CSE 240A -- Principles of Computer Architecture

Fall Quarter, 2013

Dean Tullsen

UCSD

Computer Architecture is... ???

- Computer Architect (building architect)
  - high-level design
  - organization
  - functionality
  - performance
- Hardware Designer (builder, construction engineer)
  - materials
  - implementation details

Computer Architecture is... ???

- the first computer science discipline
- Eckert and Mauchly, the first computer scientists, were computer architects, as were John von Neumann and Maurice Wilkes

Computer Architecture is... ???

- That part of the machine that is visible to the user (programmer/compiler-writer/OS writer/user)
  - the software interface (Instruction Set Design)
  - performance (Computer Organization)

Computer Architecture is… ???

- Instruction Set Design
- Computer Organization

Computer Architecture is… ???

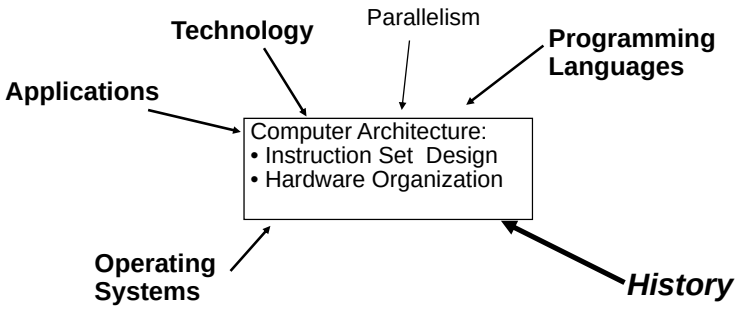
PERFORMANCE!!!!!

and power/energy/fault tolerance/fault avoidance

Why do I care?

- **You may actually do computer architecture someday**
- **You may actually care about software performance someday**
  - The ability of application programs, compilers, operating systems, etc. to deliver performance depends critically on an understanding of the underlying computer organization.
  - That becomes more true every year.
  - Computer architectures become more difficult to understand every year.

The Forces on Computer Architecture



Administration

- Who are you?
- Who am I?
- syllabus, other details

What is Computer Architecture?

Computer Architecture =
Machine Organization +
Instruction Set Architecture

What the machine looks like

How you talk to the machine

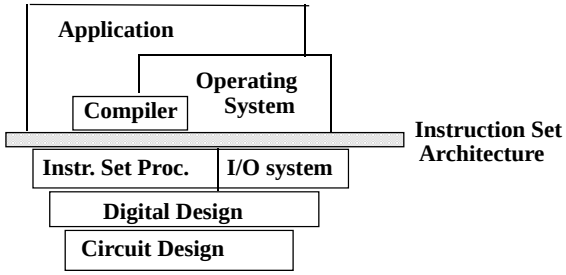
The Instruction Set Architecture

- that part of the architecture that is visible to the programmer
  - opcodes (available instructions)
  - number and types of registers
  - instruction formats
  - storage access, addressing modes
  - exceptional conditions

Examples of ISAs

- Alpha AXP
- Intel 80x86/pentium*/IA32
- Intel IA64/Itanium
- VAX
- MIPS
- SPARC
- IBM 360
- PowerPC
- ARM

The Instruction Set Architecture



•ISA provides a *level of abstraction* for both the hardware and the software

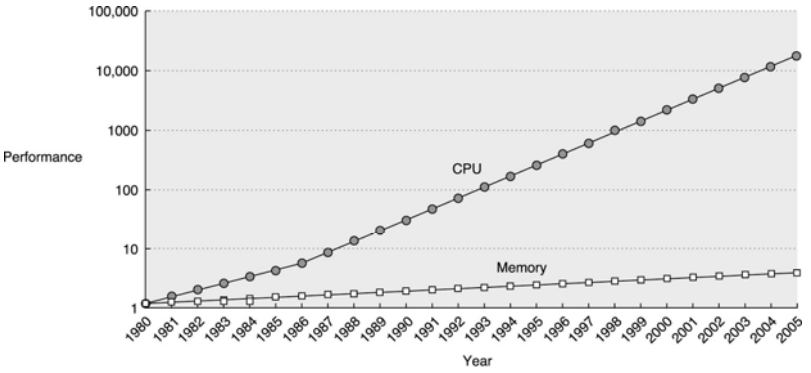
Computer Organization

- Once you have decided on an ISA, you must decide how to design the hardware to execute those programs written in the ISA as fast as possible.
- This must be done every time a new implementation of the architecture is released, with typically very different technological constraints.

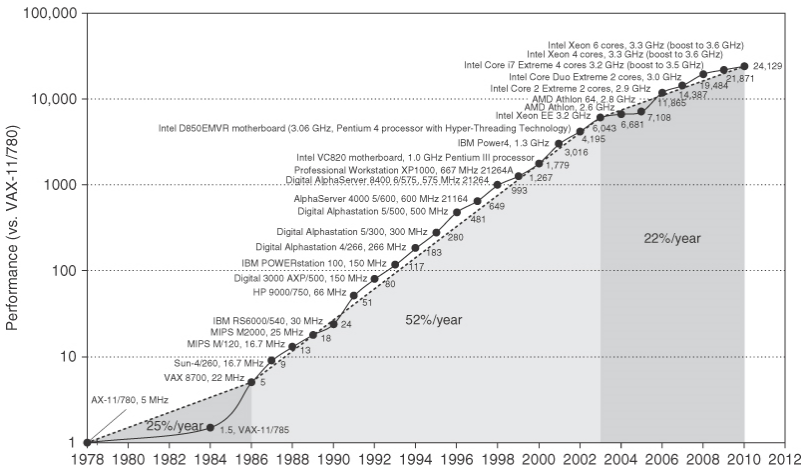
The Challenge of Computer Architecture

- This industry changes faster than just about any other.
- The ground rules change every year.
  - new problems
  - new opportunities
  - different tradeoffs
- It's all about making programs run faster than the next guy's machine.

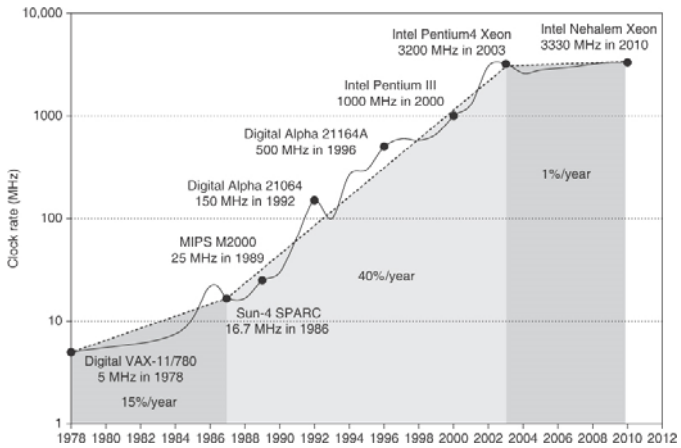
Performance Trends



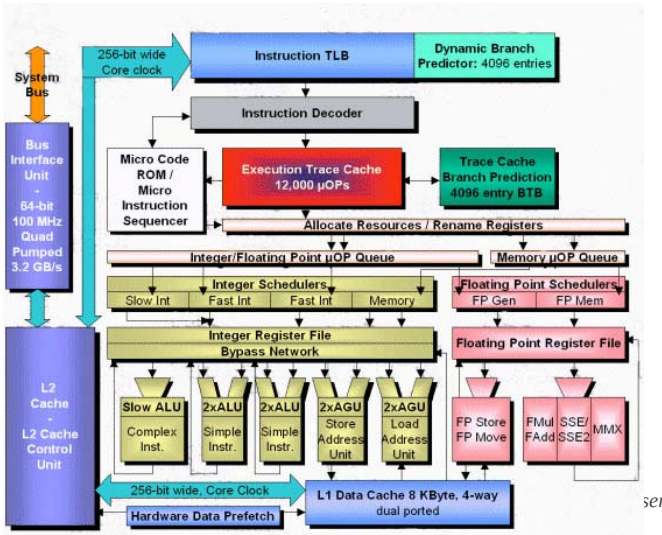
Processor Performance



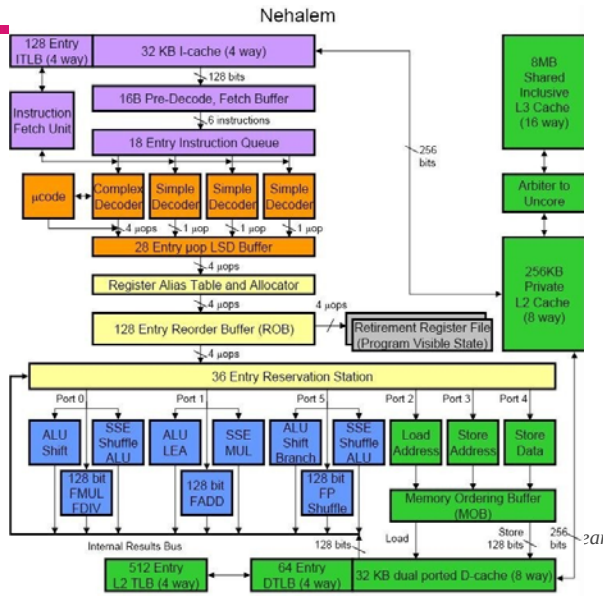
Processor Core Performance (Clock Rate)



Pentium 4



Intel Nehalem Core



Course Outline

I. Introduction
II. Computer System Performance
III. Instruction Set Architecture
IV. Pipelining
V. The Memory/Cache Hierarchy
VI. Instruction-Level Parallelism
VII. Parallel Machines

What you can expect to get out of this class

- to become conversant with computer architecture terms and concepts.
- to understand fundamental concepts in computer architecture and how they impact computer and application performance.
- to be able to read and evaluate architectural descriptions of even today's most complex processors.
- to learn experimental techniques used to evaluate advanced architectural ideas.

Key Points

- Computer Architecture defines the software-visible machine description (ISA) and the overall machine organization.
- High-performance software requires a deep understanding of the underlying machine organization.
- The instruction set architecture defines how software is allowed to use the processor. Multiple computers with vastly different organizations and performance can share an ISA.