Computer Systems Architecture

Homework 1

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What Are NZCV Flags?

Flag	Name	Meaning
N	Negative	Set to 1 if the result is negative (sign bit = 1)
Z	Zero	Set to 1 if the result equals zero
C	Carry	Set to 1 if the operation produced a carry
V	Overflow	Set to 1 if a signed overflow occurred

These flags are stored in PSR

Signed vs Unsigned Comparisons

Unsigned Arithmetic

Represent positive values only.
The Carry (C) flag is used to detect comparison outcomes.

Signed Arithmetic

MSB is the sign bit
Signed comparisons use N (Negative) and V (Overflow) flags.

Understanding NZCV Flags and Signed Conditional Codes

GE	Signed greater than or equal	$\overline{N \oplus V}$
LT	Signed less than	$N \oplus V$
GT	Signed greater than	$\overline{Z}(\overline{N \oplus V})$
LE	Signed less than or equal	Z OR $(N \oplus V)$

GE
(Greater or Equal)

$$\mathrm{GE} = \overline{(N \oplus V)}$$

Example 1 True Case

A = 9 (0000 1001)
B = 4 (0000 0100)

A − B = +5 (0000 0101)

Flags: N=0, Z=0, V=0 ⇒ N⊕V=0
GE=1

Example 1 True Case

A = −6 (1111 1010)
B = −7 (1111 1001)

A − B = +1 (0000 0001)

Flags: N=0, Z=0, V=0
GE=1

Example 1 False Case

A = −9 (1111 0111)
B = −2 (1111 1110)

A − B = −7 (1111 1001)

Flags: N=1, Z=0, V=0 ⇒ N⊕V=1
GE=0

GE
code sample

```
1  .global _start
2  _start:
3      MOV r0, #9
4      MOV r1, #4
5      CMP r0, r1
6      MOVGE r2, #1
7      MOVLT r2, #0
8      B .
9
```

LT
(Less Than)

$$\mathrm{LT} = N \oplus V$$

Example 1 True Case

A = 3 (00000011)
B = 5 (00000101)

A − B = −2 (1111 1110)

Flags: N=1, V=0
LT=1

Example 1 True Case

A = −120 (1000 1000)
B = +100 (0110 0100)

−120 − 100 = −220
(out of 8-bit range)

result looks +36 (0010 0100)
N=0 but V=1
N⊕V=1 ⇒ LT=1

Example 1 False Case

A = 7 (00000111)
B = 3 (00000011)

7 - 3 = 4 (00000100)

N=0, V=0
LT=0

LT

code sample

```
1  .global _start
2  _start:
3      MOV r0, #3
4      MOV r1, #5
5      CMP r0, r1
6      MOVLT r2, #1
7      MOVGE r2, #0
8
9      B .
10
11
```

GT
(Greater Than)

$$\mathrm{GT} = \overline{Z} \cdot \overline{(N \oplus V)}$$

Example 1 True Case

A = 7 (00000111)
B = 3 (00000011)

A − B = +4 (00000100)

Flags: Z=0, N=0, V=0
GT=1

Example 1 True Case

A = −3 (11111101)
B = −8 (11111000)
A − B = +5 (00000101)

Z=0, N=0, V=0
GT=1

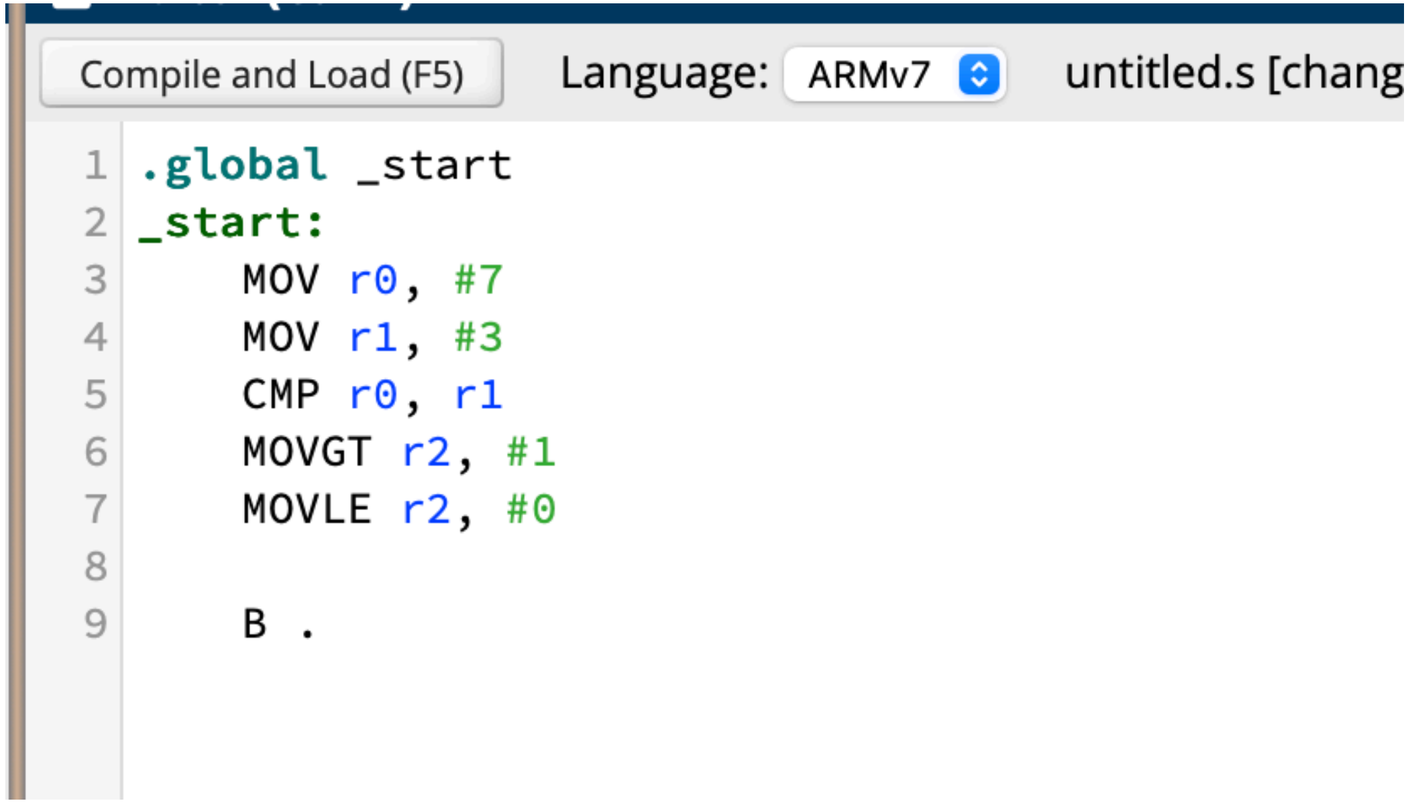
Example 1 False Case

A = 5 (00000101)
B = 5 (00000101)

5 - 5 = 0 (00000000)

Z=1
GT=0

GT
code sample



LE
(Less or Equal)

$$\mathrm{LE} = Z \ \mathrm{OR}\ (N \oplus V)$$

Example 1 True Case

A = 3 (00000011)
B = 5 (00000101)

A - B = -2 (11111110)

N=1, V=0
N⊕V=1 ⇒ LE=1

Example 1 True Case

A = 7 (00000111)
B = 7 (00000111)

A - B = 0 (00000000)

Z=1 ⇒ LE=1

Example 1 False Case

A = 8 (00001000)
B = 5 (00000101)

A - B = +3 (00000011)

Z=0, N=0, V=0
LE=0

LE
code sample

Compile and Load (F5) Language: ARMv7 untitled.s [ch

```
1  .global _start
2  _start:
3      MOV r0, #3
4      MOV r1, #5
5
6      CMP r0, r1
7
8      MOVLE r2, #1
9      MOVGT r2, #0
10
11     B .
12
```

“Mastering the meaning of NZCV flags means mastering how the processor decides logic. Every conditional branch in your code is built on these bits.”

Thank you very much!