# 1 Introduction to Calling Conventions: Print

In the previous section, we discussed throwing errors and how we can call an external (Rust) function from our generated assembly code. Note that the error case is interesting in the sense that it always terminated the program, so we didn't have to worry about coming back to our generated code.

Suppose we want to introduce a print expression, which takes an expression and then prints the result out. Like the error handling, the print expression will call an external Rust function. However, unlike the error handling, we expect the print expression to come back to the generated assembly code *after* calling the external function.

Syntactically, print looks like

```
<expr> := ... | input | (print <expr>)
```

# 1.1 Modifying start.rs

Once again, as we need to define a function in Rust to handle printing so our generated assembly code can use it, we need to modify start.rs to include this information. Let's define the following function to handle printing:

```
#[no_mangle]
#[export_name = "\01snek_print"]
fn snek_print(val : i64) -> i64 {
    if val == 3 { println!("true"); }
    else if val == 1 { println!("false"); }
    else if val % 2 == 0 { println!("{}", val >> 1); }
    else {
        println!("Unknown value: {}", val);
    }
    return val;
}
```

Note that

- 3 is our representation of true (3 is 0b11 in binary.)
- 1 is our representation of false (1 is 0b01 in binary.)

## 1.2 Calling Convention Idea

At a high level, when calling a function, we need to do the following:

- 1. "Remember where" we left off (i.e., recovering the stack).
- 2. Pass in the appropriate arguments.
- 3. Call the snek\_print function.

Regarding "remember where" we left off: remember that our compiler function has a parameter which represents the stack index. This stack index tells us how "deep" we are in the expressions that needed temporary storage/variables. So, whatever stack index we have, we need to set up the call so that it's above the stack index; after the call is done, we need to go back to where the stack index was originally.

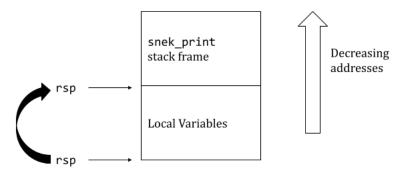
## 1.3 Implementing print

Let's now attempt to implement print into our compiler.

#### 1.3.1 Attempt 1

Our initial implementation of print might look like

In terms of what's going on, what sub rsp, {offset} is doing is moving rsp, the stack pointer, so that it's pointing *above* where all the local variables and temporaries are.



So, the stack frame for the snek\_print is where all the work for this function will happen. So, being its own function, it will rely on rsp being "kind of" like at bottom of its stack frame, since it gets its own local variable space whatnot.

```
(Exercise.) Consider the following code:

(block
    (print 37)
    (print input)
)

Using our implementation above, what would be printed if input was true?
```

This would print 37 twice. To see why, let's consider the generated assembly.

```
mov rax, 74
sub rsp, 16
mov rdi, rax
call snek_print
add rsp, 16
mov rax, rdi
```

The issue is in the third line, mov rdi, rax. We're overwriting rdi, which contains the result of input, with a different value! More specifically, we used rdi to pass in the argument for print, but this means we lose the result of rdi when we passed in the argument.

So, we just need to remember to store data from registers somewhere else before we do the call. One thing we can do is store rdi somewhere on the stack before we make the function call. To do this, we can make use of push and pop. In fact, rdi is an example of a caller-saved register; that is, before we make a function call, we should save this register if we want to restore it afterwards.

#### 1.3.2 Attempt 2

With what we just mentioned in mind, we have

```
match e {
    | Expr::Id(s) if s == "input" => "mov rax, rdi".to_string(),
    | Expr::Print(val) => {
        let offset = si * 8;
        let v_is = compile_expr(val, si, env, 1);
        format!("
            {v_is}
            sub rsp, {offset}
            push rdi
                                 ; added this line
            mov rdi, rax
            call snek_print
            pop rdi
                                 ; added this line
            add rdi, {offset}
        ")
    }
}
```

**Remark:** Remember that we want rsp to point to the spot where the pop is going to be, which is why we call pop rdi immediately after the call call.

Note that

- push pushes a value (register, immediate, etc.) to the stack. push will subtract 1 from rsp.
- pop pops whatever is on top of the stack into a register. pop will add 1 to rsp.

```
(Example.) For example,

push 17
push 23
pop rax
pop rcx

will put 23 into rax, and 17 into rcx.
```

So, in terms of what the generated assembly would do, it would

- Push rsp into the stack.
- Then, move rax into rsp.
- Then, call the snek\_print function.
- Then, put the most recently added value from stack (i.e, the old value of rsp) to the register rsp.

It just so happens that, in our example here, we only really care about rdi. But, if we have other registers that we care about (e.g., we use them a lot or need to save them between expressions), we need to save them.

## 1.4 Alignment Issues

To summarize some of the things we've said about the x86\_64 calling convention<sup>1</sup>:

- Arguments go into rdi, and then 6 other registers, and then the stack.
- [rsp] (i.e., the value stored at location rsp) should be the return pointer.
- 16-byte alignment constraint:  $rsp \pmod{16} = 0$ .

So, in our generated assembly, the third point may cause some problems with the stack pointer. One way we can resolve this is to check what stack\_offset (mod 16) is, or equivalently stack\_index (mod 2) is. For the latter, if we have an odd number, we can add 1 to the stack index so we have an even stack index.

<sup>&</sup>lt;sup>1</sup>These are calling conventions specific to x86\_64, and is the reason why we had to do this when calling snek\_print. However, when we define our own functions in our own language, we can use whatever calling convention we want (including making one up) as long as it's consistent.