  - **Telepresence**
  - **Remote Interactive Visual Supercomputing**
  - **Multi-disciplinary Scientific Visualization**







"We're using satellite technology…to demo what It might be like to have high-speed fiber-optic links between advanced computers in two different geographic locations."

— Al Gore, Senator
Chair, US Senate Subcommittee on Science, Technology and Space

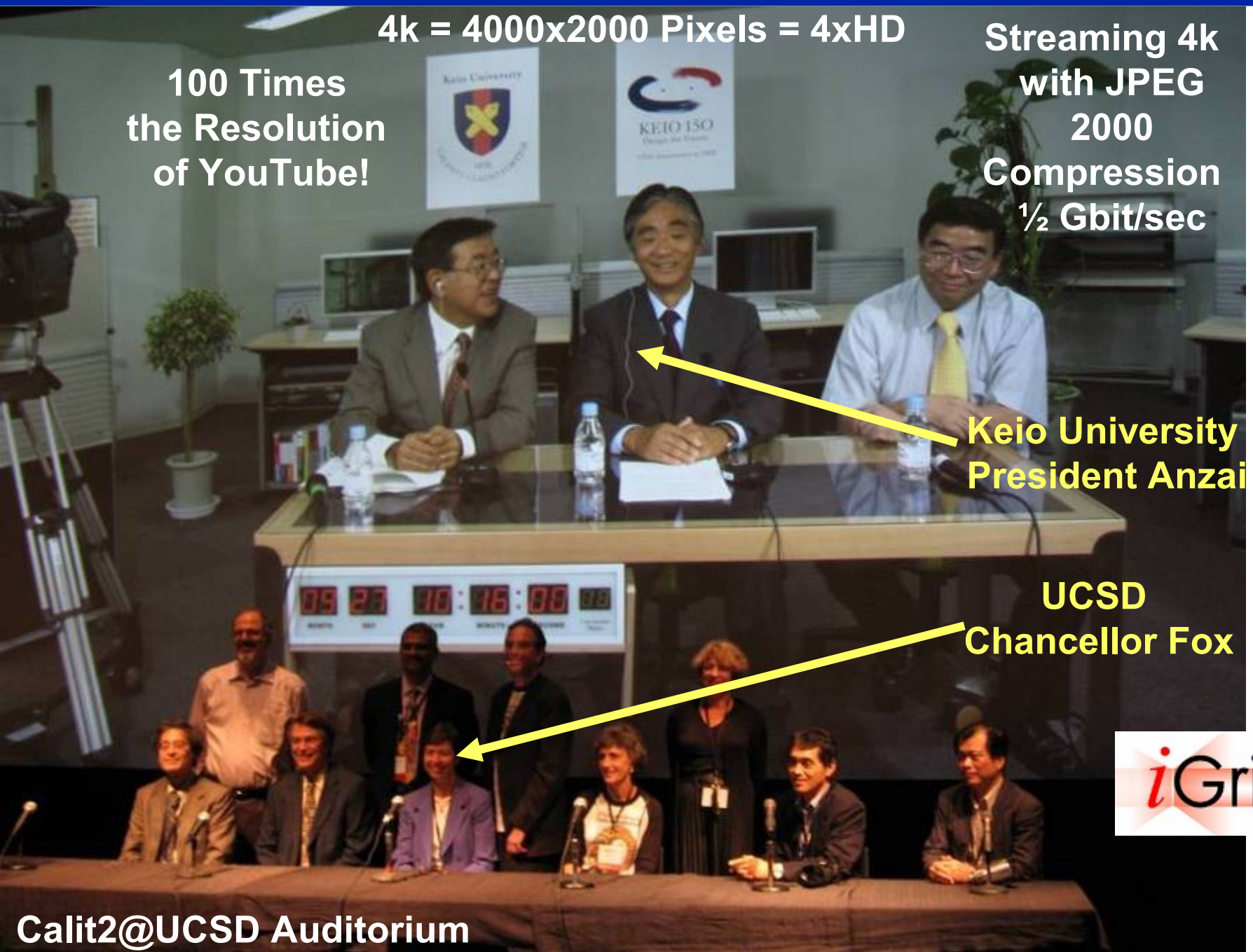
ATT & Sun

SIGGRAPH 1989

NCSA™

it²

Telepresence Meeting
Using Digital Cinema 4k Streams



CineGrid

Lays Technical Basis for Global Digital Cinema

Sony
NTT
SGI

iGrid 2005

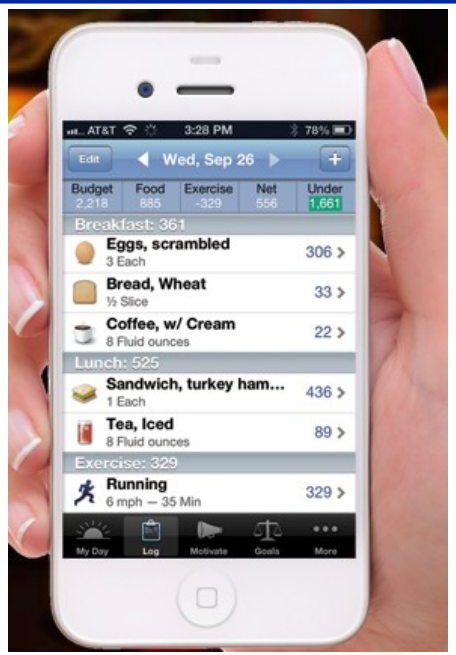
it²

Collaboration Between EVL's CAVE2 and Calit2's VROOM Over 10Gb Wavelength



Source: NTT Sponsored ON*VECTOR Workshop at Calit2 March 6, 2013

Consumer Smartphone Apps Enable Us to Read Out Our Bodies



Lose It- Calories Ingested



Body Media- Calories Burned



Withing/iPhone- Blood Pressure





EM Wave PC- Stress



Azumio-Heart Rate



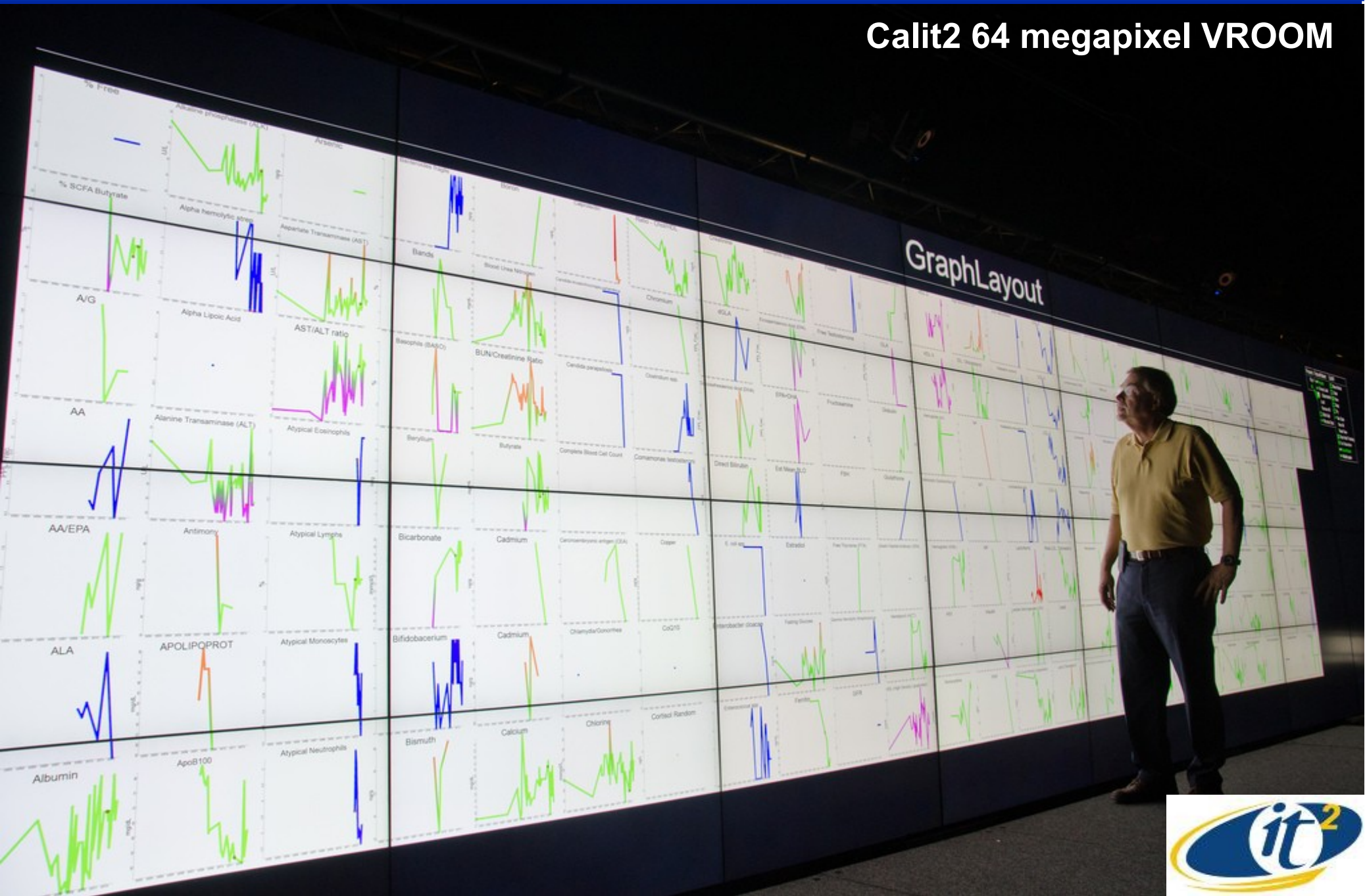
Zeo-Sleep

From Measuring Macro-Variables to Measuring Your Internal Variables



www.technologyreview.com/biomedicine/296

Visualizing Time Series of 150 LS Blood and Stool Variables, Each Over 5 Years



Google Has Given the Author of “the Singularity is Near” the Keys to the Planetary Computer

MIT Technology Review



Will Knight
January 18, 2013

Ray Kurzweil Plans to Create a Mind at Google—and Have It Serve You

A Vision for Healthcare in the Coming Decades

Using this data, the planetary computer will be able to build a computational model of your body and compare your sensor stream with millions of others. Besides providing early detection of internal changes that could lead to disease, cloud-powered voice-recognition wellness coaches could provide continual personalized support on lifestyle choices, potentially staving off disease and making health care affordable for everyone.

ESSAY
An Evolution Toward a Programmable Universe
By LARRY SMARR
Published: December 5, 2011

The New York Times

Science

The Internet Moves Into Space



@Astro_TJ: Hello Twitterverse!
We r now LIVE tweeting from
the International Space Station –
the 1st live tweet from Space! :)
More soon, send your ?s

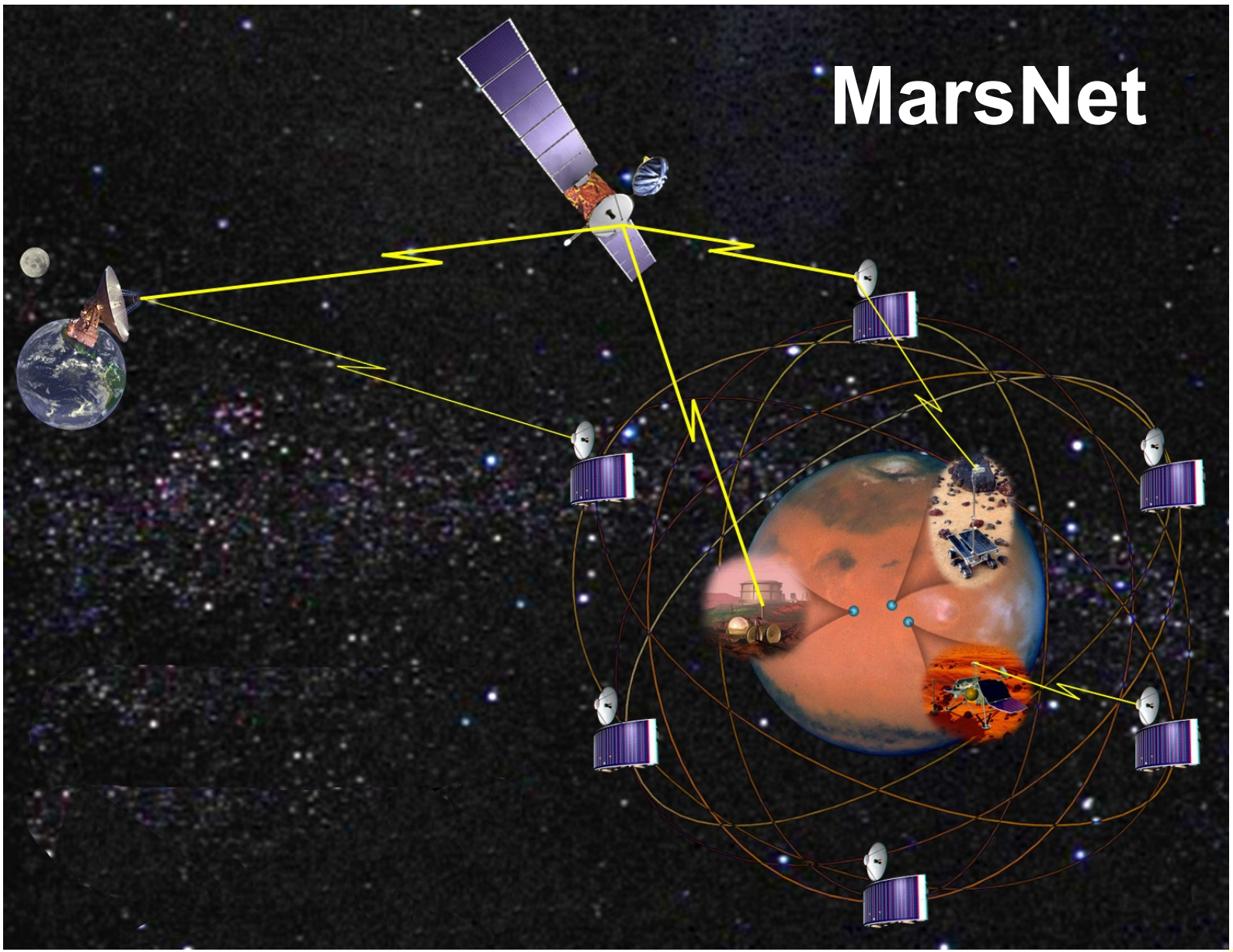
ISS Expedition 22 Flight Engineer T.J. Creamer
January 22, 2010

Using the Web in Space



Photo Source: NASA

InterPlaNetary Internet—Extending the Interactive Integrated Vision to the Exploration Initiative



Source: JPL, Vint Cerf, Google