L4 (CHAPTER 7)

Programming in Assembly Part 3: Control Structures

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Acknowledgement: some slides taken from instructor resources of Daniel Lewis textbook

Review

Condition Codes

Condition Code	***Meaning***	***Requirements***
EQ	Equal	Z = 1
NE	Not equal	Z = 0
CS	Carry set	C = 1
CC	Carry clear	C = 0
MI	Minus/negative	N = 1
PL	Plus/positive or zero (non-negative)	N = 0
VS	Overflow	V = 1
VC	No overflow	V = 0
HI	Unsigned > (“Higher”)	C = 1 && Z = 0
LS	Unsigned ≤ (“Lower or Same”)	C = 0 || Z = 1
GE	Signed ≥ (“Greater than or Equal”)	N = V
LT	Signed < (“Less Than”)	N ≠ V
GT	Signed > (“Greater Than”)	Z = 0 && N = V
LE	Signed ≤ (“Less than or Equal”)	Z = 1 || N ≠ V
AL	Always (unconditional)	only used with IT instruction

The condition is described as the state of a specific bit in the CPSR register. For example, when we compare two numbers a and b, and they turn out to be equal, we set the Zero bit (Z = 1), because a – b = 0. In this case we have EQual condition. If the first number was bigger, we would have a Greater Than condition and in the opposite case – Lower Than. There are more conditions, like Lower or Equal (LE), Greater or Equal (GE) and so on. Any one of these may be appended to any instruction mnemonic when used inside an If-Then-Else (IT) block.

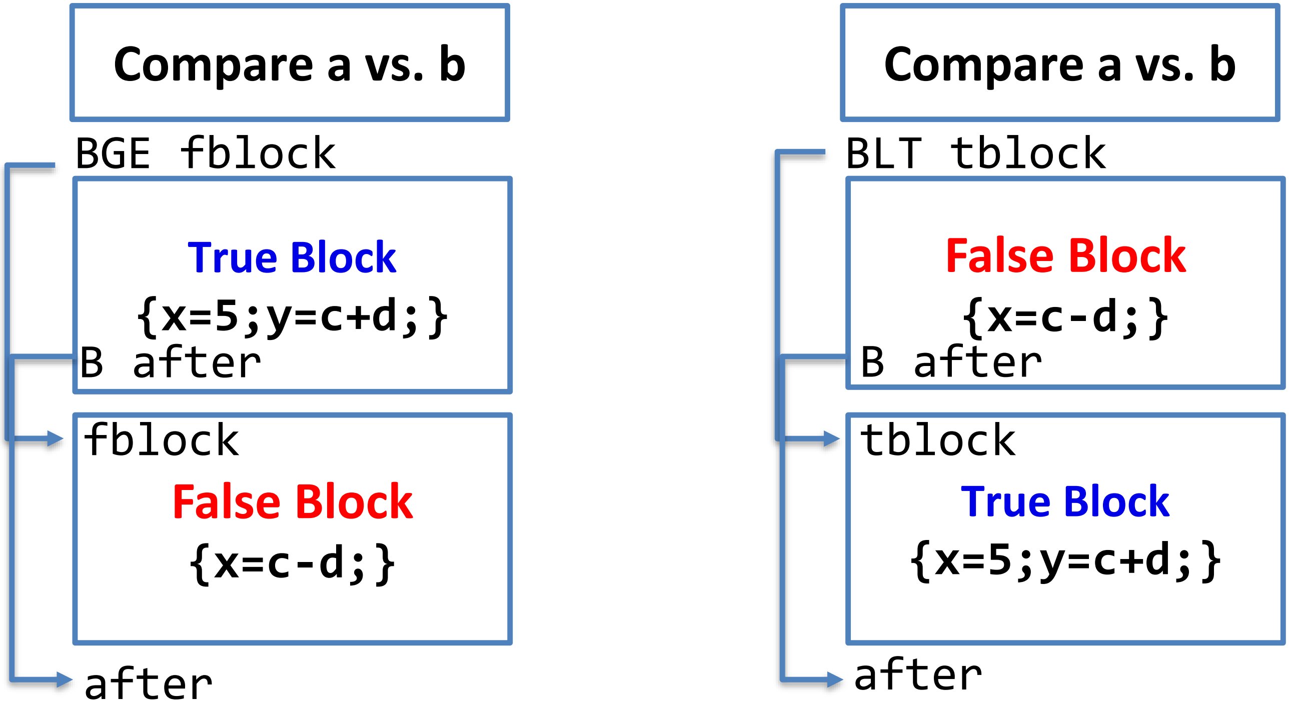
Review

Another Example:

- C code:

```
if (a < b) {x = 5; y = c + d;} else {x = c - d;}
```

- Assembler code:



Compare a vs. b

BGE fblock

True Block

{x=5;y=c+d;}

B after

fblock

False Block

{x=c-d;}

after

Compare a vs. b

BLT tblock

False Block

{x=c-d;}

B after

tblock

True Block

{x=5;y=c+d;}

after

Question: Conditional

- C program:

```
if (a == 0) {//True Block} else {//False Block}
```

- Write the assembler program for the C program, given the snippets provided

```
        ADR R4,a
        LDR R0,[R4]

        ____________

        ____________
tblock  % True Block

        ____________
fblock  % False Block
after
```

```
        ADR R4,a
        LDR R0,[R4]

        ____________

        ____________
fblock  % False Block

        ____________
tblock  % True Block
after
```

Answer: Conditional

- C program:

```
if (a == 0) {//True Block} else {//False Block}
```

- Write the assembler program for the C program, given the snippets provided

```
        ADR R4,a
        LDR R0,[R4]
        CMP R0,#0
        BNE fblock
tblock  % True Block
        B after
fblock  % False Block
after
```

```
        ADR R4,a
        LDR R0,[R4]
        CMP R0,#0
        BEQ tblock
fblock  % False Block
        B after
tblock  % True Block
after
```

Review

Loops: Predetermined #Iterations

C code:

```
for (n = 0; n < 100; n++)
{
 … //Loop body
}
```

Assembler code (option 1):

```
        LDR     R0,=0
top:    CMP     R0,#100
        BGE     done ;Branch greater than or equal to (n>=100)
        …
        ADD     R0,R0,#1
        B       top
done:
```

Assembler code (option 2):

```
        LDR     R0,=0
top:    …
        ADD     R0,R0,#1
        CMP     R0,#100
        BLT     top ;Branch  less than (n<100)
done:
```

More efficient, with fewer branch instructions.

Question: Loop

- Q: How many iterations does the following loop execute?
  - (a) for (n=0; n<100; n +=2) {...}
  - (b) for (n=0; n<100; n *=2) {...}
  - (c) for (n=1; n<100; n *=2) {...}

Answer: Loop

- Q: How many iterations does the following loop execute?
  - (a) for (n=0; n<100; n +=2) {…}
  - (b) for (n=0; n<100; n *=2) {…}
  - (c) for (n=1; n<100; n *=2) {…}
- A: (a) 50 (b) infinite (c) 7 (since n=1,2,4,8,16,32,64)

Question: Loop

- Write the assembler code for the following C program

  For (n=1; n<100; n *=2) {…}

Answer: Loop

- Write the assembler code for the following C program

  For (n=1; n<100; n *=2) {…}

- Assembler (option 1):

```
      LDR     R0,=0
top:  CMP     R0,#100
      BGE     done
       …
      MUL     R0,R0,#2
      B       top
done:
```

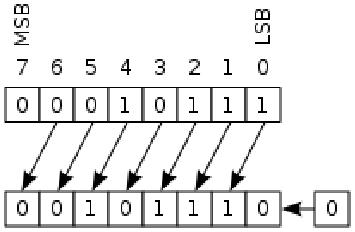
- Assembler (option 2):

```
      LDR     R0,=0
top:   …
      MUL     R0,R0,#2
      CMP     R0,#100
      BLT     top
done:
```

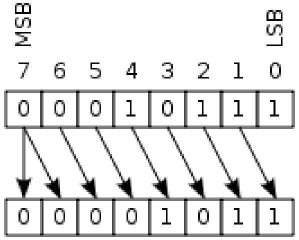
Review

Shift Instructions

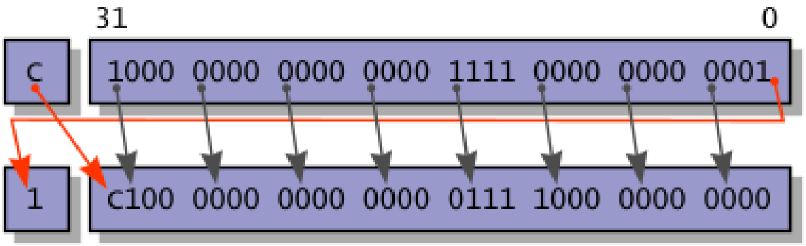
<shift>	*Meaning*	*Notes*
LSL #n	Logical shift left by n bits	Zero fills; 0 ≤ n ≤ 31
LSR #n	Logical shift right by n bits	Zero fills; 1 ≤ n ≤ 32
ASR #n	Arithmetic shift right by n bits	Sign extends; 1 ≤ n ≤ 32
ROR #n	Rotate right by n bits	1 ≤ n ≤ 32
RRX	Rotate right w/C by 1 bit	including C bit from CPSR



LSL #1



LSR #1



RRX

Any of these may be applied to the 2nd operand register in Move / Add / Subtract, Compare, and Bitwise Groups.

Answer: Loop with Shift Instruction

- Write the assembler code for the following C program

  For (n=1; n<100; n *=2) {…}

- Assembler (option 1):

```
      LDR      R0,=0
top:  CMP      R0,#100
      BGE      done
        …
      MOV R0, R0, LSL#1
      B        top
 done:
```

- Assembler (option 2):

```
      LDR      R0,=0
top:    …
      MOV R0, R0, LSL#1
      CMP      R0,#100
      BLT      top
done:
```