The Future of Information Technology

University of Colorado
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World of the Future

Information Technology will Change Everything
The Third Wave

- "We are witnessing nothing less than the rise of a new economy --- a digital economy --- a new global medium that will be the single most important global driver of business, economic, and social change in the next century"

-- LVG; June 14, 1999
Progress in information technology (IT) continues at an ever increasing pace.

- On an extended time scale and over many different generations of technology, the rate of growth in IT performance has continued to increase. New technologies for extremely dense storage, enormous bandwidth over optical fibers, and faster transistors are fueling this growth.

- Although in the next ten years substantial barriers to further progress will be encountered in many areas, history has shown that we have always found new technologies to go beyond those which are reaching their limitations.
Figure showing the progression of computer performance over time, with years from 1900 to 2020 on the x-axis and computations per second on the y-axis. The graph illustrates the increase in computational power with technological advancements, starting from mechanical and electro-mechanical systems to discrete transistors and integrated circuits. The data is derived from Kurzweil, 1999 & Moravec, 1998.
Special purpose machines, i.e. chess, molecular dynamics, protein folding.

Source: ASCI Roadmap www.llnl.gov/asci, IBM
Brain ops/sec: Kurzweil 1999, *The Age of Spiritual Machines*
For current applications, good enough performance thresholds will be passed for many compute platforms and components. (PCs, Single function servers, Displays, Hard disk drives)

Commoditization increases (silicon, disks, servers and raw bandwidth) driving providers to seek differentiation via new features and higher levels of service.

Opportunities for differentiation abound but will require higher risk and significant investment.

Technical and economic thresholds will be passed, enabling new applications and uses.
Trend 2

Connected computation everywhere will rapidly change the interaction of people and objects with the digital world, making pervasive devices the dominant means of information access.

- **The first wave of connectivity (1980's)** linked people within a business and between academic communities via e-mail.
- **The second wave of connectivity (1990's)** enabled businesses and growing numbers of people to interact via e-mail, web browsers and collaborative tools. Internet based business models and communities have evolved.
- **The third wave of connectivity (2000's)** will involve objects - products, everyday things and sensors - connecting the digital and physical worlds. New paradigms such as locality-aware devices, always-on mobile connectivity and environment-aware products, will drive the intermixing of personal and business activities and ever tighter IT integration into human lives.
Web servers with demonstrations on the internet.

- HP Vectra 5/90
- Phar Lap
- Stanford "Matchbox"
- iReady TCP/IP chip
- U. Mass. "Matchhead"

2001: Integrated with sensor, <1E-4 cm³ "chip" for 50 cents

Smart dust?

Physical Size of a Web Server

Year


Size (cm³)

1E-6
1E-2
1E+2
1E+6
802.11 wireless LAN
GPS
Cellular per 10Kb/s**
Imager (VGA)*

*imager cost drop is slower, as pixels size is limited by light wavelengths.

**assuming shared BW, i.e. cost of 2Mb/s 3G cellular is $300 in 2002.
Implications

✓ Pervasive devices will become the dominant means of information processing and access.

✓ New form factors will drive technology and innovation, and create opportunities for new applications and services.

✓ Digitally connected objects will increasingly interact autonomously.

✓ Medical and other physiological needs will increasingly drive the evolution of the human cyborg.

✓ Technical capabilities are catching up to perceptual and computational capabilities of humans, but people still will be very aware that they are dealing with machines (ie. forget HAL).

✓ The networks, servers and software infrastructure will be challenged.
Pervasive Devices Will Be the Dominant Means of Information Access

Note: Does not include cars with driver information systems (approximately 8% of 150 Million in 2006 - Jupiter)

Sources: ResearchPortal.com, Semico, EE Times, Reuters, Gartner, Ericsson...
Economic incentives increasingly support IT delivery through an information utility paradigm. This paradigm takes advantage of economies of scale (redundancy, peak load handling, skills and knowledge) and the need for companies to focus on core competencies rather than increasingly complex IT management tasks. This shift is being driven by the rise of e-business, high-speed networks, and open interoperability standards.

An intelligent infrastructure is emerging to flexibly balance the forces of centralization with opposing forces, such as limitations in local bandwidth, latency and the heterogeneity of compute platforms.
Intelligent Infrastructure

1990

Basic Transport

Client
Client
Client
Client

Evolving Today

Intelligent Network

Security
Directory
Policy Mgmt.
Transcoding

Network Mgmt.
Caching
Mobility
Class of Service

Enterprise
Application Server

Service Provider
Application Server

Enterprise
Application Server

Network Client
Network Client
Network Client
Network Client
Implications

✓ No "grand centralization" will occur, rather a hierarchy of centralized tiers will govern IT deployment.

✓ The migration of intelligence into the network will ignite battles between platforms for infrastructure function (traditional IT vs networking technology).

✓ New businesses models, based on a utility-like infrastructure will emerge based on interoperability standards.

✓ IT costs will be reduced by deploying massively redundant low cost component architectures, reducing costs over and above economies of scale.

✓ IT value will be increasingly measured, managed and optimized using business performance metrics.

✓ IT labor will be increasingly displaced by technology, accelerating the change from a human-intensive to a knowledge-intensive business.
Trend 4

IT value will advance by building higher level software components, increasingly delivered as services, on winning application platforms.

- Higher level building blocks allow programmers to focus on adding new functionality with more efficiency, flexibility and speed to market, as well as involve subject matter experts. As these building blocks mature, they standardize and become part of the winning application platform.

- The high bandwidth connectivity of the Internet and interoperability standards will allow software applications and services to be offered as building blocks to higher level applications and services through the net.
The e-business of the future will be dynamic, adaptive and continuously optimized, depending on powerful business analytics and knowledge management for survival.

- Data and information have exploded due to e-commerce, business process automation (e.g. ERP, SCM, CRM), modeling and simulation and increased connectivity through the Internet and pervasive devices. In the highly competitive world of e-business, only companies with the capability and structure to leverage this data to best advantage will survive.

- Sophisticated management and analysis of data will enable winning enterprises to rapidly and flexibly react to market events (sense and respond). For example, the static supply chains of today will be transformed by dynamic trading in business-to-business electronic marketplaces.
Information grows exponentially

Static HTML = unchanging web pages, Internet = dynamic web pages and web accessible DBs, Online=computer accessible storage, e.g. HDD. Data includes multiple copies in the world. Source: IBM

100% CGR for structured data (billing, customer, transactions...etc) [Gartner 1999]
TPC-D benchmark became obsolete on February 16, 1999. TPC-D is replaced by TPC-H (random queries) and TPC-R (known queries, e.g. reports)
Research: External Honors

- Nobel Laureates: 5
- National Medal of Technology: 4
- National Medal of Science: 4
- National Academy of Sciences: 20
- Society Fellows: ~330
- National Academy of Engineering: 46
- IBM Patents (U.S.): 25%
- Turing Award: 4
Evolution of Role

1970's
- Corporate Funded Research Agenda
- Technology Transfer
- Centrally Funded

1980's
- Collaborative Team
- Shared Agenda
- Effectiveness
- & Joint Programs

1990's
- Work on Customer Problems
- & Research in the Marketplace

2000's
- Create Business Advantage for Customers
- Emerging Business Opportunities
- & External Partnerships

Strategic Research Themes

- Pervasive computing
- Intelligent e-business infrastructure
  - Platforms: (net.commerce, WebSphere, ...)
  - eUtilities
- Unstructured knowledge management
- Next generation web
- Growing our OEM business
  - Communications & pervasive technology
  - Storage
- Exploratory research
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