A Social Transformation

The 20th Century
Transportation
Cars, planes, trains
Energy, materials
Prosperity, security
Social structures

The 21st Century
Communications
Computers, networks
Knowledge, bits
Prosperity, security
Social structures

Forces of Change

A Changing World

Age of Knowledge

Demographic Change

Globalization

Post-Cold War World

Spaceship Earth

Forces on the University

Economics

Societal Needs

Technology

Markets

Brave New World?

Society of Learning?

Some quotes...

"Thirty years from now the big university campuses will be relics. Universities won't survive. It is as large a change as when we first got the printed book."

– *Peter Drucker*

"If you believe that an institution that has survived for a millennium cannot disappear in just a few decades, just ask yourself what has happened to the family farm."

– *William Wulf*

"I wonder at times if we are not like the dinosaurs, looking up at the sky at the approaching comet and wondering whether it has an implication for our future."

– *Frank Rhodes*


ΔΥΝΑΣΘΑΙ ΤΥΧΕΙΝ ΑΥΤΗΣ ΜΗΤΕ ΠΑΝΤΩΣ ΑΠΟΤΥΓΧΑΝΕΙΝ ΑΛΛΑ

NAS/NAE/IOM/NRC Study

The Impact of Information Technology on the Future of the Research University

Information Technology and the Future of the Research University

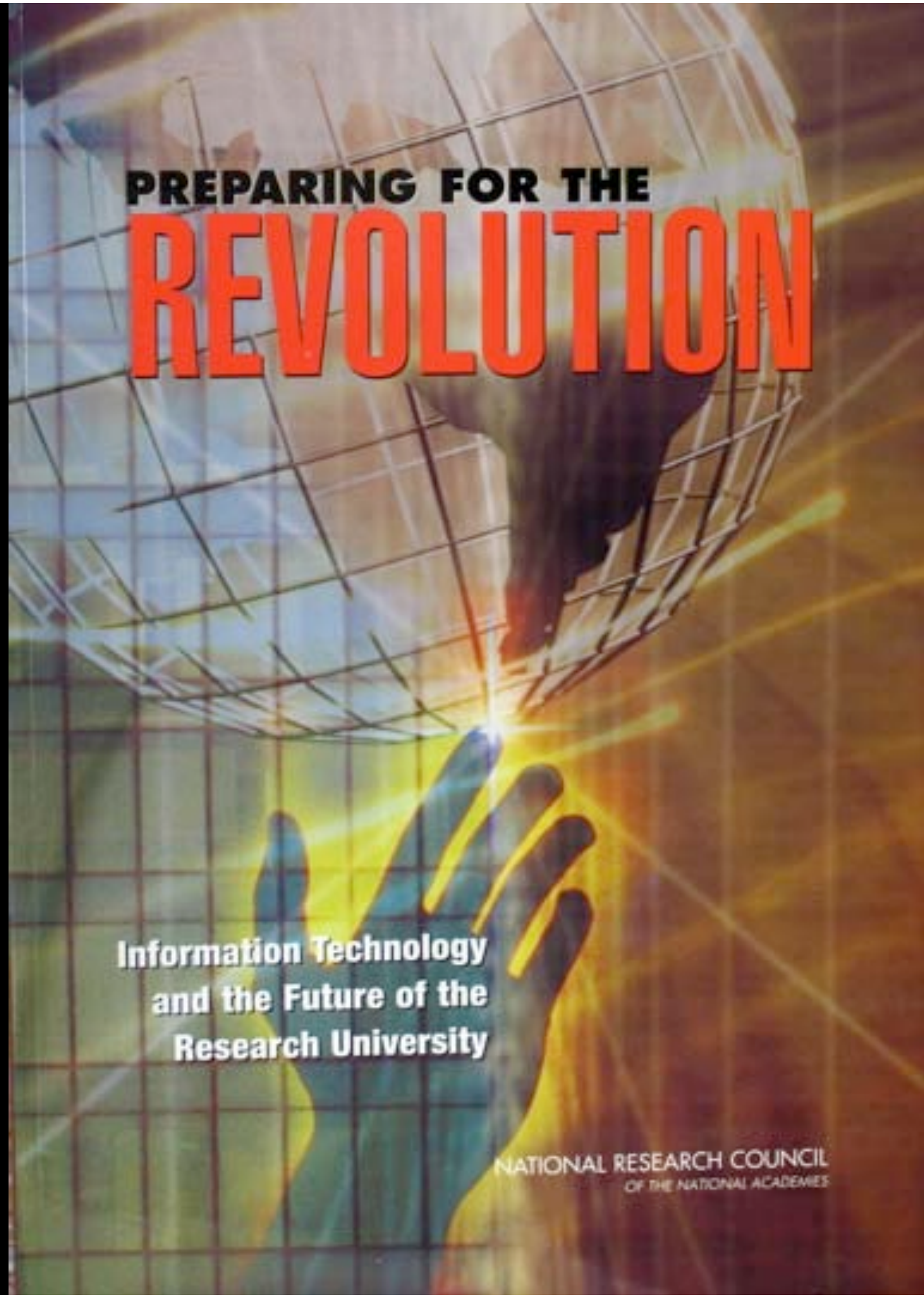
Premise: Rapidly evolving information technology poses great challenges and opportunities to higher education in general and the research university in particular. Yet many of the key issues do not yet seem to be on the radar scope of either university leaders or federal research agencies.

Phase One

- Technology scanning (a decade out)
- Implications for the future of the research university
- Possible roles for federal government and other stakeholders

ITFRU Guidance Committee

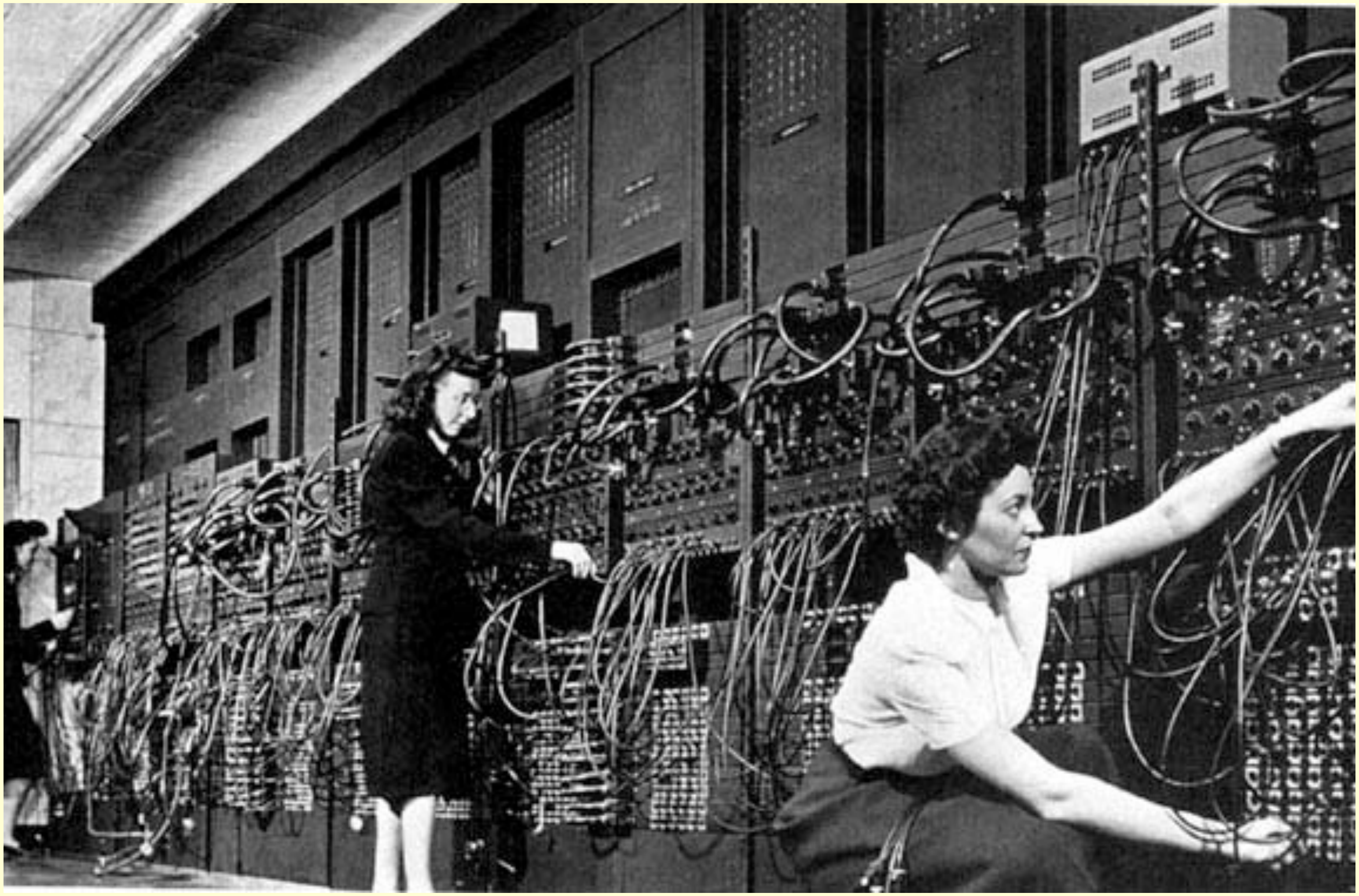
- James Duderstadt (Chair), President Emeritus, Univesity of Michigan
- Daniel Atkins, Professor of Information and Computer Science, University of Michigan
- John Seely Brown, Chief Scientist, Xerox PARC
- Marye Anne Fox, Chancellor, North Carolina State University
- Ralph Gomory, President, Alfred P. Sloan Foundation
- Nils Hasselmo, President, Association of American Universities
- Paul Horn, Senior Vice President for Research, IBM
- Shirley Ann Jackson, President, Rensselaer Polytechnic Institute
- Frank Rhodes, President Emeritus, Cornell University
- Marshall Smith, Professor of Education, Stanford; Program Officer, Hewlett Foundation
- Lee Sproull, Professor of Business Administration, NYU
- Doug Van Houweling, President and CEO, UCAIC/Internet2
- Robert Weisbuch, President, Woodrow Wilson National Fellowship Foundation
- William Wulf, President, National Academy of Engineering
- Joe B. Wyatt, Chancellor Emeritus, Vanderbilt University
- Raymond E. Fornes (Study staff), Professor of Physics, North Carolina State University


PREPARING FOR THE
REVOLUTION
Information Technology
and the Future of the
Research University
NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

Phase 1: Conclusions

- There was a consensus that **the extraordinary evolutionary pace of information technology is likely to continue for the next several decades** and even could accelerate on a superexponential slope.
- The event horizons for disruptive change are moving ever closer. There are **likely to be major technology surprises**, comparable in significance to the appearance of the personal computer in the 1970s and the Internet browser in 1994, but at more frequent intervals. The future is becoming less certain.

From Eniac

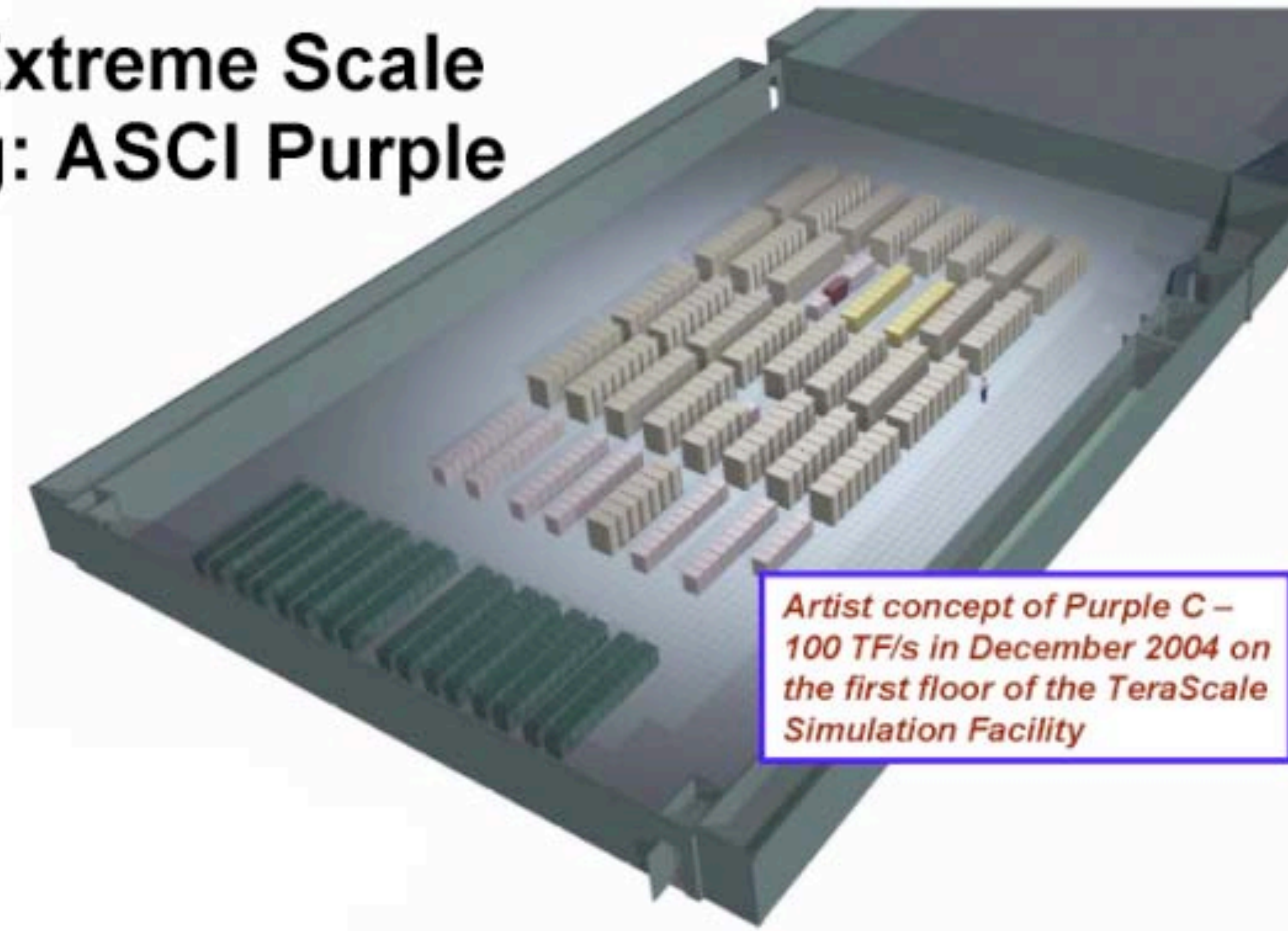


To ASCI "Q" … and beyond

Japan Earth Simulator


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

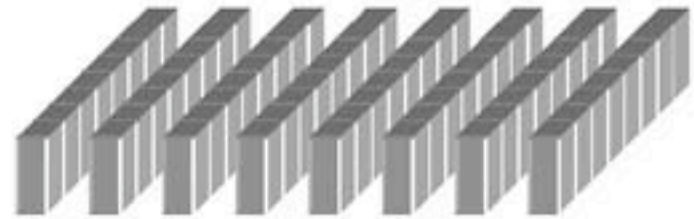
Defining Extreme Scale Computing: ASCI Purple



Artist concept of Purple C – 100 TF/s in December 2004 on the first floor of the TeraScale Simulation Facility

*Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

Building BlueGene/L



System

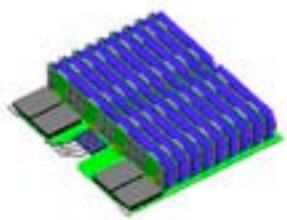
64 cabinets
65,536 nodes
(131,072 CPUs)
(32x32x64)
180/360 TF/s
16 TiB*
1.2 MW
2500 sq.ft.

Cabinet

2 midplanes
1024 nodes
(2,048 CPUs)
(8x8x16)
2.9/5.7 TF/s
256 GiB* DDR
15-20 kW

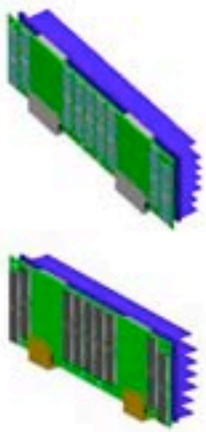
Midplane

SU (scalable unit)
16 node boards
512 nodes
(1,024 CPUs)
(8x8x8)
1.4/2.9 TF/s
128 GiB* DDR
7-10 kW



Node Card

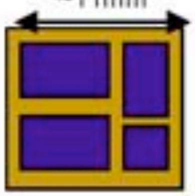
16 compute cards
0-2 I/O cards
32 nodes
(64 CPUs)
(4x4x2)
90/180 GF/s
8 GiB* DDR



Compute Card
I/O Card

FRU (field replacable unit)
25mmx32mm
2 nodes (4 CPUs)
(2x1x1)
2.8/5.6 GF/s
256/512 MiB* DDR
15 W

~11mm



Compute Chip

2 processors
2.8/5.6 GF/s
4 MiB* eDRAM

(compare this with a 1988 Cray YMP/8 at 2.7 GF/s)

* http://physics.nist.gov/cuu/Units/binary.html

ASCI Purple (2004):

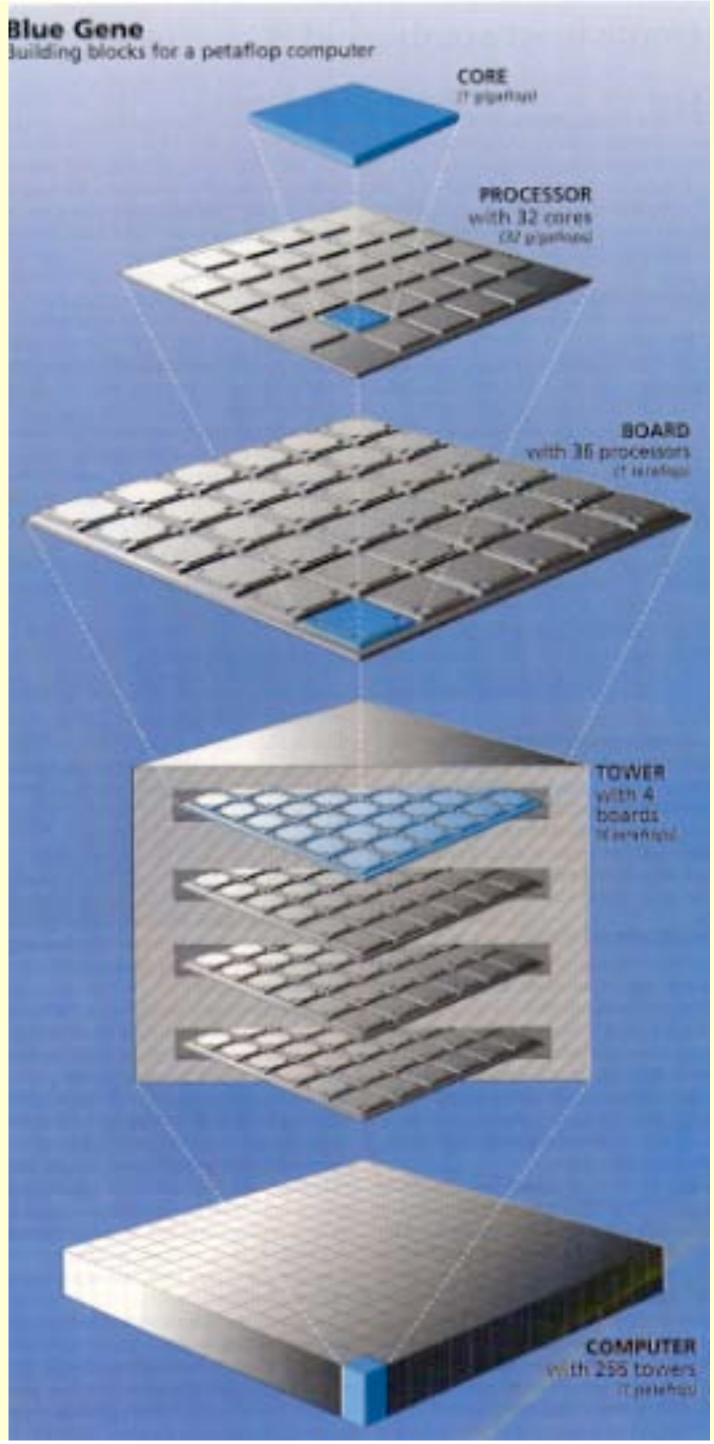
100 TeraFlops

IBM Blue Gene L (2004):

360 TeraFlops

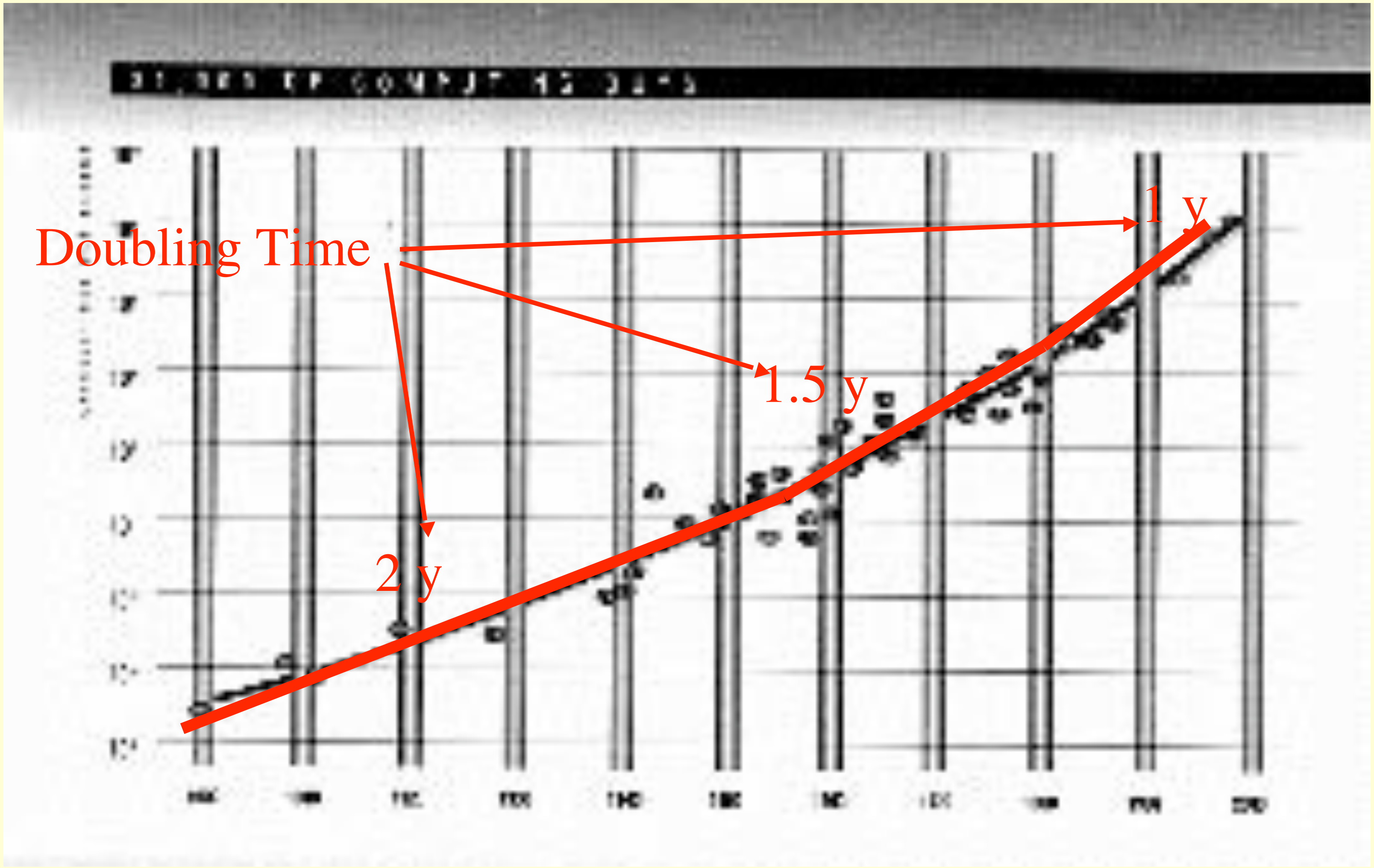
IBM Blue Gene P (2006):

“Several” PetaFlops




No
Stopping
Parking
Loading Or
Unloading
Along
Curve Or
Roadway
P.D.Q.
53'
PDQ

The Evolution of Computing



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 much 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 interconnection of resources
- Services as unit of IT, rather than bare-bones data and processing

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 to Grid to National LambaRail
- **Networks**
  - Copper to fiber to wireless to photonics
  - "Fiber to the forehead…"

Computer-Mediated Human Interaction

- **1-D (words)**
  - Text, e-mail, chatrooms, IM, telephony
- **2-D (images)**
  - Graphics, video, WWW, multimedia
- **3-D (environments)**
  - Virtual reality
  - Virtual worlds
- **And beyond… (experiences, “sim-stim”)**
  - Telepresence
  - Neural implants

An Example: Evolution of the Net

- Already beyond human comprehension
- Incorporates ideas and mediates interactions among millions of people
- 500 million today; more than 1 billion in 2010
- Internet2, National Lamba Rail, TeraGrid
- Semantic Web, Executable Internet, Web Services, Cyberinfrastructure

Conclusions (continued)

- The **impact of information technology on the university will likely be profound, rapid, and discontinuous**–just as it has been and will continue to be for the economy, our society, and our social institutions (e.g., corporations, governments, and learning institutions
- It will affect our **activities** (teaching, research, outreach), our **organization** (academic structure, faculty culture, financing and management), and the broader higher education **enterprise** as it evolves into a global knowledge and learning industry.
- Information technology is a **disruptive technology** in higher education that requires strategic attention.

IT and the University

Missions: teaching, research, service?

Alternative: Creating, preserving, integrating, transferring, and applying knowledge.

The University: A "knowledge server", providing knowledge services in whatever form is needed by society.

Note: The fundamental knowledge roles of the university have not changed over time, but their realizations certainly have.

Research

- Simulating reality
- Collaboratories: the virtual laboratory
- Changing nature of research
  - Disciplinary to interdisciplinary
  - Individual to team
  - “Small think” to “big think”
- Analysis to creativity
  - Tools: materials, lifeforms, intelligences
  - Law, business, medicine to art, architecture, engineering

Libraries

- Books to bytes (atoms to bits)
- Acquiring knowledge to navigating knowledge
- What is a book?
  - A portal to the knowledge of the world.

Teaching to Learning

- Pedagogy
  - Lecture hall to environment for interactive, collaborative learning
  - Faculty to designer, coach
- Classroom
  - Handicraft to commodity
  - Learning communities
  - Virtual, distributed environments
- Open learning
  - Teacher-centered to learner-centered
- Passive Student to Active Learner to Demanding Consumer
  - Unleashing the power of the marketplace

The Plug and Play Generation

- Raised in a media-rich environment
  - Sesame Street, Nintendo, MTV,
  - Home computers, WWW, MOOs, virtual reality
- Learn through participation and experimentation
- Learn through collaboration and interaction
- Nonlinear thinking, parallel processing

camp caen

camp caen

The computer exploration camp from The University of Michigan. Summer 2000


SIGN-IN
Sheet
WYSIWYG
Thank you!


SUPER SPORTS


caen

Conclusions (continued)

- Yet, **for at least the near term**, meaning a decade or less, **the university will continue to exist in much its present form**, although meeting the challenge of emerging competitors in the marketplace will demand significant changes in how we teach, how we conduct scholarship, and how our institutions are financed.
- Universities must anticipate these forces, develop appropriate strategies, and make adequate investments if they are to prosper during this period.
- **Procrastination and inaction are the most dangerous courses of all during a time of rapid technological change**.

Conclusions (continued)

- Because of the profound yet unpredictable impact of this technology, it is important that institutional strategies include:
  - the opportunity for **experimentation**,
  - the formation of **alliances** both with other academic institutions as well as with for-profit and government organizations, and
  - the development of sufficient **in-house expertise** among the faculty and staff to track technological trends and assess various courses of action.