

Princeton University

COS 217: Introduction to Programming Systems

ARMv8 Condition Flags

Condition Flags

Bits in the `pstate` register

`CMP Xs|SP, Xm`

CPU performs the subtraction $Xs|SP - Xm$

More precisely, CPU performs the addition $Xs|SP + \text{twoscomp}(Xm)$ and sets the condition flags depending upon the sum:

Condition Code	
Z (zero flag)	CPU sets Z to 1 iff all bits of the sum are 0.
N (negative flag)	CPU sets N to 1 iff the most significant bit of the sum is 1.
C (carry flag)	CPU sets C to 1 iff the addition caused a carry.
V (overflow flag)	CPU sets V to 1 iff both addends are ≥ 0 and the sum is < 0 , or both addends are < 0 and the sum is ≥ 0 .

Conditional Branch Instructions (Used After Comparing Unsigned Numbers)

Instruction	Branch if and only if:
<code>beq</code> (branch iff equal)	$Z==1$
<code>bne</code> (branch iff not equal)	$Z==0$
<code>blo</code> (branch iff lower)	$C==0$
<code>bhs</code> (branch iff higher or same)	$C==1$
<code>bls</code> (branch iff lower or same)	$C==0 \ \ Z==1$
<code>bhi</code> (branch iff higher)	$C==1 \ \&\& \ Z==0$

Why does `blo` branch iff $C==0$? Examples (assuming a 4-bit computer):

(1) $5 - 3 = 0101_b - 0011_b = 0101_b + 1101_b = 0010_b$, $C==1 \Rightarrow$ don't branch

(2) $3 - 5 = 0011_b - 0101_b = 0011_b + 1011_b = 1110_b$, $C==0 \Rightarrow$ branch

So branch if and only if $C==0$.

Conditional Branch Instructions (Used After Comparing Signed Numbers)

Instruction	Branch if and only if:
beq (branch iff equal)	Z==1
bne (branch iff not equal)	Z==0
blt (branch iff less than)	N!=V
bge (branch iff greater than or equal)	N==V
ble (branch iff less than or equal)	N!=V Z==1
bgt (branch iff greater than)	N==V && Z==0

Why does **blt** branch iff if **N!=V**? Examples (assuming a 4 bit computer):

- (1) $5 - 3 = 0101_B - 0011_B = 0101_B + 1101_B = 0010_B$, $N==0$, $V==0 \Rightarrow N==V \Rightarrow$ don't branch
- (2) $3 - 5 = 0011_B - 0101_B = 0011_B + 1011_B = 1110_B$, $N==1$, $V==0 \Rightarrow N!=V \Rightarrow$ branch
- (3) $-5 - -3 = 1011_B - 1101_B = 1011_B + 0011_B = 1110_B$, $N==1$, $V==0 \Rightarrow N!=V \Rightarrow$ branch
- (4) $-3 - -5 = 1101_B - 1011_B = 1101_B + 0101_B = 0010_B$, $N==0$, $V==0 \Rightarrow N==V \Rightarrow$ don't branch
- (5) $3 - -2 = 0011_B - 1110_B = 0011_B + 0010_B = 0101_B$, $N==0$, $V==0 \Rightarrow N==V \Rightarrow$ don't branch
- (6) $3 - -6 = 0011_B - 1010_B = 0011_B + 0110_B = 1001_B$, $N==1$, $V==1 \Rightarrow N==V \Rightarrow$ don't branch
- (7) $-3 - 2 = 1101_B - 0010_B = 1101_B + 1110_B = 1111_B$, $N==1$, $V==0 \Rightarrow N!=V \Rightarrow$ branch
- (8) $-3 - 6 = 1101_B - 0110_B = 1101_B + 1010_B = 0111_B$, $N==0$, $V==1 \Rightarrow N!=V \Rightarrow$ branch

So branch if and only if $N!=V$.

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