Constants and literal pools

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- Se la MOV ha bisogno di creare un valore ma questo non è nel range dei valori che esse riescono la costante viene collocata in un insieme di costanti chiamato literal pool e viene caricata con LDR Rd, [PC, #offset]. L'offset va scritto su 12 bit. Il compilatore mette di default il literal pool alla fine di tutto. Se questo dovesse essere troppo lontano per i 12 bit dell'offset il programmatore può collocare il literal pool dove vuole scrivendo .LTORG

MOV

- It assigns a value to a register.
- The value can be:
  - the content of a register
  - a constant value.
- MOV cannot assign an instruction or data address

```
myCode   MOV r0, myData    ; error
         MOV r1, myCode    ; error
stop B stop
myData   DCD 0xC90147D2
```

MOV a register into another one

```
MOV <Rd>, <Rm> {, shift}
```

Posso shiftare il dato del registro sorgente (il 2°)

- Example: `MOV r0, r1`
- `shift` is an optional shift applied to `Rm`
  - `ASR #n`: arithmetic shift right
  - `LSL #n`: logical shift left
  - `LSR #n` : logical shift right
  - `ROR #n` : rotate right
  - `RRX` : rotate right 1 bit with sing extend
- The equivalent shift instruction is preferred:

  `LSL r0,r1,#3` corresponds to `MOV r0,r1,LSL #3`

MOV a constant into a register

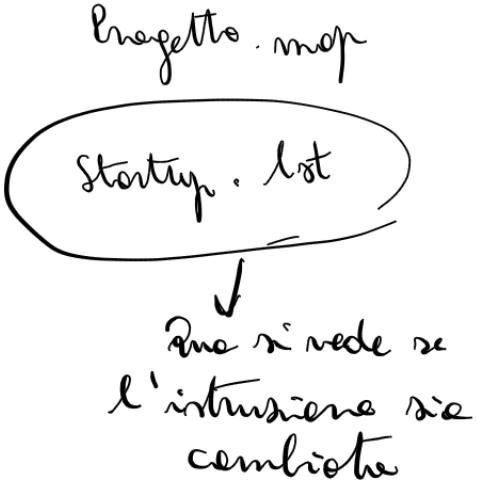
```
MOV <Rd>, #<constant>
```

- The constant can be:
  - a 16-bit value (0-65535)
  - a value obtained by shifting left an 8-bit value
    - of the form 0x00XY00XY
    - of the form 0xXY00XY00
    - of the form 0xXYXYXYXY.
- `MOVW` is like `MOV`, but it takes only a 16-bit value.

Shifted constant values

Left shift	Binary	Max decimal	Max hexadecimal
0	00000000000000000000000xxxxxxxx	255	0xFF
2	00000000000000000000xxxxxxxx00	1020	0x3FC
4	00000000000000000000xxxxxxxx0000	4080	0xFF0
6	00000000000000000xxxxxxxx000000	16320	0x3FC0
8	00000000000000000xxxxxxxx00000000	65280	0xFF00
…	…	…	…
20	0000xxxxxxxx00000000000000000000	$0\text{-}255x2^{20}$	0xFF00000
22	00xxxxxxxx00000000000000000000	$0\text{-}255x2^{22}$	0x3FC00000
24	xxxxxxxx00000000000000000000	$0\text{-}255x2^{24}$	0xFF000000

Which values are valid for MOV?



1. `MOV r0, #0x00004B4B`
2. `MOV r0, #0x004B4B00`
3. `MOV r0, #0x004B0000`
4. `MOV r0, #0x004B004B`
5. `MOV r0, #0x004B4B4B`
6. `MOV r0, #0x4B4B0000`
7. `MOV r0, #0x4B000000`
8. `MOV r0, #0x4B4B4B4B`

MVN (move negative)

- The `MVN` instruction moves a one's complement of the operand into a register.
- Same syntax as `MOV`, with one difference:
  - `MVN` does not accept a 16-bit value
- Example: `MVN r0,#0` -> `r0` = 0xFFFFFFFF
- The assembler can change a `MOV` into a `MVN` if the value is valid for `MVN` and not for `MOV`.
- `MOV r0,#-2` becomes `MVN r0,#1` because -2= 0xFFFFFFFE is not in the range of `MOV`.

MOVT (move top)

- `MOVT` moves a 16-bit value in the high halfword of a register:

```
MOVT <Rd>, #<constant>
```

- A register can be set to any 32-bit constant by using `MOV` and `MOVT` together:

```
MOV r0, #0x47D2
MOVT r0, #0xC901
```

The new value of `r0` is 0xC90147D2.

LDR for loading constants

- Besides loading values from memory, `LDR` can be used to load constants into registers:

```
LDR <Rd>, =<constant>
```

- If `constant` is among the valid values of `MOV`, then the instruction is replaced with:

```
MOV <Rd>, #<constant>
```

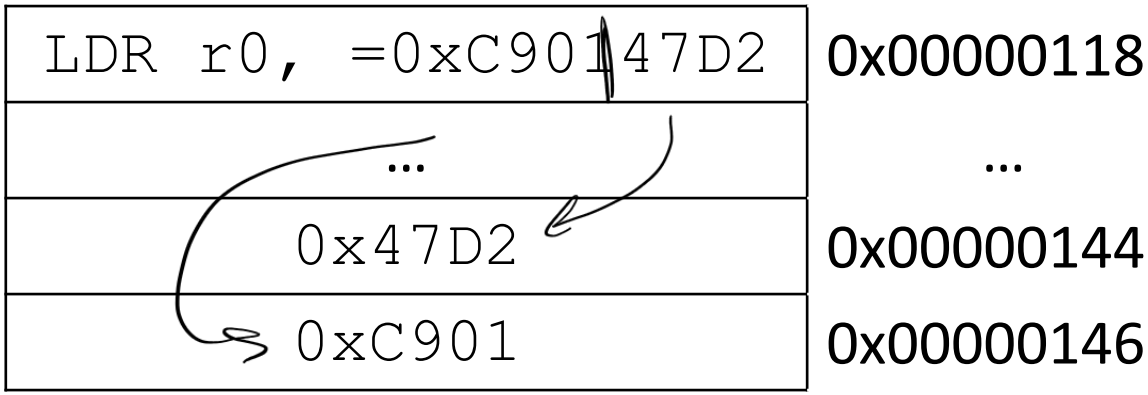
- Otherwise, a block of constant, called ***literal pool***, is created and the instruction becomes:

```
LDR <Rd>, [PC, #<offset>]
```

Computation of the offset

- The offset is the difference between the address of the literal pool and `PC`.
- The value of `PC` is computed as:
  1. the address of the current instruction
  2. plus 4
  3. clearing the second bit for word alignment.
- The offset is expressed with 12 bits.

Example of offset computation



1. 0x118 = 2_000100011000
2. 0x118 + 4 = 0x11C = 2_000100011100
3. PC = 2_000100011100 = 0x11C
4. offset = 0x144 – 0x11C = 0x28 = 40

```
LDR r0, [PC, #40]
```

Address of the literal pool

- By default, the literal pool is placed at the `END` directive, after the last instruction.
- As the offset is 12 bits, the distance between the current instruction and the last one should be lower than 4096.
- Otherwise, the `LTORG` directive must be used to put the literal pool somewhere else.

Literal pool assignment → Posso dire al compilatore dove mettere il literal pool se l'offset di 12 bit non dovesse bastare

What is the error?

```
     AREA |.text|, CODE, READONLY
Reset_Handler   PROC
     EXPORT  Reset_Handler [WEAK]
     LDR r0, =0xC90147D2
stop B stop
myEmptySpace  SPACE 4100
     ENDP
     END  ;literal pool is saved here
```

Correct version

```
     AREA |.text|, CODE, READONLY
Reset_Handler   PROC
     EXPORT  Reset_Handler [WEAK]
     LDR r0, =0xC90147D2
     B stop
     LTORG ;literal pool is saved here
stop B stop
myEmptySpace  SPACE 4100
     ENDP
     END
```

Loading addresses into registers

- Two pseudo-instructions are available:

```
LDR <Rd>, =<label>
ADR <Rd>, <label>
```

- `LDR` creates a constant in a literal pool and uses a `PC` relative load to get the data.
- `ADR` adds or subtracts an offset to/from `PC`.
- `ADR` does not increase the code size, but it can not create all offsets
  - Addresses generated with ADR must be multiple of 4
  - ADR loads addresses in the same section.

Non può leggere fuori dalla sua sezione

LDR an address into a register

```
Stack_Size      EQU     0x00000200
     AREA STACK, NOINIT, READWRITE
Stack_Mem       SPACE   Stack_Size

     AREA |.text|, CODE, READONLY
…
     LDR r12, =Stack_Mem
…
     END ;literal pool is saved here
```

LDR an address into a register

- `LDR` can reference a label outside of the current section.
- In the previous example, `r12` is loaded with the address of the bottom of the stack

```
r12 = r13 - 0x00000200
```

ADR an address into a register

```
     AREA |.text|, CODE, READONLY
Reset_Handler   PROC
     EXPORT  Reset_Handler [WEAK]
     ADR r0, myData
stop B stop
myData DCD 0xC90147D2
myEmptySpace  SPACE 4100
     ENDP
```

ADR and ADRL

- The `ADR` pseudo-instruction is replaced with

```
LDR <Rd>, [PC, #<offset>]
```

- The offset is expressed with 12 bits.
- If the offset is higher than 4095 bytes, `ADRL` must be used instead of `ADR`.
- `ADRL` generates two operations and its offset can be up to 1 MB.
- `ADR` and `ADRL` load addresses in the same section.

ADRL an address into a register

```
     AREA |.text|, CODE, READONLY
Reset_Handler   PROC
     EXPORT  Reset_Handler [WEAK]
     ADRL r0, myData
stop B stop
myEmptySpace  SPACE 4100
myData DCD 0xC90147D2
     ENDP
```