Master of Computer Applications

CAPOL403R01: Computer Organization & Architecture

Unit II: Lecture 2
Addressing Modes

Dr. D. MURALIDHARAN
Assistant Professor
School of Computing
SASTRA Deemed to be University

Addressing modes

- The operand address may be given in multiple ways
  - Only few bits in the instructions are allocated for operand
  - But many applications demand a large range of locations in main memory
  - Hence, the address information is added to the instruction in different ways or different modes

- Addressing modes convey the address information of operand
  - It is used to calculate the “Effective Address”
  - Effective address is the address of the operand

Frequently used addressing modes…

- Immediate
- Direct
- Indirect
- Register
- Register indirect
- Displacement
- Stack

Immediate addressing mode

- The operand value is in the instruction
  - Operand = A; where A is the content of the address field in the instruction
- It can be used to define and use constants
- It can be used to set initial values of variables
- Usually, the number is stored in 2's complement form
  - The sign bit is extended to the left to the full data word size when loaded on a data register
- And other times, the number is considered as a non-negative unsigned integer

Immediate addressing mode…

- Advantage
  - No memory reference is needed
- Disadvantage
  - The data size is limited to the size of the address field
  - In most machines, the address field is small compared with wordlength

Direct addressing mode

- The memory address of the operand is given in the instruction
  - EA = A
  - Operand = (A)
- This addressing mode is not common in contemporary computers
- Advantage
  - It requires only one memory access
- Disadvantage
  - Only 2^K memory locations can be referenced when the number of bits in the address field is K

Indirect addressing mode

- In this addressing, the effective memory address is the content of the memory address which is in the instruction
  - EA = (A)
  - Operand = (EA)
- Advantage
  - When the word length is N, 2^N memory locations can be referenced
- Disadvantage
  - Two memory references are needed
    - One to find the effective address and the other is to transfer the data
- Variant
  - Cascaded or multilevel indirect addressing;
  - EA = (…(A)…)

Register addressing mode

- The address field refers to a processor register
- Operand = (R)
- Advantages
  - No memory reference is needed
  - As few registers are available, only a small address field is needed in the instruction
- Disadvantage
  - The addressing range is limited to the number of user accessible registers

Register indirect addressing mode

- The content of the register is the effective address
  - EA = (R)
  - Operand = (EA)

- Advantages
  - Only one memory access
  - The address range is 2^N
  - Operand field may be kept small in the instruction set

- Disadvantage
  - Two steps are needed to fetch the data and a memory access is needed

Displacement addressing mode

- It is the combination of a direct addressing and an indirect (register) addressing
  - EA = A + (R)

- Two address fields are available in the instruction
  - The value contained in one address field is used directly
  - The other address field implicitly points a register
  - The register is decided based on the opcode
  - The content of the register is added with the direct address to form the effective address

Displacement addressing mode - Types

- Relative addressing
  - The implicit register is PC
  - Hence, it is also called as PC relative addressing
  - The next instruction address is added with the direct address to produce EA
  - Typically the address field is represented as a 2’s complement number
  - Hence, the EA is a displacement relative to the address of the instruction
  - When the operand is near to the instruction, this addressing mode saves the address bits in the instruction

Displacement addressing mode - Types

- Base – register addressing
  - The referenced register has a main memory address
  - The address field has the displacement number from that address
  - The referenced register is called as the “base register” and the address is called as the “offset”
  - It utilizes memory segmentation effectively
  - When ‘n’ registers are used to hold ‘n’ different base addresses, then one address actually points ‘n’ different locations
  - When the address length is ‘k’ bits, then ‘n’ areas of 2^k words can be referenced using a single instruction

Displacement addressing mode - Types

- Indexing
  - The address field represents a base address
  - The register has the displacement from that address
    - The register is called as “index register”
  - This mode is mainly used for iterative operations
    - At those time the mode is also called as “auto indexing mode”
    - EA = A + (R) and then (R) = (R) + 1
- Post Indexing
  - Indirect addressing and indexing are combined
  - EA = (A) + (R)
- Pre indexing
  - EA = (A+(R))

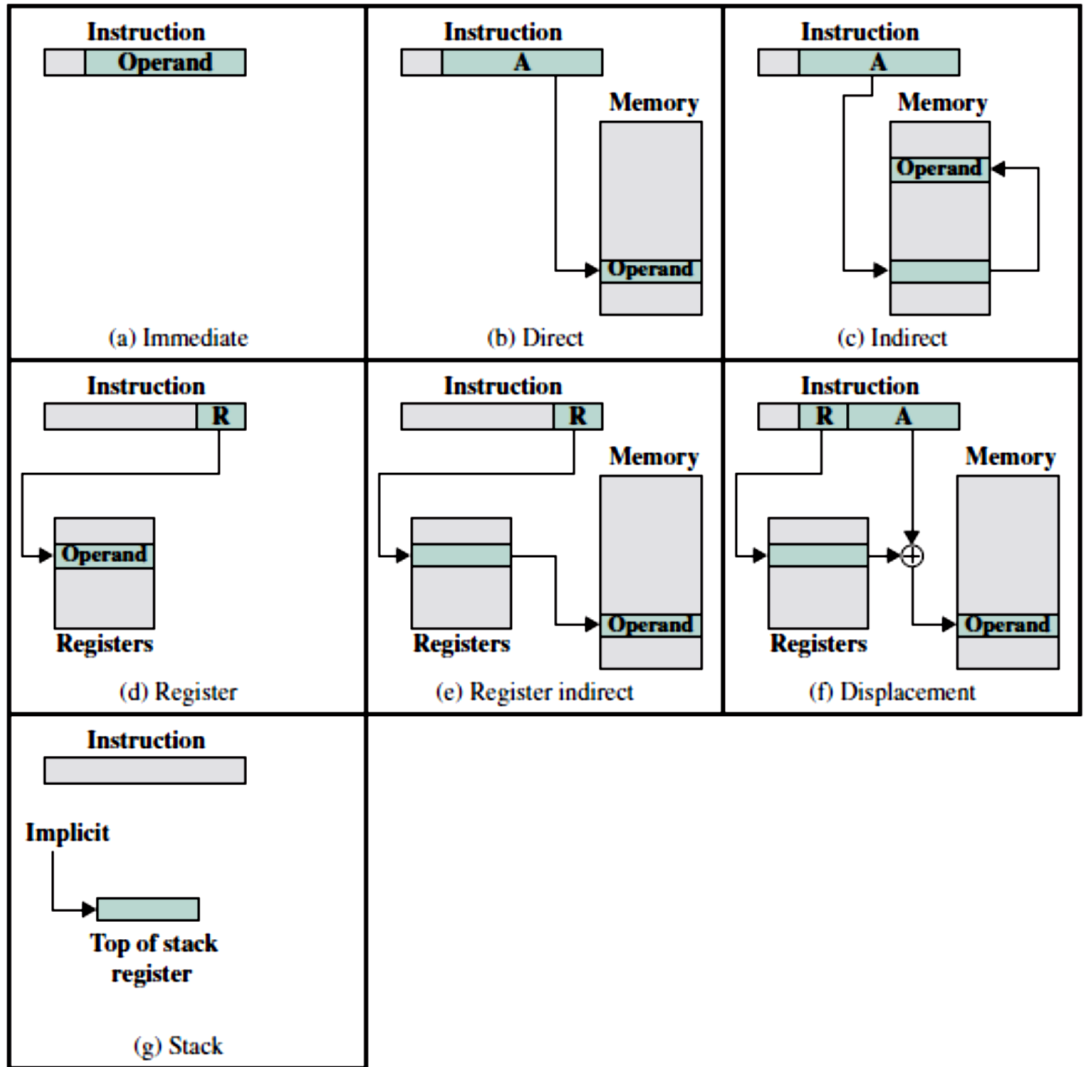
Stack Addressing Mode

- A stack is a linear array of locations
- It is also called as a *pushdown list* or *last-in-first-out queue.*
- The stack is a reserved block of locations
- Items are appended to the top of the stack
- Associated with the stack is a pointer whose value is the address of the top of the stack
- The stack pointer is maintained in a register
  - References to stack locations in memory are in fact register indirect addresses
- The stack mode of addressing is a form of implied addressing
- The machine instructions need not include a memory reference
  - They implicitly operate on the top of the stack

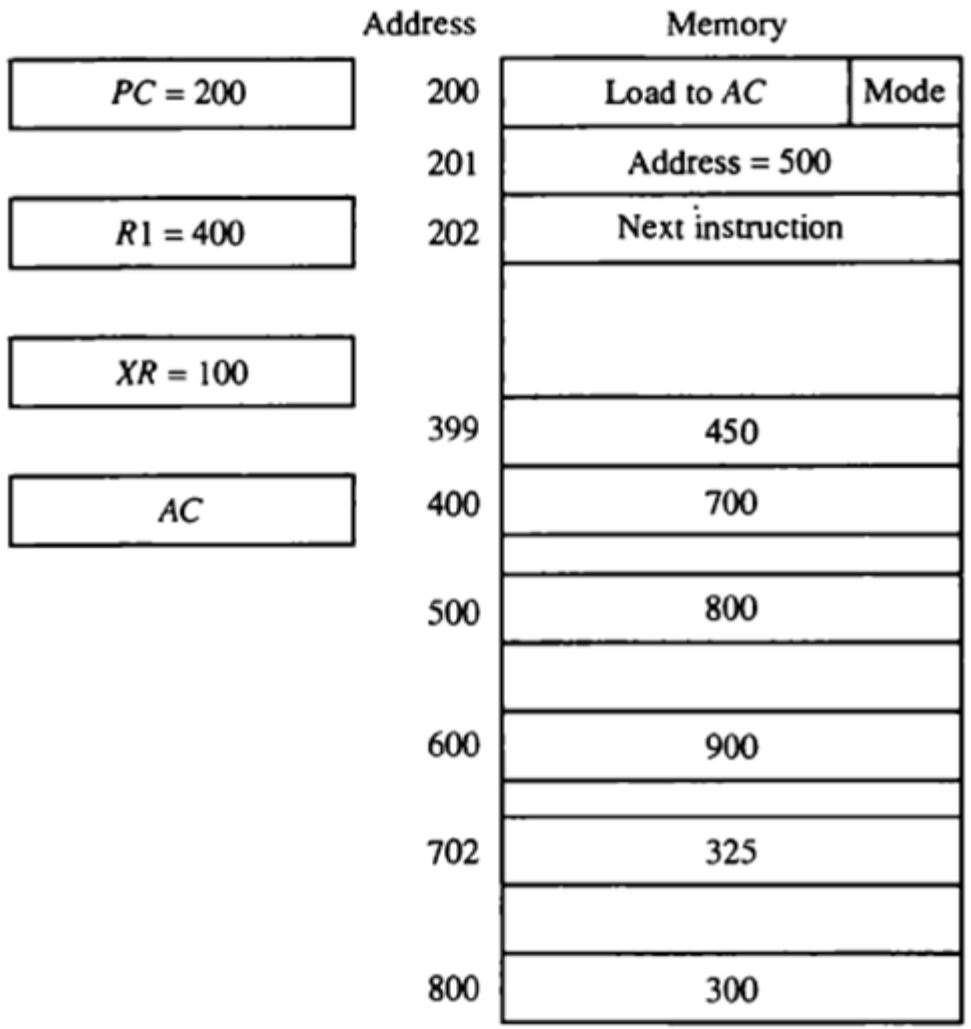
Summary of the addressing modes

Mode	Algorithm	Principal Advantage	Principal Disadvantage
Immediate	Operand = A	No memory reference	Limited operand magnitude
Direct	EA = A	Simple	Limited address space
Indirect	EA = (A)	Large address space	Multiple memory references
Register	EA = R	No memory reference	Limited address space
Register indirect	EA = (R)	Large address space	Extra memory reference
Displacement	EA = A + (R)	Flexibility	Complexity
Stack	EA = top of stack	No memory reference	Limited applicability

Summary of the addressing modes



Numerical Exercise



Addressing mode	Effective address	Content of AC
Immediate	201	500
Direct	500	800
Indirect	800	300
Register	R1	400
Register indirect	400	700
Displacement (Relative)	702	325
Displacement (Base register addressing XR is base register)	600	900
Stack addressing	ST	[ST]

Thank you