More on Instruction Sets

(including some moron instruction sets)

The MIPS instructions of Chapter 3 are summarized and unified. Alternative instructions from other architectures are discussed. An additional example, append to a list, is presented.

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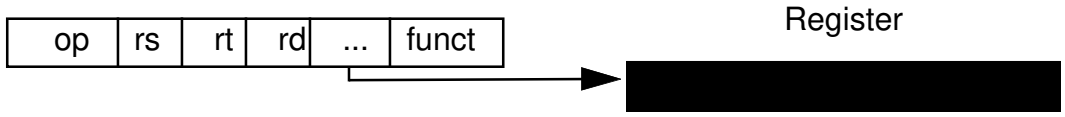
Addressing Modes

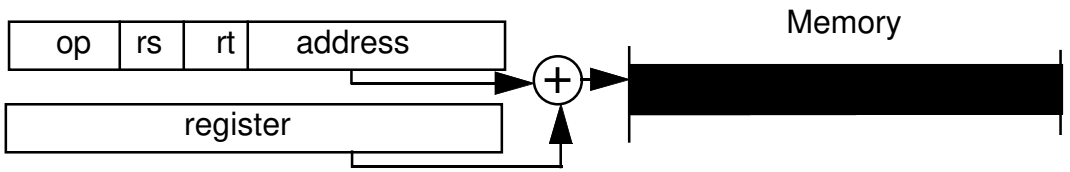
•The term "addressing modes" refers to the mechanisms computers use to refer to their operand values. MIPS has four addressing modes.

–Immediate addressing

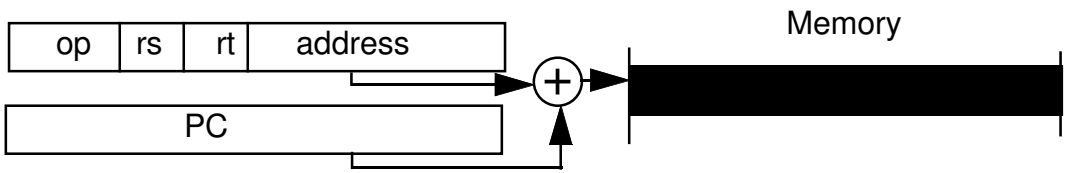
–Register addressing



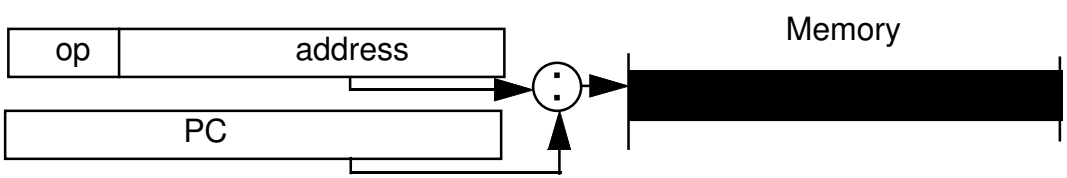
–Base/offset addressing



–PC-relative addressing



–Pseudodirect addressing



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Non Address Modes

- Two addressing modes that the MIPS doesn't have:
  - Base/displacement/index -- the operand address is found by adding two named registers to a field of the instruction; base/offset with a second register.
  - Stack addressing -- operand registers are assumed to be the top two items on a stack, which are removed during the operation and replaced by the result.

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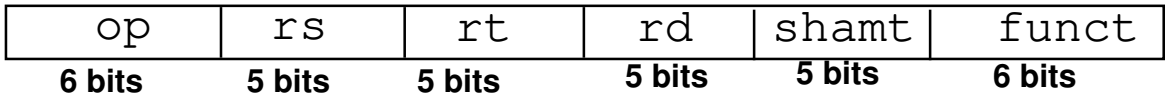
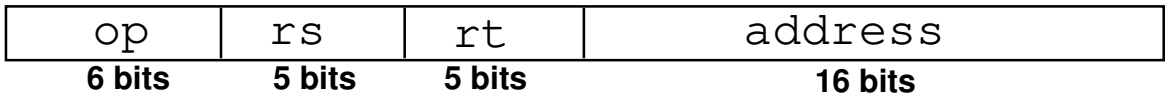
Instruction Formats

The format gives the structure of the bits of an instruction. The MIPS has three types:

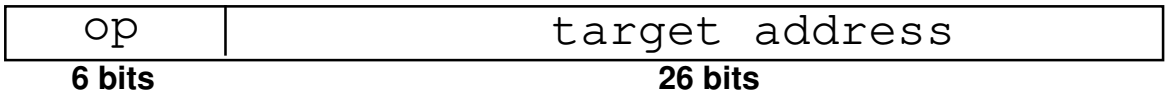
R-type



I-type



J-type



Instruction formats and addressing modes are related:

All Register addressing uses R-type instructions

Immediate addressing uses I-type

Base/offset addressing uses I-type

PC-relative addressing uses I-type and J-type instructions

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Other Instructions

Autoincrement/autodecrement: **`lwad $8, A($16)  #BOGUS`**

```
lw     $8,A($16) # Fetch A[$16]
addi   $16,$16,-4 # Reduce $16 index for next loc
```

Memory resident operands: **`subm $17,$17,A($16) #BOGUS`**

```
lw  $8, A($16)    # Fetch A[$16]
sub $17, $17, $8  # $17 = $17 - A[$16]
```

Increment/compare and branch: **`icb $16,$17,Loop #BOGUS`**

```
addi   $16,$16,1 # Bump $16
slt $8, $16, $17  # Set unless loop limit reached
bne $8, $0, Loop  # Iterate if limit not reached
```

Save Registers: **`savreg 16,31  #BOGUS`**

```
sw  $16, 0($29)   # Save register  16
sw  $17, 4($29)   # Save register  17
sw  $18, 8($29)   # Save register  18
```

•••

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Limitations of the MIPS

- The instruction set for the MIPS has some shortcomings that require multiple instructions just to form an address and reference a value. For example:
  - –Address field is only 16 bits -- limits base range
  - –Load/Store can have only one index register -- prevents use of offset, base, and index.
- Could the 16 bit address field be increased?
- Could a second index register be added?

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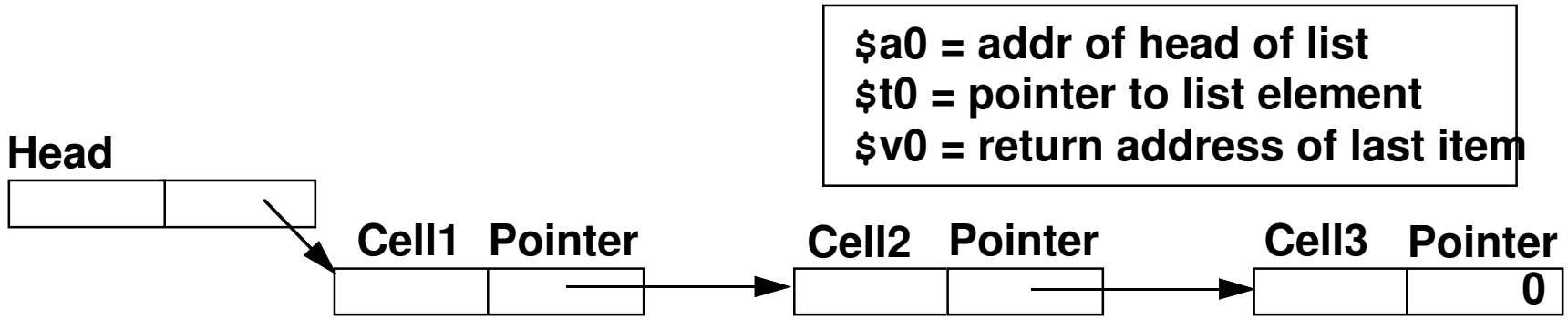
Example -- Appending

Postulate a forward linked list stored in memory:
Write a procedure that scans to find the last item in the list.
Use that procedure in another procedure to append to the list.




```
findend: add   $v0,$a0,$zero# Put head addr as return val
                            #   in case list is empty
gofwd:   lw    $t0,4($v0)    # Get addr of next item
         beq   $t0,$zero,done # If its nil, exit
         add   $v0,$t0,$zero # Move this as result register
                            #    as possible answer
         j     gofwd         # Keep looking
done:    jr    ra            # Return
```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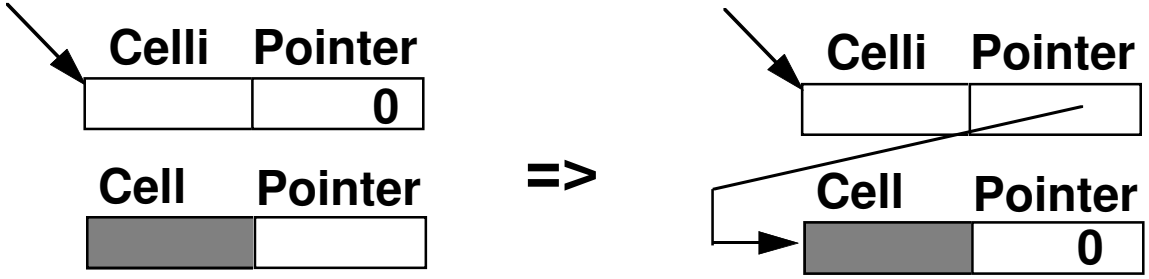
Now Append

Given the address of the head of the list ($a0), the address of an item to be appended ($a1), and the address of the last item ($v0), append it.




```
append: addi  $sp,$sp, -4   # Make space to save return
        sw    $ra,0($sp)    # Save return address
        jal   findend       # Locate last item
        sw    $a1, 4($v0)   # Link new cell
        sw    $zero, 4($a1) # Set pointer of last to nil
        lw    $ra, 0($sp)   # Recover the return  pointer
        addi  $sp, $sp, 4   #  pop stack pointer
        jr    $ra           #  and return
```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Design Goals

•A principle of computing is that computations on complex data can be realized by a program using smaller computations operating on alternate data representations.
•Applying this principle repeatedly implies computers can have a few very simple "hardwired" operations for binary values.
•Why does the MIPS instruction set look like this?
•Design principles:

-Smaller is faster

-Simplicity favors regularity

-Good design demands compromise

-Make the common case fast

			Frequency	
Category	**E.G.**	**Prog. Lang. Correspondence**	**GCC**	**Spice**
Arithmetic	add	Expressions, assignments	48%	50%
Data Xfer	lw	Data structure maniipulation	33%	41%
Branches	bne	If statements, looping	17%	8%
Jump	j, jal	Procedures/returns	2%	1%

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