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Computer Organization and Architecture

Chapter 10

Instruction Sets:

Addressing Modes

and Formats

Addressing Modes

- ⌘ Immediate
- ⌘ Direct
- ⌘ Indirect
- ⌘ Register
- ⌘ Register Indirect
- ⌘ Displacement (Indexed)
- ⌘ Stack

Immediate Addressing

- ⌘ Operand is part of instruction
- ⌘ Operand = address field
- ⌘ e.g. ADD 5
 - ☑ Add 5 to contents of accumulator
 - ☑ 5 is operand
- ⌘ No memory reference to fetch data
- ⌘ Fast
- ⌘ Limited range

Immediate Addressing Diagram

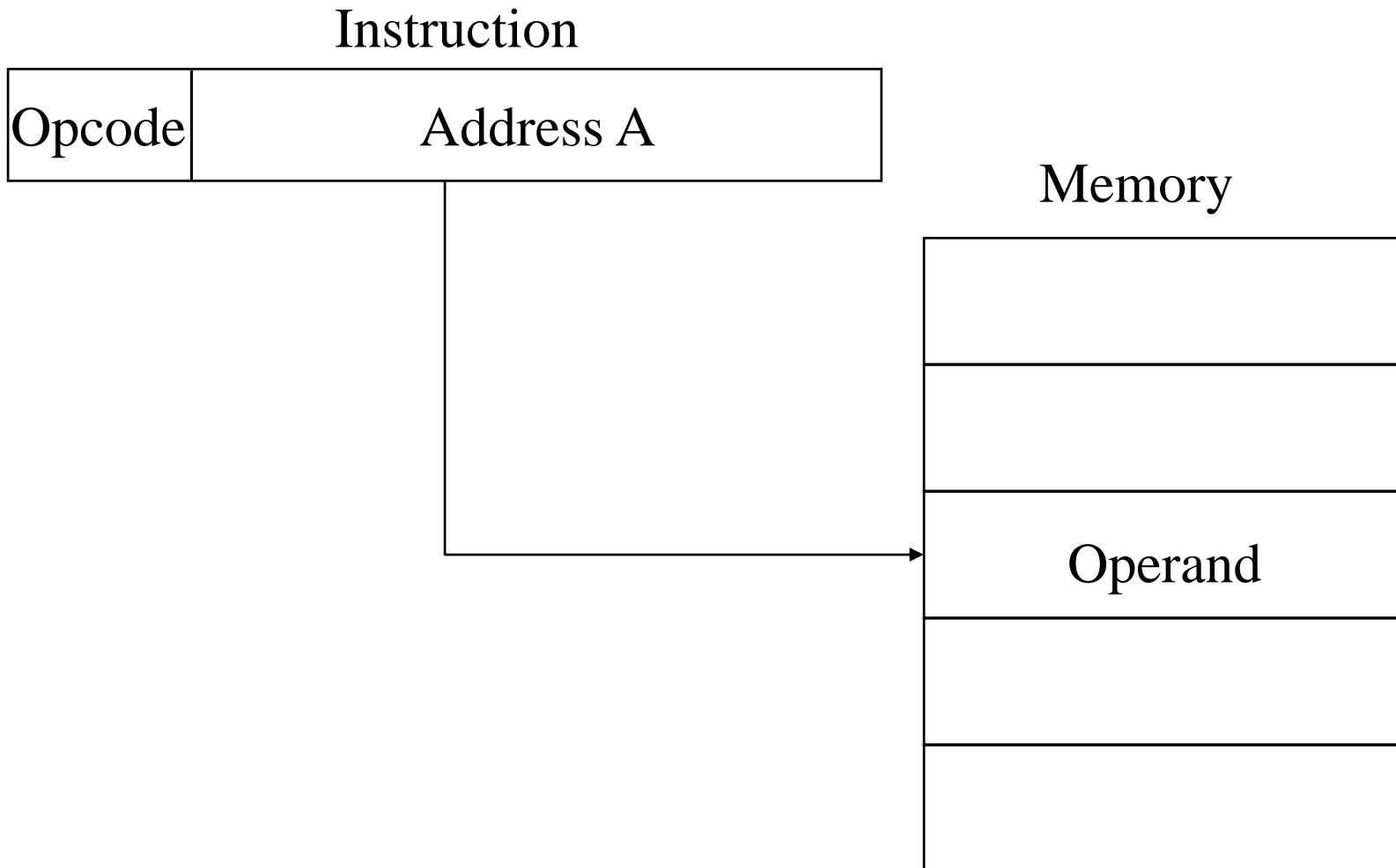
Instruction



Direct Addressing

- ⌘ Address field contains address of operand
- ⌘ Effective address (EA) = address field (A)
- ⌘ e.g. ADD A
 - ⊠ Add contents of cell A to accumulator
 - ⊠ Look in memory at address A for operand
- ⌘ Single memory reference to access data
- ⌘ No additional calculations to work out effective address
- ⌘ Limited address space

Direct Addressing Diagram



Indirect Addressing (1)

⌘ Memory cell pointed to by address field contains the address of (pointer to) the operand

⌘ $EA = (A)$

☑ Look in A, find address (A) and look there for operand

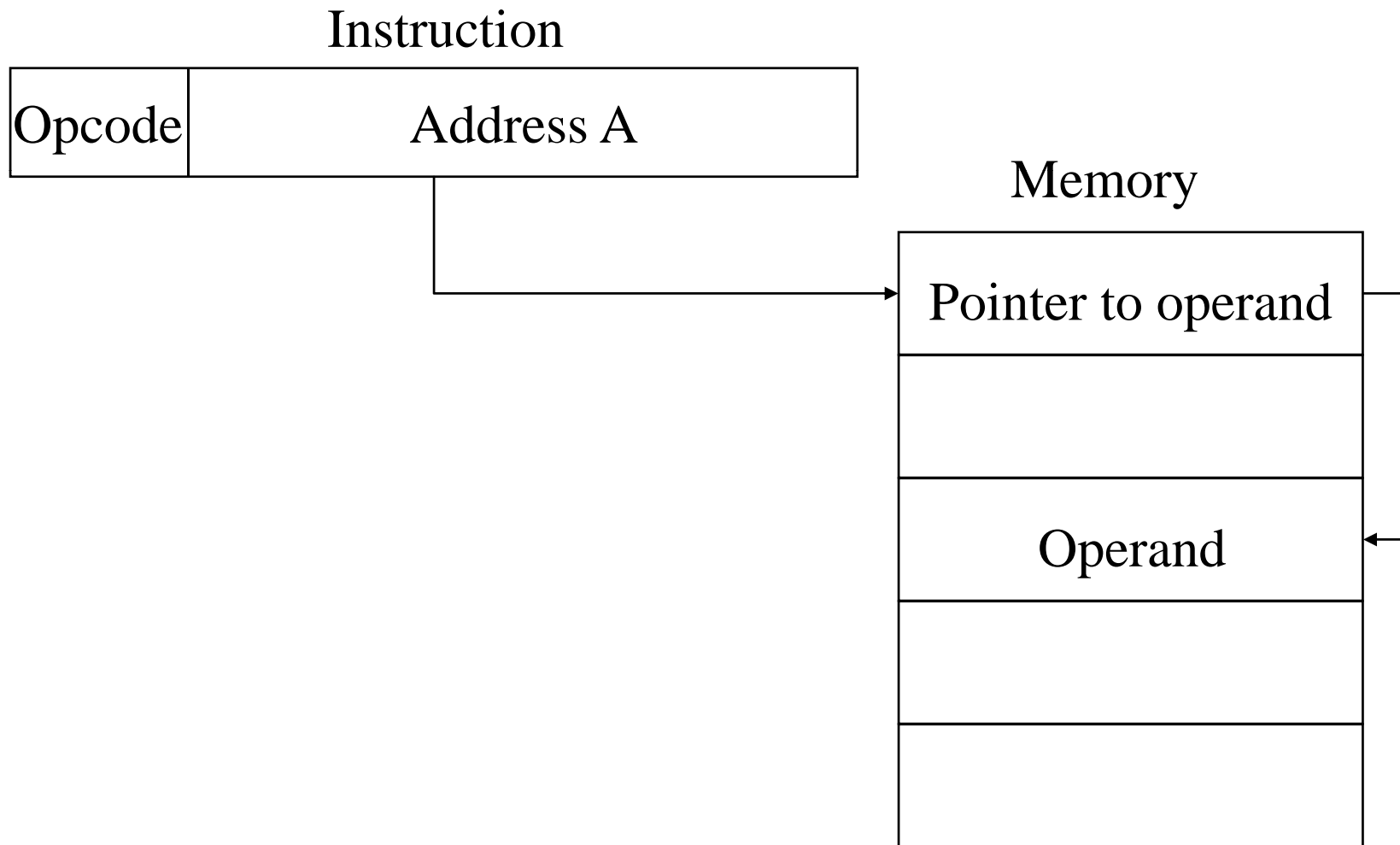
⌘ e.g. ADD (A)

☑ Add contents of cell pointed to by contents of A to accumulator

Indirect Addressing (2)

- ⌘ Large address space
- ⌘ 2^n where n = word length
- ⌘ May be nested, multilevel, cascaded
 - ⌘ e.g. $EA = ((A))$
 - ⌘ Draw the diagram yourself
- ⌘ Multiple memory accesses to find operand
- ⌘ Hence slower

Indirect Addressing Diagram



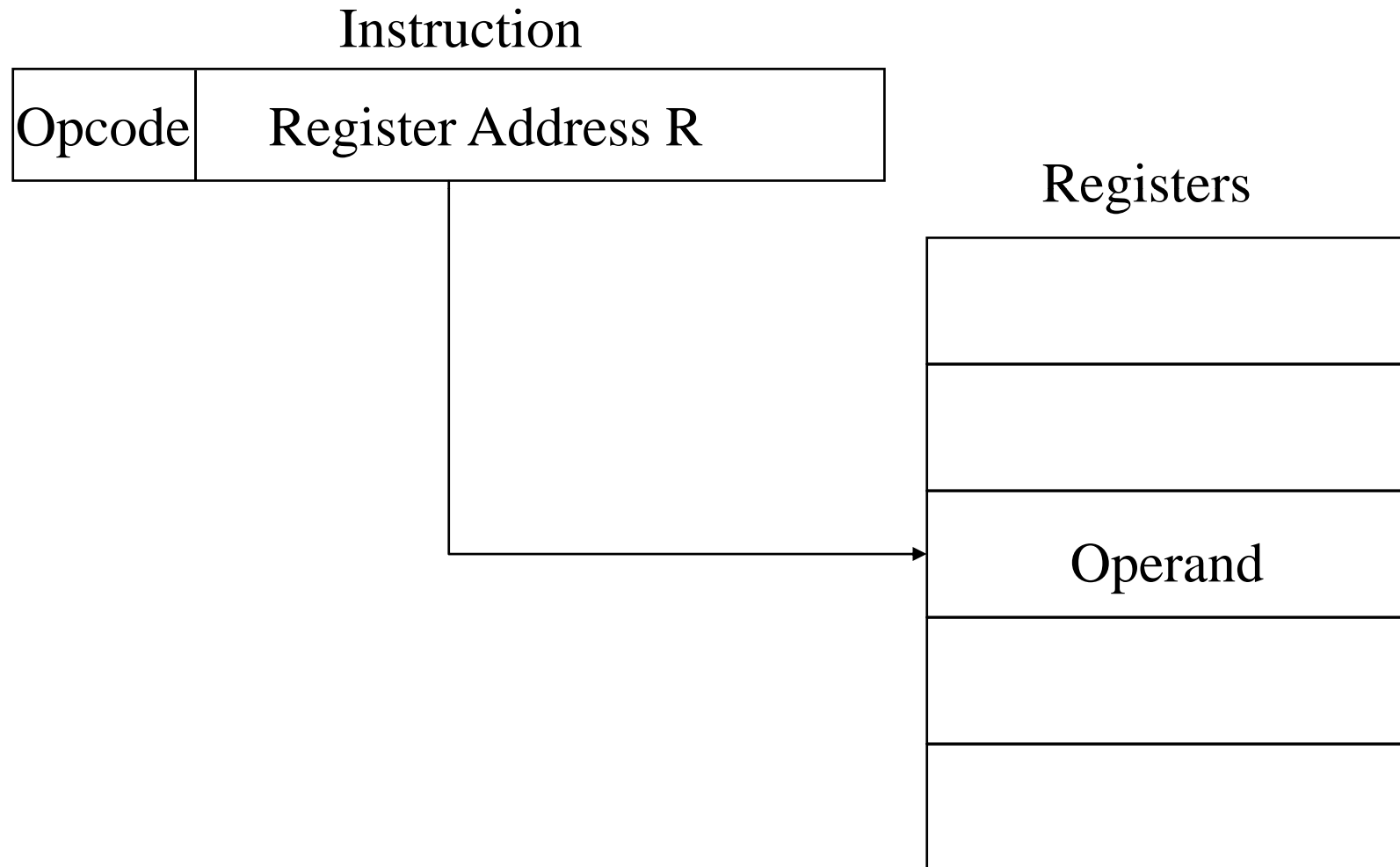
Register Addressing (1)

- ⌘ Operand is held in register named in address field
- ⌘ $EA = R$
- ⌘ Limited number of registers
- ⌘ Very small address field needed
 - ☑ Shorter instructions
 - ☑ Faster instruction fetch

Register Addressing (2)

- ⌘ No memory access
- ⌘ Very fast execution
- ⌘ Very limited address space
- ⌘ Multiple registers helps performance
 - ⊠ Requires good assembly programming or compiler writing
 - ⊠ N.B. C programming
 - ⊠ register int a;
- ⌘ c.f. Direct addressing

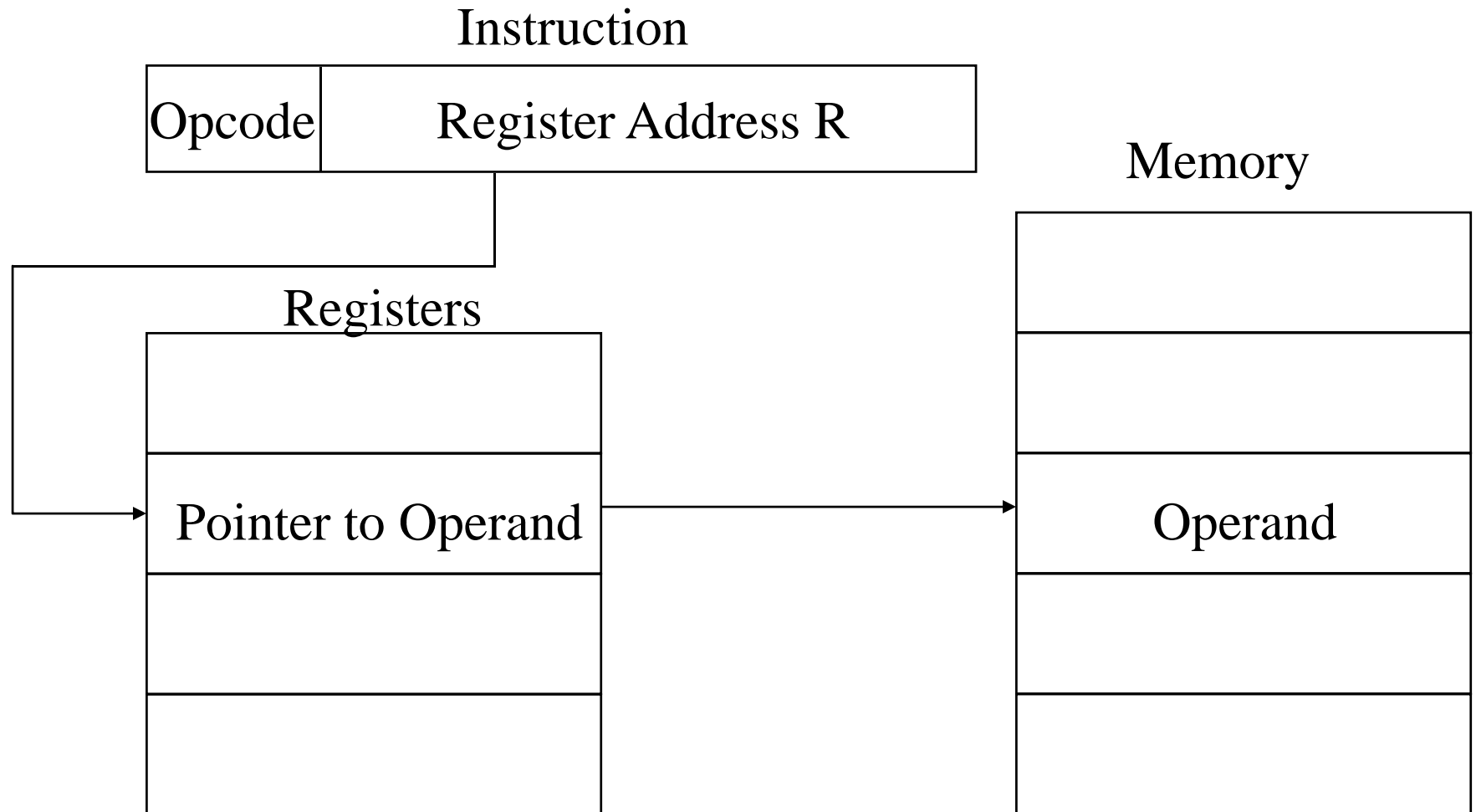
Register Addressing Diagram



Register Indirect Addressing

- ⌘ C.f. indirect addressing
- ⌘ $EA = (R)$
- ⌘ Operand is in memory cell pointed to by contents of register R
- ⌘ Large address space (2^n)
- ⌘ One fewer memory access than indirect addressing

Register Indirect Addressing Diagram



Displacement Addressing

⌘ $EA = A + (R)$

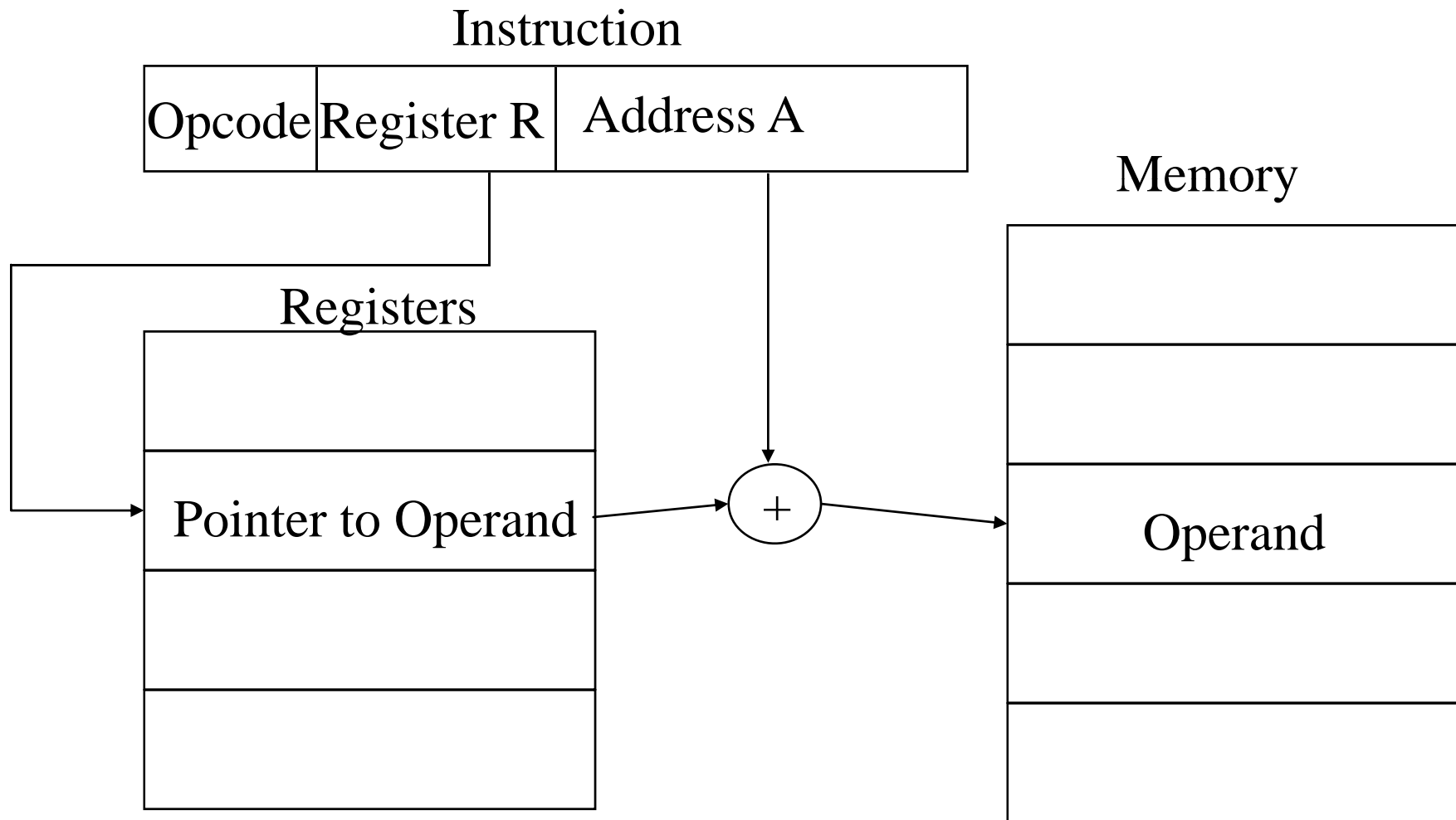
⌘ Address field hold two values

☑ A = base value

☑ R = register that holds displacement

☑ or vice versa

Displacement Addressing Diagram



Relative Addressing

- ⌘ A version of displacement addressing
- ⌘ $R = \text{Program counter, PC}$
- ⌘ $EA = A + (PC)$
- ⌘ i.e. get operand from A cells from current location pointed to by PC
- ⌘ c.f locality of reference & cache usage

Base-Register Addressing

- ⌘ A holds displacement
- ⌘ R holds pointer to base address
- ⌘ R may be explicit or implicit
- ⌘ e.g. segment registers in 80x86

Indexed Addressing

⌘ A = base

⌘ R = displacement

⌘ EA = A + R

⌘ Good for accessing arrays

☐ EA = A + R

☐ R++

Combinations

⌘ Postindex

⌘ $EA = (A) + (R)$

⌘ Preindex

⌘ $EA = (A + (R))$

⌘ (Draw the diagrams)

Stack Addressing

⌘ Operand is (implicitly) on top of stack

⌘ e.g.

⌘ ADD Pop top two items from stack
 and add

Instruction Formats

- ⌘ Layout of bits in an instruction
- ⌘ Includes opcode
- ⌘ Includes (implicit or explicit) operand(s)
- ⌘ Usually more than one instruction format in an instruction set

Instruction Length

⌘ Affected by and affects:

- ☑ Memory size
- ☑ Memory organization
- ☑ Bus structure
- ☑ CPU complexity
- ☑ CPU speed

⌘ Trade off between powerful instruction repertoire and saving space

Allocation of Bits

- ⌘ Number of addressing modes
- ⌘ Number of operands
- ⌘ Register versus memory
- ⌘ Number of register sets
- ⌘ Address range
- ⌘ Address granularity

Foreground Reading

⌘ Stallings chapter 10

⌘ Intel and PowerPC Web sites