

ADVANCED PROCESSOR
ARCHITECTURES AND MEMORY
ORGANISATION –
Lesson-17: Memory organisation,
and types of memory

1. Memory Organisation

Random access model

- A memory-, a data byte, or a word, or a double word, or a quad word may be accessed from or at all addressable locations with a similar process would be used to access from all locations and there is would be equal access time for a read or for a write that is independent of a memory address location. This mode differentiates from another model called serial access mode

Addresses

- Memory (both RAM and ROM) divided into a set of storage locations, each of which can hold 1 byte (8 bits) of data.
- The storage locations are numbered, and the number of a storage location (called its *address*) is used to tell the memory system which location the processor wants to reference.
- Important characteristics of a computer system is the width of the addresses it uses, which limits the amount of memory that the processor can address. Most current computers use either 32-bit or 64-bit addresses, allowing them to access either 2^{32} or 2^{64} bytes of memory.

RANDOM ACCESS MODEL OF MEMORY

- Simple model for RAM and ROM
- Both has random-access model of memory
- All memory operations take the same amount of time independent of the address of the byte or word at the memory.

Example

- Assume that the memory system will support two operations: load (read operation into processor from memory) and store (read operation from processor into memory).
- Load from one set of addresses (2 or 4) will take same time for store from another set of addresses (2 or 4)

ROM

- Contents of the read-only memory cannot be modified by the computer but may be read.
- A system has ROM unit(s) —for bootstrap program(s), basic input-output system (BIOS) program(s) and for vector addresses for the interrupts
- Used to hold bootstrap program that is executed automatically by the system every time it is turned on or reset. Instructs the system to load its operating system off

ROM image

- ROM image holds the programs, operating system, and data required by the system.

Random-access memory (RAM)

- Can be both read and, written,
- Hold the programs, operating system, and data required by the system.
- Generally volatile, meaning that it does not retain the data stored in it when the system 's power is turned off. A
- Data that needs to be stored while the system is off must be written to a permanent storage device, such as a flash memory or hard disk.
- An example is as follows: A mobile phone has 128 kB or 256 kB of RAM to hold the stack and temporary variables of the programs, operating system, and data.

ALIGNMENT OF MULTIBYTE STORE AND LOAD IN A MEMORY ORGANISATION

- Some memory organisation requires loads and stores to be "aligned. A 4-byte word has been aligned at address 0x000C or 0x1000, which is a multiple of 4. This simplifies the organisation of the memory system.

LITTLE ENDIAN AND BIG ENDIAN IN A MEMORY ORGANISATION

- Some processor and memory organisation requires *little endian* and other *big endian* aligned multiple bytes when there is store into the memory or load into the processor from memory.
- ARM processor permits programming at the start and enables a programmer to define one of the word-alignments *little endian* or *big endian* at the beginning.

Princeton Architecture

- 80x86 processors and ARM7 have Princeton architecture for main memory. 8051-family microcontrollers have Harvard architecture.). Vectors and pointers, variables, program segments and memory blocks for data and stacks have different addresses in the program in Princeton memory architecture.

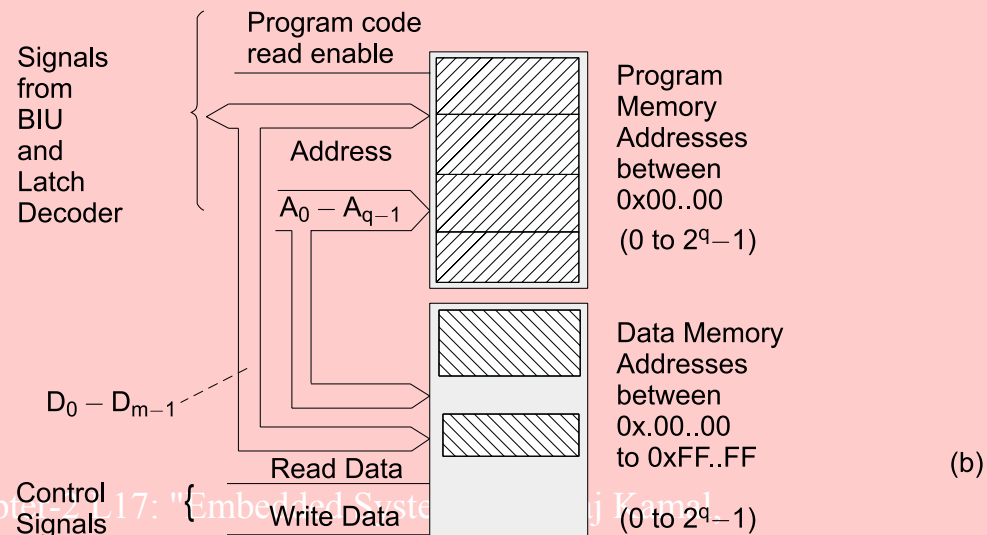
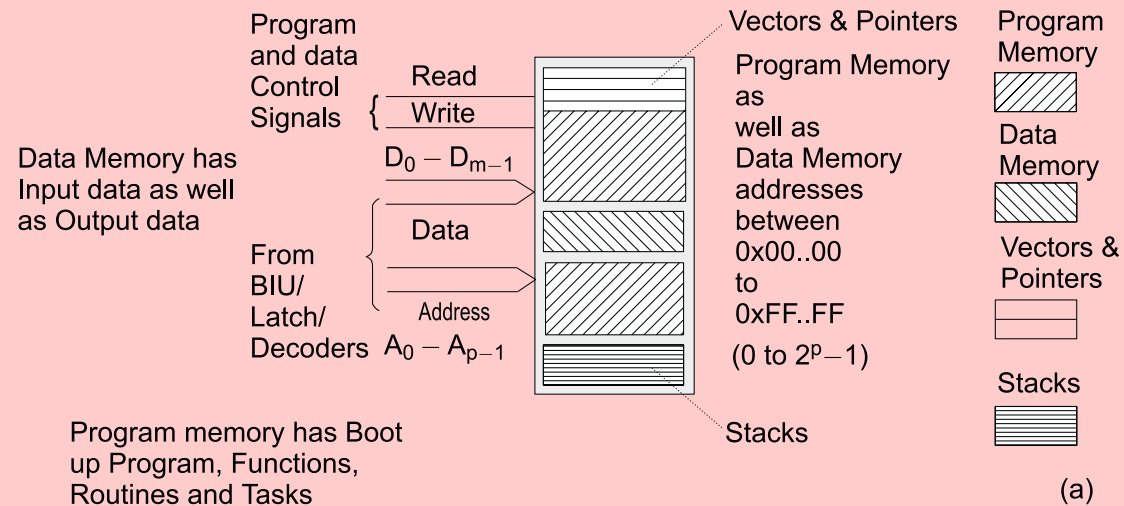
Harvard architecture

- When the address spaces for the data and for program are distinct
- Handling streams of data that are required to be accessed in cases of single instruction multiple data type instructions and DSP instructions.
- Separate data buses ensure simultaneous accesses for instructions and data.

Harvard Architecture

- Program segments and memory blocks for data and stacks have separate set of addresses in Harvard architecture.
- Control signals and read-write instructions are also read-write instructions are also separate for accessing the program memory and data memory.

Harvard and Princeton Memory Organizations



2. Types of Memory

Memory types

- Most systems two types of memory— *read-only memory* (ROM) and *random-access memory* (RAM).
- A computer system has ROM unit(s) for bootstrap program(s), basic input-output system (BIOS) program's) and for vector addresses for the interrupts
- An embedded system has ROM unit(s) for storing ROM image and flash to save non-volatile data and results

ROM Uses

- Language specific bits for the fonts corresponding to each character to a printer or display unit.
- Images bits for a display.
- Pictogram bytes for the full bit-image corresponding to the pixels for a pictogram. Sequential changes at the inputs of display unit repeatedly generate the full pictogram.
- In a CISC as a control ROM at a micro-programmed unit for implementing instructions

- 1) Masked ROM – Used for large scale manufacturing; mask prepared for foundry
 - A finalised ROM image of system program and data, pictograms, image pixels, pixels for the fonts of a language, combination-circuits implementing a truth-table

- 2) EPROM – Used in place of masked ROM during development phase; UV Erasable and Electrically programmable by a device programmer

- 3) E²ROM – Used during the program run to save non-volatile data and results (for examples, date and time of a transaction, present port status, port driving history, system malfunctions history); Electrically Erasable by writing a byte or a set of bytes with all 1s and Electrically programmable during a program run one byte write at each write instance.

- 4) Flash – A flash memory functions as the ROM. Electrically Erasable sector of 16 kB to 256 kB at an instance and Electrically programmable one byte at each instance during a program run.

Flash memory applications

- ROM image and OS,
- Used during the program run to save non-volatile data and results, for examples, a picture in a digital camera, voice mail;
- Storing SMS, MMS messages in a mobile phone. phone book, address book
- Storing voice compressed form in a voice recorder. [Recall of prerecorded message from a telephone exchange.]

- 5) Boot Block Flash – Flash with a sector reserved for programming once only; that sector can be used for saving ROM image or boot program of the system

- 6) **Memory Stick** — a removable flash memory card format. [An 8 GB card was unveiled at a 2006 show at Las Vegas]

Exemplary uses: Removable stick in digital camera, Mobile phone, Handheld devices, Handheld compressed voice or video recording in a voice or video recorder

- 6) PROM (OTP) - Used for small scale manufacturing and for saving once only data; used for saving ROM image or boot program of the system and for storing data like user photo and ID and account type and bank details on a card;

RAM

- The RAM can be both read and, written, and is used to hold the programs, operating system, and data required by a computer system. In embedded systems, it holds the stack and temporary variables of the programs, operating system, and data

RAM Characteristics

- RAM is generally volatile,
- does not retain the data stored in it when the system 's power is turned off.
- Any data that needs to be stored while the system is off must be written to a permanent storage device, such as a flash memory or hard disk.

Example :A mobile phone has 128 kB or 256 kB of RAM to hold the stack and temporary variables of the programs, operating system, and data

RAM Types

- 1) SRAM (static RAM) and DRAM (dynamic RAM) – Used for saving the variables, stacks, process control blocks, input buffer, output buffer, decompressed format of program and data at the ROM image

- 2) EDO (Extended Data Out) RAM – Used up to 100 MHz clock rate, zero wait state between two fetches, single cycle read or write

- 3) SDRAM (Synchronous DRAM) –
Synchronised read operation; keeps next word ready while previous one is being fetched; used up to 1 GHz clock cycle

4) RDRAM (Rambus* DRAM) – Burst accesses of four successive words in single fetch; used for 1 GHz + performance of the system

* A developer company name

- 5) Parameterised Distributed RAM – when slow bus accesses exist RAM distributed for the specific tasks of the system and devices - for examples for fast IO buffers, fast stacks, ..
- 6) Parameterised Block RAM – Specific block dedicated for specific use, for example, for DCT operations

Summary

We learnt

- Random access memory model, ROM, RAM
- Addresses
- Data alignment
- Little and big endian
- Flash
- Princeton and Harvard architectures

End of Lesson 17 of Chapter 2