
Master of Computer Applications

CAPOL403R01: Computer Organization & Architecture

Unit II: Lecture 3
Instruction Formats

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

Instruction Format

- It defines the layout of the bits of an instruction, in terms of its constituent fields.
- An instruction format must include an opcode
- It includes zero or more operands
- The operands are given either implicitly or explicitly
- Each explicit operand is referenced using one of the addressing modes
- The format must, implicitly or explicitly, indicate the addressing mode for each operand
- Most instruction sets use more than one instruction format

Key design issues – Instruction length

- Instruction Length affects, and is affected by,
 - Memory size
 - Memory organization
 - Bus structure
 - Processor complexity
 - Processor speed
- Powerful instruction set / Space
 - A 64-bit instruction occupies twice the space of a 32-bit instruction but is probably less than twice as useful

Key design issues – Instruction length...

- Relationship between instruction length and memory-transfer length
 - Either both should be equal or one is a multiple of the other
- Memory transfer rate
 - If it is low then memory will be the bottleneck to the performance
 - 32 bit instructions will be fetched twice the rate of 64 bit instructions
 - Hence, performance may demand low instruction length
- Instruction length should be a multiple of the character length
- Instruction length should be a multiple of the length of the fixed point number

Key design issues – Allocation of bits

- Number of opcodes
 - Affects the address field
 - Variable instruction format is a solution
- Number of addressing modes
 - Addressing mode may be either implicit or explicit
 - If explicit, one or more bits should be allocated
- Number of operands
 - Few operands in instruction lead to a lengthy program
 - Typical instructions have two operand address fields
 - These operands may need the addressing mode indicator

Key design issues – Allocation of bits

- Register versus memory
 - Fewer bits are needed when going towards register addressing
 - Contemporary machines have at least 32 user visible registers
- Number of register sets
 - Most contemporary machines have one set of general purpose registers
 - Some architectures have a collection of two or more specialized sets
 - The advantage of the second one is, fewer bits are needed for a particular operation
 - For example, with two sets of 8 registers, only 3 bits are needed in the instruction

Key design issues – Allocation of bits

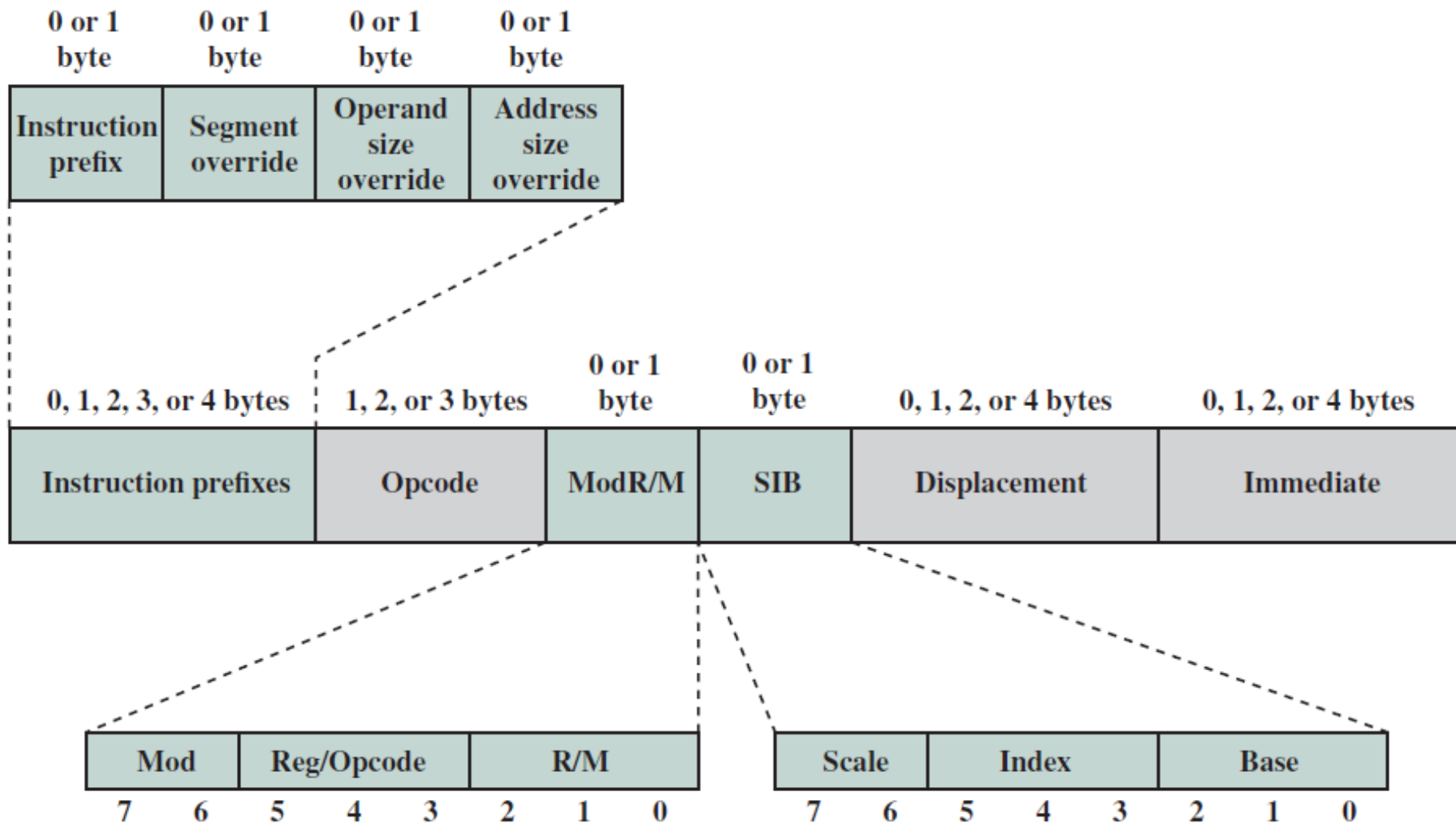
- Address range

- The range of addresses that can be referenced is related to the number of address bits
- Direct addressing is rarely used by contemporary machines
- Range in displacement addressing depends on the length of the address register
- Still, it is convenient to allow more bits in the address field to allow large displacements from the register address

- Address granularity

- A memory with 16- or 32- bit words, an address can reference a word or a byte
- Byte addressing is convenient for character manipulation but needs more address bits

Example: Instruction format of x86 processor



Instruction prefixes

- Instruction prefix
 - LOCK or one of the repeat prefixes
- Segment override
 - Override the default segment and tell about the segment used by the instruction
- Operand size
 - An instruction has a default operand size of 16 or 32 bits
 - The operand prefix switches between these two operand sizes
- Address size
 - The processor can address the memory using either 16 or 32 bit addresses
 - The address size determines the displacement size in instructions
 - It decides the size of the address offsets generated during address calculations
 - This prefix switches between 16- and 32- bit address generation

Instruction fields

- Opcode
 - This field is 1,2 or 3 byte wide
 - It includes bit to specify the data width
 - It tells about whether the immediate data must be sign extended or not
- ModR/M
 - It and SIB provides addressing information
 - It tells about the location of operand – register or memory
 - Mod field with R/M is used to form 32 values
 - 8 registers and 24 indexing modes
 - Reg/opcode points a register or provides 3 more bits for opcode

Instruction fields

- SIB

- Certain encoding of the ModR/M specifies the inclusion of this byte
- Scale field specifies the scale factor for scaled indexing
- Index field specifies the index register
- Base field specifies the base register

- Displacement

- When it is used an 8-, 16- or 32- bit signed displacement values is added

- Immediate

- It provides the value of 8-, 16- or 32- bit operand

Thank you