

# Welcome

## cs294-8 Design of Deeply Networked Systems

Spring 2000

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<http://www.cs/~culler/cs294-s00>

<http://www.cs/~randy/Courses/CS294.S00/>

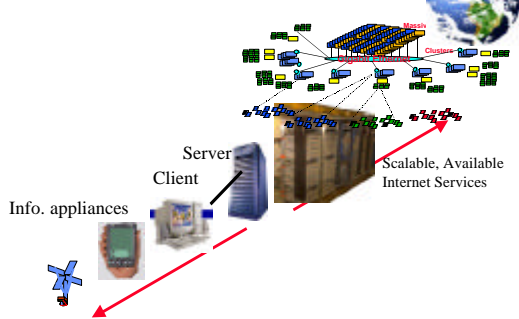
## Outline

- Motivation for the Seminar
- Today's Technology Revolution
- Emerging Application Paradigms
- A Call to Architecture
- Course Plan
- Discussion

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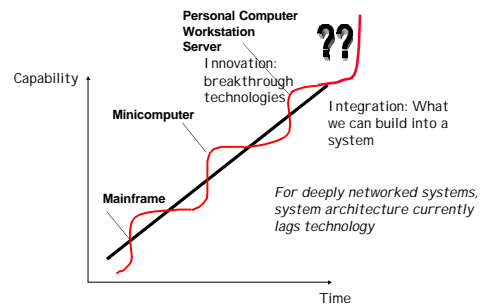
## Away from the 'average' Device



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## Technology as a Process



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## Exciting components



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## Historical Perspective

- New eras of computing start when the previous era is so strong it is hard to imagine that things could ever be different
  - mainframe -> mini
  - mini -> workstation -> PC
  - PC -> ???
- It is always smaller than what came before.
- Most think of the new technology as "just a toy"
- The new dominant use was almost completely absent before.
- Technology spread increases

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## Historic Perspective (cont)

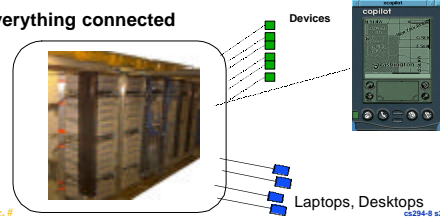
- **Technology discontinuities drive new computing paradigms, applications, system architectures**
- **E.g., Xerox Alto**
  - 3Ms-1 mips, 1 megapixel, 1 mbps
  - Fourth M: 1 megabyte of memory
  - From time sharing to LAN-connected client-server with display intensive applications
- **What will drive the next discontinuity? What are the new metrics of system capability?**
  - This seminar: deeply networked systems
  - eXtreme Devices: the small, the large, the numerous

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## Away from the "average device"

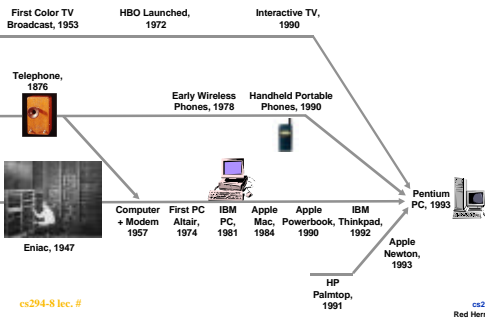
- **Powerful, personal capabilities from specialized devices**
  - small, highly mobile or embedded in the environment
- **Intelligence + immense storage and processing in the infrastructure**
- **Everything connected**



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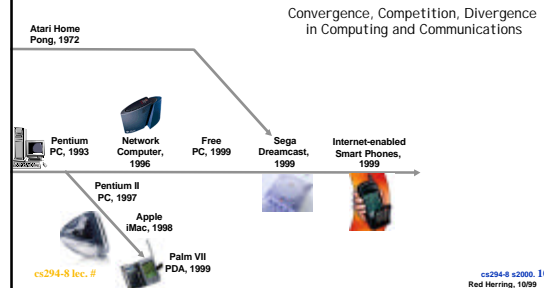
## Convergence in the PC



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## To Competition & Divergence



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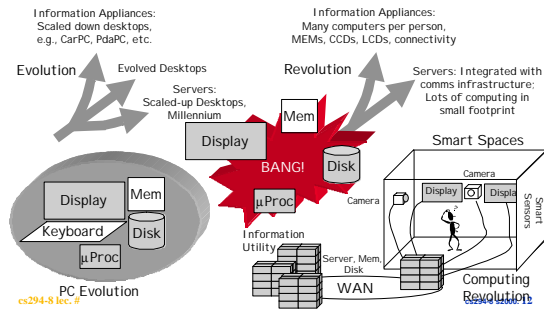
## Today's Technology Revolution

- **Moore's law => miniaturization, integration**
  - PDAs, Embedded Servers, ... , scalable systems
- **Communication**
  - low power wireless, ... , multigigabit links & switching
- **Sensors (on CMOS)**
  - CCD, ... , MEMS
  - enhanced through integrated image/signal processing
- **Localized Algorithms**
- **Actuators**
- **Positional, directional**
  - GPS, signal processing
- **Alternative Energy Sources**
  - ambient, harvesting, solar, battery

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## Evolution vs. Revolution: Devices in the eXtreme



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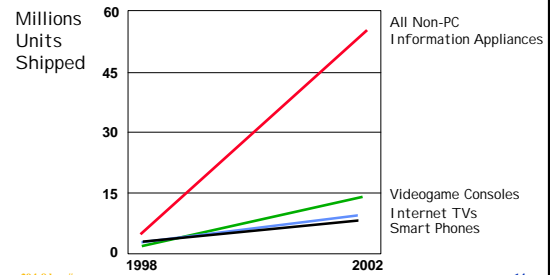
## The Big 3

- Diversity of Devices
- Connected
- Integrated with the physical world

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## Fast Projected Growth in Non-PC Terminal Equipment



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Red Herring, 10/99

## Industry Shifts

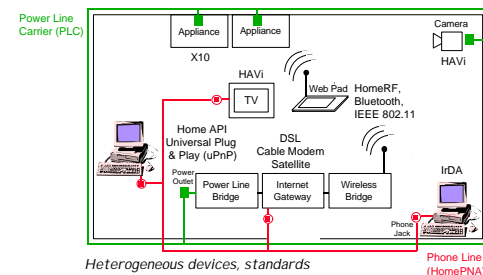
- Implications of PCs as commodity
  - Increasingly narrow profit margins
- Some Reactions:
  - Intel: recent strategic acquisitions focus on owning silicon for communications, networking, signal processing, multimedia PLUS network services
  - Sun: focus on infrastructure servers (clusters, RAID storage)-JAVA/JINI sells more server processing and storage
  - HP: focus on non-desktop "information appliances", e.g., HP CapShare Portable E-copies



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## Home Networking



Heterogeneous devices, standards  
Distributed intelligence  
Plug and play, self-configuration, adapt on the fly  
Connectivity according to device's needs

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Red Herring, 10/99

## Information Appliances

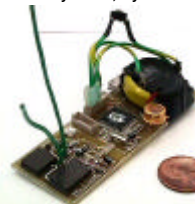
- Universal Devices vs. Specialized Devices
  - E.g., Swiss Army Knife vs. Butcher, Butter, Steak, Bread knife
- Different design constraints based on intended use, enhances ease of use
  - Desktop PC
  - Mobile PC
  - Desktop "Smart" Phone
  - Mobile Telephone
  - Personal Digital Assistant
  - Set-top Box
  - Digital VCR
  - ...

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## Truly eXtreme Devices: Pister's Dust Motes

- COTS RF Mote
  - Atmel Microprocessor
  - RF Monolithics transceiver
    - » 916MHz, ~20m range, 4800 bps
  - 1 week fully active, 2 yr @1%



	2 Axis Magnetic Sensor
	2 Axis Accelerometer
	Light Intensity Sensor
	Humidity Sensor
	Pressure Sensor
	Temperature Sensor

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### COTS Dust - Optical Motes

**Laser mote**

- 650nm laser pointer
- 2 day life full duty

**CCR mote**

- 4 corner cubes
- 40% hemisphere

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### Virtual Keyboard

Interfaces for people with Disabilities?

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### Emerging Application Paradigms

- Ubiquitous Computing
- Smart Spaces
- Sensor Nets
- Active Badges and Tags
- Home Networking, e-everything
- information Appliances
- Wearables
- Metaverse
- ...

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### Call to Architecture

- Technology exists (or will soon) to realize grand visions of where computing can go
- What's missing?
- **Architecture**
- Framework that realizes the application vision from emerging technology
  - systematic application of design methods

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### Architectural Components

- Internet "SuperServer" multitiered clusters
- TinyStations (PDAs, Embedded Servers)
- Service Discovery
- Location Awareness
- Management (telemetry, diagnosis, debug)
- Power Adaptation
- Protocols
- Redundancy

=> Namespace, datapaths, control, principles of operation, error handling, security, robustness

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### What is Needed?

- **Automatic Self-Configuration**
  - Personalization on a Vast Scale
  - Plug-and-Play
- **The OS of the Planet**
  - New management concerns: protection, information utility, not scheduling the processor
  - What is the OS of the Internet? TCP plus queue scheduling in routers
- **Adapts to You**
  - Protection, Organization, Preferences by Example

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## Technology Changes & Architectural Implications

- **Zillions of Tiny Devices**
  - Proliferation of information appliances, MEMS, etc.
- **“Of course it’s connected!”**
  - Cheap, ample bandwidth
  - “Always on” networking
- **Vast (Technical) Capacity**
  - Scalable computing in the infrastructure
  - Rapid decline in processing, memory, & storage cost
- **Adaptive Self-Configuration**
- **Loosely Organized**
- **“Good Enough” Reliability and Availability**
- **Any-to-Any Transducers (dealing with heterogeneity, over time--legacy--and space)**
- **Communities (sharing)**

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## Deeply Networked Systems

- **“Everything” is networked**
  - Even very small things like sensors and actuators
  - Explosion in the number of connected end devices
- **Processing moves towards the network edges**
  - Protocol stack plus some ability to execute mobile code in network end devices
- **Processing moves towards the network core**
  - Services executing inside the network

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## Who Will Own the System Software of the 21st Century? Sony versus Microsoft

- **Interactive Television**
  - Set-top Box OS: AperiOS vs. WinCE, something else
  - Sony/GI alliance
  - 7.8 million units sold in 2002
- **Direct Broadcast Satellite Television**
  - TVs with built-in satellite receivers
  - 14 million units sold in 2002
- **“Smart” Phones**
  - Sony and Microsoft involved in numerous phone alliances
  - 6.8 million units sold in 2002
- **Video Games**
  - Sony Playstation (AperiOS) vs. Sega Dreamcast (WinCE)
  - 18.5 million units sold in 2002
- **Electronic Toys**
  - Microsoft Barney (WinCE) vs. Sony robot pets (AperiOS)
  - \$1.86 billion in sales in 2002

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## Convergence, Competition, Diversity



- **Implications:**
  - Shift from computer design to consumer design
  - Heterogeneous “standards,” hybrid networking
  - Interactive networking, access on demand, QoS

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## Representative Research Challenges in Deeply Networked Systems

- **Embedded/Networked Systems**
  - Support for deeply networked systems and mobile code
  - OS services in support of sensor/actuator I/O
  - Low-latency feedback across software component boundaries
  - Tuning of performance and configuration at runtime
  - Runtime support for networked, embedded systems
- **Sensor Information Technology**
  - Large Scale Distributed Micro Sensor Networking
  - Fixed and Mobile Internetworking
  - Collaborative Signal Processing
  - Nano-cryptography

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## Course Plan

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## Goals / Outcome

- Knowledge base
- Lightning Rods
- Emergence of Architectural structure
  - sense of direction

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## Project Concepts

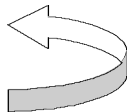
- Hands-On Miniproject (weeks 3 - 6)
  - BYO embedded server
- Major Group Design Project
  - weeks 7-15, not 12-15!
  - studio option?
- One-week “think pieces”
  - 3-page reasoned thoughts on unusual topics
  - ‘there is no box’
  - eg: systems powered by their environment of application

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## Topic Cycle

- Technology (push)
- Application (pull)
- Architecture (abstraction)



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## Weekly Plan

- Monday (2:30 - 4)
  - student summaries of 2-3 assigned readings
  - topic discussion
  - scribe produces on-line summary
  - class adds relevant links
  - instructor sets topic stage
  - broader class discussion / relationship to projects
- Thurs (3:30 - 4:30) System Seminar
- Thurs (4:30 - 5:30)
  - discussion with speaker (over coffee)

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## Administrivia

- Workload
  - reading, browsing, scribe summary, knowledge base
  - think pieces, mini-project, project
- Grading
  - 20% class participation, 20% think pieces, 20% mini project, 40% project
- Course worksite
- Class experts
- Who gets in

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## Assignment for Thursday 3:30 1/28

- Prepare 5 minute (max) presentation
  - unique or important background, experience, training, or talents
  - one visionary scenario that you'd like to see happen
  - something you can contribute toward it
- Web-based visual aids
  - max 3-slide equivalent

... Interviewing for the expedition

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## Questions?

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