Lecture 15: Subroutines

Today's Topics

- What is subroutines?
- Learn how to call subroutines from an assembly program.
- Learn the properties of well-written subroutines.
- Learn how to use pass-by-reference and pass-by-value to send parameters to a subroutine.

What is Subroutines?

A definition of subroutines

- A subroutine in a self-contained section of code that implements **a specific function** that **can be called from many different places**.

- Reasons why we use subroutines
  - Save memory
    - The amount of memory required to store a program is reduced if the code to implement a function is stored only once instead of each time the function is needed in the program.
  - Improve reusability of code
    - Functions implemented subroutines are often easier to insert into future programs for code reuse.
  - Better organization
    - A complicated program can be more organized with subroutines.
    - Execution time increases and code size may increase as well.

Need Something for Subroutine Operation

Let's take a look at this code.

```
        ORG     $2000
        LDAA    #17     ; 2000
        BRA     MagA    ; 2002
Ret1    STAA    $1000   ; 2004
        LDAA    #-1     ; 2007
        BRA     MagA    ; 2009
Ret2    STAA    $1001   ; 200B
        SWI             ; 200E

;  Subroutine MagA
; compute magnitude of a single byte number
; input: byte in register A
; output: magnitude returned in register A

        ORG     $2200
MagA    TSTA
        BPL     return
        NEGA
Return  BRA     ?????
```

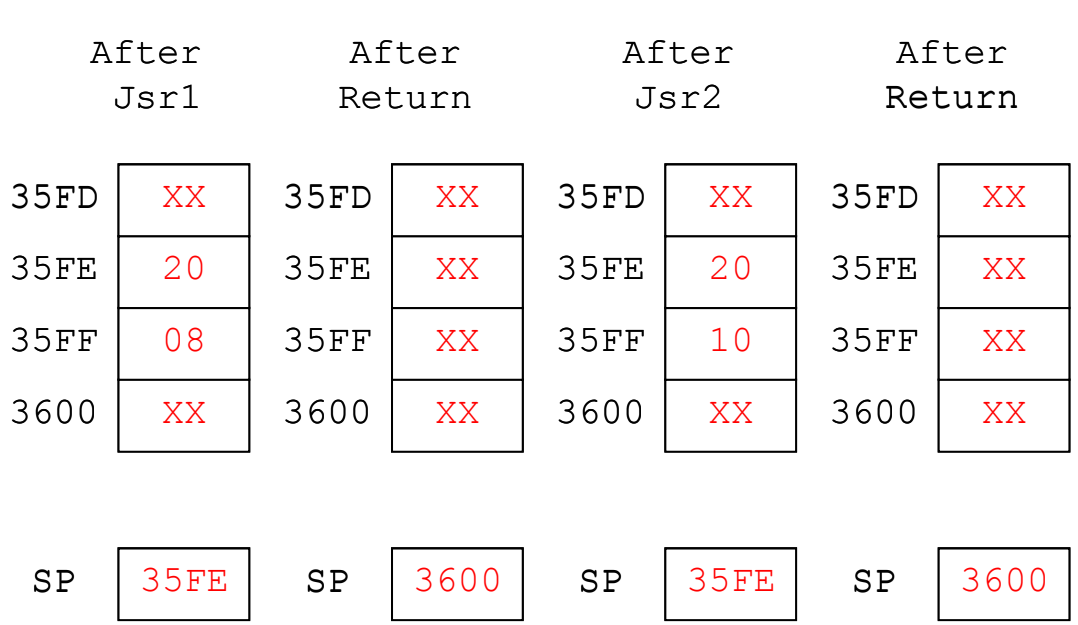
Subroutine Instructions

JSR and RTS

- JSR (Jump Sub Routine)
  - Pushes two-byte address of the next line of code on the stack first.
  - Jump/Branch to the subroutine.
- RTS (ReTurn from Subroutine)
  - Pulls two bytes off the stack and jumps to that address.

Example for Subroutines

```
        ORG     $2000
        LDS     #$3600              ; 2000
        LDAA    #17                 ; 2003
Jsr1    JSR     MagA                ; 2005
Ret1    STAA    $1000               ; 2008
                LDAA    #-1         ; 200B
Jsr2    JSR     MagA                ; 200D
Ret2    STAA    $1001               ; 2010
                SWI                 ; 2013
; compute magnitude of a single byte number
; input: byte in register A
; output: magnitude returned in register A
MagA    TSTA
        BPL     return
        NEGA
Return  RTS
```



Nesting Subroutines

```
                ORG     $2000
                LDS     #$3600      ; 2000
                LDAA    #17         ; 2003
                LDAB    #-1         ; 2005
JsrAB           JSR     MagAB       ; 2007
                SWI                 ; 200A

MagAB           JSR     MagA        ; 200B
PSHA1           PSHA                ; 200E
                TFR     B,A         ; 200F
JSR1            JSR     MagA        ; 2011
                TFR     A,B         ; 2014
PULA1           PULA                ; 2016
RTS1            RTS                 ; 2017

MagA            TSTA                ; 2018
                BPL     return      ; 2019
                NEGA                ; 201B
Return          RTS                 ; 201C
```

	After JsrAB	After MagAB	After Return	After PSHA1
35FB	XX	XX	XX	XX
35FC	XX	20	XX	XX
35FD	XX	0E	XX	11
35FE	20	20	20	20
35FF	0A	0A	0A	0A
3600	XX	XX	XX	XX
SP	35FE	35FC	35FE	35FD

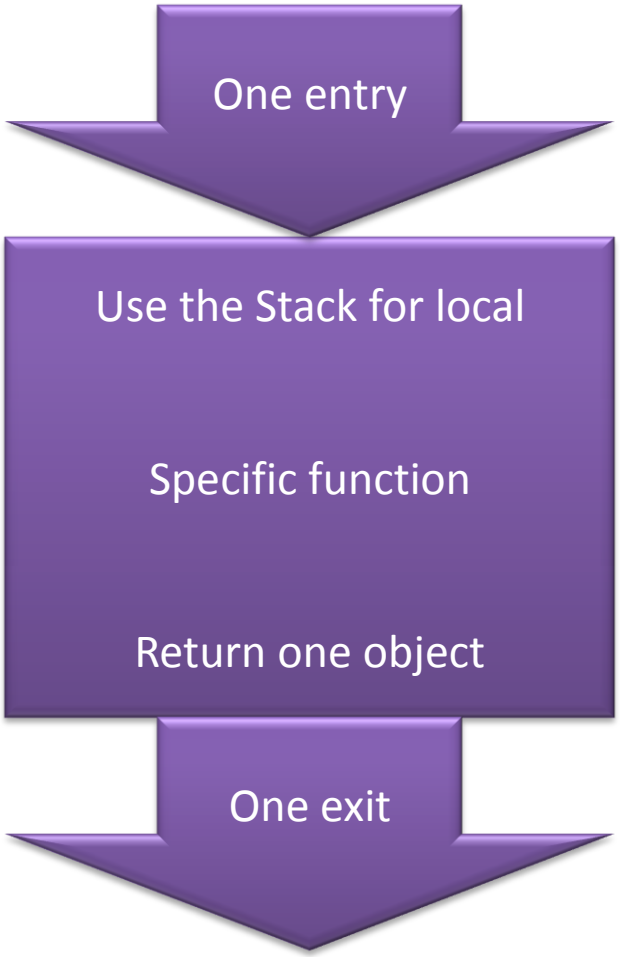
Nesting Subroutines –cont'd

```
                ORG     $2000
                LDS     #$3600      ; 2000
                LDAA    #17         ; 2003
                LDAB    #-1         ; 2005
JsrAB           JSR     MagAB       ; 2007
                SWI                 ; 200A

MagAB           JSR     MagA        ; 200B
PSHA1           PSHA                ; 200E
                TFR     B,A         ; 200F
JSR1            JSR     MagA        ; 2011
                TFR     A,B         ; 2014
PULA1           PULA                ; 2016
RTS1            RTS                 ; 2017

MagA            TSTA                ; 2018
                BPL     return      ; 2019
                NEGA                ; 201B
Return          RTS                 ; 201C
```

	After Jsr1	After Return	After PULA1	After RTS1
35FB	20	XX	XX	XX
35FC	14	XX	XX	XX
35FD	11	11	XX	XX
35FE	20	20	20	XX
35FF	0A	0A	0A	XX
3600	XX	XX	XX	XX
SP	35FB	35FD	35FE	3600

Well-written Subroutines**

- One entry point
- One exit point
- One specific function
- One returned object
- Use the stack to store local variables



Parameter Passing

- Pass-by-value
  - The **data** itself is passed
- Pass-by-reference
  - The **address** of the data is passed

Questions?

Wrap-up

What we've learned

- Subroutines
- JSR, RTS

What to Come

- Parameter passing