CS 214: Introduction to computing systems
Winter Term, 2018

Assembly Operations

The right column gives the command followed by its arguments. Arguments beginning with r are registers. An `imm` argument is a number; its subscript is the maximum size in bits. For commands with a result, `rd` is the destination. Operations marked with $*$ are pseudoinstructions, which translate into other instructions.

Arithmetic operations

Add	`add rd, rs, rt`
Add immediate	`addi rd, rs, imm`$_{16}$
Subtract	`sub rd, rs, rt`
Multiply$*$	`mulo rd, rs, rt`
Unsigned multiply$*$	`mulou rd, rs, rt`
Divide s by $t*$	`div rd, rs, rt`
Remainder$*$	`rem rd, rs, rt`
Unsigned remainder$*$	`remu rd, rs, rt`
Absolute value	`abs rd, rs`
Negate value$*$	`neg rd, rs`

Bit operations

Count leading ones	`clo rd, rs`
Count leading zeros	`clz rd, rs`
Bitwise AND	`and rd, rs, rt`
Bitwise AND immediate	`andi rd, rs, imm`$_{16}$
Bitwise NOR	`nor rd, rs, rt`
Bitwise NOT	`not rd, rs`
Bitwise OR	`or rd, rs, rt`
Bitwise OR immediate	`ori rd, rs, imm`$_{16}$
Bitwise XOR	`xor rd, rs, rt`
Bitwise XOR immediate	`xori rd, rs, imm`$_{16}$
Shift left (by immediate; fill with 0s)	`sll rd, rs, imm`$_5$
Shift left (by register value; fill with 0s)	`sllv rd, rs, rt`
Shift right (by immediate; fill with 0s)	`srl rd, rs, imm`$_5$
Shift right (by register value; fill with 0s)	`srlv rd, rs, rt`
Shift right arithmetic (by immediate; fill with MSB)	`sra rd, rs, imm`$_5$
Shift right arithmetic (by register value; fill with MSB)	`srav rd, rs, rt`
Circular shift left$*$	`rol rd, rs, rt`
Circular shift right$*$	`ror rd, rs, rt`
Load immediate$*$	`li rd, imm`$_{32}$
System call (see table below)	`syscall`

The behavior of `syscall` is controlled by register $\$v0$. The following are useful codes:

1	Print int stored in $\$a0$
4	Print string whose address is stored in $\$a0$
5	Read int into $\$v0$
8	Read string into buffer at address $\$a0$ of length $\$a1$
10	Exit simulation
11	Print character stored in $\$a0$
12	Read character into $\$v0$

Comparison, branch, and jump instructions
Set instructions place 1 or 0 in `rd` depending on the condition. For example, `seq` sets `rd` to 1 when `rs` = `rt`.

Set if equal	`seq rd, rs, rt`
Set if not equal	`sne rd, rs, rt`
Set if greater than∗	`sgt rd, rs, rt`
Set if greater than or equal∗	`sge rd, rs, rt`
Set if greater than unsigned∗	`sgtu rd, rs, rt`
Set if greater than or equal unsigned∗	`sgeu rd, rs, rt`
Set if less than	`slt rd, rs, rt`
Set if less than immediate	`slti rt, rs,` $\texttt{imm}_{16}$
Set if less than or equal∗	`sle rd, rs, rt`
Set if less than unsigned	`sltu rd, rs, rt`
Set if less than or equal unsigned∗	`sleu rd, rs, rt`
Set if less than unsigned immediate	`sltiu rd, rs,` $\texttt{imm}_{16}$
Unconditional branch∗	`b label`
Branch if equal	`beq rs, rt, label`
Branch if not equal	`bne rs, rt, label`
Branch if greater than∗	`bgt rs, rt, label`
Branch if greater than or equal∗	`bge rs, rt, label`
Branch if greater than or equal unsigned∗	`bgeu rs, rt, label`
Branch if greater than unsigned∗	`bgtu rs, rt, label`
Branch if less than∗	`blt rs, rt, label`
Branch if less than or equal∗	`ble rs, rt, label`
Branch if less than or equal unsigned∗	`bleu rs, rt, label`
Branch if less than unsigned∗	`bltu rs, rt, label`

Memory instructions

"the following goes in the text segment"	`.text`
"the following goes in the data segment"	`.data`
"store `str` as a string"	`.ascii str`
"store `str` as a null-terminated string"	`.asciiz str`
"store these words in memory"	`.word w1 w2 ...`
"reserve `n` bytes of space"	`.space n`
"align on 2^n-byte boundary"	`.align n`
Load address (not contents) ∗	`la rd, address`
Load byte	`lb rd, address`
Load unsigned byte	`lbu rd, address`
Store byte	`sb rt, address`
Load word	`lw rd, address`
Store word	`sw rd, address`

The normal load instructions for less than a word sign-extend the value; the unsigned versions do not. Addresses for memory instructions can be any of the following forms:

(register)	contents of register
imm	immediate
imm(register)	contents of register + immediate
label	address of label
label ± imm	address of label ± immediate
label ± imm(register)	address of label ± (immediate+register)