Master of Computer Applications

CAPOL403R01: Computer Organization & Architecture

Unit II: Lecture 1 – Part 1

Instruction set – Characteristics & functions

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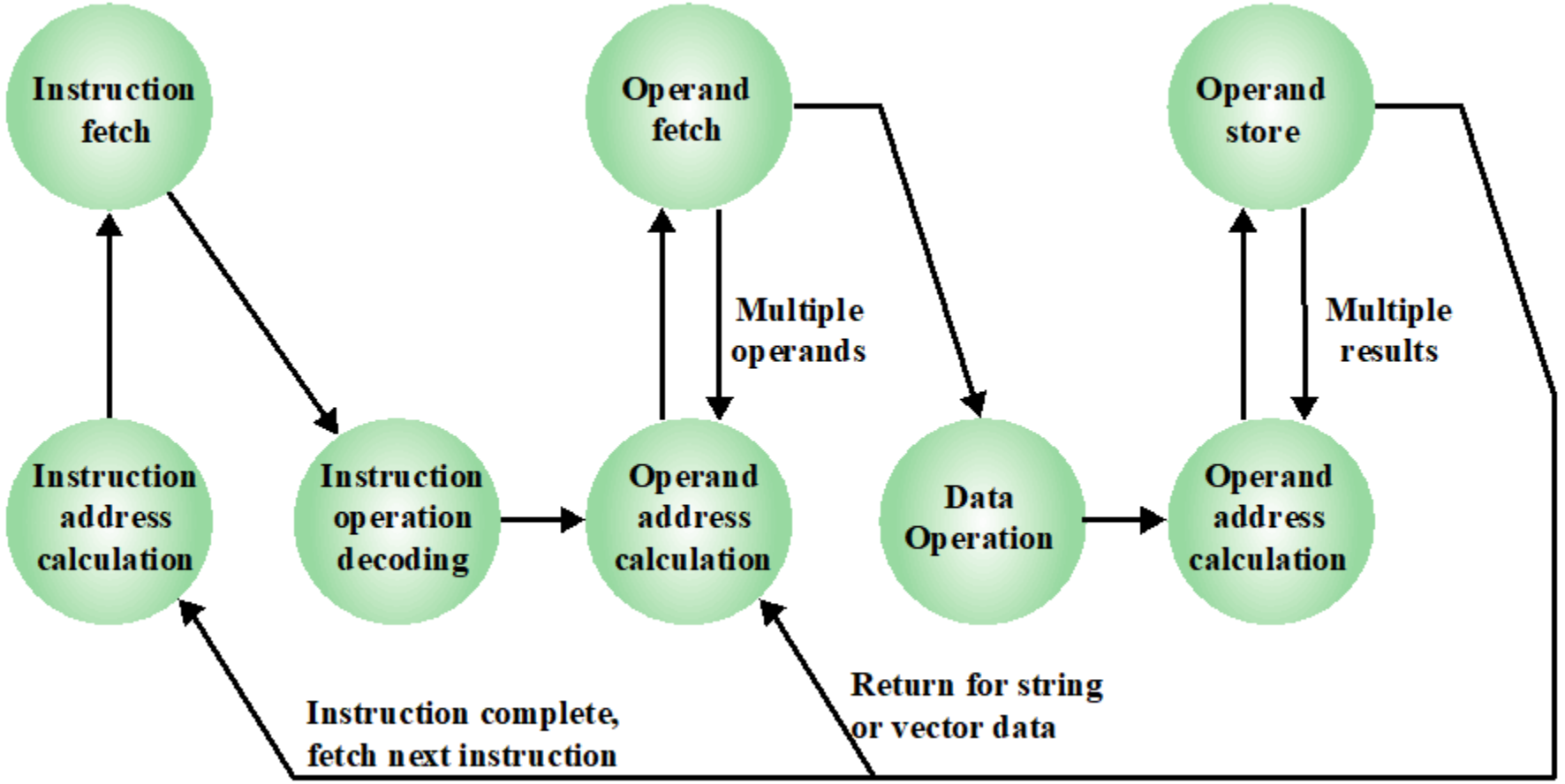
Instruction set

- Instructions
  - They are commands given to the machine
- Machine instruction
  - It is in binary form so that the machine can understand and act upon.
- Instruction Set
  - The collection of all instructions which could be executed by the processor

Instruction cycle - State diagram



Elements of a machine instruction

- Operation code
- Source operand(s) reference(s)
- Destination operand(s) reference(s)
- Next instruction reference

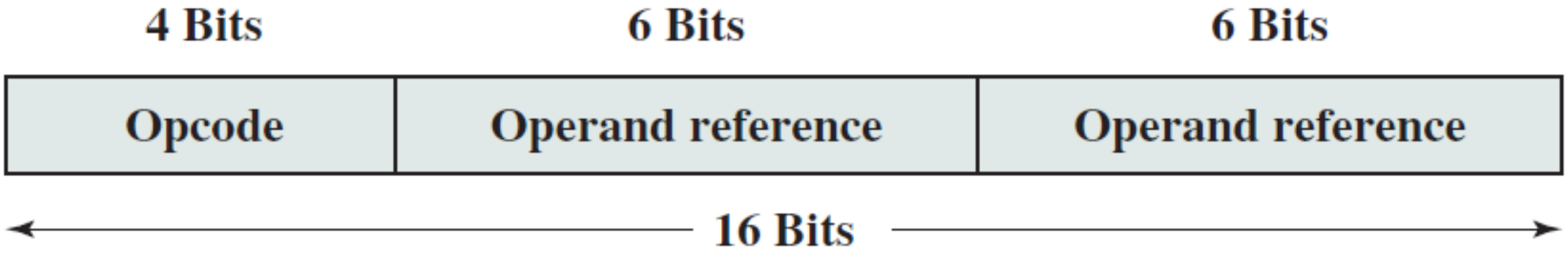
Elements of a machine instruction

- Operation code
  - It specifies the operation to be performed.
  - The operation is specified by a binary code.
  - It is commonly known as the operation code, or opcode.
- Operand reference
  - It helps to find the location of source and the destination
  - It may refer main memory, processor register, IO devices or the operand itself

Elements of a machine instruction

- Next instruction reference
  - Usually the next instruction of the program is fetched
    - In that case, the instruction doesn't have this field
  - Sometimes, the next instruction may be branching from the normal flow
  - In these cases, this field is included in the machine instruction
  - The reference may indicate a real memory or a virtual memory

A simple instruction format



- Each instruction is represented by a sequence of bits
- Instruction is divided into fields
- An instruction set uses more than one format
- It is difficult to follow machine codes
- Hence, symbolic opcode (for ex: ADD) is used to understand instructions
- The operands may be represented symbolically
- For example: ADD R1,Y

Types of instructions

- Data processing
  - It has arithmetic and logical instructions
- Data storage
  - Movement of data into/out of register and/or memory locations.
- Data movement
  - I/O instructions
- Control
  - Test and branch instructions

Number of addresses

- Three address instructions
  - It has two source operands and a destination operand
- Two address instructions
  - It has two source operands
  - one source address becomes destination after the execution
- One address instruction
  - Accumulator is the implicit operand
- Zero address instruction
  - Operands are assumed to be in stack memory

Example :

- Consider the equation $$Y = \frac{A-B}{C+(D\times E)}$$
- Write programs to implement it using 3,2 and 1 address instructions without changing the inputs
- ADD, SUB, MPY, DIV instructions are used for addition, subtraction, multiplication and division
- MOVE is used to move the data from one location to another location
- LOAD and STOR are used to load/store accumulator data

$$\frac{A - B}{C + (D \times E)}$$

Three address instructions	Two address instructions	One address instructions

Number of addresses…

Number of Addresses	Symbolic Representation	Interpretation
3	OP A, B, C	A ← B OP C
2	OP A, B	A ← A OP B
1	OP A	AC ← AC OP A
0	OP	T ← (T − 1) OP T

Instruction Set Design

- **Operation repertoire**
  - Number of operations
  - Types of operations
  - Complexity of operations
- **Data types**
  - The various types of data upon which operations are performed
- **Instruction format**
  - **Instruction length, number of addresses, size of various fields etc.,**
- **Registers**
  - Number of processor registers that can be referenced by instructions, and their use
- **Addressing**
  - The mode or modes by which the address of an operand is specified.

Types of operands

- The type of the operand decides the meaning of the bit pattern
- The operands may be any one of the following four categories
  - Addresses
  - Numbers
  - Characters
  - Logical data

Operand type - Number

- Binary fixed point
- Binary floating point
- BCD
  - It avoids the binary to decimal conversion and vice versa
  - 4 bits are used to represent the numbers 0 -9 (0000 to 1001)
  - Remaining 6 combinations are not used
  - A byte may have two BCD numbers – Packed BCD
  - A 4 bit combination is used to indicate the sign
    - 1100 is used for positive & 1101 is used for negative
    - Added to the left or right most place of BCD stream.
  - Arithmetic operations are same as binary (decimal carry has to be considered)

Operand type - Character

- The characters are coded in binary to process text data
- International Reference Alphabet (or) American Standard Code for Information Interchange
  - 7 bit code – 128 pattern set has both printable and control characters
  - Decimal representation – 011XXXX
  - 8th bit may be either 0 or parity bit
- Extended Binary Coded Decimal Interchange Code
  - 8 bit code
  - Decimal compatible – 1111XXXX

Operand type - Logical

- The n bit vector may be considered as n one bits
- Each bit is considered as a logical data
- Advantages:
  - Storing an array of Boolean type data is space efficient
  - Bits can be manipulated
  - Example : To convert IRA to decimal, extract the LSB four bits

Thank you