

ELEC6027: VLSI Design Project
Part 1: Microprocessor Research
Topic: Subroutines

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1 Introduction

2 Research

2.1 Subroutine Context Save

Context save, also known as, allows

2.2 Operation of Stack Frames

2.2.1 8086

The assembler held in listing 1 and 2 is written for the Intel 8086 microprocessor. A basic example of how stack frames are built to pass parameters to and from a subroutine. The main program in listing 1 loads two immediate values into registers then begins building a stack frame by pushing them to the stack. The subroutine is called to act upon the arguments passed via the stack. When control is passed back to these set of instructions and the return value is extracted by using relative addressing from the base pointer then finally two stack pops completely destroy the stack frame.

```
main:                ; Main loop
    MOV    bp,sp      ; Init base ptr
    MOV    ax,42       ; Load arg1
    MOV    bx,69       ; Load arg2
    PUSH   bx          ; Push arg1 to stack
    PUSH   ax          ; Push arg2 to stack
    CALL   adder       ; Call the subroutine
    MOV    cx,[bp-12]  ; Access return value
    POP    ax          ; Restore all registers
    POP    bx
    JMP    main
```

Listing 1: 8086Caller.asm

When the subroutine, in listing 2, is called the return address is pushed onto the stack. This built-in support for the stack handles branching and next line address storage using a call function. To start the base pointer is placed on the stack so stack pointer has value to which to be restored. Reducing the value of the stack pointer allocates space for local variables. The first argument is placed in memory as local variable; this is unnecessary but serves as example. The second argument is loaded into a working register. The first local variable is added to the working register which is then placed in to the memory for the second local variable. Finally the stack pointer and the base pointer are restored and a return instruction hands control over the caller. This is all part of the calling convention for subroutines using stack frames on the 8086 [1].

```
adder PROC           ; Subroutine
    PUSH   bp        ; Push base ptr to stack
    MOV    bp,sp      ; Set base ptr to stack ptr
    SUB    sp,4       ; Allocate local variable space (2 ints)
    MOV    ax,[bp+4]   ; Load arg1 into Working
    MOV    [bp-2],ax   ; Load arg1 into Local1
    MOV    ax,[bp+6]   ; Load arg2 into Working
    ADD    ax,[bp-2]   ; Add to contents of working reg
    MOV    [bp-4],ax   ; Write Local2 with result
```

```

MOV    sp, bp      ; Return stack ptr
POP     bp          ; Restore base ptr
RET                      ; Done
addrer ENDP

```

Listing 2: 8086Callee.asm

This code was tested upon an 8086 emulator [4]. The emulator provides a complete overview of the flow of data within the processor including the stack. Figure 1a shows the emulator during the execution of the subroutine just before the stack pointer is overwritten with the base pointer.

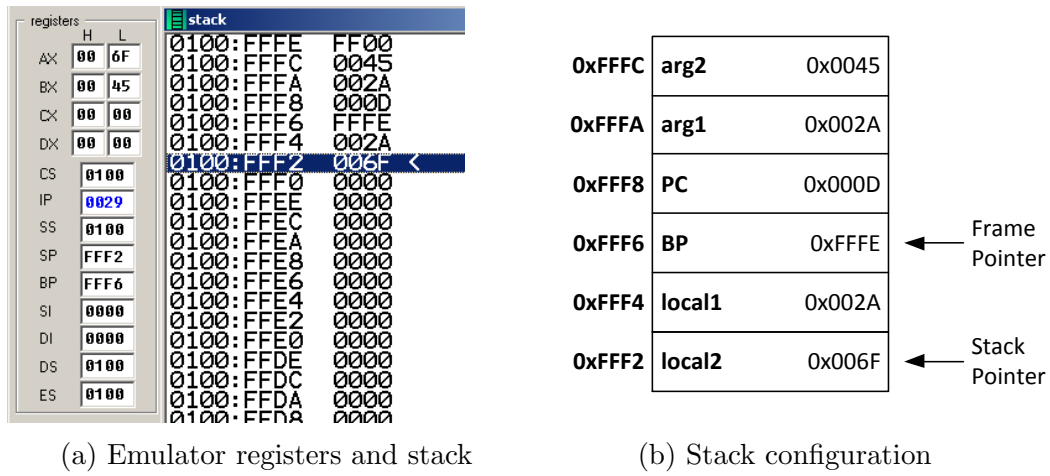


Figure 1: 8086 stack operation

2.2.2 ARM7TDMI using Arm Thumb

The ARM7TDMI is a 32-bit RISC microprocessor with an emphasis on low-power design and pipelining for high throughput [2]. It has two instruction sets one of which is Arm Thumb, a low density 16-bit subset of the ARM assembly language [3]. A user selectable flag is set to switch between instruction sets therefore drawing on each sets advantages.

This architecture does not have built-in support for calling subroutines using the stack. When the branch instruction is used, as seen in listing 3, the program counter is overwritten with the address of the corresponding label. The address of the next line of code, which should be returned to after the subroutine, is placed into the link register. Calling conventions suggests leaving this register untouched and simply moving the data back into the program counter on a return.

```

main  MOV    r0,#42    ; Load arg1
      MOV    r1,#69    ; Load arg2
      PUSH   r0        ; Push arg1 to stack
      PUSH   r1        ; Push arg2 to stack
      BL     adder     ; Branch to subroutine
      POP    r0        ; This line is held in the link register
      POP    r0        ; Result pop from arg1 spot
      BL     main

```

Listing 3: ArmCaller.asm

In this case the link register is pushed onto the stack from the subroutine therefore requiring the subroutine to pop the value into the program counter in order to return. Listing 4 holds the subroutine and handles placing the return address on the stack. Relative addressing on the stack is required to draw the two arguments out and replace the first with the output of the function.

```

adder PUSH   lr        ; Link register holds return address
      LDR    r0, [sp,#12] ; Get arg1 off stack
      LDR    r1, [sp,#8]  ; Get arg2 off stack
      ADD    r0,r1       ; Do the add
      STR    [sp,#12], r0 ; Replace arg1 on the stack
      POP    pc         ; Restore program counter and return

```

Listing 4: ArmCallee.asm

3 Conclusion

References

- [1] James Archibald. The c calling convention and the 8086: Using the stack frame. <http://ece425web.groups.et.byu.net/stable/labs/StackFrame.html>, 2013. Online. Accessed Feb 2014.
- [2] ARM Holdings plc. Arm7tdmi data sheet. <http://www.ndsretro.com/download/ARM7TDMI.pdf>, Aug 1995. Online. Accessed Feb 2014.
- [3] ARM Holdings plc. Thumb instruction set quick reference card. http://www.eng.auburn.edu/~nelson/courses/elec5260_6260/Thumb%20Instructions.pdf, Oct 2003. Online. Accessed Feb 2014.
- [4] Daniel B. Sedory, Randall Hyde, Eric Isaacson, Barry Allyn, Tomasz Grysztar, Saul Coval, Bob Brodt, Jordan Russell, and Jeremy Gordonii. emu8086. <http://www.emu8086.com/>, 2013. Online. Accessed Feb 2014.

Bibliography

- [1] Leslie Lamport, *TEX: A Document Preparation System*. Addison Wesley, Massachusetts, 2nd Edition, 1994.