Computer Systems Organisation (CS2.201)

Summer 2021, IIIT Hyderabad

11 June, Friday (Lecture 9) – Condition Codes

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Condition Codes

The CPU maintains a set of single-bit condition code registers describing attributes of the most recent arithmetic or logical operation.
Some of them are

- `CF` (the carry flag) – carry out of the MSB; used to detect overflow of unsigned operations
- `ZF` (zero flag)
- `SF` (sign flag)
- `OF` (overflow flag) – 2's complement overflow

For example, if `t = a + b` is the last executed operation, then the flags are set in the following cases:

`CF`: `(unsigned)t < (unsigned)a`
`ZF`: `(t == 0)`
`SF`: `(t < 0)`
`OF`: `(a < 0 == b < 0) && (t < 0 != a < 0)` [*i.e.*, `a` and `b` have same sign but `t` and `a` have opposite sign]

All operations except `leaq` set some condition codes.

For logical operations, `CF` and `OF` are set to 0.

For shift operations, `CF` is the last bit shifted out and `OF` is 0.

The `inc` and `dec` instructions set `OF` and `ZF` but don't affect `CF`.

Conditional Instructions

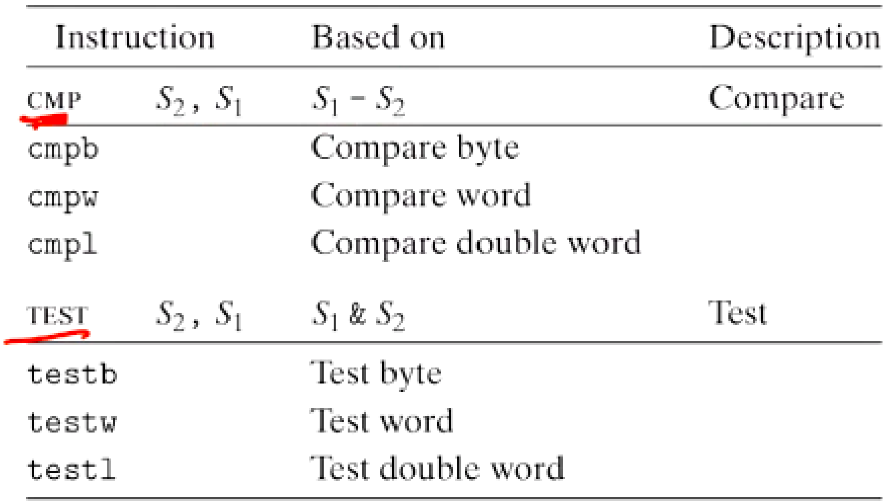
There are two instruction classes – `cmp` and `test` – that set the condition codes.

They are similar to `sub` and `and` respectively, but do not alter the destination register.

Use Cases

There are three common ways to use the condition codes:

- Conditionally set a single byte to 0 or 1 (`set` instructions)
- Conditionally jump to some other part of the program (Control Flow Transfer)



Instruction		Based on	Description
CMP	S_2, S_1	$S_1 - S_2$	Compare
`cmpb`		Compare byte	
`cmpw`		Compare word	
`cmpl`		Compare double word	
TEST	S_2, S_1	S_1 & S_2	Test
`testb`		Test byte	
`testw`		Test word	
`testl`		Test double word	

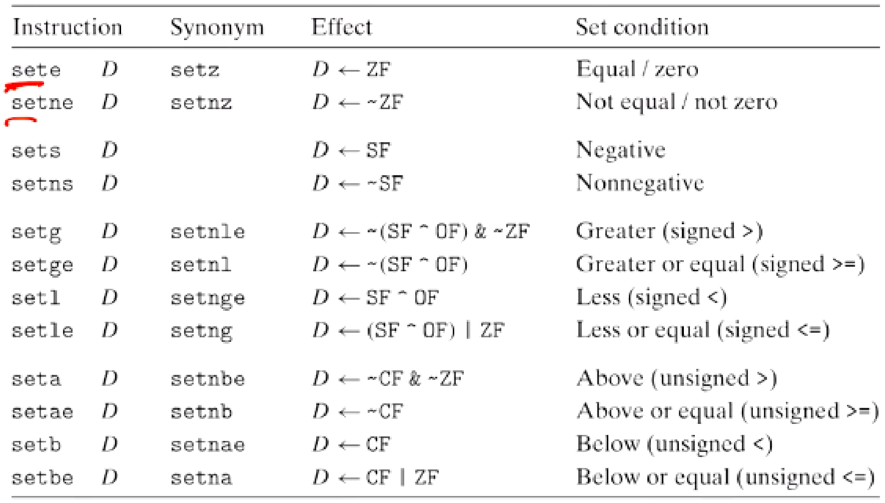
Figure 1: Conditional Instructions

- Conditionally move data (Data Flow Transfer)

The `set` instruction class is used to read the condition codes.

Note that the instruction suffixes are not the data type but the comparison operation to be read.
For example, for `a < b`, where `a` is in `%edx` and `b` in `%eax`:

```
cmpl %eax, %edx
setl %al
movzbl %al, %eax
```



Instruction		Synonym	Effect	Set condition
sete	*D*	setz	*D* ← ZF	Equal / zero
setne	*D*	setnz	*D* ← ~ZF	Not equal / not zero
sets	*D*		*D* ← SF	Negative
setns	*D*		*D* ← ~SF	Nonnegative
setg	*D*	setnle	*D* ← ~(SF ^ OF) & ~ZF	Greater (signed >)
setge	*D*	setnl	*D* ← ~(SF ^ OF)	Greater or equal (signed >=)
setl	*D*	setnge	*D* ← SF ^ OF	Less (signed <)
setle	*D*	setng	*D* ← (SF ^ OF) | ZF	Less or equal (signed <=)
seta	*D*	setnbe	*D* ← ~CF & ~ZF	Above (unsigned >)
setae	*D*	setnb	*D* ← ~CF	Above or equal (unsigned >=)
setb	*D*	setnae	*D* ← CF	Below (unsigned <)
setbe	*D*	setna	*D* ← CF | ZF	Below or equal (unsigned <=)

Figure 2: Set Instructions