CSE 340 (Chap -2)

Supplementary Slides for: Function/ Procedure/ Subsection

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Function

```
Main (){
int x=0;
int y=9;
int z = addition(x,y);
.
. }

int addition(int a, int b){
int c = a+b;
return c;
}
```

Main function is the Caller function, where a function is called, and the parameters are provided for the called function

Parameters for function can be passed using 4 Registers, that are $a0, $a1, $a2, $a3 (argument Registers)

Return address from function to origin is stored is $ra

Value can be returned from function using 2 registers: $v0 and $v1.

Register Usage

- $a0 – $a3: arguments (reg's 4 – 7)
- $v0, $v1: result values (reg's 2 and 3)
- $t0 – $t9: temporaries
  - Can be overwritten by callee
- $s0 – $s7: saved
  - Must be saved/restored by callee
- $gp: global pointer for static data (reg 28)
- $sp: stack pointer (reg 29)
- $fp: frame pointer (reg 30)
- $ra: return address (reg 31)

Procedure Calling

- Steps required
  1. Place parameters in registers
  2. Transfer control to procedure
  3. Acquire storage for procedure
  4. Perform procedure’s operations
  5. Place result in register for caller
  6. Return to place of call

```
Main (){
int f=0;
f = f + 1;

int z = addition(x,y);
Int c = x-y;
}

int addition(int a, int b){
int f = a+b;
return f;
}
```

```
add $s0, $zero, $zero
addi $s0, $s0, 1

jal addition
```

f → $s0

#jumps to addition function and

#creates link with where the function is called from, by storing the address in $ra

Save the register values used by the procedure, to recover any value that can get lost

Procedure Call Instructions

- Procedure call: jump and link

  jal ProcedureLabel

  - Address of following instruction put in $ra
  - Jumps to target address
- Procedure return: jump register

  jr $ra

  - Copies $ra to program counter
  - Can also be used for computed jumps
    - e.g., for case/switch statements

Leaf Procedure Example

```
Main (){
int f=0;
f= f + 1;
int z = leaf_example (1,2,4,3);
int y = f + z;
.
. }
int leaf_example (int g, h, i, j)
{ int f;
  f = (g + h) - (i + j);
  return f;
}
```

jal leaf_example

- Arguments:

g □ $a0

h □ $a1

i □ $a2

j □ $a3

- f in $s0 (hence, need to save $s0 on stack)
- Result in $v0

Saved value registers ($s0 - $s7) that are used by the function are stored in Stack, to recover any value that can get lost

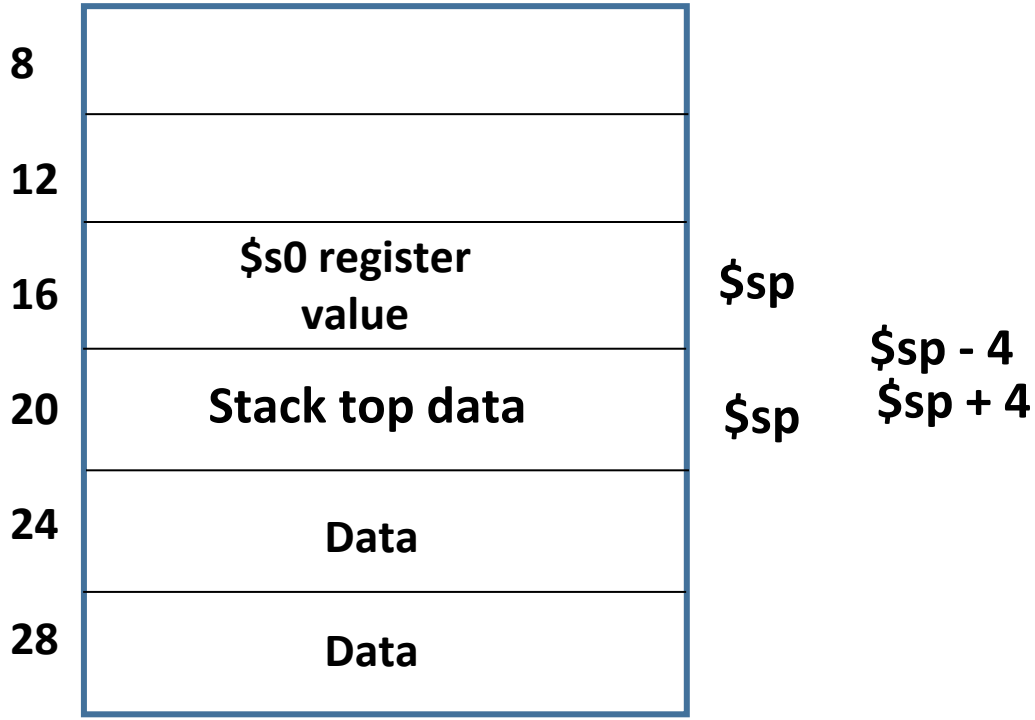
Storing data in stack

$s0 register value

```
addi $sp, $sp, -4
sw $s0, 0($sp)
```

Retrieving data from stack

```
lw $s0, 0($sp)
addi $sp, $sp, 4
```



When a value is inserted in stack, the stack pointer register moves 4 slots upwards, hence $sp = $sp - 4

- Arguments:

g □ $a0, h □ $a1, i □ $a2, j □ $a3

- f in $s0 (hence, need to save $s0 on stack)
- Result in $v0

C Code:

```
int leaf_example (int g, h, i, j)
{ int f;
  f = (g + h) - (i + j);
  return f;
}
```

jal leaf_example

MIPS Code:

```
leaf_example:
    addi $sp, $sp, -4
    sw  $s0,   0($sp)
    add   $t0, $a0,$a1
    add   $t1, $a2,$a3
    sub   $s0, $t0, $t1
    add   $v0, $s0, $zero
    lw   $s0,   0($sp)
    addi $sp, $sp, 4
    jr      $ra
```

Leaf Procedure Example

```
Main (){
int f, x=0;
f= f + 1;
int z = leaf_example (1,2,4,3);
int y = f + z + x;
.
. }
```

```
int leaf_example (int g, h, i, j)
{ int f, x;
  f = (g + h) - (i + j);
  x= f+1;
  return f;
}
```

jal leaf_example

- Arguments:

g □ $a0

h □ $a1

i □ $a2

j □ $a3

- f in $s0, x in $s1 (hence, need to save $s0, $s1 on stack)
- Result in $v0

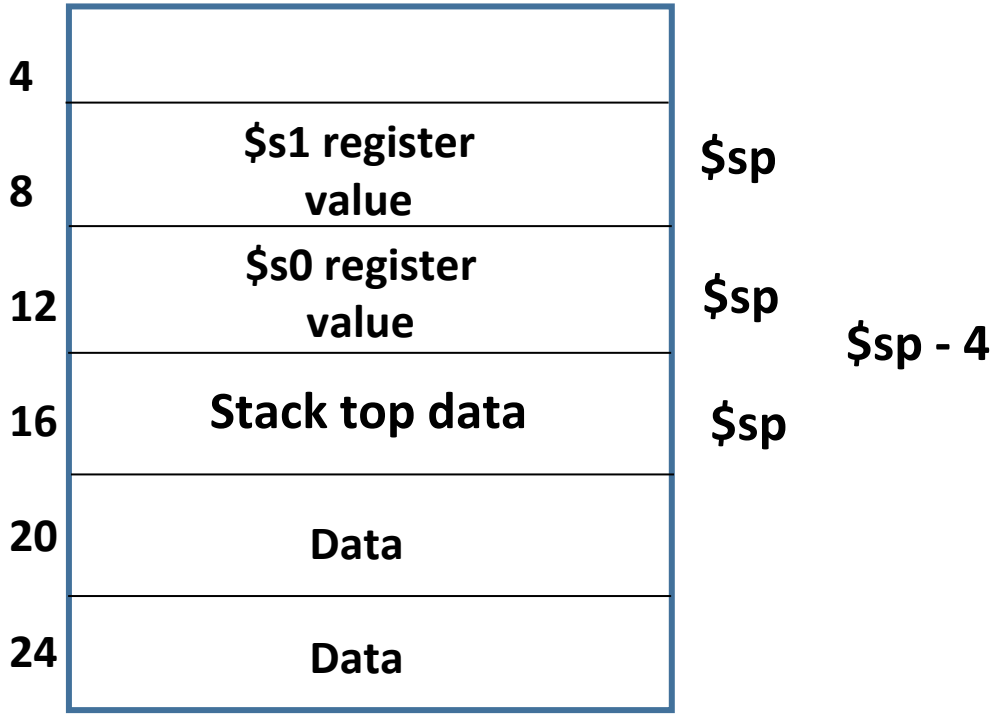
Saved value registers ($s0 - $s7) are stored in Stack used by the function, to recover any value that can get lost

Storing data in stack

$s0 register value

$s1 register value

```
addi $sp, $sp, -4
sw $s0, 0($sp)
addi $sp, $sp, -4
sw $s1, 0($sp)
```



Retreving data from stack

Last In First Out

```
lw $s1, 0($sp)
addi $sp, $sp, 4
lw $s0, 0($sp)
addi $sp, $sp, 4
```

When a value is inserted in stack, the stack pointer register moves 4 slots upwards, hence $sp = $sp - 4

- Arguments:

g □ $a0, h □ $a1, i □ $a2, j □ $a3

- f in $s0, x in $s1 (hence, need to save $s0, $s1 on stack)
- Result in $v0

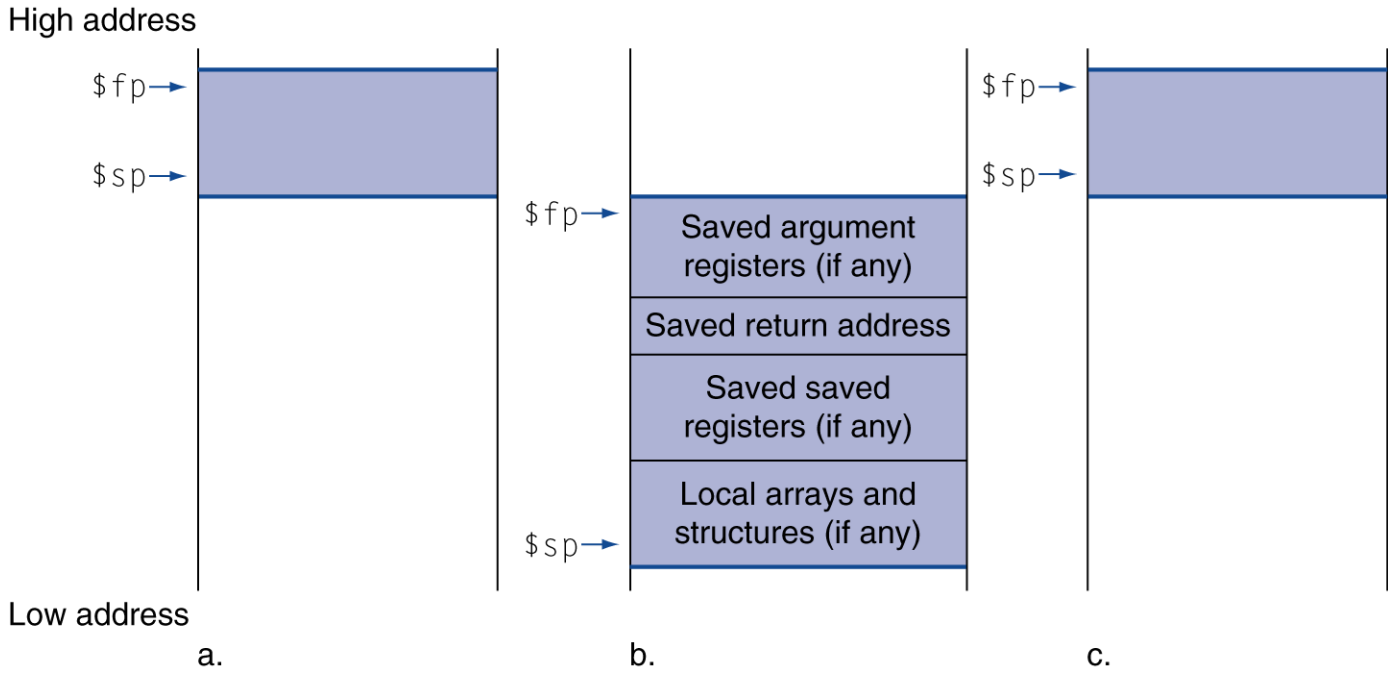
C Code:

```
int leaf_example (int g, h, i, j)
{ int f, x;
  f = (g + h) - (i + j);
  x= f+1;
  return x;
}
```

MIPS Code:

```
leaf_example:
        addi $sp, $sp, -4
        sw  $s0,   0($sp)
        addi $sp, $sp, -4
        sw  $s1,   0($sp)
        add   $t0, $a0, $a1
        add   $t1, $a2, $a3
        sub   $s0, $t0, $t1
        addi $s1, $s0, 1
        add   $v0, $s1, $zero
        lw   $s1,   0($sp)
        addi $sp, $sp, 4
        lw   $s0,   0($sp)
        addi $sp, $sp, 4
        jr      $ra
```

Local Data on the Stack



- Local data allocated by callee
  - e.g., C automatic variables
- Procedure frame (activation record)
  - Used by some compilers to manage stack storage