



Heap

Page

_____ mmap

big array of bytes _____ sbrk brk

many small array of byte - malloc / free

many objects _____ C++ new/delete — alignment

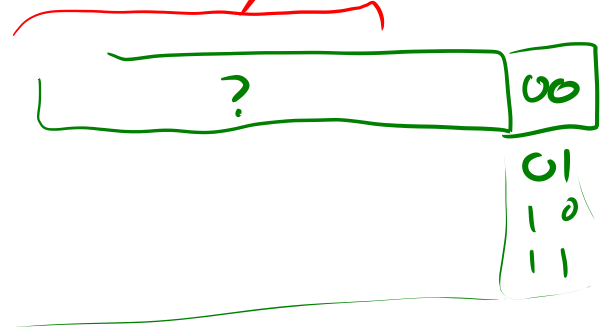
↳ w/ no delete _____ Java

↳ w/ no new _____ Python

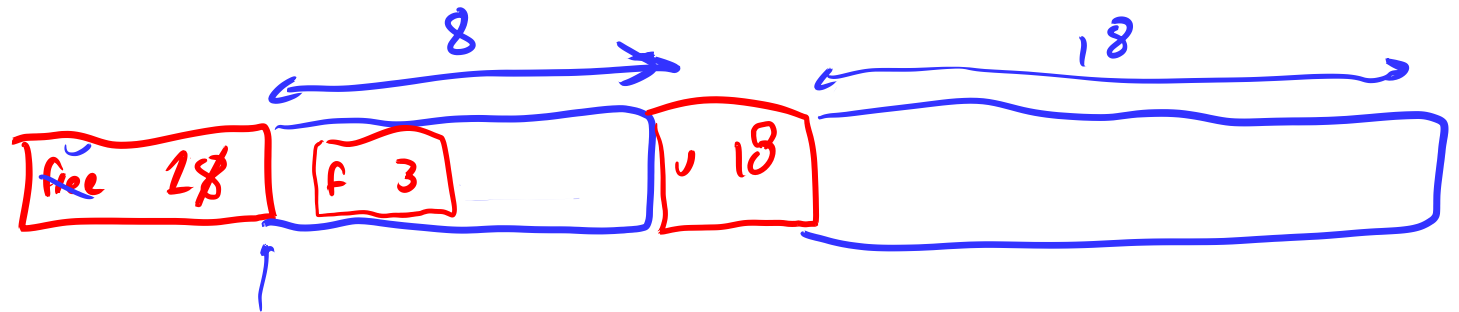
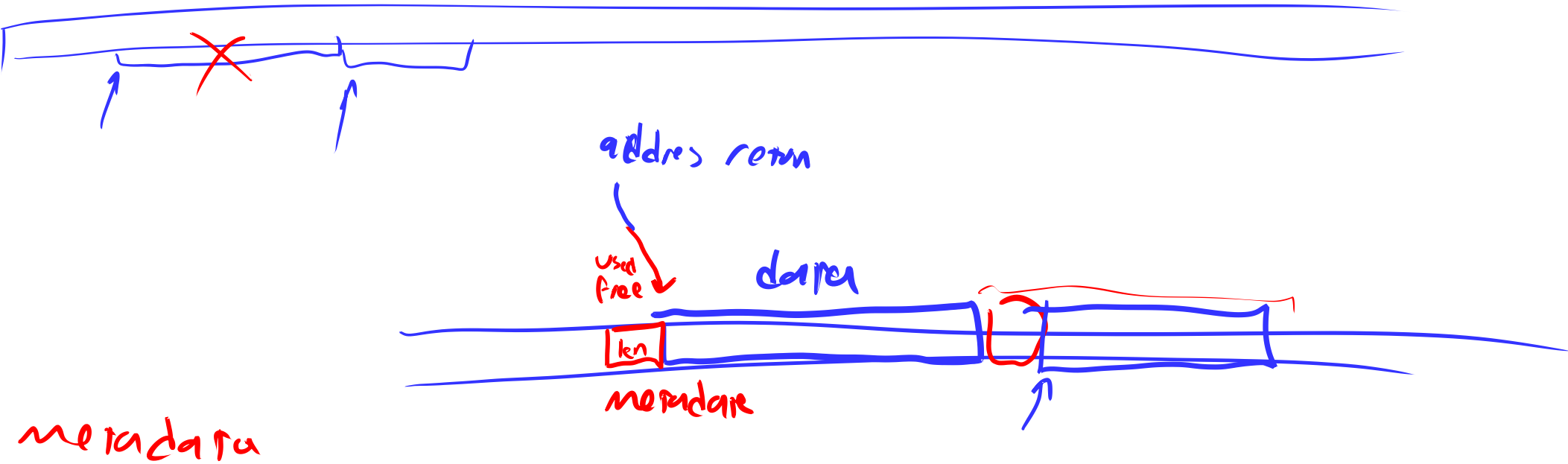
4-byte address mult of 4
8
8

Page number

index try



malloc / free



Garbage Collection

$x = \text{malloc}(\dots)$

||
||
||
||
||
||
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||
||
||

$y = x[0]$ // last use of x

||
||
||
||
||

$x = \text{null}$

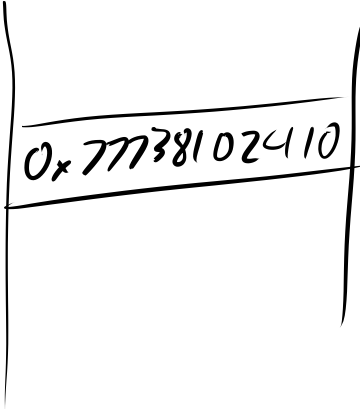
↓ unreachable

↓ Garbage

How to collect garbage



1. Stop everything
2. scan the stack + globals looking for pointers
3. " heap found so far " " " "
4. free any used block w/ no pointers to it
5. resume everything



means to us:

1. no free/delete needed 😊
2. Slow 😞

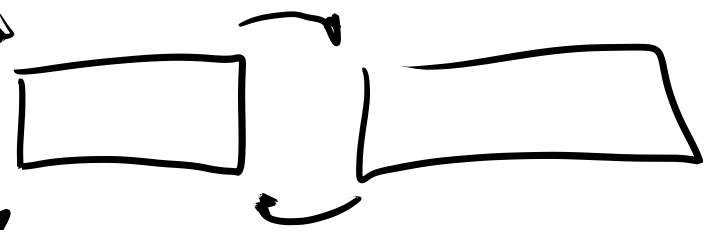
Owner
Borrow

- What code owns a heap chunk?

- code have ptr not own

Code

Code



read

return array[i]

arr[i] = x
write

ref count pointer
Smart pointer

