Tutorial 2:

The New Assembler-Simulator (nas)

```
$ flex nas.l
$ bison -d nas.y
$ gcc -o nas lex.yy.c nas.tab.c
$ nas fact.as
$ …
```

nas

Special registers of the machine: **sp** (stack pointer), **fp** (frame pointer) which points ***near*** the bottom of the current frame, and **sb** (stack base) … and **in** (index register) for implementing arrays

Also called **ac** (accumulator), and can be used as a general register, if you need one.

- A stack machine: all operations use push/pop
- Variables
  - In sas, there are 26 of them, and are named (a, b, …, z)
  - In nas, variables are unnamed, stored inside the stack, and there can be as many as you want (or as the stack can hold)

```
push "Enter 5 numbers: "; puts_
geti // = fp[0]
geti
geti
geti
geti // = fp[4]
push 4; pop in // in = 4
```

Treat these as variables

The "index register" (registers are named)

Assignment 2: The named variables are mapped from the compiler's symbol table to these; the nas code from the compilation keeps no names

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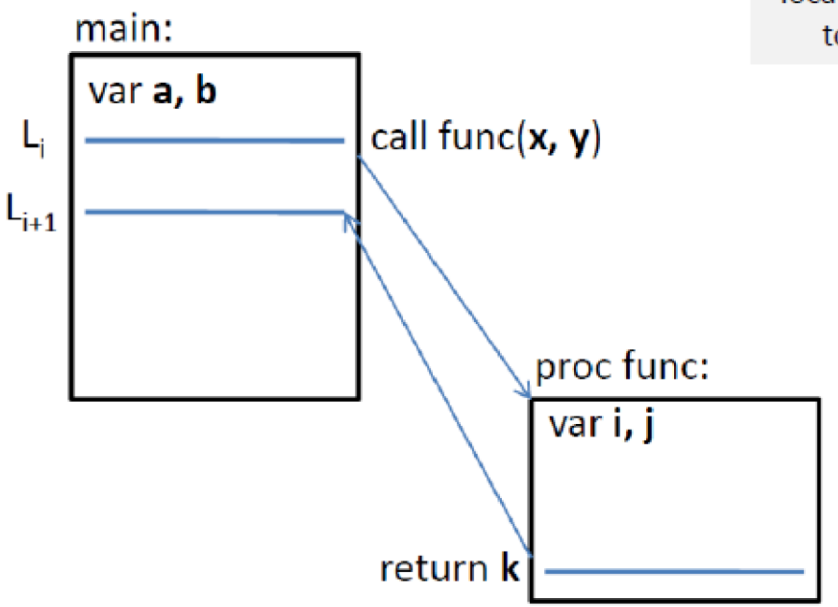
Also called **ac** (accumulator), and can be used as a general register, if you need one.

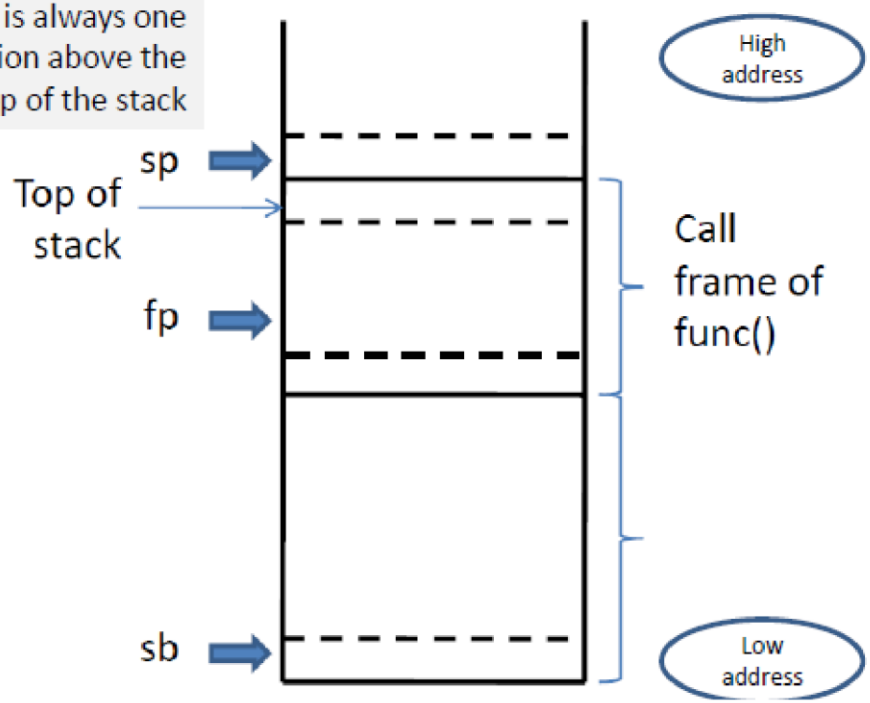
Note: This "main" is different from C's main() which is a function; here it is simply the outermost scope. Hence, **a, b** are global variables; **i, j** are local variables of func(). Assuming pass-by-value, **x, y** are copied to func() and treated as local variables. **k** is the return value copied back to main.



Function Call

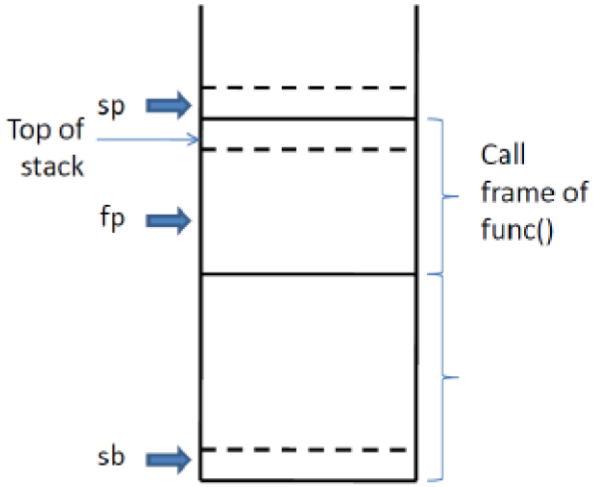
When func() is executing, the stack should look like:

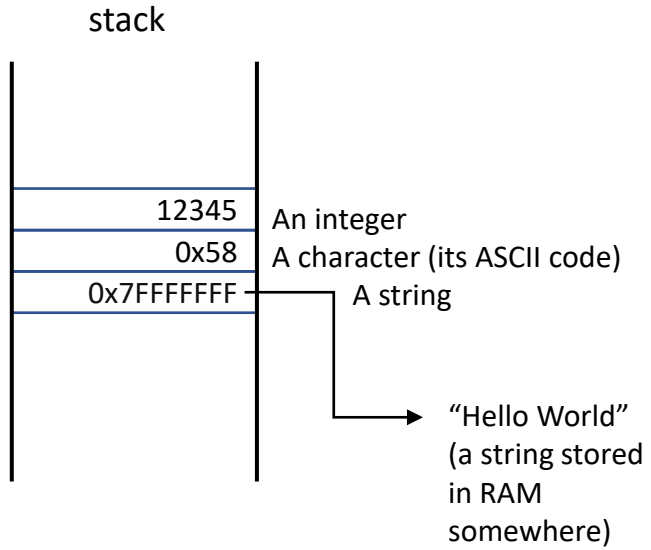
"sp" is always one location above the top of the stack



Using Variables

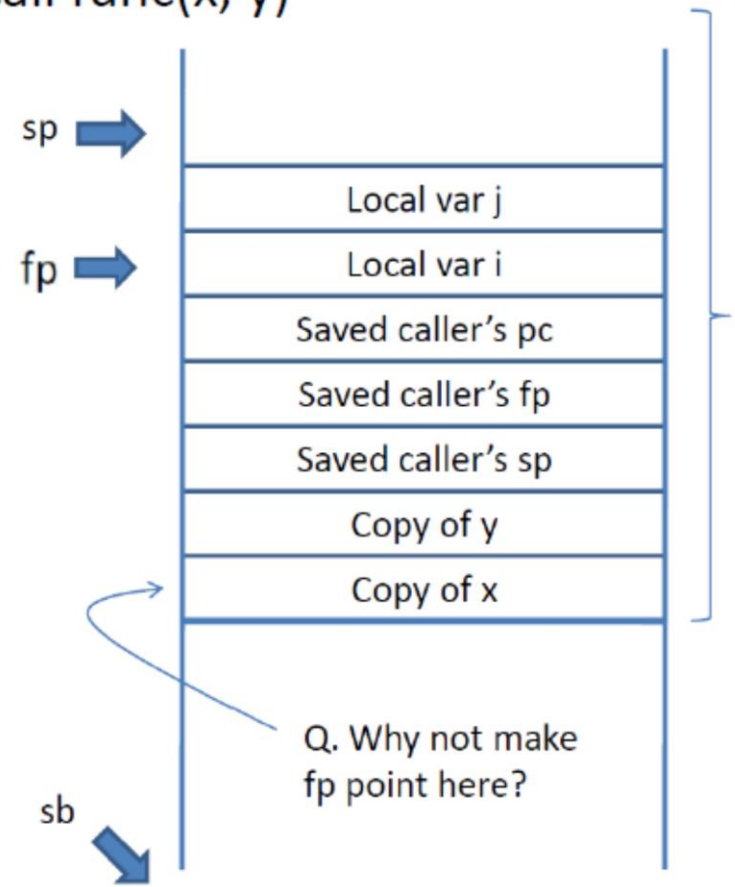
- Everything is on the stack, except strings (their addresses are pushed instead)
- To access local variables inside a function:
  - Relative to fp → e.g. “fp[-1]”
- To access global variables:
  - Relative to sb → e.g. “sb[3]”
- Only can access own frame and main, but not other frames in between



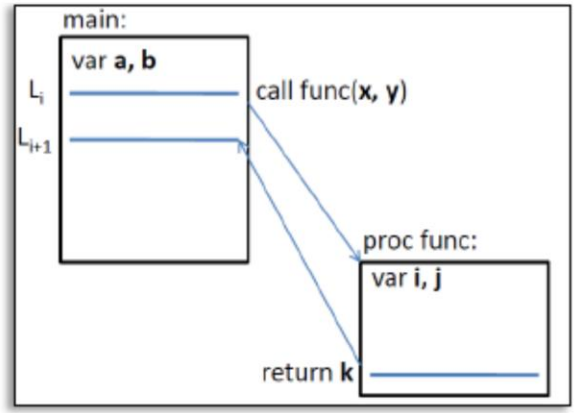


A Call Frame

" call func(x, y) "



Call frame of function/callee



i is referred to as fp[0]
j ... fp[1]
x ... fp[-5]
y ... fp[-4]
...
a ... sb[0]
b ... sb[1]
...
k, the return value will be left on top of the stack after the restoration

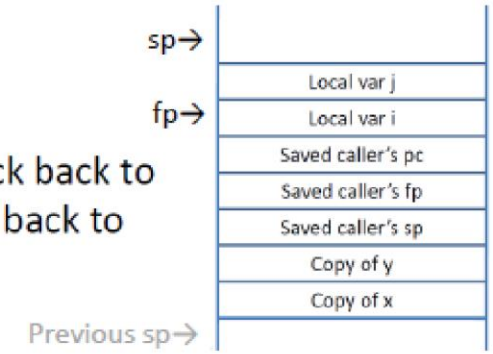
The General Call Pattern

```
        push 12         // x = 12
        push 34         // y = 34
        …
        …
        push fp[0]      // x as parameter
        push fp[1]      // y as parameter
        call L001, 2
        …
        …
        end
L001:   push 56         // i = 56
        push 78         // j = 78
        …
        push fp[-5]     // use x
        push fp[1]      // use j
        …
        push …          // the last pushed value is the return value
        return
```

This whole thing is the "call"

When we say "restore the stack back to what it was before", we mean back to this point

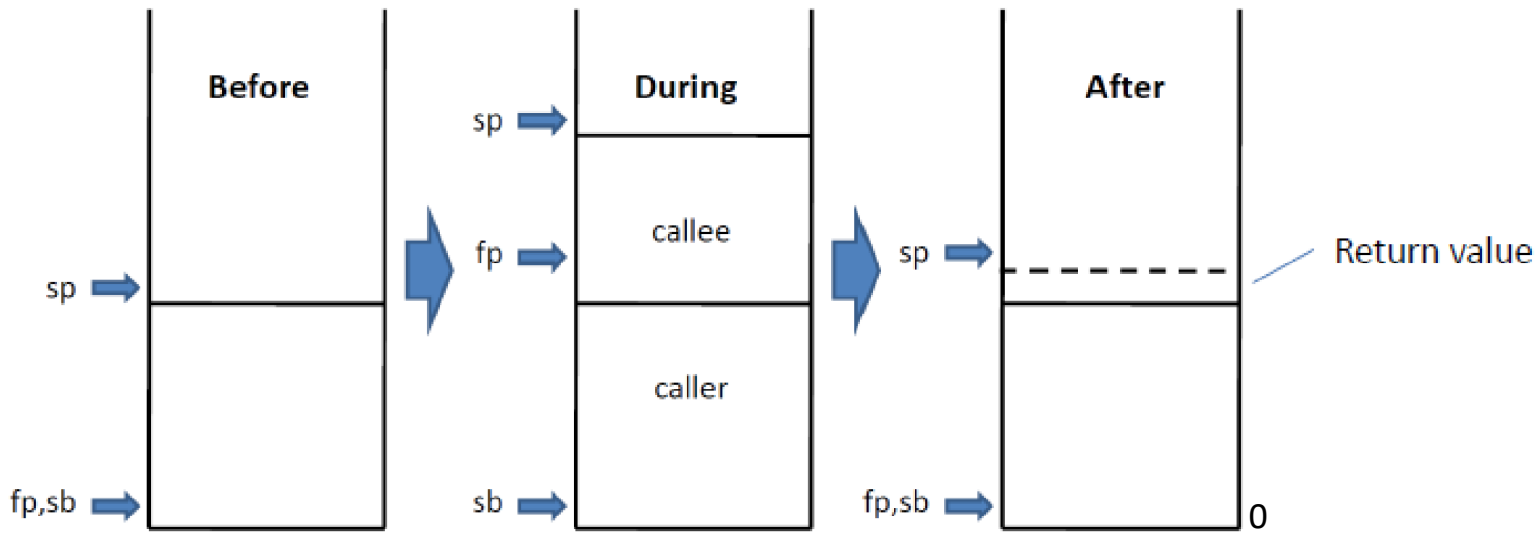
The 2 here means "two parameters", which helps the call mechanism to later on figure out the previous sp value (before the call)



Stack Frames

For all that we do in this course, sb is always = 0; in real machines however, sb could be any value, depending where your program is loaded by the system

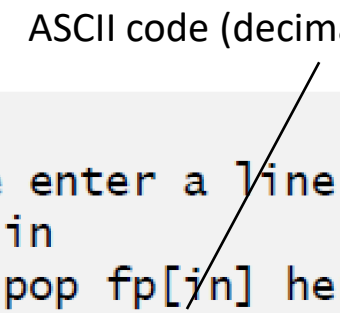
- When a program begins, fp = sp = sb = 0
  - sp rises and drops as actions in Main unfolds
- After a call, the stack must be restored to what it was before the call (+ the return value if there's one)
- At the moment of calling, caller's sp, fp, and pc (program counter) which points at the caller's next instruction (L_{i+1}) are saved in the callee's frame



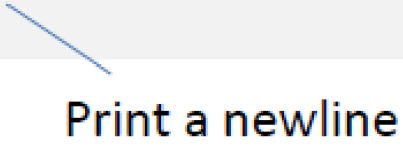
Push & Pop

push 123	push “123” onto the stack
push -456	push “-456” onto the stack
push fp[2]	push the content of “where fp is pointing + 2”
push fp[-7]	push the “… - 7”
pop sb[4]	pop the stack and store the value in “the stack bottom + 4”
push fp[in]	push … “where fp is pointing + the value of in”
push fp[-in]	Illegal; instead, you can make the value of in negative
push in	push the value of in
pop in	pop the stack and store the value in in
push fp	push the value of fp
push fp[0]	push the content of where in the stack fp is pointing

Example: rev-c.as




```
// rev-c.as
        push "Please enter a line:"; puts
        push 0; pop in                              // in = 0
L001:   getc; // NO pop fp[in] here !!               // fp[in] = getc
        push fp[in]; push 10; compeq; j1 L002       // if newline goto L002
        push in; push 1; add; pop in                // in++
        jmp L001
L002:   push in; push 1; sub; pop in                // in--
        push fp[in]; putc_
        push in; j0 L003; jmp L002
L003:   push ''; putc
        end
```



Example: max.as

```
// max.as
        push "Enter 2 numbers: "; puts_
        geti
        geti
        call L001, 2
        puti_  // print the return value
        push " is larger"; puts
        end
L001:   push fp[-4]
        push fp[-5]
        compgt
        j1 L002
        push fp[-5]
        ret
L002:   push fp[-4]
        ret
```

Do not print \n

Reads inputs and passes them as arguments to function

Which is at the stack's top

Retrieves and pushes the two arguments

Return value

Example: fact.as

```
// recursive fact.as
        push "Please enter a +ve int < 13: "; puts_
        geti
        call L001, 1
        puti
        end

// factorial():
L001:   push fp[-4]
        j0 L002
        push fp[-4]; push 1; sub
        call L001, 1    // recursive call
        push fp[-4]
        mul
        ret
L002:   push 1
        ret
```

Read n

Call fact(n)

Print return value

n

n = n – 1

Return n x fact(n - 1)