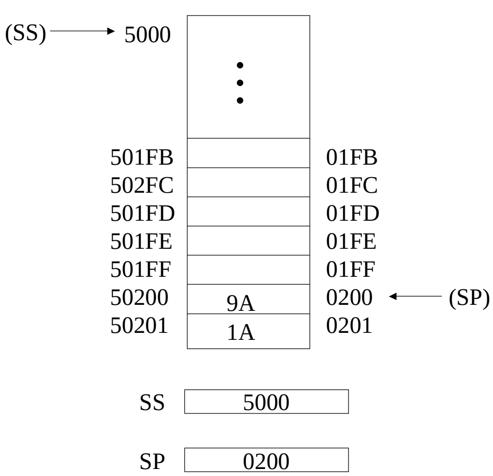
Lecture 14: The Stack

- What is it?
- What is it used for?

The Stack

- A special memory buffer (outside the CPU) used as a temporary holding area for addresses and data
- The stack is in the stack segment.
- The stack is a buffer of *words*.
- SP holds the address (offset from SS) of the last data element to be added to the stack. -> the TOP of the stack.
- The stack is a LIFO structure (last-in, first-out)

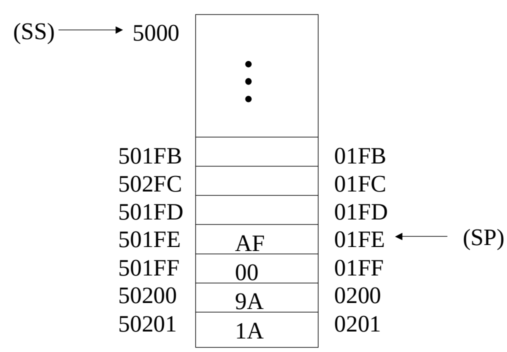
The Stack



Adding Elements

- Elements are added by *pushing* them on to the stack.

```
mov ax, 0AFh
push ax
```

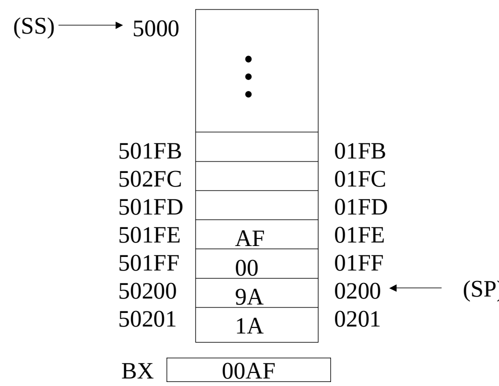


Adding elements, cont.

- When data is pushed,
  - SP = SP – 1
  - high order data byte is stored in SS:SP
  - SP = SP – 1
  - low order data byte is stored in SS:SP
- SP is left pointing to the item just pushed (the “top” of the stack)

Removing (Retrieving) Information

- Elements are removed by *popping* them from the stack.
  - pop bx



Retrieving, cont.

- When data is popped:
  - copy SS:SP into low-order byte of the register/memory location
  - increment SP
  - copy SS:SP into high-order byte of the register/memory location
  - increment SP
- SP is pointing to the new top of stack.
- Notice: the data does not get deleted from the memory location it was in, but it will be overwritten the next time data is pushed on to the stack.

A Word of Warning!

- The book draws the stack going from high memory to low memory:
  - picture from Irvine

Warning, cont.

- Why draw it that way?
- Well, the stack grows down, from high memory to low memory until SP = SS.
- If it's drawn like the book has it, then "down" is actually down.
- If it's drawn like I've done it, it looks more like the other drawings of memory we've seen in this class. Plus the item at the top of the stack looks like it's on top.

So…

- You need to be aware of what is happening to SP when items are being pushed and popped.
- Remember that memory can be drawn differently but the assembly code is still doing the same thing!
- SP *always* points to the "top" (the item that would be popped first).
- It's important when drawing the stack to be sure write the offset or address next to it so you can tell what is going on.

Push

- PUSH decrements SP and copies a 16 bit or 32 bit register or memory operand onto the stack at the location pointed to by SP.
- Allowed forms:
  - push reg
  - push memval
  - push immed
- Examples:
  - push AX
  - push count ;where count dw ?
  - push 0a23h
- You can't push a byte on to the stack!

Push Examples

```
;assume SP =
  0202

mov  ax, 124h
push  ax
push   0af8h
push  0eeeh
```

⋮		
	01FB	
EE	01FC	← (SP)
0E	01FD	
F8	01FE	
0A	01FF	
24	0200	
01	0201	

Pop

- POP copies the contents of the stack pointed to by SP into a register or variable and increments SP. Two registers (CS and IP) cannot be used as operands.
- Allowed forms:
  - pop reg
  - pop memval
- Examples:
  - pop cx
  - pop count ;where count dw ?

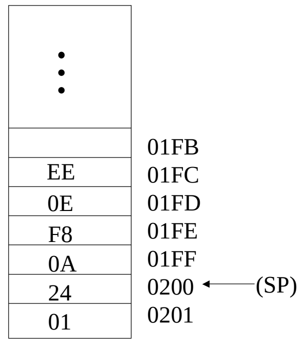
Pop Examples

;initial SP = 01FD

pop BX
pop DX

BX = 0EEEh
DX = 0AF8

If we were to pop again, the next value popped off would be 0124.



More Instructions

- PUSHF – pushes the flags register on to the stack
- POPF – restores the flags register from the stack

Common Stack Uses

- A good temporary save area for registers.
- Subroutine return addresses are saved on the stack.
- Procedure arguments can be passed on the stack (high level languages typically do this).
- High level languages use the stack as a place to store local variables.

Stack Overflow

- The 8086 hardware does *not* check for stack overflow!
- The CPU will let you keep pushing beyond bounds of the stack (possibly destroying important memory).
- Your program must check by:

  CMP SP, 0

  If there is *any* chance that stack overflow might occur.

Saving and Restoring Registers

- example p 135, Irvine

Procedures

- As with high-level languages, it is useful to be able to call procedures from your assembly program.
- You did this in homework 3 with wrint.
- Some terms:
  - function: a procedure that returns a value
  - subroutine: a procedure (the terms are interchangeable)

PROC and ENDP

- PROC identifies the start of a procedure
- ENDP identifies the end
- example 1, p. 136 in Irvine

CALL and RET

- CALL – pushes IP on the stack (recall, IP holds the address of the next instruction), puts the address of the label (subroutine) into IP.
- RET – pops the stack into IP to return to the point at which the subroutine was called.

```
        TITLE   Procedure Calls
;       two calls to a procedure that increments every element
;       of an array

        .model small
        .stack 100h

        .data
List            DW      5FFFh, 0Ah, 12h, 17h
Array           DW      -9, 4, 7, 0, 14, 9
count1  DW      4
count2  DW      6

        .code
        .startup
        mov     bx, offset List     ;first call
        mov     cx, count1
        call    IncProc

        mov     bx, offset Array    ;second call
        mov     cx, count2
        call    IncProc

        nop                         ;can examine arrays with
                                    ;the debugger here
        .exit
        ;return to DOS
```

```
;procedure to increment all the elements in an array of
words
;BX contains the base address of the array
;CX contains the number of elements in the array

IncProc proc
        sub     si, si              ;start index at 0
Lup:    inc     word ptr [bx] [si]  ;use indexed
addressing
        add     si, 2
        ;dealing with words, not bytes
        loop    Lup                 ;go to next element
        ret
        ;return - must be used with Call
IncProc endp

        end                         ;end of assembly
```

Nested Procedure Calls

- example 4 from text

Near vs Far Calls

- When the caller and subroutine are in the same segment, the CALL instruction generates code for a NEAR CALL.
- When the caller and subroutine are in different segments, the assembler generates a FAR CALL.

FAR CALL

- FAR CALL
  - saves both CS and IP on the stack (pushes CS first).
  - loads the subroutine's CS and IP
  - generates a different form of return (RETF) that restores CS and IP from the stack

Using FAR CALL

- Use FAR:
  - when linking asm routines to HLL programs (some require FAR calls)
  - when calling certain library routines that are set up for far calls
  - when your program size exceeds 64K (medium or large memory models). In this case, there will be multiple code segments, requiring far calls.
- Mostly, you will use NEAR. The assembler assumes you want NEAR unless you tell it otherwise.
- NEAR calls will execute faster (less pushing and popping)

Far Call, cont.

- example, p. 140 in Irvine