#### Outline

COMP 3221
Microprocessors and Embedded Systems
Lecture 42: End Episode http://www.cse.unsw.edu.au/~cs3221
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Saeid Nooshabadi
Saeid@unsw.edu.au
200021 (2010 cm2)
200022 (2010 cm2)
201022 (2010 cm2)
<sup>6</sup> Review Big Ideas and Examples
<sup>9</sup> Path from here
<sup>9</sup> Predicting the Future
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# Lecture 1: What's in it for you?

- °14 weeks to learn big ideas in CSE&EE
  - Principle of abstraction, used to build systems as layers
  - Compilation v. interpretation to move down layers of system
  - Pliable Data: a program determines what it is
  - Stored program concept: instructions are data
  - Interrupts and exception: User vs Privileged modes
  - Principle of Locality, exploited via a memory hierarchy (cache)

# Principle of abstraction, systems as layers

- <sup>°</sup> Programming Languages:
  - C / Assembly / Machine Language
- °Translation:
  - Compiler / Assembler / Linker / Loader
- <sup>°</sup> Memory Hierarchy:
  - Registers / Caches / Main memory / Disk
- °Computer Design
  - datapath / control / I/O
  - functional units / busses > gates + wires > ...

#### Compilation v. interpretation to move down Pliable Data: program determines what it is ° Instructions <sup>o</sup> Programming Languages: ·C / Assembly / Machine Language fetched from memory using PC Compilation <sup>°</sup> Types include Signed Integers, Unsigned Integers, Characters, Strings, Single Precision Floating Point, Double Precision <sup>°</sup>Memory Hierarchy: Caches / Main memory / Disk: Interpretation **Floating Point** Registers / Cache: Compilation <sup>o</sup> Everything has an address ( $\Rightarrow$ pointers) indirection is fundamental <sup>°</sup>Computers manipulate representations of things Saeid Nooshabadi Saeid Nooshabadi COMP3221 lec42-final-review.5 COMP3221 lec42-final-review.6 Stored program concept: instructions as data **Principle of Locality** <sup>°</sup>Allows a computers to do many things <sup>°</sup>Exploited by automatic memory hierarchy - blocks, LRU, ... => universal device (keep HW simple and fast) <sup>°</sup> Simplifies compile, assembly, link, load <sup>°</sup>Registers: Temporal Locality (data reused), explicitly managed, small names <sup>°</sup> Distributing programs easy: on any disk, just like data <sup>°</sup>Disks transfer in large blocks: spatial locality $\Rightarrow$ binary compatibility, upwards compatibility (8086, 80286, 80386, 80486, Pentium I, II, III) <sup>°</sup>Networks: most traffic is local, so LAN vs WAN, gateway routing <sup>°</sup>Allows for Dynamic Libraries: modify the code to run time loading of library codes <sup>°</sup>Locality in translations: TLB, just-in-time ° viruses: Send message that overflows stack, starts executing code in stack area, take over compilers machine,... Saeid Nooshabadi COMP3221 lec42-final-review.8 Saeid Nooshabadi



# Looking to Your Graduation Window...

° 500 million transistor microprocessor

easy

<sup>°</sup>gigabit DRAM, gigahertz desktop, gigabyte network

piece of cake

° terabyte (10<sup>40</sup> !!!) of personal storage

no sweat

° computing going where is has never been before

# ° changing the fabric of society

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# **Remember the "library"**

- ° It had books, you searched around in those weird card catalogs, then hunted around the shelves, flipped though the pages and made notes...
- <sup>°</sup> Today, you expect to get the world's information at a search and a click
- ° and the web is less than 10 years old..
- <sup>°</sup> welcome to the end of "prerecorded history"
- °what if everything you ever saw or heard was on-line?

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# **CMOS: Tiny Computing Gets Physical**







servers wireless networks on an 'exponential shrink'

add a few years, system design, intelligence, creativity and software



and imagine surgery performed by a teaspoon of tiny devices

then look back at today's technology



sensors and



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# **Computing on a Truly Universal Scale**

- ° amazon.com annual on-line sale \$1 billion
- °AOL has 20 million people on line at a time!
- <sup>°</sup> extrapolate networks, storage and processing out a few years...
- ° worldwide storage
- <sup>°</sup> ubiquitous access, everywhere ...

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### and What Might You Compute?

# <sup>°</sup>how about the origin of the universe?



l agoon Nebula • M8 • A. Caulet (FSA), NAS

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#### ° or the earth's climate? or create Ambient Intellgence!, or Tackling Societal Scale

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# **Ambient Intelligence**

- An environment where technology is embedded, hidden in the background
- An environment that is sensitive, adaptive, and responsive to the presence of people and object
- An environment that augments activities through smart non-explicit assistance
- An environment that preserves security, privacy and trustworthiness while utilizing information when needed and appropriate

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#### Towards Fully Integrated Embedded Systemson-a-Chip or in-a-Package

While increased performance has been the hallmark result of Moore's law, miniaturization and cost reduction opens the door for truly ubiquitous electronics



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# Tackling Societal Scale Problems



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#### **Environment Monitoring**



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 Sensor network measures soil and environment conditions in garden or field



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# Precision Agriculture



Ad hoc, wireless embedded network for precision agriculture. Sensors detect temperature, light levels, and soil moisture at hundreds of points across a field. The system communicates the data over a multihop network

for analysis.

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