The Evolution of Information Technology

The Themes of Our Times

- An Age of Knowledge, in which educated people and their ideas have become the strategic commodities determining prosperity, security, and social well-being.
- The global nature of our society.
- Rapidly evolving information technology that reshapes, strengthens, and accelerates the activities of knowledge driven organizations.
- Networking, the degree to which cooperation and collaboration among individuals and institutions are replacing more formal social structures such as governments and states.

A Detour:
The Evolution of Computers

Mainframes (Big Iron)
…IBM, CDC, Amdahl
…Proprietary software
…FORTRAN, COBOL
…Batch, time-sharing

Minicomputers
…DEC, Data Gen, HP
…PDP, Vax
…C, Unix

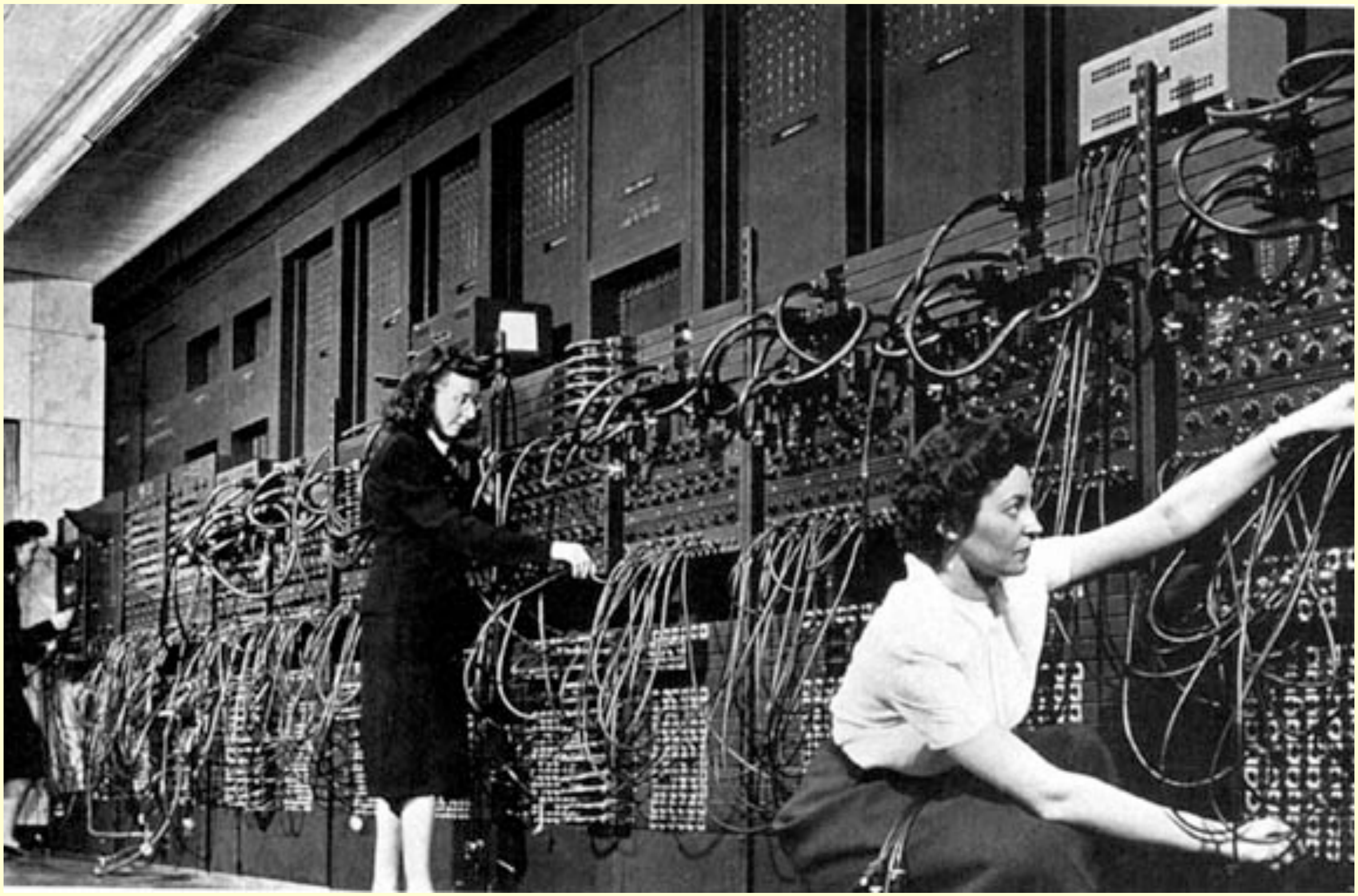
Microcomputers
…Hand calculators
…TRS, Apple, IBM
…Hobby kits -> PCs

Supercomputers
…Vector processors
…Cray, IBM, Fujitsu
…Parallel processors
…Massively parallel

Networking
…LANs, Ethernet
…Client-server systems
…Arpanet, NSFnet, Internet

Batch → Time-sharing → Personal → Collaborative

From Eniac



To ASCI "Q" … and beyond


NPACI
Blue Horizon


ASCI White


ASCI
Blue Mountain


ASCI Q


ASCI Cplant


ASCI Blue-Pacific


ASCI
Whitecap


ASCI Red

Platforms Help

Using ASCI White

Using ASCI Blue-Pacific

Using ASCI Q

Using ASCI Red

Using ASCI Blue Mountain

Using ASCI Cplant

Using NPACI Blue Horizon
(available for special ASCI unclassified use)

Using ASCI Whitecap

Platforms Contacts
Mark Seager
seager@llnl.gov

James Tomkins
jltomki@sandia.gov

ASCI Purple RFP

ASCI Home

Red's Home
Users' Home
Policies
Getting Started
Getting Help
System Status
Hardware Environment
Software Environment
Frequently Asked Questions
Running Jobs
Bonus Links

No-Frames version

For technical information, contact: janus-help@sandia.gov

Privacy and Security

ASCI Red
Users' Guide

The hardware for ASCI Red, the world's fastest computer, is now complete, as the picture above shows. ASCI Red is a first-of-a-kind computer, and the operating software is under development, as are these web pages.

Using ASCI White

About ASCI White...

ASCI White is the third step in the DOE's five stage Accelerated Strategic Computing Initiative (ASCI) plan to achieve a 100 TeraOP/s supercomputer system by 2004. It is part of the DOE's science-based Stockpile Stewardship Program to maintain the safety and reliability of the US nuclear stockpile without underground testing. See ASCI White news for details.

ASCI White is actually comprised of three separate systems based upon IBM's POWER3 SP technology. The largest system is a 512 node SMP (16 CPUs/node) system that is currently ranked as the world's fastest computer, with a peak speed slightly greater than 12 TeraOP/s.

The table below sumarizes the systems that comprise ASCI White. For more detailed configuration and architecture information, please see the Hardware section.

Privacy & Legal Notice

LANL Consulting Help
consult@lanl.gov

ASCI@LANL Web Site
http://www.lanl.gov/asci/

ASC Quick Facts
http://public.lanl.gov/consult/qsc/

Using ASCI Q

ASCI Q is the fourth step in the DOE's five-stage Advanced Simulation and Computing (ASCI) plan to achieve a 100 TeraOP/s supercomputer system by 2004. It is part of the DOE's science-based Stockpile Stewardship Program to maintain the safety and reliability of the U.S. nuclear stockpile without underground testing.

ASCI Q, located at Los Alamos National Laboratory, comprises multiple systems based on HP/Compaq's latest technology. The first 1024-node unit of ASCI Q, FS-QA, was installed and certified July 1, 2002.

Consult **Using LANL's Parallel Q Machines (QA, QB, QSC)** [PDF] for information on accessing and using ASCI Q.

For technical information, contact the Livermore Computing Hotline, lc-hotline@llnl.gov, telephone (925) 422-4531

TOP500™ SUPERCOMPUTER SITES

PRESENTED BY
UNIV. OF MANNHEIM
UNIV. OF TENNESSEE
NERSC/LBNL

SUBMIT YOUR SITE

SEARCH FOR:

GO

Clusters @ TOP500

TOP500 List for November 2002

R_{max} and R_{peak} values are in GFlops. For more details about other fields, please click on the button "Explanation of the Fields"

DETAILS

EXPLANATION OF THE FIELDS

Rank	Manufacturer Computer/Procs	R_{max} R_{peak}	Installation Site Country/Year
1	**NEC** Earth-Simulator/ 5120	**35860.00** 40960.00	Earth Simulator Center Japan/2002
2	**Hewlett-Packard** ASCI Q - AlphaServer SC ES45/1.25 GHz/ 4096	**7727.00** 10240.00	Los Alamos National Laboratory USA/2002
3	**Hewlett-Packard** ASCI Q - AlphaServer SC ES45/1.25 GHz/ 4096	**7727.00** 10240.00	Los Alamos National Laboratory USA/2002
4	**IBM** ASCI White, SP Power3 375 MHz/ 8192	**7226.00** 12288.00	Lawrence Livermore National Laboratory USA/2000
5	**Linux NetworX** MCR Linux Cluster Xeon 2.4 GHz - Quadrics/ 2304	**5694.00** 11060.00	Lawrence Livermore National Laboratory USA/2002
6	**Hewlett-Packard** AlphaServer SC ES45/1 GHz/ 3016	**4463.00** 6032.00	Pittsburgh Supercomputing Center USA/2001
7	**Hewlett-Packard** AlphaServer SC ES45/1 GHz/ 2560	**3980.00** 5120.00	Commissariat a l'Energie Atomique (CEA) France/2001
8	**HPTi** Aspen Systems, Dual Xeon 2.2 GHz - Myrinet2000/ 1536	**3337.00** 6758.00	Forecast Systems Laboratory - NOAA USA/2002
9	**IBM** pSeries 690 Turbo 1.3GHz/ 1280	**3241.00** 6656.00	HPCx UK/2002
10	**IBM**	**3164.00**	NCAR (National Center for

地球シミュレータセンター

EARTH SIMULATOR

- Tetsuya Sato Director - General of ESC
- Outline of The Earth Simulator
- Link
- Reference
- Access map

What's new

New

02/11/21 The Earth Simulator Center handout for SC2002

- The page only for users (Required password)
- Registration

Updating history

02/11/21 Regarding International Cooperation of the Earth Simulator Center


Japan Earth Simulator


PN-07-12/13
PN-08-08/09
PN-09-14/15

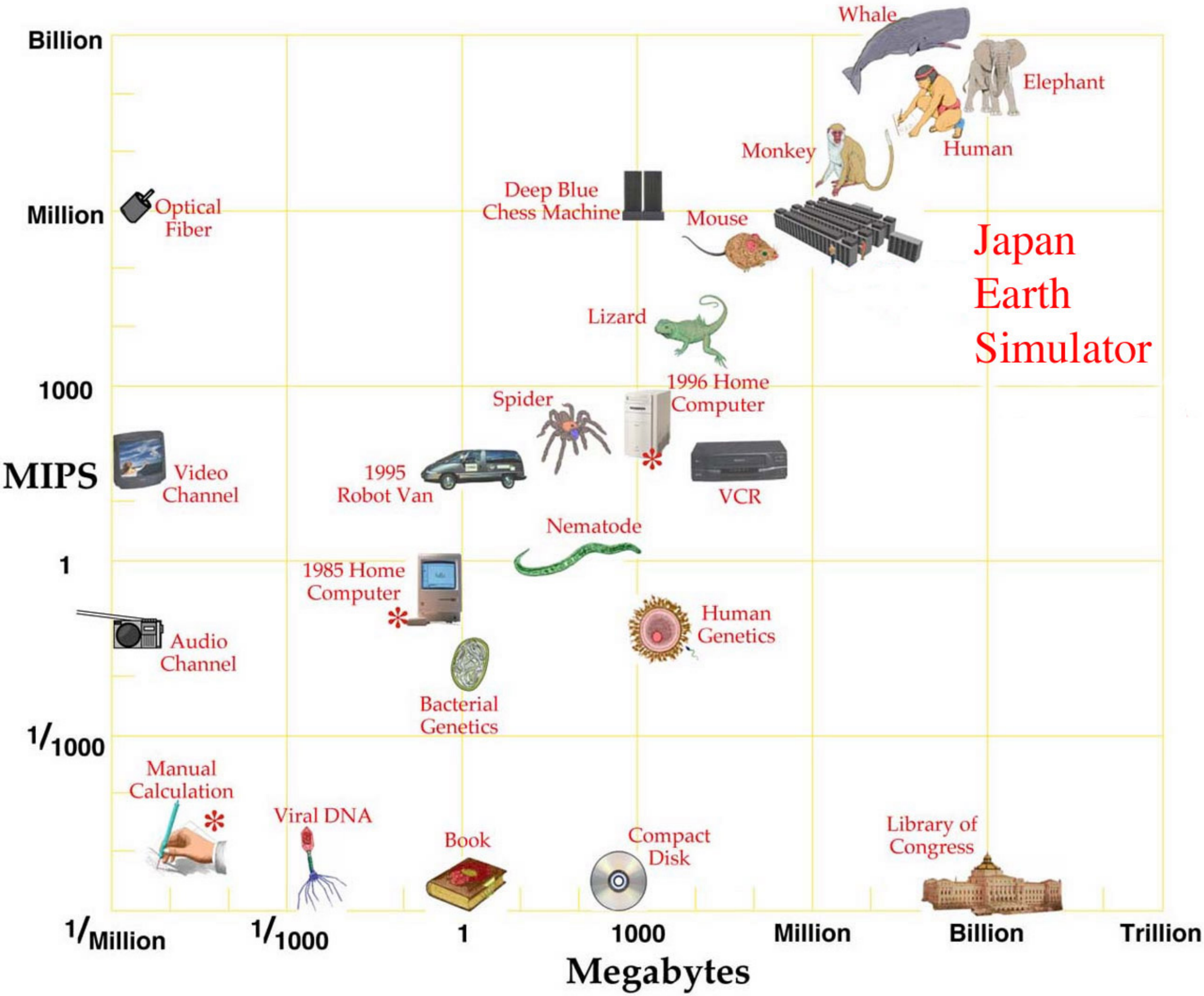
ASCI Purple RFP

Privacy & Legal Notice

The Purple RFP was issued on February 22, 2002

RFP RESPONSES ARE DUE 4:00 P.M. PDT APRIL 29, 2002

All Thinks, Great and Small



ASCI Purple (2004):

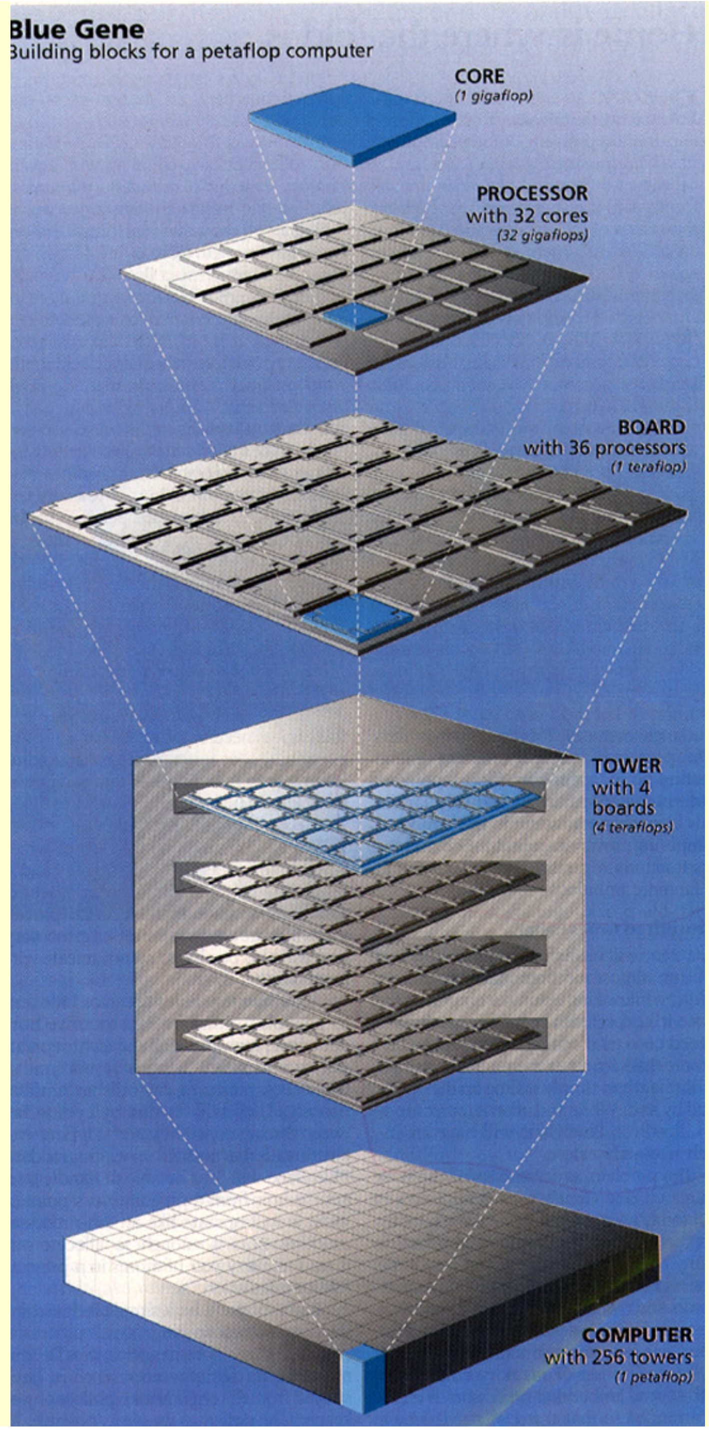
100 TeraFlops

IBM Blue Gene L (2004):

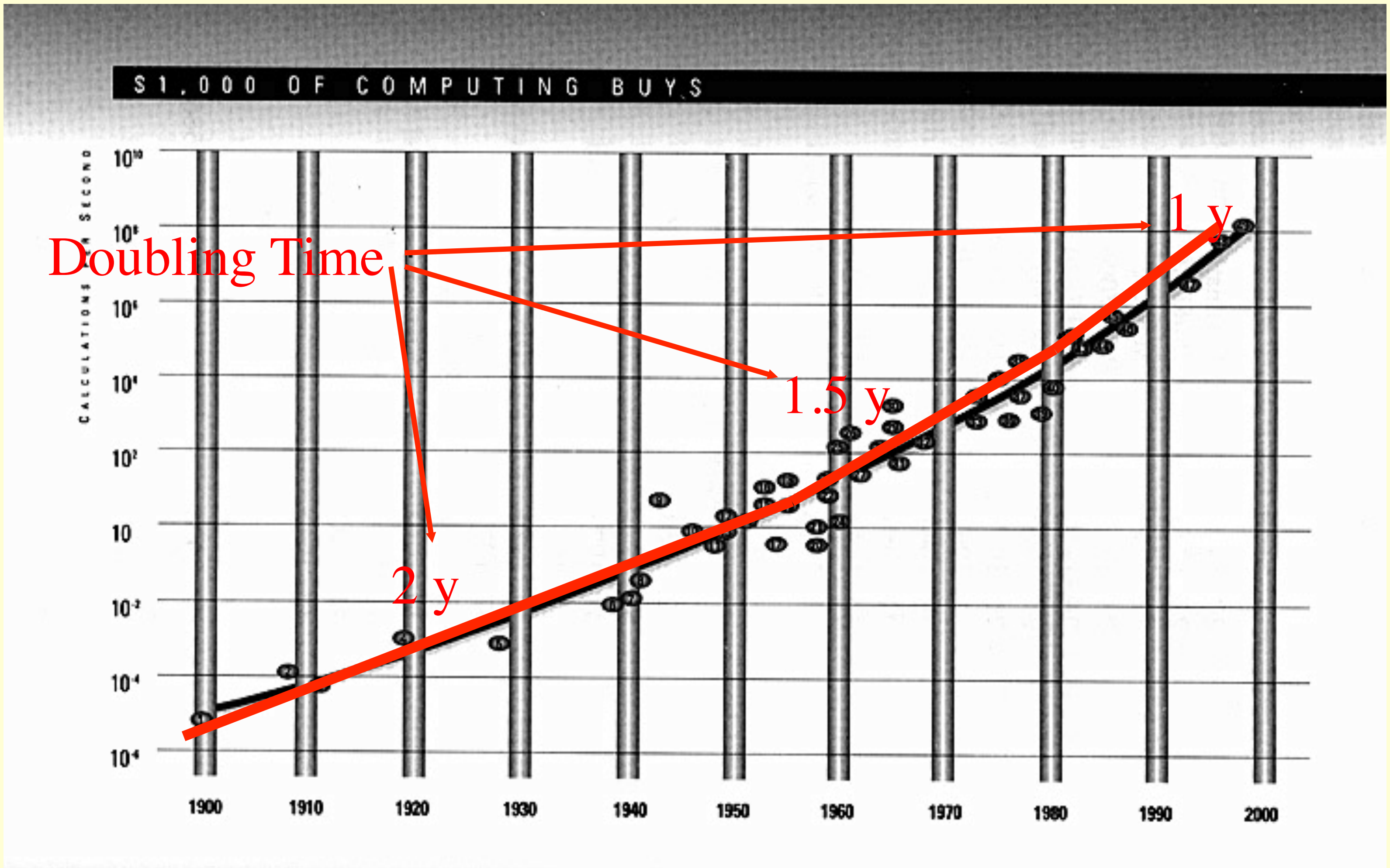
360 TeraFlops

IBM Blue Gene P (2006):

“Several” PetaFlops



The Evolution of Computing



Some Extrapolation of the PC

	2000	2010	2020
Speed	10^9	10^{12}	10^{15}
RAM	10^8	10^{11}	10^{14}
Disk	10^9	10^{12}	10^{15}
LAN	10^8	10^{12}	10^{15}
Wireless	10^6	10^9	10^{12}

Some Examples

- **Speed**
  - MHz to GHz to THz to Peta Hz
- **Memory**
  - MB (RAM) to GB (CD,DVD) to TB (holographic)
- **Bandwidth**
  - Kb/s (modem) to Mb/s (Ethernet) to Gb/s
  - Internet2 (Project Abilene): 10 Gb/s
- **Networks**
  - Copper to fiber to wireless to photonics
  - “Fiber to the forehead…”

Hardware Technology Trends

- Processing (Moore's Law) (increasing 40% per year)
  - Current speed record: 150 GHz chips
- Disk storage (increasing 60% to 100% per year)
  - 3.5 disk can hold 320 Gb
  - Far cheaper than paper or microfilm
- Bandwidth
  - Lab demo on single fiber: 11 Tb/s
  - Real communication at 40 Gb/s
- Mobility
  - 802.11 (a, b, g, I) at 55 Mb/s and beyond
- Displays
  - Full wall projections
  - Resolution must better than paper

Software and System Trends

- Algorithm improvements
- Embodiment of techniques and processes into software
  - Formalization and standardization
  - People are the exception rather than the main line
- Distribution of computing, data, applications, and services
- Grid intercollection of resources
- Services as unit of IT, rather than bare-bones data and processing

Technology Directions

Technology: Today -> 2003-2006 -> 2010

- Access Bandwidth: 56 kb/s -> Mb/s -> 100 Mb/s-1 Gb/s
- Backbone Bandwidth: 155 Mb/s -> Tb/s -> Pb/s
- Intercontinental Bandwidth: 45 Mb/s -> 3 Tb/s -> many Tb/s
- Wireless: 32 kB/s -> 55 Mb/s -> Gb/s
- Enterprise database: 30 TB -> PB -> 10 PB +
- Supercomputing: 40 TFLOPS -> PFLOPS -> 100 PFLOPS
- Display: .5 Mpixel, 5. sqft -> 9 Mpixel, 60 sqft > much more

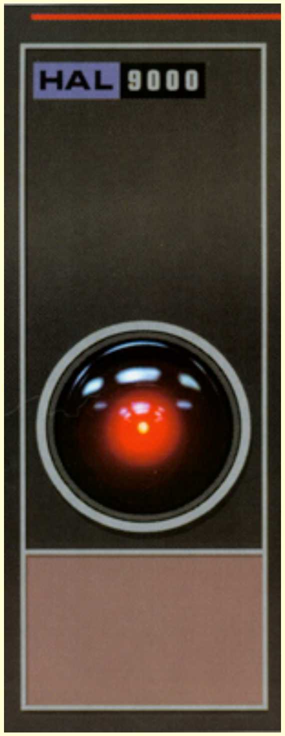
Computer-Mediated Human Interaction

- **1-D (words)**
  - Text, e-mail, chatrooms, telephony
- **2-D (images)**
  - Graphics, video, WWW, multimedia
- **3-D (environments)**
  - Virtual reality, distributed virtual environments
  - Immersive simulations, avatars
  - Virtual communities and organizations
- **And beyond... (experiences, “sim-stim”)**
  - Telepresence
  - Neural implants

Evolution of the Net

- Already beyond human comprehension
- Incorporates ideas and mediates interactions among millions of people
- 200 million today; more than 1 billion in 2005
- Internet II, Project Abilene

Some Other Possibilities



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- **Agents and avatars?**
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  - Plugging the nervous system into the Net
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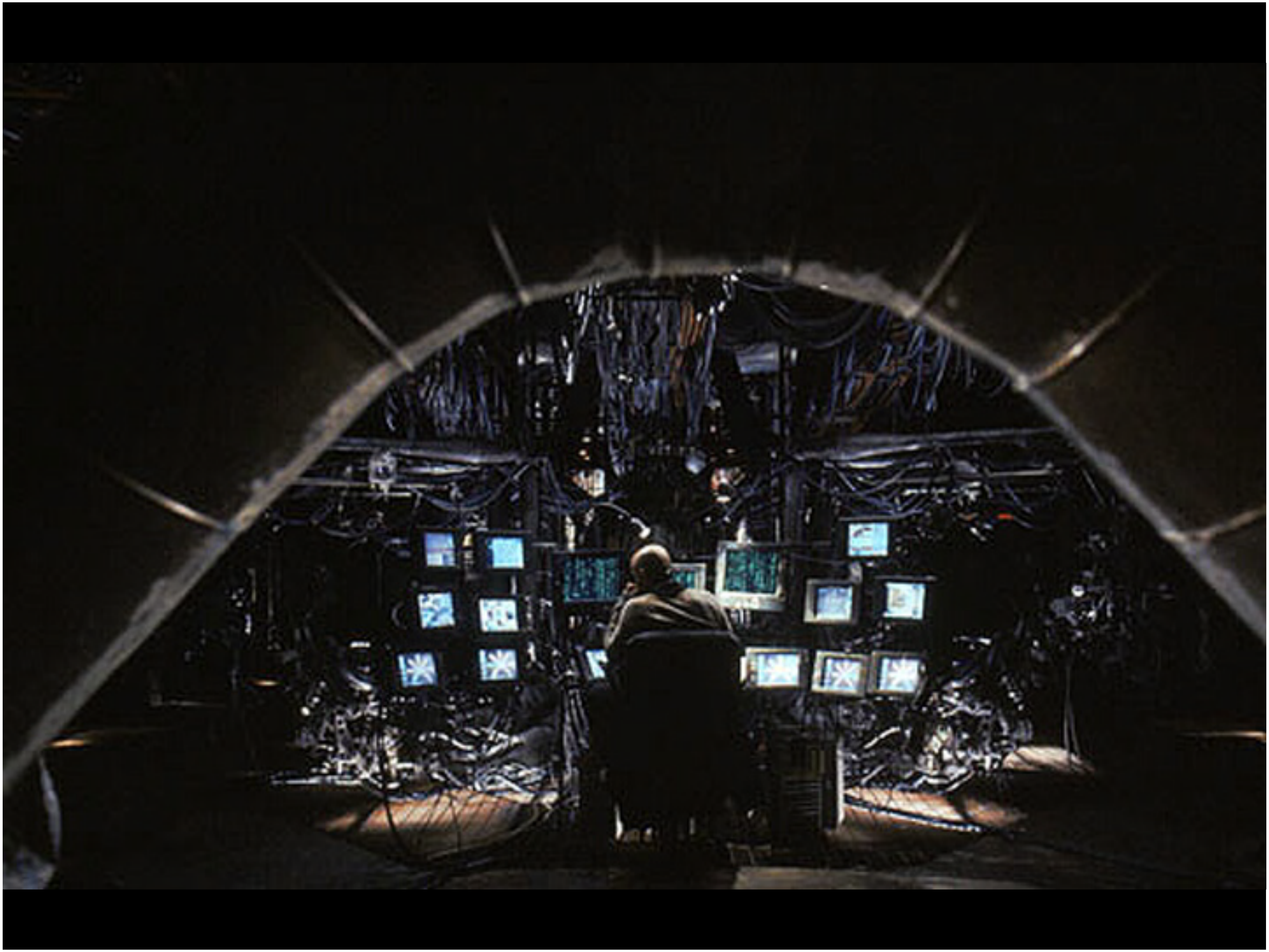
  - … Self organization
  - … Learning capacity
  - … Consciousness (HAL 9000)



Cyberinfrastructure

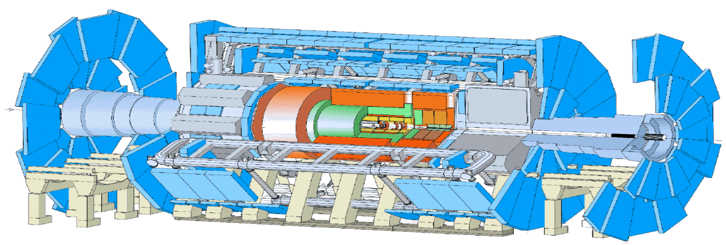
e-Science

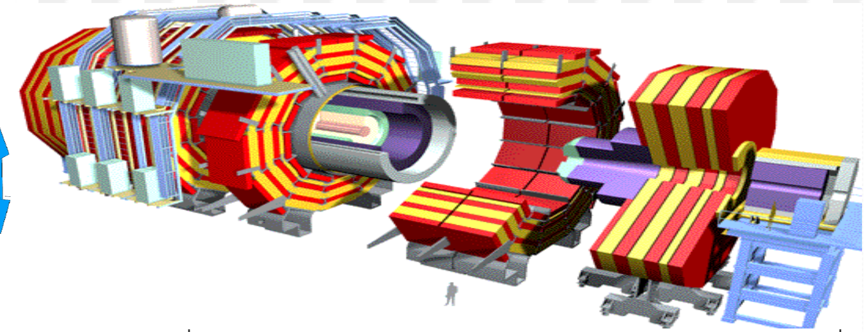
- science increasingly done through ***distributed global collaborations*** between people, enabled by the internet
- using very large data collections, terascale computing resources and high performance visualisation
- derived from instruments and facilities controlled and shared via the infrastructure
- Scaling X1000 in processing power, data, bandwidth

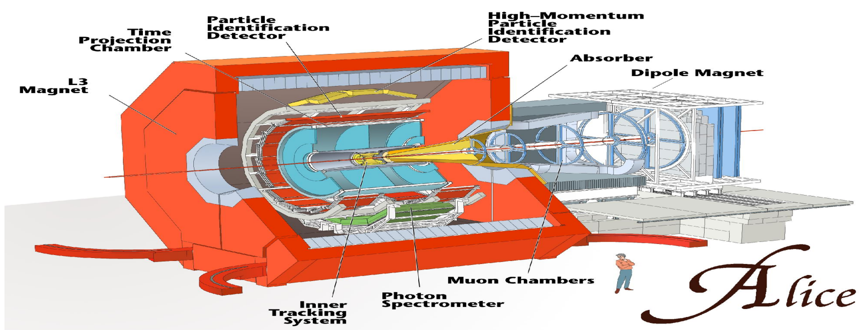
Four LHC Experiments: The Petabyte to Exabyte Challenge

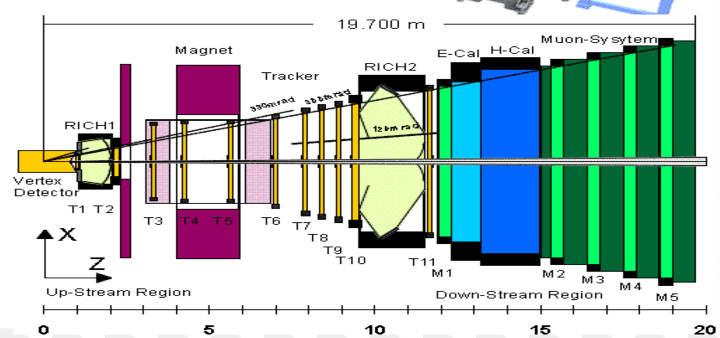
ATLAS, CMS, ALICE, LHCB

Higgs + New particles; Quark-Gluon Plasma; CP Violation







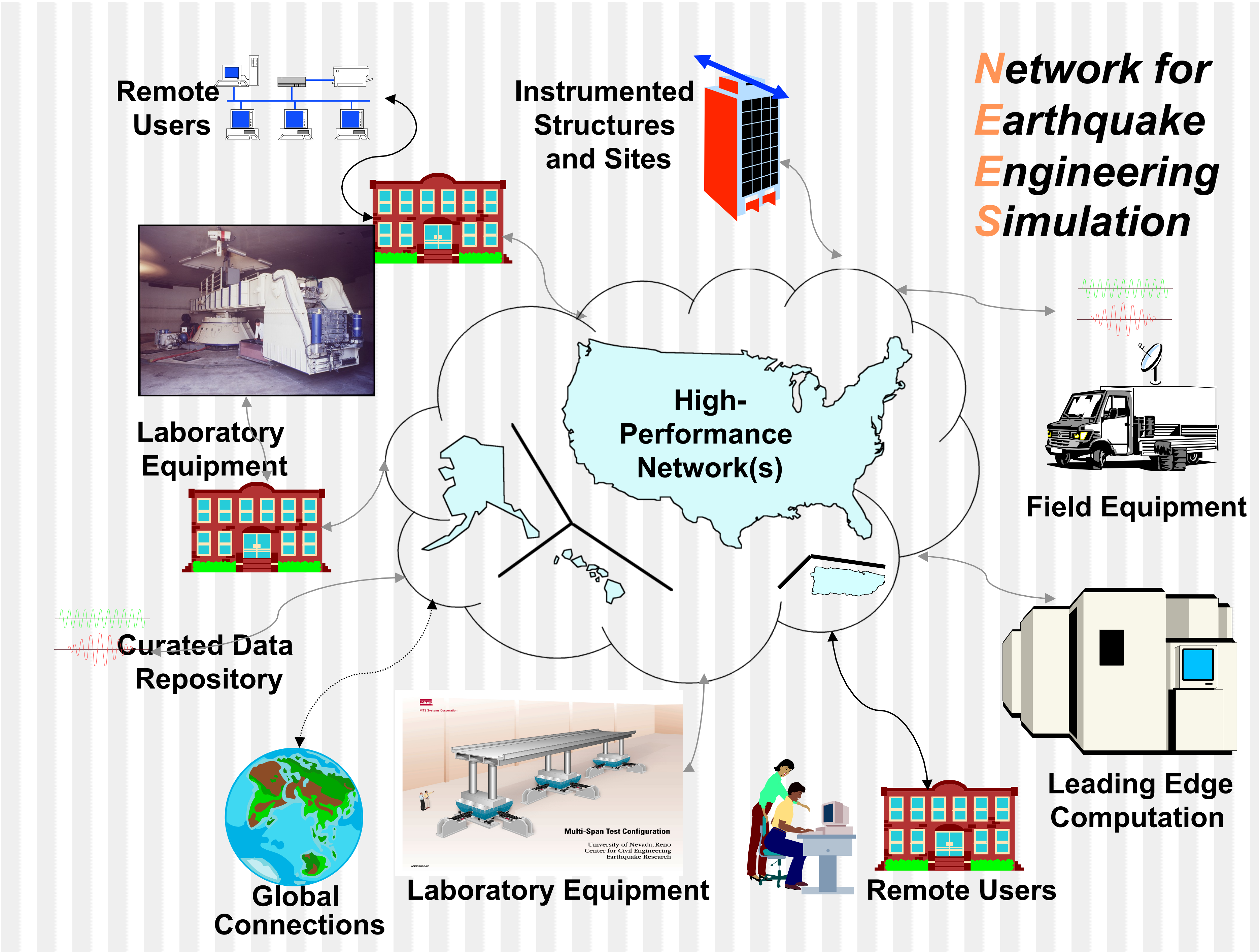


Data stored ~40 Petabytes/Year and UP;

CPU 0.30 Petaflops and UP

0.1 to 1 Exabyte (1 EB = 10^{18} Bytes)

(2007) (~2012 ?) for the LHC Experiments


Network for
Earthquake
Engineering
Simulation
Remote Users
Instrumented Structures and Sites
Laboratory Equipment
High-Performance Network(s)
Field Equipment
Curated Data Repository
Global Connections
Multi-Span Test Configuration
University of Nevada, Reno
Center for Civil Engineering
Earthquake Research
Laboratory Equipment
Remote Users
Leading Edge Computation

TELESCIENCE: REMOTE ACCESS FOR DATA ACQUISITION, GRID - BASED COMPUTING, DISTRIBUTED DATA STORAGE

Project leaders:

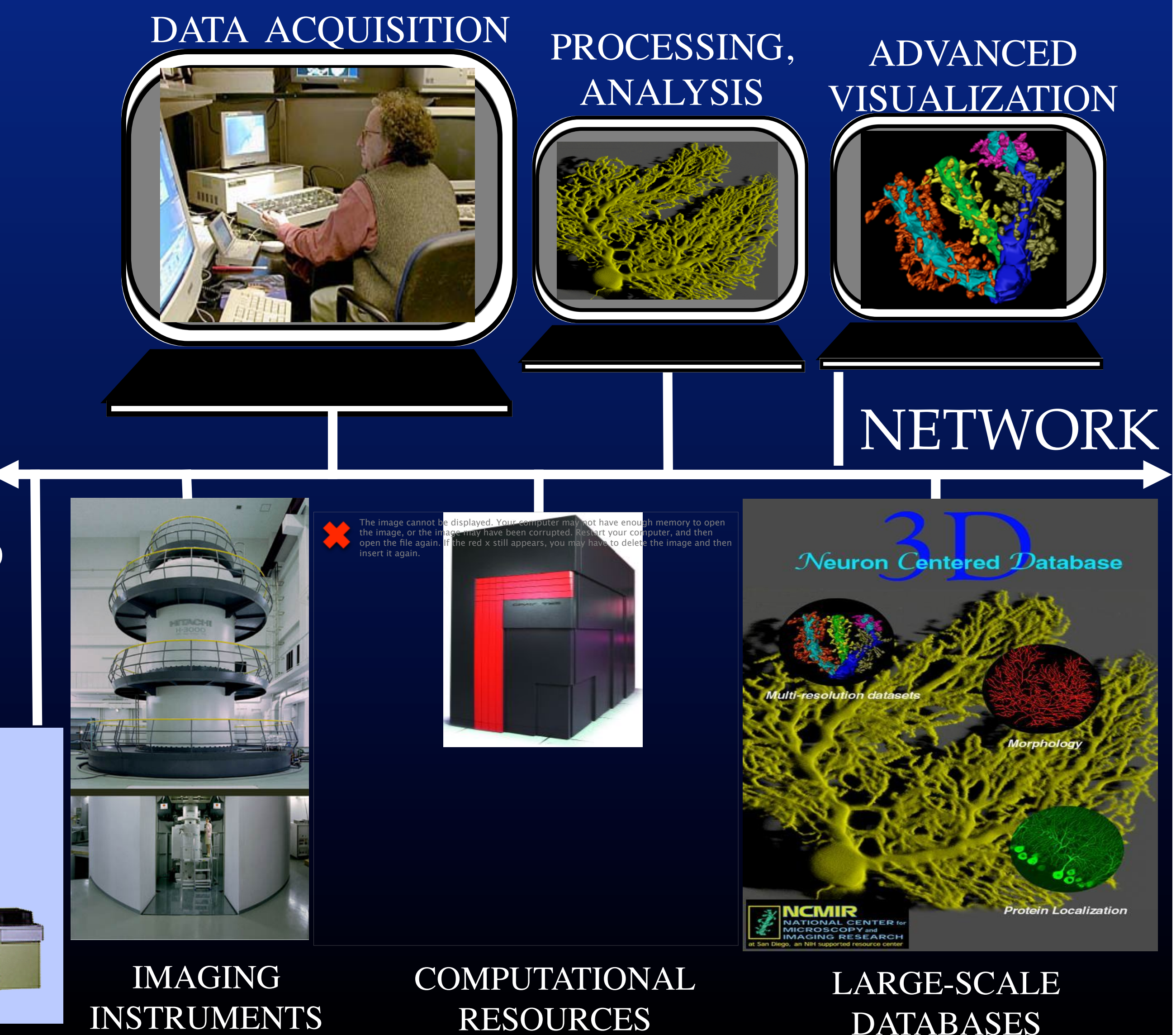
- Mark Ellisman, UCSD;
- Carl Kesselman, USC;
- Fran Berman, UCSD;
- Rich Wolski, UCSB;

Project Manager:

- Steve Peltier, UCSD

Senior Participants:

- Gwen Jacobs, Montana State U.
- Reagan Moore, SDSC/UCSD
- Maryann Martone, UCSD/NCMIR
- Amarnath Gupta, SDSC/UCSD
- Bertram Ludaescher, SDSC/UCSD
- Chandrijt Bajaj, U.Texas
- Steve Lamont, UCSD
- Shinji Shimojo, Osaka Univ.



(Cyber) infrastructure

- The term *infrastructure* has been used since the 1920's to refer collectively to the roads, bridges, rail lines, and similar public works that are required for an industrial economy to function.
- The recent term *cyberinfrastructure* refers to an infrastructure based upon computer, information and communication technology (increasingly) required for discovery, dissemination, and preservation of knowledge.
- Traditional infrastructure is required for an industrial economy. Cyberinfrastructure is required for an information economy.

Cyberinfrastructure: the Middle Layer

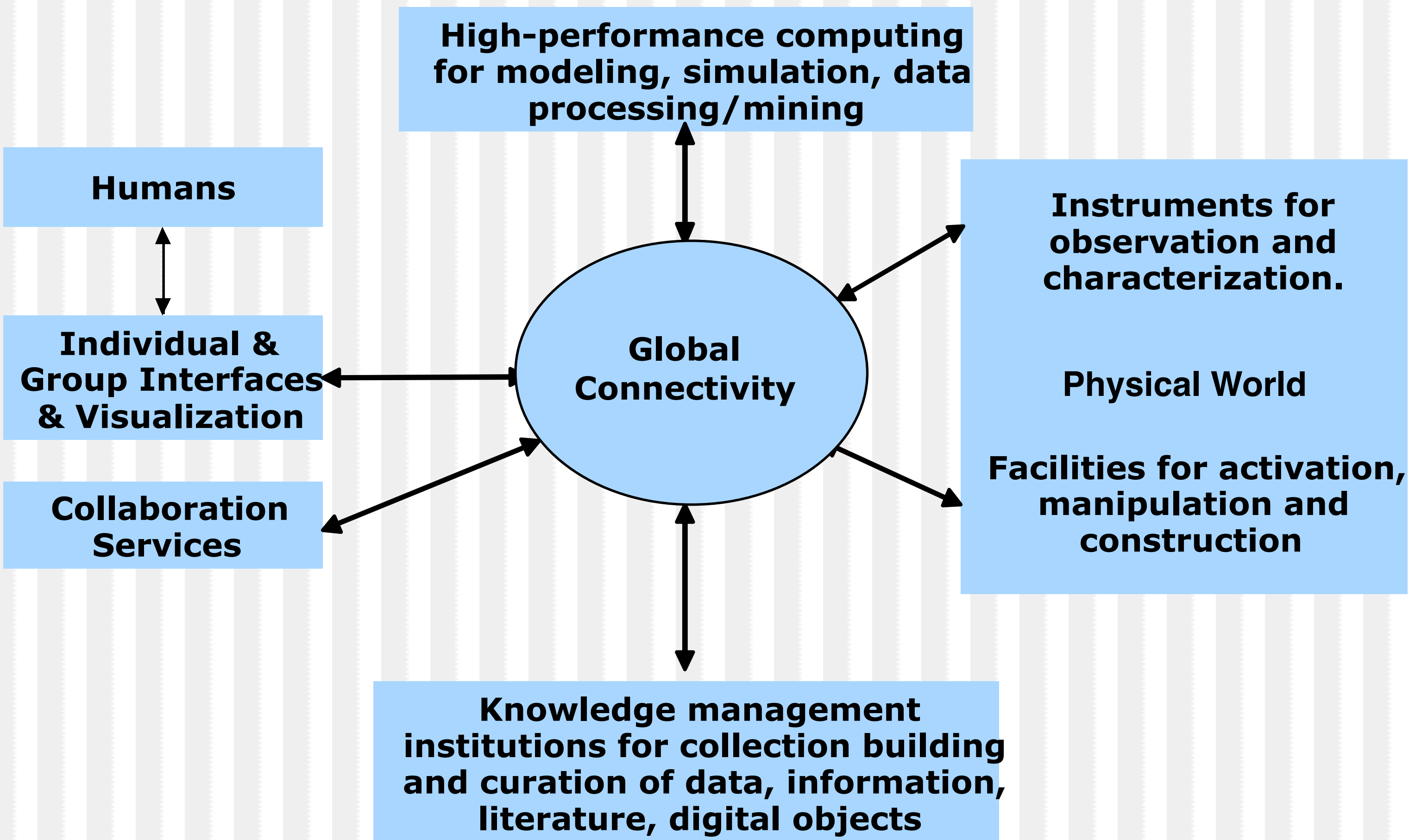
Applications in science and engineering research and education

Cyberinfrastructure: hardware, software, personnel, services, institutions

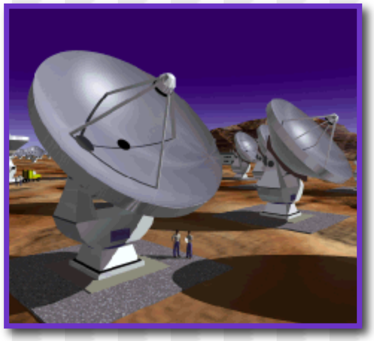
Base-technology: computation, storage, communication

Components of CI-enabled science & engineering

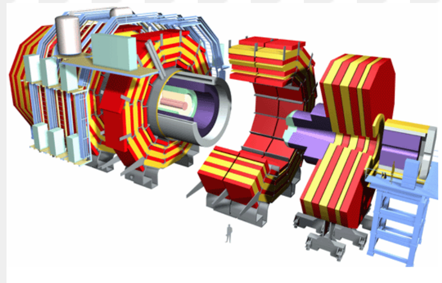
A broad, systemic, strategic conceptualization

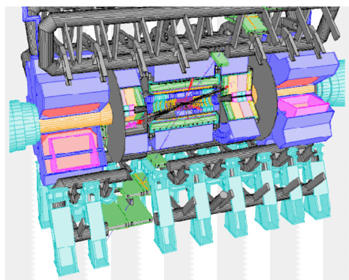


Cyberinfrastructure Enabled Science

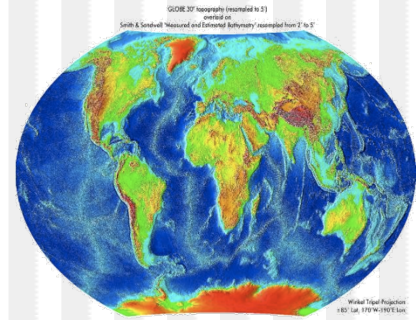


NVO and ALMA





ATLAS and CMS



Climate Change

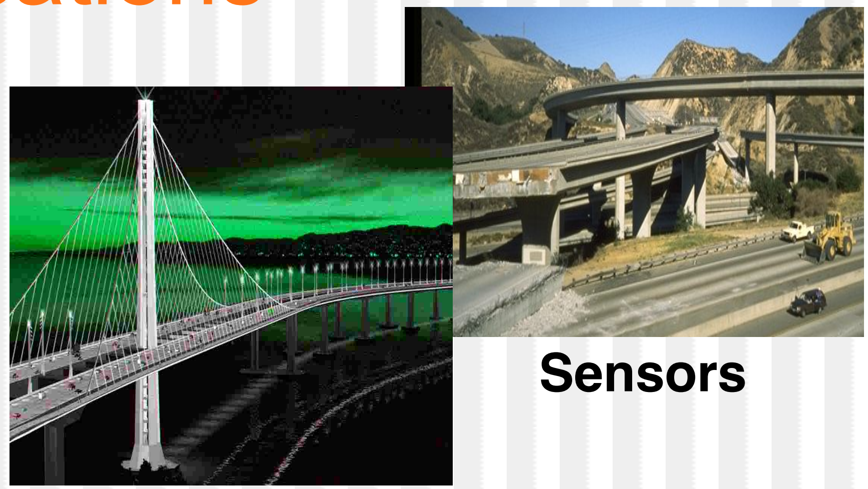
United States virtual observatory

LIGO

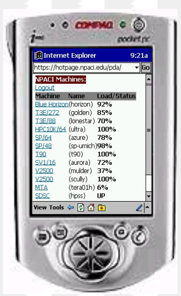
The number of nation-scale projects is growing rapidly!

More Diversity, New Devices, New Applications

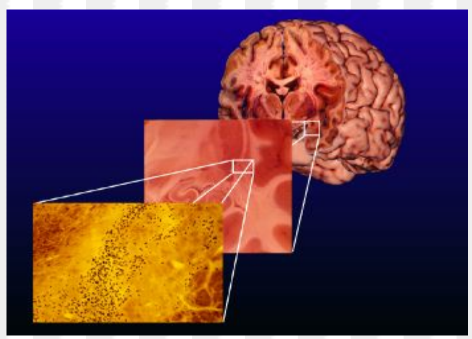
Personalized Medicine



Sensors



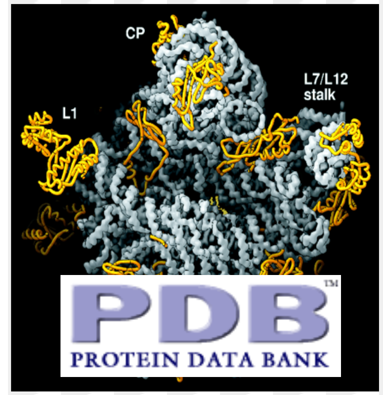
Wireless networks



Knowledge from Data

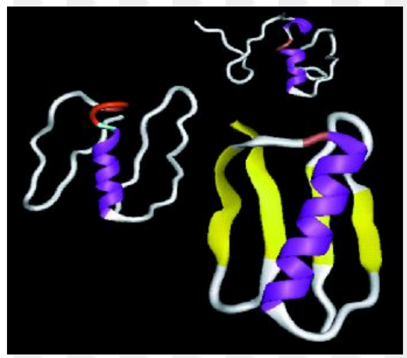
Instruments

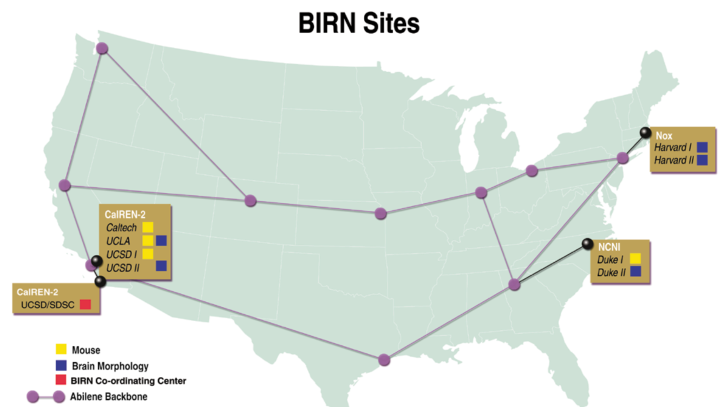
Cyberinfrastructure is a First-Class Tool for Science

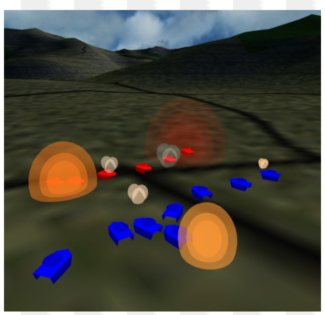


GriPhyN
Data Intensive Science

iVDgL

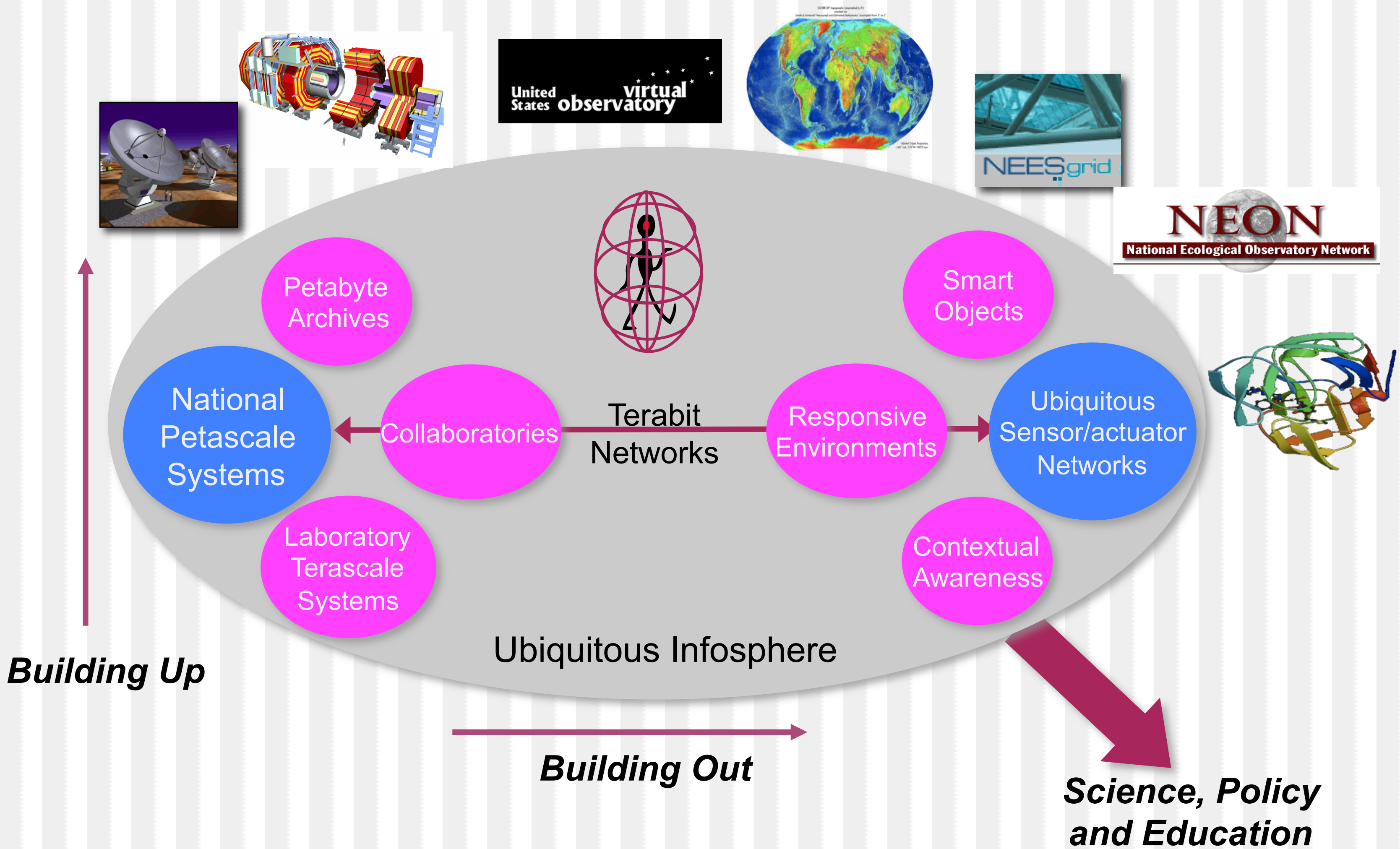






United States virtual observatory

Futures: The Computing Continuum



Two leading U.S. initiatives

- Next Generation Abilene
  - Advanced Internet **backbone**
    - connects entire campus networks of the research universities
  - 10 Gbps nationally
- TeraGrid
  - **Virtual machine room** for distributed computing (Grid)
  - Connecting 4 HPC centers initially
    - Illinois: NCSA, Argonne
    - California: SDSC, Caltech
  - 4x10 Gbps: Chicago ↔ Los Angeles
- Ongoing collaboration between both projects

About Internet2®

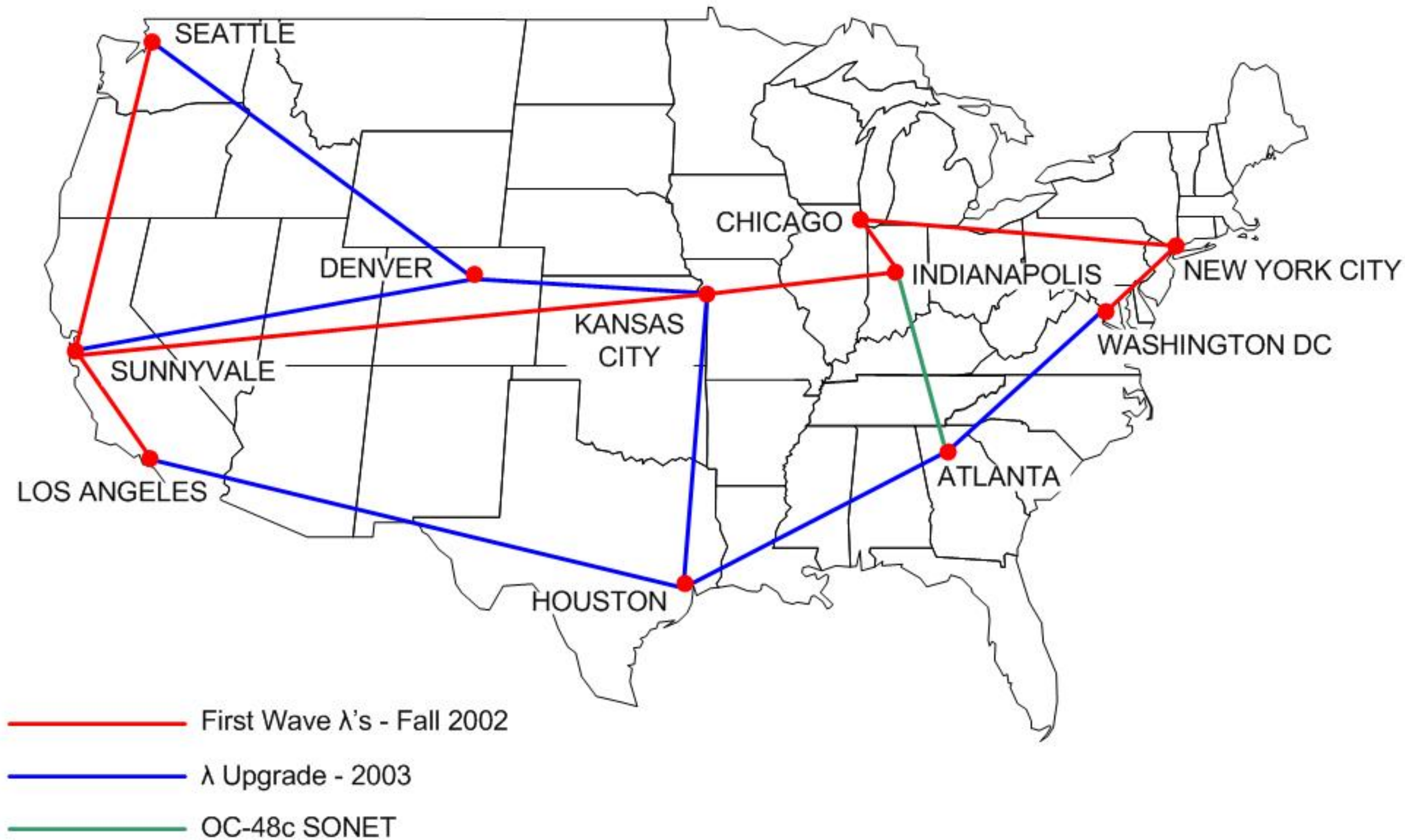
Internet2 is a consortium being led by over 200 universities working in partnership with industry and government to develop and deploy advanced network applications and technologies, accelerating the creation of tomorrow's Internet. Internet2 is recreating the partnership among academia, industry and government that fostered today´s Internet in its infancy. The primary goals of Internet2 are to:

- Create a leading edge network capability for the national research community
- Enable revolutionary Internet applications
- Ensure the rapid transfer of new network services and applications to the broader Internet community.

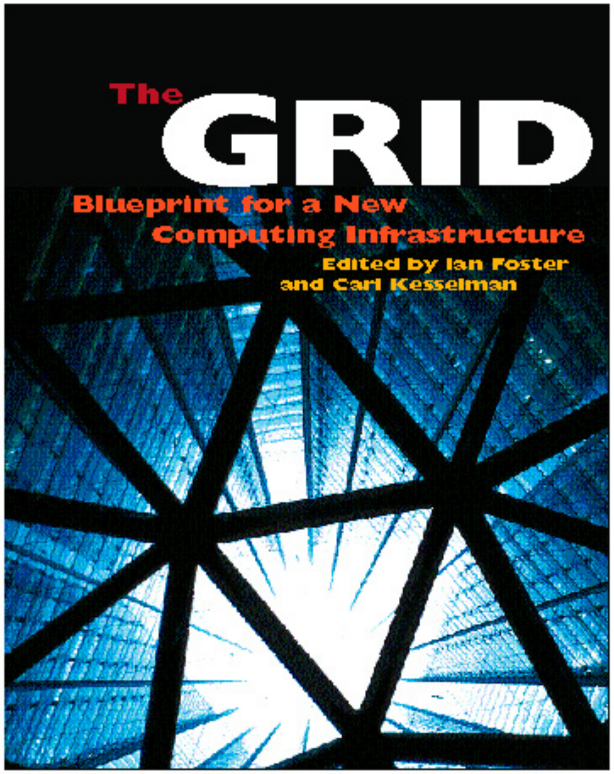
Through Internet2 Working Groups and initiatives, Internet2 members are collaborating on:

- Advanced Applications
- Middleware
- New Networking Capabilities
- Advanced Network Infrastructure
- Partnerships and alliances
- Initiatives

ABILENE NETWORK 10-Gbps OPTICAL UPGRADE - 2002-2003



The Grid



Ian Foster and Carl Kesselman, editors, "The Grid: Blueprint for a New Computing Infrastructure," Morgan Kaufmann, 1999, http://www.mkp.com/grids

Why Grids?

- A biochemist exploits 10,000 computers to screen 100,000 compounds in an hour
- 1,000 physicists worldwide pool resources for petaop analyses of petabytes of data
- Civil engineers collaborate to design, execute, & analyze shake table experiments
- Climate scientists visualize, annotate, & analyze terabyte simulation datasets
- An emergency response team couples real time data, weather model, population data

Why Grids? (contd)

- A multidisciplinary analysis in aerospace couples code and data in four companies
- A home user invokes architectural design functions at an application service provider
- An application service provider purchases cycles from compute cycle providers
- Scientists at a multinational company collaborate on the design of a new product
- A community group pools members’ PCs to perform environmental impact study

The Grid from a Services View

Applications

Chemistry | Cosmology | Environment

Biology | High Energy Physics

Application Toolkits

- Distributed Computing Toolkit
- Data-Intensive Applications Toolkit
- Collaborative Applications Toolkit
- Remote Visualization Applications Toolkit
- Problem Solving Applications Toolkit
- Remote Instrumentation Applications Toolkit

Grid Services (Middleware)

<u>Resource-independent and application-independent services</u>

authentication, authorization, resource location, resource allocation, events, accounting, remote data access, information, policy, fault detection

Grid Fabric (Resources)

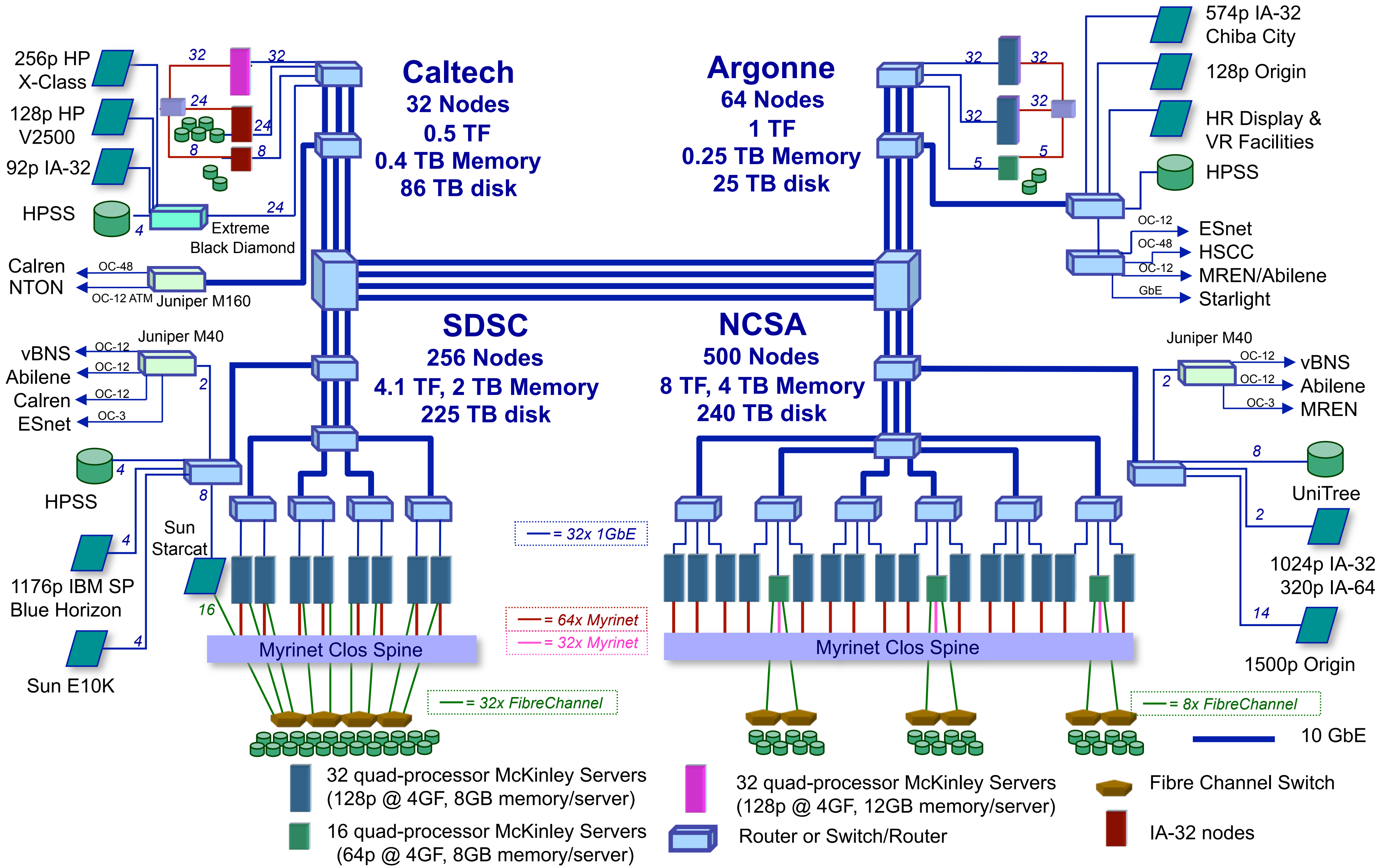
<u>Resource-specific implementations of basic services</u>

E.g., Transport protocols, name servers, differentiated services, CPU schedulers, public key infrastructure, site accounting, directory service, OS bypass

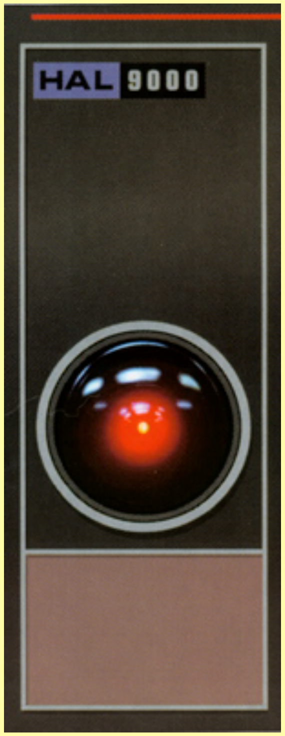
Global Data Grid Challenge

"Global scientific communities, served by networks with bandwidths varying by orders of magnitude, need to perform computationally demanding analyses of geographically distributed datasets that will grow by at least 3 orders of magnitude over the next decade, from the 100 Terabyte to the 100 Petabyte scale [from 2000 to 2007]"

TeraGrid Architecture – 13.6 TF



Some Other Possibilities



- **Ubiquitous computing?**
  - Computers disappear (just as electricity)
  - Calm technology, bodynets
- **Agents and avatars?**
  - Fusing together physical space and cyberspace
  - Plugging the nervous system into the Net
- **Emergent behavior?**
  - … Self organization
  - … Learning capacity
  - … Consciousness (HAL 9000)

WWW and "infocern", the 1st web address ~1990 html (xml) open standards

- A great achievement and a fantastic idea, at the right time, making the internet available to everybody
- It proves something about the benefits of assembling together urgent needs, infrastructure and smart people, and letting them interact..
- And why it is exciting to work at CERN, and in computing
- And why we should not always listen to wise people who tell us that industry will always do better than we will….

Tim Berners-Lee

Some Further Speculation

The Age of Spiritual Machines:

When Computers Exceed Human Intelligence

–Ray Kurzweil

2009

- A $1,000 PC delivers Terahertz speeds
- PCs with high resolution visual displays come in a range of sizes, from those small enough to be embedded in clothing and jewelry up to the size of a thin book.
- Cables are disappearing. Communication between components uses wireless technology, as does access to the Web.
- The majority of text is crated using continuous speech recognition. Also ubiquitous are language user interfaces.
- Most routine business transactions (purchases, travel, etc.) take place between a human and a virtual personality. Often the virtual personality includes an animated visual presence that looks like a human face.

2009 (continued)

- Although traditional classroom organization is still common, intelligent courseware has emerged as a common means of learning.
- Translating telephones (speech-to-speech language translation) are commonly used.
- Accelerating returns from the advance of computer technology have resulted in a continued economic expansion.
- The neo-Luddite movement is growing.

2019

- A $1,000 PC is now approximately equal to the computational ability of the human brain.
- Computers are now largely invisible and are embedded everywhere–in walls, tables, chairs, desks, clothing, jewelry, and bodies.
- 3-D virtual reality displays, embedded in glasses and contact lenses, as well as auditory “lenses”, are used routinely as primary interfaces for communication with other persons, computers, the Web, and virtual reality.
- Most interaction with computing is through gestures and two-way natural-language spoken communication.

2019 (continued)

- Nanoengineered machines are beginning to be applied to manufacturing and process control.
- High-resolution, 3-D visual and auditory virtual reality and realistic all-encompassing tactile environments enable people to do virtually anything with anybody, regardless of physical proximity.
- Paper books or documents are rarely used and most learning is conducted through intelligent, simulated software-based teachers.
- The vast majority of transactions include a simulated person.
- Automated driving systems are now installed in most roads.

2019 (continued)

- People are beginning to have relationships with automated personalities and use them as companions, teachers, caretakers, and lovers.
- There are widespread reports of computers passing the Turing Test, although these tests do not meet the criteria established by knowledgeable observers.

2029

- A $1,000 unit of computation now has the computation capacity of roughly 1,000 human brains.
- Permanent removable implants for the eyes and ears are now used to provide input and output between the human user and the worldwide computing network.
- Direct neural pathways have been perfected for high-bandwidth connection to the human brain. A range of neural implants is becoming available to enhance visual and auditory perception and interpretation, memory, and reasoning.
- Automated agents are now learning on their own, and significant knowledge is being crated by machines with little or no human intervention.

2029 (continued)

- Computers have read all available human- and machine-generated literature and multimedia material.
- There is widespread use of all-encompassing visual, auditory, and tactile communication using direct neural connections, allowing virtual reality to take place ("sim-stim")
- The majority of communication does not involve a human; rather it is between a human and a machine.
- There is almost no human employment in production, agriculture, or transportation. Basic life needs are available for the vast majority of the human race.

2029 (continued)

- There is a growing discussion about the legal rights of computers and what constitutes being “human”. Although computers routinely pass apparently valid forms of the Turing Test, controversy persists about whether or not machine intelligence equals human intelligence in all of its diversity.
- Machines claim to be conscious. These claims are largely accepted.

2049

- The common use of nanoproduced food, which has the correct nutritional composition and the same taset and texture of organically produced food, means that the availability of food is no longer affected by limited resources, bad weather, or spoilage.
- Nanobot swarm projections are used to create visual-auditory-tactile projections of people and objects in real reality.
- Picoengineering begins to become practical.

By 2099

- There is a strong trend toward a merger of human thinking with the world of machine intelligence that the human species initially created.
- There is no longer any clear distinction between humans and computers.
- Most conscious entities do not have a permanent physical presence.
- Machine-based intelligences derived from extended models of human intelligence claim to be human, although their brains are not based on carbon-based cellular process, but rather electronic and photonic equivalents. Most of these intelligences are not tied to a specific computational process unit. The number of software-based humans vastly exceeds those still using native neuron-cell-based computation.

By 2099 (continued)

- Even among those human intelligences still using carbon-based neutrons, there is ubiquitous use of neural-implant technology, which provides enormous augmentation of human perceptual and cognitive abilities. Humans who do not utilize such implants are unable to meaningfully participate in dialogues with those who do.
- Because most information is published using standard assimilated knowledge protocols, information can be instantly understood. The goal of education, and of intelligent beings, is discovering new knowledge to learn.
- Life expectancy is no longer a viable term in relation to intelligence beings.

Many Milleniums Hence …

Intelligent beings consider the fate of the Universe …

To Infinity and Beyond!

"A small group of thoughtful people could change the world. Indeed, it's the only thing that ever has. "

Margaret Mead