Laying the Foundations for the Next Digital Revolution:
Innovation in the College of Engineering at Berkeley

5th Asian Leadership Conference
Shanghai, China
November 2001

Dean A. Richard Newton

The Weather Forecast ...

◆ Rate of change will only accelerate - life will be more complex, busier . . .
◆ Adaptability, agility & momentum will be the key to success!
◆ Innovation, opportunities & entrepreneurship will thrive
◆ Disruption will be the order of the day
◆ Fun, fortunes & failure will be in abundance

Source: Vinod Khosla, Kleiner Perkins
Leading U.S. Engineering Programs

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35 of the 36 units on the Campus are ranked in the top 10 in the nation!

CITRIS
The Center for Information Technology Research
In the Interest of Society

Core Technologies
- Distributed Info Systems
- Micro sensors and actuators
- Human-Computer Interaction
- Prototype Deployment

Applications
- Quality-of-Life Emphasis
- Initially Leverage Existing Expertise on campuses

Foundations
- Security, Policy
- Probabilistic Systems
- Formal Techniques
- Data management
- Simulation

Professor Richard Newton
newton@coe.berkeley.edu
The Best Technology for The World’s Biggest Challenges

◆ Energy Efficiency
◆ Transportation Planning
◆ Monitoring Health Care

The Berkeley Highway Lab

- Twelve cameras with overlapping fields of view covering 1.5 miles of Interstate 880

- Video data are processed to obtain position and speed of every vehicle

Source: Prof. Pravin Varaiya
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Lane-Changing Maneuver and Shockwave

Source: Prof. Pravin Varaiya

The Best Technology
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Wireless Measurement, Diagnosis, and Cure

Source: Professors Tom Budinger, Jan Rabaey, Al Pisano

The Best Technology for The World’s Biggest Challenges

◆ Education
◆ Emergency Response
◆ Land and Environment
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Microair Vehicles and Smart Dust:
Connecting the Civil and Environmental Infrastructure

Source: Professors Kris Pister & Ron Fearing

Mote and TinyOS Demonstration at 29 Palms

- UAV drops nodes along road:
  - hot-water pipe insulation for package
- Nodes self configure into linear network:
  - Synchronize to 1/32 sec
  - Calibrate magnetometers
    - correct for earth's magnetic field
  - Each detects passing vehicle
  - Share filtered sensor data with five neighbors
  - Each calculates estimated direction & velocity
  - Share results
- As plane passes by:
  - Joins network
  - Upload as much of missing dataset as possible from each node when in range

7.5 KBytes of code!

Source: Professor David Culler
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**eMerging Societal-Scale Systems**

New System Architectures
New Enabled Applications
*Diverse, Connected, Physical, Virtual, Fluid*

“Client”

“Server”

Clusters
Massive Cluster
Gigabit Ethernet

New System Architectures
New Enabled Applications
*Diverse, Connected, Physical, Virtual, Fluid*

MEMS
BioMonitoring

Source: Professor Randy Katz

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**Implementation & Deployment of an Oceanic Data Information Utility**

- Ubiquitous devices require ubiquitous storage
- 10,000 9Gbyte IBM Microdrives in a single rack provides 90 terabytes/m² (Professors Dave Patterson & Kathy Yellick)
- Confederations of (Mutually Suspicious) Utilities

Source: Professor John Kubiatowicz

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The Future of Moore’s Law

- 1000X Improved Computationally
- Energy Optimized (MOPS/watt)
- Mixed Signal Platforms

New Architectures

Source: Professor Shankar Sastry

Nanosciences
Molecular Electronics/Quantum/Bio
3-D CMOS + - HYBRIDS

Source: Professor Shankar Sastry

eMerging Societal-Scale Systems

Source: Professor Randy Katz

Information Architecture

Clusters
Massive Cluster
Gigabit Ethernet

MEMS
BioMonitoring

Scalable, Reliable,
Secure Services

Source: Professor Randy Katz

Information Architecture

The Future of Moore’s Law

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EUV

15nm

1nm

100nm

1000nm

Intel8080

1 million transistors

Intel486

100 million

PentiumPro

10 billion

Pentium

1000nm

10nm

1nm

Intel486

PentiumPro

Pentium

IA-64

Unicom

EUV

Bipolar, NMOS

CMOS


Intel386

Pentium

10nm

15nm

Feature size (nanometers)

Intel8080

1 million transistors

Intel486

100 million

PentiumPro

10 billion

Pentium

1000nm

10nm

1nm


Bipolar, NMOS

CMOS

15nm

EUV

Source: Professor Shankar Sastry

Nanosciences
Molecular Electronics/Quantum/Bio
3-D CMOS + - HYBRIDS

Source: Professor Shankar Sastry
High-performance Printed Circuits

Inkjet System

Substrate

Oxide-passivated silicon substrate

Source: Professor Vivek Subramanian

Gecko Adhesive

- Sticks to wet or dry surfaces
- Sticks to rough or smooth surfaces (e.g. concrete or glass)
- Self cleaning
- Leaves no residue
- Reusable
- Can be turned on/off at 10 Hz
- Pull-off 10N/cm²

Goal: artificial nanofabricated structures with gecko adhesive performance

Source: Professor Ron Fearing
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It’s all about Communication!

It’s all about Power!

Source: Professor Jan Rabaey
Is the End of Moore’s Law an Economic One?

◆ Silicon is not suited for low-end human-centric consumer appliances
  ❖ Baseline costs of traditional chips are high
  ❖ Cannot easily integrate human interaction component

◆ The solution: Organic Semiconductors
  ❖ “Spray on circuits” – no clean rooms
  ❖ Easy to integrate display, computation and sensing

Source: Professor Vivek Subramanian

“Smart Soup”

Electronic “Bar Code”
Passive RF circuit that talk to the outside world... no need for scanners

Real-time Labeling
Develop new generations of reflective display technology for ultra-low power "electronic paper" displays No more incorrect pricing!

Closed Loop Content Monitoring
No more expiration dates... the can knows when it has expired!

Source: Professor Vivek Subramanian
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A MEMS Microgenerator

Energy density comparison between liquid hydrocarbon fueled power supply and typical batteries

- 11,000
- 5,000
- 1,000
- 0

Liquid Hydrocarbon Fuel

- 40% Efficient Micro-Engine
- 20% Efficient Micro-Engine
- Zinc-Air Battery
- Lithium Battery
- Alkaline Battery

Power Conditioning, Logic, and Engine Control

H₂O and CO₂ Exhaust

MEMS Rotary Engine and Integrated Power Generator Chipset (PGC)

Source: Professors Carlos Fernandez-Pello, Al Pisano and Dorian Liepmann

The Rotary Microengine

- Measured power in mini-engine
  (3.7 W @ 9300 RPM)
- Fabrication of 3 mm meso-scale engine complete
- Fabrication of 1 mm micro-rotary engine initiated

Mini-Rotary Engine

SiC m-rotor (3 mm dia)

Micro-Rotary Engine

1 mm micro-engine fabricated from silicon

Source: Professors Carlos Fernandez-Pello, Al Pisano and Dorian Liepmann
CITRIS is a Partnership with Industry

“I believe we are now entering the Renaissance phase of the Information Age, where creativity and ideas are the new currency, and invention is a primary virtue, where technology truly has the power to transform lives, not just businesses, where technology can help us solve fundamental problems.”

Carly Fiorina, CEO, Hewlett Packard Corporation

Berkeley Engineering: A Tradition of Impact in Research

- Berkeley Unix
- Relational Database Technology
- Electronic Design Automation: SPICE to Synopsys
- RISC (with Stanford)
- RAID
- CyberCut online manufacturing systems
- NOW (Networks of Workstations)
- IEEE Floating Point
- Infopad (now called WebPad)
- Semiconductor Devices & Modeling
- MEMS

- Berkeley faculty are fundamentally motivated by high-potential-impact, long-range research

Berkeley Engineering: A Tradition of Impact in Research