ECE 231 – 1a
Intermediate Programming

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THE UNIVERSITY of NEW MEXICO

About this class

- Sitting in a room listening to somebody talk is not the best way to learn (and much research backs this up).
- This course will de-emphasize listening to me talk and emphasize your learning ideas from resources out of class, and discussing problems and questions in class.
- We will try to make our classroom a place of active conversation, rather than passive listening.

We will also use a lot of classroom time as "lab time".

ECE 231

Course Catalog Description – Required course for CompE

- **ECE 231 – Intermediate Programming and Engineering Problem Solving-** **Introduction to elementary data structures, program design and computer-based solution of engineering problems. Topics include use of pointers, stacks, queues, linked lists, trees, graphs, systems and device level programming and software design methodology. Prerequisites: ECE 131.**

Credit Information

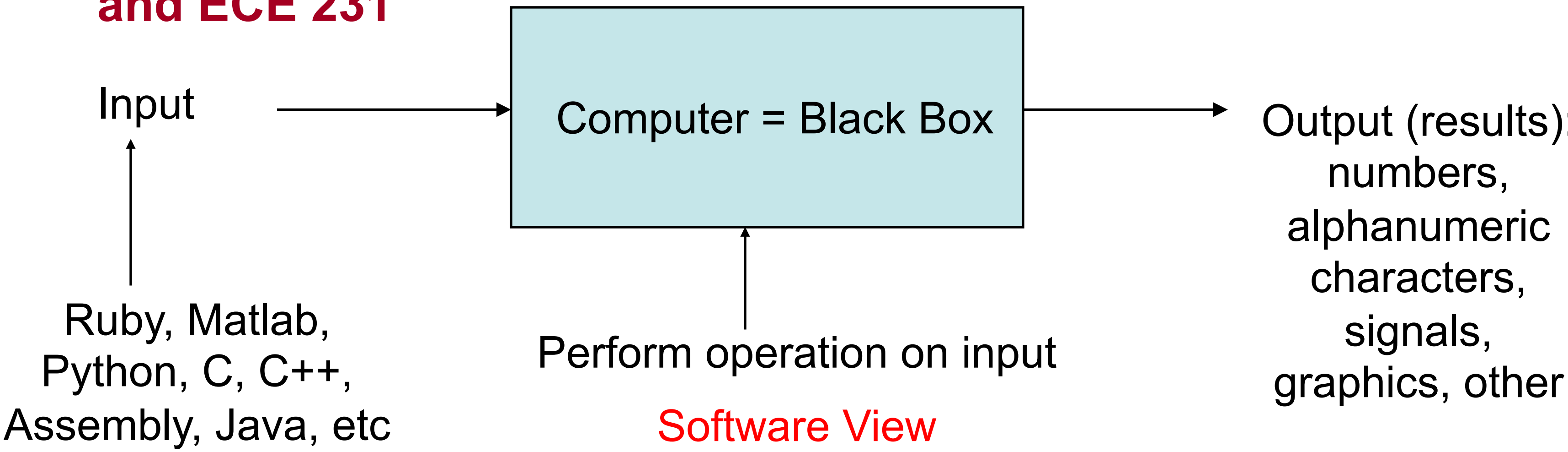
- **We have three credit hours for lecture. We will setup a lab/recitation session to work on assignments. Preferably Tue and Thu from 2 to 4 pm in ECE Room 215.**

Digital System

- **Manipulates discrete elements of information**
- **Best example: digital computer, smartphone, tablets**
- **Capable of greater accuracy and reliability than analog systems**

Two views

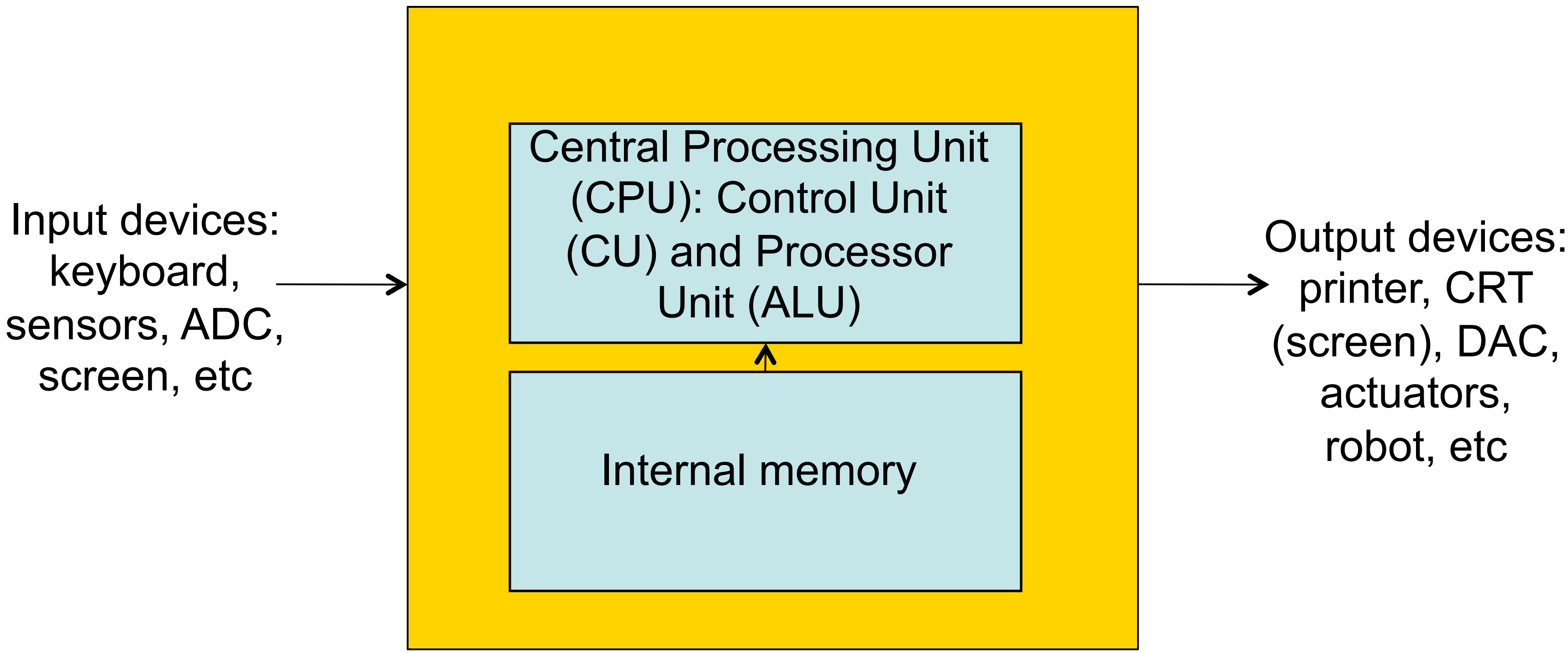
- **From an introductory programming course (software); ECE 131 and ECE 231**



Digital System

Two views

- **From ECE 238L view, hardware**
- **CPU: coordinates activities; timing operations; execution of instructions in sequence, “manager”**

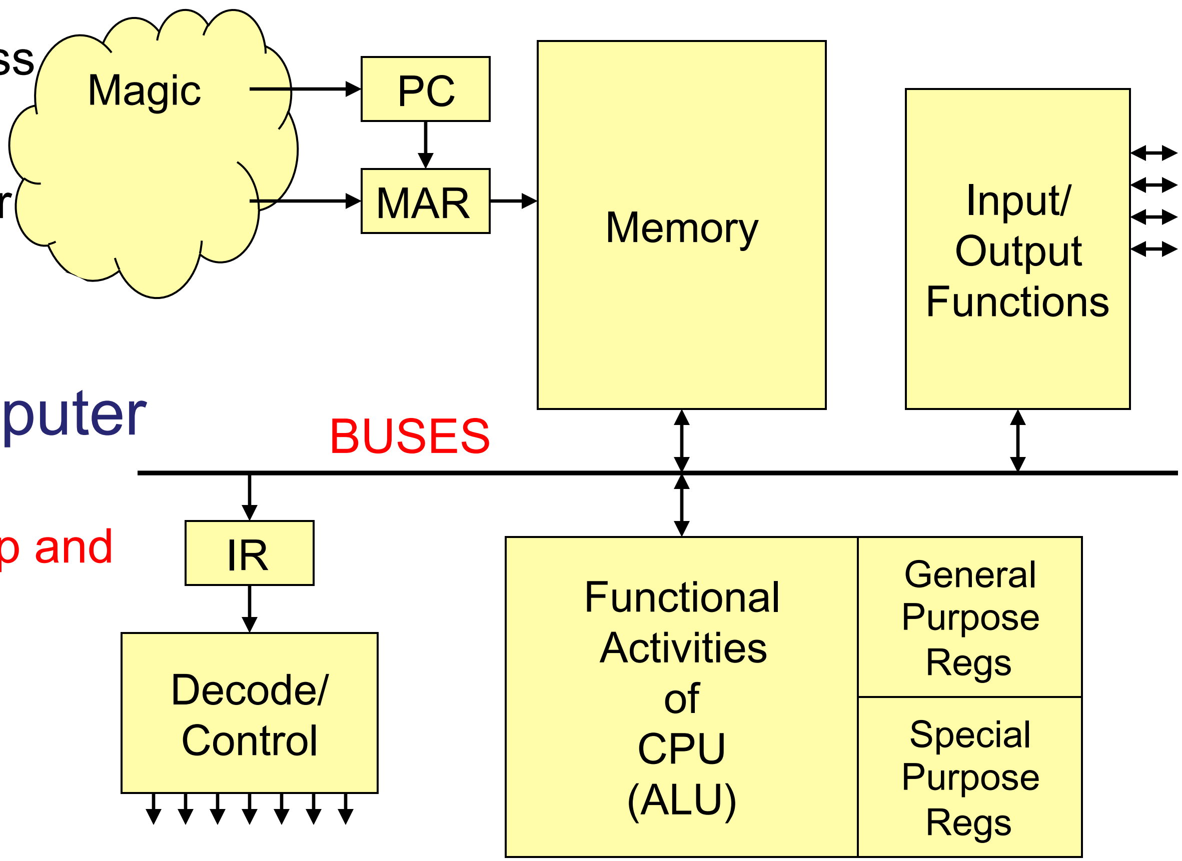


Hardware View

Basic Computer Organization

PC = program counter
MAR = memory address register

IR = instruction register



Inside the Computer

BUSES (inside the chip and outside):

Address Bus

Data Bus

Control Bus

Hardware View

Digital System

Digital Components

- **Central Processing Unit (CPU): Control Unit (CU) (manager) and the Arithmetic Logic Unit (ALU) (data processing)**
- **Memory Unit (MU): program development, holds program and data**
  - **Two types: a) Main (primary or internal) very fast, temporary storage; and b) Secondary or external, slower, long-term storage (disks, CDs, DVDs, optical storage devices, other)**
- **Input/Output (I/O) Devices or Peripherals**
  - **Communication with outside world: Network Interface Card (NIC), Monitor (CRT), plotter, printer, actuators, other**

Digital System

Digital Components

- **All internal and external digital components are connected via BUSES (highways)**
  - **Address Bus**
  - **Data Bus**
  - **Control Bus**

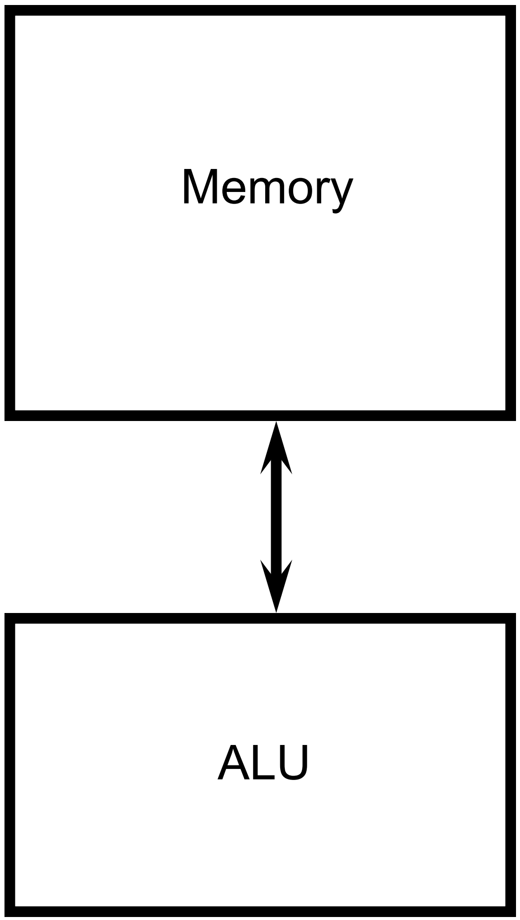
- **Data: physical quantities (signals) can assume only discrete values. Internal signals are either ON or OFF, True or False, 0 or 1, 0v or 5v, other**
  - **Collection of symbols**
  - **Valid only when we give the symbols meaning**

EXAMPLE: MC68000 - A 16/32 Bit Architecture

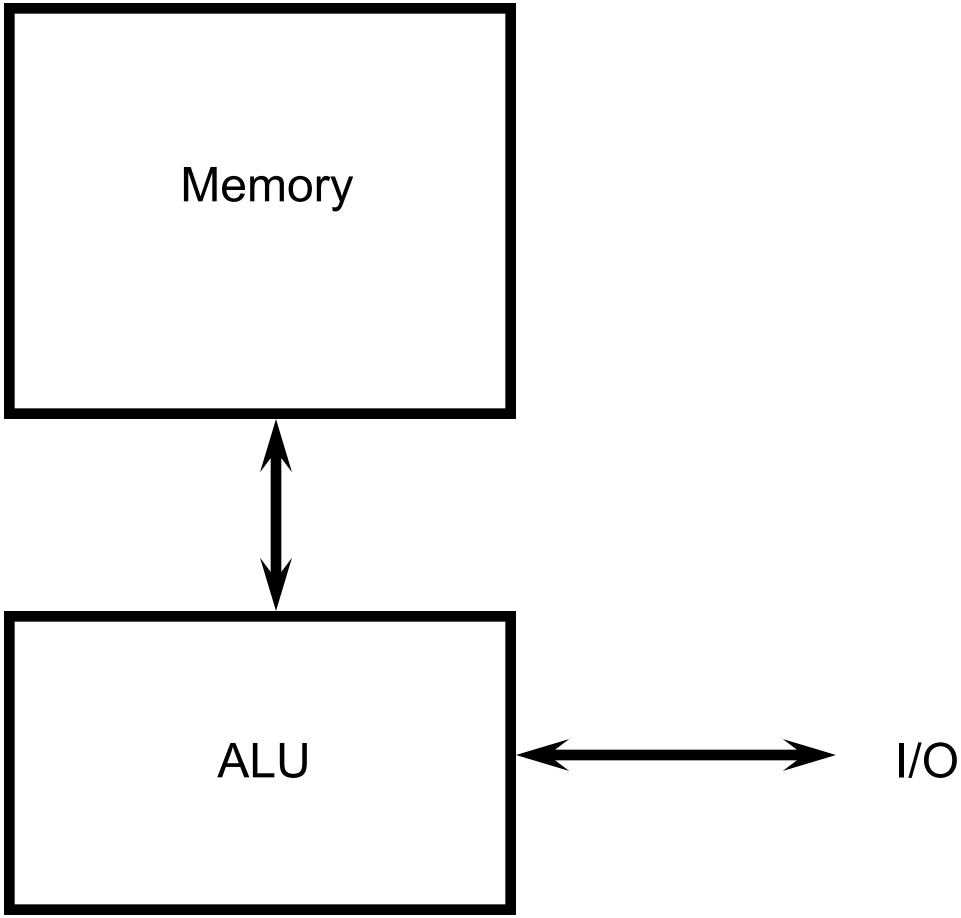
- **17 32 bit data and address registers**
- **16 Mbyte addressing range**
- **56 Instruction types**
- **5 Data types (bit, BCD, byte, word, longword)**
- **Memory mapped I/O**
- **14 Addressing modes**
- **Other family members → more features**

Basic Computer Architecture

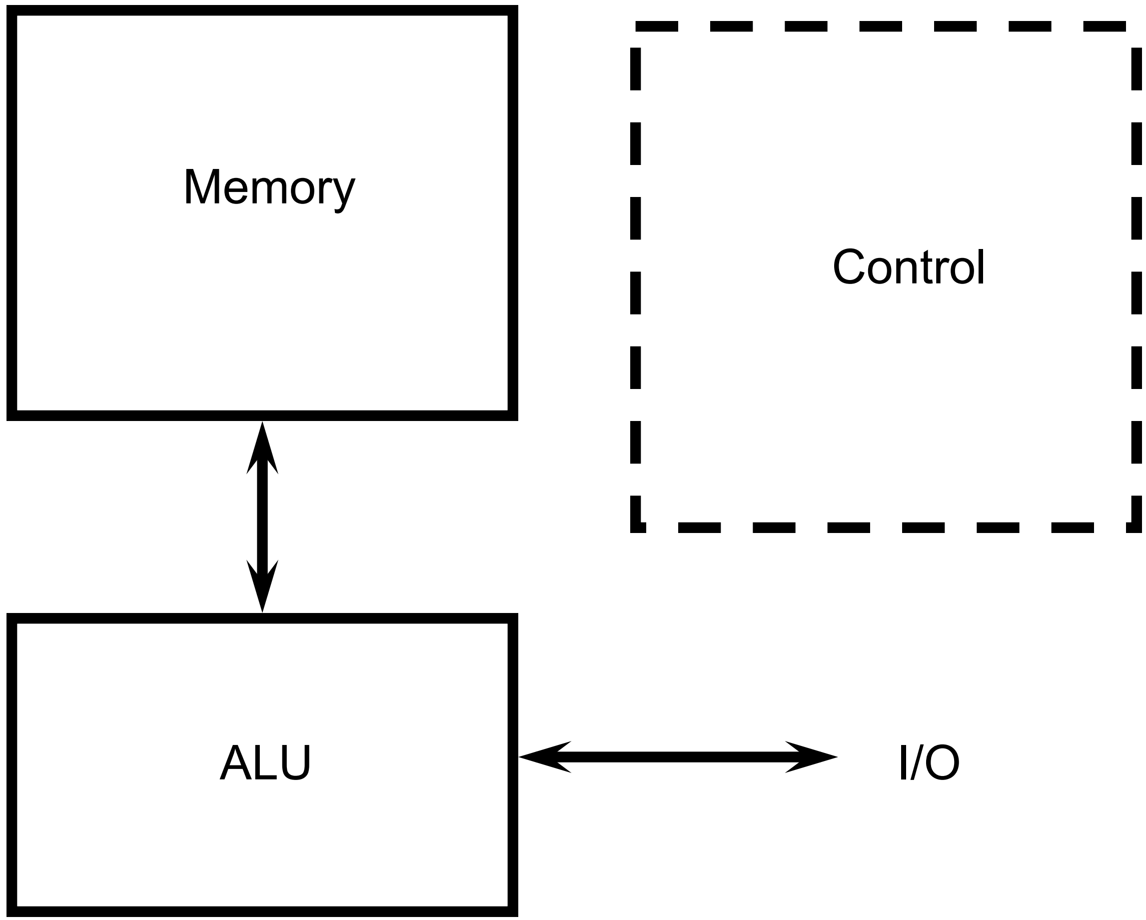
Basic Computer Architecture



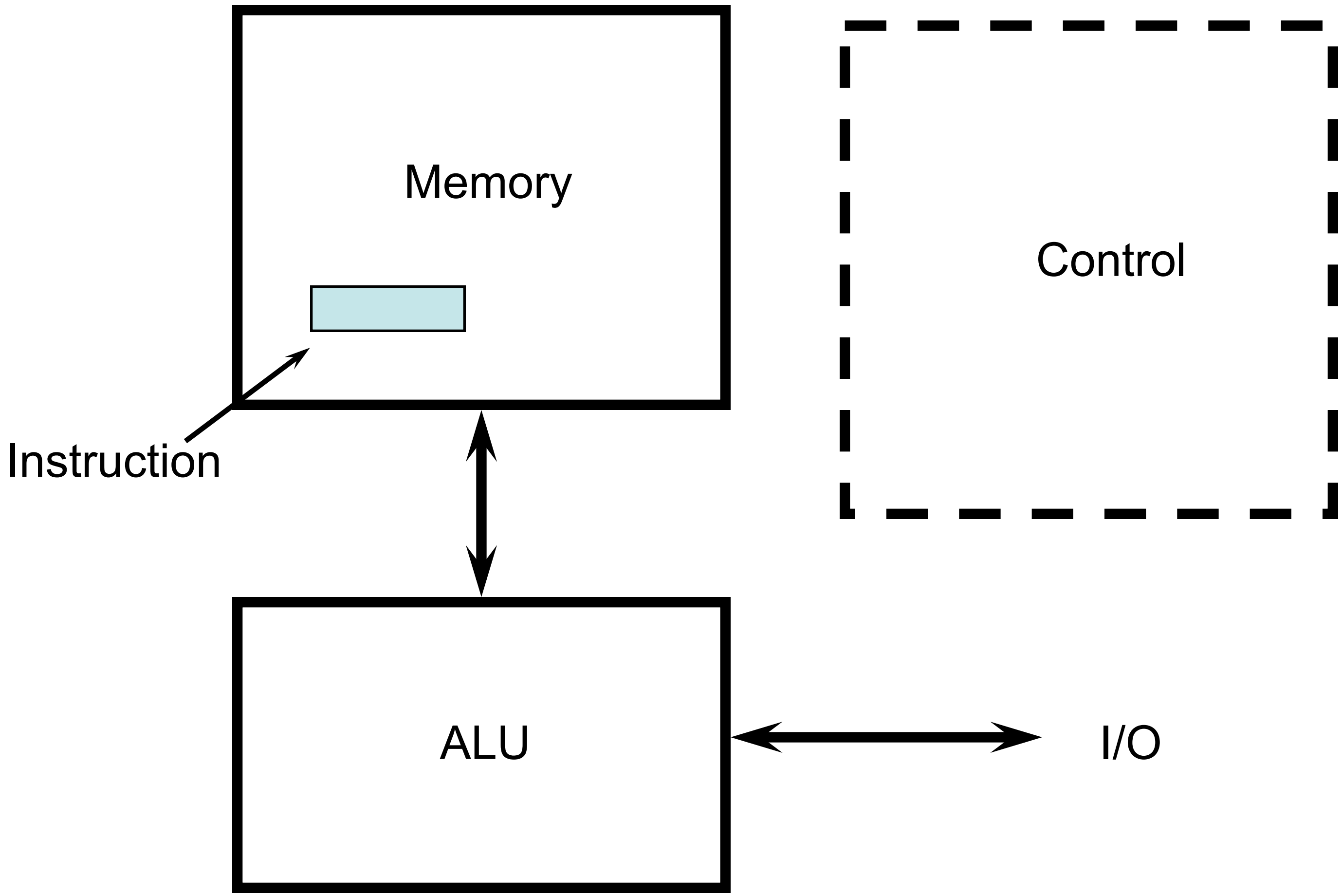
Basic Computer Architecture



Basic Computer Architecture



Basic Computer Architecture



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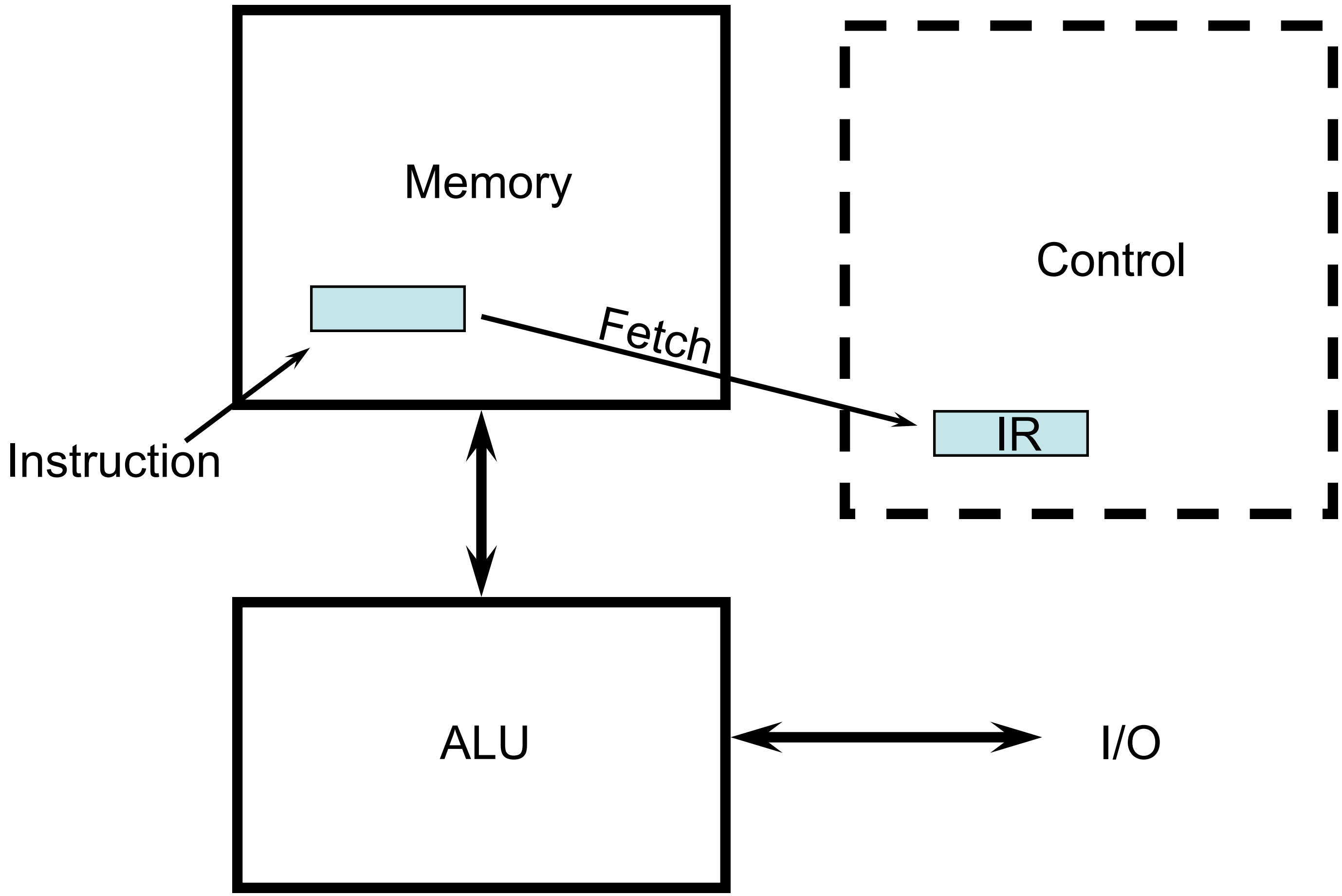
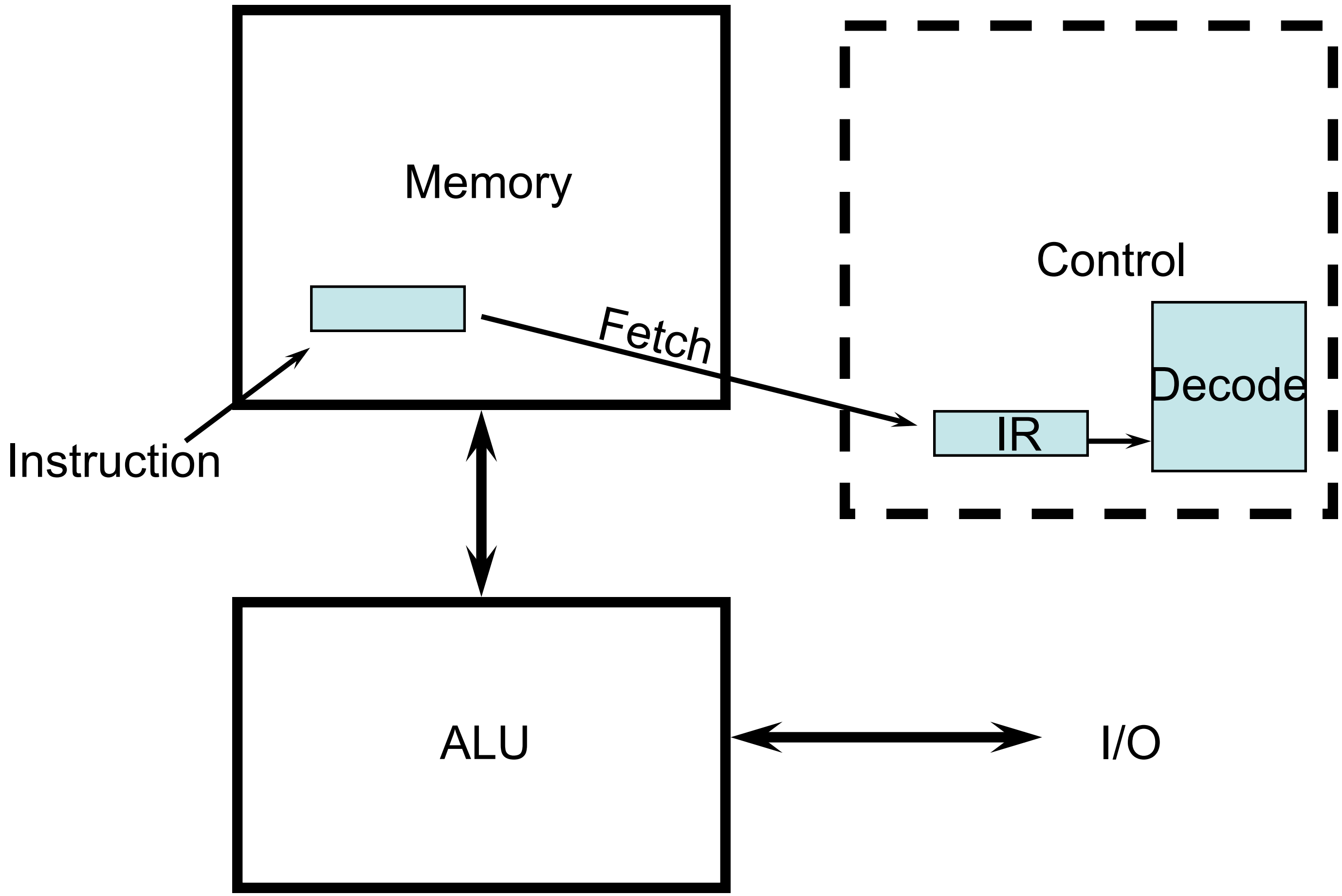
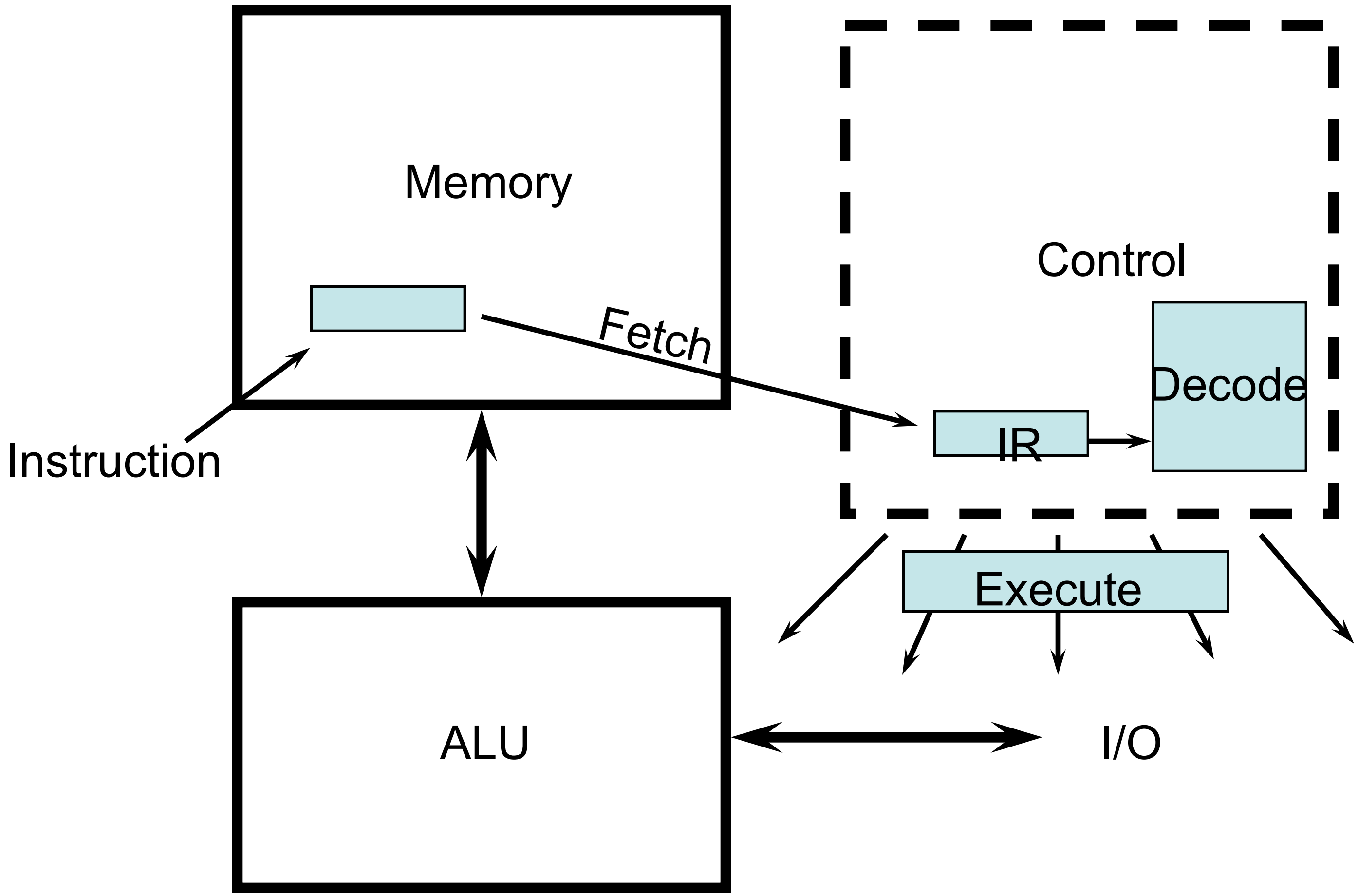


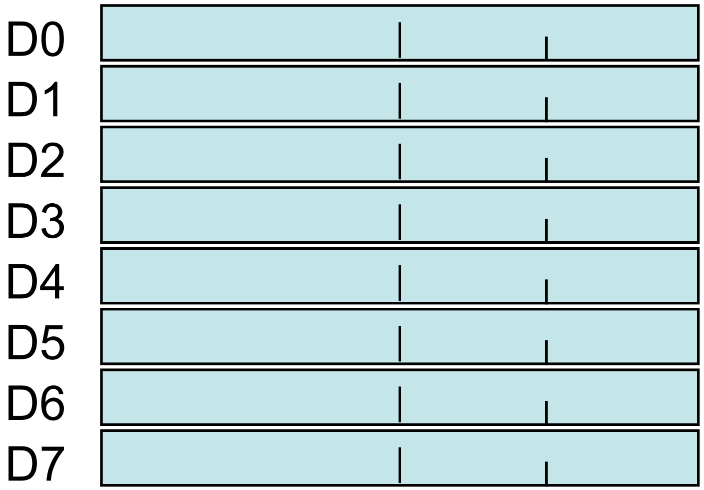
Basic Computer Architecture



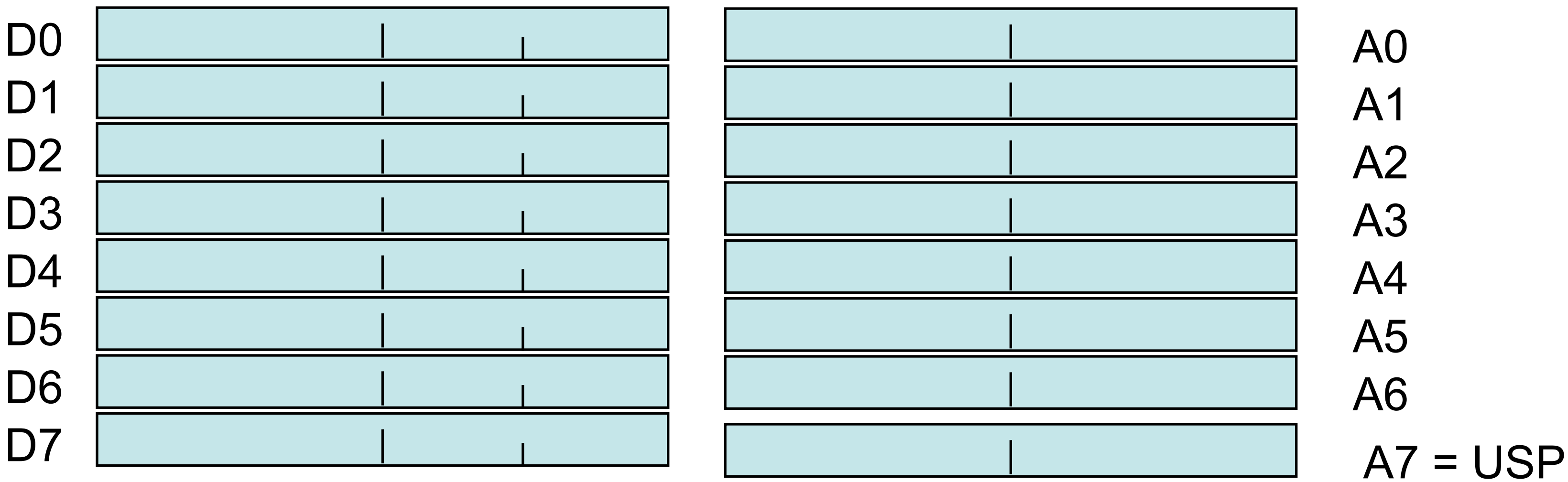
Basic Computer Architecture



ISA of 68000 Processors

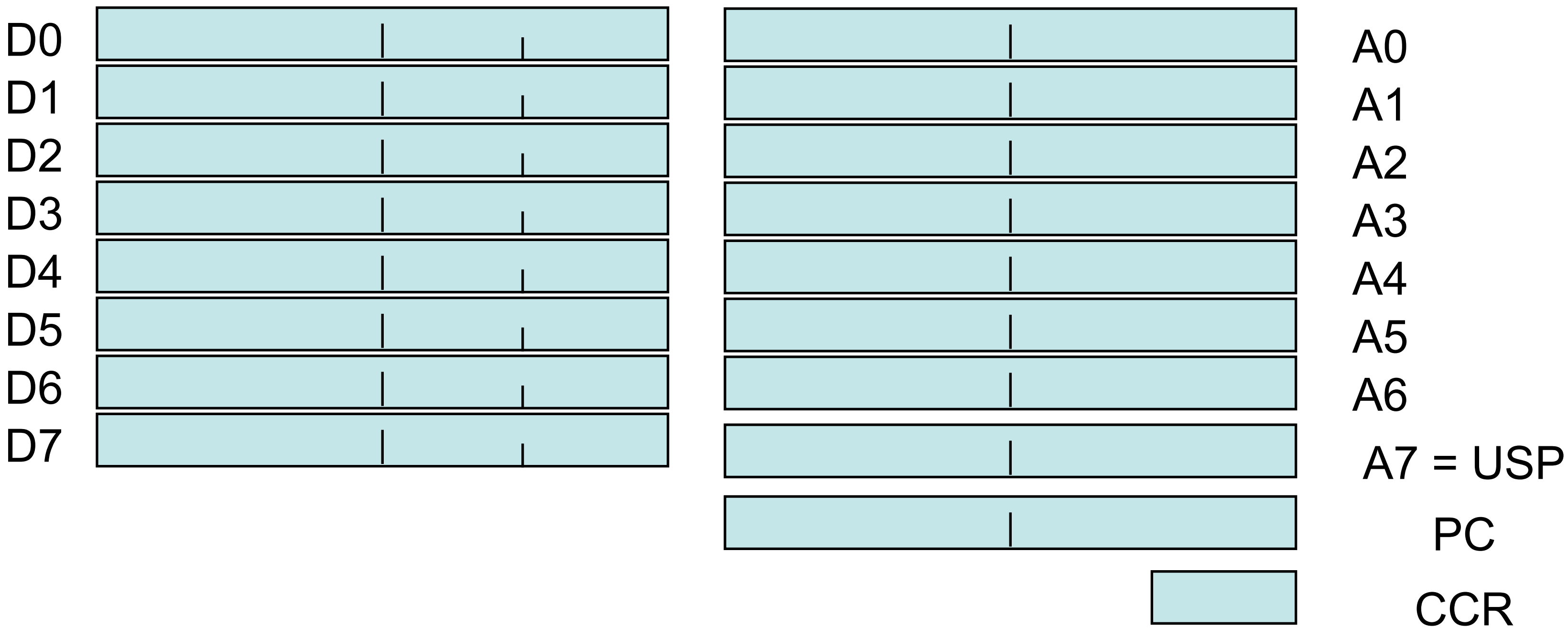


ISA of 68000 Processors



Address registers allow us to perform pointer operations in C and C++. Much faster!!!!!

ISA of 68000 Processors



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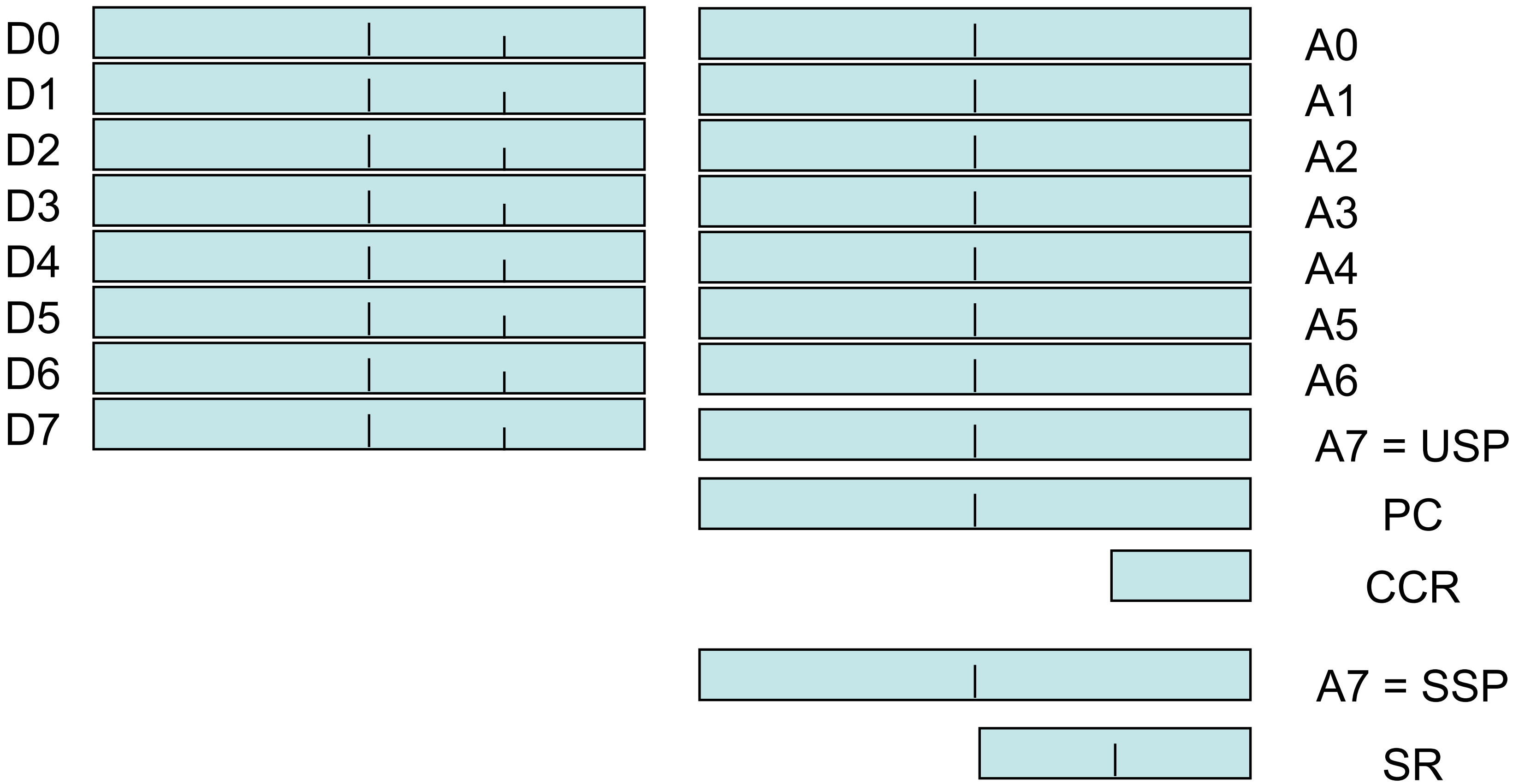

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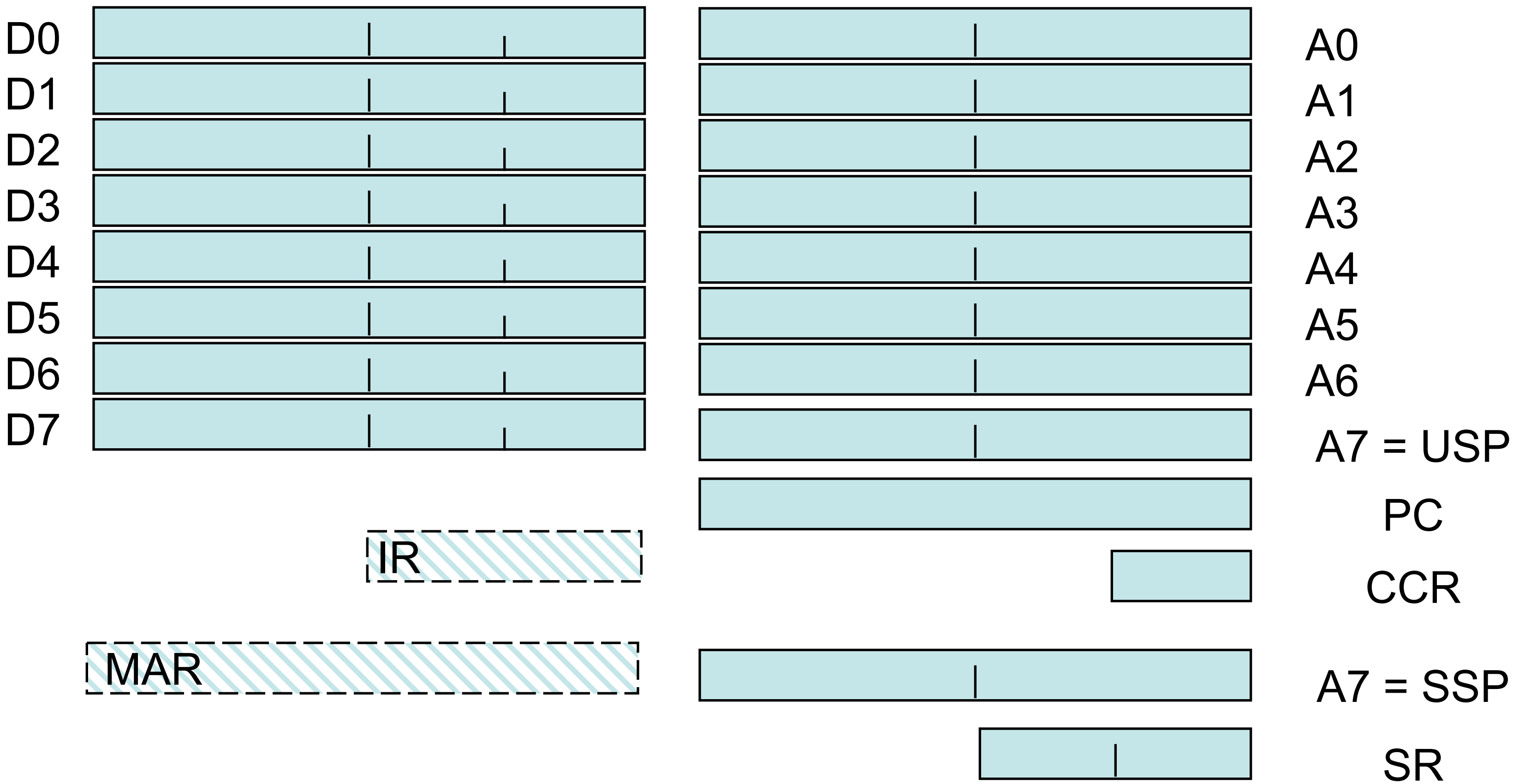
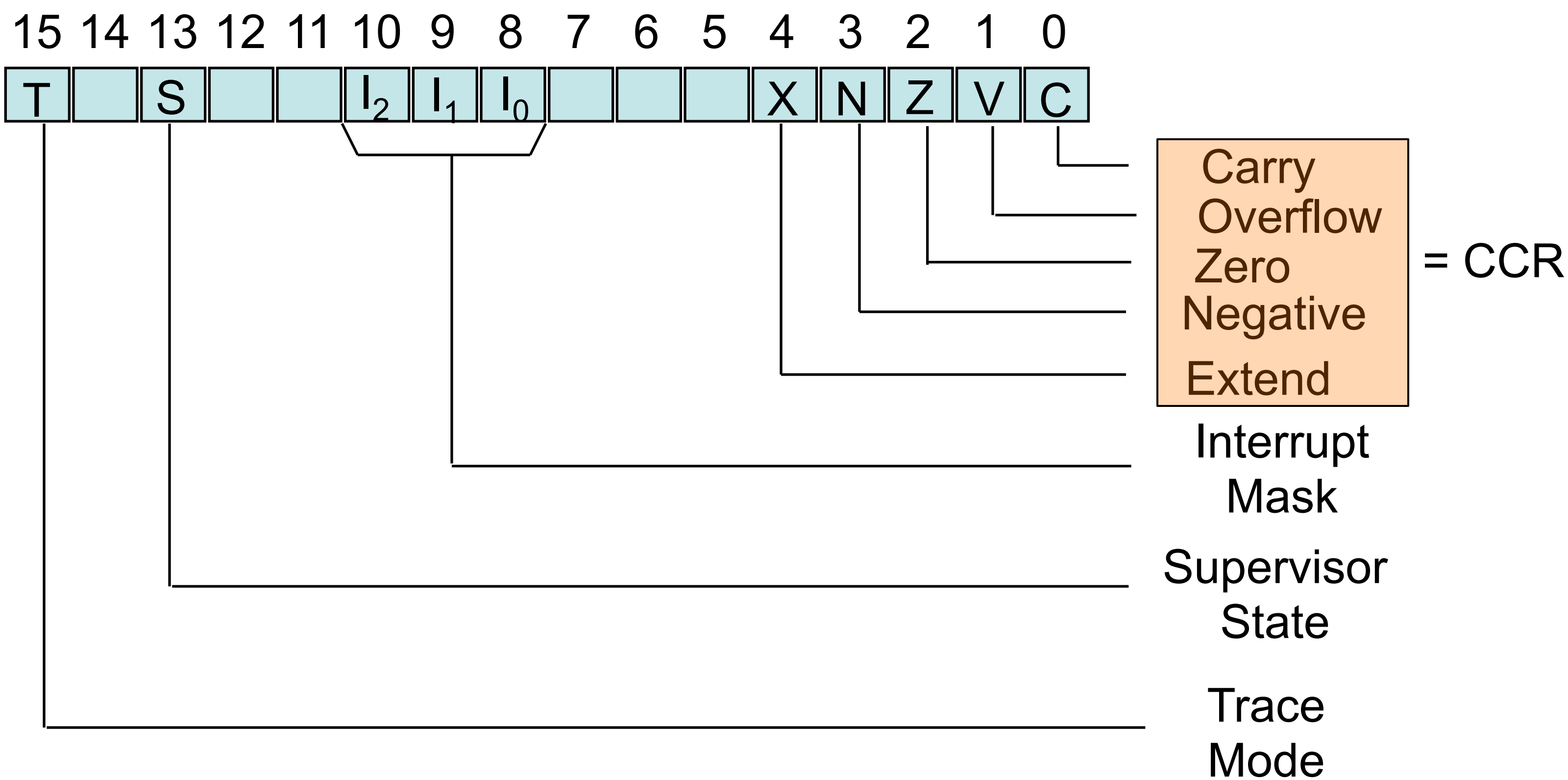


SR of 68000 Processor



SR = status register

CCR= condition code register

RTL for ADD D0, D1

Assembly Language Statement

***fetch*:** **MAR ← PC**

PC ← PC+N

IR ← M[MAR]

***decode*:**

***execute*:** **D1 ← D1 + D0**

ADD/SUB/MUL/DIV/AND/OR/EXOR

Basic Computer Organization

Cycles: Fetch

Decode

Execute

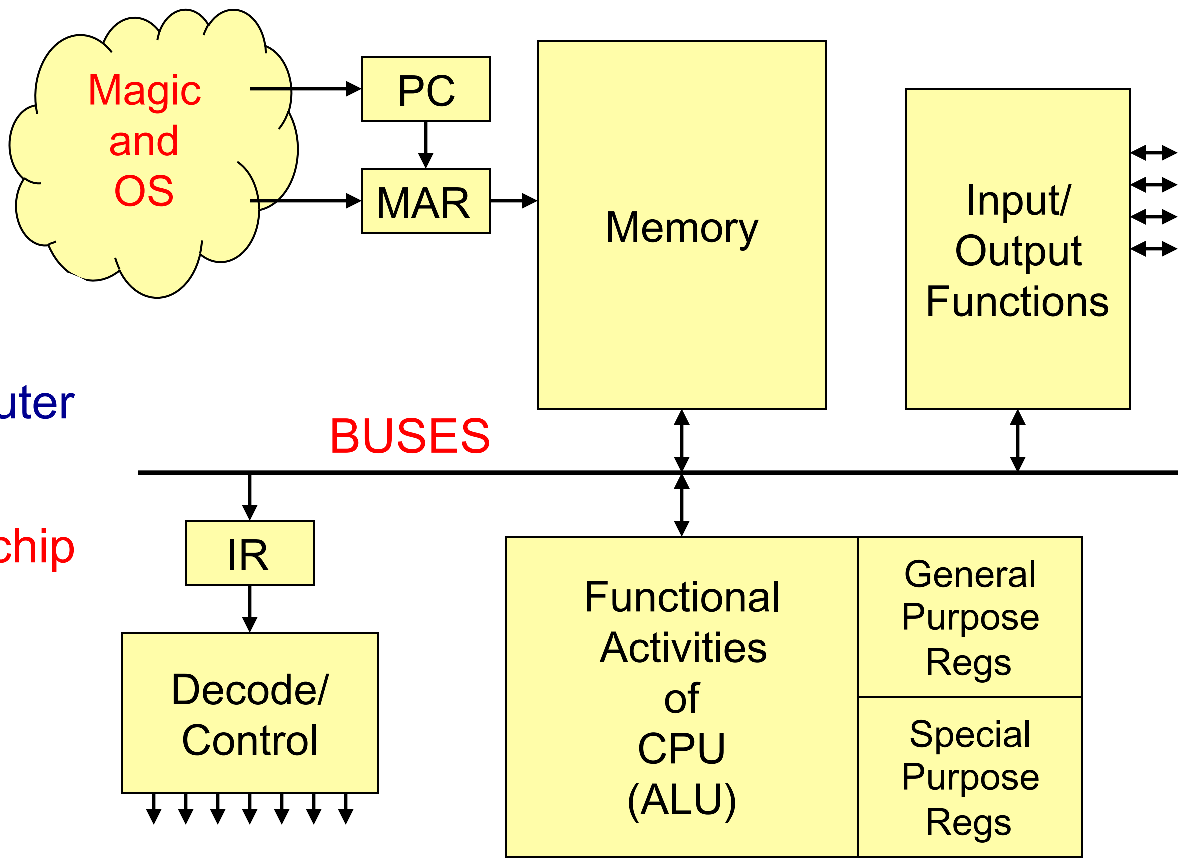
Inside the Computer

BUSES (inside the chip and outside):

Address Bus

Data Bus

Control Bus



Hardware View

Computer

Programming (Magic)

- **Computers are dumb, they do what they are told to do**
  - **The basic operations of a computer system form what is known as the instruction set**
  - **To solve a problem, you must express the solution to the problem in terms of the instructions of the particular computer**
  - **The approach or method that is used to solve a problem is known as the algorithm**
  - **With an algorithm then you translate into a program**
- **High-Level Languages**
  - **At the beginning programming was done in terms of binary numbers (octal, hexadecimal) that correspond directly to the machine instructions and locations in the computer's memory**

Computer

Programming (Magic)

- **High-Level Languages**
  - **Next technological software advance was the development of Assembly languages**
  - **Assembly language (low level language) permits the user to use symbolic names to perform various operations and to refer to the to specific memory locations**
  - **Assembler, a special program that translates the assembly language program from its symbolic format into the specific machine instructions**
  - **One-to-one correspondence between each assembly language statement and a specific machine instruction**
  - **Each microprocessor/microcontroller has its own assembly language; its own instruction set**
  - **Assembly language programs are not portable**

RTL for ADD D0, D1

Assembly Language Statement

fetch: MAR $\leftarrow$ PC

PC $\leftarrow$ PC+N

IR $\leftarrow$ M[MAR]

decode:

execute: D1 $\leftarrow$ D1 + D0

ADD/SUB/MUL/DIV/AND/OR/EXOR

Computer

Programming (Magic)

- **High-Level Languages**
  - **FORTRAN, C, C++, PASCAL, PHP, Python, Ruby, others no longer have to be concerned with the architecture of the particular computer**
  - **Operations performed by these languages are more sophisticated and far removed from the particular instruction set of the particular computer**
  - **One high-level language statement results in many different machine instructions being executed (object code)**
  - **Compiler, translates statements in a high-level language into a form that the computer can understand, that is, into the instruction set of a particular computer (object code)**
  - **Linker, combines the object code produced by the compiler from your C++ programs with the object code of routines (EX. I/O) used by your program (libraries)**

Programming (Magic) Computer

There are two primary ways for a program to be executed:

Compiler - A program that transforms source code into the machine readable code that a CPU can execute.

Ex: Programs written in C, C++, Java, Fortran and Pascal are typically executed using a compiler.

Interpreter - A program that executes source code directly, line-by-line, as each line of source code is encountered.

Ex: Programs written in Matlab, Ruby, Perl and Python are typically executed using an interpreter.

Computer

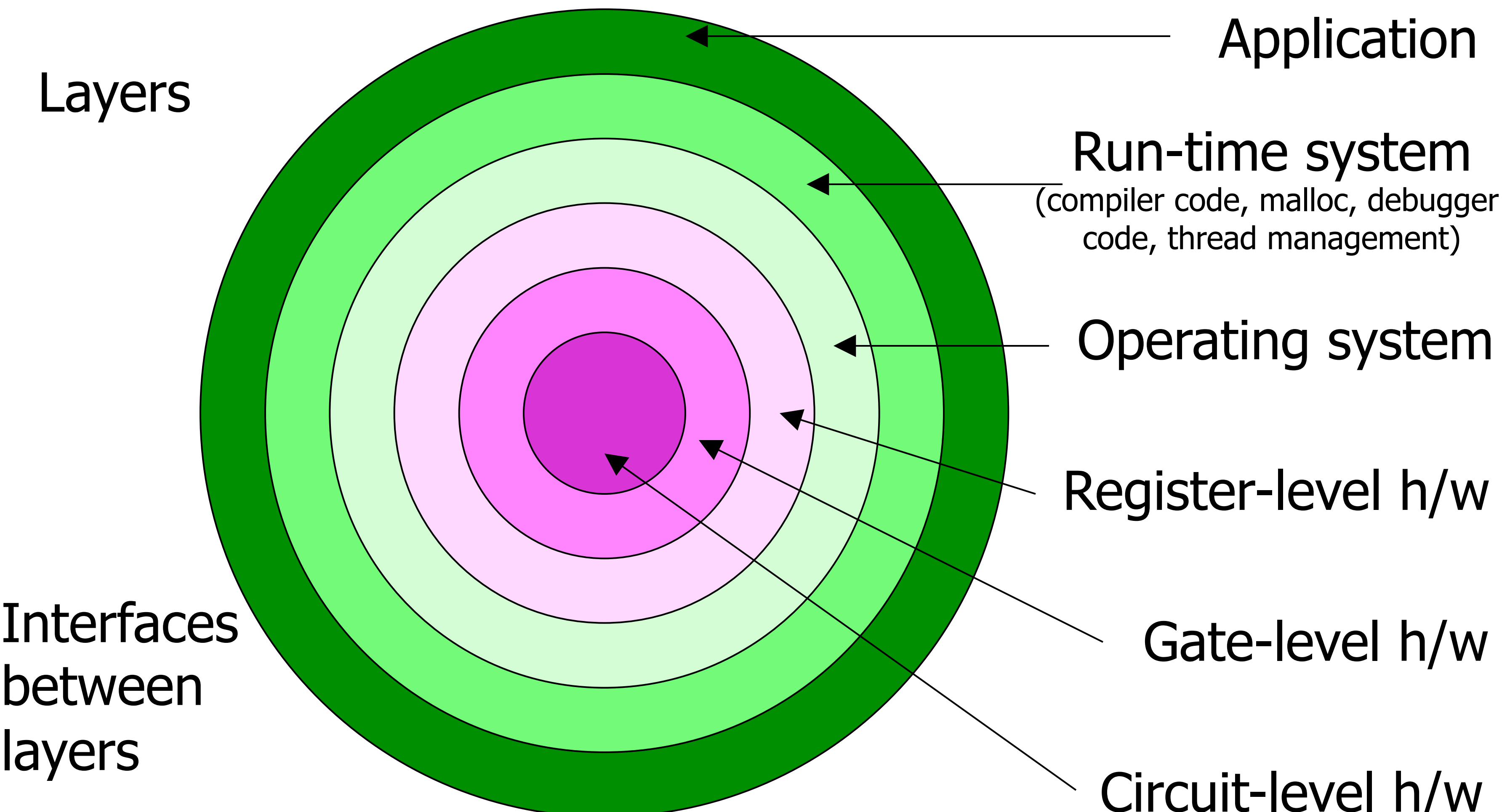
Operating Systems

- **Is a program that controls the entire operation of a computer system – Manager.**
  - **Manages input and output (I/O) operations**
  - **Manages all the resources available**
  - **Manages the execution of programs – YOURS!!!!**
  - **EX. UNIX, Windows, MAC OS, Android, others**

WEB Services

- **The Internet now has become an innovative software platform.**

Software/Hardware Organization: Another View



Types of Languages

- **Programming languages**
  - (e.g., C, C++, assembly language)
- **Scripting languages**
  - Shell scripts (OS) – controls other software programs
  - Emacs, QuakeC
- **Specification languages**
  - Used for system design/analysis
  - UML
- **Machine Code**
  - (the non human-readable form other languages are translated into, sometimes on the fly)
- **Query language**
  - SQL, OQL, XQuery
- **Markup languages**
  - typically used for producing documents
  - HTML, XML, XHTML
- **Transformation languages**
  - transform some input text in a certain formal language into a modified output text that meets some specific goal
  - XQuery
- **Template processing languages**
  - combine one or more templates with a data model to produce one or more result documents
  - Perl, Python
- **Visual programming languages**
  - Labview, Matlab
- **Hardware description languages**
  - Executables for hardware
  - Verilog, SystemC, VHDL
- **Configuration file formats (e.g., INI file)**

ECE 231 - Environments

- UNIX/LINUX: linux.ece.unm.edu OR linux.unm.edu
  - All UNM students have an account in linux.unm.edu
  - To have access to the ECE environment, linux.ece.unm.edu, you need to request an account from the ECE IT personnel
- WINDOWS (Linux like environments for your laptop)
  - CYGWIN or MinGW (my own preference)
  - Bloodshed
  - devc++
  - VisualC++
  - UBUNTU
- MAC
  - Need to install application Xcode to have Unix
  - Application Terminal is a Unix environment

ECE 231 - Environments

- UNIX/LINUX: linux.ece.unm.edu
  - This is the ECE working environment
    - SHELL – interpreter of OS commands
    - .alias – setup your environment to your liking and needs
  - This is the preferred environment where your code will be written, compiled, debugged, executed, and tested
  - Compilers used: gcc for C; g++ for C++
  - Use putty to access the system from a Windows machine; it is an application that runs on top of Windows and emulates a terminal. Through the terminal application you can access the UNIX systems at UNM
  - Use ssh, scp, and sftp to access it from any machine (including Windows/Cygwin or Windows/MinGW). Google(ssh) for usage details.

Setting Up Your ECE Linux Environment

- There are many OS SHELLs
  - I prefer the shell bash, which is the default
    - To change to the C shell execute the command csh
- Setup your environment
  1) Login to your UNIX/LINUX account and create a sub-directory named ece231.
     - You do this by executing the command   mkdir ece231
  2) Go into that sub-directory
     - You do this by executing the command   cd ece231
  3) Create another sub-directory called Ccode
     - You do this by executing the command mkdir Ccode
       - » Download all the C code examples given to you into this sub-directory.
       - » These examples are given to you so you can refresh your C programming skills

Setting Up Your ECE Linux Environment

- Setup your environment

  4) Create another sub-directory called CPPcode
     - You do this by executing the command mkdir CPPcode
       - » In this directory you will develop all the code in C++

  5) .alias file allow you to create short cuts to commands and to setup your UNIX environment

  6) In your home directory create a .alias file that has the aliases below.
     - (Copy/download .alias file from my shared folder if you like. You can add your own aliases and commands by editing this file.
     - The aliases provided below will need to be modified to reflect your UNIX environment, especially the first two aliases.
     - Add the line "source ~/.alias" to your .bashrc file.

  7) After setting up your .alias file, run ". .bashrc".

Setting Up Your ECE Linux Environment

- Sample .alias file

```
# Use these for convenience
alias lss='ls -al'
alias 231='cd ~/ece231'
alias ccode='cd ~/ece231/CCode'
alias cppcode='cd ~/ece231/CPPCode'

# Make compilers more helpful
alias gcc='gcc -std=c99 -Wall -Werror'
alias g++='g++ -Wall -Werror'

# Use these for safety
alias rm='rm -i'
alias cp='cp -i'
alias mv='mv -i'
```

Setting Up Your ECE Linux Environment

- Download from BBLearn the file unixman.txt for a quick reference to UNIX OS commands
- Download from BBLearn the file vim-cheat-sheet.txt for a quick reference to the editor vi commands. (vi is implemented with Vim.)

Q&A