ECE3120: Computer Systems
Chapter 4: Subroutines

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Subroutines

- A sequence of instructions that can be called from various places in the program
- Allows the same operation to be performed with different parameters
- Simplifies the design of a complex program by using the divide-and-conquer approach

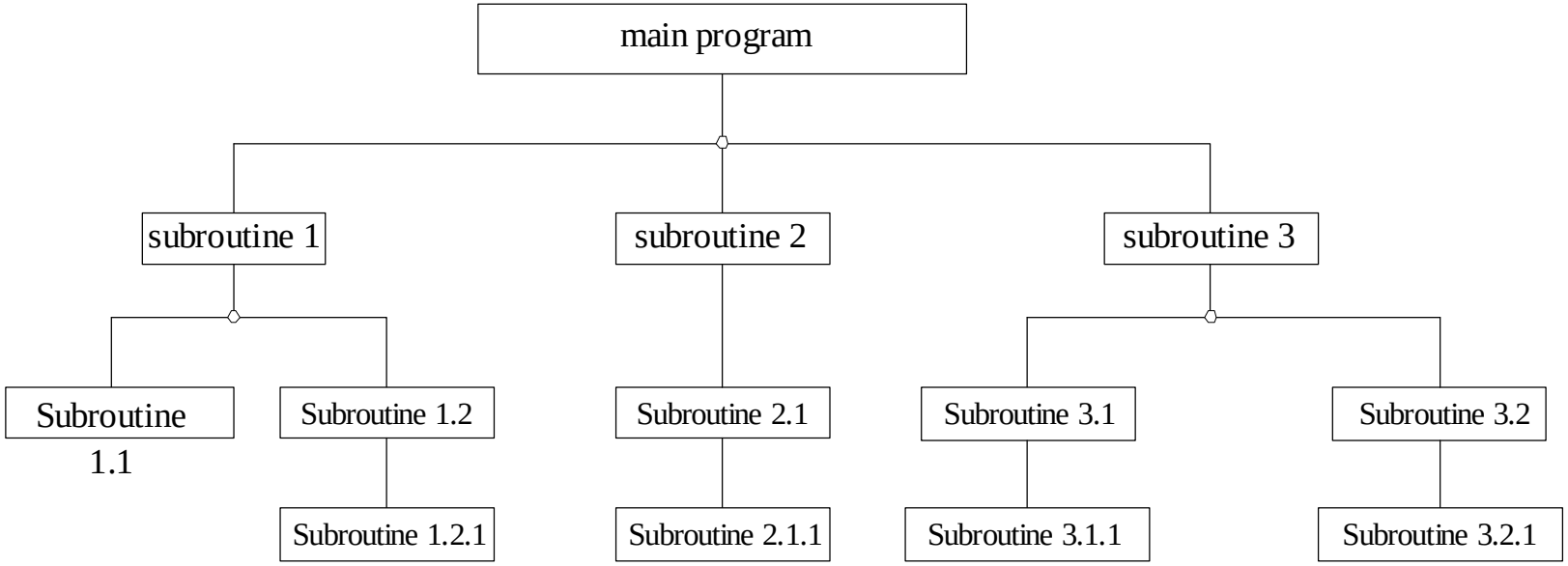

Figure 4.7 A structured program

Subroutine Processing

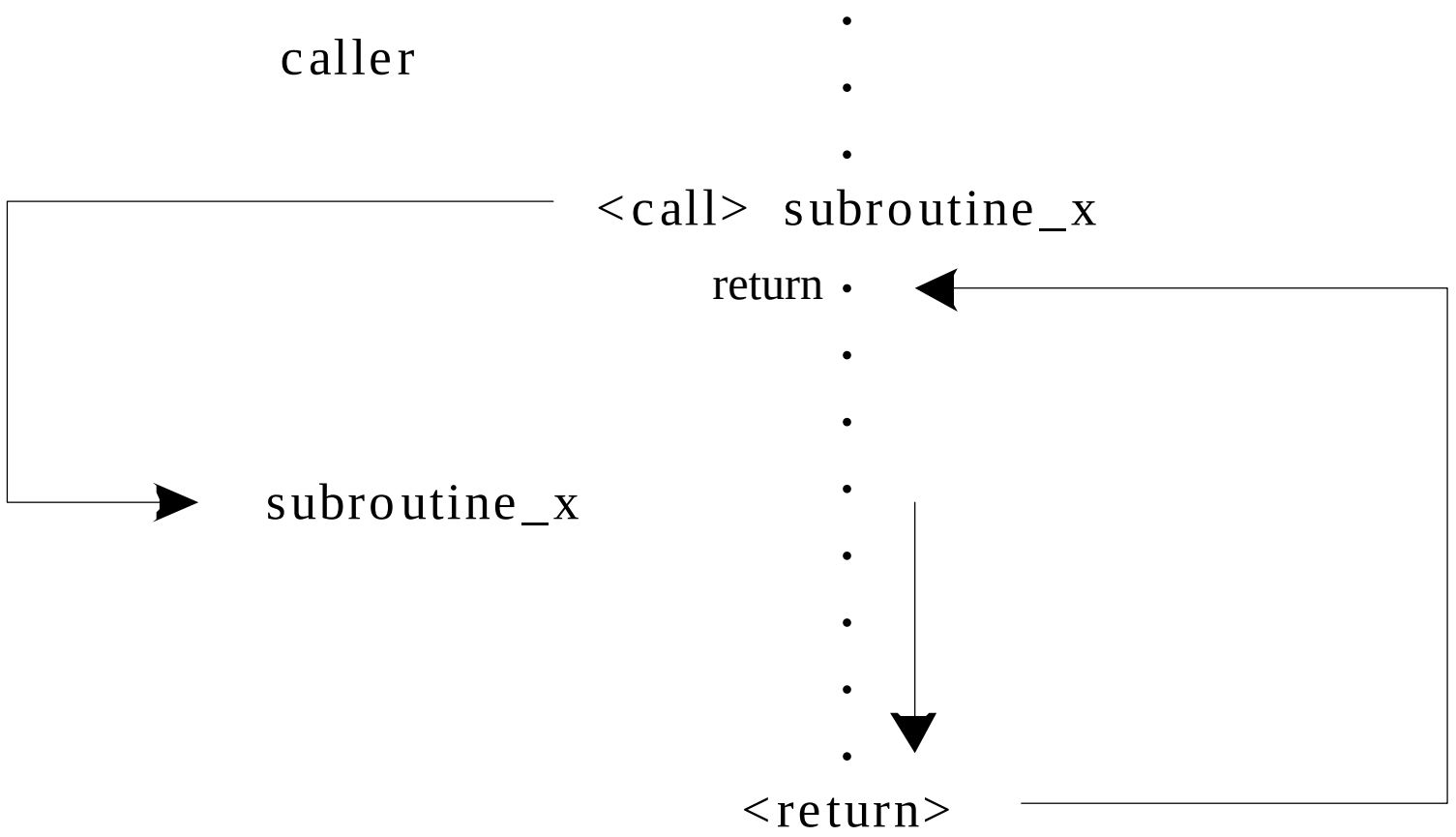

Figure4.8 Program flow during a subroutine call

Instructions Related to Subroutine Calls

[<label>]	BSR	<rel>	[<comment>]	; branch to subroutine
[<label>]	JSR	<opr>	[<comment>]	; jump to subroutine
[<label>]	RTS		[<comment>]	; return from subroutine
[<label>]	CALL	<opr>	[<comment>]	; to be used in expanded memory
	RTC			; return from CALL

where

<rel> is the offset to the subroutine

<opr> is the address of the subroutine and is specified in the direct, extended, Indexed, or indexed indirect addressing modes.

```
bsr bubble

jsr $ff

jsr sq_root

jsr 0,x
```

Issues in Subroutine Calls

1. ***Parameter passing***
   - Use registers
   - Use the stack
   - Use global memory
2. ***Returning results***
   - Use registers
   - Use the stack
   - Use global memory
3. ***Local variable allocation***
   - Allocated by the callee
   - The following instruction is the most efficient method of local variable allocation.

```
leas  -n,sp        ; allocate n bytes in the stack for local variables
```

4. ***Local variable deallocation***
   - space allocated to local variables must be deallocated
   - The following instruction is the most efficient method of local variable deallocation.

```
leas  n,sp         ; deallocate n bytes from the stack
```

Stack Frame

- The region in the stack that holds incoming parameters, the subroutine return address, local variables, and saved registers is referred to as stack frame.
- The stack frame is also called **activation record**.

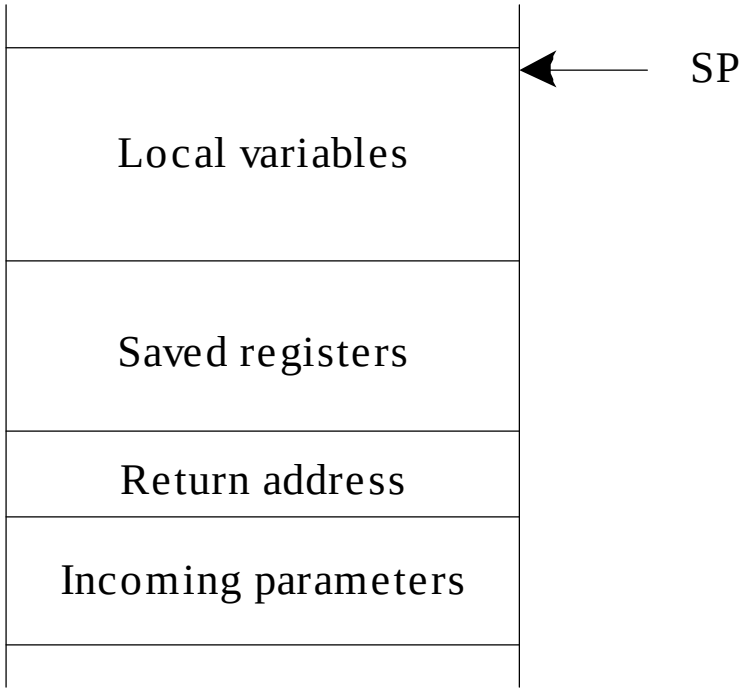

Figure 4.9 Structure of the 68HC12 stack frame

Example 4.10 Draw the stack frame for the following program segment after the leas –10,sp instruction is executed:

```
            org     $1800
            ldd     #$1234
            pshd
            ldx     #$4000
            pshx
            jsr     sub_xyz
            ldaa    $3000
            …
            swi
            org $2000
sub_xyz     pshd
            pshx
            pshy
            leas    -10,sp
            …
            rts
```

Solution:

The stack frame is shown in Figure 4.10.

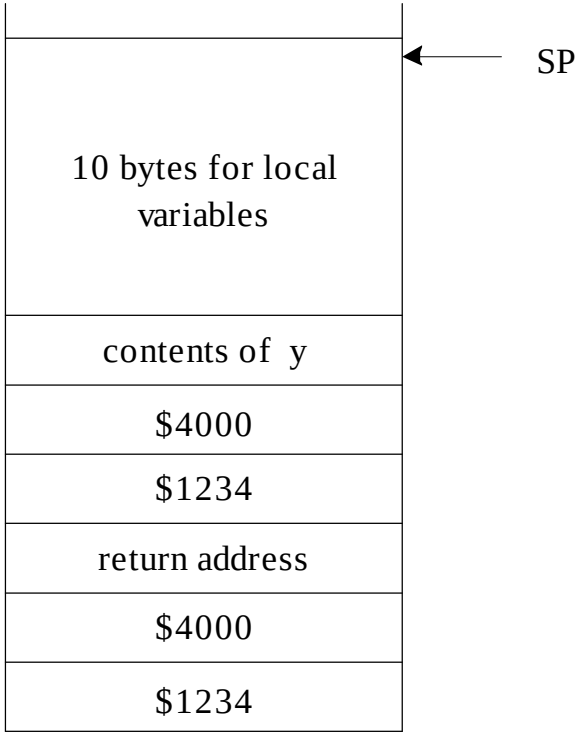

Figure 4.10 Stack frame of example 4.10