Emerging Models & Technology

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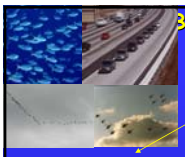
Emerging Models & Technologies
Computing & Communications Foundations
CISE Directorate
National Science Foundation

CCF Division Research Clusters

1. Theoretical Foundations
2. Foundations of Computing Processes and Artifacts
3. Emerging Models and Technologies for Computation (11th Floor, 1115)



Biologically Inspired Computing

MODELS

Neural Networks (Connectionism)

Evolutionary Computation (Survival of the fittest)

Social Systems

Membrane

Multilayer Perceptrons

Hopfield Networks

Cellular Neural Networks

Genetic Programming

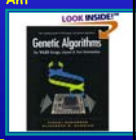
Genetic Algorithms

Grammatical Evolution

Swarm

Ant

Artificial Immune Systems



Self-healing, Self-repairable VLSI Chips

Mazumder '89

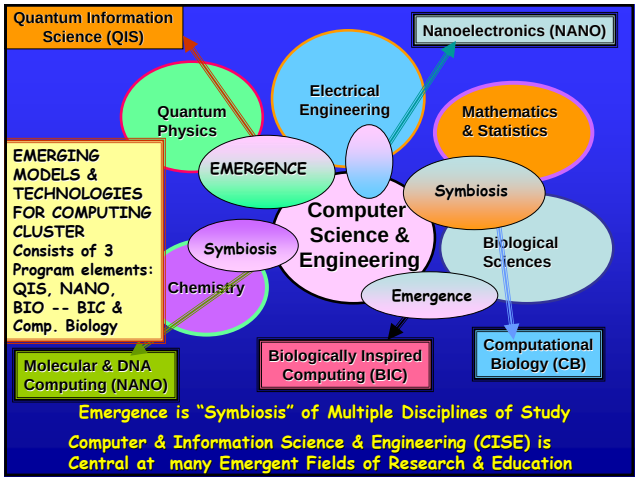
Nanoarchitectures Self-assembled Quantum Dot Array for image processing, & video motion detection.

Mazumder '04-08

- VLSI Cell Placement
- Chip Wire Routing
- Chip Floorplanning
- Chip Testing
- Logic Synthesis

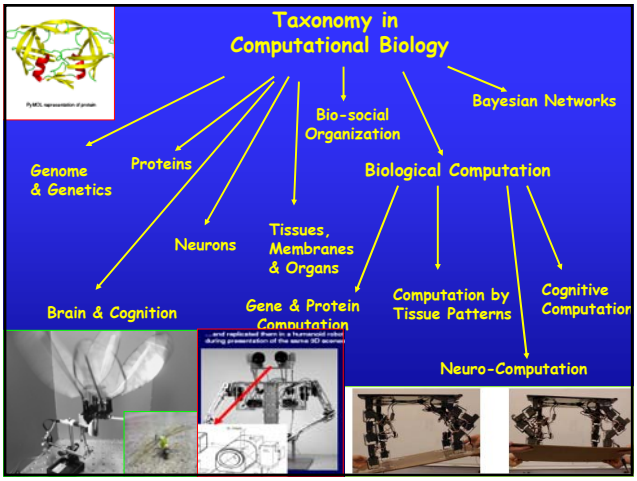
Mazumder '88-94

Mazumder's book. His research employs BIC in Micro & Nano Systems Design



Emergence is "Symbiosis" of Multiple Disciplines of Study

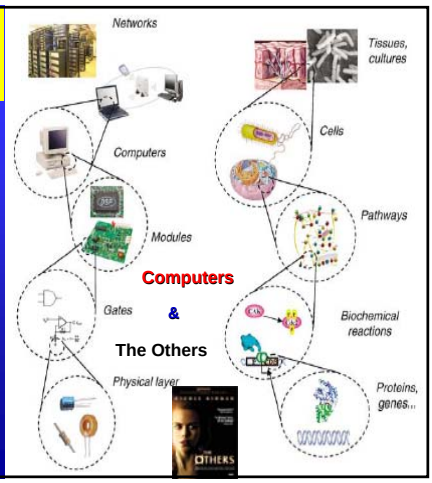
Computer & Information Science & Engineering (CISE) is Central at many Emergent Fields of Research & Education



From in-Silico To in-Vivo Computing

APPLICATIONS

- Drug manufacturing
- Biomaterial manufacturing
- Nanomachine assembly
- Sensor/effector arrays
- Programmed therapeutics
- Tools for studying genetic regulatory networks

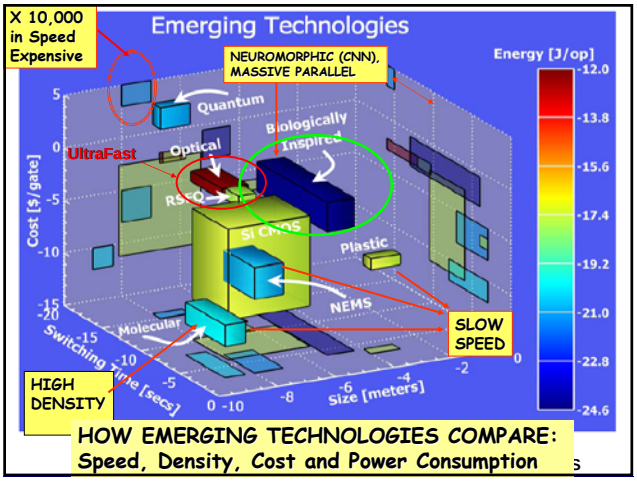


STATUS OF QUANTUM COMPUTING

QC Approach	The DiVincenzo Criteria: Quantum Computation #1	#2	#3	#4	#5	QC Networkability #6	#7
NMR	●	●	●	●	●	●	●
Trapped Ion	●	●	●	●	●	●	●
Neutral Atom	●	●	●	●	●	●	●
Cavity QED	●	●	●	●	●	●	●
Optical	●	●	●	●	●	●	●
Solid State	●	●	●	●	●	●	●
Superconducting	●	●	●	●	●	●	●
Unique Qubits	This field is so diverse that it is not feasible to label the criteria with "Promise" symbols.						

Legend: ● = a potentially viable approach has achieved sufficient proof of principle
● = a potentially viable approach has been proposed, but there has not been sufficient proof of principle
● = no viable approach is known

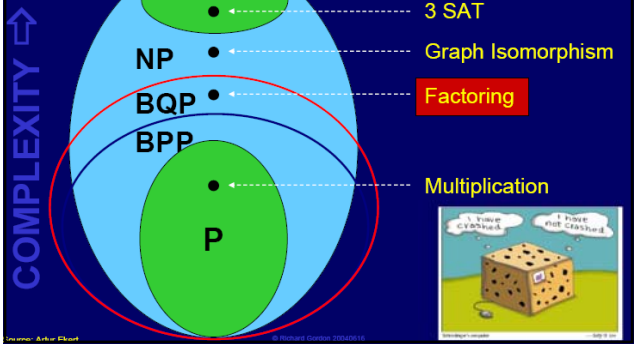
X 10,000 in Speed Expensive



HOW EMERGING TECHNOLOGIES COMPARE: Speed, Density, Cost and Power Consumption

Quantum Computation is Powerful

QUANTUM ALGORITHMS



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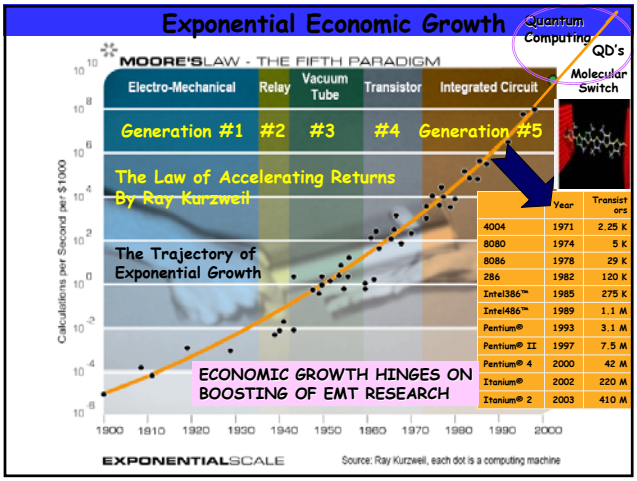
CORE EMT BUDGET FOR QIS PROGRAM ELEMENT

Quantum Information Processing	Props. Funded 2004	Funding Amount 2004	Props Funded 2005	Funding Amount 2005	Props Funded 2006	Funding Amount 2006	Props Funded 2007	Funding Amount 2007
Quantum Algorithms			5	$1,165,000			1	$300,000
Quantum Hardware	2	$637,674	3	$800,000	3	$925,000	3	$925,000
Quantum Communications, Error Correction	2	$700,000	2	$706,000	3	$940,000	2	$300,000
Theoretical Modeling	3	$788,295	4	$980,000	4	$945,000	3	$700,000
Quantum Measurements			1	$150,000				
TOTAL	7	$2,125,969	15	$3,801,000	10	$2,810,000	9	$2,225,00
TOTAL (APX.)	7	$2.1 M	15	$3.8 M	10	$2.8 M	9	$2.2 M

QIS Funding Needs Boosting → QuBIC + ITR @ NSF

→ QuIST @ DARPA

Exponential Economic Growth



	Year	Transistors
4004	1971	2.25 K
8080	1974	5 K
8086	1978	29 K
286	1982	120 K
Intel386™	1985	275 K
Intel486™	1989	1.1 M
Pentium®	1993	3.1 M
Pentium® II	1997	7.5 M
Pentium® 4	2000	42 M
Itanium®	2002	220 M
Itanium® 2	2003	410 M

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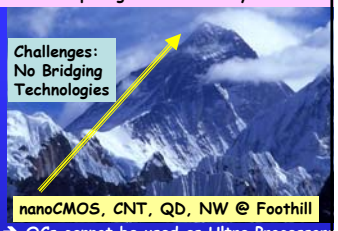
Quantum Computing @ The Himalayas Summit

OPPORTUNITIES

Quantum Computing Offers – 10,000 Speed Advantages over CMOS, CNT, QD, NW, SET, … QC is likened with Mount Everest (29,000 ft.), while CMOS, CNT, … are at its Foothill (19,000 ft.).



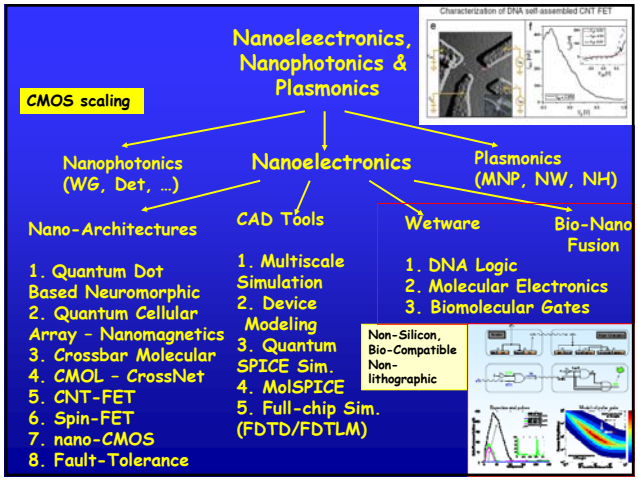
CHALLENGES

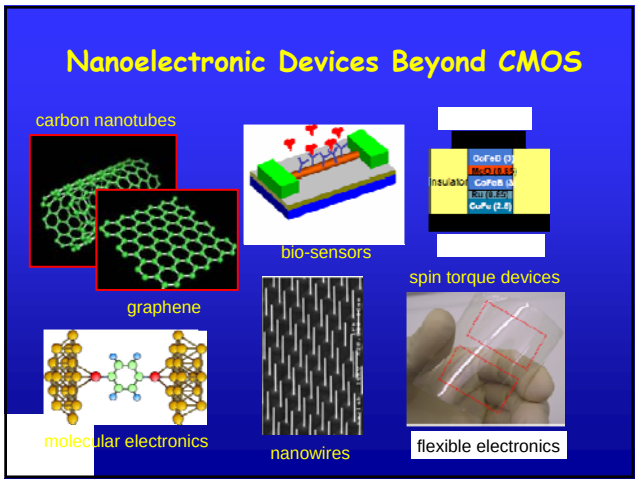
No bridging technologies to interface → QCs cannot be used as Ultra Processors like Super Computers (Cray, Fujitsu FACOM, …) interface with Main Computers

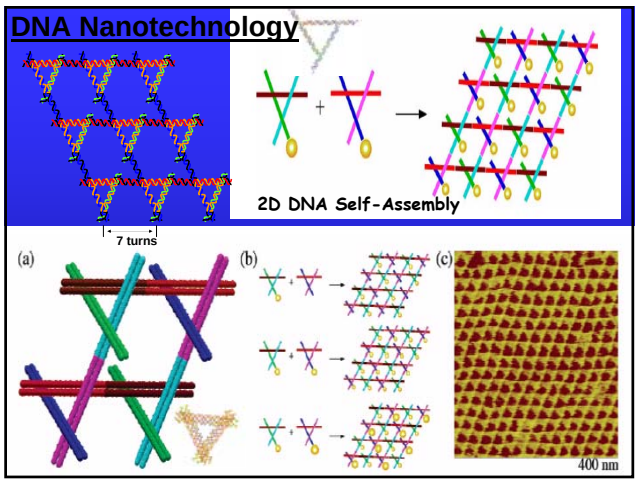
Quantum Computers are ~ 100,000 more expensive than Pentium Chips → QC will not enter mass PC/PDA/Notebook market for several billions of people.

Quantum Computers are suited for Application Specific Complex Scientific Tasks However, QCs need I/O support to interface with the Surrounding Environment. (Measurement & Sensing of QC's should be High Priority in Research).

Ultimately, Quantum Computers in some form will prove that God indeed plays with dice to solve intractable problems and have fun! Einstein was wrong.




Nanoelectronic Devices Beyond CMOS
carbon nanotubes
graphene
bio-sensors
spin torque devices
molecular electronics
nanowires
flexible electronics


DNA Nanotechnology
7 turns
2D DNA Self-Assembly
(a)
(b)
(c)
400 nm