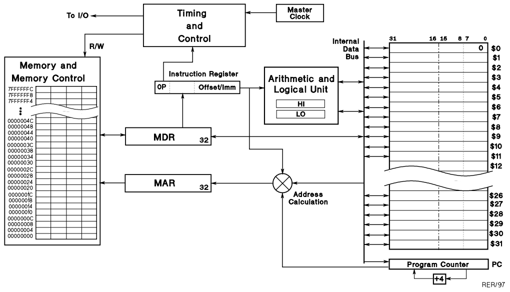
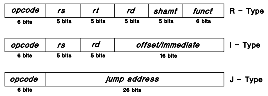
MIPS R2000 – Instruction Reference Card

Programmer's Model of the MIPS R2000 Microprocessor



• MIPS Binary Instruction Formats



opcode	*rs*	*rt*	*rd*	*shamt*	*funct*	R – Type
6 bits	5 bits	5 bits	5 bits	5 bits	6 bits	
opcode	*rs*	*rd*	*offset/immediate*			I – Type
6 bits	5 bits	5 bits	16 bits			
opcode	*jump address*					J – Type
6 bits	26 bits					

Fields in the instruction formats are:

- ***opcode*** - (6 bits)
- ***rs*** - (5 bits) first source register
- ***rt*** - (5 bits) second source register
- ***rd*** - (5 bits) destination register
- ***shamt*** - (5 bits) shift amount
- ***funct*** - (6 bits) additional opcode
- ***off/imm*** - (16 bits) immediate value/address offset
- ***jmp addr*** - (26 bits) jump address

• Addressing Modes Used with Load/Stores

Mode	Syntax	Effective Address
Relative	RSYMB	EA = [PC] + offset
Register Indirect	($*n*)	EA = [$*n*]
Base	offset($*n*)	EA = [$*n*] + offset

• Load/Store, Data Movement Instructions

Description	Opcode	Operand	Format
Load Address	`la`	rd, mem	†
Load Byte	`lb`	rd, mem	I
Load Byte Unsigned	`lbu`	rd, mem	I
Load Halfword	`lh`	rd, mem	I
Load Half Unsigned	`lhu`	rd, mem	I
Load Word	`lw`	rd, mem	I
Load Immediate	`li`	rd, imm	†
Load Upper Immed	`lui`	rd, imm	I
Store Word	`sw`	rs, mem	I
Store Halfword	`sh`	rs, mem	I
Store Byte	`sb`	rs, mem	I
Move	`move`	rd, rs	†

• Register Conventional Usage

Name	Register	Description/Usage
	$0	Hardwired constant 0
`$at`	$1	Reserved for assembler
`$v0-$v1`	$2-$3	Return results from functions
`$a0-$a3`	$4-$7	Used for subroutine arguments.
`$t0-$t7`	$8-$15	"Temporary," not saved across a call
`$s0-$s7`	$16-$23	"Saved," saved across a call
`$t8-$t9`	$24-$25	More temporary
`$k0-$k1`	$26-$27	"Kernel" - reserved for OS use
`$gp`	$28	Pointer to global data area
`$sp`	$29	Stack Pointer
`$fp`	$30	Frame pointer
`$ra`	$31	Return address of subroutine

• Arithmetic/Logical Instructions

Description	Opcode	Operand	Format
Add	`add`	rd, rs, rt	R
Add Immediate	`addi`	rd, rs, imm	I
Add Unsigned	`addu`	rd, rs, rt	R
Add Unsigned Immed	`addiu`	rd, rs, imm	I
Divide	`div`	rd, rs, rt	†
Divide Unsigned	`divu`	rd, rs, rt	†
Multiply	`mul`	rd, rs, rt	†
Multiply Unsigned	`mulu`	rd, rs, rt	†
Negate	`neg`	rd, rs	†
Remainder	`rem`	rd, rs, rt	†
Subtract	`sub`	rd, rs, rt	R
Subtract Unsigned	`subu`	rd, rs, rt	R
And	`and`	rd, rs, rt	R
And Immediate	`andi`	rd, rs, imm	I
Nor	`nor`	rd, rs, rt	R
Not	`not`	rd, rs	†
Or (Inclusive)	`or`	rd, rs, rt	R
Or Immediate	`ori`	rd, rs, imm	I
eXclusive OR	`xor`	rd, rs, rt	R
eXclusive OR Immed	`xori`	rd, rs, imm	I

• Branch/Jump Instructions

Description	Opcode	Operand*	Fmt
Branch (always)	`b`	label	†
Jump	`j`	label	J
Branch if Equal	`beq`	rs, rt, label	I
Branch if Not Equal	`bne`	rs, rt, label	I
Branch if Greater	`bgt`	rs, rt, label	†
Branch if Greater or Equal	`bge`	rs, rt, label	†
Branch if Greater Unsigned	`bgtu`	rs, rt, label	†
Branch if Greater or Equal Unsigned	`bgeu`	rs, rt, label	†
Branch if Less Than	`blt`	rs, rt, label	†
Branch if Less or Equal	`ble`	rs, rt, label	†
Branch if Less Unsigned	`bltu`	rs, rt, label	†
Branch if Less or Equal Unsigned	`bleu`	rs, rt, label	†
Branch if Equal to Zero	`beqz`	rs, label	†
Branch if Not Equal to Zero	`bnez`	rs, label	†
Branch if Greater Than Zero	`bgtz`	rs, label	I
Branch if Greater or Equal to Zero	`bgez`	rs, label	I
Branch if Less Than Zero	`bltz`	rs, label	I
Branch if Less or Equal to Zero	`blez`	rs, label	I

* In the three operand branch instructions, `rt` can be replaced with a constant, i.e., operands can be `rs,imm,label`. All such instructions are pseudoinstructions.

† - pseudoinstruction

• Shift and Rotate Instructions

Description	Opcode	Operand	Fmt
Rotate Left	`rol`	rd, rs, rt	†
Rotate Right	`ror`	rd, rs, rt	†
Shift Left Logical	`sll`	rd, rs, sa	R
Shift Left Log Variable	`sllv`	rd, rs, rt	R
Shift Right Logical	`srl`	rd, rs, sa	R
Shift Right Log Variable	`srlv`	rd, rs, rt	R
Shift Right Arithmetic	`sra`	rd, rs, sa	R
Shift Right Arith Variable	`srav`	rd, rs, rt	R

• Comparison Instructions

Description	Opcode	Operand	Fmt
Set if Equal	`seq`	rd, rs, rt	†
Set if Not Equal	`sne`	rd, rs, rt	†
Set if Less Than	`slt`	rd, rs, rt	R
Set if Less or Equal	`sle`	rd, rs, rt	†
Set if Greater Than	`sgt`	rd, rs, rt	†
Set if Greater or Equal	`sge`	rd, rs, rt	†
Set if Less Unsigned	`sltu`	rd, rs, rt	R
Set if Less or Equal Unsigned	`sleu`	rd, rs, rt	†
Set if Greater Unsigned	`sgtu`	rd, rs, rt	†
Set if Greater or Equal Unsigned	`sgeu`	rd, rs, rt	†
Set if Less Than Immed	`slti`	rd,rs,imm	I
Set if Less Than Imm Unsigned	`sltiu`	rd,rs,imm	I

• Subroutine Instructions

Description	Opcode	Operand	Format
Jump and Link (Call)	`jal`	label	J
Jump Register	`jr`	rs	R

• Miscellaneous Instructions

Description	Opcode	Operand	Format
No Operation	`nop`		†
System Call	`syscall`	code	R

• Assembler Syntax

```
label:   mnemonic    operands    # comment
```

• Assembler Directives - SPIM Subset

Directive	Description
`.text`	Put next code into *text* section
`.data`	Put next code into *data* section
`.globl` *`name`*	Make *name* be a global symbol
`.space` *`n`*	Allocate *n bytes* of space
`.word` *`val1,val2,`* `...`	Allocate one word for each value
`.half` *`val1,val2,`* `...`	Allocate a halfword for each value
`.byte` *`val1,val2,`* `...`	Allocate a byte for each value
`.ascii "`*`string`*`"`	Allocate space for the ASCII chars
`.asciiz "`*`string`*`"`	Allocate space for string, NULL terminated
`.align` *`n`*	Start next on 2^n byte boundary

• SPIM System Services

Routine	Code in `$2`	Arguments	Result
`print_int`	1	`$4` = integer	
`print_str`	4	`$4` = addr of string	
`read_int`	5		integer in `$2`
`read_str`	8	`$4` = addr of buffer (memory) `$5` = max length of str + 1	str in buffer
`malloc`	9	`$4` = # of bytes desired	address in `$2`
`exit`	10		