MODULE 6: Instruction Set Architecture

Lecture 6.3
Addressing

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Lecture 6.3 Objectives

- Explain the motivation for an instruction architecture to support multiple addressing modes

- Describe the operation of common addressing modes:

  - Immediate

  - Direct

  - Register

  - Indirect

  - Register indirect

  - Indexed or based

Motivation for Addressing Modes

- Different addressing modes can be used to reference memory locations and operands

- Provides both efficiency and clarity in coding at the assembly language level

- Provides efficiency in execution at the machine code level

- Example (fictitious):

```
ADD        R1,R2,R4    ! Address of next element
LOAD       R4,R5       ! R5 := next element
```

can be re-written using just one instruction

```
LOAD       R1+R2,R5    ! %r5 := next element
```

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Some Notation

X: the value X

(Rn):   the contents of register Rn

M[X]:   memory location with address X

(M[X]):   the contents of the memory location with address X

General Addressing Modes

Addressing Mode	Syntax	Meaning
Immediate	#X	X
Direct	X	(M[X])
Register	Rn	(Rn)
Indirect	(X)	(M[(M[X])])
Register Indirect	(Rn)	(M[(Rn)])
Indexed or Based	(Rm + X)	(M[(Rm) + X])
Stack		(M[(SP)])

There are other variations

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Immediate Addressing Mode

- The instruction contains the operand value

- Operand value must be known at assembly time since it is part of the instruction

- Example:

  - ADD #-4,R4 – Immediate operand negative 4 is added to the contents of R4

Addressing Mode	Syntax	Meaning
Immediate	#X	X

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Direct Addressing Mode

- Instruction contains the address of the operand

- Address must be known at assembly time

- Example:

    - LOAD 800,R1

Addressing Mode	Syntax	Meaning
Direct	X	(M[X])

Register Addressing Mode

- Instruction specifies a register and the register contains the operand value

- Example:
  - ADD #5,R1 – Contents of R1 are used as an operand

Addressing Mode	Syntax	Meaning
Register	Rn	(Rn)

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Explain the motivation for an instruction architecture to support multiple addressing modes

- Describe the operation of Immediate, Direct, and Register Addressing modes

If you have any difficulties, please review the lecture video before continuing.

Indirect Addressing Mode

- Instruction contains the address of a pointer stored in memory that points to the operand

- Pointer address must be known at assembly time, but the operand address can be changed dynamically by changing the contents of the pointer

- Not commonly implemented since it requires two accesses to memory

  - First access to retrieve contents of pointer

  - Second access, using pointer contents as the address, to load or store operand

Indirect Addressing Mode (2)

- Example:

  - ADD (800),R1 – Contents of memory location 800 used to address a memory location; contents of that location are added to R1 and stored in R1

Addressing Mode	Syntax	Meaning
Indirect	(X)	(M[(M[X])])

Register Indirect Addressing Mode

- Instruction specifies a register and the register contains the memory address of the operand

- Allows location of operand to be changed at execution time

- Unlike the standard indirect (or memory indirect) addressing mode, requires just one access to memory

- Example

  - LOAD (R1),R2   -- Contents of R1 used to address memory; contents of the memory location moved to R2

Addressing Mode	Syntax	Meaning
Register Indirect	(Rn)	M[(Rn)]

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Based or Indexed Addressing Mode

- Instruction specifies an operand and a register, with the sum of the operand and the register contents specifying the memory address of the operand

- Indexed addressing

  - Operand specifies a block of memory and the register is incremented (or decremented) to index into the block

  - Need long operand and short index register value

- Based addressing

  - Register specifies a block of memory (the base) and the operand provides an offset in the base

  - Need long base register and short operand as offset

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Based or Indexed (2)

- Example
    - LOAD (R1+800),R2 – 800 is added to the contents of R1 to determine memory location; contents of memory location are stored in R2

Addressing Mode	Syntax	Meaning
Indexed or Based	(Rm + X)	(M[(Rm) + X])

Instruction Implications

- The machine instruction (and, hence, assembly instructions) has to specify the addressing mode to be used

- This can be implied by the operation, for example…

  - LOAD 800,R1 for direct addressing

  - LOADI 800,R1 for immediate addressing

- This can be specified by a field in the machine instruction and by special syntax in the assembly statement, for example:

  - LOAD 800,R1 for direct addressing

  - LOAD #800,R1 for immediate addressing

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Describe the operation of Indirect, Register Indirect, and Based or Indexed Addressing modes

If you have any difficulties, please review the lecture video before continuing.

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Summary

- Examined general addressing modes

    - Immediate

    - Direct

    - Register

    - Indirect

    - Register indirect

    - Indexed or based

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