Mutation

In C: `int x, y;`
`y=x=0;`

$e_1[e_2] := e_3 \Longrightarrow$ new value

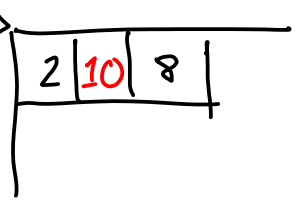
tuple — index — new value

0xf7000001

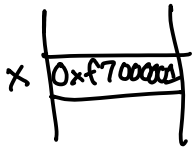
```
let x=(3,4) in
x[0] := 5
```

5

0xf7000000



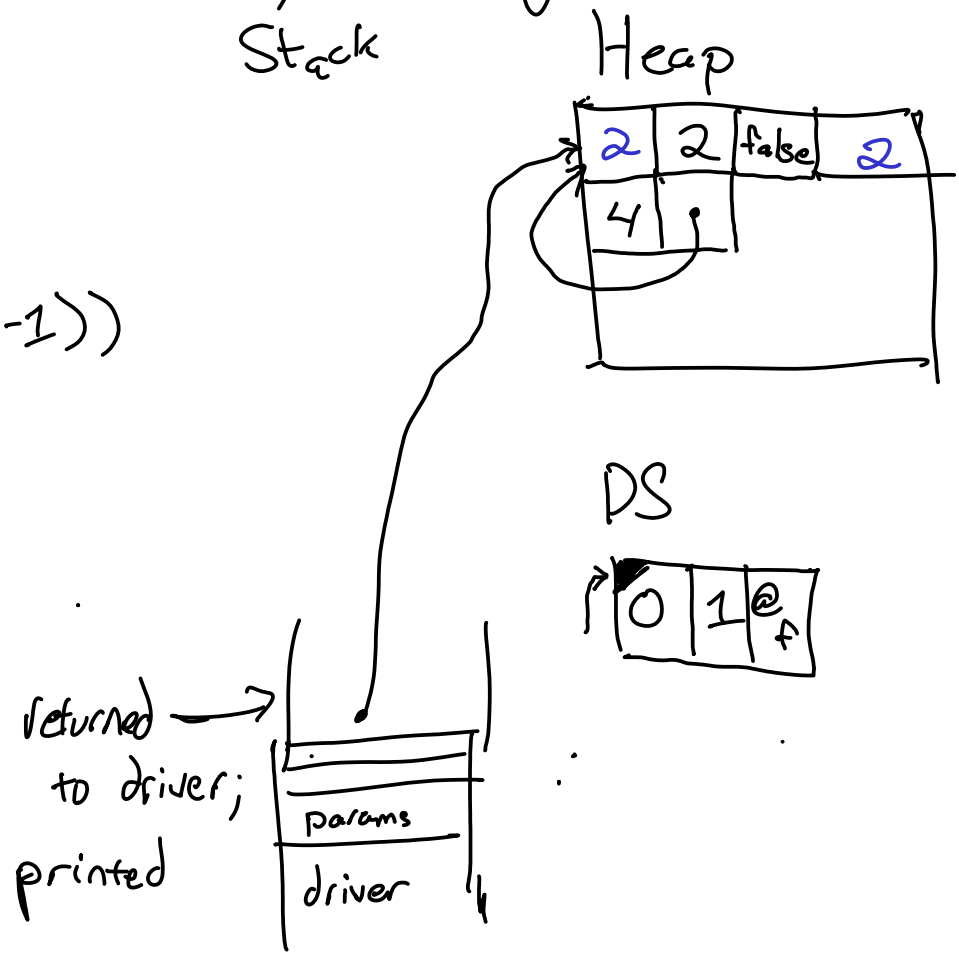

```
let x = (3, 4) in
x[0] := x
```



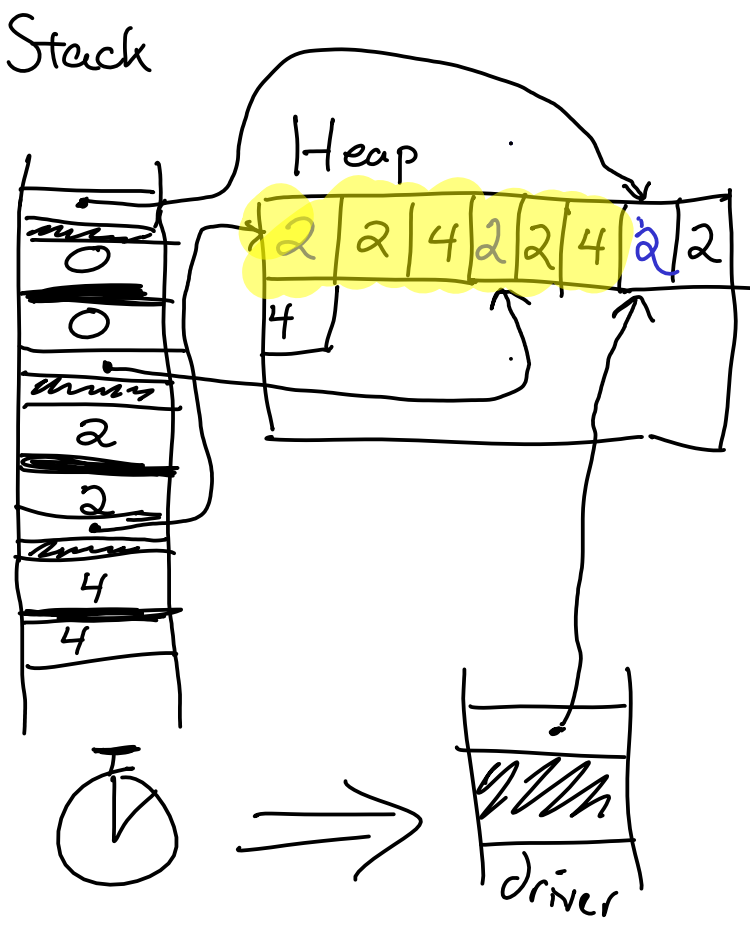
Garbage Collection & Memory Management

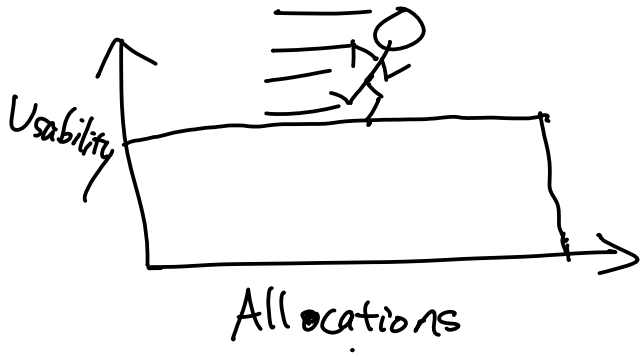
```
def f x =
  if x < 1 then
      false
  else (x, f (x-1))
end

f 2
```

(2, (1, false))



```
def f x =
    let y = (1,2) in
    if x<1 then
        y
    else
        f (x-1)
end
f 2
```



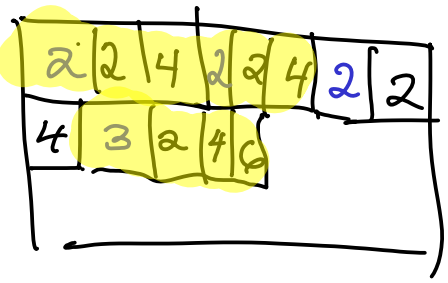


Memory Management

how memory (resource) is allocated & deallocated

not exclusive

- manual (C, C++, etc.)
- automated / garbage collection

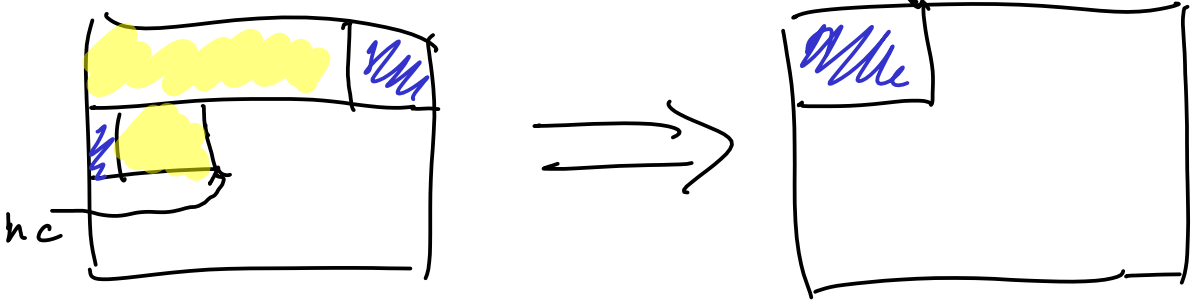


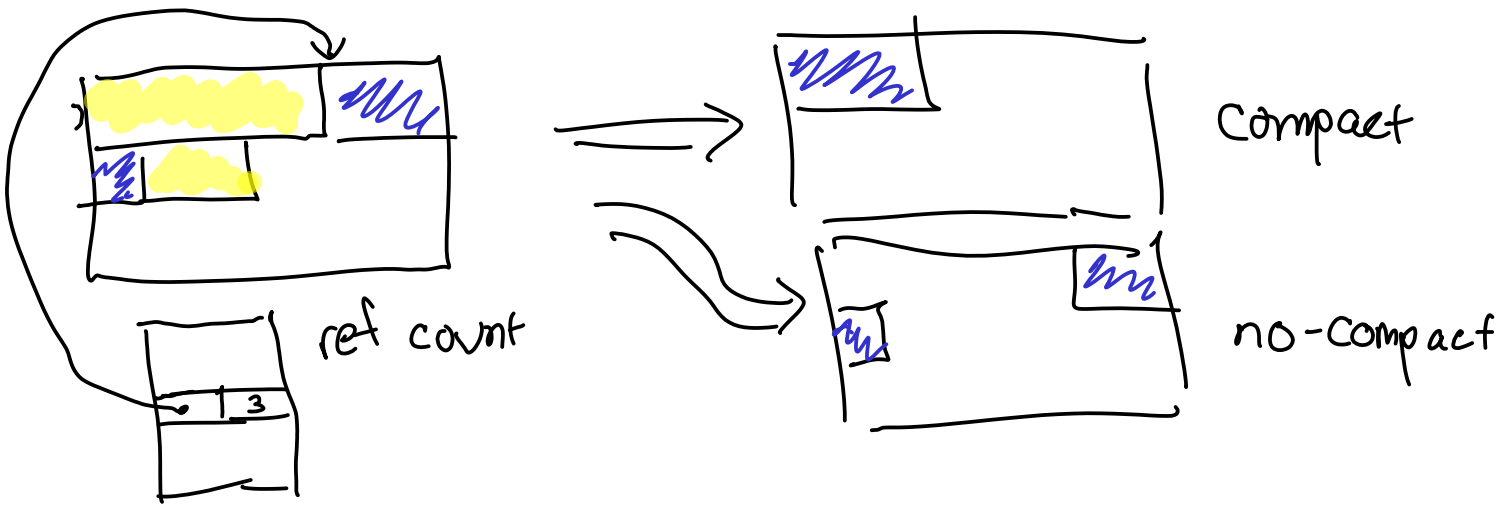
Mark-Compact

algorithm: what is reachable?

marking

1. reachable from stack
2. reachable from some other reachable heap object





C++ shared_ptr<T>