

William Stallings

Computer Organization and Architecture

Chapter 15

Micro-programmed Control

Micro-programmed Control

- ⌘ Use sequences of instructions (see earlier notes) to control complex operations
- ⌘ Called micro-programming or firmware

Implementation (1)

- ⌘ All the control unit does is generate a set of control signals
- ⌘ Each control signal is on or off
- ⌘ Represent each control signal by a bit
- ⌘ Have a control word for each micro-operation
- ⌘ Have a sequence of control words for each machine code instruction
- ⌘ Add an address to specify the next micro-instruction, depending on conditions

Implementation (2)

⌘ Today's large microprocessor

- ☒ Many instructions and associated register-level hardware
- ☒ Many control points to be manipulated

⌘ This results in control memory that

- ☒ Contains a large number of words
 - ☒ co-responding to the number of instructions to be executed
- ☒ Has a wide word width
 - ☒ Due to the large number of control points to be manipulated

Micro-program Word Length

⌘ Based on 3 factors

- ☑ Maximum number of simultaneous micro-operations supported
- ☑ The way control information is represented or encoded
- ☑ The way in which the next micro-instruction address is specified

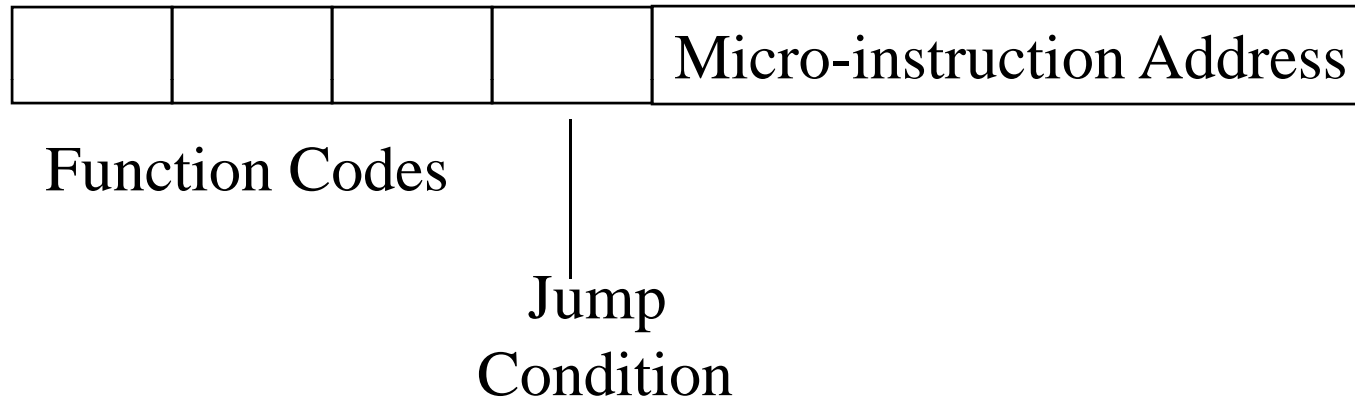
Micro-instruction Types

- ⌘ Each micro-instruction specifies single (or few) micro-operations to be performed
 - ☐ (*vertical* micro-programming)
- ⌘ Each micro-instruction specifies many different micro-operations to be performed in parallel
 - ☐ (*horizontal* micro-programming)

Vertical Micro-programming

- ⌘ Width is narrow
- ⌘ n control signals encoded into $\log_2 n$ bits
- ⌘ Limited ability to express parallelism
- ⌘ Considerable encoding of control information requires external memory word decoder to identify the exact control line being manipulated

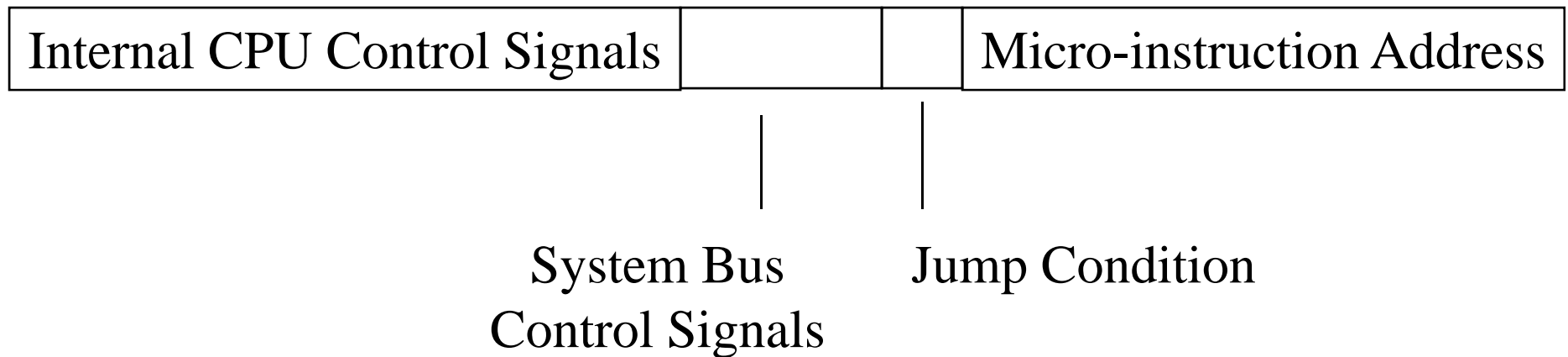
Vertical Micro-programming diag



Horizontal Micro-programming

- ⌘ Wide memory word
- ⌘ High degree of parallel operations possible
- ⌘ Little encoding of control information

Horizontal Micro-programmed diag



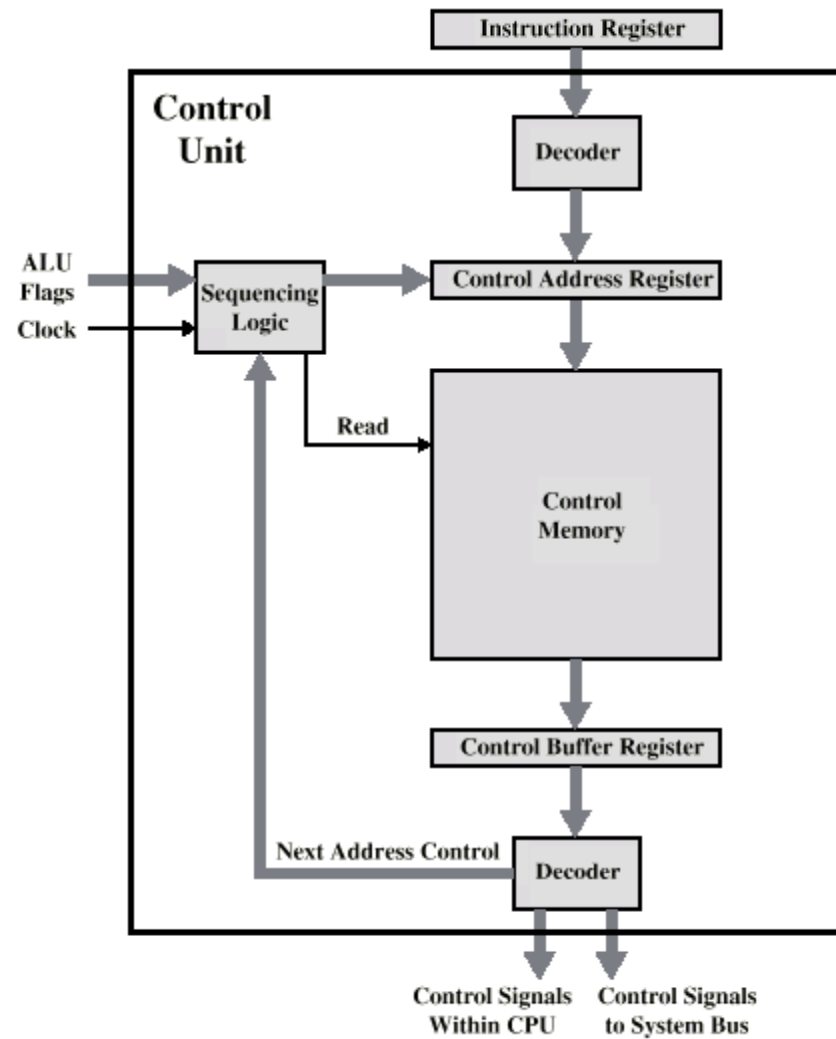
Compromise

- ⌘ Divide control signals into disjoint groups
- ⌘ Implement each group as separate field in memory word
- ⌘ Supports reasonable levels of parallelism without too much complexity

Control Memory

· Jump to Indirect or Execute	Fetch cycle routine
· Jump to Execute	Indirect Cycle routine
· Jump to Fetch	Interrupt cycle routine
Jump to Op code routine	Execute cycle begin
· Jump to Fetch or Interrupt	AND routine
· Jump to Fetch or Interrupt	ADD routine

Control Unit



Control Unit Function

- ⌘ Sequence login unit issues read command
- ⌘ Word specified in control address register is read into control buffer register
- ⌘ Control buffer register contents generates control signals and next address information
- ⌘ Sequence login loads new address into control buffer register based on next address information from control buffer register and ALU flags

Advantages and Disadvantages

⌘ Simplifies design of control unit

☑ Cheaper

☑ Less error-prone

⌘ Slower

Tasks Done By Microprogrammed Control Unit

- ⌘ Microinstruction sequencing
- ⌘ Microinstruction execution
- ⌘ Must consider both together

Design Considerations

- ⌘ Size of microinstructions

- ⌘ Address generation time

- ☒ Determined by instruction register

- ☒ Once per cycle, after instruction is fetched

- ☒ Next sequential address

- ☒ Common in most designed

- ☒ Branches

- ☒ Both conditional and unconditional

Sequencing Techniques

- ⌘ Based on current microinstruction, condition flags, contents of IR, control memory address must be generated
- ⌘ Based on format of address information
 - ☑ Two address fields
 - ☑ Single address field
 - ☑ Variable format

Address Generation

⌘ Explicit

Implicit

⌘ Two-field

Mapping

⌘ Unconditional Branch

Addition

⌘ Conditional branch

Residual control

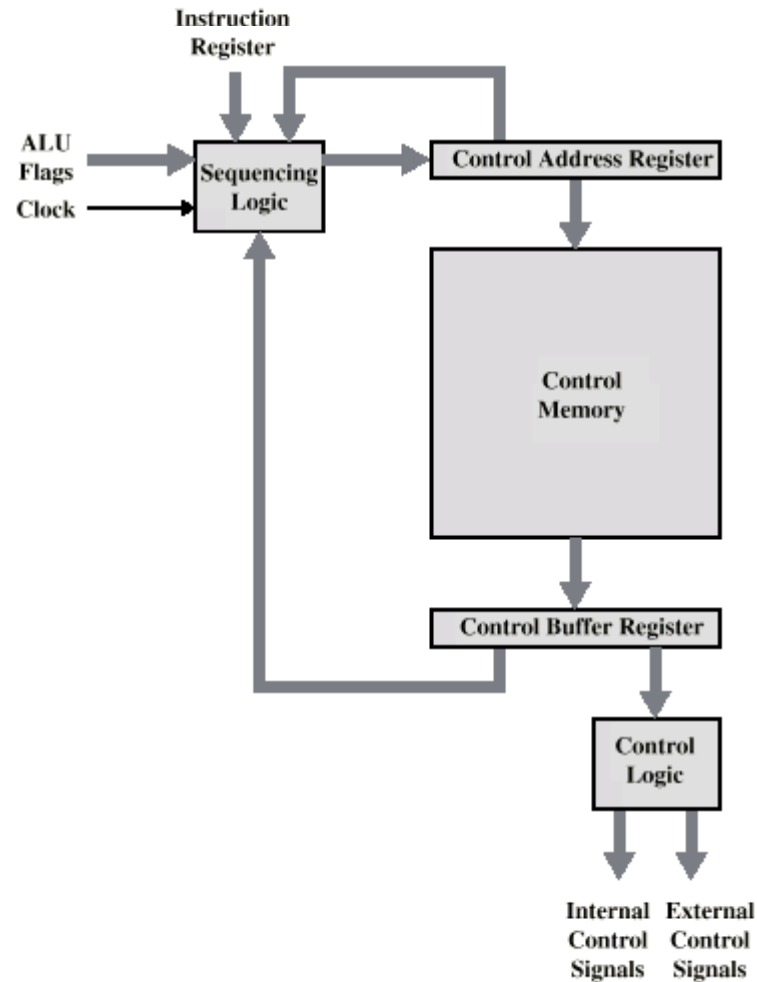
Execution

- ⌘ The cycle is the basic event
- ⌘ Each cycle is made up of two events
 - ⊞ Fetch
 - ⊞ Determined by generation of microinstruction address
 - ⊞ Execute

Execute

- ⌘ Effect is to generate control signals
- ⌘ Some control points internal to processor
- ⌘ Rest go to external control bus or other interface

Control Unit Organization



Required Reading

⌘ Stallings chapter 15