Recursion and the hardware stack

CSE 30: Computer Organization and Systems Programming

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Stack Models

0x418
0x400
0x3e8

(1) (2) (3) (4)
The AAPCS specifies a

- Full descending stack
- Stack is 8 byte aligned
The following ARM statements are translations of the given C code, variables i and j should be maintained on the stack.

Q: Is the state of memory the same after each code is executed?

```
int i =10, j=20;
i=i+j;
```

A. Yes
B. No

```
MOV r0, #10
MOV r1, #20
SUB sp, sp, #8
STR r0, [sp]
STR r1, [sp, #4]
ADD r0, r1, r2
```
New instruction STM

STMDB sp!, {r0 – r1}

foo:
MOV r0, #10
MOV r1, #20
SUB sp, sp, #8
STR r0, [sp]
STR r1, [sp, #4]
ADD r0, r0, r1
BX lr

foo:
MOV r0, #10
MOV r1, #20
STMDB sp!, {r0, r1}
ADD r0, r0, r1
BX lr
Is the given C and ARM code equivalent?

A. Yes
B. No

int foo()
{
    int i=10, j=10;
    return i+j;
}

foo:
    MOV r0, #10
    MOV r1, #20
    STMDB sp!, {r0, r1}
    ADD r0, r0, r1
    BX lr
Recursion Example

```c
int fact (int n)
{
    if (n < 1)
        return 1;
    else
        return n * fact(n - 1);
}
```
Recursion in ARM

```
fact:
  CMP r0, #1
  BLE ret_one
  MOV r1, r0
  SUB r0, r0, #1
  BL fact
  MUL r0, r0, r1
  B end

ret_one:  MOV r0, #1
end:
  BX lr
```

```cpp
int fact (int n)
{
    if (n < 1)
        return 1;
    else
        return n * fact(n - 1);
}
```

What is the value returned by fact(1)?

A. One  
B. Two  
C. Three  
D. Six  
E. None of the above
Recursion in ARM

fact:

CMP r0, #1
BLE ret_one
MOV r1, r0
SUB r0, r0, #1
BL fact
MUL r0, r0, r1
B end

ret_one: MOV r0, #1
end:

BX lr

int fact (int n)
{
    if (n < 1)
        return 1;
    else
        return n * fact(n - 1);
}

What is the value returned by fact(2)?
A. One
B. Two
C. Four
D. Six
E. None of the above
Recursion in ARM

Fact: push {lr}
CMP r0, #1
BLE ret_one
MOV r1, r0
SUB r0, r0, #1
BL fact
MUL r0, r0, r1
B end

Ret_one: MOV r0, #1
End: pop {lr}
BX lr

int fact (int n)
{
    if (n < 1)
        return 1;
    else
        return n * fact(n - 1);
}

What is the value returned by fact(3)?
A. One
B. Two
C. Four
D. Six
E. None of the above
Recursion in ARM

fact: push {r1, lr}
    CMP r0, #1
    BLE ret_one
    MOV r1, r0
    SUB r0, r0, #1
    BL fact
    MUL r0, r0, r1
    B end

ret_one: MOV r0, #1
end: pop {r1, lr}
    BX lr

int fact (int n)
{
    if (n < 1)
        return 1;
    else
        return n * fact(n - 1);
}

What is the value returned by fact(3)?
A. One  
B. Two  
C. Four  
D. Six  
E. None of the above
int read_and_sum() {
    int l1, l2;
    scanf("%d%d", &l1, &l2);
    return l1 + l2;
}

read_int:
    push {r4-r11, ip, lr}
    sub sp, sp, #8 @ reserve 8 bytes for the 2 local integers

    ldr r0, =scan_ints @ format string
    mov r1, sp @ address of l1
    add, r2, sp, #4 @ address of l2
    bl scanf

    ldr r0, [sp] @ read l1
    ldr r1, [sp, #4] @ read l2
    add r0, r0, r1

    add sp, sp, #8 @ de-allocate 8 bytes, restore sp to
    @ value after push

    pop {r4-r11, ip, lr}
    bx lr