Machine-Level Programming I: Basics

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Today: Machine Programming I: Basics

- **History of Intel processors and architectures**
- C, assembly, machine code
- Assembly Basics: Registers, operands, move
- Arithmetic & logical operations

Intel x86 Processors

- **Dominate laptop/desktop/server market**

- **Evolutionary design**
  - Backwards compatible up until 8086, introduced in 1978
  - Added more features as time goes on

- **Complex instruction set computer (CISC)**
  - Many different instructions with many different formats
    - But, only small subset encountered with Linux programs
  - Hard to match performance of Reduced Instruction Set Computers (RISC)
  - But, Intel has done just that!
   - In terms of speed. Less so for low power.

Intel x86 Evolution: Milestones

Name	Date	Transistors	MHz
8086	**1978**	**29K**	**5-10**

- First 16-bit Intel processor. Basis for IBM PC & DOS
- 1MB address space

Name	Date	Transistors	MHz
386	**1985**	**275K**	**16-33**

- First 32 bit Intel processor , referred to as IA32
- Added "flat addressing", capable of running Unix

Name	Date	Transistors	MHz
Pentium 4E	**2004**	**125M**	**2800-3800**

- First 64-bit Intel x86 processor, referred to as x86-64

Name	Date	Transistors	MHz
Core 2	**2006**	**291M**	**1060-3500**

- First multi-core Intel processor

Name	Date	Transistors	MHz
Core i7	**2008**	**731M**	**1700-3900**

- Four cores (our shark machines)

Intel x86 Processors, cont.

- **Machine Evolution**

  - 386   1985   0.3M
  - Pentium   1993   3.1M
  - Pentium/MMX   1997   4.5M
  - PentiumPro   1995   6.5M
  - Pentium III   1999   8.2M
  - Pentium 4   2001   42M
  - Core 2 Duo   2006   291M
  - Core i7   2008   731M
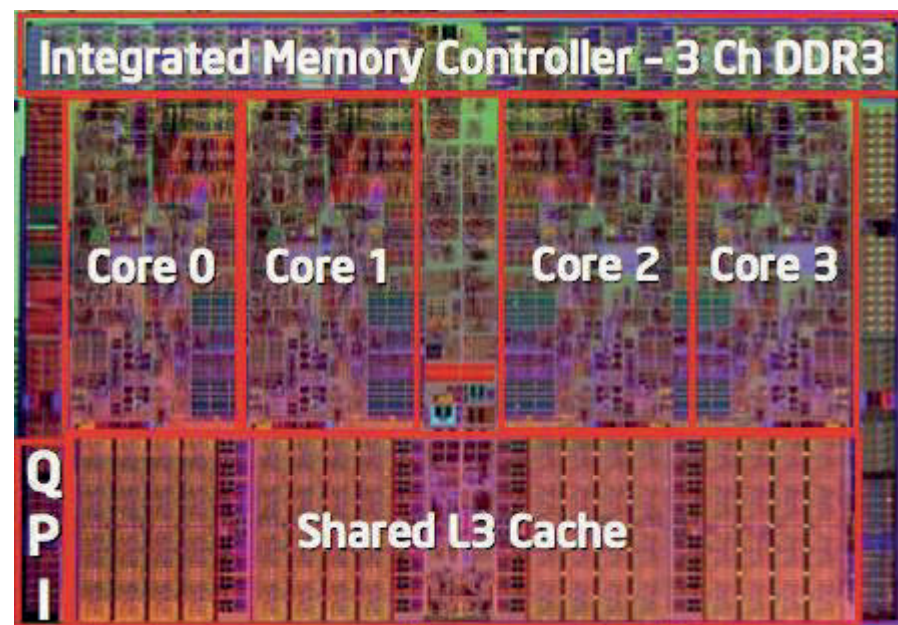
- **Added Features**

  - Instructions to support multimedia operations
  - Instructions to enable more efficient conditional operations
  - Transition from 32 bits to 64 bits
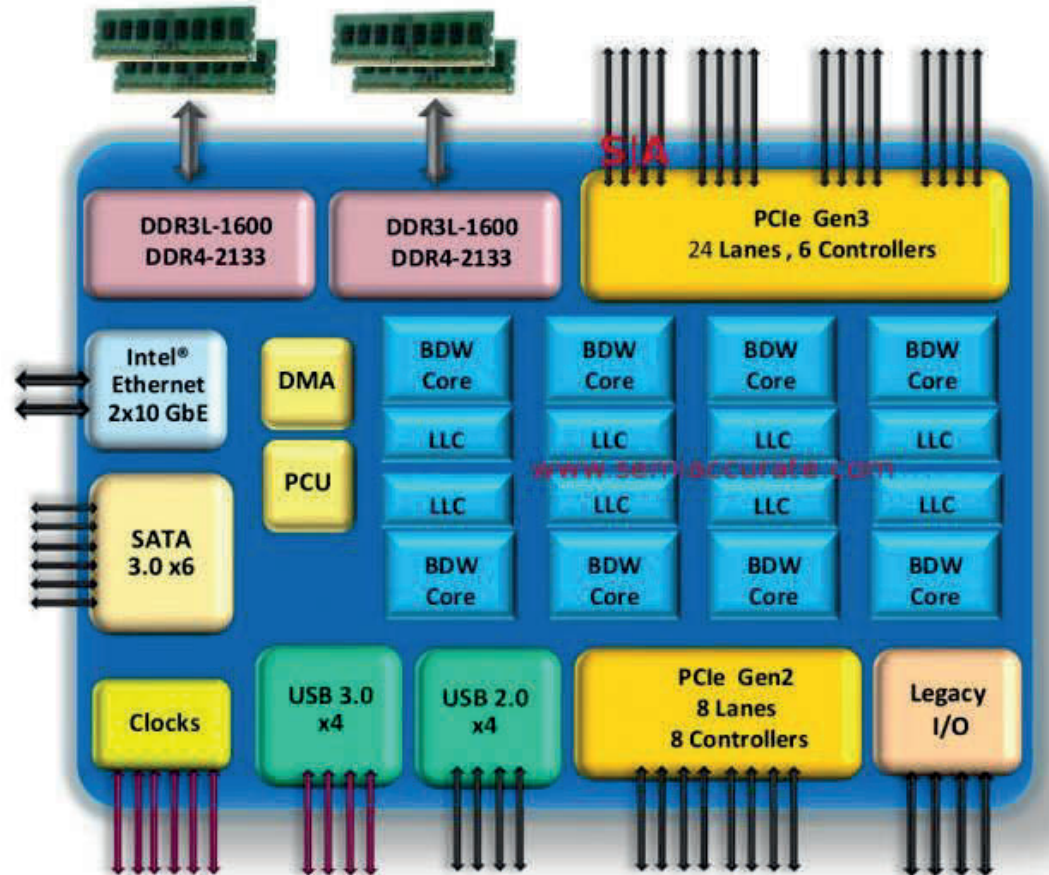 - More cores

2015 State of the Art

- Core i7 Broadwell 2015

■ Desktop Model

- 4 cores
- Integrated graphics
- 3.3-3.8 GHz
- 65W

■ Server Model

- 8 cores
- Integrated I/O
- 2-2.6 GHz
- 45W

x86 Clones: Advanced Micro Devices (AMD)

- **Historically**
  - AMD has followed just behind Intel
  - A little bit slower, a lot cheaper

- **Then**
  - Recruited top circuit designers from Digital Equipment Corp. and other downward trending companies
  - Built Opteron: tough competitor to Pentium 4
  - Developed x86-64, their own extension to 64 bits

- **Recent Years**
  - Intel got its act together
    - Leads the world in semiconductor technology
  - AMD has fallen behind
    - Relies on external semiconductor manufacturer

Intel's 64-Bit History

- **2001: Intel Attempts Radical Shift from IA32 to IA64**
  - Totally different architecture (Itanium)
  - Executes IA32 code only as legacy
  - Performance disappointing
- **2003: AMD Steps in with Evolutionary Solution**
  - x86-64 (now called "AMD64")
- **Intel Felt Obligated to Focus on IA64**
  - Hard to admit mistake or that AMD is better
- **2004: Intel Announces EM64T extension to IA32**
  - Extended Memory 64-bit Technology
  - Almost identical to x86-64!
- **All but low-end x86 processors support x86-64**
  - But, lots of code still runs in 32-bit mode

Our Coverage

- **IA32**
  - The traditional x86

- **x86-64**
  - The standard
  - `shark> gcc hello.c`
  - `shark> gcc –m64 hello.c`

- **Presentation**
  - Book covers x86-64
  - Web aside on IA32
  - We will cover x86-64 mainly

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