Introduction

1 Computing n!

Imperative style:

```
for i in range(1, n+1):
  factorial=factorial * i
```

Functional Style

```
def factorial(n):
  if n==1:
    return 1
  else:
    return n*factorial(n-1)
```

2 What is a functional language

A style of programming where the building block of computation is an application to arguments.

3 Side effects

Side effect - Modify some (internal/hidden) state as well as returning a value

An example of this:
`y1=f(1)`
`y2=f(2)`

You would expect `y1==y2`, however if f has an internal state that affects the answer this will not be true

```
state=0
def f(n):
  global state
  state +=1
  return n+ state

print(f(1))=> "2"
print(f(1))=> "3"
```

4 A functional approach

- Forbid variable assignment and side effects in the language ”pure functional”

✓ Makes reasoning about code simpler (for humans and compilers)

✗ A new programming paradigm: takes some time to get used to

5 Why programming languages

5.1 Abstracting from the machine

$$b = a + 3$$

```
mov addr_a, reg1 ##Load address of a into reg1
add 3, reg1, reg2 ## add 3 to reg1 and write into reg2
mov reg2, addr_b ## write reg2 to address of b
```

✓ Explicit about what is going on

✗ Obfuscates algorithm from implementation

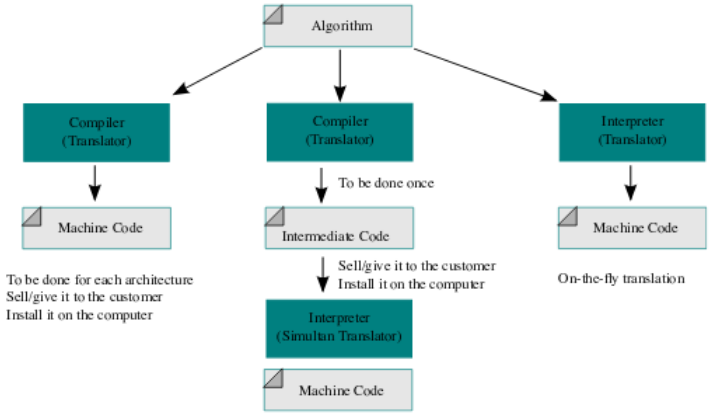
✗ Not portable (would need different instructions for different hardware e.g. different registers)

✗ Not easy to modify

✗ Not succinct

5.2 Programming languages

- Allow writing code to an abstract machine model
- A translator of some kind (perhaps a compiler) transforms this code into something that executes on some hardware (sometimes this hardware is a virtual machine)
- Some virtual machines are ”hybrid”: they do just-in-time compilation
- The Haskell distribution we will use has both Compiler and Interpreter mode



- Micro-architecture just reads an instruction stream
- Note easy to program complex algorithms in such a ”language” so use abstractions leading to high level languages
- Features driven by programming paradigm considerations, domain knowledge, wanting to target particular hardware...
- Compiler or interpreter maps this language onto machine instructions
- Therefore we need a formal specification

6 Example

```
filter:: (a -> Bool) -> [a] -> [a]
filter p [] = []
filter p (x:xs)
  | p x    = x: filter p xs
  | otherwise  = filter p xs
```

- Higher order
- Polymorphic (works for all types a) (functions that take functions as parameters)
- Function defined with recursion and pattern matching

7 Syntax and Semantics

Syntax - What are valid sentences (expressions) in a language?
Semantics - What do these valid sentences (expressions) mean?

8 Naming Requirements

- Can have characters in function names, for example `x'`
- s at the end to show a list
- lowercase letter to start

9 Comments

```
-- Comment like this
{- Or like this if you have multiple
lines -}
```