The New Assembler-Simulator (nas) for A3

15.11.2013

nas

- A stack machine: all operations use push/pop
- Variables
  - In “as” (A2), there are 26 of them (a..z)
  - Can’t have a..z in nas because functions can have local variables which may clash with the global ones
  - In nas, variables are unnamed, stored inside the stack, and there can be as many as you want

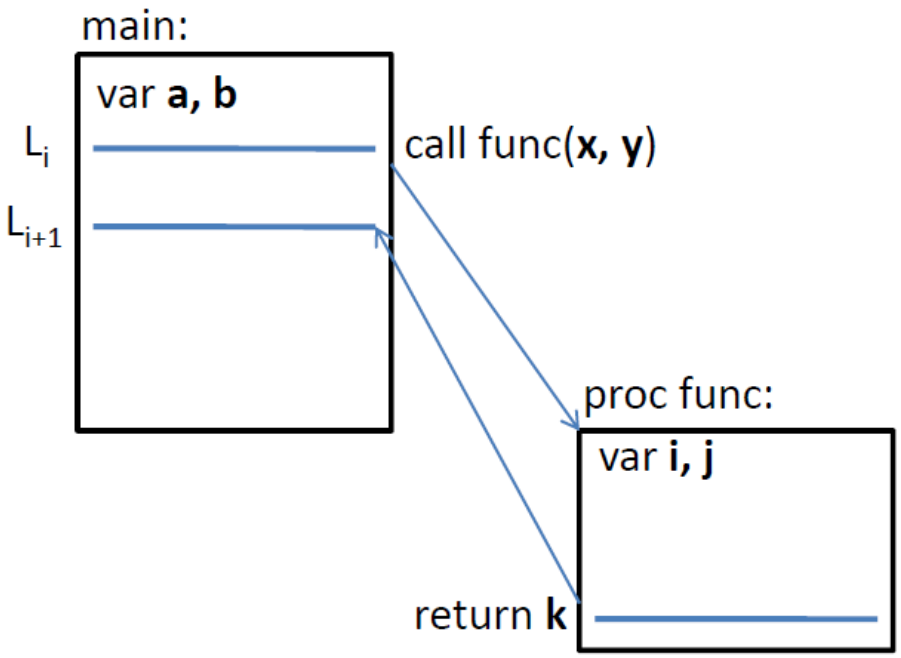
```
push "Enter 5 numbers: "; puts_
geti // = fp[0]
geti
geti
geti
geti // = fp[4]
push 4; pop in // in = 4
```

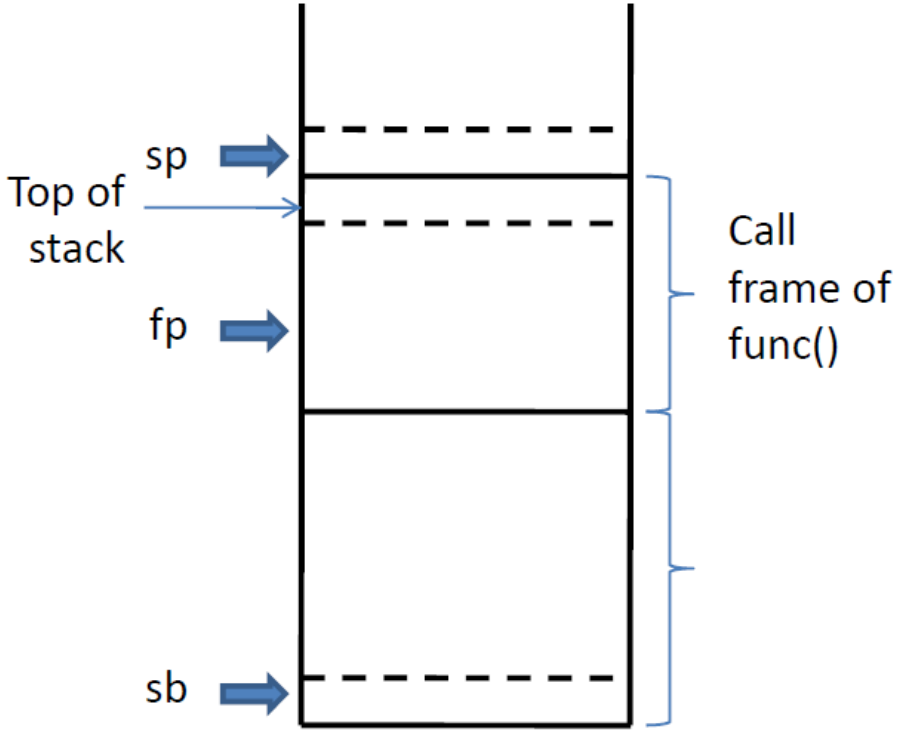
Treat these as variables

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:

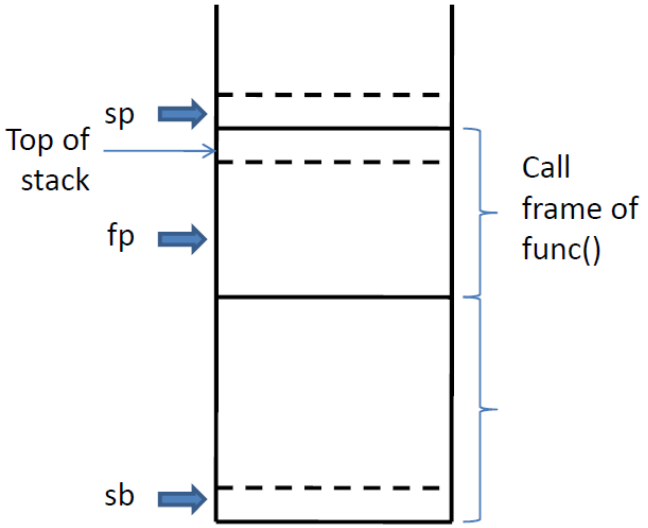




Special registers of the machine: **sp** (stack pointer), **fp** (frame pointer) which points ***near*** the bottom of the current frame, and **sb** (stack base) … and **in** (index register) for implementing arrays

How to use Variables

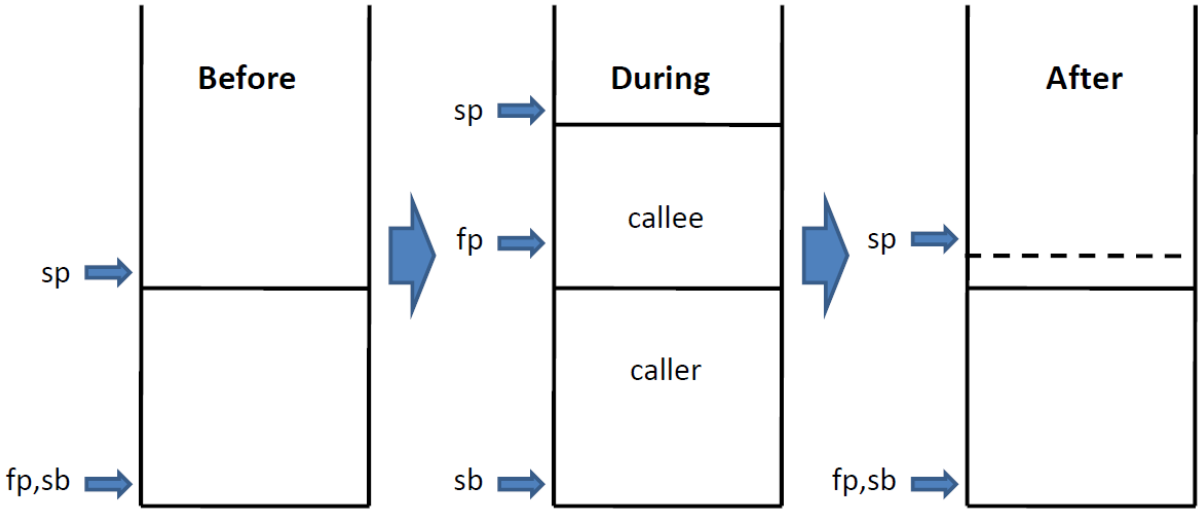
- Everything is on the stack, except strings (their addresses are pushed)
- To access local variables inside a function:
  - Relative to fp → e.g. “fp[-1]”
- To access global variables:
  - Relative to sb → e.g. “sb[3]”



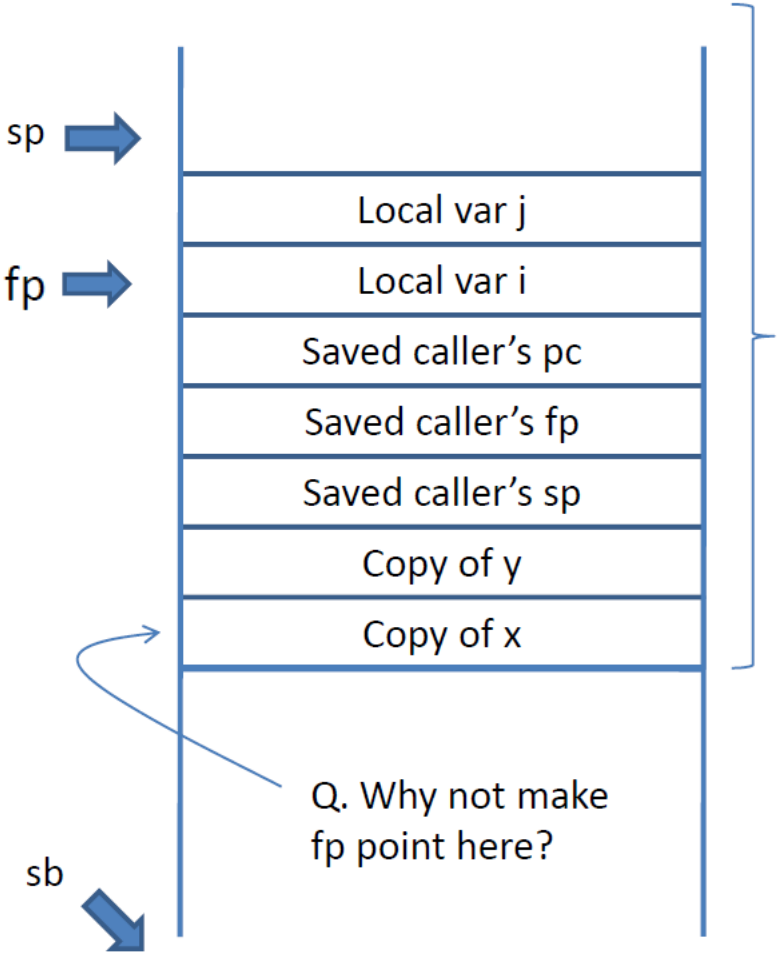
- Only can access own frame and main, but not other frames in between (is this a limitation?)

Stack Frame Come & Go

- When a program begins, fp = sp = sb = 0
- 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



A Call Frame



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

How You or the Compiler Write Code

```
        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
```

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

This whole thing is the "call"

The 2 means the two parameters, which is needed to find out the value of sp before the call (i.e., before the parameters were pushed)

Integer and Address Operands

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

The index register, in, is specially added for implementing arrays

It should be possible to implement multi-dimensional arrays in c7c using single dimensional arrays in nas

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

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)

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
```

Print a newline