

IPv6, 4G, and the Ever Smarter World

10 Leadership Opportunities for IPv6 Innovators

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Wanted: IPv6 Innovators

- “We need people who create supply and demand for IPv6” – Quote from this morning, Ministry of Science and Technology, Spain
- George Washington Carver (100 uses for peanut, entire dinner of peanut products)
- Thomas Edison (over 1,050 patents, direct current and hundreds of way to use it)
- Larry Smarr (from 100 scientists with SC access to 30,000, Mosaic/IE, Apache). The importance of CREATIVITY and VISION!

Ten Opportunities for IPv6 Innovators 1

1. The basis for an explosion of evolutionary experiments, followed by robust survivors.
2. Massive increase in feedback loops (output changes input), assisting civilization.
3. Historical opportunity to increase subscriptions, and thus service exports.
4. Million fold increase in sensors (and data...)
5. Commercial explosion, keep public interest.

Ten Opportunities for IPv6 Innovators 2

6. Give every person thousands of IP addressed nanodocs, reduce cancer, aging.
7. Head start in 5 way race to be 1st in 4G and win a multitrillion dollar grand prize.
8. Augmented memory (hyper documentation of one's life, uploading) and augmented reality (info overlays).
9. Endowing users with superpowers.
10. Computational collective intelligence.

Evolution Explosion > Development Pruning

- Introduction of a new computational substrate creates an explosion of new forms (convexity) via evolution, then a pruning (concavity) via development.
- Example: Cambrian explosion 570 million years ago produced 35 body plans.
- No new body plans since then!
- Adaptive radiation, chaos, pseudorandom search, mutation, niche domination followed by selection/emergence, phase space collapse, extinctions and winners.

Feedback Loops: The Ultimate Multiplier

- Feedback loops allow for learning outputs to change behavior, prices, decisions...
- IPv6 adoption fosters HUGE feedback loops.
- Advanced civilizations are based on an ever expanding quality, quantity and diversity of feedback loops. IPv6 supports this growth.
- Societies with the most sophisticated ecosystems of feedback loops win in war and peace. IPv6 adoption will determine social progress, justice, and prosperity.

Feedback Loops: The Ultimate Multiplier

Saudi Arabia

- 280 bb of proven reserves, or 14K bpc (\$420K NPV each for 20 m citizens @\$30/b).
- SA per capita income drop over the last two decades from \$18,000 to \$6,000.

US

- 20 bb of proven reserves. US oil production peaked in 1971.
- US per capita income doubled from \$17,000 to \$34,000.

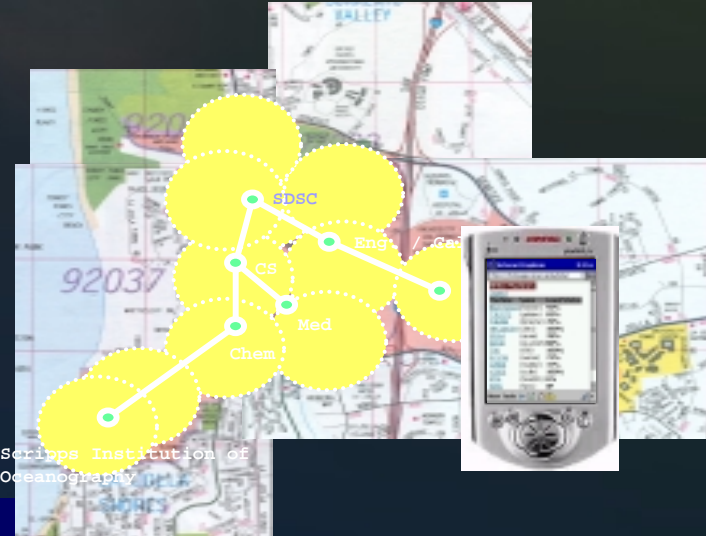
Trade Deficit Feedback... Export Services!

- Services: over 80% of US \$11 T GDP.
- Annual deficit of \$500 B in goods (about one third oil, one third autos)
- Annual surplus of \$15 B in agriculture, \$50 B in services
- Biggest leverage: increase service exports from less than 1% to 5% of US services.
- The first IPv6 Cluster has opportunity to double GDP as service export and 4G hub.

Sensors provide a way to monitor the fundamental behavior of our physical and virtual world



Instrumentation



Scriptus Institution of Oceanography

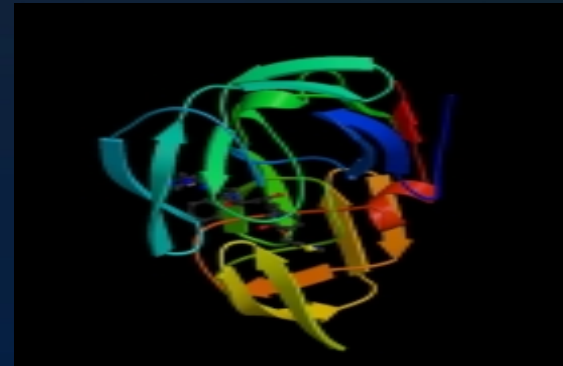
Wireless and Wireline Networks



Global Grid Environments



Homeland Defense



Health and Life Sciences

Sensors and Information Infrastructure

- Sensors are emerging as fundamental components in the design of next generation homes, cars, bridges, clothing ...
- Over the next decade, sensors will become a fully integrated part of our information infrastructure
- IPv6 allows us to design, develop and deploy immense number of sensors to provide data about the physical and virtual world
- Sensors = Data Producers. With tiny radios, they become sources of subscription revenue/services.

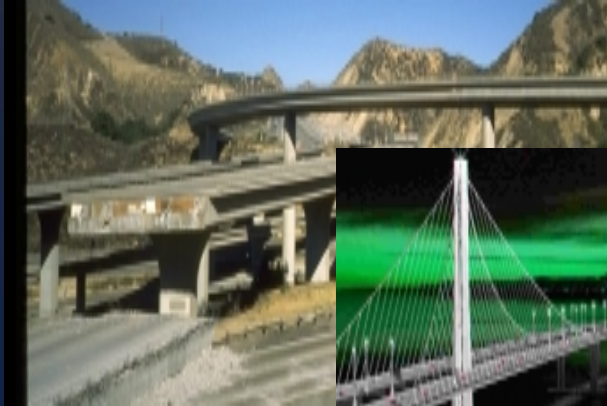
Microsoft's advanced R & D discovery

- Dan Rosen, former Dir of Adv R & D for Microsoft: “The most valuable thing we’ve learned is that in the future everything that costs over \$25 except food will be connected to the Internet.”
- IPv6 + a pico radio could compliment, then embrace and extend, then replace, bar codes and RFID tags.
- Gillette: just ordered 500,000 RFID tags. Razorblade sweeping.

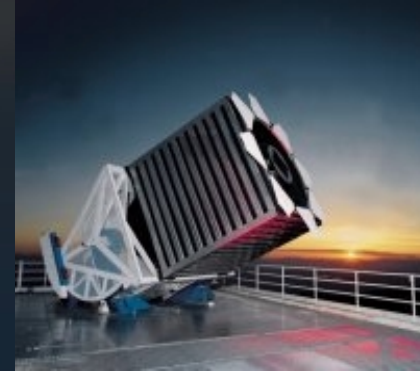
Sensors subscriptions very valuable!

- Eric Frost: 30 measures of oil extraction allows doubling, from 35% to 70%, of recoverable oil from a given reservoir.
- Will Recker: World Wide Wagon Train of 737 million to 1 billion vehicles that exchange information on the road ahead.
- John Orcutt: From Buoys to MEN (Marine Environmental Networking). Weather prediction, climate change, government.
- Articles are on <http://www.calit2.net>. Search site for “Alex Lightman”

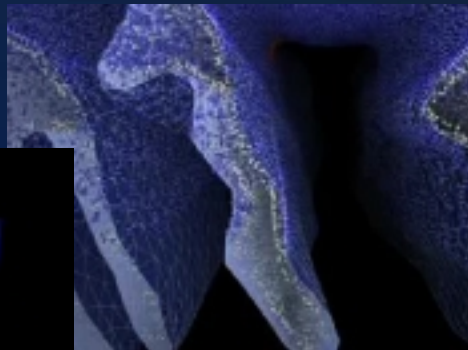
Data is a fundamental driver for Information Technology



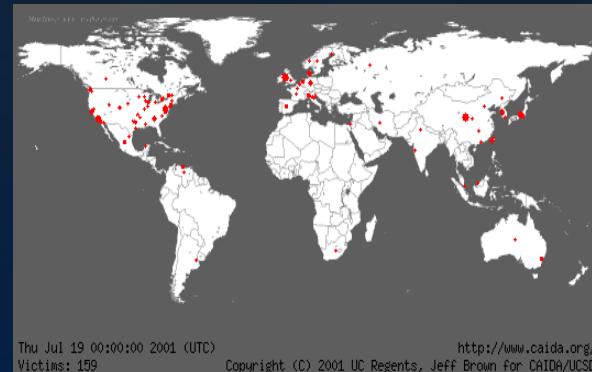
Data from sensors



Data from instruments

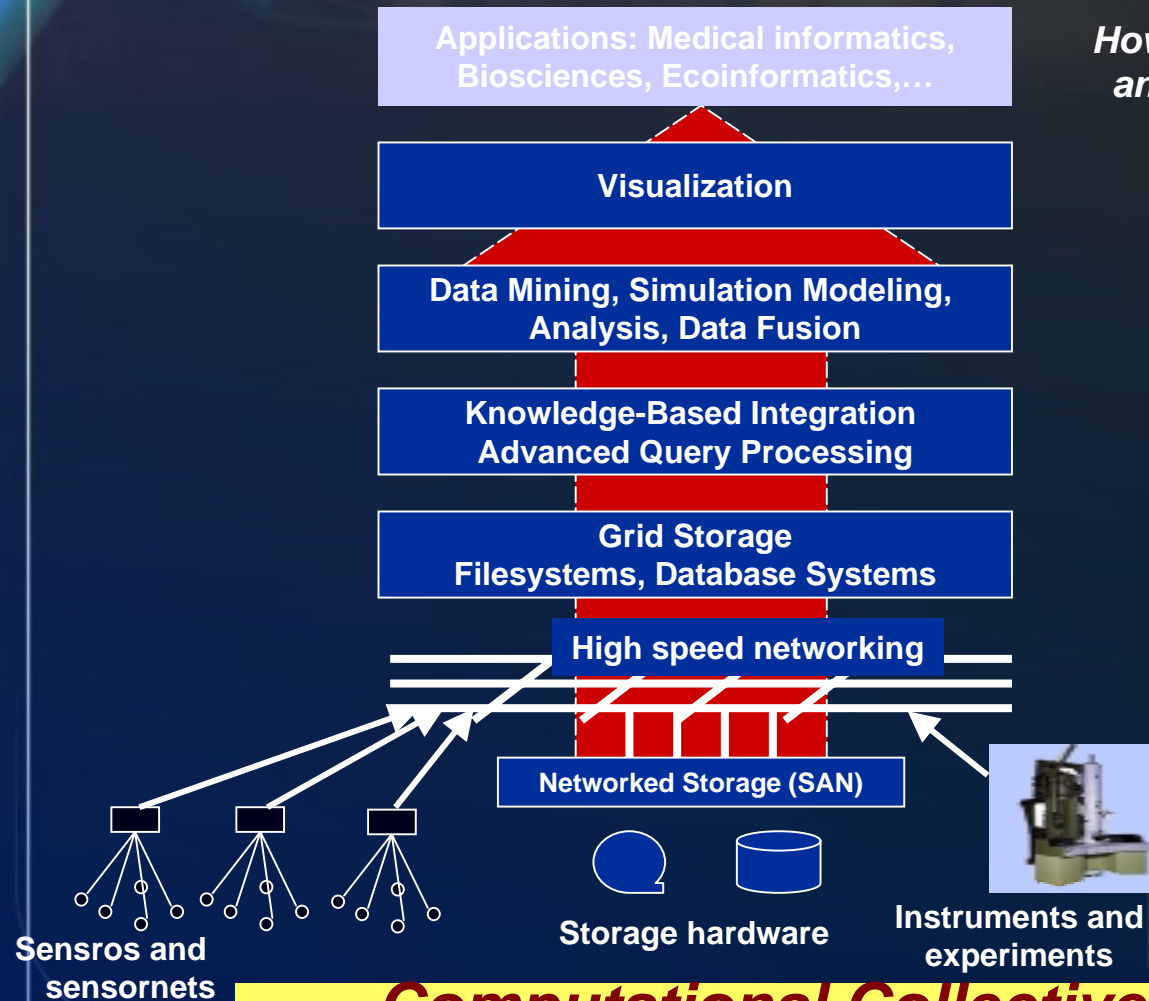


Data from simulations



Data from analysis

IPv6: Data to Information to Knowledge



How do we combine data, knowledge and information management with simulation and modeling?

How do we represent data, information and knowledge to the user?

How do we detect trends and relationships in data?

How do we obtain usable information from data?

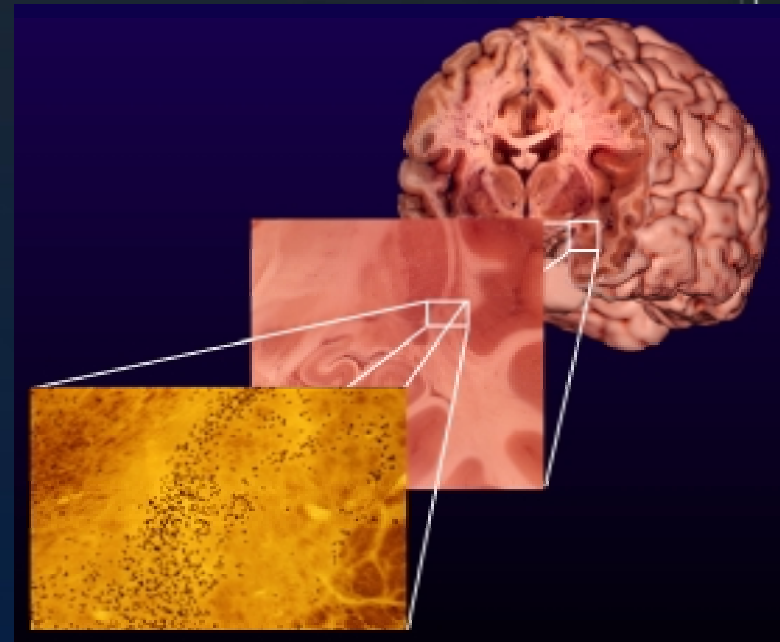
How do we collect, access and organize data?

How do we configure computer architectures to optimally support data-oriented computing?

Computational Collective Intelligence

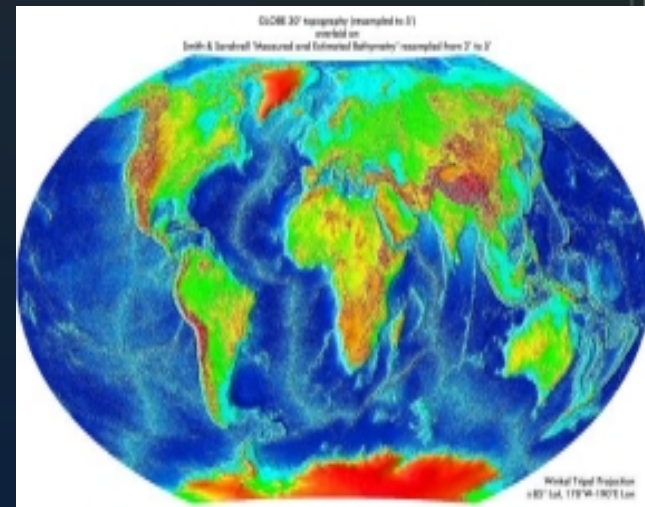
IPv6 Contributions to an Ever Smarter World

- **Data collection to knowledge synthesis, data mining**
 - Data → Information → Knowledge
 - *IPv6 will help us collect & mine usable information from massive amounts of data.*
- **Integrated technologies**
 - **Sensors, computation, data management**
 - *IPv6 will enable us to develop end-to-end applications which integrate ALL technologies.*



IPv6 Contributions to an Ever Smarter World

- **Universal Access**
 - Location-independence, ubiquitous access to computing, data, resources
 - *IPv6 enables us to develop applications that can be initiated from anywhere at anytime*
- **Global-scale collaboration**
 - Collaboration tools, access, interoperability
 - *IPv6 enables us to communicate, work, and recreate with people all over the world, even as we go nomadic and constantly mobile*



Is IPv6 wearable?



The big picture

- IPv6 has features that make it perfectly suited for Wearable Computing
 - ✓ 3.4×10^{38} unique addresses available
 - ✓ Stateless autoconfiguration
 - ✓ Security: authentication and encryption
 - ✓ Mobility management
 - ✓ Jumbograms (up to 4 Gb > share augmented memory/ augmented reality)

Protecting your mobile mind: Security in IPv6

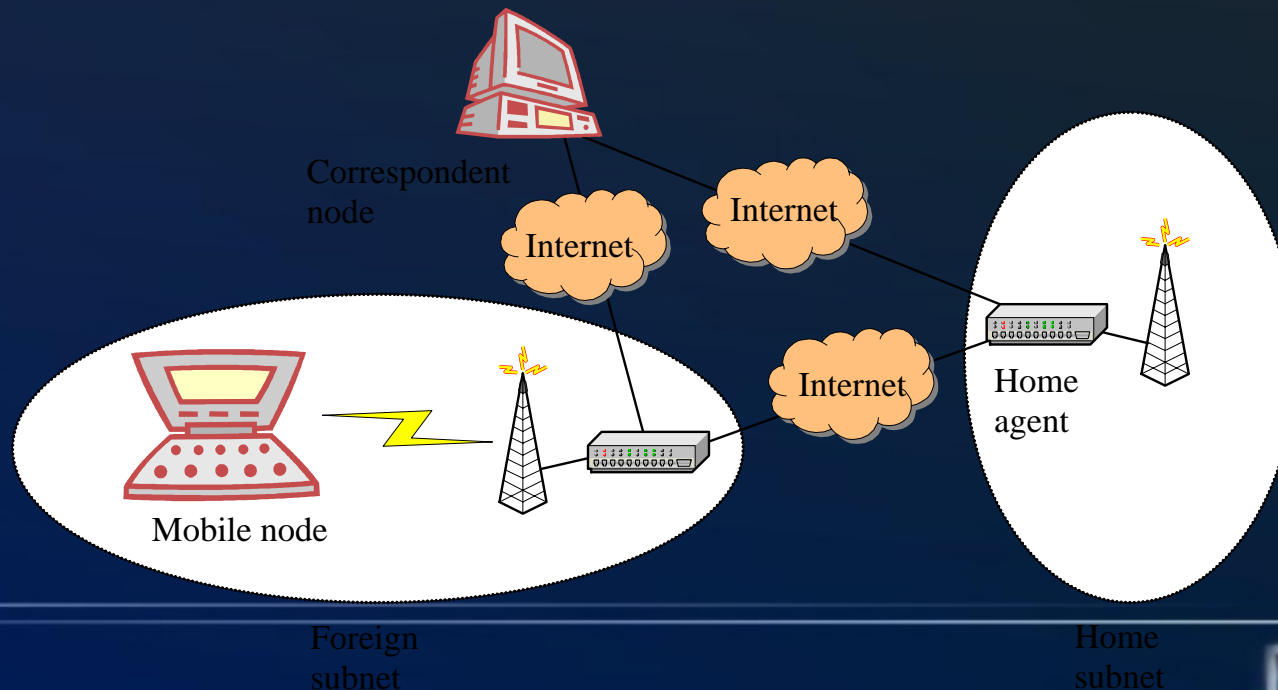
■ IPSec

- uses IPv6 extension headers
- security modes
 - authentication on IP level
 - encryption on IP level
- based on private and public key algorithms
 - manual or automatic key distribution
- allows secure end-to-end communication and Virtual Private Networks

Mobility management in IPv6

■ Goals

- transparency of mobility to higher layers
- addressability using the home address



MobileIPv6

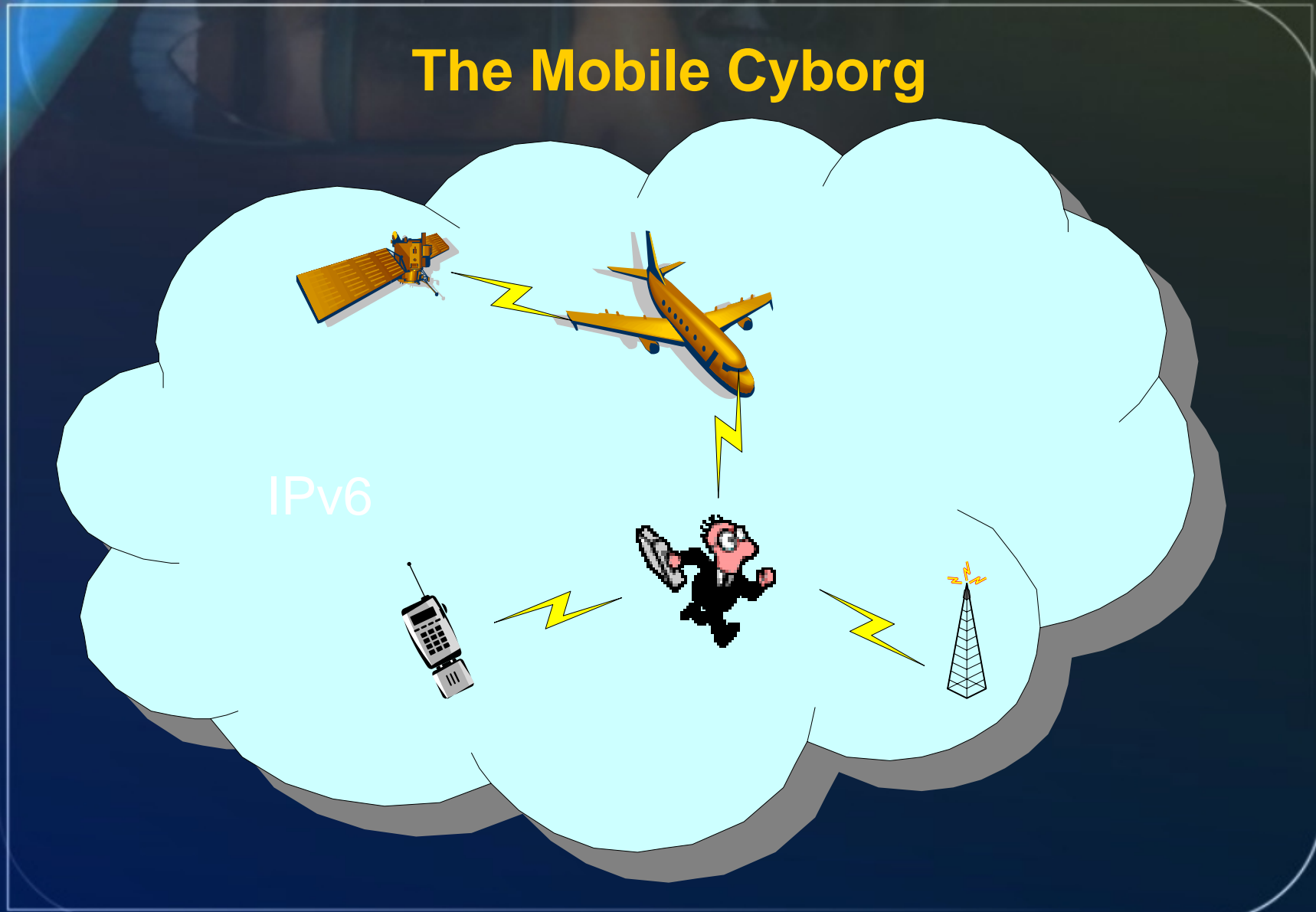
- **Important functionality**
 - Triangular routing
 - Route optimizations
- **Successful initial 3G tests in Europe**

Scenarios

- **The Mobile Cyborg**
- **Wireless communication on navy ships**
- **IPv6 in badge systems**
- **Integrated hospital communication**



The Mobile Cyborg



The Mobile Cyborg

- **IPv6 features in this example**
 - Mobility management
 - Security
 - **This scenario requires**
 - ✓ Wearable computers equipped with an IPv6 stack
 - ✓ Mobile telephony networks based on IPv6
 - ✓ Wireless internet access in airplanes
- ... now, all we need is a global IPv6 infrastructure!

New Devices! Who will be first? When?

■ IPv6 Pager

- global access by unique IPv6 address anywhere
- page a person using your favorite instant-messenger



■ IPv6 Mobile Phone

- easily reachable by e-mail address worldwide
- identification via IPv6 address



IPv6 IS wearable, opening door to 4G

- ✓ beneficial for wearable computing in many ways
- ✓ mobile and wearable computing could become killer applications for IPv6 after the Cambrian Explosion

What is a Commercial Explosion?

- Rapid growth of a new product / service
- Deep penetration of market
- Spawns new, supporting industry
- Transforms the economy
- Examples: automobiles, PCs

Drivers Of Commercial Explosions

- **Satisfies a compelling consumer need**
 - Possibly one they didn't know they had
 - Leads to deep penetration of the market

- **Requires convergence of:**
 - Technologies
 - Government policy
 - Standards
 - Companies via partnerships and alliances

- **Ultimate winners represent best trade-off along a number of dimensions**
 - Simple metrics not easy to define early on

- **Transportation: why did the gasoline powered automobile win?**

Economics Powered by Convergence:

- Convergence of devices and innovations: clock, axle, wheel, lever, odometer, steering, speedometer, better tires, brakes, navigation systems, CDs...) with a dozen or more improvements every year.
- Convergence of networks (oil industry consolidation, self service stations, national highways, cheap maps, driver's licensing, parts, used cars, repairs, warranties, AAA...) with improvements.
- Many parallels to communications industry. Success is about the convergence of multiple device capabilities and of networks.

On The Verge of A Commercial Explosion

Personal Computer

Internet

Telecommunications

Personal Electronics

Service economy

4G

Access to any data

Ubiquitous

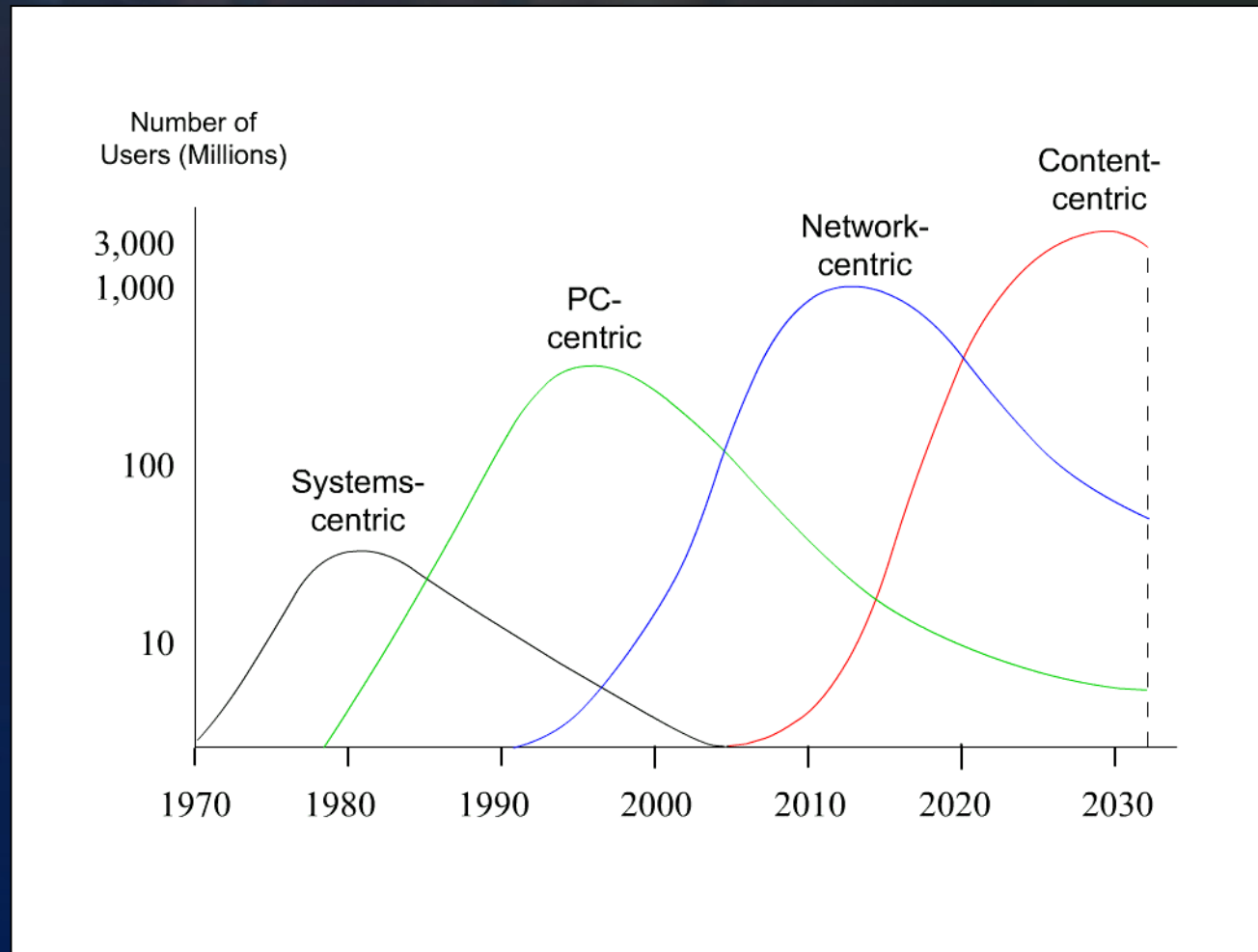
Portable processing power

Intuitive, augmented reality interfaces

Context / location aware

Simplifying and enriching people's lives

Stages of IT industry growth



Waves of Power, David C. Moschella, 1997, AMACOM

Trends that will drive us toward 4G

- Shrinking computers
- Cooper's Law
- Shifting from Hardware to software to services
- Tracking users in a galaxy of devices

The Incredible Shrinking Computer

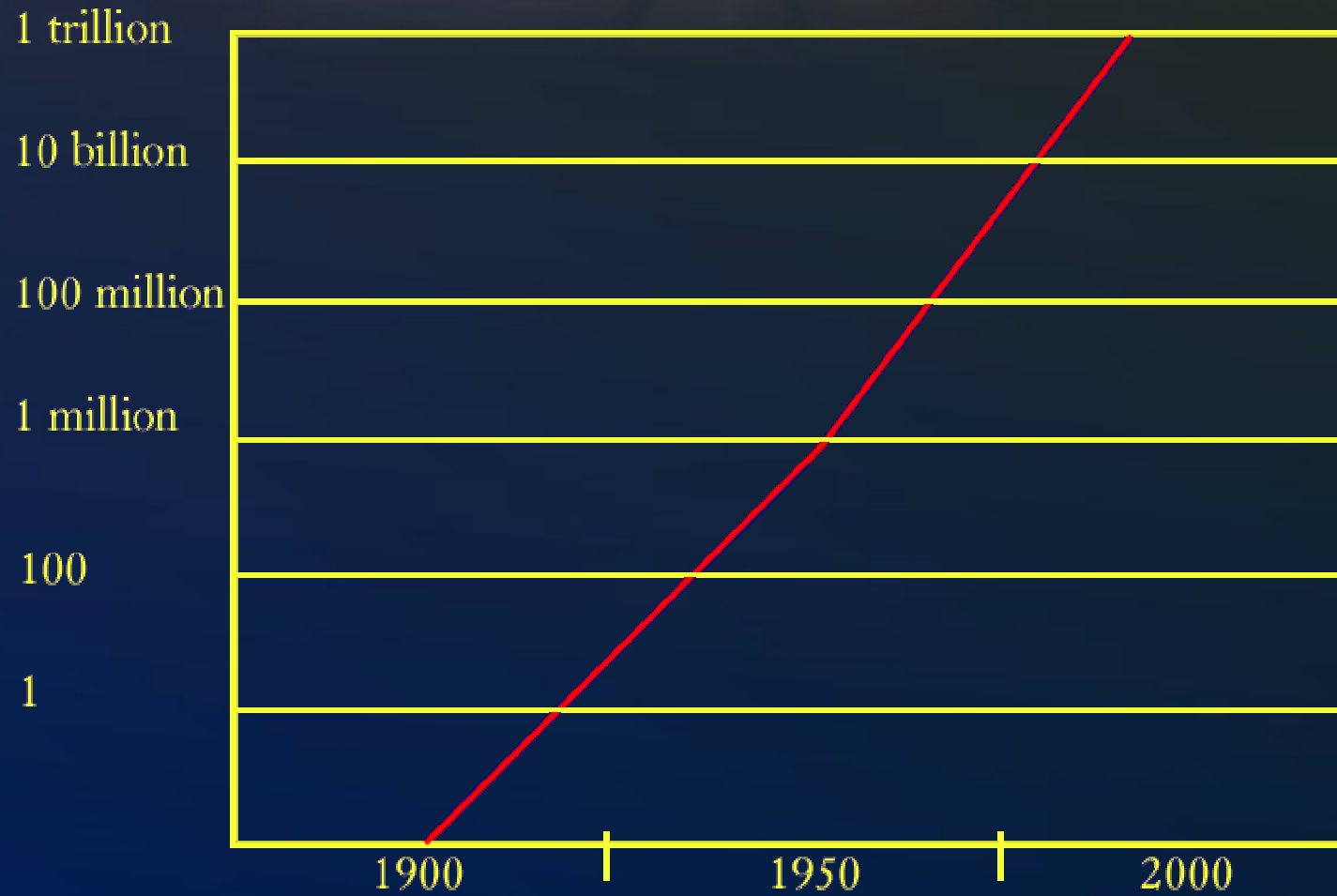


Through the History Of Computing



Cooper's Law

Spectral efficiency doubles every 2.5 years



The Shifting Market

Hardware → Software → Services



Form

Visual

Home

Public

E-books, PDA's,
web pads

Computers

TV set top boxes
+ game consoles

Public kiosks

Gas pumps

digital cameras,
smart appliances

Handicapped tech.

Head gear

Wearable

Plain old phones

Charms + fashion
Communicator badges

95% audio
(cars, walkmans)

Cell phones

2 way pagers

Watches

Mobile

Audio

Multimodal

USER



A First pass list of 4G technologies and methodologies

- 1.** 802.11x and OFDM (802.11a and 802.11g are OFDM)
- 2.** Bluetooth/Zigbee and related watch battery capable standards.
- 3.** WiMedia and Ultrawideband,
- 4.** Software radios and cognitive radios,
- 5.** Smart antenna/Spatial Division Multiple Access,

A First pass list of 4G (II)

5. Code Division Multiple Access,
6. Adaptive technology,
7. Evolvable/self-adapting hardware, including MEMs, minimal instruction set chips, low power FPGAs and ASICs
8. Wireless power transmission and other portable power advances,
9. Wearable computers in dozens of form factors, and head up displays (both optical- and video-see through)

A First pass list of 4G (III)

- 11. Augmented reality,**
- 12. Session Initiation Protocol with enum,**
- 13. IPv6 (June 23 to 27, SDSU, www.usIPv6.com)**
- 14. "4Ground" family of sensors and sensornets
inexpensive enough to be put/tossed everywhere
- land, sea, even air, to allow for massive ad hoc
networks of cameras, etc.**
- 15. "4Geo" (geolocation with URLs),**
- 16. "4Good" (Reputation system that includes
recording, scoring and ranking of voluntary and
benevolent acts).**

A First pass list of 4G (IV)

- 17. "4Gold" (a new and novel m-commerce system that includes advanced security).**
- 18. Modular design, so that terminals, base stations, routers, and servers share snap together components.**
- 19. New, additional spectrum allocation, based on enhanced data rates, and better price/performance/power consumption trade-offs, both in the licensed and unlicensed band, dynamically allocated, and automatically increased based on the relative increase in throughput.**
- 20. Seamless integration of all of the above so that 4G is "the next and last generation of wireless computers and communication" because it can be easily upgraded and evolved**

4G Has The Potential To Radically Alter The World Economy

Market potential

Wireless broadband business could generate revenues of \$2.0 Trillion/year⁽¹⁾

Greatly improve efficiency of our service economy

Potential to create new, profitable industries, eg

- **Augmented Reality gaming**
- **Tele-Services (medicine, etc)**

Impact on industry structure

New entry points, beach heads for competitive activity

- **Who will own the device space?**

Radically alter existing distribution channels for content and services

Collaboration will become a key differentiator

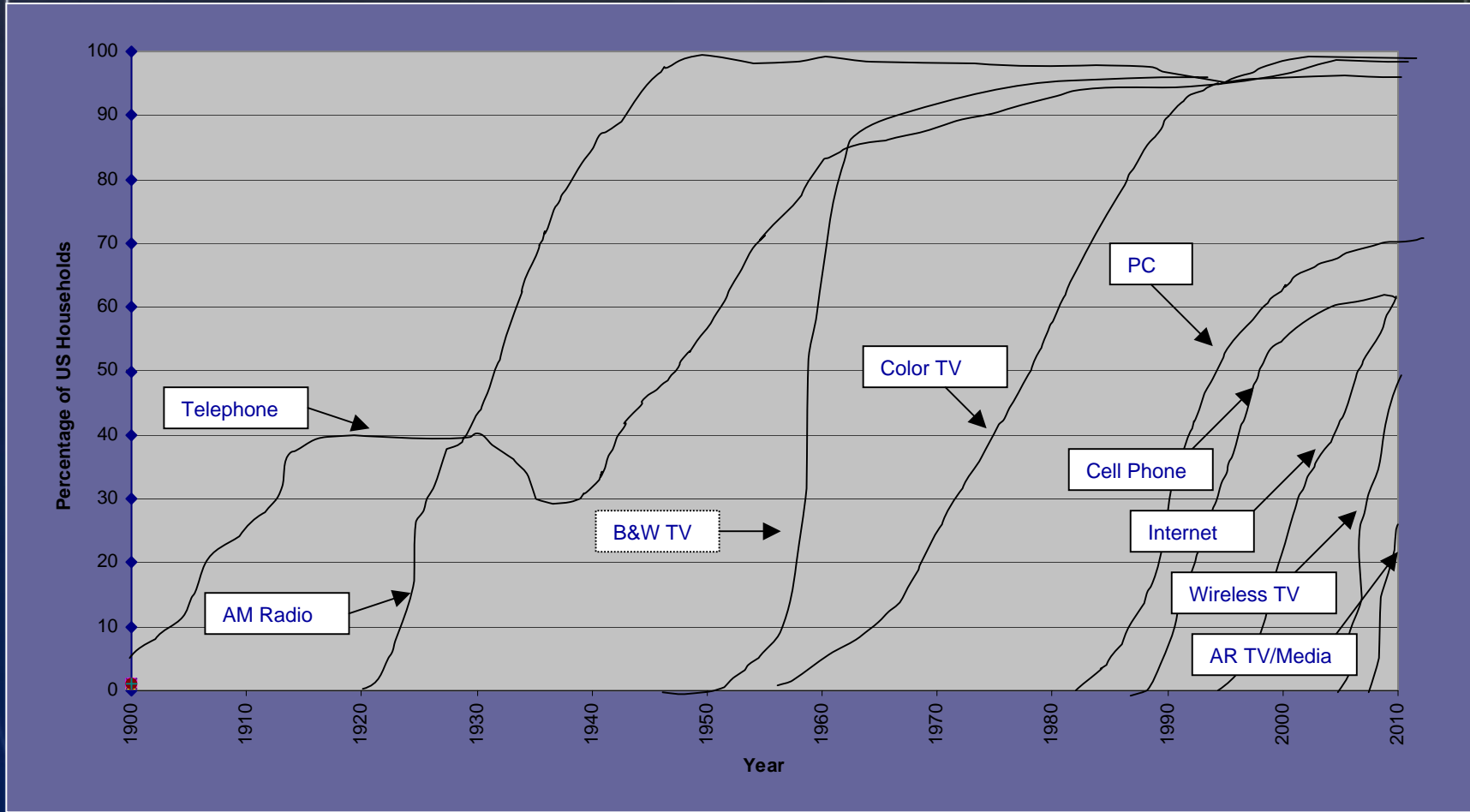
- **Capitalizing on need for convergence**

(1) Assumptions:

- \$100/month from 1B people for all-inclusive information, communication, education
- \$40/month from an additional 1B people
- \$300B/year in consulting, integration, and related services

4G Is Just One Of A Series Of Explosions In Communications

Communication Technology Adoption Rates



The 4G Body

- Given Imaging's camera/sensor pill that you swallow, with data recorded onto a hiptop Personal Black Box.
- Medical Microelectronic Machines (later nanodocs) tied to NIH databases doing realtime assessment against millions of high resolution medical records, each with IPv6 address.
- Localizers as described in Vernor Vinge's A Deepness in the Sky will link internal and external 4G bodies.
- The value of curing cancer, heart disease approx. \$50 trillion each. Milken Institute.

The Great Augmentation

Augmented memory allows hyper documentation of one's life, recording everything and keeping the Life Bits on your 100 GB hard drive on your hip.

In the future, after emergence of AI, you may want to upload yourself to the net.

Augmented reality allows us to overlay semitransparent text, images, video, from context awareness. Head tracking enables hands free operation.

Endowing IPv6 Users with Superpowers

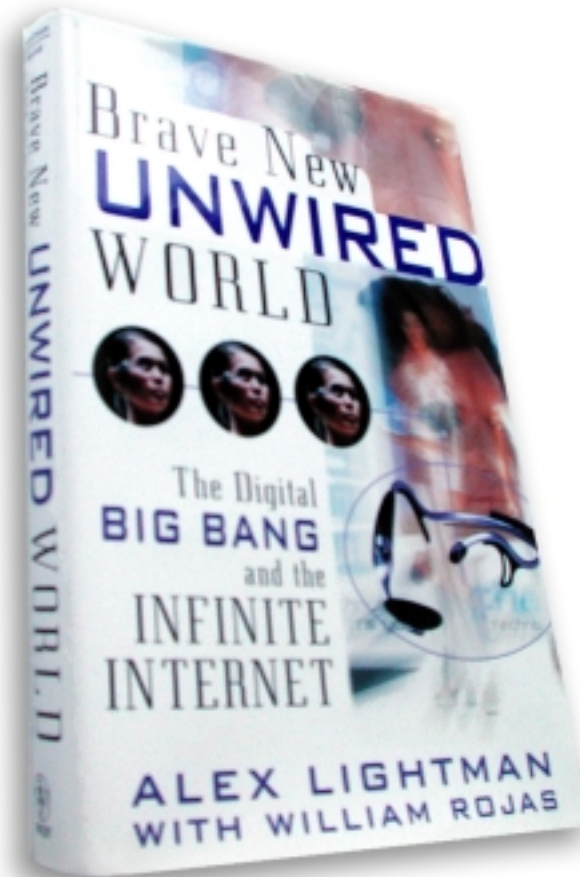
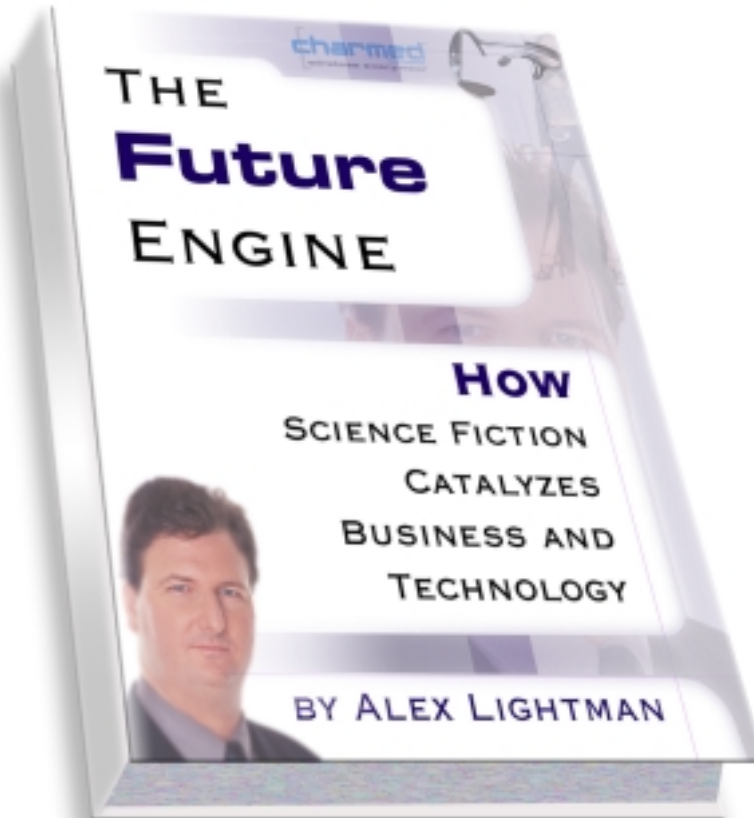
- *Omniscience*: ability to know almost anything, instantly (John Doe)
- *Clairvoyance*: ability to see what is happening anywhere on earth
- *Omnipresence*: ability to project power or influence anywhere
- *Collective Intelligence*: joining minds

Towards the Ever Smarter World

- Thales: GPS to 10 centimeter resolution > Give every cm, 10 cm, 1 m, 10 m, etc. its own IPv6 address. Use for location, robotic maintenance, tests of different plant growth, fiber optics digging, post it notes.
- “313 million addresses per every cubic millimeter of Earth. This will hopefully be the LAST change of network protocols FOREVER - Once we have the 313 Million appliances per square mm don't even think of introducing IPv8!”

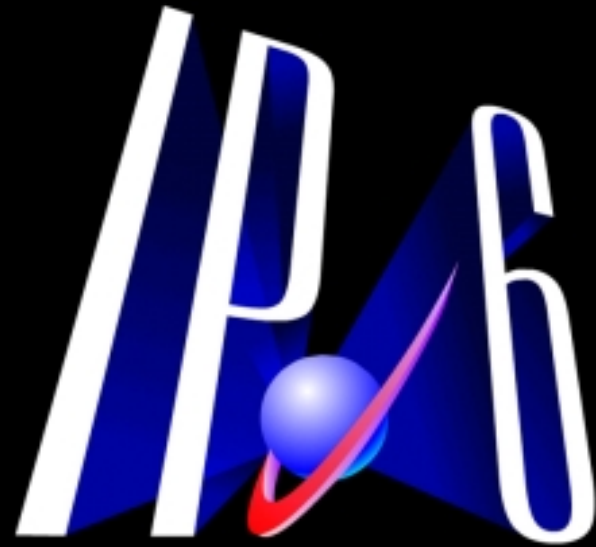
The Killer App of Ubiquitous IPv6

- Six billion people online...
- using human-centric wearable devices...
- that allow reception, context-aware processing, retransmission of signals...
- including electromagnetic spectrum (television, radio, cellular, satellite, medical, etc.)...
- and molecules (smells and chemicals)...
- all provided for an affordable fee...
- and constituting the largest industry.



Books come with 24 hour tech support, lunch, and a friendship

UNITED STATES



GLOBAL SUMMIT

Thank you!

Please stay in touch.

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Please join us at the San Diego IPv6 Global Summit, June 23 to 27, 2003, San Diego State University/ Radisson Hotel.