The Next Revolution in Communications and Information Technology: Its Implications for Economic Growth and Innovation

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Information on UC San Diego www.ucsd.edu

- Young! Created in 1959
- 23,000 students (growing to 30,000): 2nd largest number of undergraduate student applicants in US
- 8 Nobel Prize Winners
- #6 in US in research & development funds
- Top ten in National Research Council PhD training ratings and in membership in National Academies of Science and Engineering
- Major Research Institutes include: California Institute on Telecommunications and Information Technology and San Diego Supercomputer Center

Graduate School of International Relations and Pacific Studies (IR/PS): www-irps.ucsd.edu

- The only graduate school in US devoted to professional school training focused on Asia and the Americas
- Masters (2 years) and PhD Training along with mid-career professional training (ICAP)
  - 160 students in entering Masters class from 22 countries
  - Specializations ranging from public policy through environmental policy and international management of firms and non-profits
- Faculty of distinguished political scientists and economists
  - UCSD ranks 2nd in comparative politics, 9th in international relations, and 15th in economics in US
- Unique training: All students take micro-economics, finance, accounting, international politics, public policy analysis, and comparative politics and economics

Strong Long-Term Prospects for Communications Networks and Information Technology as Catalysts for Economic Growth

- The current market downturn ignores fundamental economic advantages of digital communications and information technology (CIT) in long-term
- The stakes are high
  - Productivity is the key to long-term growth
  - In mature economies, CIT can raise productivity by 0.25% to 0.50% annually—a huge difference cumulatively.
  - In all countries, “digital sciences” are key to transforming traditional scientific research and its application to social problems

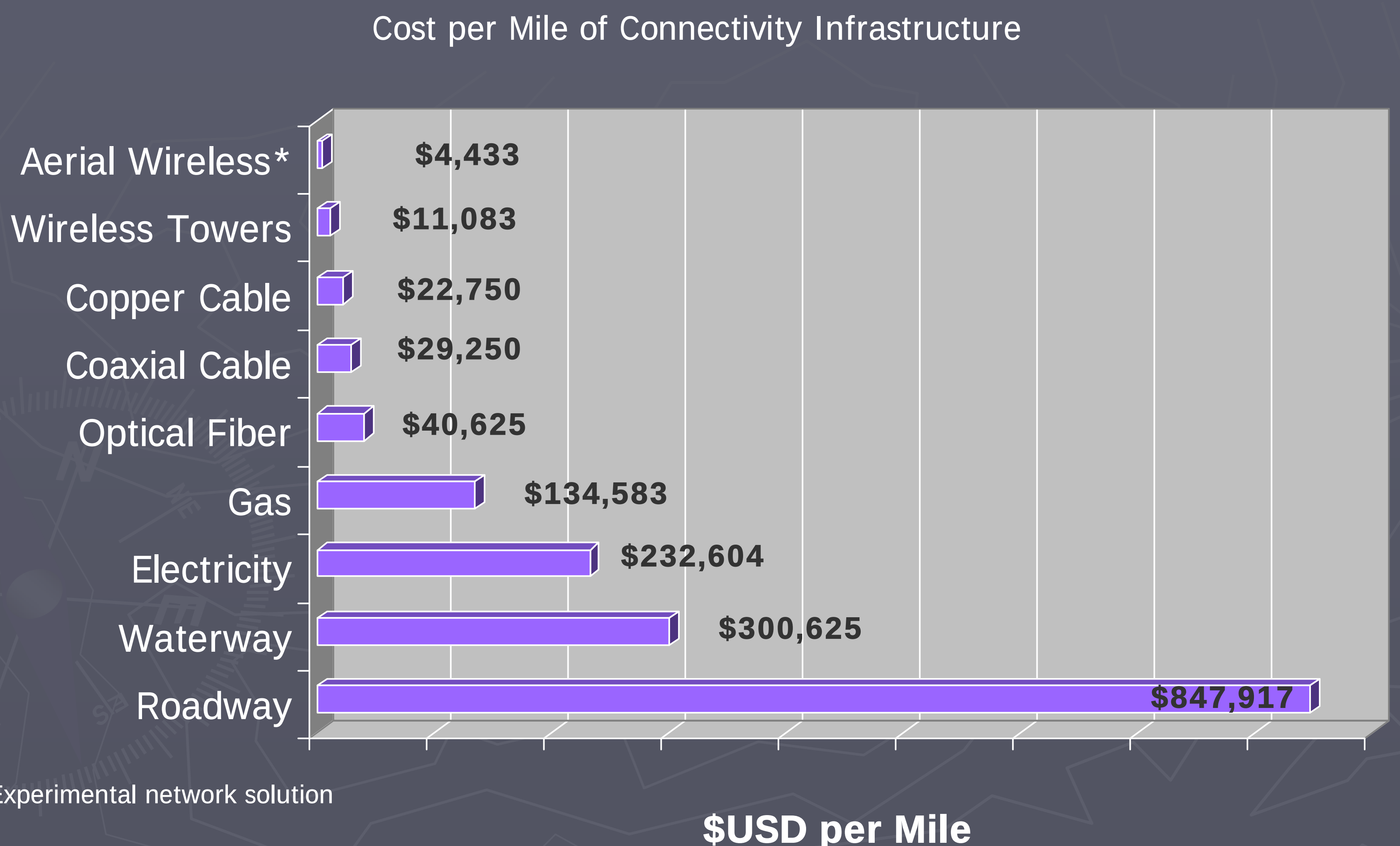
A Lesson From Railroad History: Infrastructure Explosions Are Uneven!!!

- Railroads had busts and booms in U.S.
  - Cost and flexibility of the infrastructure will influence severity of the bust and boom problem
- They required complementary innovations to be sustainable—the Standard Oil and Armour Meatpacking Trusts created new uses of Railroads
- They require regulatory and policy decisions to prosper—time zones and Railroads

Why communications networks are in a better position than railroads

- Cost
- Technology
- Flexibility of use

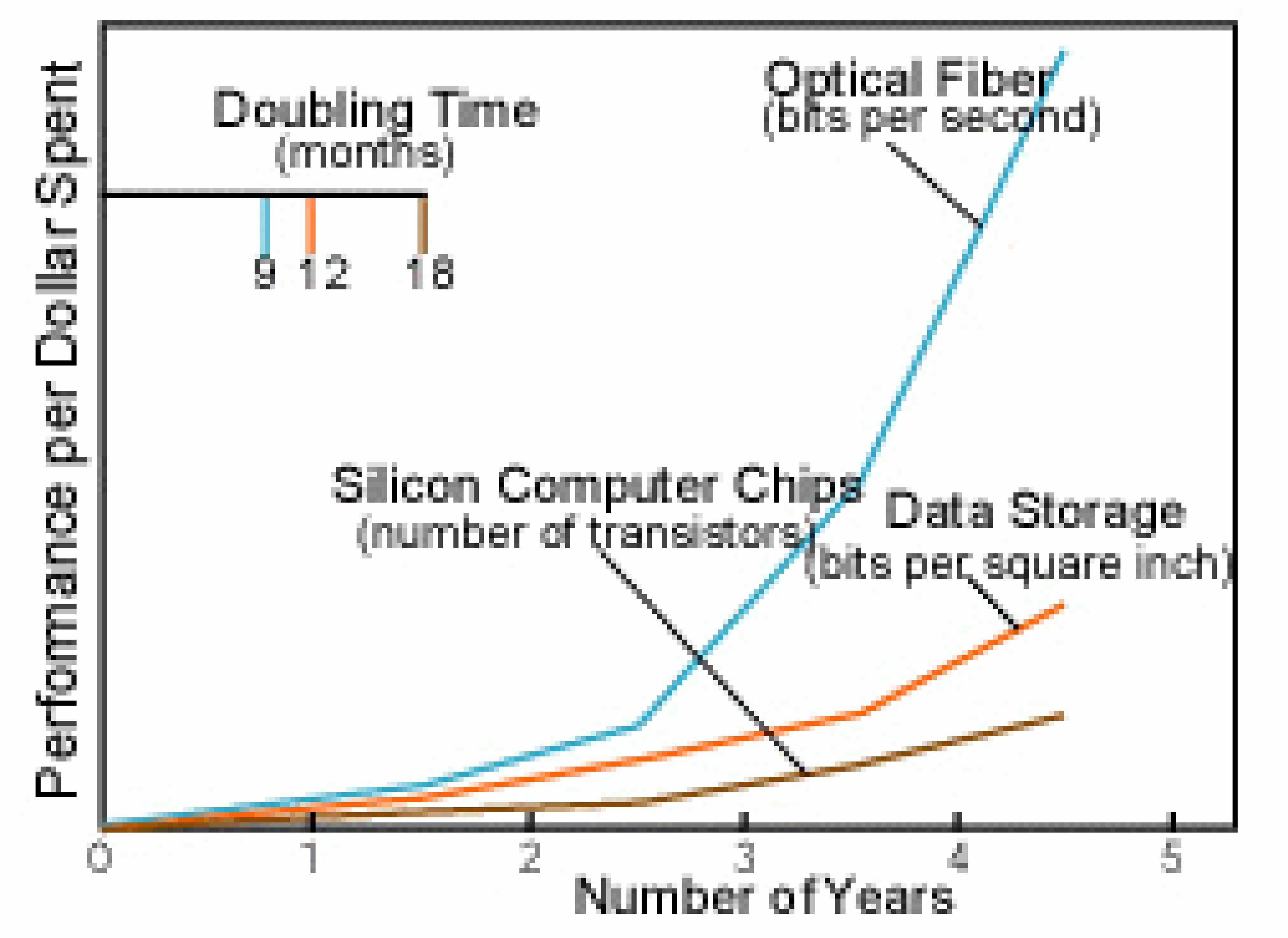
The Cost of Communications Networks Is Low



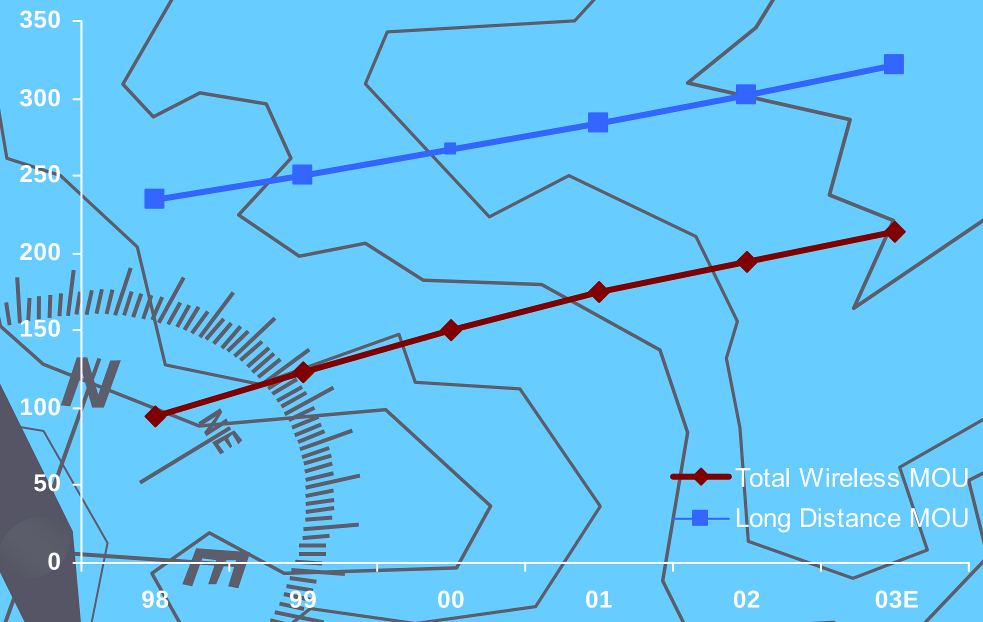
* Experimental network solution

Source: Canadian National Broadband Taskforce and InfoAmericas

Fiber Optic and Data Storage Are Moving Faster Than Moore's Law



Network Demand staying high!
(Source: Perelman, SAIC)



Internet: (1 Year)
# of hosts + 16%
data volume +100%
metro fiber + 80%
Sensors
RFID + 30%
(RFID=Radio Frequency Identification Devices)

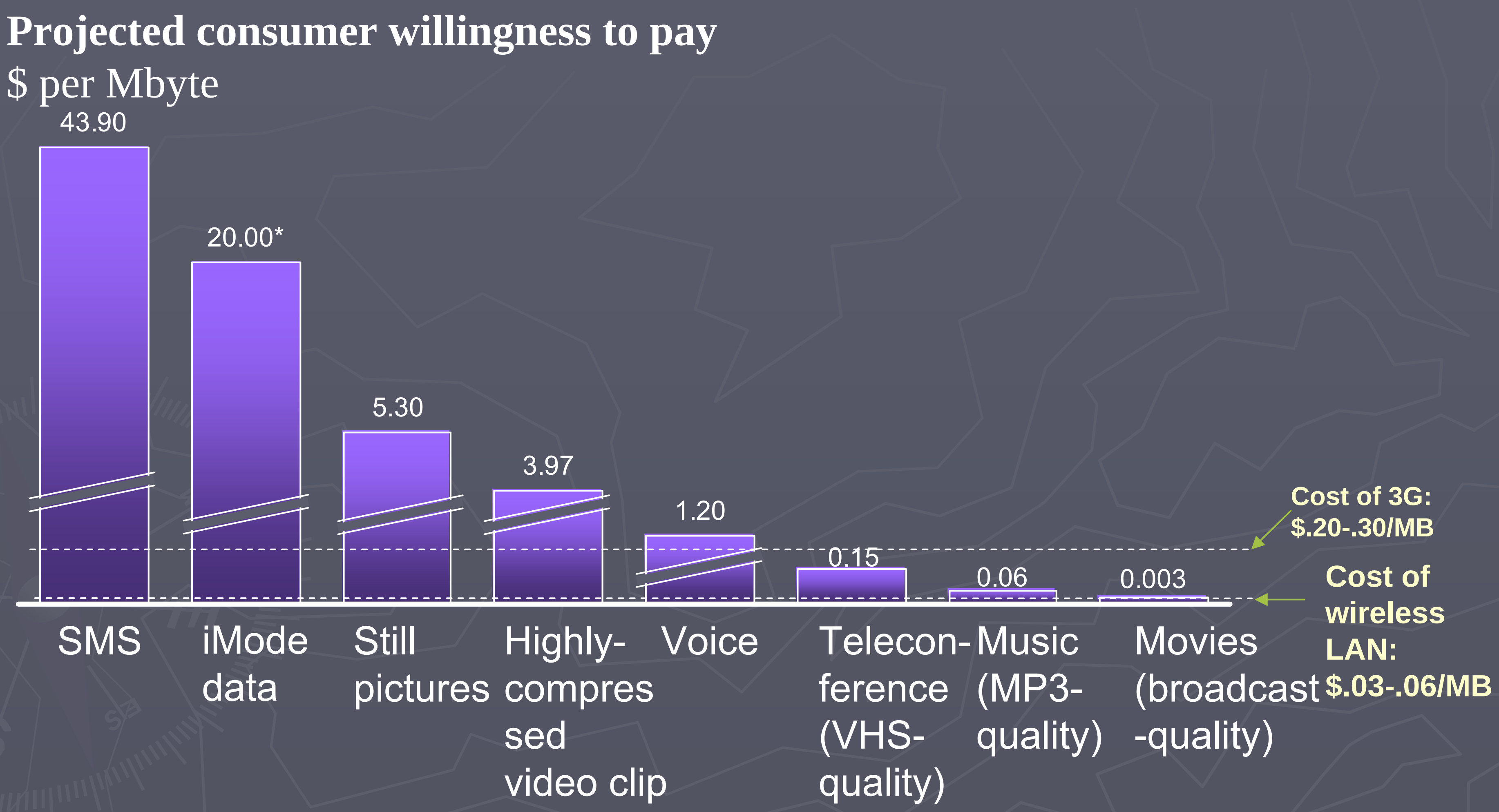
Network technologies change rapidly so need flexible evolutionary path!

- Broadband to the Home and Small Businesses requires multi-technology networks with different cost structures & business models depending on demand patterns
- Need to experiment with best network design! An example:
  - The youth market does not dominate wireless in US (unlike Korea)
  - Most fiber is in biggest "15% of office buildings": Need to expand high speed access to other businesses and homes
  - 3G = *Wide Area Mobile* Data Network on licensed bands
    - Use for secure high speed mobility at a fixed price AND for remote high speed networking
  - Wi-Fi (or 802.11) = *Local Area Fixed* Data Networks—primarily on unlicensed bands
    - Wi-Fi for campus environments fed by high capacity fiber
  - WiFi won't replace 3G! *100,000* Wi-Fi hotspots equal coverage area of ***3*** 3G cell sites (100,000 3G cell sites in US by 2006)
  - We need big fiber capacity for some needs, but wireless may be more effective than fiber for many users

Complementary technologies for the use of networks

- Growth of remote sensors and radio identification devices
- Growth of new computing systems (e.g., the GRID)

Consumers are more sensitive to the total cost of a service than the price per bit!



* Based on compressed file transmission, estimated willingness to pay

Source: GS Research; McKinsey analysis

Elements of the Revolution: Wireless and New Computing Models

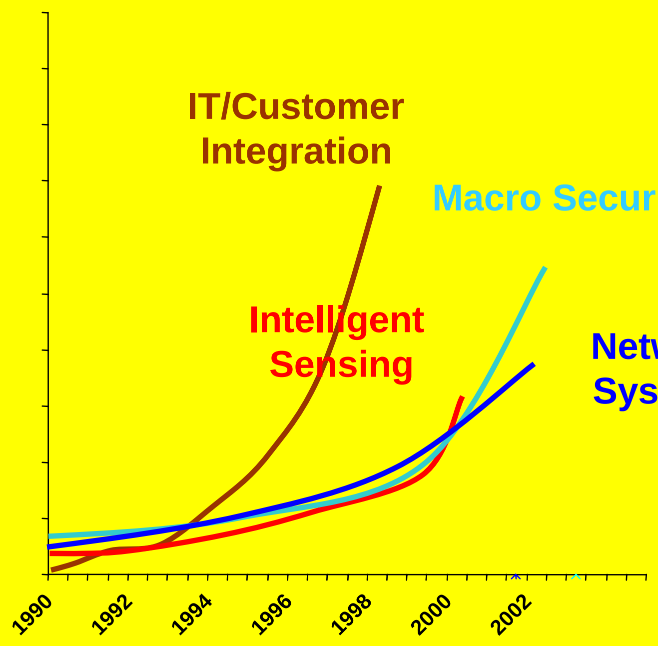
- Vast Increase in Internet End Points
  - Embedded Processors everywhere in old products
    - Your car is a computer and sensors gathering data
    - Radio frequency identification devices (RFIDs)
  - New uses – every human body is a data stream
- Emergence of a Distributed (Networked) *Planetary* Computer
  - Storage of Data Everywhere
  - Scalable Computing Power (the GRID)

Selected 3-5 year needs for customers with security needs for RFIDs (Source: SAIC)

The Issue	Factoids
► Marco Personal Security	
▪ 9-11	Homeland Security sensor systems
▪ Lost retail sales	Control theft: 2-4% revenue lost, mostly employee
► Intelligent Sensing	In the supply chain, cost reduction est. of 10-30% inventory, 5-40% labor and sales increase of 1-2%
	#1 issue in preparing for Iraq for DOD logistics

So, Where Are We Today? (Source: SAIC)

Adoption Rate of New Technologies



4 Critical Technologies on the cusp on moving into the customer innovation cycle

All of These Are Moving to Mass Customer Cycles

Macro Security
- Def: Detection, Authentication, and Authorization of people & cargo
- Core Science – Biometrics, Invasive sensors, recognition software, etc.

IT/Customer Integration
- Def. Creating cost effective interfaces between IT systems and customers
- Core Science – Voice recognition, CRM, IT System simplification

Intelligent Sensing
- Def. Identification, Location, and Condition
- Core Science - RFID, GPS, Intell. Sensors

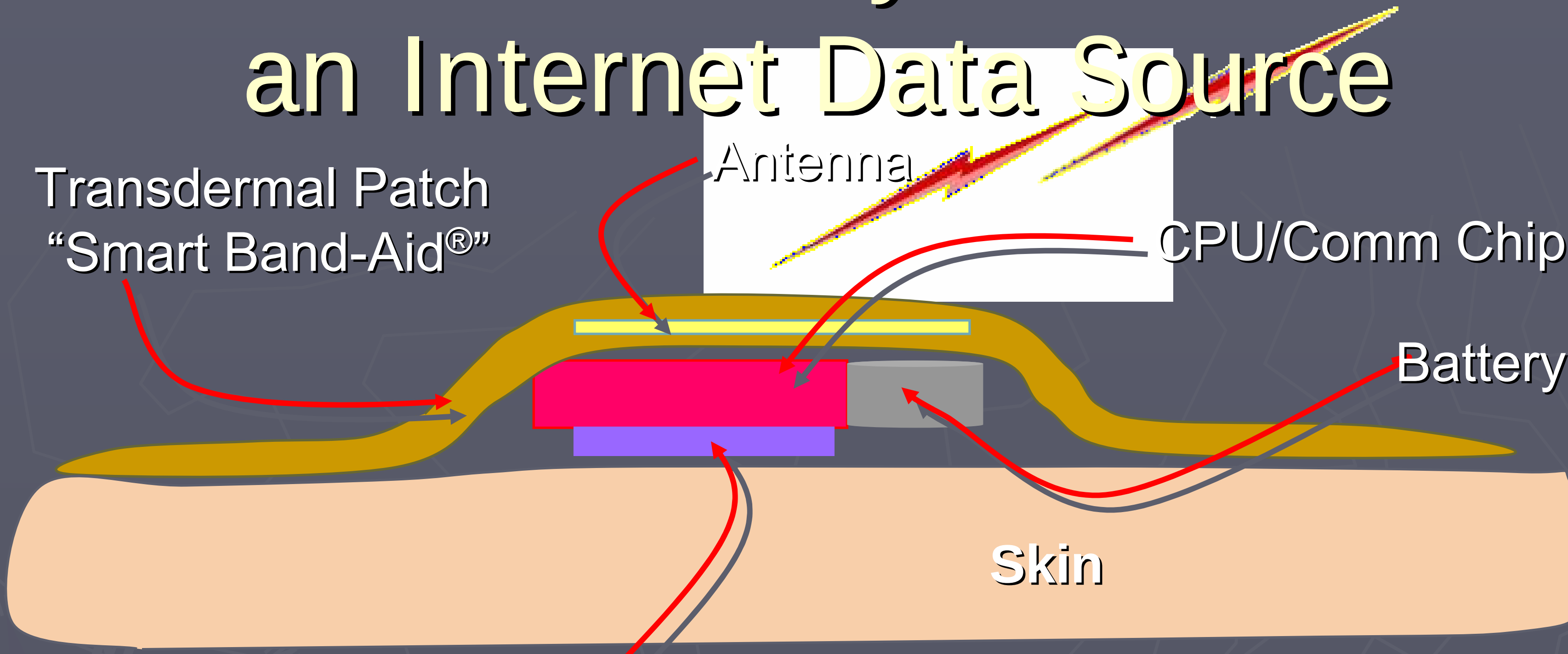
Network Systems
- Def. Overlapping, self repairing, multi tech. networks
- Core Science – Mesh networks

All 4 arena's impact each other and are dependent upon communications

NOTE: This is a conceptual analysis intended to depict a probable picture of the adoption rates. It represents work in progress by Jeffrey Perelman of SAIC

Source: SAIC Analysis by Jeffrey Perelman, TvHandbook.com, FCC Databases at FCC.GOV, Zarkon.org, IDC's Information Industry & Technology Update

The Human Body Will Become an Internet Data Source



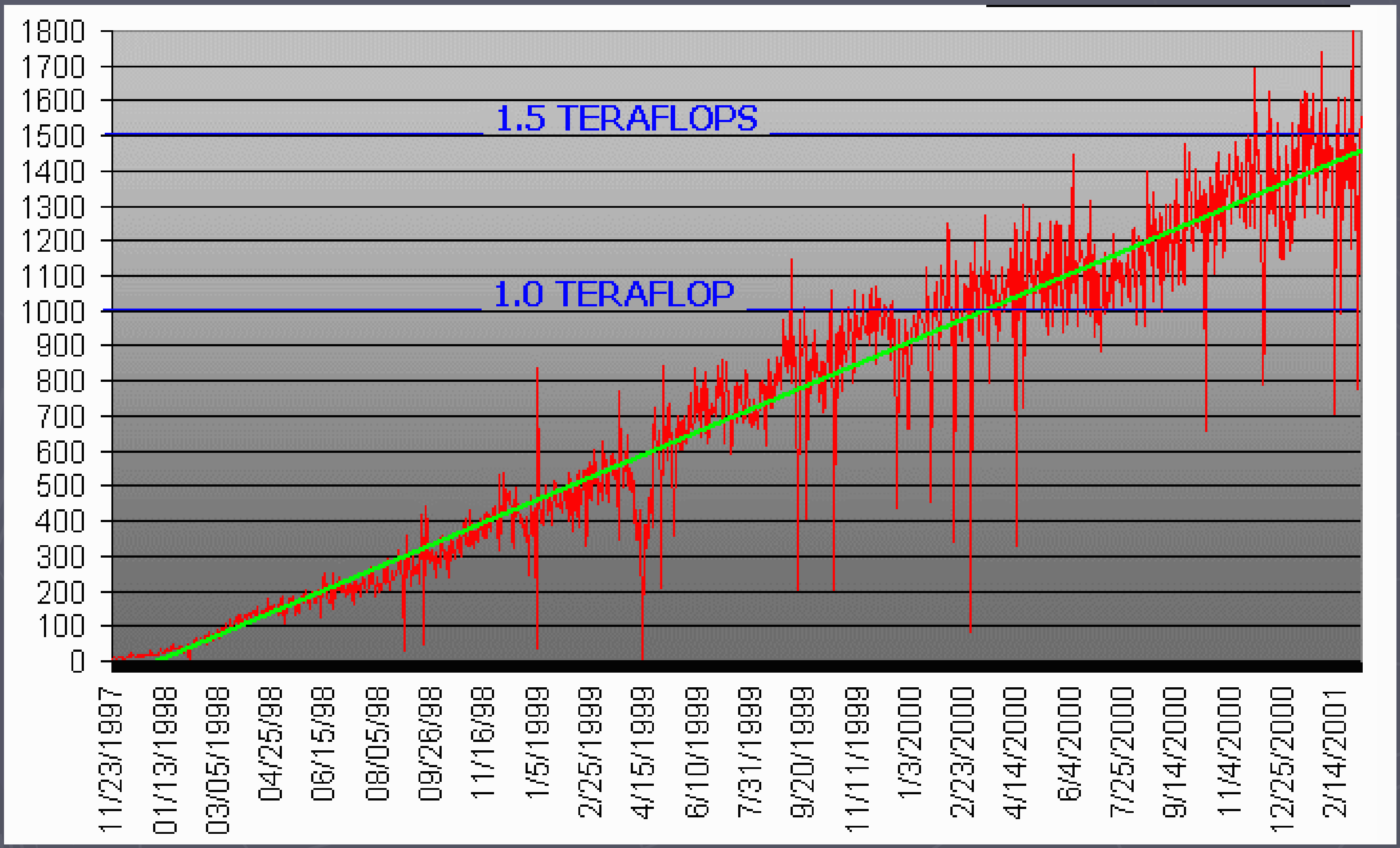
Sensors:
- Physical
- Chemical
- Biological

- Patent Pending

Non-Invasive Platform
- Smart Band-Aid®
Can Also Link to Invasive Sensors

Source: PhiloMetron

Scalable Computer Grids: Entropia achieved 1 teraflop capacity in 19 months

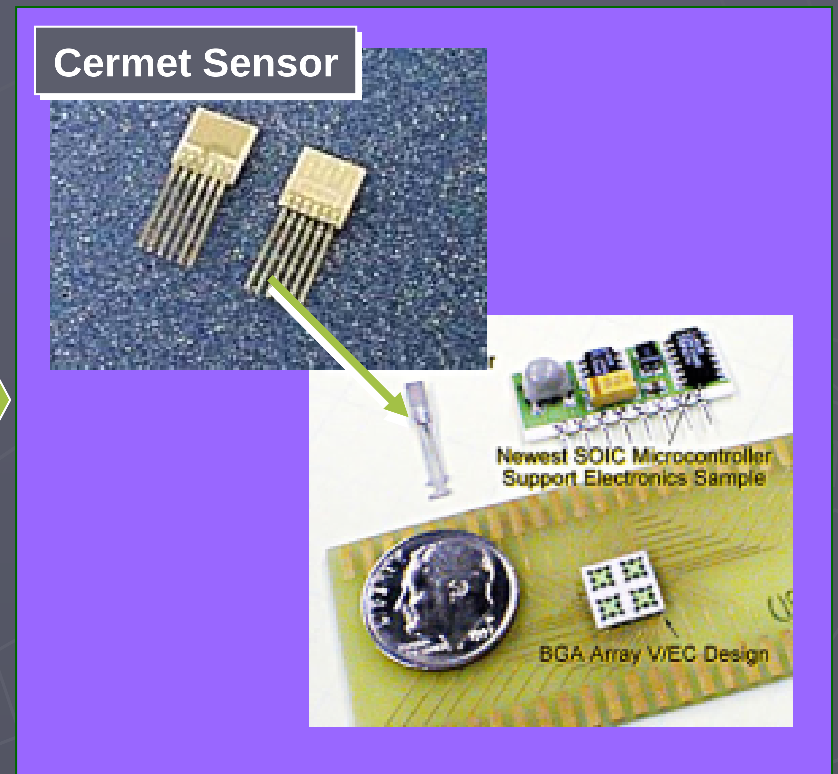


A Key challenge: Small Radios

- Size is critical: 1 centimeter or smaller goal achieved for some designs
- Cost is critical: The goal is US$0.01 per radio—for complex radios the cost is just below $1 while it is less than $0.10 for simple RFIDs
- Other drivers on applications
  - Novel uses of RFIDs (tracking pets and improving clothes washing)
  - Military security expenditures enable new economies of scale

Key Challenge for This Decade
Put Laboratories on a Chip

$ 300,000

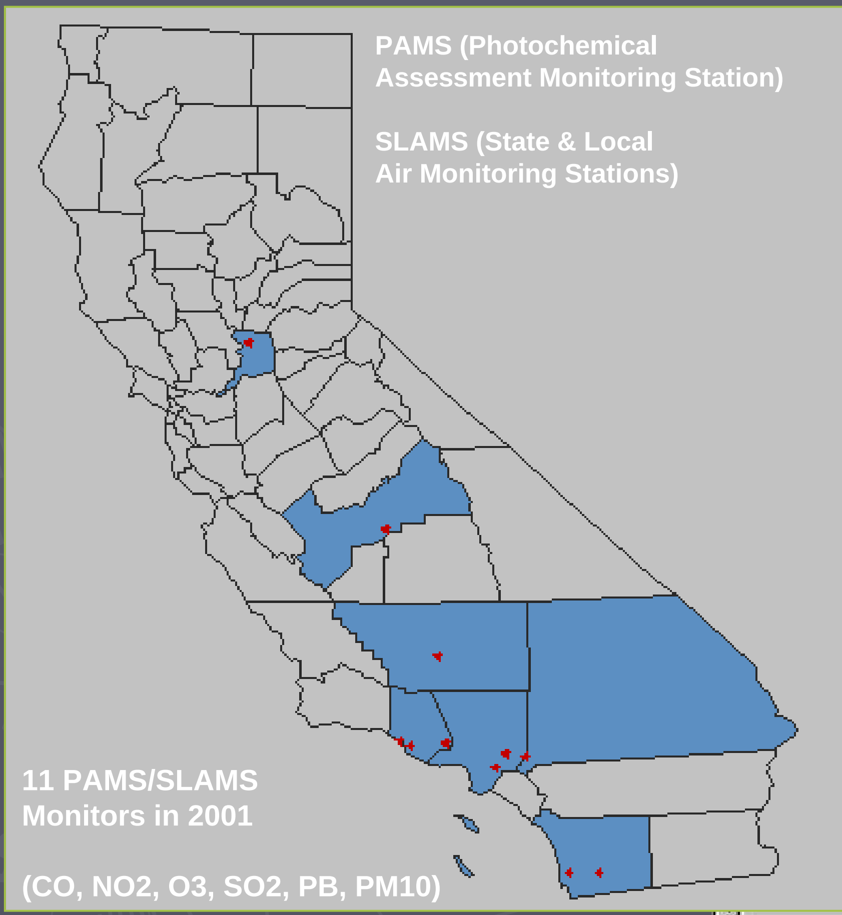


$ 10

Source: Greg McRae, MIT and ANL

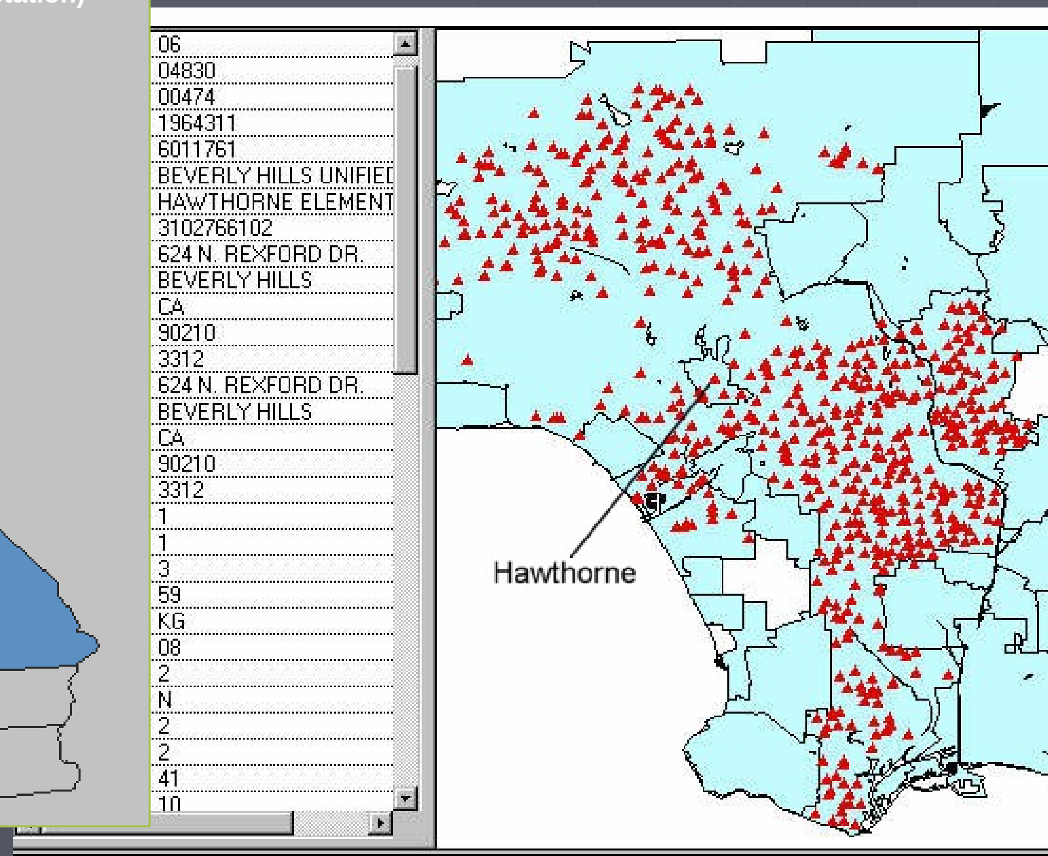
Putting a Lab in Every School Creates the Potential for a Dramatic Increase in Spatial Coverage of Environmental Sensors

US EPA Air Monitoring Sites



California Air Resources Board

Schools in Los Angeles Unified School District



Source: Prof. Gregory McRae, MIT

Revolutionizing the rest of the economy with IT and Communications

- There is substantial national variation in the uses of e-commerce, but finance, large-chain stores, and global manufacturing dominate
- About two-thirds of enterprises are largely missed
- When do we get “fiber to the cow”?? Example: The “smart tractor” combines computing and mobile networks
- Is greater speed really the most important measure of network?
- Internet lesson: Allow users to “co-invent” and manage the network

Competition Policy Challenges

- Technology innovation requires frequent review of competition policies. Transparency in decision-making is critical for investor confidence and market efficiency.
- Competition within and between network platforms (e.g., wireless and wired)
  - Some infrastructure still does not have effective substitutes! E.g. local voice service termination on phone networks --- there is no alternative to NTT for ADSL infrastructure
  - Policy should not favor one platform over another: Termination charges between wired and wireless networks should not favor one kind of network over another
  - Competition policy should foster innovation in the economy by fostering “co-invention” by users
    - Use competition policy to limit rigid vertical integration of services and technology! Example: U.S. regulation discouraged vertical integration of phone companies into control of computer networking
    - Reduce level of detailed regulation of spectrum use and technology standards by governments. (Cave report to UK Government shows why planning “4G” is bad idea.)

Other Policy Challenges

- R&D Policy vs. Subsidies and Picking Winners:
  - Funding research on networks and applications vs. subsidizing build-out of new infrastructure
  - Subsidies for infrastructure can create harmful rigidity:
    - Those getting subsidies resist flexibility, but flexible response to surprise is critical in an era of massive innovation
    - Subsidies often have anti-competitive effects
  - You can sometimes pick an optimal mandatory standard. But it is very hard to reverse a mistake. As the sources of innovation diversify it becomes important to combine R&D test beds with voluntary standards

- Proprietary vs. Open Source
  - Growth of Open Source successes--Linux and Apache--required a start in communities created by university R&D centers
  - Open Source will increasingly be made into a hybrid with proprietary Intellectual Property
  - Cannot weaken traditional IP to build Open Source. They "co-evolve."
  - Making Japanese university more global by becoming leaders in global test beds is essential to Japan's future prosperity