TECHNOLOGY FUTURES INC.

Your Bridge to the Future

SRC/Sematech Center for Environmentally Benign Semiconductor Manufacturing

GLOBAL MANUFACTURING

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www.tfi.com

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World Current Status—Drivers

- We live in an information age, driven by needs for precision, accuracy, and timeliness in all of our endeavors—personal, business, and governmental.

- As society becomes increasingly mobile and global, reliance on the worldwide availability of information will increase.

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Information Avalanche

The Situation
- We can record everything
- Everything is a LOT!

The Good News
- Changes science, education, medicine, entertainment…
- Shrinks time and space
- Can augment human intelligence

The Bad News
- The end of privacy
- Cyber crime/cyber terrorism
- Monoculture

The Technical Challenges
- Amplify human intellect
- Organize, summarize, and prioritize information
- Make discovery and analysis easy

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How the World Has Changed

- Most businesses are global at launch

- Businesses are increasingly real time

- Convergence has become a way of life

- Science, product development, and product cycles are compressing

- The source of value has shifted for manufacturing

- Competencies, future capabilities, and "ultra tech" are the prime driver

- The traditional value chain is forever dead

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Technology Webster's

- The science of the practical or industrial arts

- Applied science

- A method of achieving a practical purpose

- The totality of the means employed to provide objects necessary for human sustenance and comfort

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What is Technology?

"Application of knowledge to objectives"

——J. P. McTague, "Wielding a Three-Edged Sword," *Federal Lab Technology Transfer: Issues and Policies* (1988)

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America gets more than half its economic growth from industries that barely existed a decade ago— such is the power of innovation, especially in the information and biotechnology industries.

—The Economist

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The Internet has forever changed the way that manufacturing organizations do business.

The Web's global access to people, data, software, documents and multimedia have allowed organizations to shorten the development cycle for new products, decrease the costs associated with procuring parts from suppliers, and achieve lead time reductions while providing personalized service and support.

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What is Convergence?

Of Network:

- Audio (voice, music), data (text, transactions, messages, sensors), images (still, video, movies)
- Wireline, wireless

Of Industry:

- Telecom, information technology, broadcast
- Business systems, PCs, consumer electronics
- Movies, publication, Internet services

Of Content:

- Image production for games, Internet, TV, movies

Of Research:

- Business, government, academia

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Global Convergence

A second point of convergence is global convergence. The point of convergence here is at least fourfold:

1) The world is getting smaller due to technology

2) A consensus is emerging about markets

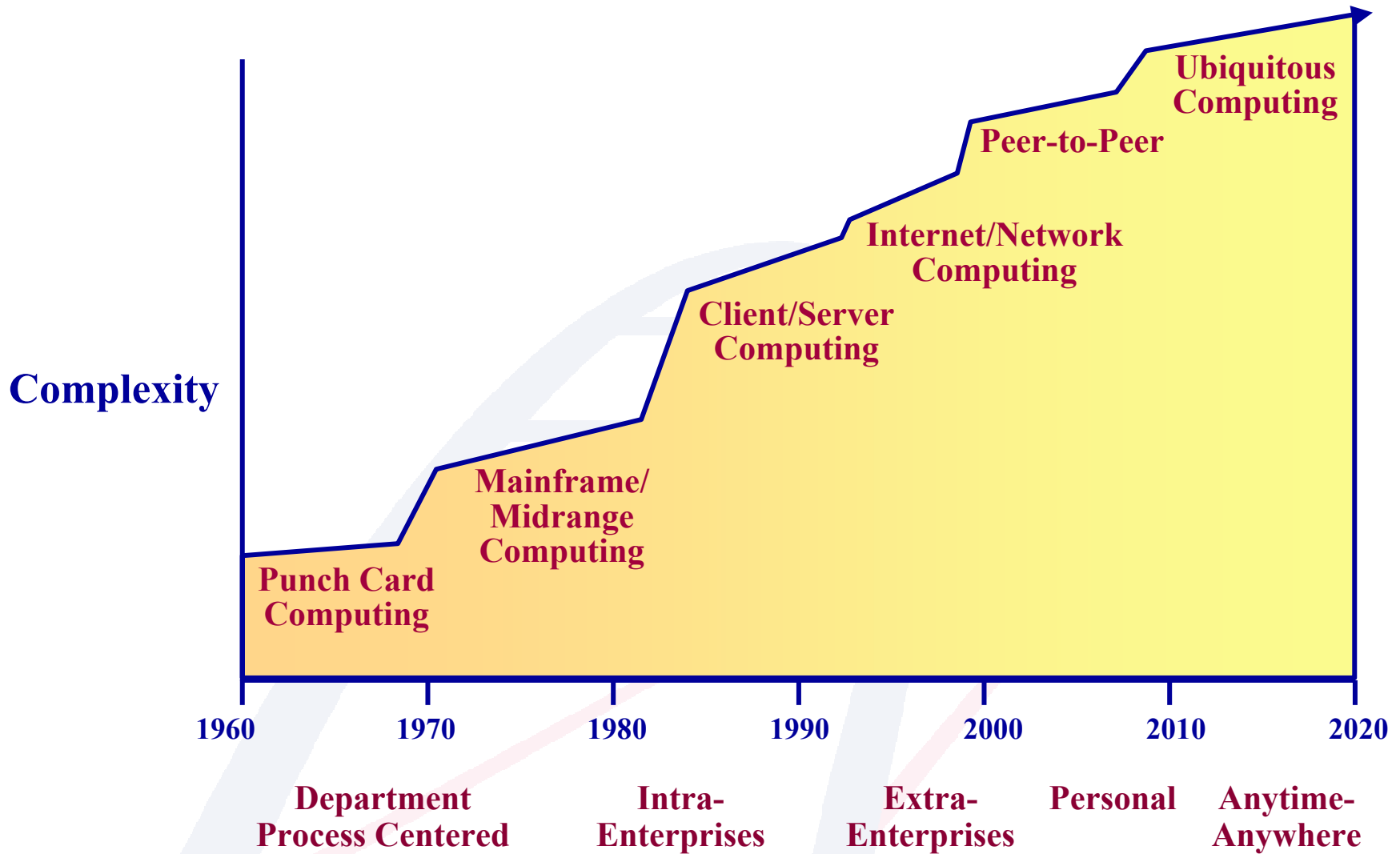3) The world is becoming real-time

4) Every device is a server

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Final View on Convergence

Complexity

- Punch Card Computing
- Mainframe/Midrange Computing
- Client/Server Computing
- Internet/Network Computing
- Peer-to-Peer
- Ubiquitous Computing

1960　1970　1980　1990　2000　2010　2020

Department Process Centered　Intra-Enterprises　Extra-Enterprises　Personal　Anytime-Anywhere

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Ubiquitous Computing

- Laptops outsell desktops already

- Handheld PCs are gaining market share

- Appliances become smart

  – Microprocessors in TVs, VCRs, refrigerators, stoves, etc.

    - As the profit margin on basic hardware gets squeezed out, smarts are the next competitive area
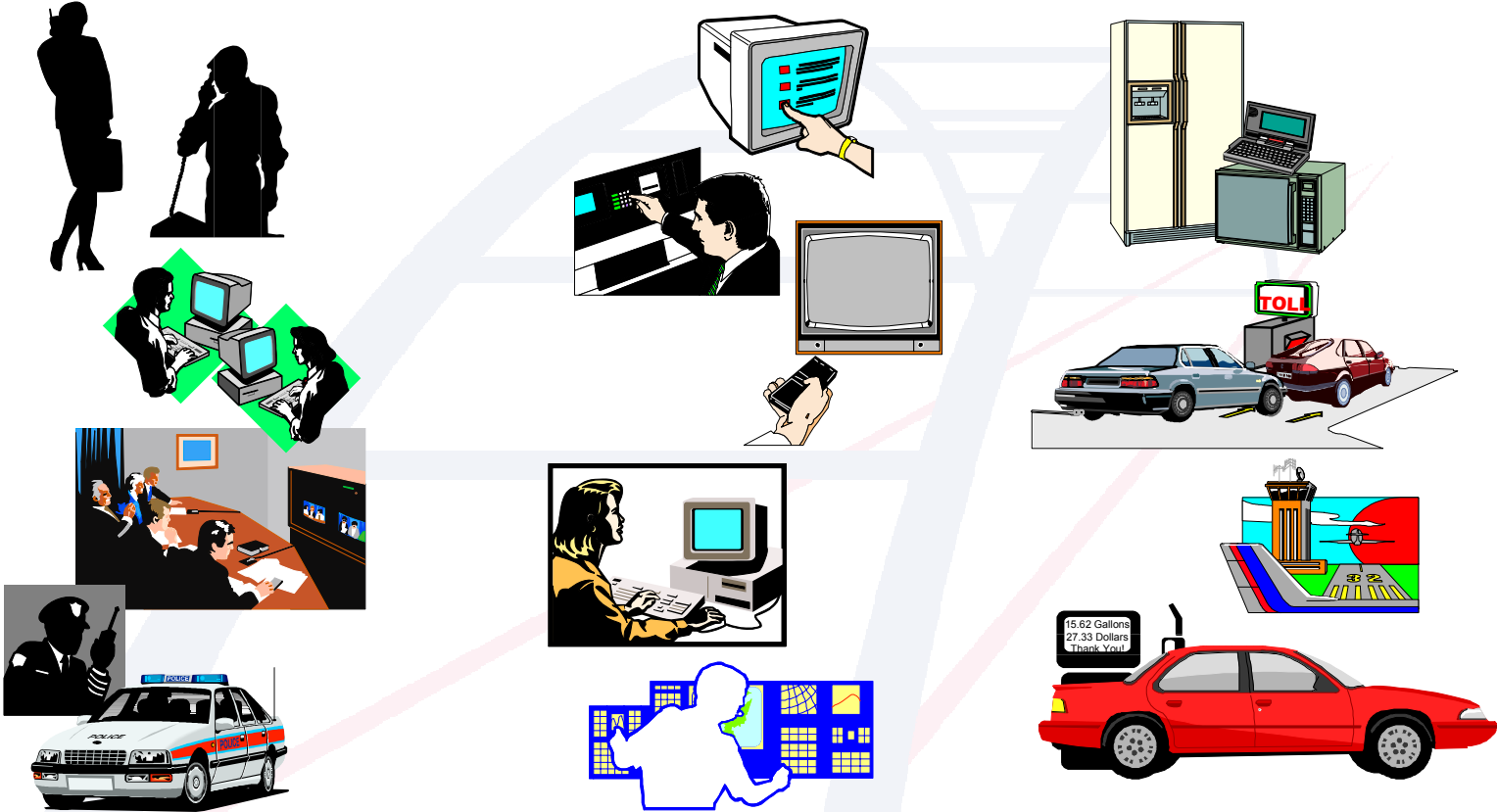
- Even your pet…

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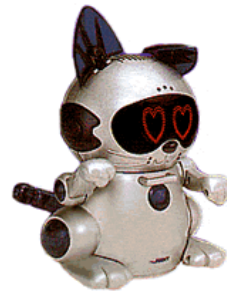
Embeddedness
The Invisible Computer

- Embeddedness – digital convergence technologies will "form the invisible technical infrastructure for human action – analogous to the visible infrastructure provided by buildings and cities" (Nordman 2004).

- Embeddedness is driven by cost-effective computing, Moore's Law, miniaturization, ubiquitous communication, and advanced materials and sensing devices.

- In 2000, 98% of computing devices sold are embedded in products and are not apparent to the product's user (Borriello and Want 2000).

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The Nature of Communications Has Been Changing...

People to People	➤	People to Things	➤	Things to Things

TOLL

15.62 Gallons
27.33 Dollars
Thank You!

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The Global Grid

From Client/Server…   **…to every computer's a server**

Global Computing Managers
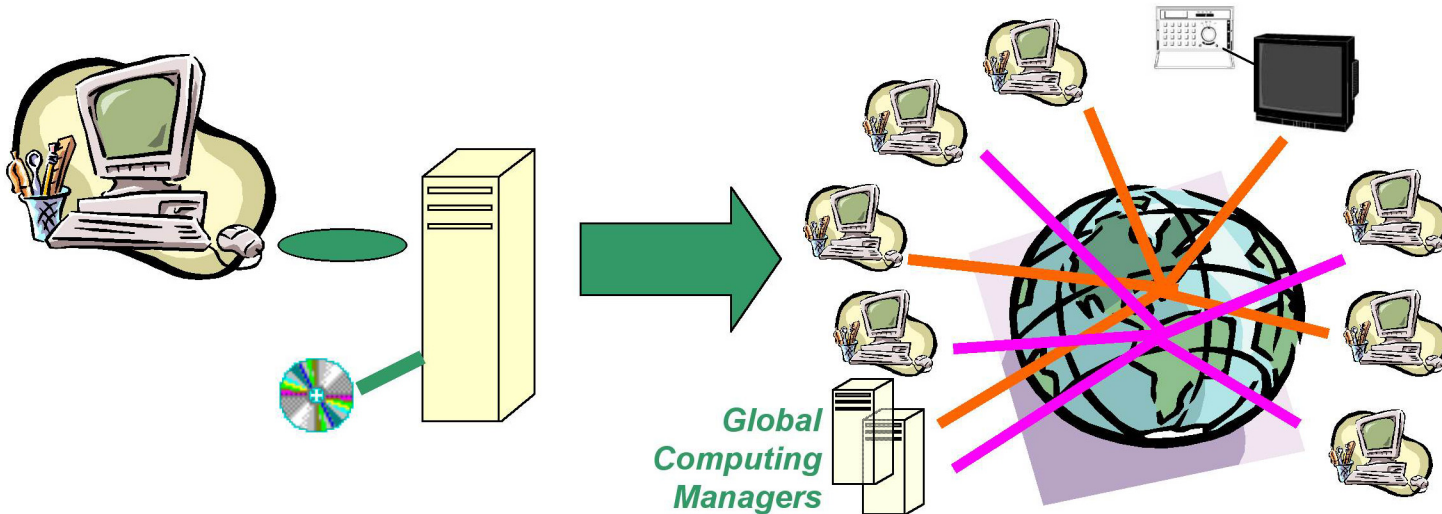
Client systems are dedicated to needs of a user	→	Clients systems do work and store data for other users
Single application running in client or server	→	Application "chunks" run concurrently in multiple systems
A data object resides on a single server	→	Data object is segmented and stored redundantly

Source: Technology Futures, Inc.

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To Every Sensor is a Server

Phone -PDA

Smart Dust

- **Processor**
- **Data Storage**
- **Communications**
- **Rich variety of sensors**
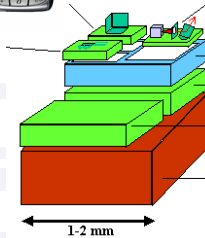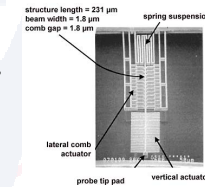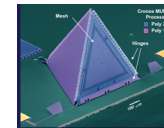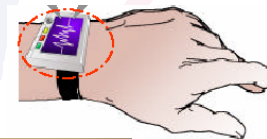
Microstorage

(Areal density 100x's CD)

Microphone

Embedded Biofluidics Chip

Robot

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Micro Servers

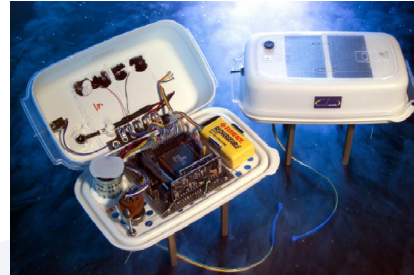
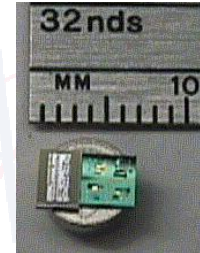**Rockwell Scientific Remote Sensor**

NASA/JPL Sensor Web 2 Pod

NASA/JPL Sensor Web 1 Pod

UCLA Medusa MK-2

XPort Embedded Device Server

Berkeley Mote (1999)

Crossbow MIICA Mote

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Convergence

- Cable companies are providing phone and ISP service

- Telephone companies in entertainment programming business

- Newspapers online

- Yahoo/eBay magazines

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General Drivers

- We are leaving the age of physics and entering the age of bio.

- Mobility will expand even more as a driver.

- Computing and broadband communications will become ubiquitous.

- New forms of computing will emerge (e.g., quantum, DNA, optical).

- There will be a proliferation of location-based services.

- Material science, in conjunction with biotechnology, will create fundamental new industries.

(continued)

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General Drivers *(continued)*

- Machines will probably surpass overall human intellectual capability by 2020.

- There will be a proliferation of intelligent devices that communicate to provide telemetry, tracking, metering, monitoring, surveillance, control, response, etc.

- Increased appreciation of the impacts of global warming will motivate major changes in energy production and utilization. There will be a major increase in the use of nuclear power, and there will be a migration to non-fossil fuel and an intelligent energy economy.

- Nanotechnology will not only change medicine, but revolutionize many aspects of our society.

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Households Using Digital Services— Minimum Competitive Data Rates
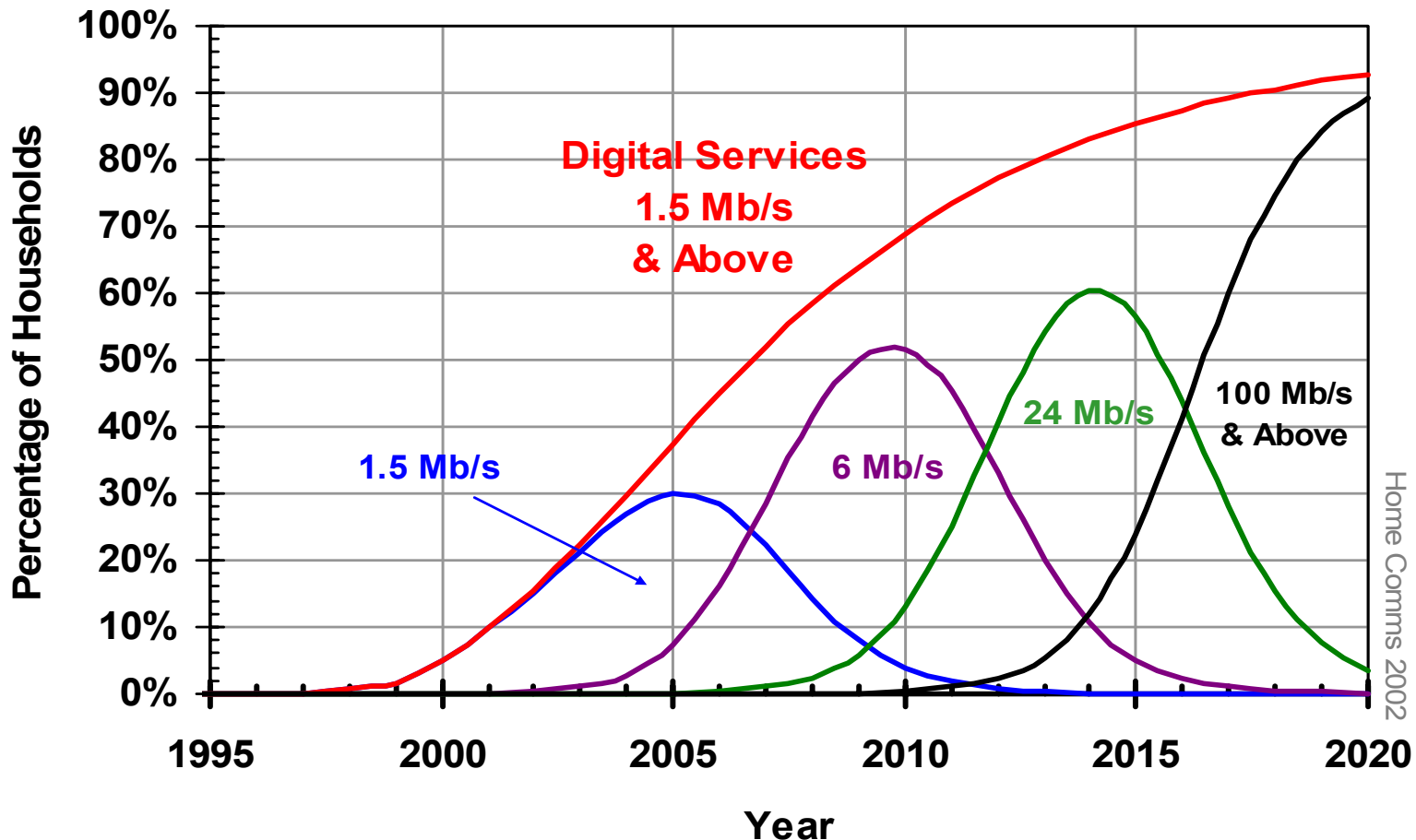
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Broadband Subscriber Trends

Worldwide Service Type

Subscribers (Millions) vs year (2001–2004) for Cable, DSL, Other

Worldwide Customer Mix

$ Billions vs year (2001–2004) for Consumer and Business

2001 Household Penetration

Penetration by country: Korea, Canada, Hong Kong, US, Sweden, Taiwan, Netherlands, Germany, Spain, Japan, France, Italy, UK
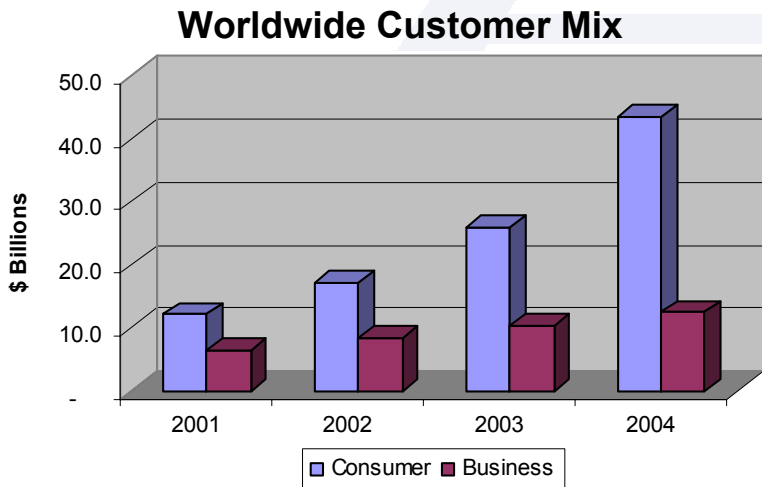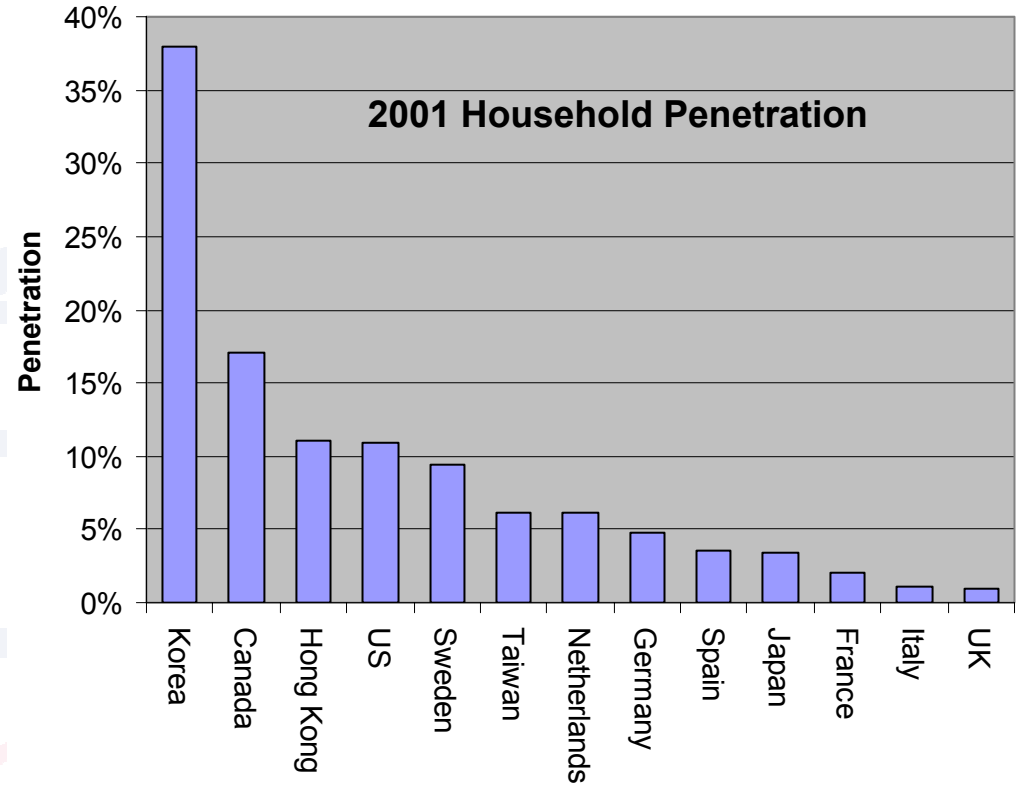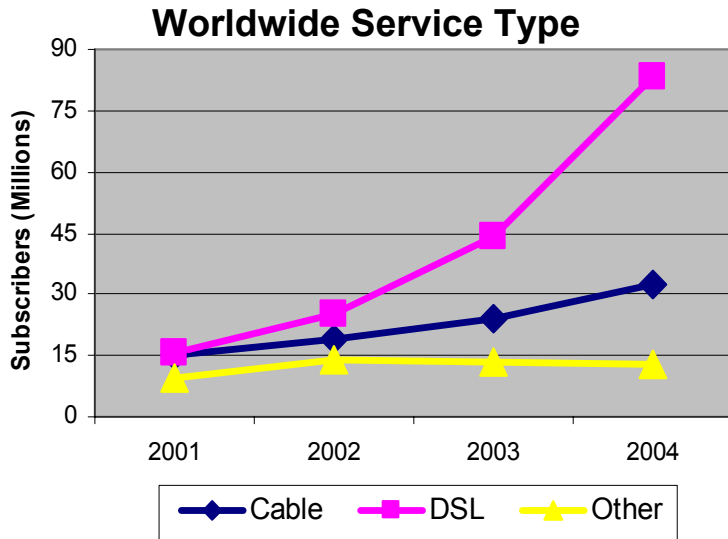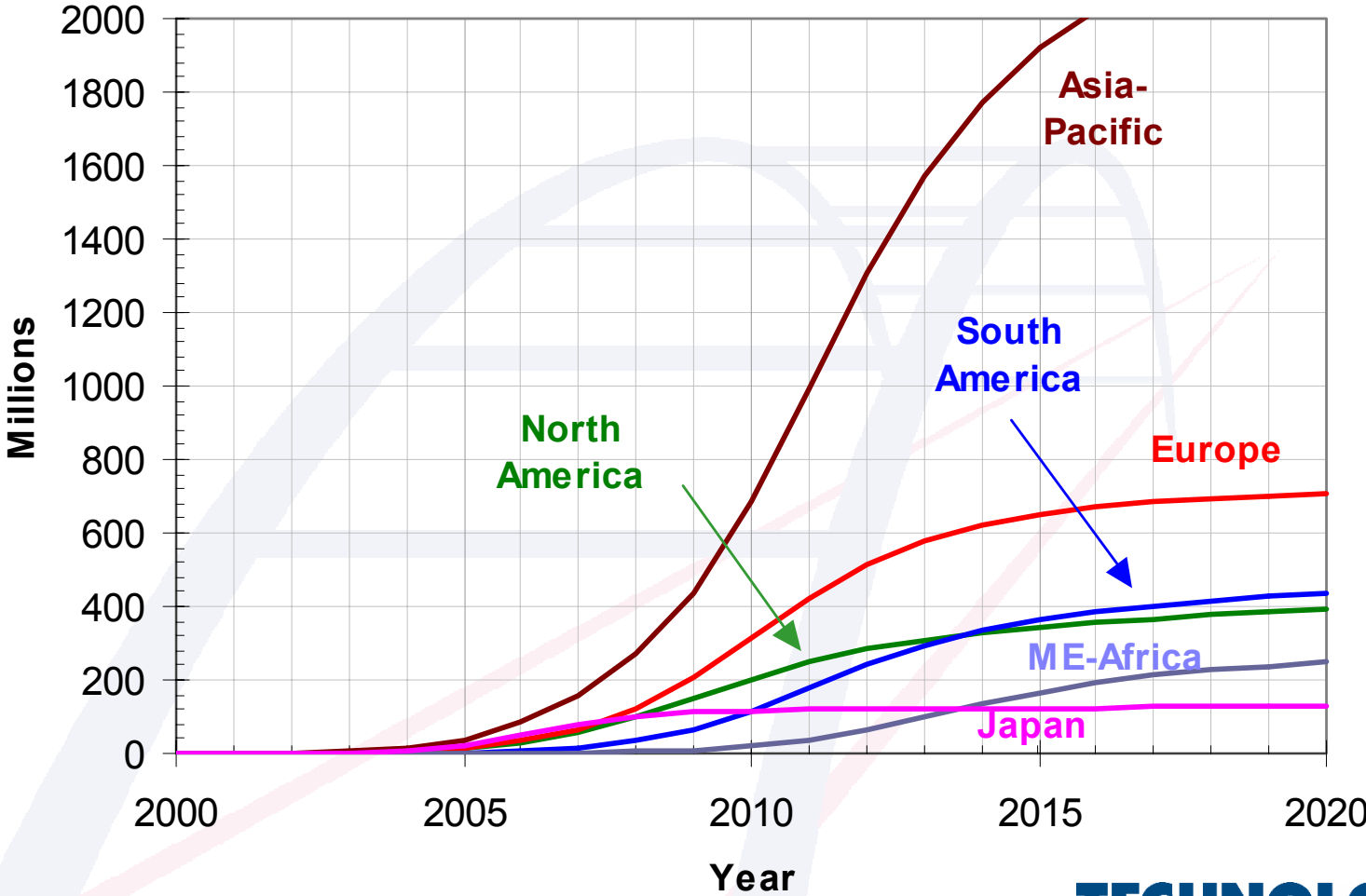
- DSL is projected to be the leading WW technology
- U.S. is falling in broadband penetration
- Residential dominates growth, cable's predominant focus

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Forecast of 2.5G and Above Subscribers by Region—Millions

Growth at the Edge of the Network
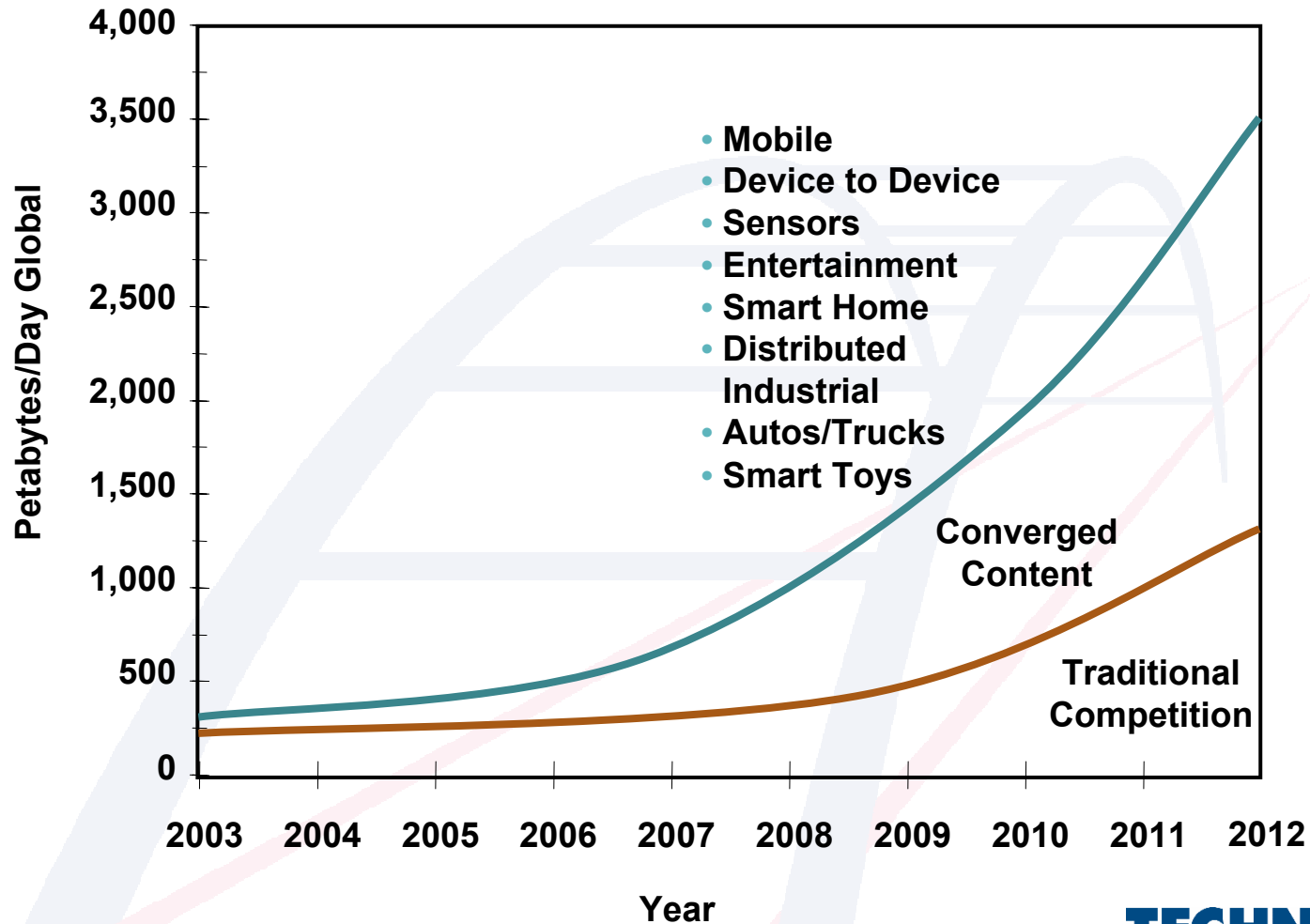
- Mobile
- Device to Device
- Sensors
- Entertainment
- Smart Home
- Distributed Industrial
- Autos/Trucks
- Smart Toys

Converged Content

Traditional Competition

Petabytes/Day Global

4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0

2003 2004 2005 2006 2007 2008 2009 2010 2011 2012

Year

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The Converged, Collaborative, Managed Network of 2010
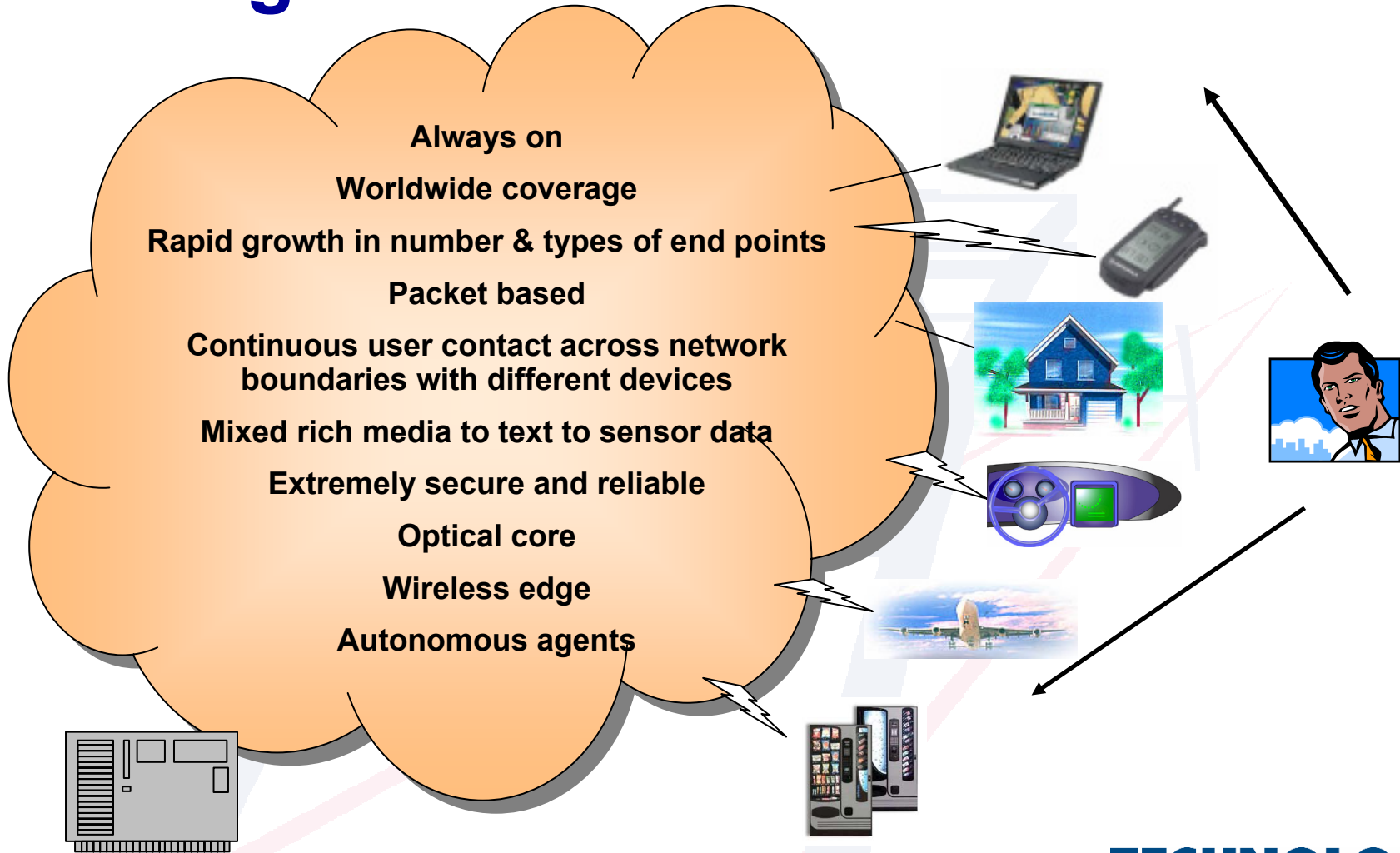
Always on

Worldwide coverage

Rapid growth in number & types of end points

Packet based

Continuous user contact across network boundaries with different devices

Mixed rich media to text to sensor data

Extremely secure and reliable

Optical core

Wireless edge

Autonomous agents

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What company shipped the most computer processing power last year?

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Moore's Law continues to be the benchmark

Transistors Per Die
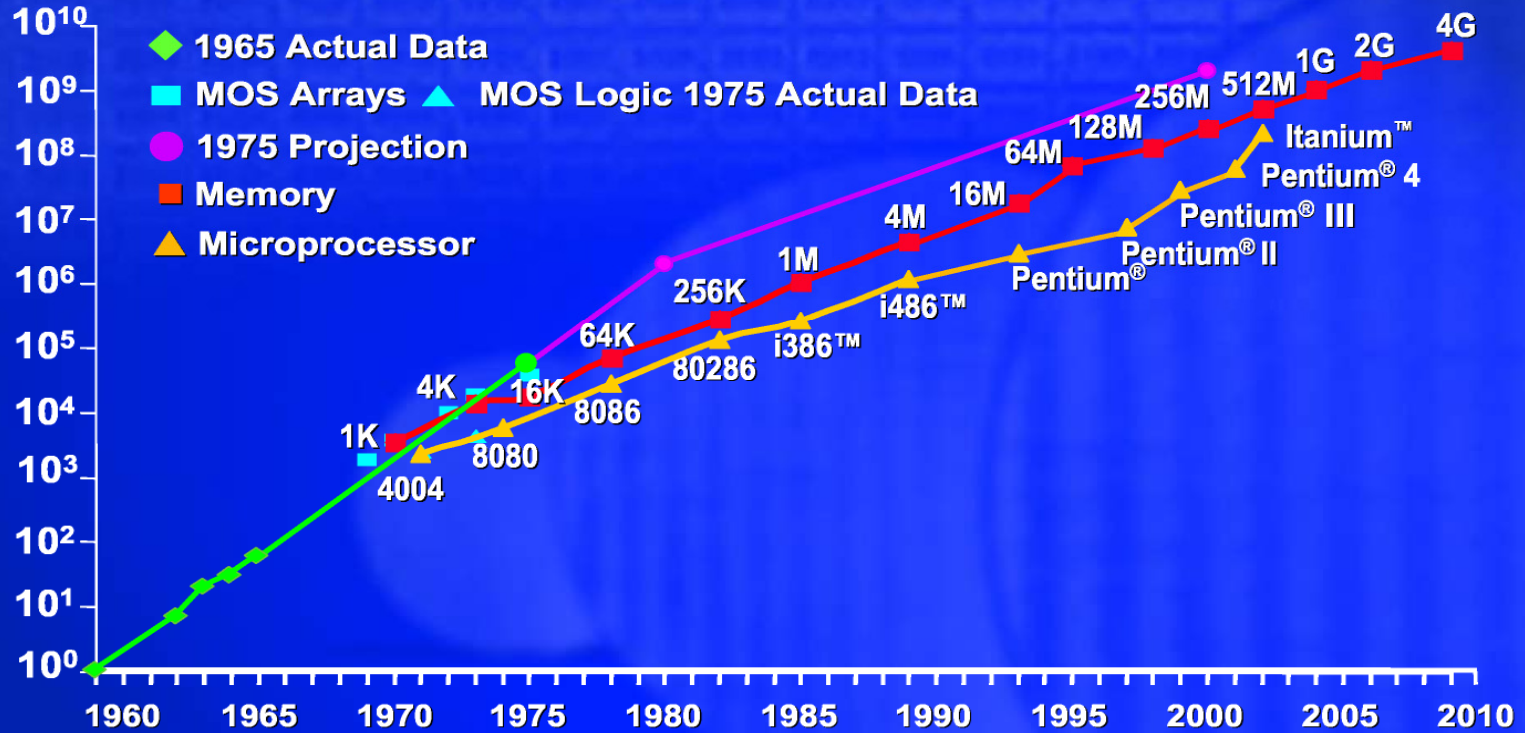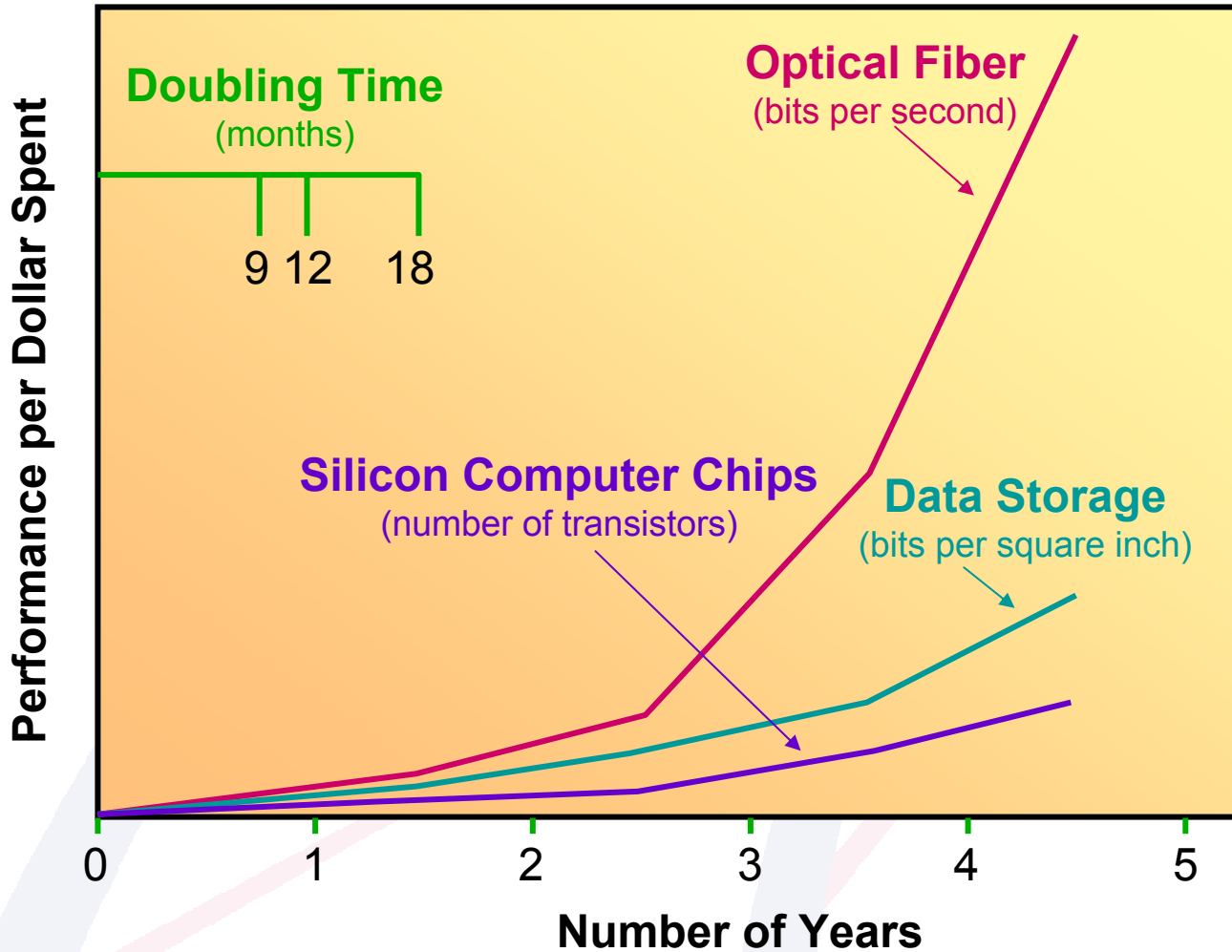
Source: Intel

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Moore Was Not Right in Some of His Forecast

Projected 2000 Wafer, circa 1975

57"
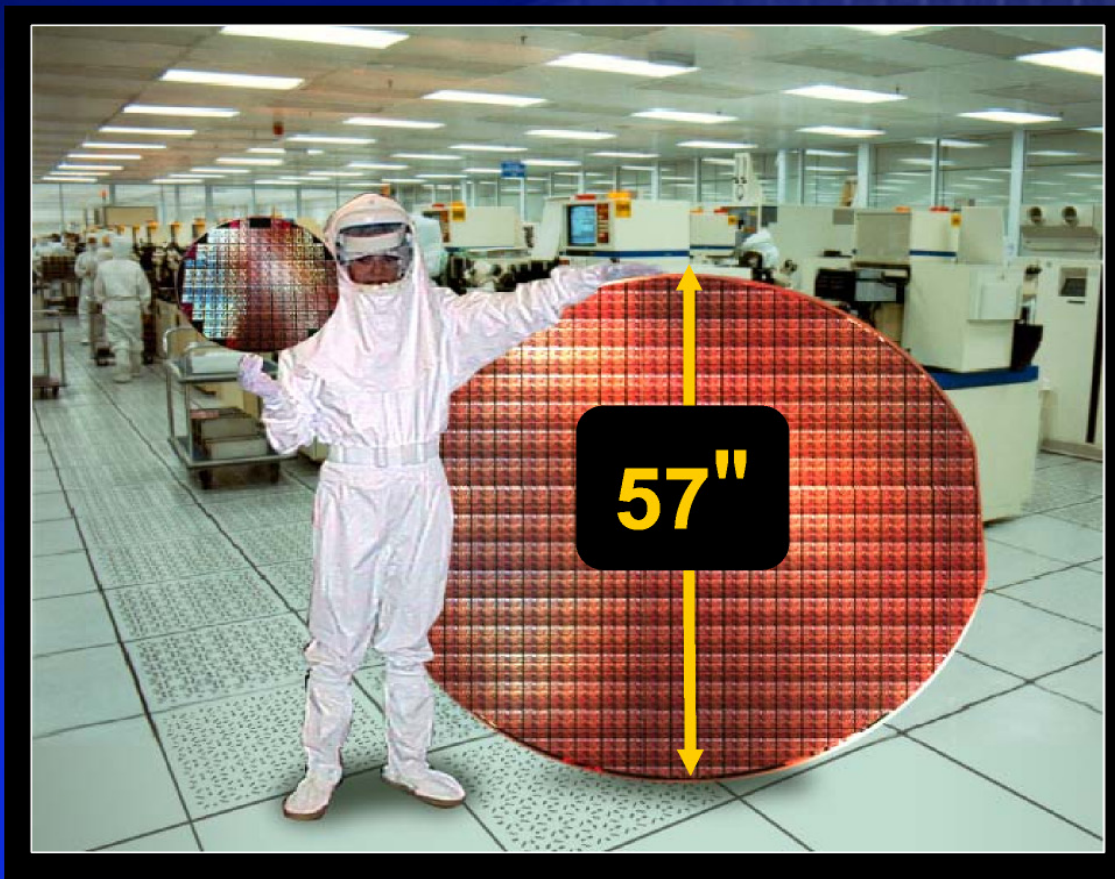
Source: *Scientific American* (June 2001)

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Competing in a Global Manufacturing Environment

Taylor's Law
(1910 – 1950s)
Scientific Management

Sarnoff's Law
(1960 - 1980)
"Human Side" Management
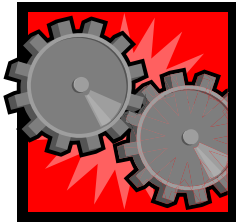
Metcalfe's Law
(1980 - 2000)
Quality Management Era

Reed's Law
(2000 - Future)
E-Manufacturing

Value Chain

Firm Infrastructure				
Human Resources Management				
Technology Development				
Procurement				
Inbound Logistics	Operations	Outbound Logistics	Marketing & Sales	After-sales Service

MARGIN

Value Shop

| Firm Infrastructure |
| Human Resources Management |
| Technology Development |
| Procurement |

Infrastructure Support

Problem Finding & Acquisition → Problem Solving

Simon's Problem Solving Model → Choice

Control/ Evaluation ← Execution

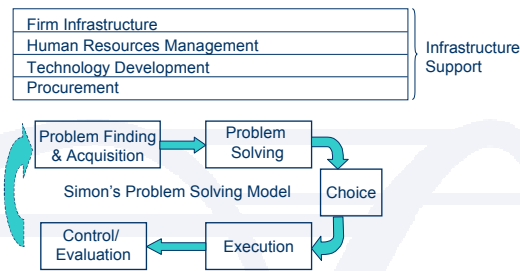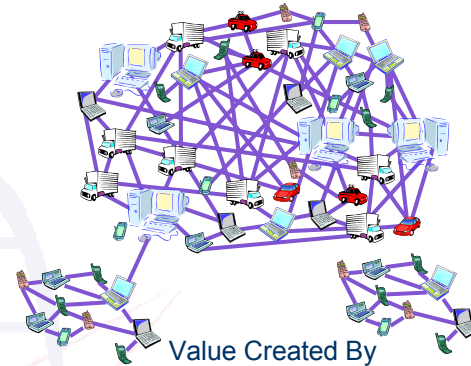Value Created in the Assembly Line (Operations)

Value Created by Transforming Inputs Into Products
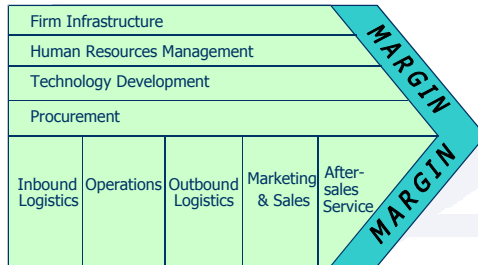
Value Created by Providing Solutions, Not Services

Value Created By Self Forming Groups
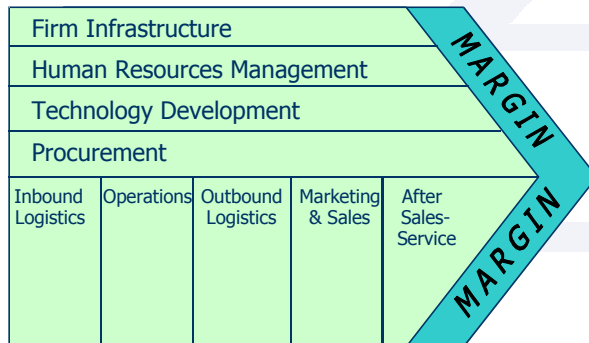
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Sarnoff's Law –1960s to mid 1980s

For one-way broadcast communication, the value of the network itself rises proportionally to N, the potential number of listeners.

Value Chain
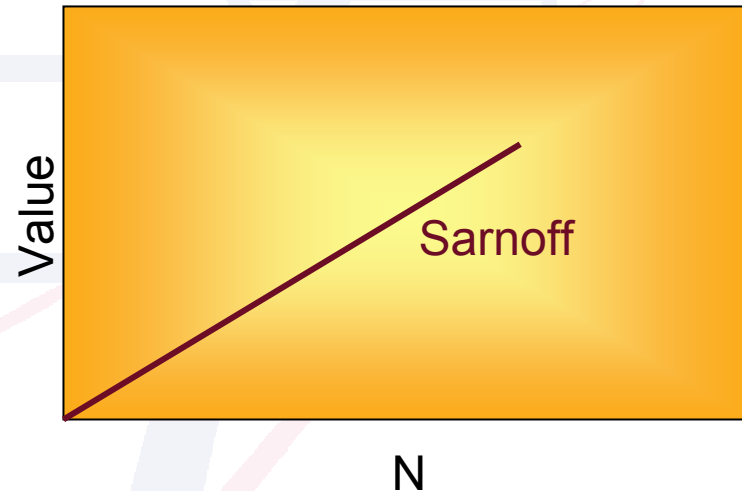
Firm Infrastructure					
Human Resources Management					
Technology Development					
Procurement					
Inbound Logistics	Operations	Outbound Logistics	Marketing & Sales	After Sales-Service	*MARGIN*

Value created by transforming inputs into products

Value

Sarnoff

N

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Internet Direction
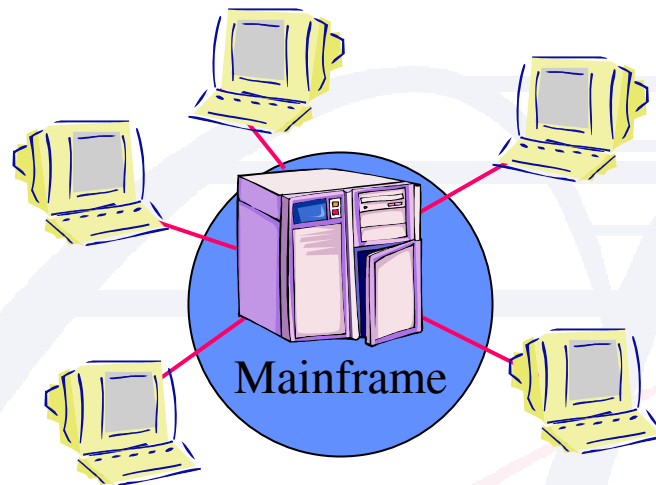
Metcalfe's Law — Mid 1980s to 2000s

The value of a network increases exponentially with the number of nodes – N^2. A network becomes more useful as more users are connected.

Value Shop
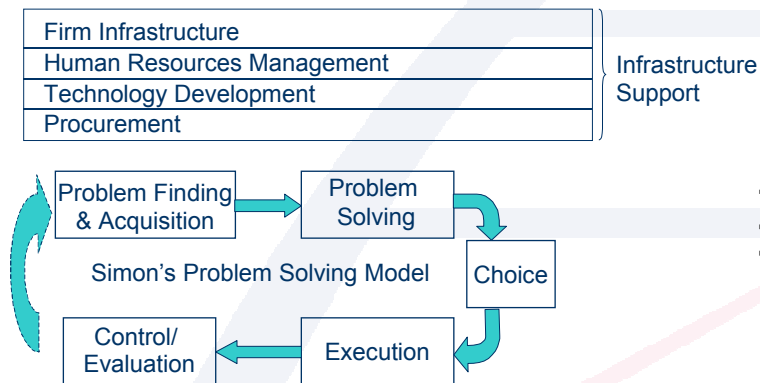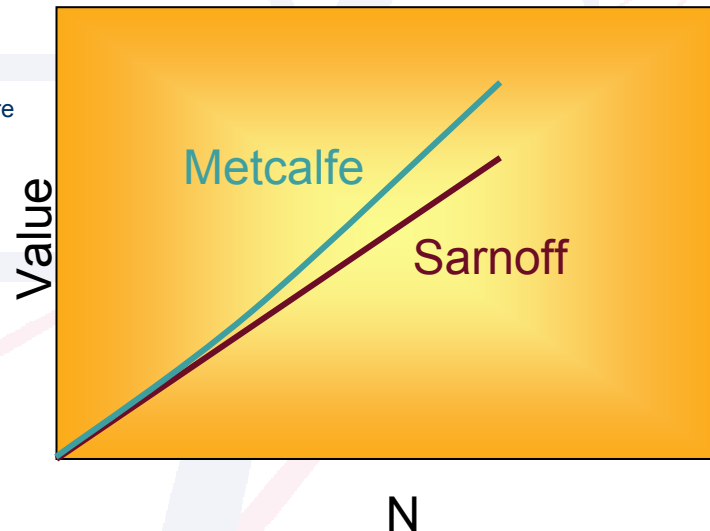
Firm Infrastructure
Human Resources Management
Technology Development
Procurement

Infrastructure Support

Problem Finding & Acquisition → Problem Solving

Simon's Problem Solving Model

Choice

Control/ Evaluation ← Execution

Value created by providing solutions, not services

Metcalfe

Sarnoff

Value

N

Internet Direction

Servers

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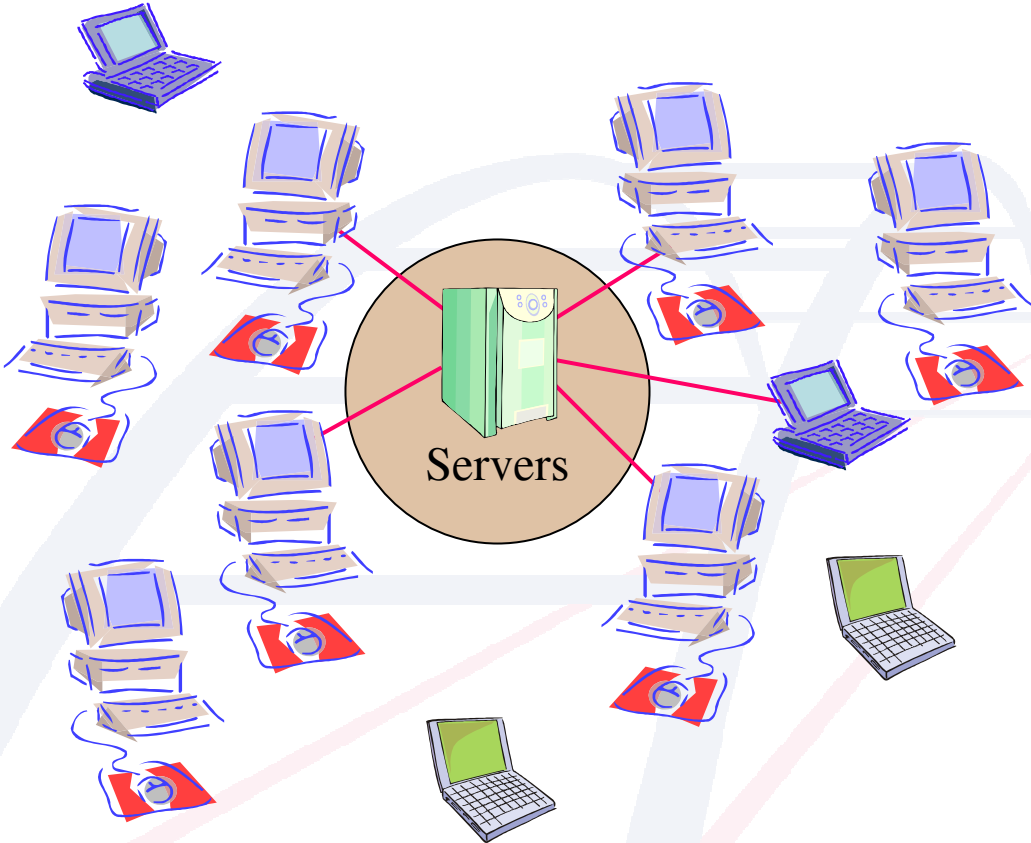
Murphy's Laws and the Early 2000s

- Dot-Com Bust

- VC/IPO

- Telcom Bust

- Call Centers

DOT COM DISCLOSURES

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Reed's Law — 2001 and into the future

Any system that lets users create and maintain groups creates a set of group-forming options that increase exponentially with the number of potential members. And as a function, 2N dominates N2 - which means that even if each individua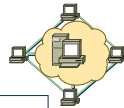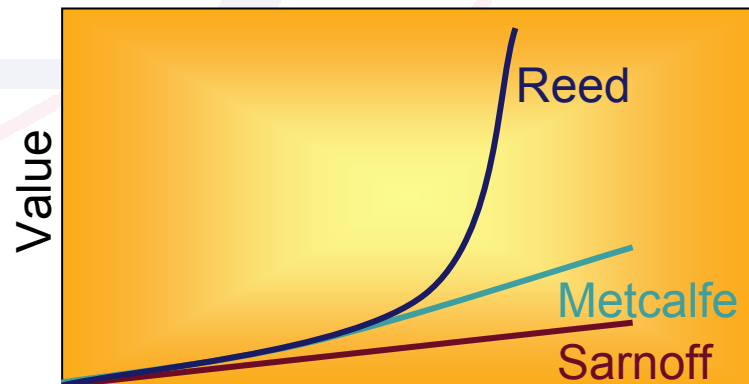l group-forming option is worth much less than an individual connection, eventually the total set of group-forming options will have far more option value.

Value Network

- Mediating technology facilitates exchange relationships

| Firm Infrastructure |
| Human Resources Management |
| Technology Development |
| Procurement |
| Network Promotion and Contract Management |

| • Invite and select customers to join network

• Initialize, manage, and terminate contracts | Service Provisioning

• Establish, maintain and terminate links

• Billing for value received | Infrastructure Operation

• Maintain and run physical and information network |

Value

Reed

Metcalfe

Sarnoff

N

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Internet Direction

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Competing in a Global Manufacturing Environment

Taylor's Law	Sarnoff's Law	Metcalfe's Law	Reed's Law
(1910 – 1950s)	**(1960 - 1980)**	**(1980 - 2000)**	**(2000 - Future)**
Scientific Management	"Human Side" Management	Quality Management Era	E-Manufacturing

Value Chain

Firm Infrastructure				
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MARGIN

Value Shop

Firm Infrastructure
Human Resources Management
Technology Development
Procurement

Infrastructure Support

Problem Finding & Acquisition → Problem Solving → Choice → Execution → Control/Evaluation

Simon's Problem Solving Model

Value Created in the Assembly Line (Operations)

- Standardization Parts and Processes
- Economies of Scale
- Producer-Centric Design, Mfg., and Delivery
- Vertical Orientation
- Required inventory buffers
- Locally Oriented
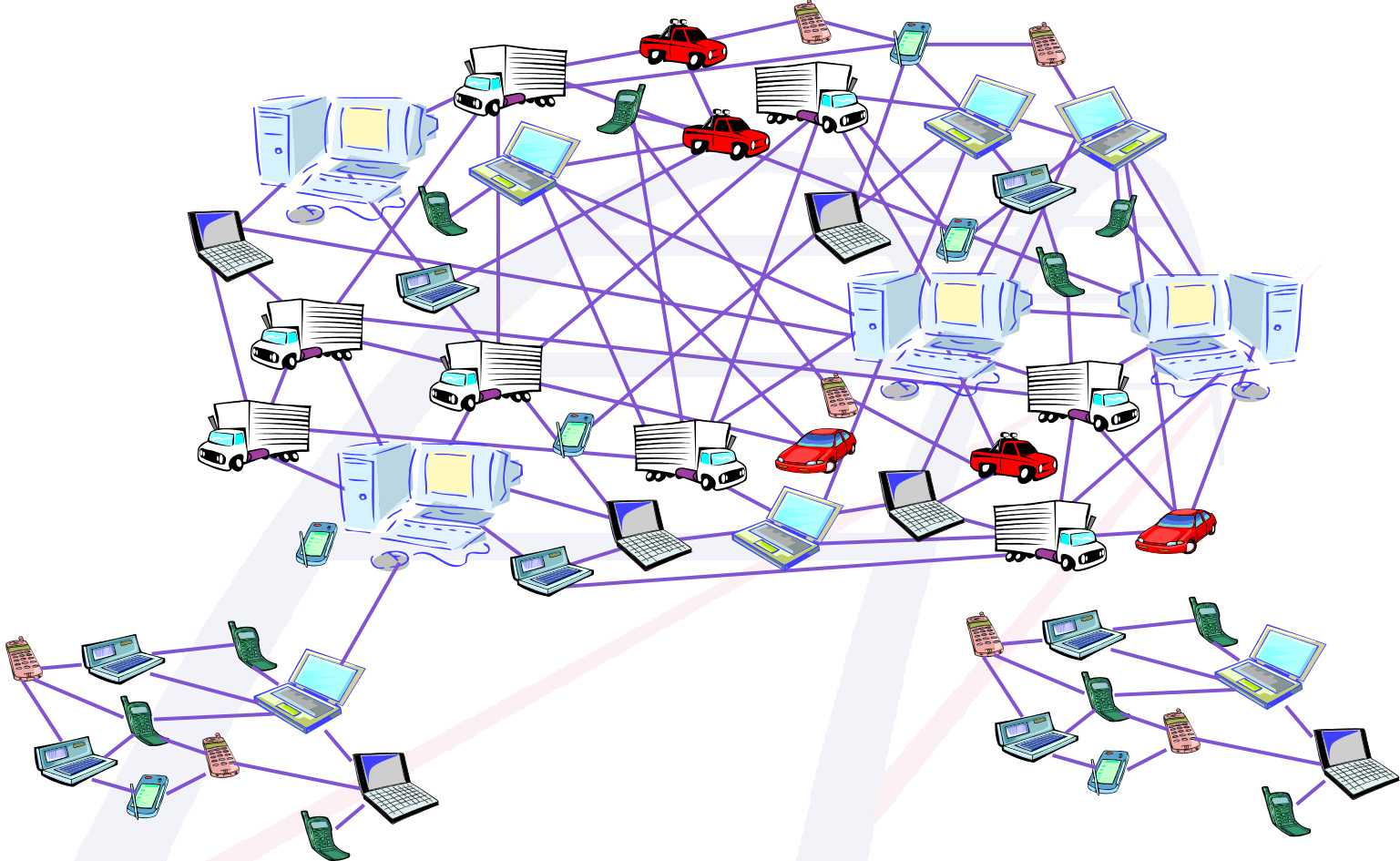
Value Created by Transforming Inputs Into Products
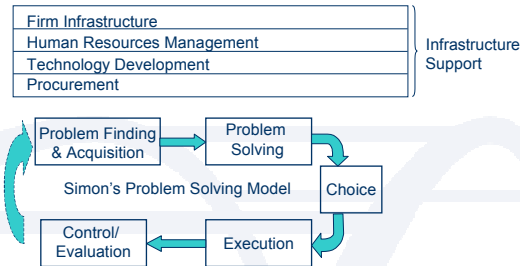
- Stable Relationships
- Price Conscious
- Producer Led Design
- Global Companies
- Regionalism
- Productivity
- Subsidiaries
- Plant Replication by Region

Value Created by Providing Solutions, Not Services

- Lean Manufacturing
- Shift to Horizontal Structure
- Focus on Core Competency
- Reliability and Durability
- Producer Led Design
- Multinational Trade
- Market Centric Design & Delivery
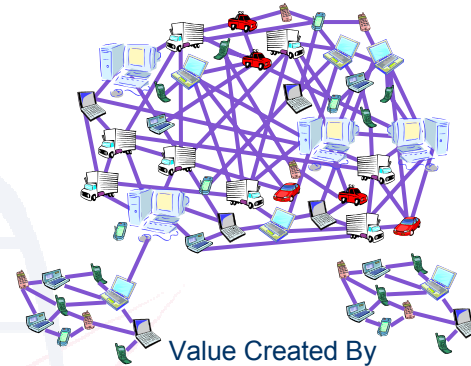
Value Created By Self Forming Groups

- Consumer Centric Design and Delivery
- Flat Corporate Structures
- Collaborative Virtual Networks
- Mass Customization
- Transparency
- Speed and Agility
- Global Orientation

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Location of world's high-technology manufacturing output: 1990–2003

EU = European Union

NOTE: Asia-8 includes South Korea, India, Indonesia, Malaysia, Philippines, Singapore, Taiwan, and Thailand.

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High-technology share of total manufacturing, by country/region: 1990–2003

EU = European Union

NOTE: Asia-8 includes South Korea, India, Indonesia, Malaysia, Philippines, Singapore, Taiwan, and Thailand.

Source: National Science Foundation

S&E Doctorates Awarded, by Country/Region: Most Recent Year
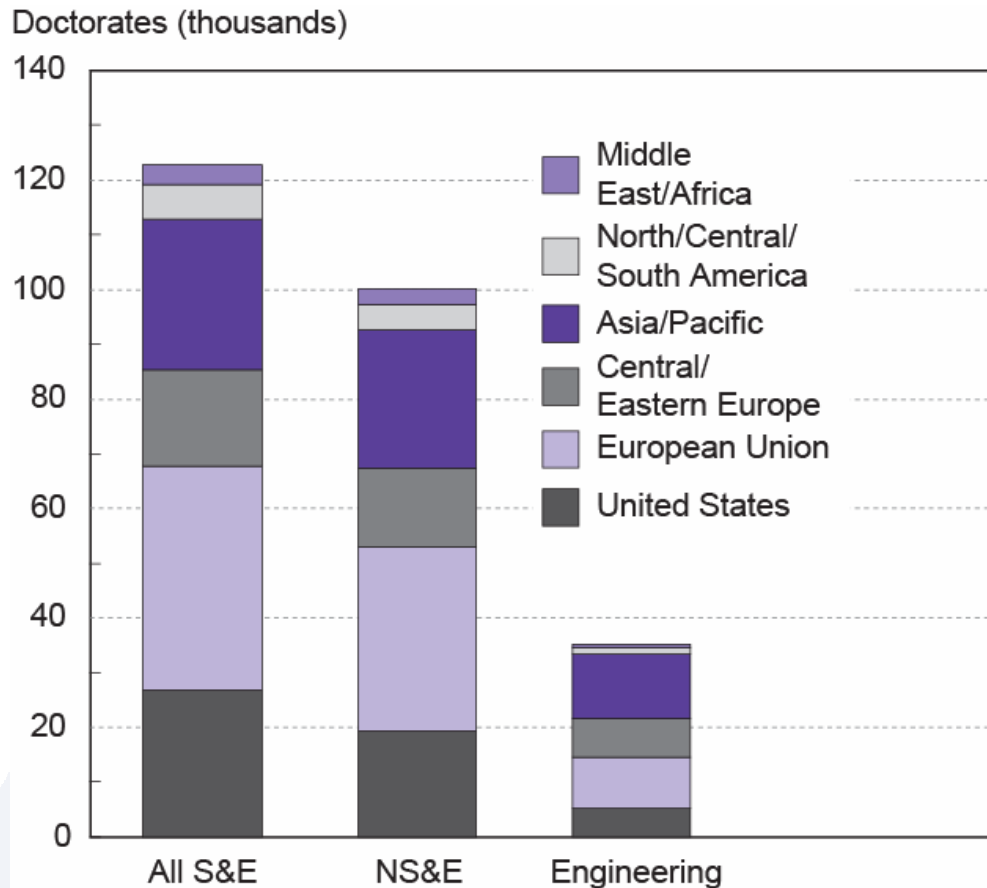
NS&E = natural sciences and engineering

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Geographic distribution of U.S. firms' overseas R&D: 1994–2002

Source: National Science Board, *Science and Engineering Indicators 2006*
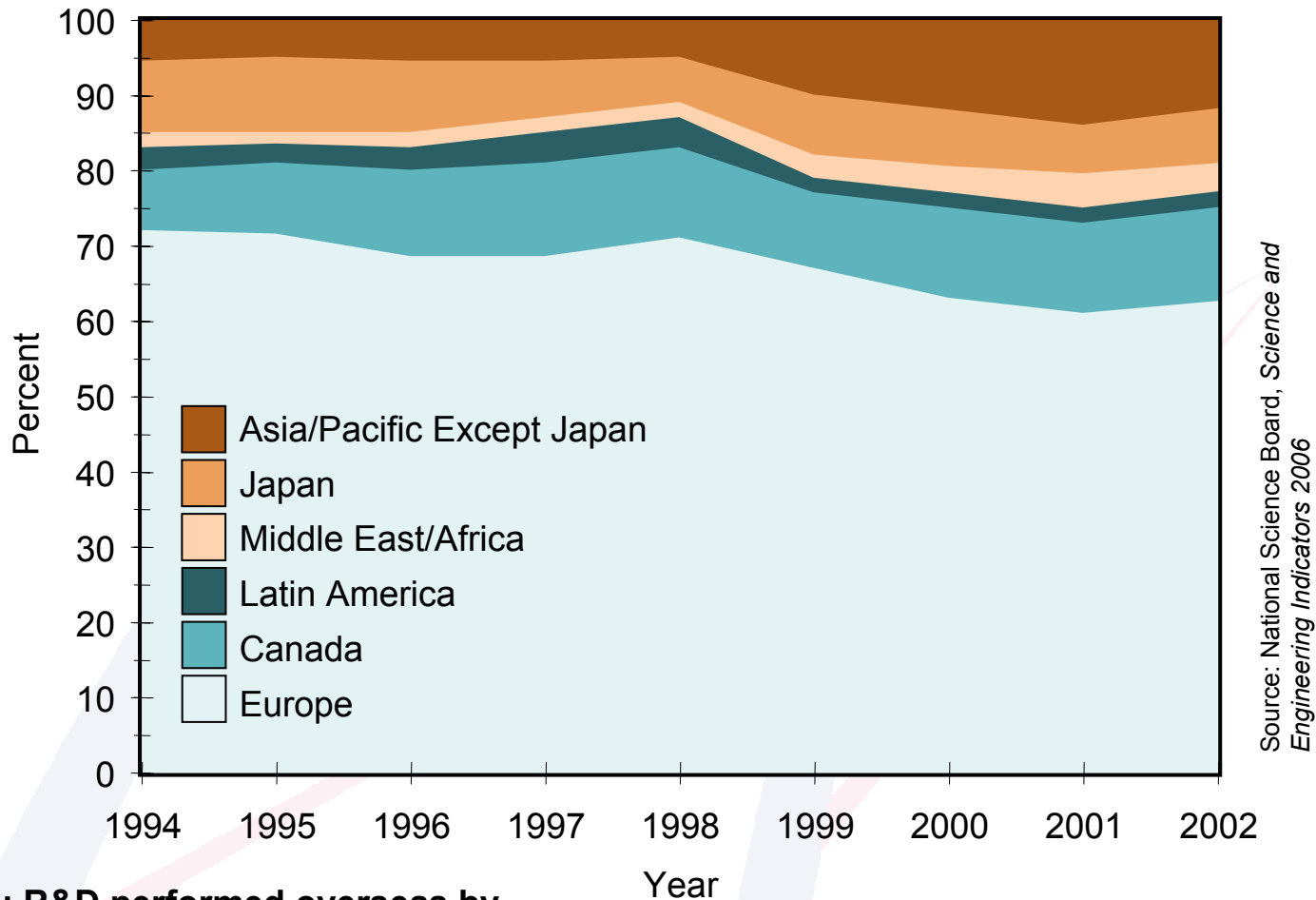
Note: R&D performed overseas by majority-owned affiliates of U.S. firms.
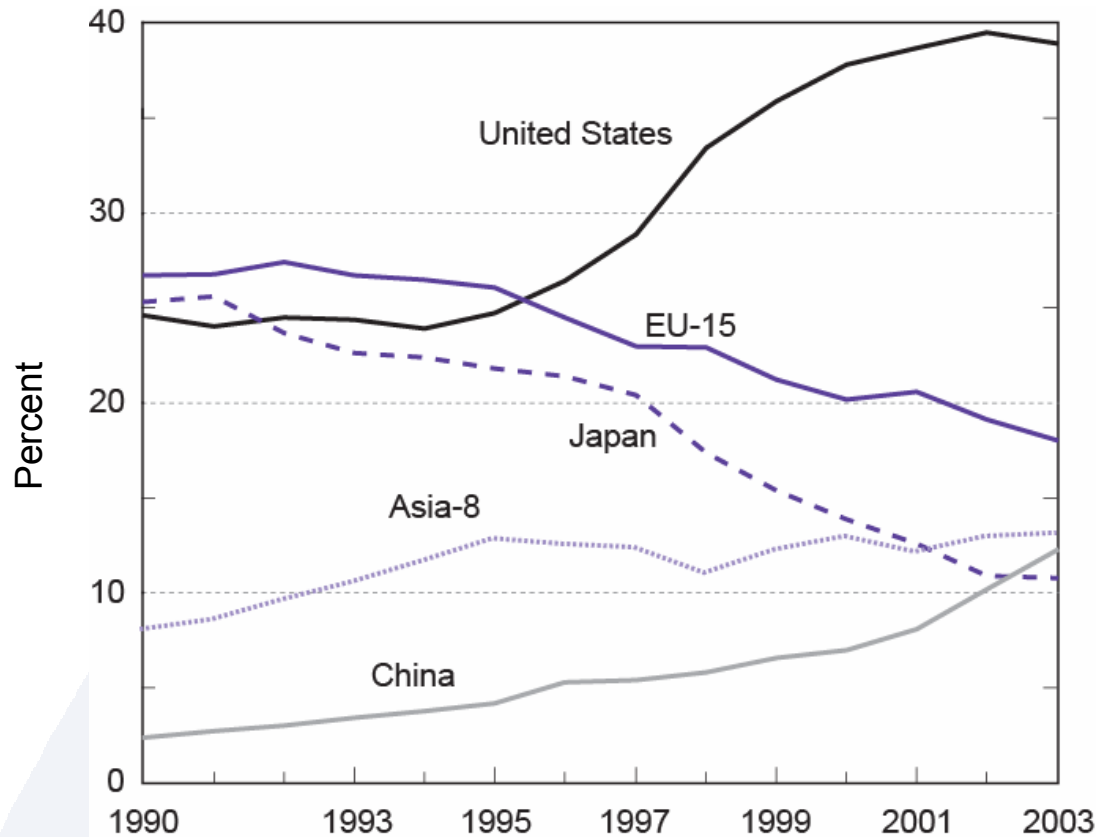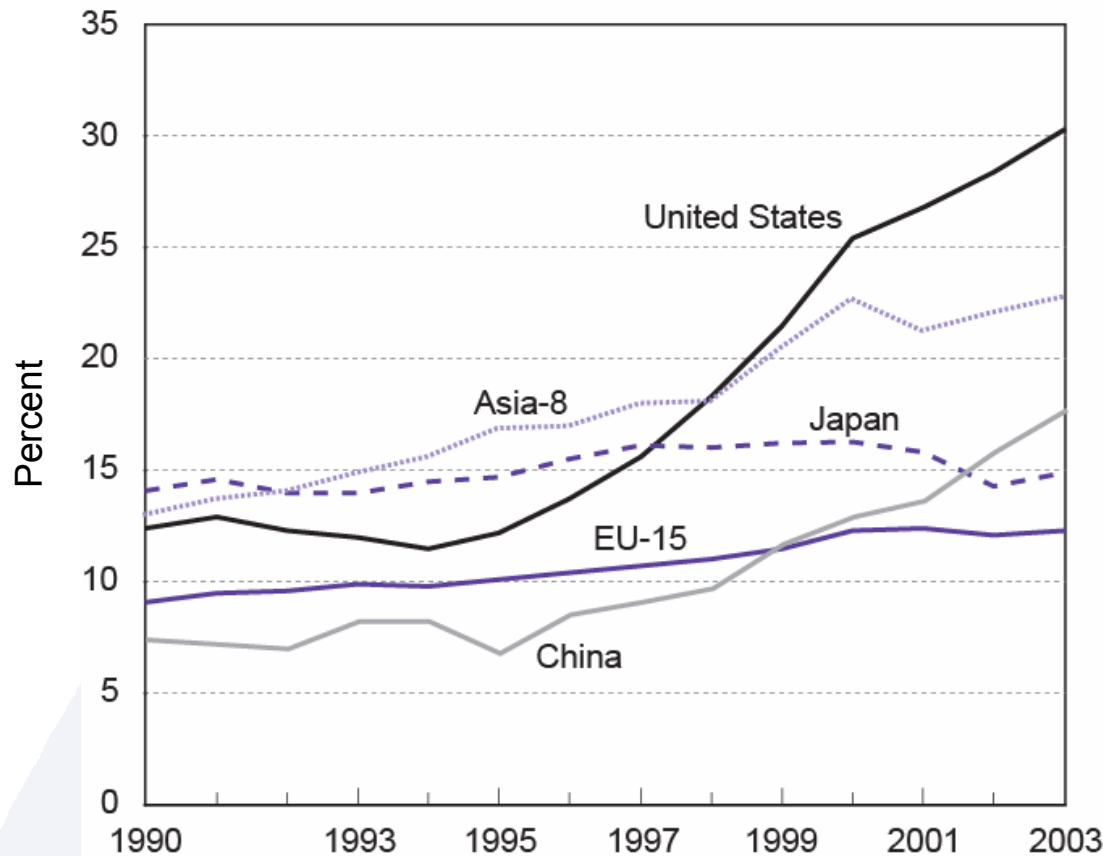
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S-Curve for Innovation, Development, and Product Life
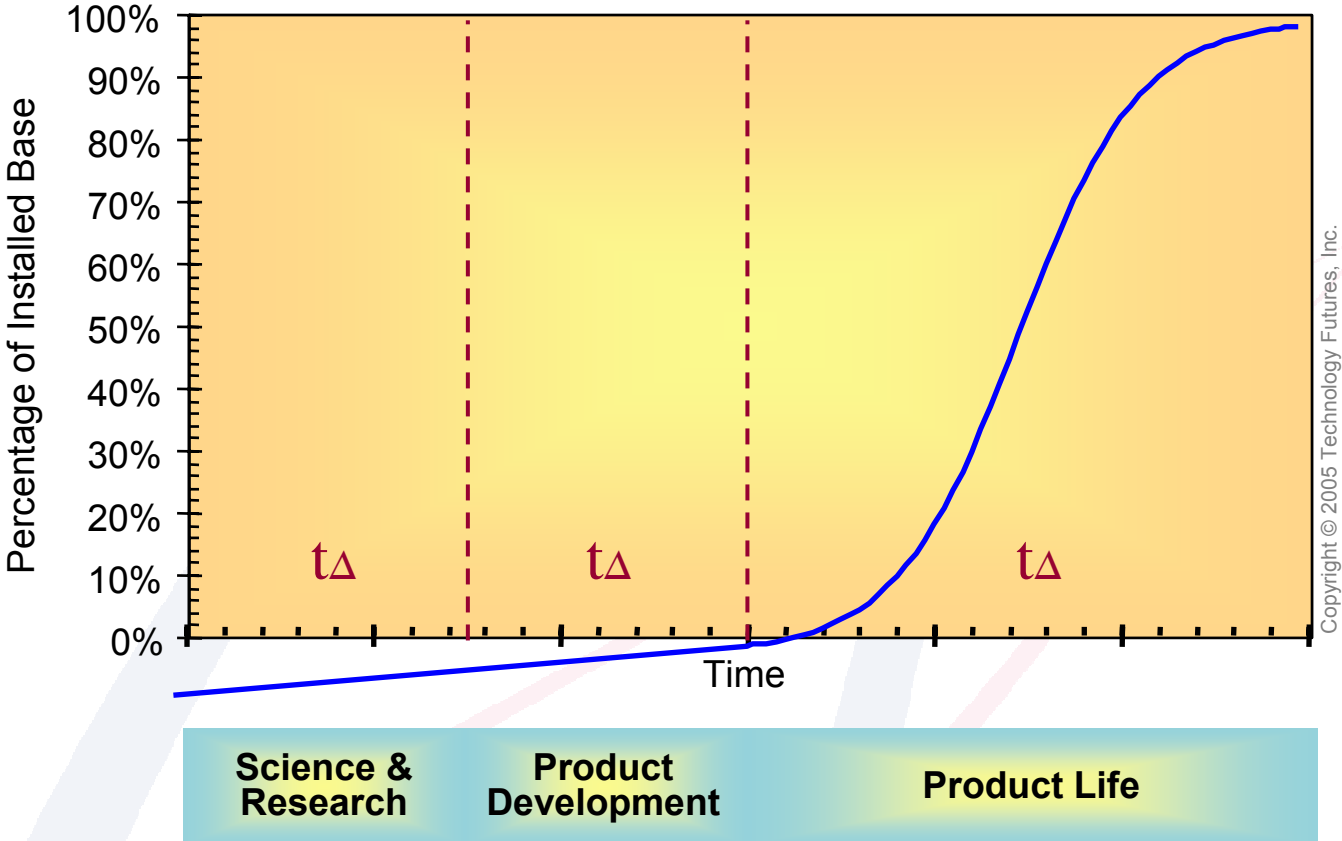
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Research/Product Life Cycle

Research	Development	Product Life

Introduction	Preliminary	Active	Mature	Legacy	Obsolete
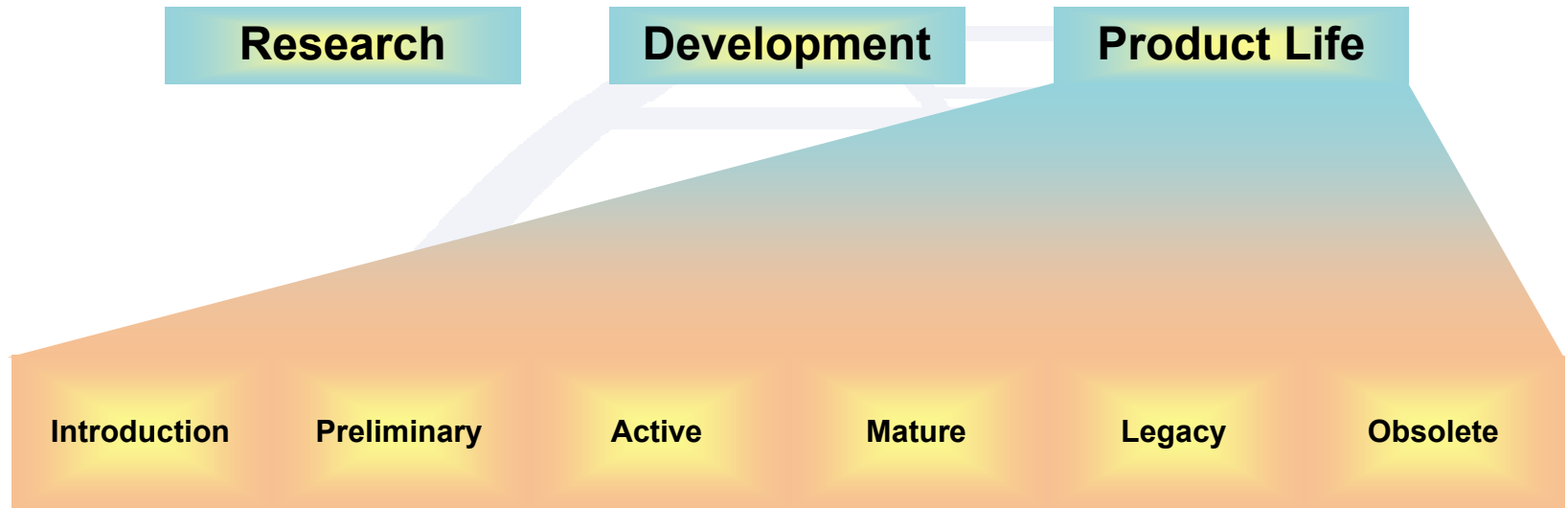
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Research/Product Life Cycle

Research	Development	Product Life

Product Generation	Product Screening	Concept Development & Testing	Business & Marketing Strategy	Product Development —Alpha	Test Marketing —Beta	Deployment

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Research/Product Life Cycle

Research	Development	Product Life

Sand Box	Discovery	Basic Science	Experimental Science	Directed Research	Applied Research

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Consequences of the Internationalization of R&D

- Establishing Competence Centres at Different Locations

  – To interact specific technological competence is of greater relevance than the traditional motives for sending production abroad.

  – The trend towards research competencies and leading -edge centers at various location.

  – Global technology strategy.

  – The competition between innovation systems will increase, incremental innovation, radical innovation.

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Consequences of the Internationalization of R&D

- Formation of High Performance Units and "Clusters"

  - "Non Geographic Cluster formation"

  - "Centers of excellence"

  - R&D laboratories are set up primarily where the best conditions are to be found world-wide

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Consequences of the Internationalization of R&D

- The variety of co-ordination mechanisms

  - ....growing problems of co-ordination led to disillusion and the increasing formation of centers in a global context

  - .... many multinational enterprises are experimenting with various mechanisms for steering and integration, with the aim of creating synergies world-wide and avoiding the duplication of tasks

  - The hybrid co-ordination mechanisms are often used for the simultaneous co-ordination

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Consequences of the Internationalization of R&D

- Change the National Innovation Policy

    - The national innovation policies will lose in significance as a result of internationalization

        - Impact on Education, Research and Technology

        - The Significance of "Lead markets"

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Critical Success Factors of Internationalizing R&D

- Approach collaboration and avoid "intellectual colonialism."

- Be highly integrated with business directions. But remain independent in thinking of how to meet business needs.

- Throw nets wide, and keep the "Global/Local" thinking

- Foster the personal relationships over time between researchers that are critical to reducing cultural and stylistic differences

- Make maximum use of available information systems

- Supplement the need for occasional face-to-face interaction with an effective communication system

- Press for speed. 80% of the value of a new technology goes to the one who gets to market first
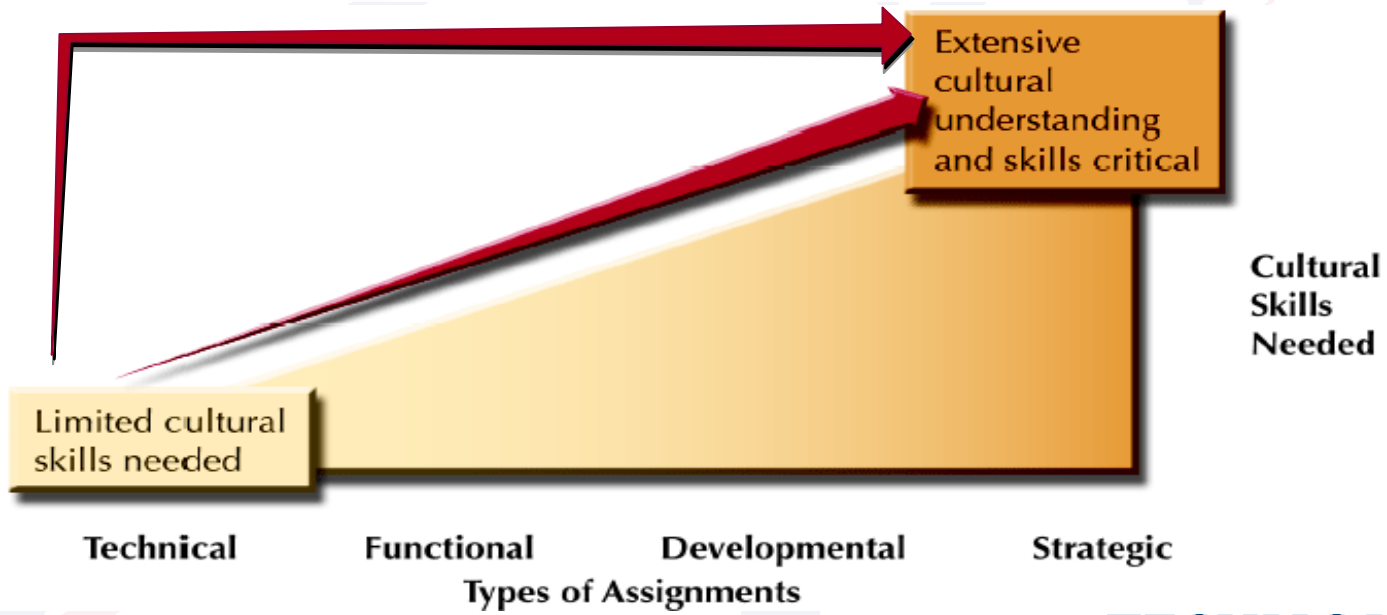
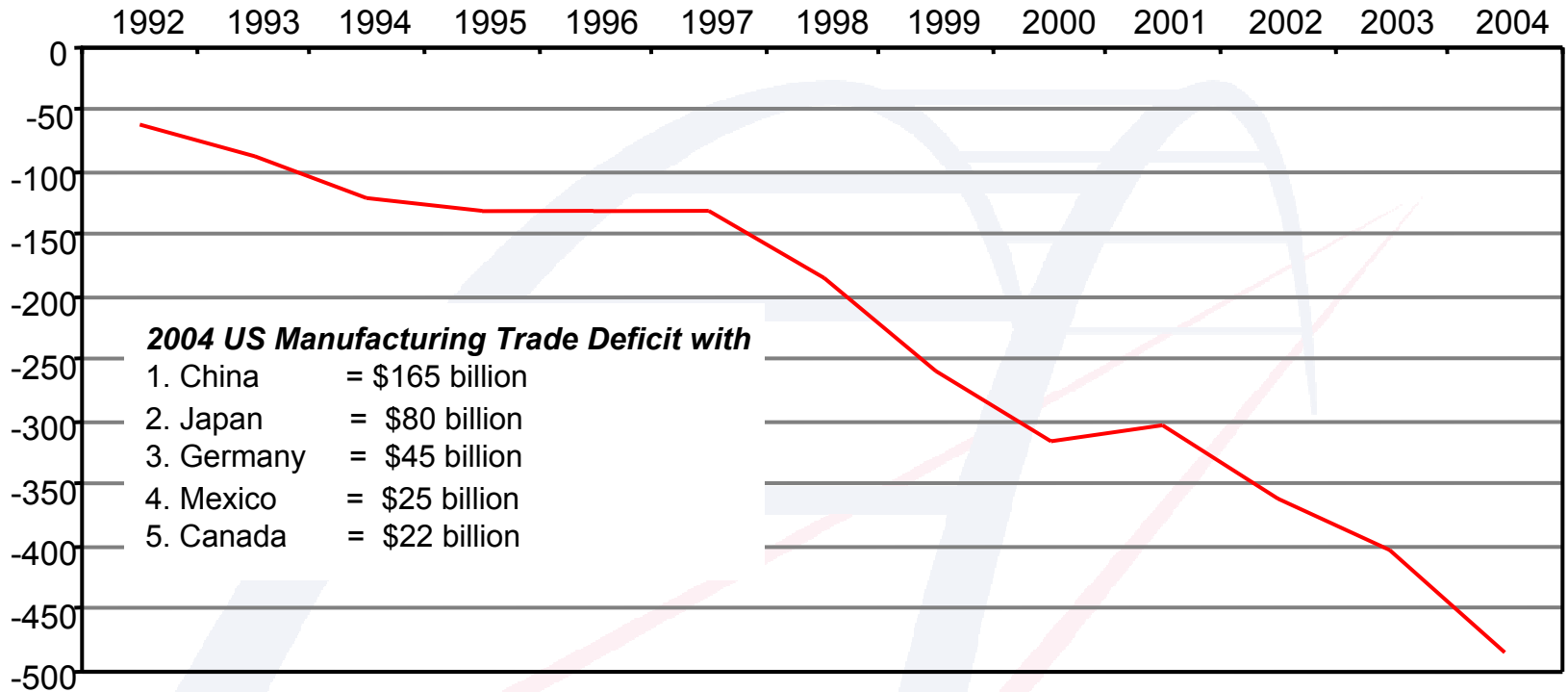**TECHNOLOGY FUTURES INC.**

Extensive cultural understanding and skills critical

Cultural Skills Needed

Limited cultural skills needed

Technical   **Functional**   **Developmental**   **Strategic**

Types of Assignments

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Trade Deficit Has Not Improved So Far

2004 US Manufacturing Trade Deficit with
1. China   = $165 billion
2. Japan   = $80 billion
3. Germany   = $45 billion
4. Mexico   = $25 billion
5. Canada   = $22 billion

Source: International Trade Administration, Department of Commerce.

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Not Just the Berlin Wall Fell

- National identity

- National protection of subnational interests

- Unresponsive systems

- Small scale, small scope business ~ a luxury of the past?

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The Contribution of Trade to the Post 2000 Job Loss Came From Exports: Why Were US Exports Weak?

- Global slowdown? No.
  World Trade grew strongly. The US export share declined.

- US in the wrong products? No.
  High-tech was weak, but other US export areas showed solid growth.

- US selling to countries that grew slowly? Yes a little.
  Markets where US sells did not grow quite in line with world trade. Not a major factor.

- US loss of "competitiveness?" Yes.
  This is the big factor in export weakness.
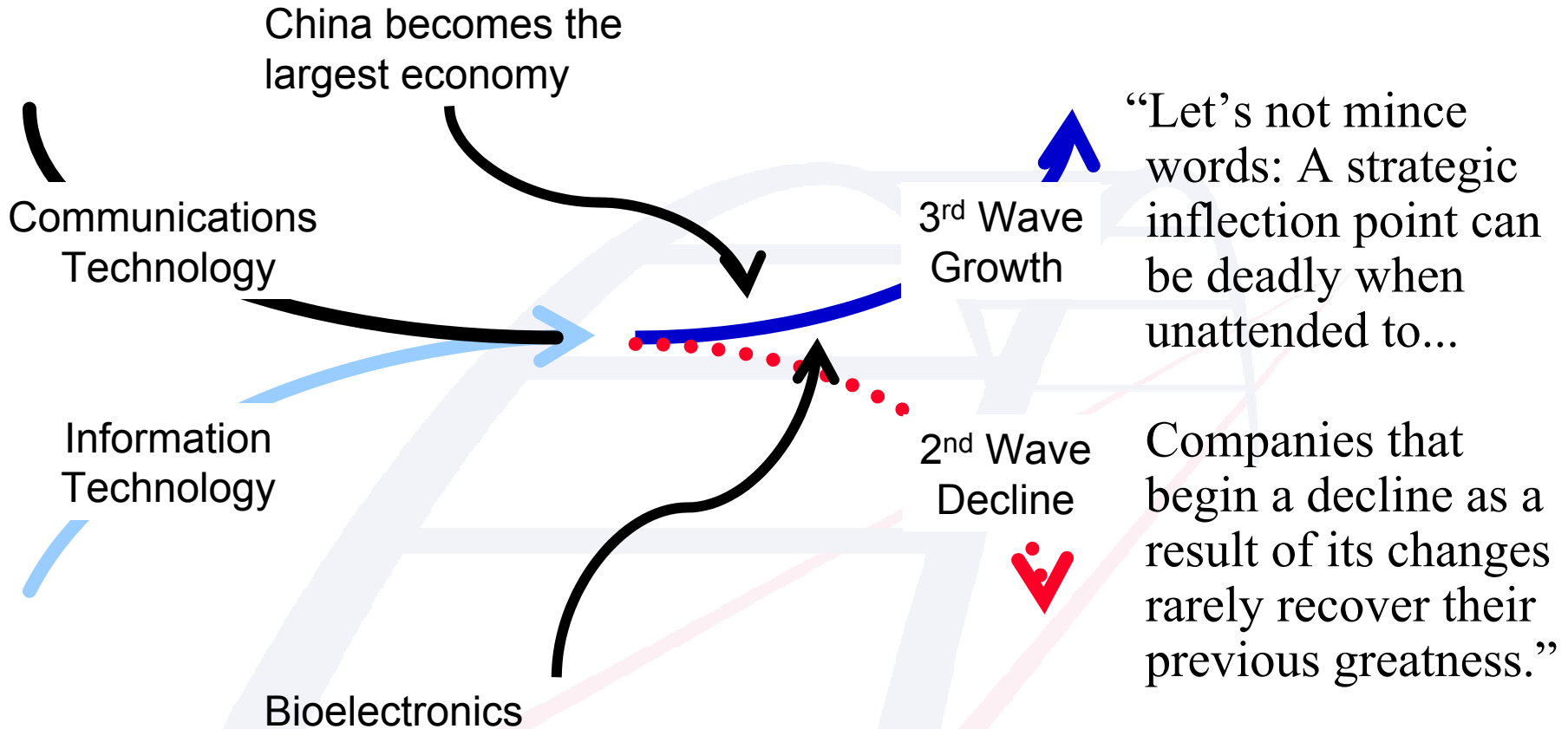
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The world's largest manufacturers are no longer simply multinationals operating autonomously in a number of countries. Today, they are global enterprises with consolidated investment, planning, and decision-making functions, but with trade and supply networks, production activities, and investments spread throughout the world.

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The Coming Strategic Inflection Points

China becomes the largest economy

Communications Technology

"Let's not mince words: A strategic inflection point can be deadly when unattended to...

3rd Wave Growth

Information Technology

2nd Wave Decline

Companies that begin a decline as a result of its changes rarely recover their previous greatness."

Bioelectronics

• Adapted from Dr. Robert McCarthy (Roche) and Andy Grove's <u>Only the Paranoid Survive</u>)

The Age of Bio

Genome Discovered (1930s)

Fruit Fly (1999)

100 Organisms Sequenced (June 2001)

First Organism Sequenced (Glow Worm) 1998

95% Human Genome (Feb. 2001)

Vertical axis: 10^3, 10^2, 10^1, 10^0

Horizontal axis: 1980, 1990, 2000, 2010, 2020
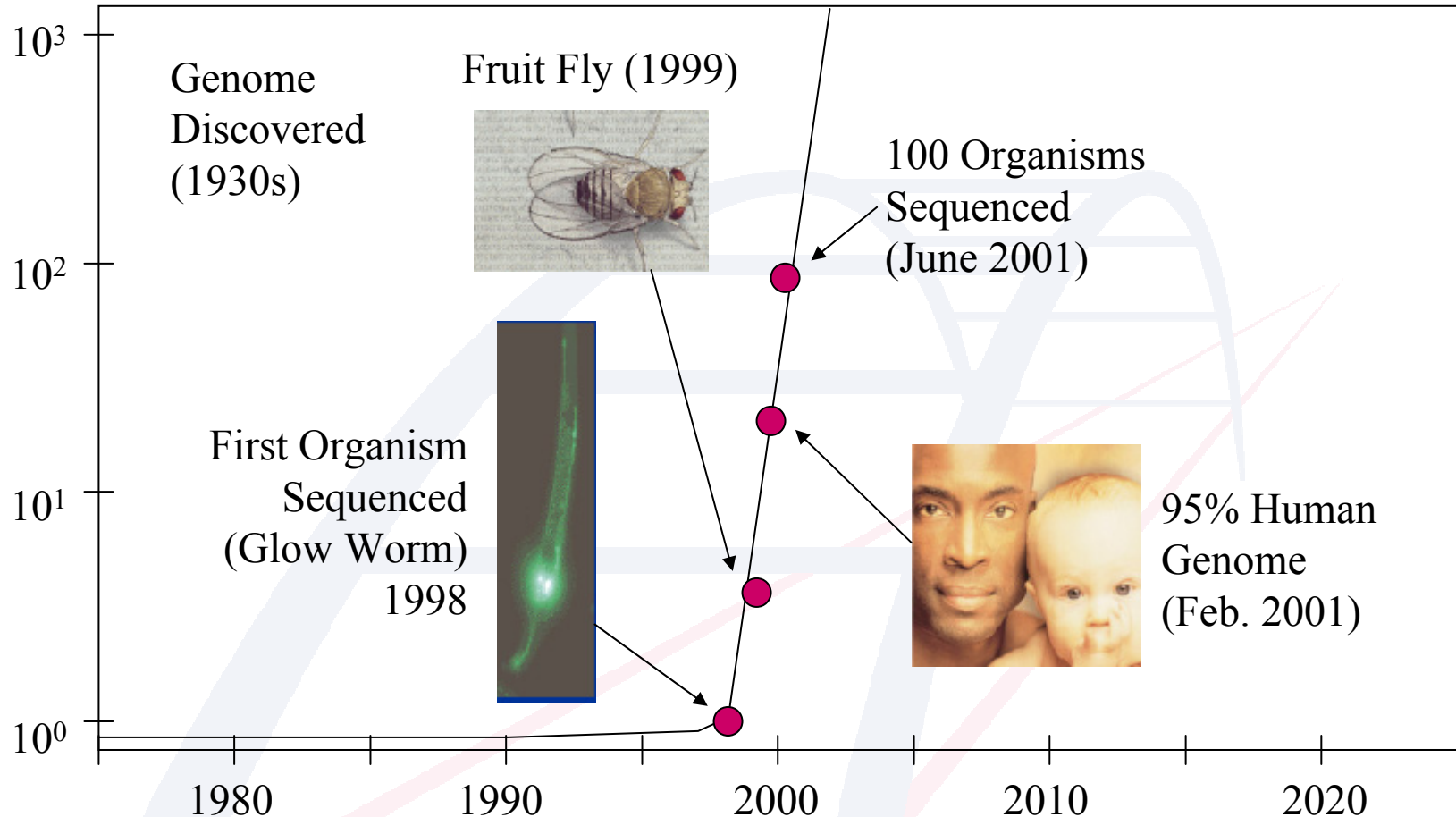
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"The corporation as we know it, which is now 120 years old, is unlikely to survive the next 25 years. Legally and financially, yes, but not structurally and economically."

—Peter Drucker, quoted in
Business 2.0, August 22, 2000

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Reed's Law Will Drive New Innovation for Manufacturing

Corporate Ventures	• Fund key startups or skunkworks. • Lessons for the future.
Contract Research Labs	• Rapidly respond to new ideas. • New sources of invention. • Provide transformation for invention to products.

(continued)

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Reed's Law *(continued)*

Free Agents	• Use the new self-forming networks to work with independent entrepreneurs worldwide. • Cost-effective approach to innovation (like Eli Lilly online InnoCentive or In-Q-Tel). • Brokering.
Academia	• In the U.S., 73% of all patents originate in academic research. • Most are never commercialized. • New approach needed to address changing models and cycle times.

(continued)

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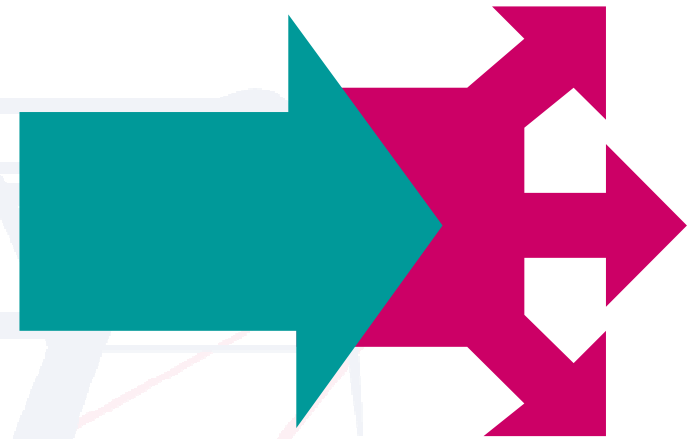
Reed's Law *(continued)*

New Markets	• Use third parties on network to mitigate risk in new markets.
	• Co-innovate with customers.
	• Harvest across all units of company at all global locations.
	• Scout for talent across national and company boundaries.
	• Shift suppliers very fluidly to mate core competencies and the services required. A new value chain.

Many other areas with suppliers, customers, governments, and even competitors.

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If we don't change our direction, we'll end up exactly where we are headed.

—Ancient Chinese Proverb

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Your Bridge to the Future