Memory and Addressing

How and Where Information is Stored
What is Stored

Strings of bits  \( \text{word} = 32\) bits

a word may represent:

- an address in memory

- a value
  
  signed integer
  
  positive integer
  
  four characters

- an instruction
  
  interpreted according to instruction format (ISA)
Where Things are Stored

Registers on CPU

- general purpose registers (32)
- PC  Program Counter
  holds address of next instruction to be executed
- IR  Instruction Register
  holds current instruction

Memory

- A very very large array of memory locations
  byte addresses
  word (32 bits) addresses are multiples of 4
Addressing Modes

Purpose

- to find a value (operand)
- to find an instruction

Places where target or address can be found

- anywhere some bits can be
  - in the instruction
  - in a register
  - in memory
MIPS Addressing Modes

• Register Direct
  – value found in register

• Immediate
  – value is part of instruction

• Register Indirect with offset
  – value found in memory, address in register plus offset

• PC-relative
  – address of next instruction is offset plus PC

• (Pseudo-) Direct
  – address of next instruction is in current instruction
Register Direct

R-Type Instructions

| op | rs | rt | rd | ... | funct |

Register
**Immediate**

**Arithmetic/Logical Immediate Instructions**

<table>
<thead>
<tr>
<th>op</th>
<th>rs</th>
<th>rt</th>
<th>immediate</th>
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Register Indirect with Base
Load / Store Instructions

\[ \text{op} \quad \text{rs} \quad \text{rt} \quad \text{offset} \]

\[ \begin{align*}
\text{Register} & \quad + \\
\text{Memory} & \quad + \\
\end{align*} \]
PC-relative
Conditional Branch Instructions (beq, bne)
Pseudo-Direct
J-type (jump) Instructions

op address

PC

00

Memory