Emerging Technologies & Megatrends

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MetroCon 2002

Institute for Scientific Research, Inc.

- West Virginia non-profit, 501(c) (3) tax exempt organization
- Specializing in R&D of software & related emerging technologies
- Research includes both focused & interdisciplinary studies
  - Providing solutions to technology-related problems
  - Defined by broad public interests & societal needs
- Collaboration
  - NASA Centers
    - » Goddard, Marshall, & Dryden, IV&V
  - Other Partners
    - » Carnegie Mellon U., Virginia Tech, U. of Florida, SAIC, Boeing, EWA
- ISR Offers
  - Environment for cultivating fresh ideas & disciplines required for a panorama of scientific discoveries
  - Highly skilled workforce of distinguished scientists, engineers, mathematicians, & physicists

ISR Capabilities

- Nuclear Engineering
- Radar Systems Engineering
- Antennas & Radiating Systems
- Electrodynamics
- Orbital & Planetary Mission Design
- Spectroscopy
- Acoustics
- RF System Design
- Statistical Sampling & Analysis
- Data Mining
- Modeling
- Optimization Strategies & Analysis
- Statistical Database Design
- Decision Analysis
- Advanced Computer Modeling & Simulation
- Neural Network Analysis, Design & Implementation
- Cluster-based Computing Systems
- Remote Sensing
- Image Processing

Emerging Technologies Overview

- Setting the Stage
  - Megatrends, Perspectives, Universal Laws
  - Technical, Organizational, Societal
- Materials science
  - Physics & chemistry of materials, manufacturing, etc.
  - Make devices smaller, faster, more efficient, flexible, adaptable
- Systems science
  - Focused on integration of these materials & processes
  - Systems to solve problems, to perform applications, etc.
  - Organization & integration of tasks, processes, etc.

Setting the Stage

- National Nanotechnology Initiative
- Improving Human Performance
- What Man-Machine Interface?
- Thinking, Organizing, & Problem Solving
- Megatrends Overview
- Three Perspectives
- Laws Governing the 21st Century
- The Open Source Metaphor
- The Virtual, Organic Corporation
- Commons-Based Peer-Production

National Nanotechnology Initiative

- $500M government inter-agency effort to fund basic research & education
- Societal report (250 pages)
  - http://itri.loyola.edu/nano/societalimpact/nanosi.pdf
- *"When you introduce a new technology, it's almost impossible to foresee what the consequences will be."*

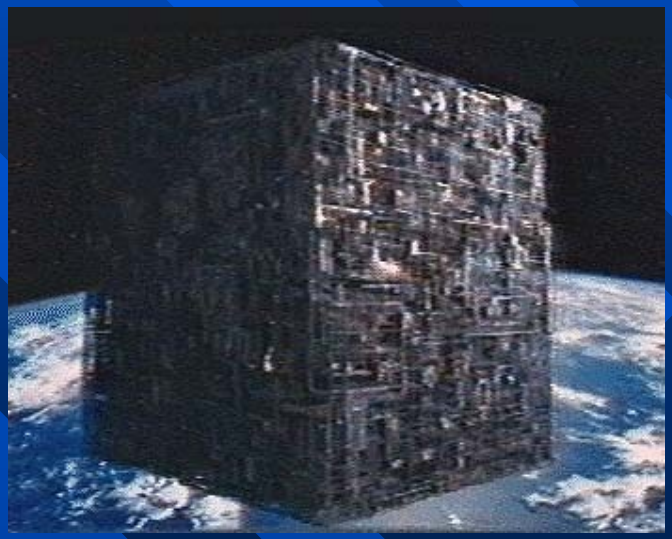
Improving Human Performance

- Converging Technologies
  - Nanotechnology, Biotechnology, Information Technology, & Cognitive Science
- Improving Human Performance
  - Merging human consciousness with machines
  - Brain-to-brain connections
    - » *"local groups of linked enhanced individuals"*
    - » *"a global collective intelligence"*
- NSF/DOC-sponsored report (400+ Pages)
  - http://itri.loyola.edu/ConvergingTechnologies/

What Man-Machine Interface?

- Stephen Hawking, Cambridge U. physicist
  - *"It is vital to develop ways of keeping biological systems superior to electronic ones …"*
  - *"Humans must develop an interface that allows the human brain to be directly connected to a computer,…"*
  - *"The artificial brain contributes to human intelligence, rather than opposing it."*
  - Focus, Munich, http://www.focus.de/

Do We Prepare to Be Borg'd?



Thinking, Organizing, & Problem Solving

- New Models of *Thinking*, of *Organizing*, of *Problem Solving*
  - From linear cause-effective thinking processes
    - » Von Neumann architectures, etc.
  - To a discontinuous integral non-linear consciousness
    - » Real-time interaction with what currently is happening
    - » Neural nets, etc.
  - *"The medium is the message"*— They are inseparable
    - » Copyright laws must be rethought

    Marshall McLuhan, Understanding Media: The Extensions of Man

Megatrends Overview

Technological	Organizational	Cultural
Moore's Law Metcalfe's Law	Coase's Law of Diminishing Firms	Downes' Law of Disruption
Appliancization	Convergence	Mass Customization
Open Source Metaphor	Virtual Corporation	Organic Corporation

Three Perspectives

- Organizational
  - Infrastructure to provide flexibility to take advantage of golden opportunities?
  - Minimize continually occurring obsolescence of existing programs, services, etc.?
- Technical
  - Take advantage of these emerging technologies?
  - Adopt what approaches, methodologies, etc.?
- Cultural
  - Mindset to cultivate with employees, customers, etc.?
  - Actions & policies—formal & informal—to introduce?

Laws Governing the 21st Century

- *Moore's Law*
  - Exponential improvements in information & communications processing
- *Metcalfe's Law*
  - Explosive non-linear adoption of new technologies
- Coase's *Law of Diminishing Firms*
  - Market efficiency v. corporate efficiency (bureaucracy)
- Downes' *Law of Disruption*
  - Social systems improve incrementally v.
  - Technology improves exponentially
  - Discontinuous, disruptive, indeed revolutionary change

Sustaining v. Disruptive

Appliancization

- Computing & communications costs shrink
- Devices & applications become
  - Less general-purpose & more task-specific
- Replacement/substitution of one device or application by another
  - *Cheaper* to buy, to operate, to maintain
  - *Better suited* to perform task for which designed
- Gordon Bell, Smithsonian Institution
  - Computer Industry Laws, Heuristics & Class Formation: Why computers are like they are
  - http://americanhistory.si.edu/csr/comphist/montic/bell/index.htm

Mass Customization

- World where mass-market goods & services are uniquely tailored
  - *Customized* — to needs of individuals
- Shift in the focus of all commerce
  - From *industrial-focused* to *digital-focused* society
  - Demotion of *products* & promotion of *customers*
  - What *services* are all about

Joseph Pine, Mass Customization—The New Frontier in Business Competition

Convergence

- Of communications, processes, operations, management, content, marketing, etc.
- Enables *dynamic*, *opportunistic partnering*
  - Transparently to the customer & Seamlessly among the partners
- Shift in persistent *strategic relationships*
  - From: products and services To: satisfying the customer
- Delicate balancing
  - Forces of *mass production* & *mass customization*
  - Pull of *customer demand* & push of *technology enablement*

The New Corporate Image

- Open Source Metaphor
  - Alliance for Converging Technologies
  - Donald Tapscott, http://www.actnet.com
- Virtual Corporation
  - The new corporate model of organization and operation
  - Donald Tapscott, The Digital Economy, 1996
- Organic Corporation
  - Megan Santosus, CIO Magazine, January 1, 1999
  - http://www.cio.com/archive/010199_over.html

The Open Source Metaphor

- Alliance for Converging Technologies
  - *"We consider this to be the new form of organization."*
  - The form of organization for the industrial age was the *vertically integrated company* — Henry Ford's Ford.
  - *"In the new model, it's about focusing on what you do best and acquiring partners* [including your customers] *to create everything else you need to bring your service to* [those same] *customers."*
- Sharing
  - the risk, the labor, the support, the profit, …
- Economic version of Metcafe's Law
- *Peer-to-Peer* Computing, *Mesh* Networking

The Virtual Corporation

- Corporations will not disappear, but …
  - Become smaller, leaner, more focused, …
  - Be comprised of webs of *well-managed relationships*
- Business *partners* will include
  - Not just suppliers, but also customers, regulators,
  - Even shareholders, employees, and competitors
- *Convergence* now the preferred approach
  - Achieving competitive efficiencies
  - Enhancing the ability to adapt—in realtime
  - To the customer's ever-changing demands
- *Grid* Computing, *Mesh* Networking

The Organic Corporation

- Long-term, sustainable viability derives from
  - Speed of adaptability
  - Self-organizing capacity
- Ability to
  - Interpret broad marketplace trends
  - Anticipate what customers want
  - Expand beyond traditional markets
- Such companies are *organic* in that they
  - Process continuous feedback from the environment
  - Convert such information into fluid plans of action
- IBM's *Autonomic* Computing

Innovation by User Communities

- Learning From Open-Source Software
  - Eric von Hippel, MIT Sloan School of Management
  - *"... manufacturing companies need to be concerned not only about what they produce, but also about what their customers might produce without them."*
  - *"... aggregations of individuals who share a common need or desire and exert a collective effort to fulfill it independently of any commercial enterprise"*
  - *"... extends beyond software to more flamboyant arenas."*
  - *"Aided by the Internet to support collaboration and distribution, the power and pervasiveness of such communities could become enormously amplified."*

Commons-Based Peer-Production

- New, Third Mode of Production
  - Yochai Benkler, law professor at New York University
    - » http://www.benkler.org/CoasesPenguin.html
  - Open source signals "*a broad and deep emergence of a new, third mode of production in the digitally networked environment.*"
  - Distinguished from *property-based* & *contract-based* models of firms & markets
    - » Groups & individuals successfully collaborate on large-scale projects
    - » Following a diversity of motivational drives & social signals
    - » Rather than either market prices or managerial commands

Emerging Technologies Classified

- Materials science
  - Physics & chemistry of materials, manufacturing processes, etc.
  - Make devices smaller, faster, more energy efficient, flexible, adaptable, etc.?
- Systems science
  - Integration of these materials & processes
  - Form systems to solve problems, to perform applications, etc.
  - Better ways to organize & to integrate the tasks, processes, etc.?

Emerging Technologies Surveyed

- Materials Science
  - Nanotechnology
  - Single-Atom Transistor
  - Single-Molecule Machine
  - Organic Polymer Magnet
  - Protein-Enabled NanoMagnets
  - Power Paper
  - Polymer Electronics
  - Molecular Electro-Luminescence
  - Molecular Photonics
  - Plastic Laser
  - Photonic Crystals
  - The Perfect Mirror
  - UWB—Ultra-Wideband
- System-Level Design
  - Spherical IC's
  - SOC—System-on-a-Chip
  - Reconfigurable Computing
  - Autonomic Systems
  - All-Optical Computer
  - DNA Computing
  - Genetic Engineering
  - Neuromorphic Engineering
  - Computational Sensing
  - Bionic Connections
  - Artificial Retina
  - Electronic Eye
  - Patents You Will NOT Believe!

Nanotechnology

- Central Thesis
  - *"Almost any chemically stable structure that can be specified can in fact be built."*
- Advanced in 1959 by Richard Feynman
  - *"The principles of physics, as far as I can see, do not speak against the possibility of maneuvering things atom by atom."*
  - DNA is nature's realization of this technology—so it is plausible, reasonable technology to pursue!
  - http://www.foresight.org/NanoRev/index.html
  - http://www.nanotechinvesting.com/

Single-Molecule Transistor

- *"The ability to build a whole circuit on a single molecule has always been the holy grail of computing."*
- Create logic circuit in single molecule
- IBM, Park Ridge, IL.
- Mass-production of nanoelectronic circuits within decade
- Enable switches 5 nms across
  - 100 times smaller than today's switches
  - Operate at terahertz speeds

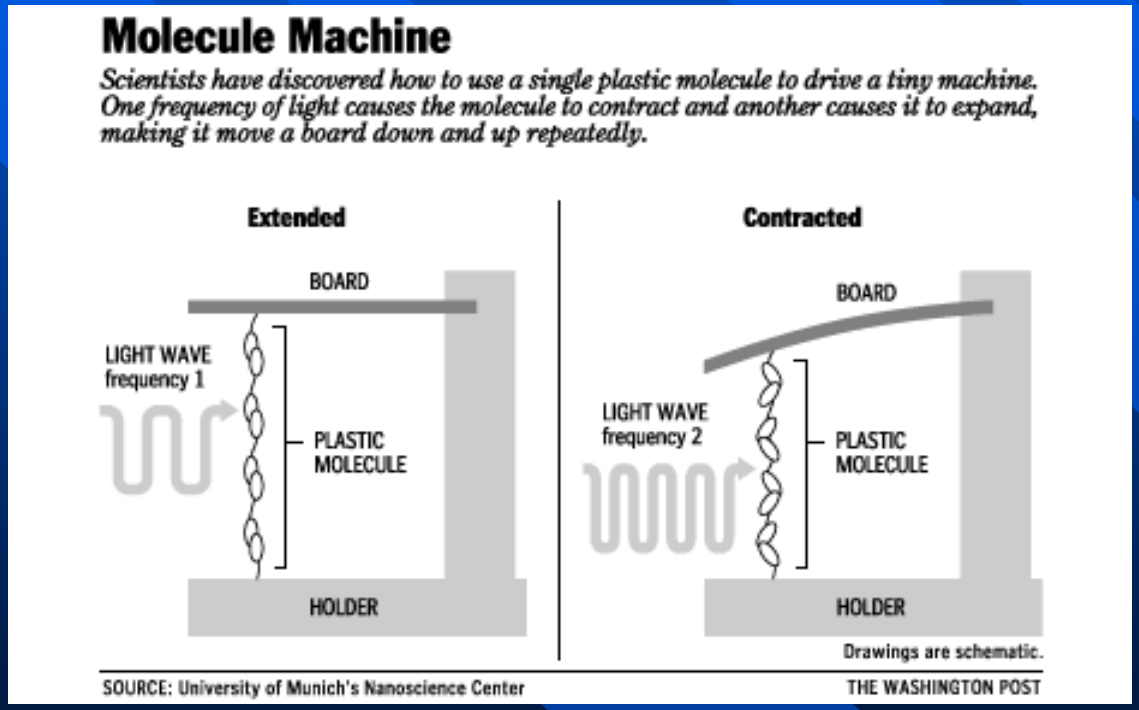
Single-Atom Transistor

- Using a single cobalt atom as a switch
  - Represents the ultimate in physical compactness for traditional logic states
  - Paul McEuen of Cornell University
- New approach
  - Molecular switch between ‘0’ and ‘1’
  - By changing shape
  - DNA molecular properties determined by how they “fold” as well as what “codes” they carry.

Single-Molecule Machine

- University of Munich's Nanoscience Center
- Power of light to create mechanical energy for a microdevice
- Converting light into mechanical energy
- Making a single molecule of plastic drive a tiny machine
- Used azobenzene
  - Well known for its *kinkiness*
  - Looks like a length of knotted telephone cord
- Shining different frequencies of light on the device
  - One frequency crimps the molecule, causing it to pull the diving board downward
  - Another frequency causes the molecule to become relaxed

Single-Molecule Machine



Organic Polymer Magnets

- The world's first magnetic organic polymer
  - Andrzej Rajca - Chemistry Professor at University of Nebraska
  - Japanese theoretician Noboru Mataga predicted room-temperature devices were possible
- Photo-induced magnetism in a polymer
  - Ohio State University & The University of Utah
  - Polymer molecules change their shape
- Organic magnet advantages
  - Lighter, more flexible, transparent

Protein-Enabled NanoMagnets

- Biological templates as routes to nanotechnology
  - Ferritin protein used to build tiny nanomagnets of consistent size
- Other applications
  - Catalysis
  - Microwave radiation shielding and antennae
  - Magnetic RAM (MRAM)
  - Ferrofluids for stereo speakers and hard disk drive actuators
  - MRI contrasting agent
- Dr. Eric Mayes @ NanoMagnets
  - http://www.NanoMagnetics.com

Clean Energy—Power Paper!

- Power Paper characteristics
  - Requires no casing
  - Printed, pasted, or laminated onto paper, plastic, & other media
  - Mass produced with silk screen printing in any custom size or shape
  - Non-toxic & disposable
  - Cannot explode or overheat
  - 1.5 volts with a shelf-life of 2½ years
  - http://www.powerpaper.com/

Solar Panels in Your Clothes

- Plastic solar cells
  - Paul Alivisatos, chemistry professor, U. of California, Berkeley
  - Plastic solar cell that can be painted or sprayed onto any surface
  - Works like commercially available photovoltaic cells
  - 1000th thickness of human hair produces ½ voltage of a common flashlight battery
  - Costs of 1/10th current technologies

All-Organic Displays

- Compared to conventional LCDs—liquid crystal displays
  - Consumes less than 1/500th power
  - 30% brighter
  - Manufacturable at a much lower temperatures—100°C
- Bridgestone & Penn State
  - Other groups @ Lucent, IBM, 3M, Xerox, & Sarnoff
- Flexics' alternative polysilicon

Nano-scale Molecular Memory

- Rolltronics Corp
  - Today, 640 MB cards at ½ cost of today's flash memory cards
  - 2004, 64GB on PC card & 5TeraB on 3 ½ floppy size
- Performance
  - No data loss after 7000 hours without power
  - No data degradation after 1.5B read-write cycles

All-Optical Switching Networks

- Fiber-Optic Amplifiers
  - MOEC patent process for *fiber-optic amplifiers*
  - Build optical amplifiers optimized for virtually *any wavelength* that installed fiber can carry
  - Chip-based process could open up frequency range 10 times wider
- The Goal — All-optical switching networks

Electrically Powered Plastic Laser

- First Electrically Powered Plastic Laser
  - Bell Labs Develops
  - Open possibilities for electrically driven lasers
  - Inexpensive to manufacture
  - Tailored to produce a wide range of wavelengths
  - Can be driven by today's silicon circuitry
  - May someday be combined with plastic transistors
  - Reduce production costs and lead to lightweight, flexible products

Molecular Electro-Luminescence

- Electro-Luminescence from Individual Molecules
  - Single molecules emit one photon at a time
  - Normally achieved with DC voltage
  - High-frequency AC voltage (> 150 mhz) produced a response 10K greater
  - Injects electron charge at just the right time
- Basis for high-efficiency quantum information processing and cryptography
  - Robert Dickson, Georgia Tech's School of Chemistry and Biochemistry

Photonic Crystals

- Photonic Crystals
  - Shawn Lin & Jim Fleming at Sandia National Laboratories
  - Microscopic three-dimensional lattice
  - Able to confine light at optical wavelengths
  - Regularly repeating structure can direct light
    - » Mimicking the properties of a true crystal
  - Optical lattice — smallest ever fabricated
  - Structure — *microscopic tunnel of silicon slivers*

The Perfect Mirror

- Combines best characteristics of existing mirrors
  - Metallic mirrors — reflect light from all angles and polarizations
  - Dielectric mirrors — can be extremely low-loss
- The perfect mirror
  - Reflect light at any angle with no loss of energy
  - "Tuned" to reflect certain wavelength ranges & transmit rest

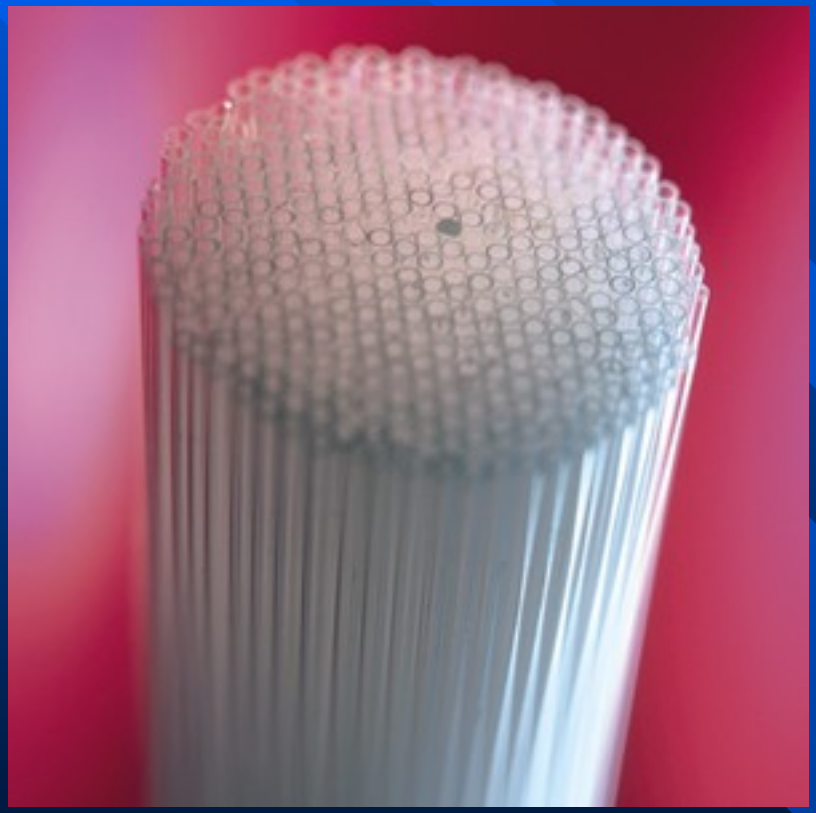
Omni-Guides

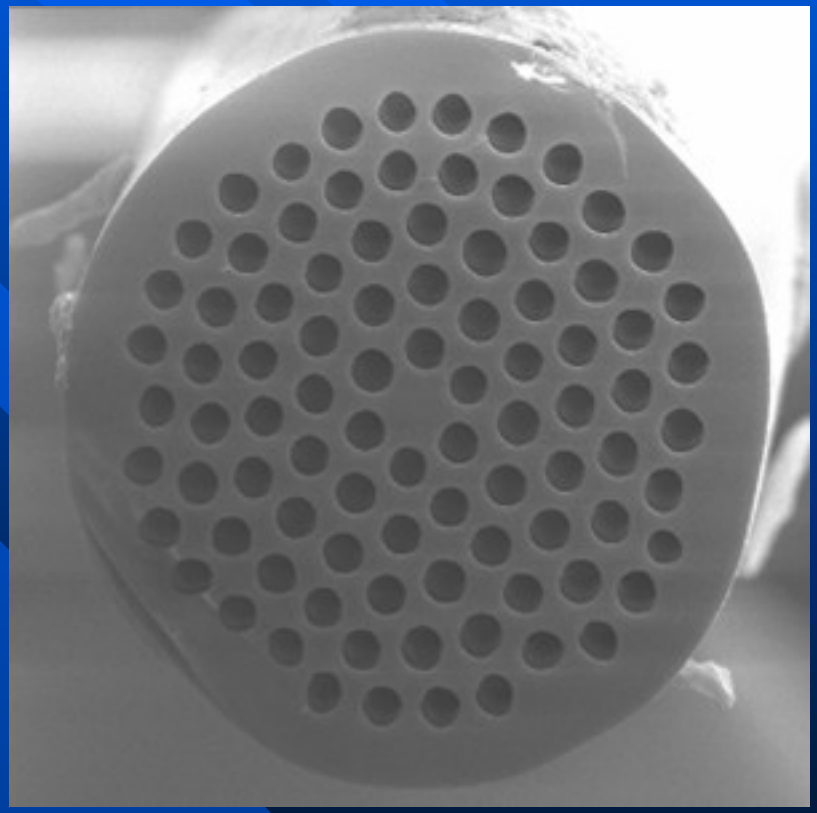
- Carry light with far less loss of energy
  - Thousands of miles without amplifiers
  - Not limited to small wavelength band by amplifier technology
- Could be made to reflect radio waves, so
  - Used to boost the performance of cellular telephones
- Revolutionize power transmission
  - Dual duty: power & communications

OmniGuide Communications Inc.

- Omni-directional waveguide from perfect mirror tube
  - Conventional waveguides — must make wide turns to ensure the light within them does not escape
  - Omni-directional waveguide — can turn light quickly and efficiently in small spaces
- Technological advances in devices such as an optical chip
  - http://www.omni-guide.com/

Producing Omni-Guides





University of Bath, in England

UWB—Ultra-Wideband

- Background
  - Time-domain electromagnetics begun in 1962
  - Describe microwave networks through their characteristic impulse response (Ross 1963, 1966)
  - Alternately called *baseband*, *carrier-free* or *impulse* & more recently *ultra-wideband*
  - Applicable to communications & radar
  - *Ultra-Wideband*, Paul Withington, Time Domain Corporation, MetroCon'2001
- FCC battle is won!

Ultra-Wideband in Your Home

- XtremeSpectrum — www.xtremespectrum.com
  - Shipping chipset—full production next year
  - NO *classical* spectrum reqs, e.g., 2.4GHz for 802.11b
  - Initially, 100Mb/sec, 10 meters, $20/chip
  - 3 years, 400Mb/sec, < $5/chip
- BE LABS — www.belabs.com
  - Transmitted DVD-quality video signal
  - Concrete walls & steel girders in a residential environment
  - Distance of approximately 150 feet
- Pulse~LINK, Inc — UWB over cable infrastructure
- What else can UWB do?
  - Radar-like capability to *locate* components
  - Home-based *LBS*—location-based services

Systems Science

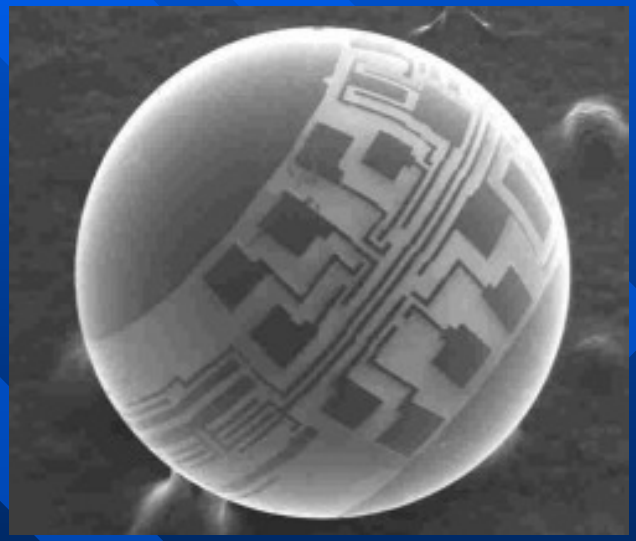
- Spherical IC's
- SOC—System-on-a-Chip
- Reconfigurable Computing
- Autonomic Systems
- All-Optical Computer
- DNA Computing
- Genetic Engineering
- Neomorphic Engineering
- Computational Sensing
- Bionic Connections
- Artificial Retina
- Electronic Eye
- Patents You Will NOT Believe!

Spherical IC's — the Process

- Flat chips replaced by spherical ball devices
  - All processes — deposition, etch, diffusion, etc.
  - Fabricated as traveling through pipes & tubes
- System's design & engineering advantages
  - Reduce capital investment — $100M vs. $1.5B
  - Reduce time to process — 3 months to 5 days
  - Componentize SoC design & fabrication
  - Mass production of IC components for final assembly

Spherical IC's — Redefine Systems

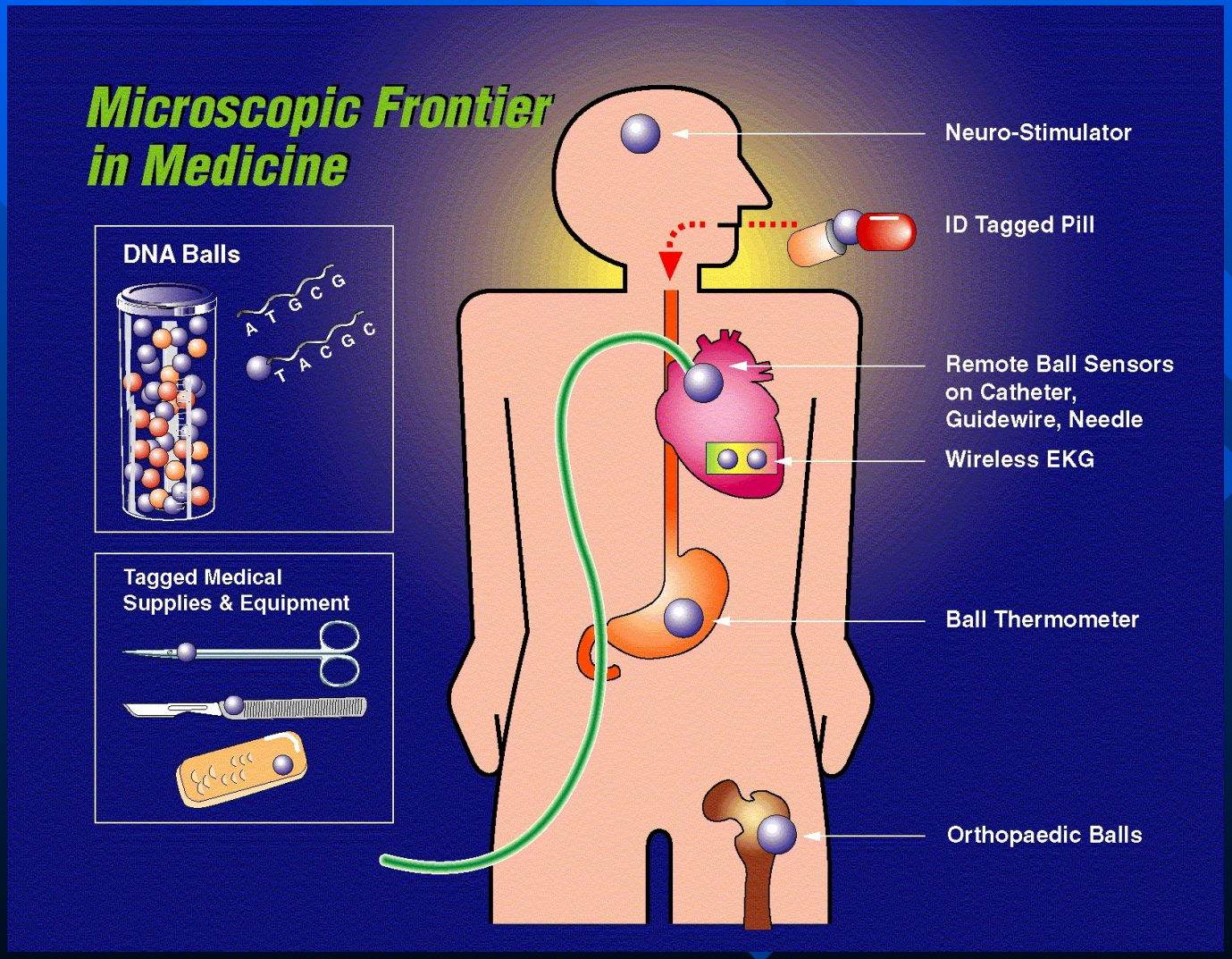
- New systems architectures & applications
  - Complex interconnection geometries, strategies, & computational models
  - Switch-on-a-chip, Neural-nets
  - Natural language, image processing, & artificial vision



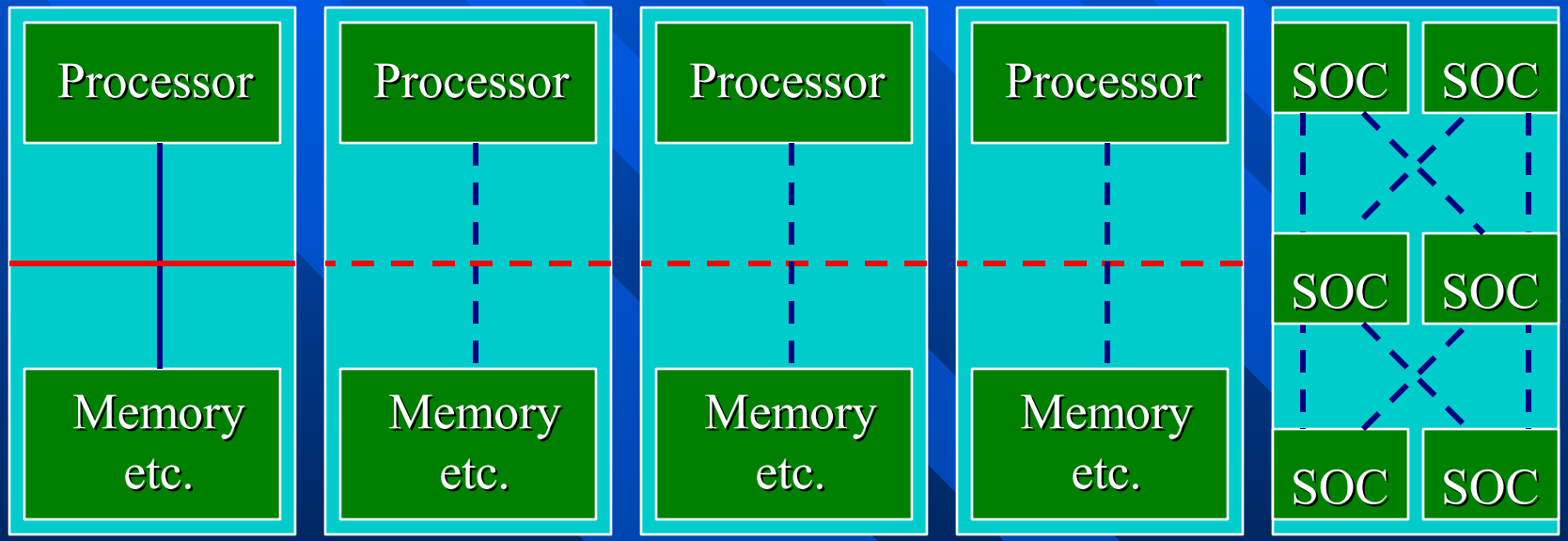
Ball Semiconductor's MedBalls

- Integrated circuits on microscopic spheres for medical purposes
  - Wirelessly communicate from within the body
  - May be ingested or implanted
  - Acquisition of vital statistics convenient & automatic
  - http://www.ballsemi.com/medical/images/medballs.gif

Ball Semiconductor's MedBalls



Systems Science — In Transition



Real Buses Connecting Distinct Chips

Emulated Buses On-a-Chip

Virtual Buses On-a-Chip

Point-to-Point Paths On-a-Chip

Multi-Point to Multi-Point On-a-Chip

SOC — System-on-a-Chip

- Purpose & design of buses in SOC undergoes significant rethinking
  - SHORT-TERM — map current *'real'* buses between 'real' devices, to *'virtual bus'* between *'virtual'* devices all of which reside on the same chip.
  - MID-TERM — development of new *'virtual'* buses capitalize on system-on-a-chip flexibility—with only moderate redesign of of IP interfaces.
  - LONG-TERM — development point-to-point integration of IP on the same chip
  - MSOC = Multi-Systems-on-a-Chip

Reconfigurable Computing

- OLD — develop & compile step-by-step algorithms for a fixed circuit configuration
  - Bypass von Neumann computational model of a sequential processor acting upon a stored memory program
- NEW — use FPGA's to prewire/rewire the circuit for the problem
  - Map application systems/object model into executable silicon

Dynamic Computing

- Borrow from (today's) conventional programming
  - High-level-language/compiler/CPU technology widely accepted, available, & supported
- Programming — build custom circuit-generator objects from library of circuit-generator objects
- Dynamic Computing — synthesize & configure circuits as a program is running

Autonomic Systems

- Characteristics, as IBM sees them
  - Possesses a sense of self
  - Adapts to changes in its environment
  - Strives to improve its performance
  - Heals when it is damaged
  - Defends itself against attackers
  - Exchanges resources with unfamiliar systems
  - Communicates through open standards
  - Anticipates users' actions
  - *"Autonomic Computing,"* W. Wayt Gibbs, Scientific American, August 6, 2002

First Integrated Photonic Circuit

- Infinitera's Integrated Photonic Ciruit
  - Photonic properties allow integration of lasers, detectors, dynamic components, passive waveguides, & electronics
  - Chip makers design a photonic circuit & etch onto InP wafer in much the same way as with silicon
- Competition:
  - Genoa, CyOptics, Opto Speed, & Qusion
  - Using planar light wave circuits (PLCs)
  - PLCs with conventional electronic chips to reduce network costs

All-Optical Computer

- Lenslet Labs—Israeli startup
  - http://www.lenslet.com/
- All-optical engine
  - Size of a Palm Pilot handheld computer
  - Process 256 x 256 matrix array multiplication in a single cycle
- Optical Digital Signal Processing Engine
  - Spatial light modulator (SLM)
  - Made in a gallium arsenide process
- Applications are many, e.g., in 3G basestations

DNA Computing

- Similarities in biological & math operations
  - Complex structure of a living being
    - » Result of applying simple operations to initial information encoded in a DNA sequence
  - Result *f*(*w*) of applying computable function to arg *w*
    - » Obtained by applying combination of simple functions to *w*
- Use DNA *strings* to encode info for math systems
- Tutorial:
  - http://dna2z.com/dnacpu/dna.html
- DNA Turing Machine:
  - http://www.ugcs.caltech.edu/~pwkr/oett.html

Unrestricted Computing Model

- *Synthesis* of a desired strand
- *Separation* of strands by length
- *Merging*: combine two test tubes to perform union
- *Extraction*: extract strands containing given pattern
- *Melting/Annealing*: break/bond two ssDNA molecules with complementary sequences
- *Amplification*: use PCR (Polymerase Chain Reaction) to copy DNA strands
- *Cutting*: cut DNA with restriction enzymes
- *Ligation*: Ligate DNA strands with complementary sticky ends using ligase
- *Detection*: Confirm presence/absence of DNA

DNA Microarrays

- DNA microarrays, or DNA chips
  - Fabricated by high-speed robotics
  - For which *probes* with known identity are used to determine complementary binding
  - Massively parallel gene expression & gene discovery studies
  - http://www.gene-chips.com/
- A single DNA chip can provide information on thousands of genes simultaneously
  - Two major application forms of DNA microarrays
    - » *Identification* of sequence (gene / gene mutation)
    - » Determination of expression level (*abundance*) of genes

Genetic Self-Organizing Circuits

- Goal—create oscillator from self-organizing electronic circuit
  - Transistors on circuit board of programmable switches
  - Switches acted analogous to genes
  - Allowing new circuits to evolve
- Instead—turns itself into a radio receiver
  - Paul Layzell & Jon Bird, University of Sussex
  - http://www.newscientist.com/news/news.jsp?id=ns99992732

Genetic v. Systems Engineering

- Systems and software engineering
  - Fundamentally a top-down (problem to solution) process
- Genetic Algorithms
  - Transformed into a bottom-up (discover and explore) process
  - Many millions (billions) of outcomes can be explored
- Distinctions between *purposeful* (planned) activity and *opportunistic* activity are blurred

Neuromorphic Engineering

- Neuromorphic Engineering
  - Design & fabrication of artificial neural systems
  - Such as vision chips, head-eye systems, & roving robots
  - Architecture & design principles based on biological nervous systems
  - Relies on nature's biological short-cuts
  - http://www.ini.unizh.ch/telluride/
- Build machines that work in the same way as the brain
  - Look at brain structures such as the retina & the cortex
  - Devise chips that contain neurons & a primitive rendition of brain chemistry
- In short, they are wholly analog machines, not digital ones

Computational Sensing

- Strategy behind computational sensing
  - Instinctive decision making performed at lowest levels
  - Before higher-level analysis & synthesis is begun
  - Ralph Etienne-Cummings of Johns Hopkins U.
- How it works — all on one SOC
  - Performs analog & digital processing
  - Extracts relevant information
  - Makes decisions & communicates results
  - Much faster than other robotic vision systems
- Open-heart surgery WITHOUT stopping the heart's beating!
  - ERC for Computer Integrated Surgical Systems & Technologies
  - http://cisstweb.cs.jhu.edu/

Bionic Connections

- Organic Polymers Connect Prostheses to Nerves
  - Tobias Nyberg & Helena Jerregård at Linköping University, Sweden
  - Structured to allow severed nerves to grow right into them & connect with electrodes
  - For example, in a prosthetic hand
  - Plastics etched with patterns of tiny channels 20 micron in size
  - Covered by an electrically conductive polymer & a protein on which the nerves can grow

Artificial Silicon Retina

- Optobionics Corp., Weaton, IL.
  - http://www.Optobionics.com
- Replaces damaged photoreceptors
  - Light-sensing cells that convert light into electrical signals within the retina
  - Microscopic solar cells convert light into electrical impulses
  - No batteries or wires — completely self-contained
  - Powered by light that enters the eye

Optobionics Corp's ASR

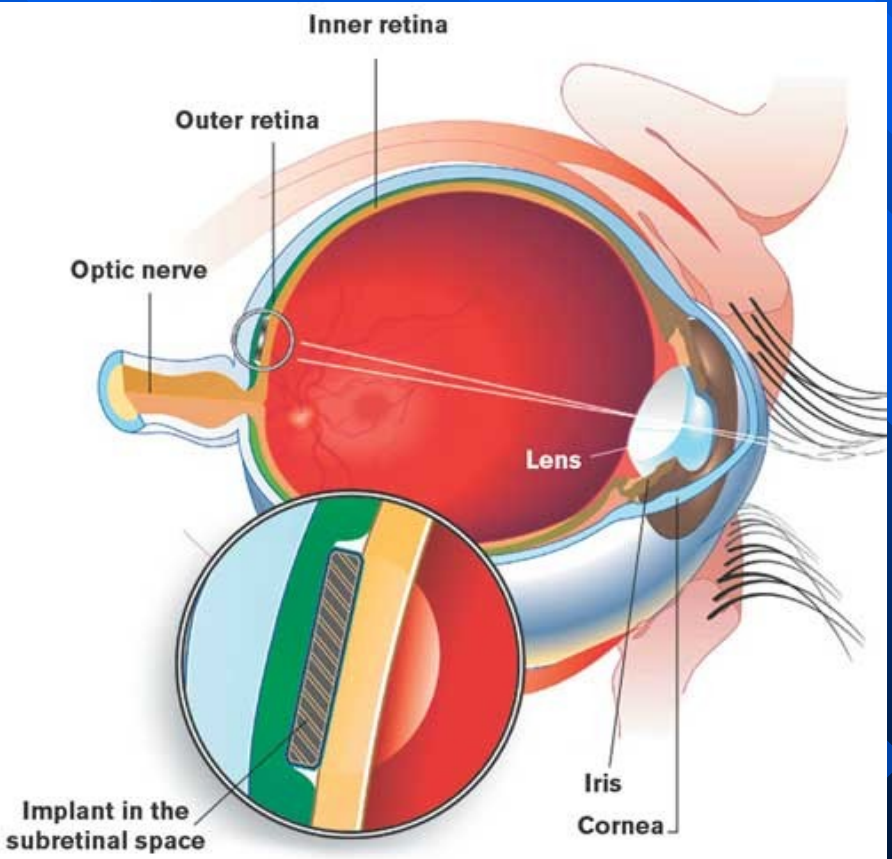
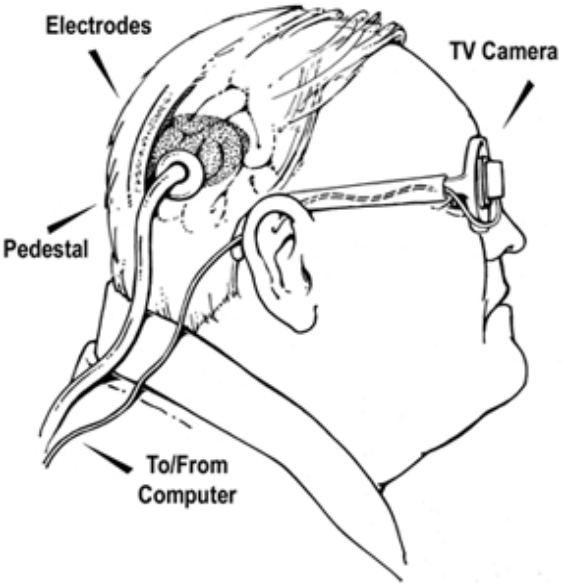


Figure 1 Diagram showing location of the implant in the subretinal space.

Electronic Eye Gives Back Sight

- Implantation of Electronic Eye Prosthesis
  - The Dobelle Institute, Portugal—not approved for USA
  - Special glasses, a la, Geordi LaForge of StarTrek
  - Microcomputer & stimulator on waist, belt, or in a bag
  - Attach cable to device implanted in the skull
  - Electrodes on surface of brain part controling sight
  - See white flashes of light in patterns—resembling stars on a black background, like a *photographic negative*
  - 4 of 8 patients saw brilliantly colored flashes
  - Creating hope future prostheses may work in full color
  - http://www.artificialvision.com/vision/news.html

Electronic Eye Prosthesis



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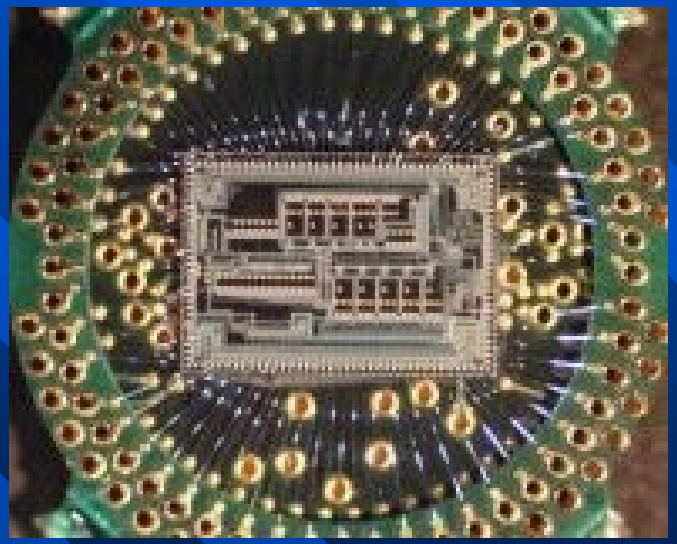
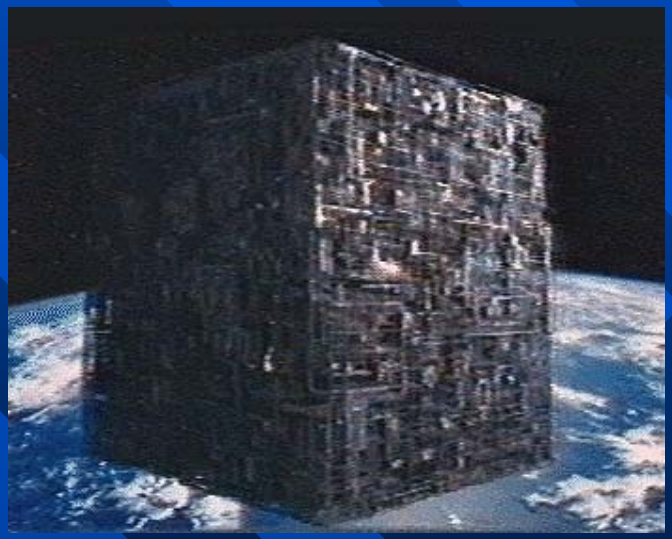
Another Bionic Eye Prosthesis

- Bionic eye sits in eyeball, replacing the retina
- Camera-glasses worn by patient
- Broadcasts data from camera to chip
- Radio range of 25 millimeters
- Aluminium wires send signals from the chip
- Device about size of a nickel
- About to begin human trials
- Gregg Suaning, University of Newcastle



Are YOU Prepared to Be Borg'd?



Thought Process Patented

- Californian patents thought process
  - Hugh Harlan of California, head of a company called The Brain
  - Patented the operation of code that mimics the human thought process
  - US Patent 6031537
  - Applied for a global patent WO 0057257

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