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| **Architetture dei Sistemi**  **Di Elaborazione** | Delivery date:  14th December 2023 |
| **Laboratory**  **8** | Expected delivery of lab\_08.zip must include:   * zipped project folders for Exercise1, Exercise2 * this lab track completed and converted to pdf format. |

**Exercise 1)**

* Download the **template project** for Keil µVision “***03\_sample\_BUTTON\_LED***” from the course material.

Implement an 8-bit “signed counter” by usingLANDTIGER board; the software permits to use buttons to update a counting value which could be either positive or negative, and the LEDs to show the current value. By first using emulation capabilities (later, move your firmware on the board), please implement the following functionalities:

* increment a variable every time the button KEY1 is pressed
* decrement when KEY2 if pressed (in case, go to negative number)
* reset the count when INT0 is pressed.

LEDs are showing the current count in a binary, 2’s complement representation.



**HINT**: It could be useful to use a global variable to keep the information about turned ON LEDs. For example, using a variable called “char led\_value”, already available in the project.

**Q1:** Do you observe any unexpected behaviour on the board with respect to SW emulation? Please describe.

Si verifica l’effetto “bouncing”, ovvero il pulsante nonostante sia tenuto fermo crea delle leggere fluttuazioni del voltaggio che possono essere interpretate come nuovi interrupt producendo, quindi, risultati inaspettati. Nonostante il simulatore TigerBoard può simulare tale fenomeno, non tiene in considerato il caso in cui il pulsante sia tenuto premuto e si muova leggermente lungo l’asse ortogonale alla pressione, creando di conseguenza conteggi diversi in base al modo d’uso.

**Exercise 2)** Experiment the SVC instruction.

* Download the **template project** for Keil µVision “**01\_SVC**” from the course material.
* You must execute the debug of the project on the LandTiger Board.

2.1) Write, compile, and execute a code that invokes an SVC instruction in the reset handler.

You must set the control to user mode(unprivileged).

By means of invoking a SuperVisor Call, we want to implement a RESET, a NOP and a MEMCPY functions. The MEMCPY function is used to copy a block of data from a source address to a destination address and return information about the data transfer execution.

In the handler of SVC, the following functionalities are implemented according to the **SVC number**:

1. 0 to 7: RESET the content of register R?, where ? can assume values from 0 to 7
2. 8 to 15: NOP (no operation)
3. 64 to 127: the SVC call must implement a MEMCPY operation, with the following input parameters and return values:
   * the 6 least significant bits of the SVC number indicates the number of bytes to move.
   * source and destination start addresses of the areas to copy are 32 bits values passed through stack.
   * by again using the stack, it returns the number of transferred bytes.



Example: the following SVC invokes MEMCPY from a given source to a destination

LDR R0, SourceStartAddress

LDR R1, DestinationStartAddress

PUSH R0  
PUSH R1

SVC 0x48; 2\_**01**001000 binary value of the SVC number

POP R0

Q1: Describe how the stack structure is used by your project.

La struttura dello stack è di tipo LIFO (last in, first out) ovvero l’ultimo elemento inserito nello stack tramite push sarà anche il primo ad essere recuperato tramite pop.

Q2: What need to be changed in the SVC handler if the access level of the caller is privileged? Please report code chunk that solves this request.

Quando si impostano i bit del control register, l’ultimo bit deve rimanere ad uno, quindi:

MOV R0, #2\_10

MSR CONTROL, R0

In R0 bisogna caricare il numero decimale “2” per evitare che l’utente sia identificato come non privilegiato.

Q3: Is the encoding of the SVC numbers complete? Please comment.

Vi sono due range non considerati: 16-63 e 128-255. Mentre nel primo caso si può considerare come un’estensione del range 8-15 in quanto anche lì non vengono azioni, potrebbe accadere in futuro di voler aggiungere delle funzionalità per quel range di parametri e bisognerebbe modificare leggermente il codice per permettere tale implementazione, la stessa cosa vale per il range finale da 128 a 255. In conclusione non vi è un completo encoding del parametro passato a SVC però allo stesso tempo le possibiliti implementazioni risultano abbastanza lineari considerando l’astrazione permessa eseguendo il programma come subroutine.