ICOM 4215: Computer Architecture and Organization

Introduction to Computer Architecture
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Slides modified from Dr. T. Noack course slides
Original source: Authors of Heuring and Jordan book
And Stallings book
Architecture & Organization 1

- Architecture is those attributes visible to the programmer
  - Instruction set, number of bits used for data representation, I/O mechanisms, addressing techniques.
  - e.g. Is there a multiply instruction?

- Organization is how features are implemented
  - Control signals, interfaces, memory technology.
  - e.g. Is there a hardware multiply unit or is it done by repeated addition?

This slide is from Stallings Architecture
All Intel x86 family share the same basic architecture

The ARM11 family share the same basic architecture

This gives code compatibility
- At least backwards

Organization differs between different versions
Structure & Function

○ Structure is the way in which components relate to each other
○ Function is the operation of individual components as part of the structure
Function

- All computer functions are:
  - Data processing
  - Data storage
  - Data movement
  - Control
Functional View

This slide is from Stallings Architecture
Operations (a) Data movement
Operations (b) Storage
Operation (c) Processing from/to storage
Operation (d)
Processing from storage to I/O
Structure - Top Level

Computer

- Central Processing Unit
- Main Memory
- Systems Interconnection
- Input Output

Peripherals

Communication lines
Structure - The CPU

Diagram:
- Computer
  - I/O
  - System Bus
  - Memory
  - CPU
- CPU
  - Registers
  - Arithmetic and Logic Unit
  - Internal CPU Interconnection
  - Control Unit
Structure - The Control Unit
Computer Architecture - Basics

Computer organization
  The region of system design from HLL and basic functionality to ISA (Instruction set architecture)

Computer architecture
  System design from ISA to VLSI specification

ISA (Instruction Set Architecture)
  Registers and memory organization
  Instruction formats
  Addressing modes
  Instruction set
  Exception and interrupt handling
Logic and system performance, then and now

Comments

Logic speed has improved much more than memory speed – one solution – cache memory
This slide doesn’t show density improvement
In the intel performance slide
   Light gray area shows process improvement
   Dark gray is what organization and architecture accomplished

Both figures are copied from Stallings architecture book
Logic and Memory Performance Gap

This slide is from Stallings Architecture
Intel Microprocessor Performance

This slide is from Stallings Architecture
Processor structure – then and now

The first slide is the 1946 IAS (institute for advanced studies – Princeton) machine
Actually, Von Neumann wrote a paper based on the ENIAC architecture and got the credit
This is almost the unavoidable basic structure of a stored-program machine
Many copies of the IAS machine were made – some were in service until 1967

The second slide is a modern architecture showing:
Multiple cores
Caches
Interconnect
Note that the original IAS ideas are still there
Structure of IAS (1946) – detail

This slide is from Stallings Architecture
Course Goals: Understanding Structure and Function of Digital Computer at 3 Levels

Multiple levels of computer operation

- Application level
- High Level Language(s), HLL, level(s)
- Assembly/machine language level: instruction set
- System architecture level: subsystems & connections
- Digital logic level: gates, memory elements, buses
- Electronic design level
- Semiconductor physics level

Interactions and relations between levels

- View of machine at each level
- Tasks and tools at each level

Historical perspective

Trends and research activities

This slide is from Heuring and Jordan
Prerequisites

Experience with a high level language
Java
C, etc.

Assembly language programming

Digital logic circuits

Appendix A summarizes logic design in sufficient detail so the text can be used in courses without digital logic circuits as a prerequisite.
1: The General Purpose Machine
2: Machines, Machine Languages, and Digital Logic
3: Some Real Machines
4: Processor Design at the Gate Level
5: Processor Design - Advanced Topics
6: Computer Arithmetic and the Arithmetic Unit
7: Memory System Design
8: Input and Output
9: Peripheral Devices
10: Communications, Networking and the Internet
Course Overview – Basic aspects

1: The General Purpose Machine
   ISA (Instruction Set Architecture)
   The architect’s view
   The Logic designers view

2: Machines, Machine Languages, and Digital Logic
   SRC (Simple RISC Computer) an example for the entire course
   RTN (Register Transfer Notation) – a simple language that describes from ISA to logic

3: Some Real Machines
Speedup methods – pipelining and parallelism

4: Processor Design at the Gate Level
This introduces
  Stages of an instruction – Fetch, Decode, Operand Fetch, Execution, Writeback
  The LogicWorks version of the SRC will be the primary example

5: Processor Design - Advanced Topics
The crux chapter – this introduces
  Pipelining
  Instruction-level parallelism
  Microcoded control units
    A processor within a processor
Components – arithmetic and memory

6: Computer Arithmetic and the Arithmetic Unit
   Arithmetic operations and types
   - Integer
   - Floating point
   Specialized – logic operations and bit fiddling
   Design or arithmetic units

7: Memory System Design
   Memory cells – static/dynamic, RAM/ROM variants
   Memory organization – SDRAM and DDR RAM examples
   Cache memory organization
Components again – I/O and peripherals

8: Input and Output
   Primarily how the processor handles interrupts, exceptions and DMA

9: Peripheral Devices
   Just background information

10: Communications, Networking and the Internet
   Not covered in this course – others cover it well