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EE 3613: Computer Organization

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Outline

- How did we get here – a brief history
- Why study Computer Organization?
- Course Outline
- Why Architects need Friends

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Ubiquitous Computing

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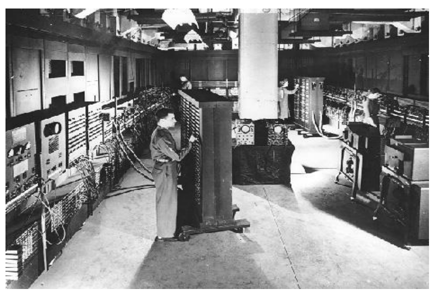
Introduction

- Vacuum Tubes → Transistors → VLSI
- ENIAC (Electronic Numerical Integrator and Computer)
  - Eckert and Mauchly
  - 1946
  - 18,000 vacuum tubes,
  - 1,800 instructions/sec, 3,000 ft^3
  - Could add 5,000 numbers in a sec



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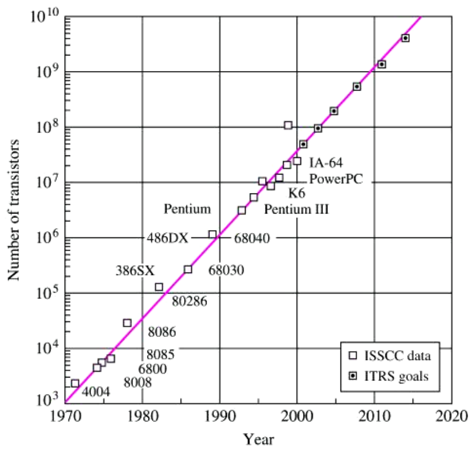
Computer Engineering: Transistor



- Intel Microprocessor
  - Introduced in 1970
  - 2,250 transistors, 12 mm^2, 108 KHz
- Processor speed doubles every 18 months (Moore's Law)
- Memory speed doubles every 4-5 years

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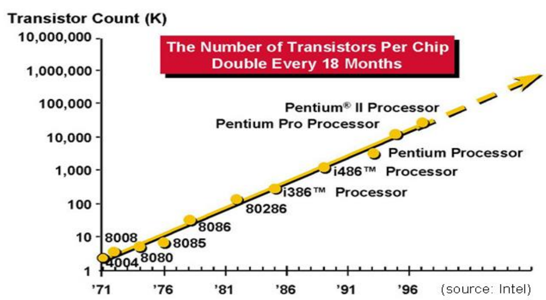
Moore's Law

- No. of transistors on a chip will double every year
- Cost of the chip remained almost same
- Higher packing density
  - shorter electrical paths
  - higher performance
- Smaller size
  - Increased flexibility



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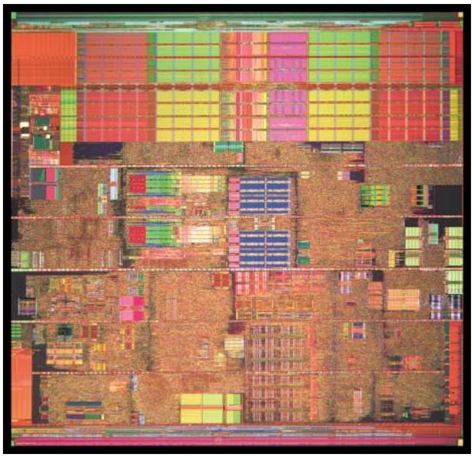
Pentium - 4



- 55,000,000 Transistors
- 146 mm^2
- 3 Ghz
- Introduced in 2000

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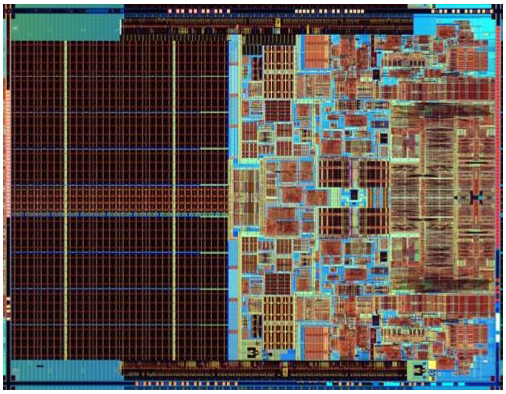
Intel Core 2 Duo E6600



- 65nm technology node
- 291 Million transistors
- 143 mm^2

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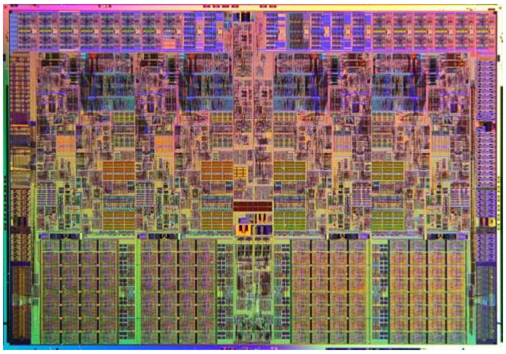
Intel Core i7



- 45 nm technology
- 731 million transistors
- 263 mm^2

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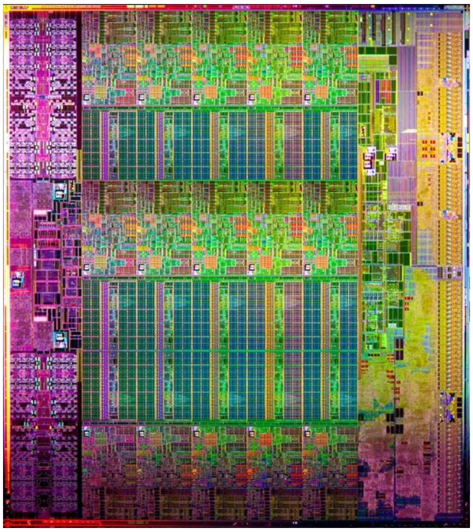
15-core Xeon Ivy Bridge



- 22 nm technology
- 4.3 Billion transistors
- 541 mm^2

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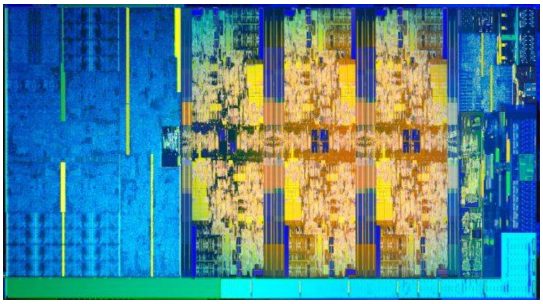
Intel Core i9



- 10 – 18 cores with 2 thread per core
- Billions of transistors
- 10 nm
- PC, big data and gaming

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Newer Processors

- CPUs
  - IBM – z13 Storage Controller (7.1 Billion, 22nm technology, 678 mm^2)
  - 22-core Xeon Broadwell-E5 (7.2 Billion, 14 nm technology, 456 mm^2)
  - SPARC M7 (10 Billion, 20 nm technology node)
- GPUs
  - Fiji (8.9 Billion, AMD, 28 nm, 596 mm^2)
  - GP100 Pascal (15.3 Billion, Nividia16 nm technology, 610 mm^2)
- Mobile
  - Apple A8 (2 Billion, 20nm technology, 89 mm^2)

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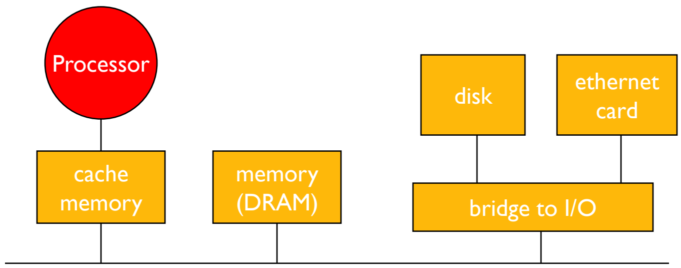
Computer Architecture 101

- Computer architects design computer systems
  - Processors: Intel Pentium 4, Intel Core i3, i5, i7, IBM PowerPC,
  - Also: memory systems, interconnections, ???



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Intro to Microarchitecture

- Microarchitects design processors
- Goals for processors:
  - Faster!!!!
  - Higher bandwidth communication with memory system
  - Backward-compatible with previous models
- How do we make processors faster?
  - Faster clocks (>2 GHz)
  - Do more work (execute instructions) at same time

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What do you expect to get out of this course?

- To understand how computer systems are organized and what tradeoffs are made in the design of these systems
  - Instruction Set Architecture, Processor Microarchitecture, Systems Architecture (Cache, I/O)
- Things you will be learning
  - How computers work?
  - How to analyze their performance ?
  - Issues affecting the design of modern processors?
- Why learn this stuff?
  - You want to design a state-of-the-art system
  - You want to build software people use
  - You need to make a purchasing decision or offer "expert" advise

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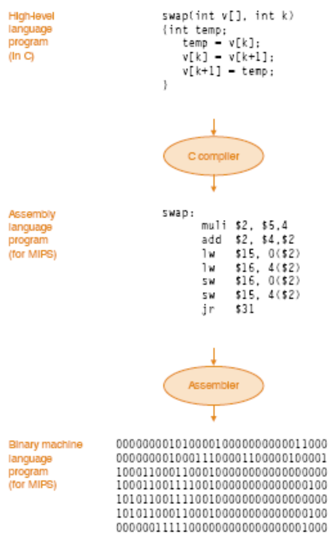
Abstraction

- Delving into the depths reveals more information
- An abstraction omits unneeded detail, helps us cope with complexity
- A very important abstraction is the Instruction Set Architecture (ISA)
  - Provides interface between hardware and software
  - Examples: 80x86/Pentium, PowerPC, DEC Alpha, MIPS, Sparc, HP



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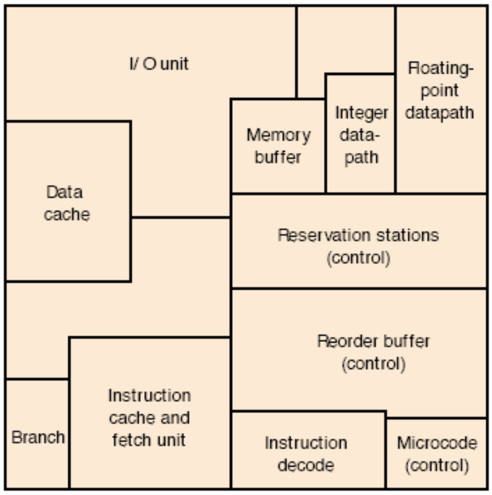
Internal Structure of a Processor Chip

- Major Components
  - Instruction Cache
  - Data Cache
  - Instruction Decode
  - Control/Microcode
  - Register File
  - Data path
  - Data Cache
  - I/O Unit
  - Memory Buffer



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Course Outline

- CPU Performance & Evaluation
- Instruction Set Architecture
- Computer Arithmetic
- Data and Control Path
- Pipelining
- Hardware Security
- Cache and Main Memory
- I/O and Storage

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Why Architects Need Friends

- Architecture is considered both computer engineering and computer science

- Architects interact with other areas
  - Circuit design (Electrical Engineering)
  - Transmission lines (EE)
  - Power (EE, Mechanical Engineering)
  - Compilers (Comp Sci)
  - Operating systems (CS)
  - Networking (EE, CS)
  - Databases (CS)
  - Queuing theory (CS, EE, Industrial Engineering)

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How Architecture Relates to Other Areas

Application Software
Operating Systems, Compilers, Networking Software
Computer Architecture
Circuits, Wires, Network Hardware

- Hardware software co-design

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