# Advanced heap exploitation

Angelboy
scwuaptx@gmail.com

# Who am I

- Angelboy
- 中央大學資工系碩士班
  - Advanced Defense Lab
- Member of
  - Bamboofox CTF team
  - HITCON CTF team

# 前言

- 請先服用 Heap exploitation
- 這邊會在列出幾個常見的 heap 漏洞利用方式
- 如果這份投影片內容有錯誤的地方，記得一定要告訴我
- 環境
  - glibc - 2.19
  - kernel - 4.2
  - 64 bit

# Outline

- Fastbin corruption
- Shrink the chunk
- Extend the chunk

# Outline

- Fastbin corruption
- Shrink the chunk
- Extend the chunk

# Fastbin corruption

- 假設程式存在著 double free 的漏洞
- 目的：
  - 我們可以利用 fastbin chunk 改掉 fd 使得下下次 malloc 該 chunk 時可以取得自己想要的位置
- 為了利用 double free 的漏洞來改變 free chunk 中的 fd ，我們可以利用一些 fastbin 的特性達到我們的目的，但我們也必須通過一些 chunk 的檢查

# Fastbin corruption

- fastbin 的檢查
- in free(p) :
  - chunk address < - size 且 alignment
  - chunk size >= MINSIZE(0x20) 且為 0x10 的倍數
  - nextchunk->size
    - 大於 MINSIZE(0x20)
    - 小於 system_mem (0x21000)
  - 檢查屬於該 size 的 fastbin 中的第一塊 chunk 與 p 是否不同

# Fastbin corruption

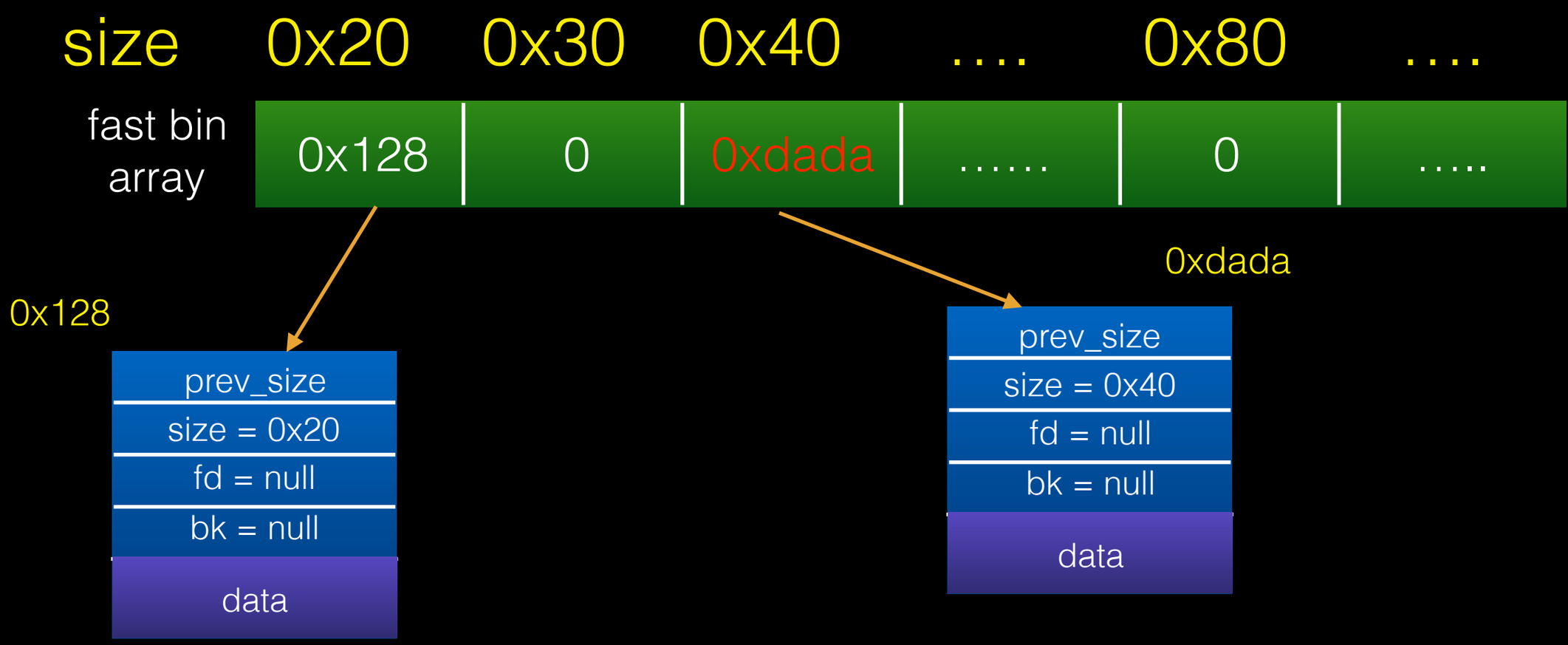
- fastbin 的檢查
- in malloc(bytes) :
  - 根據 bytes 大小取得 index 後，到對應的 fastbin 找，取出後檢查該 chunk 的 (unsigned long) size 是否屬於該 fastbin
    - 但實際比較的時候是先以 fastbin 中第一塊 size 取得 fastbin 的 index ，再去用這個 index 跟剛剛算的 index 是否相同，不過這取 index 的方式是用 unsigned int (4 byte)

# Fastbin corruption

- fast bin
  - a singly linked list
  - chunk size <= 0x80 byte
  - 不取消 inuse flag
  - 依據 bin 中所存的 chunk 大小，在分為 10 個 fast bin 分別為 size 0x20,0x30,0x40…
  - LIFO
    - 當下次 malloc 大小與這次 free 大小相同時，會從相同的 bin 取出，也就是會取到相同位置的 chunk

# Fastbin corruption

- fastbin layout

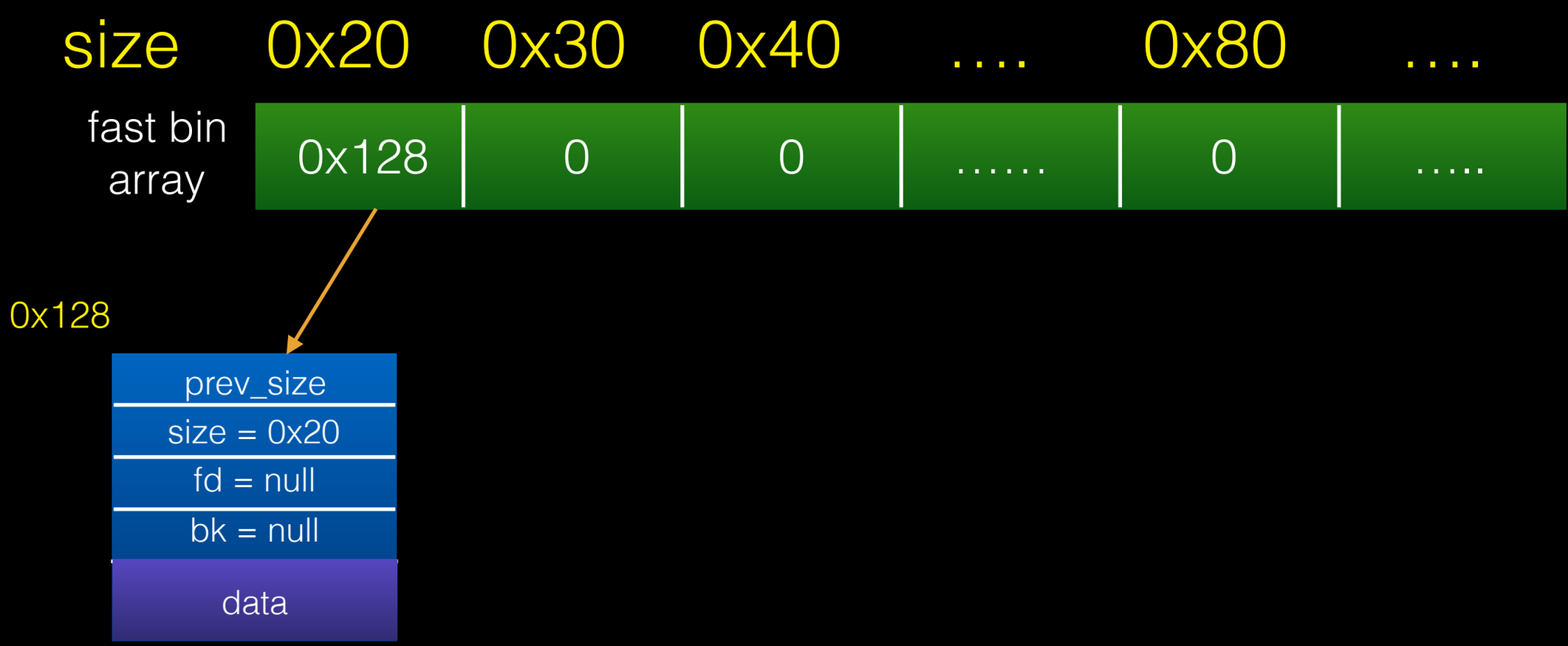


# Fastbin corruption

- 我們可以利用 fastbin 的 chunk 在 free 的時候只檢查屬於該 size 的 fastbin 中的第一塊 chunk 與 p 是否不同這項特性，來創造 overlaps chunk
- 創造出一個 circle 的 singly linked list，這樣就可以達到類似 UAF 的效果

# Fastbin corruption

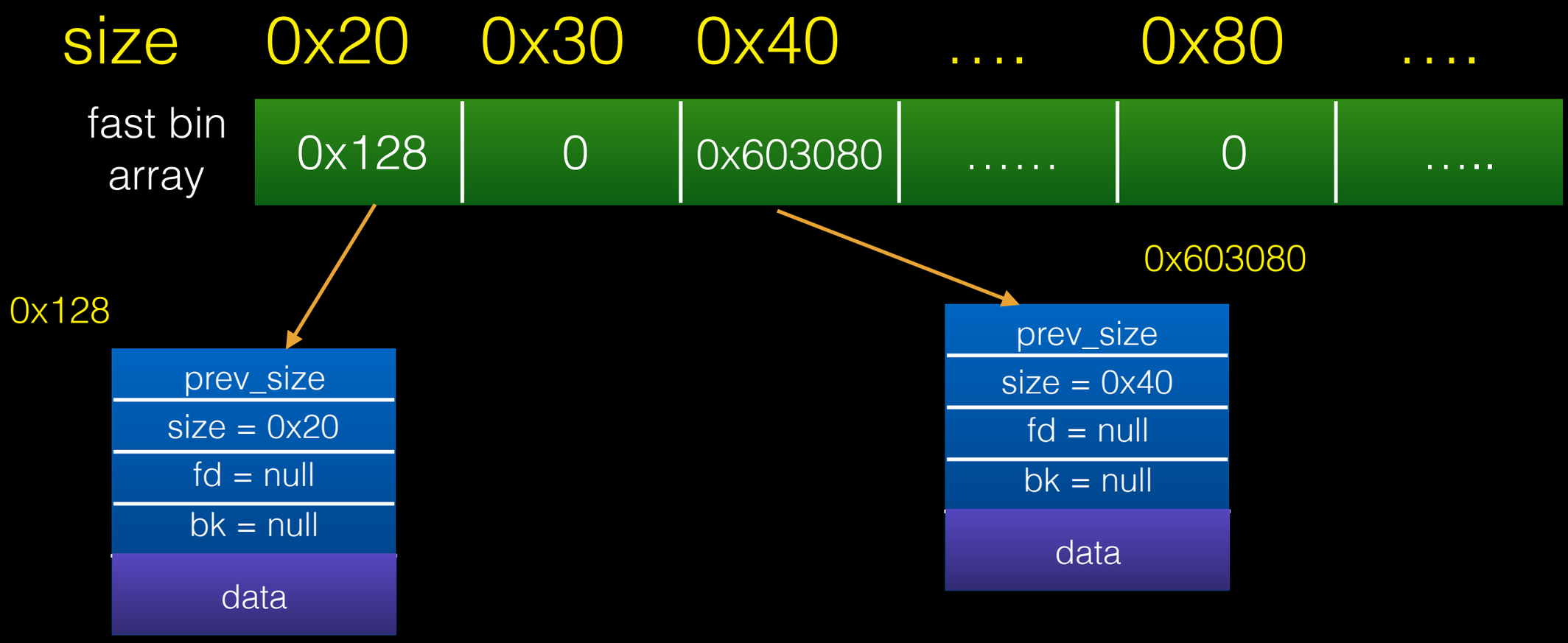
- fastbin layout




free(0x603090)

# Fastbin corruption

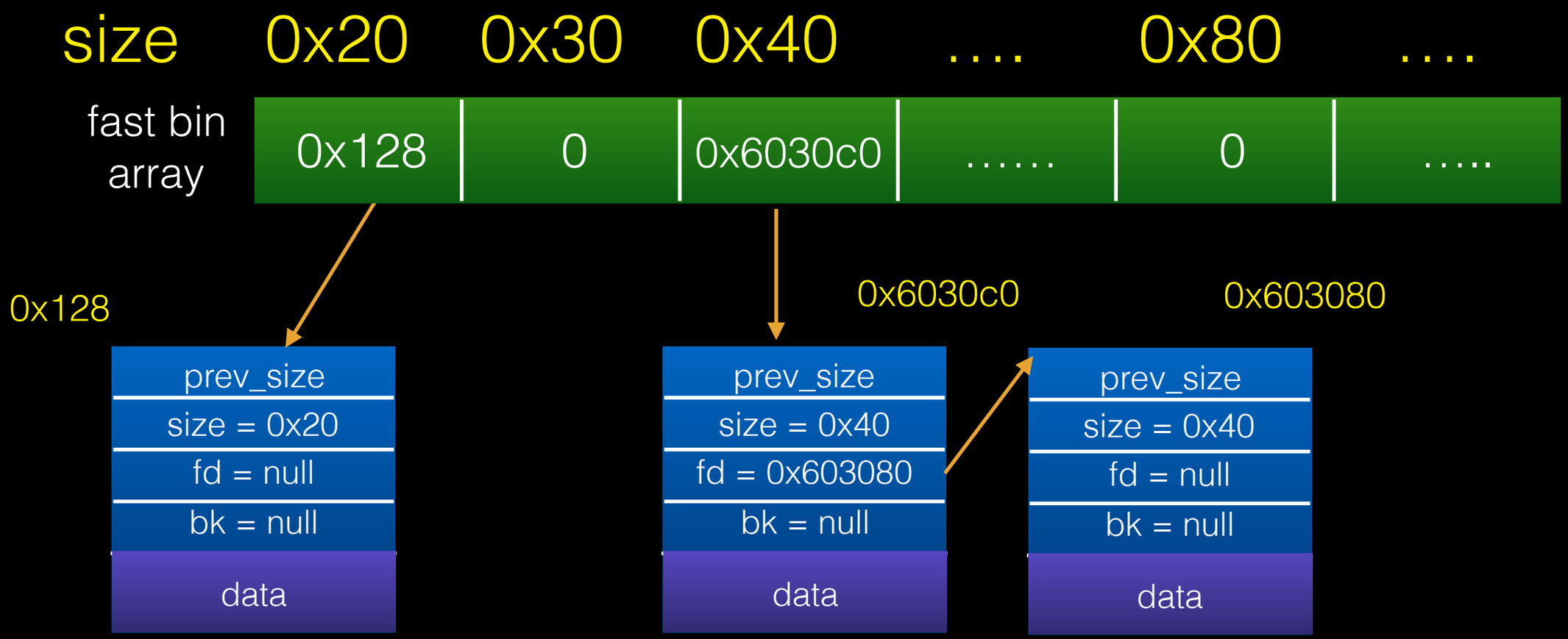
- fastbin layout




free(0x6030d0)

# Fastbin corruption

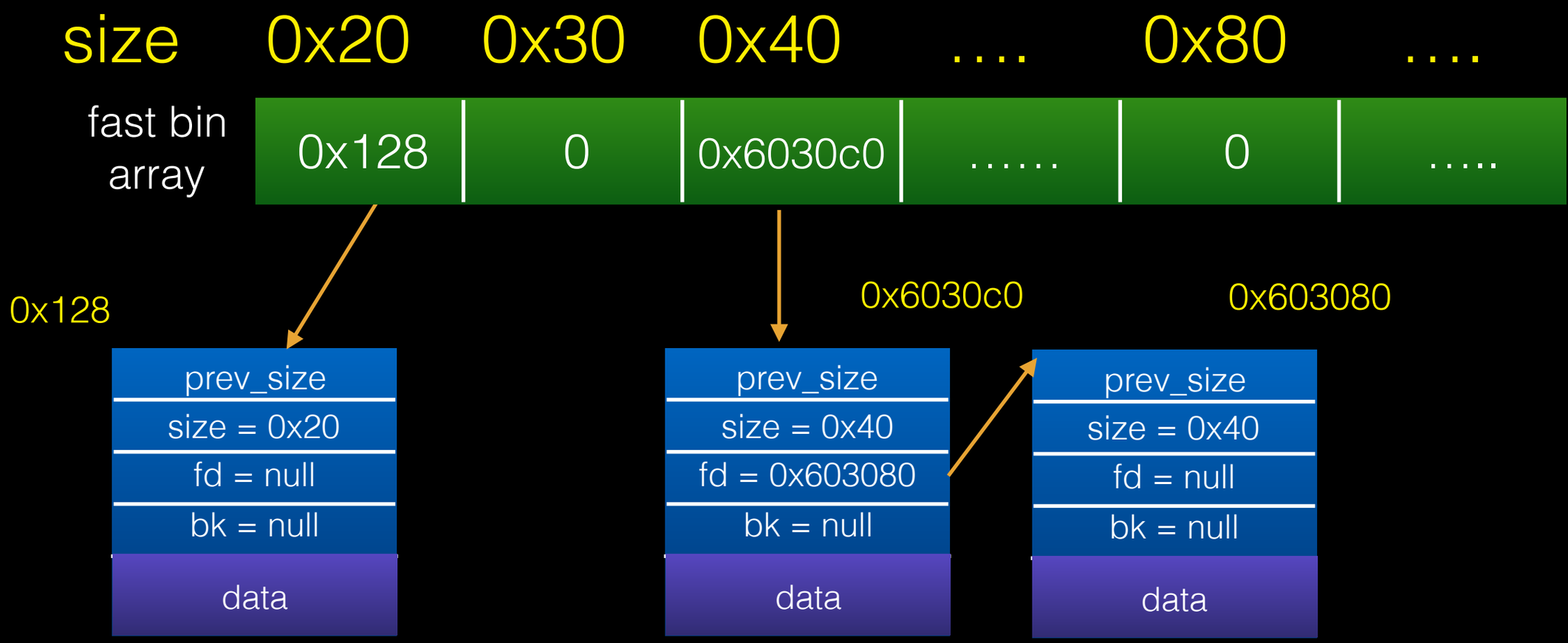
- fastbin layout




free(0x603090) ← double free

# Fastbin corruption

- fastbin layout

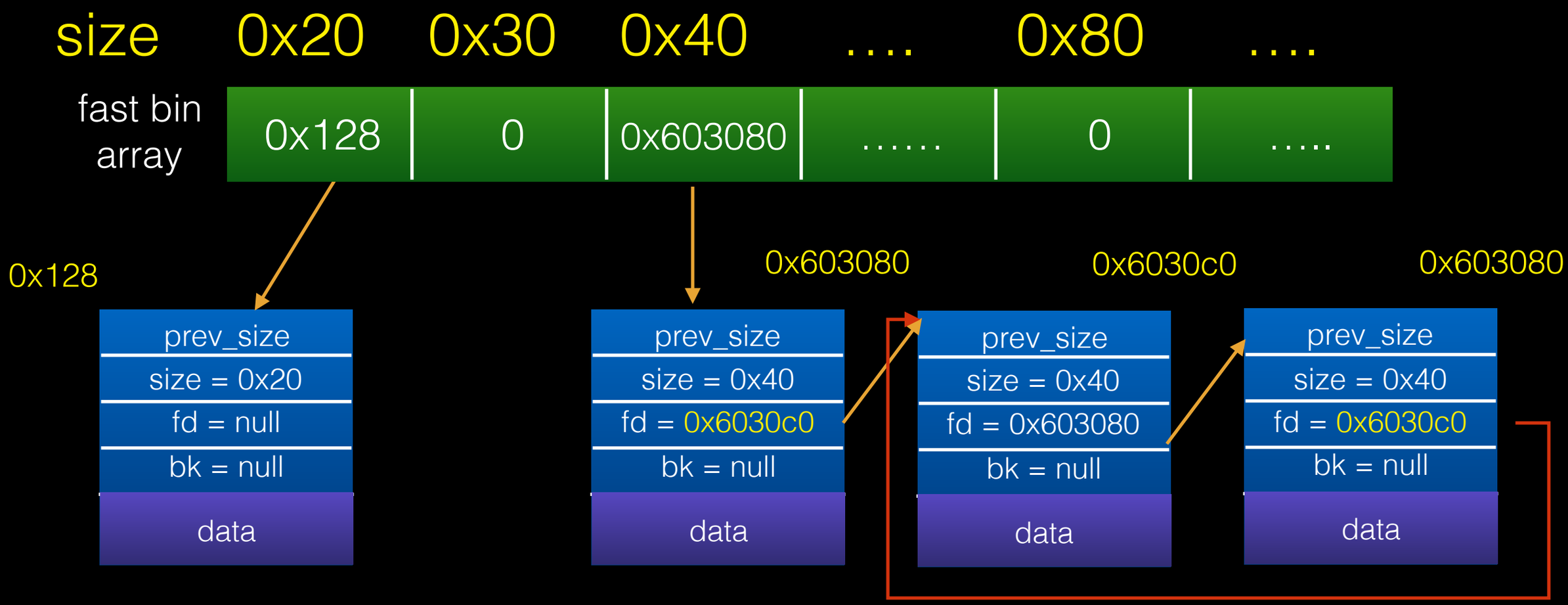



free(0x603090) ← double free

但因為 fastbin 只會檢查 fastbin 的第一塊，故通過檢查

# Fastbin corruption

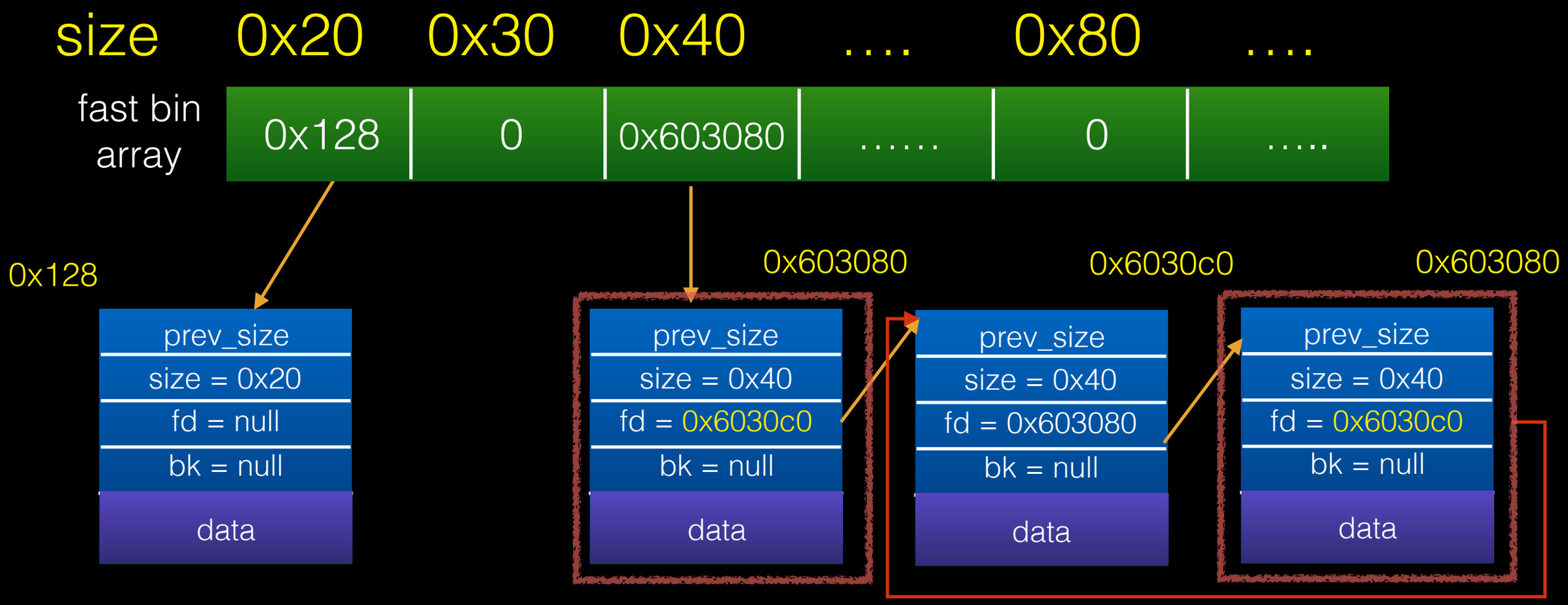
- fastbin layout




Circle singly linked list

# Fastbin corruption

- fastbin layout

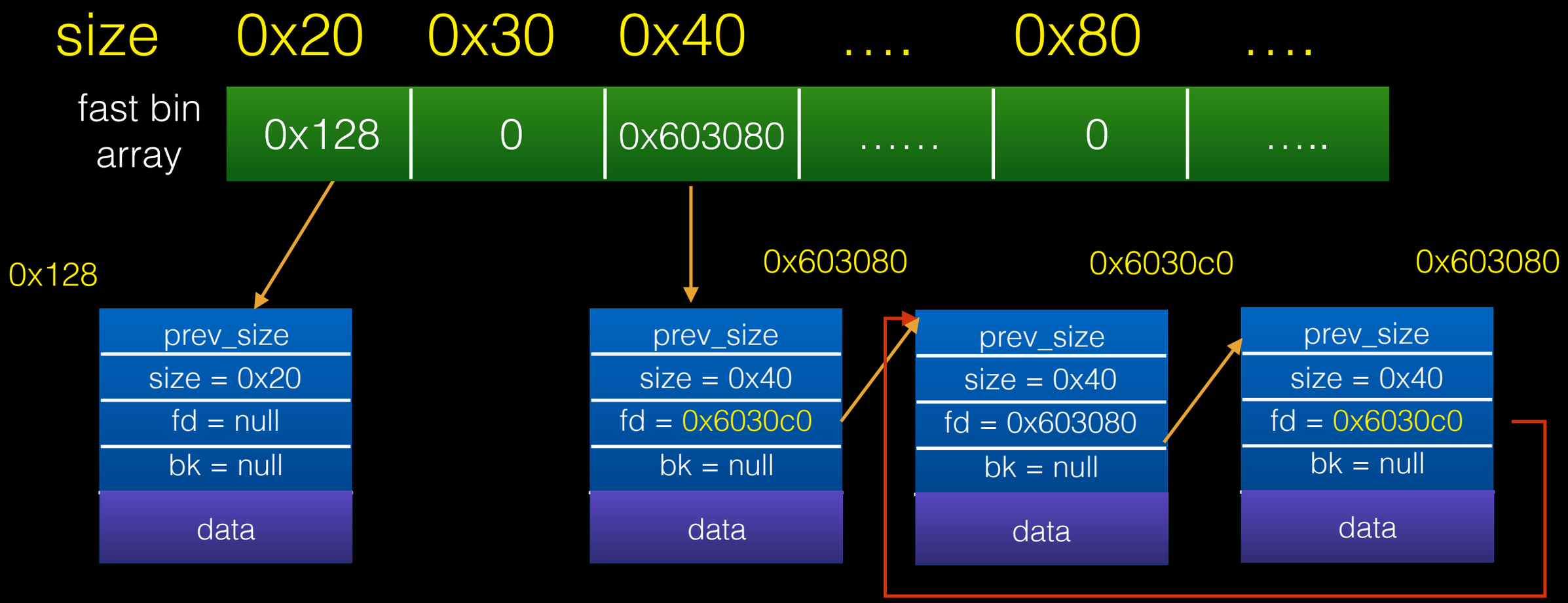



Same chunk in the fastbin

這樣在之後 malloc 時會有 overlap 情形發生

# Fastbin corruption

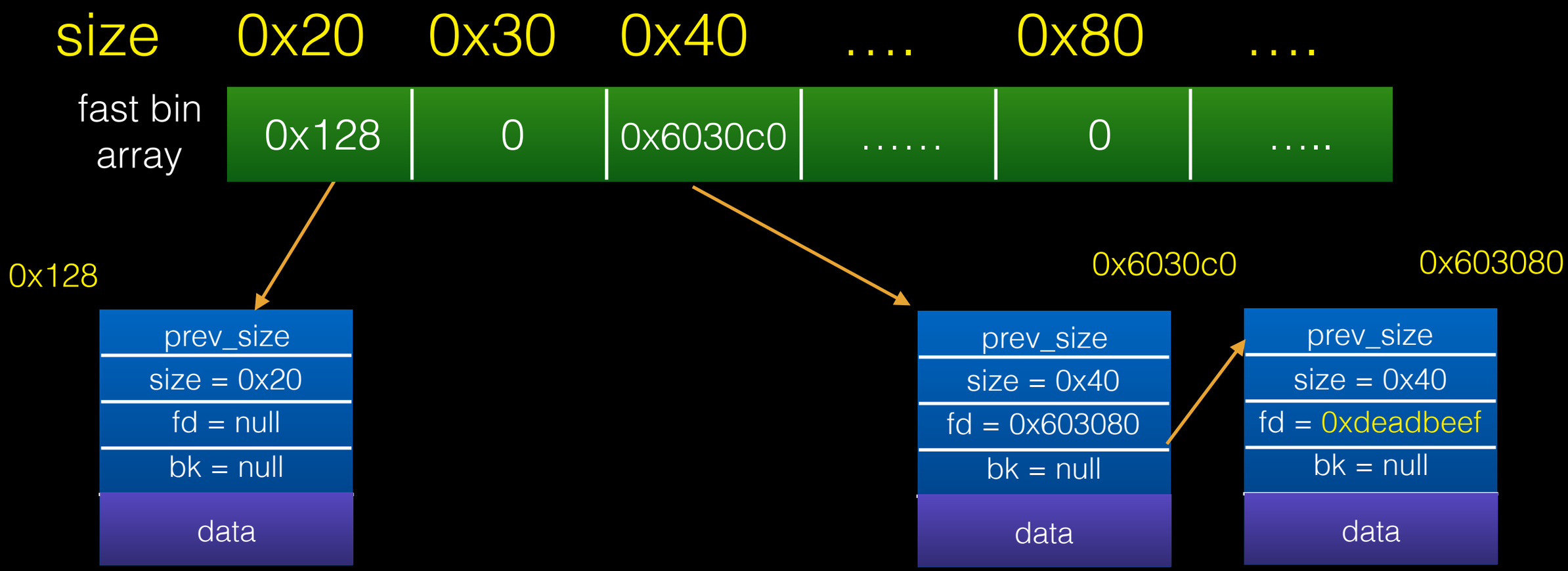
- fastbin layout




malloc(0x30)

# Fastbin corruption

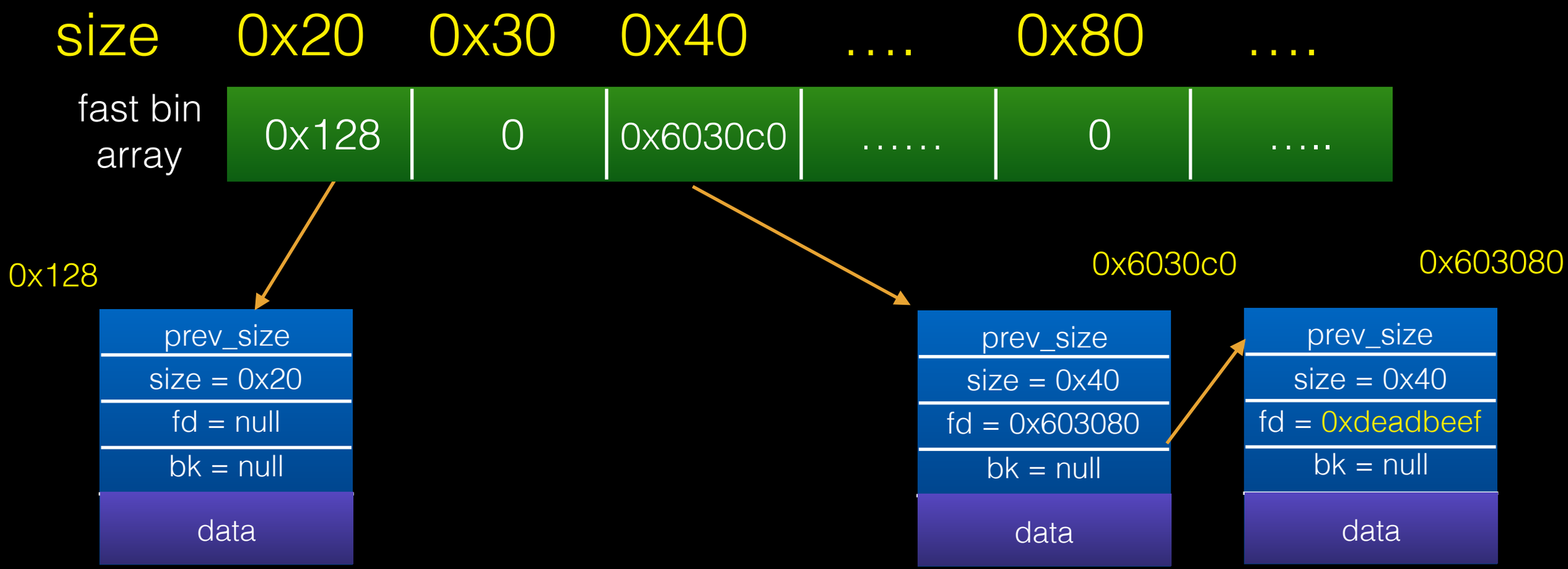
- fastbin layout




You will get the 0x603080 chunk ,and overwrite the fd
But the chunk is also in the fastbin

# Fastbin corruption

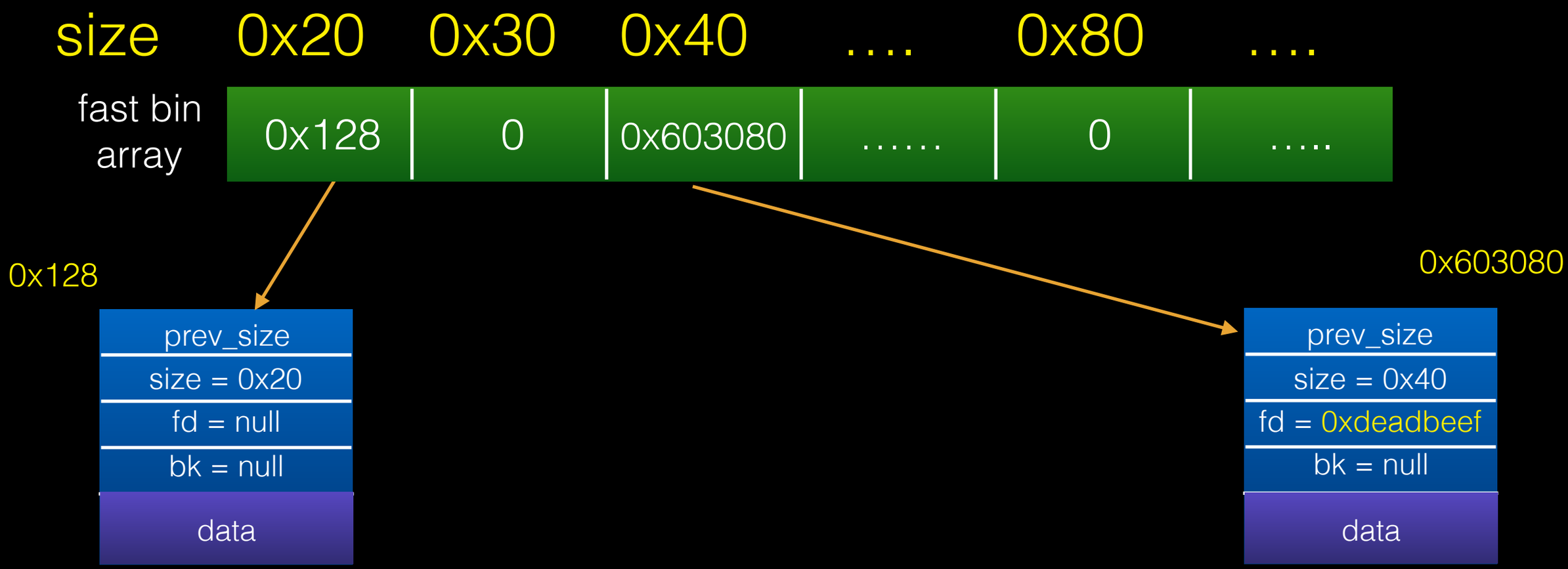
- fastbin layout




malloc(0x30)

# Fastbin corruption

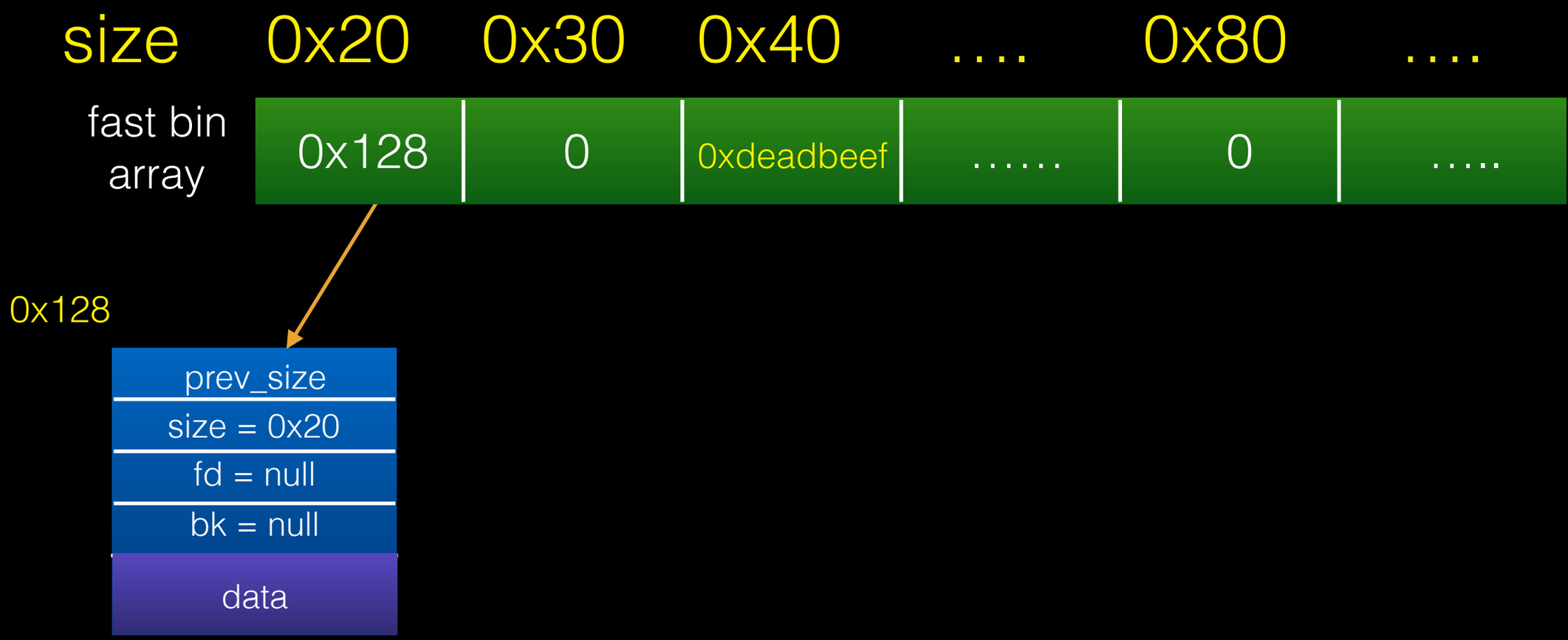
- fastbin layout




malloc(0x30)

# Fastbin corruption

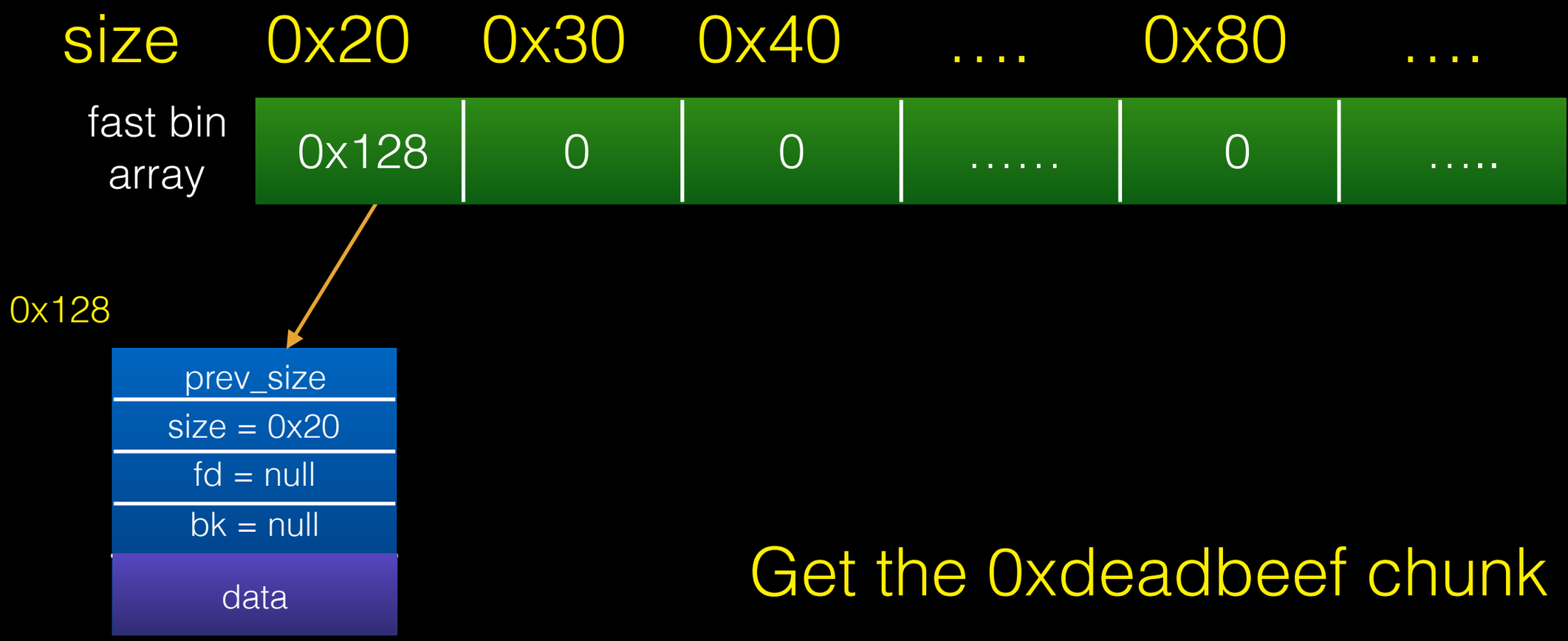
- fastbin layout




malloc(0x30)

# Fastbin corruption

- fastbin layout




Get the 0xdeadbeef chunk

# Fastbin corruption

- fd 只要符合 size 是否屬於該 chunk 就可以通過 malloc 檢查即可，因此只要想寫入的位址附近有屬於該 bin 的 size 就可以讓 malloc 分配到該位置
  - 根據 bytes 大小取得 index 後，到對應的 fastbin 找，取出後檢查該 chunk 的 (unsigned long) size 是否屬於該 fastbin
    - 但實際比較的時候是先以 fastbin 中第一塊 size 取得 fastbin 的 index ，再去比 index 跟剛剛算的 index 是否相同，不過這取 index 的方式是用 unsigned int (4 byte)，所以偽造時不用滿足 8 byte
  - 因此沒有檢查 alignment 所以不一定要以八的倍數作為 chunk 的 address

# Outline

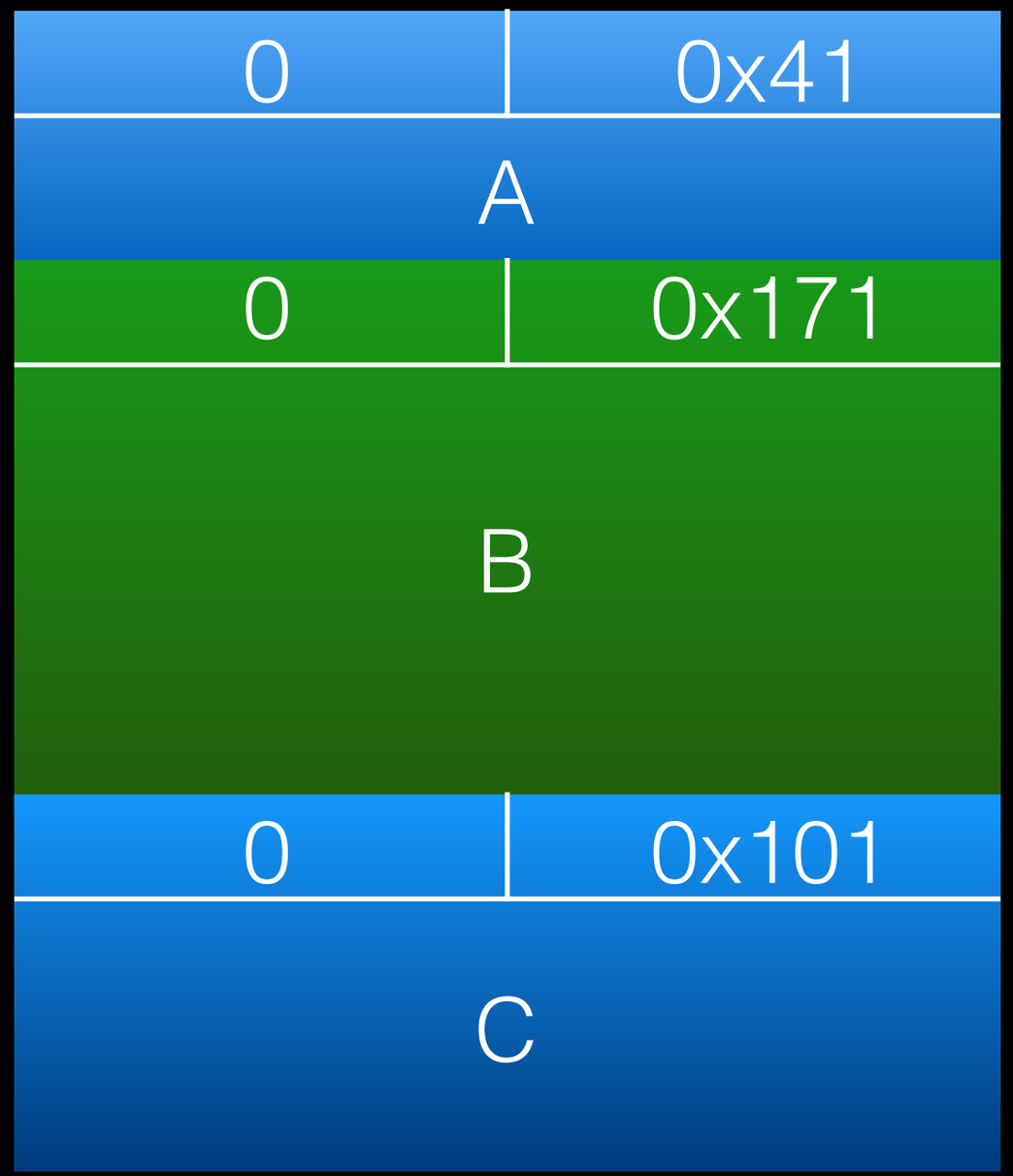
- Fastbin corruption
- Shrink the chunk
- Extend the chunk

# Shrink the chunk

- 假設存在一個 off-by-one null byte 的漏洞
- 目的：
  - 創造出 overlap chunk ，進而更改其他 chunk 中的內容
- 主要利用 unsortbin ,smallbin 會 unlink 做合併的特性來達到我們的目的

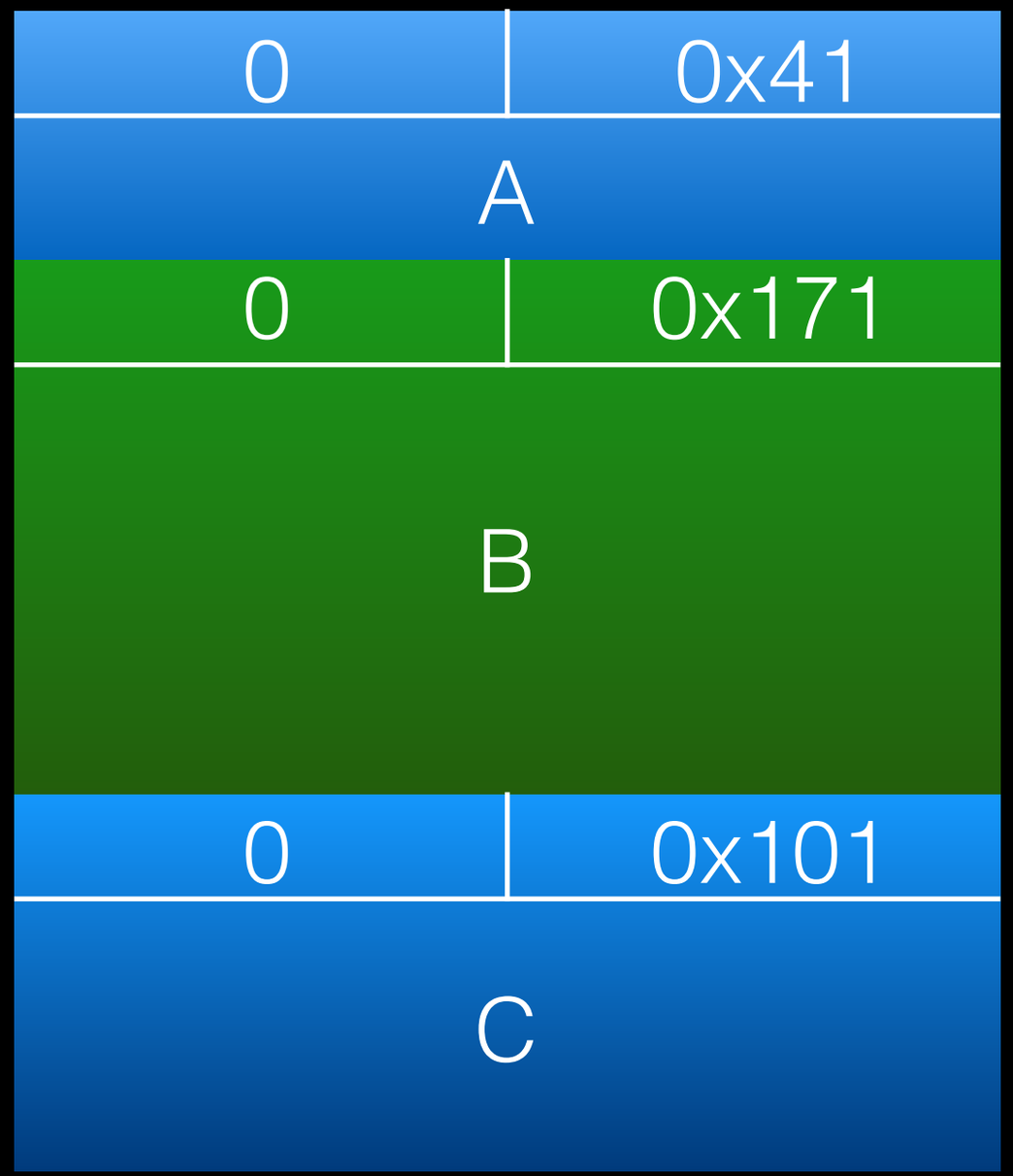
# Shrink the chunk

- 一開始先 malloc 3 塊 chunk 至 heap 段，且 fastbin 是空的



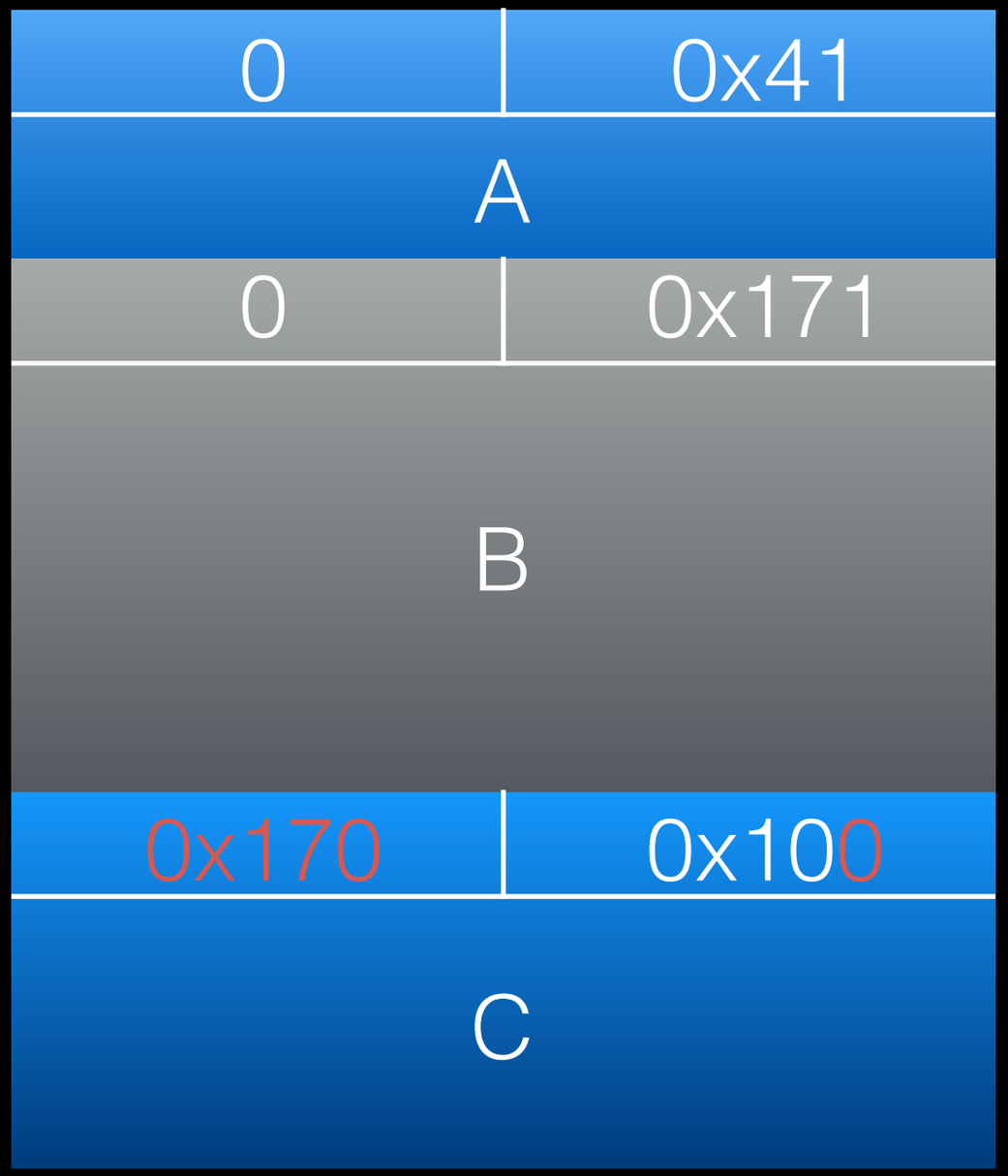
# Shrink the chunk

- free(B)



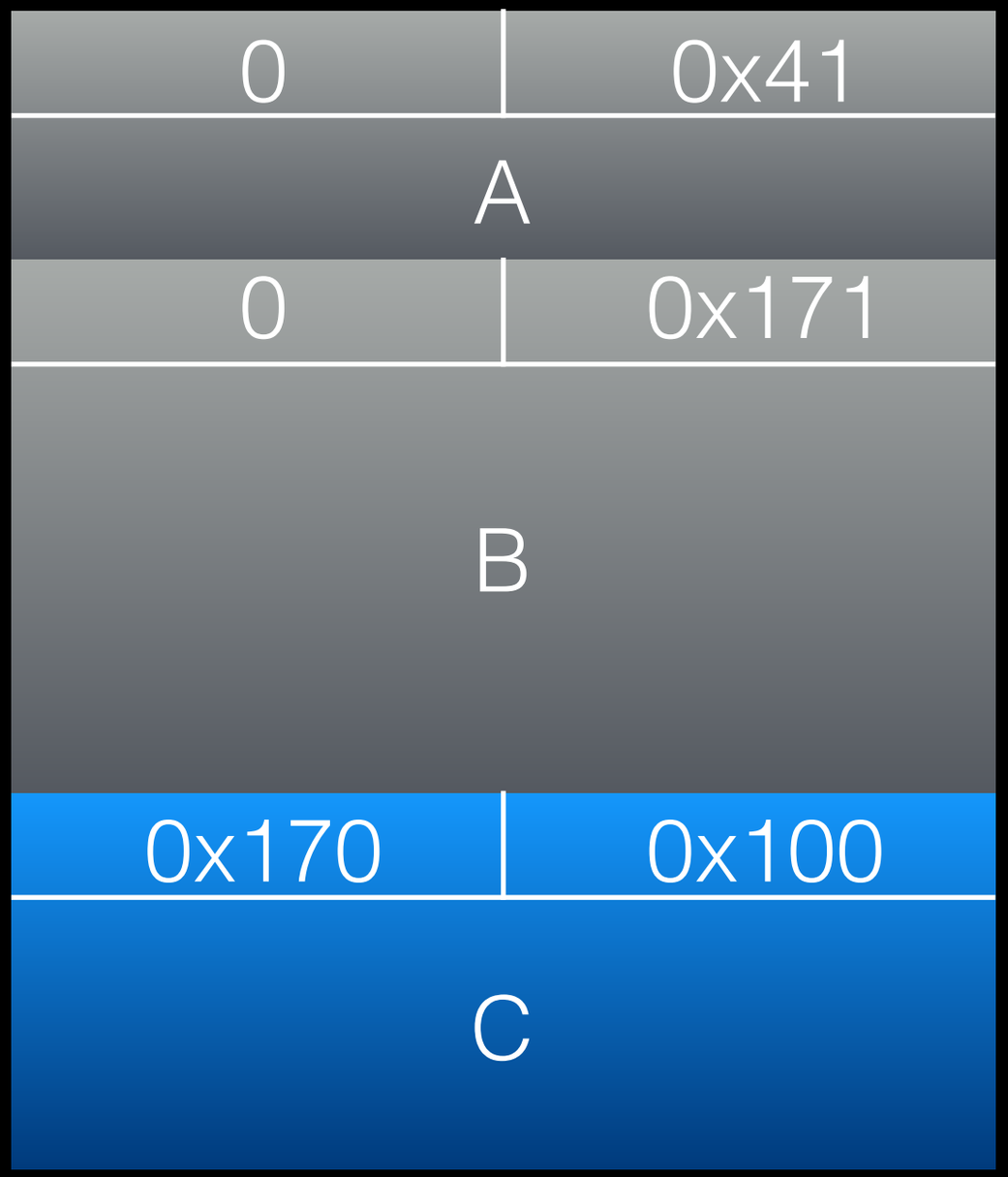
# Shrink the chunk

- free(A)



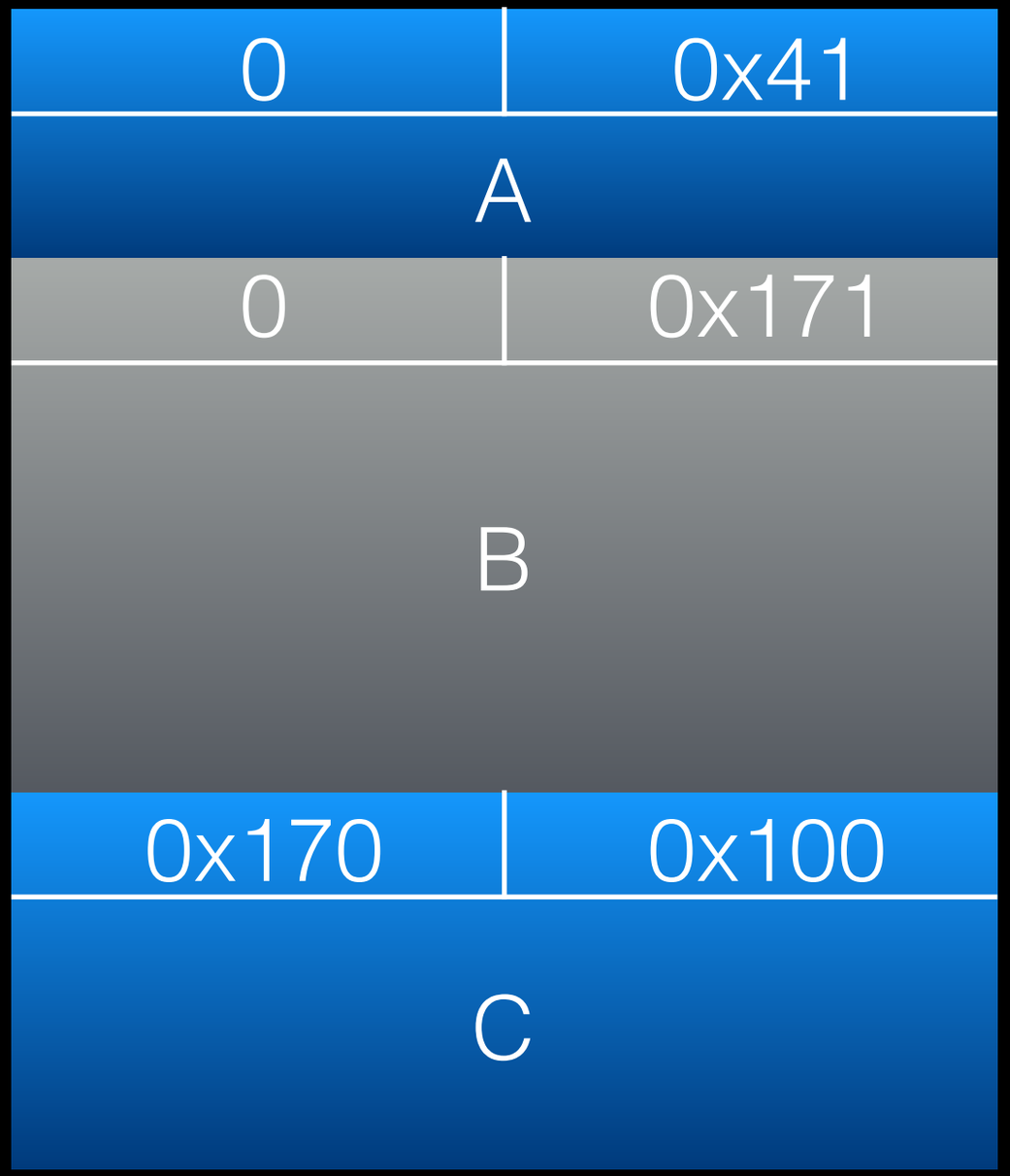
# Shrink the chunk

- malloc(0x38)



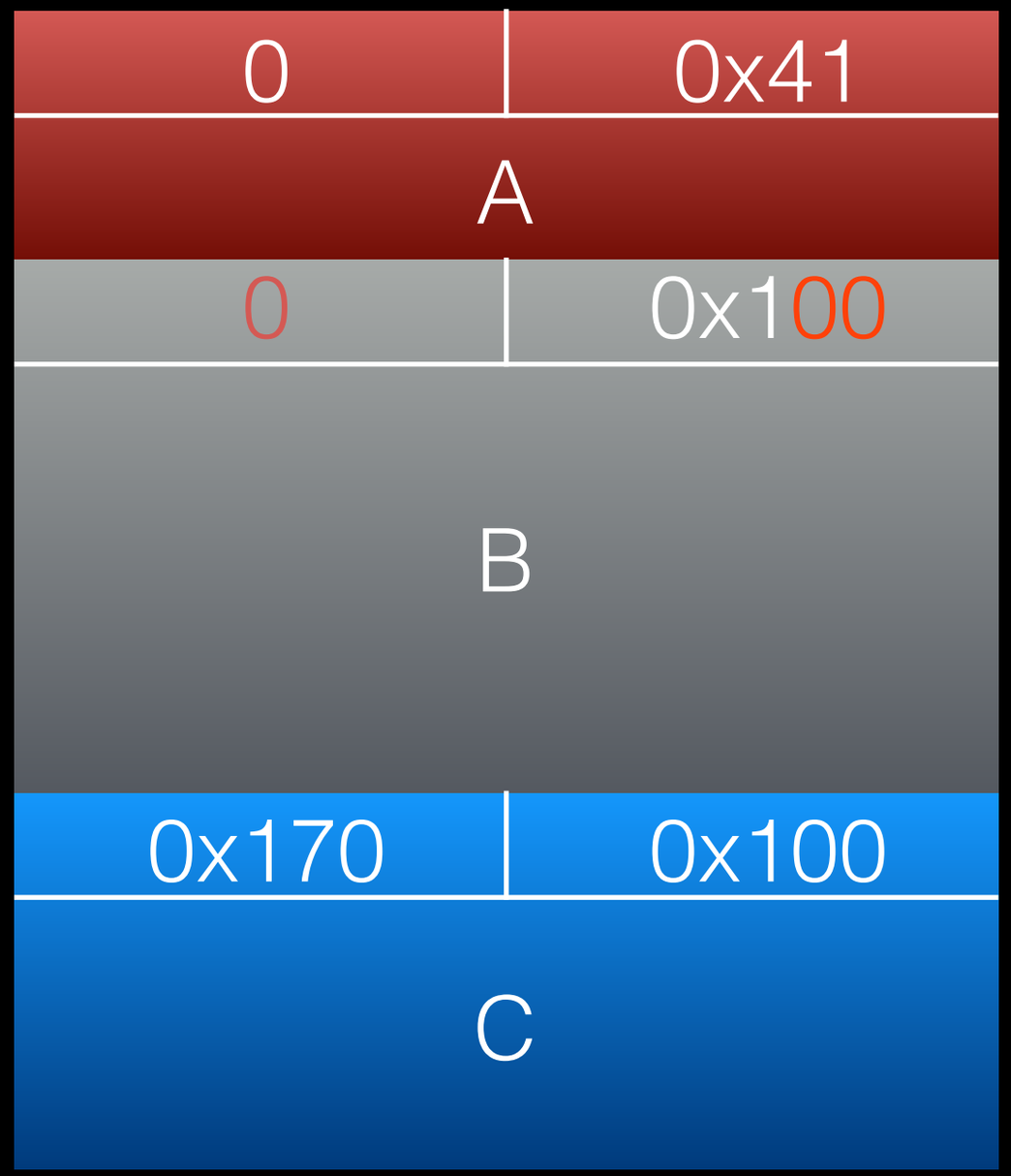
# Shrink the chunk

- read data to A and off-by-one overflow



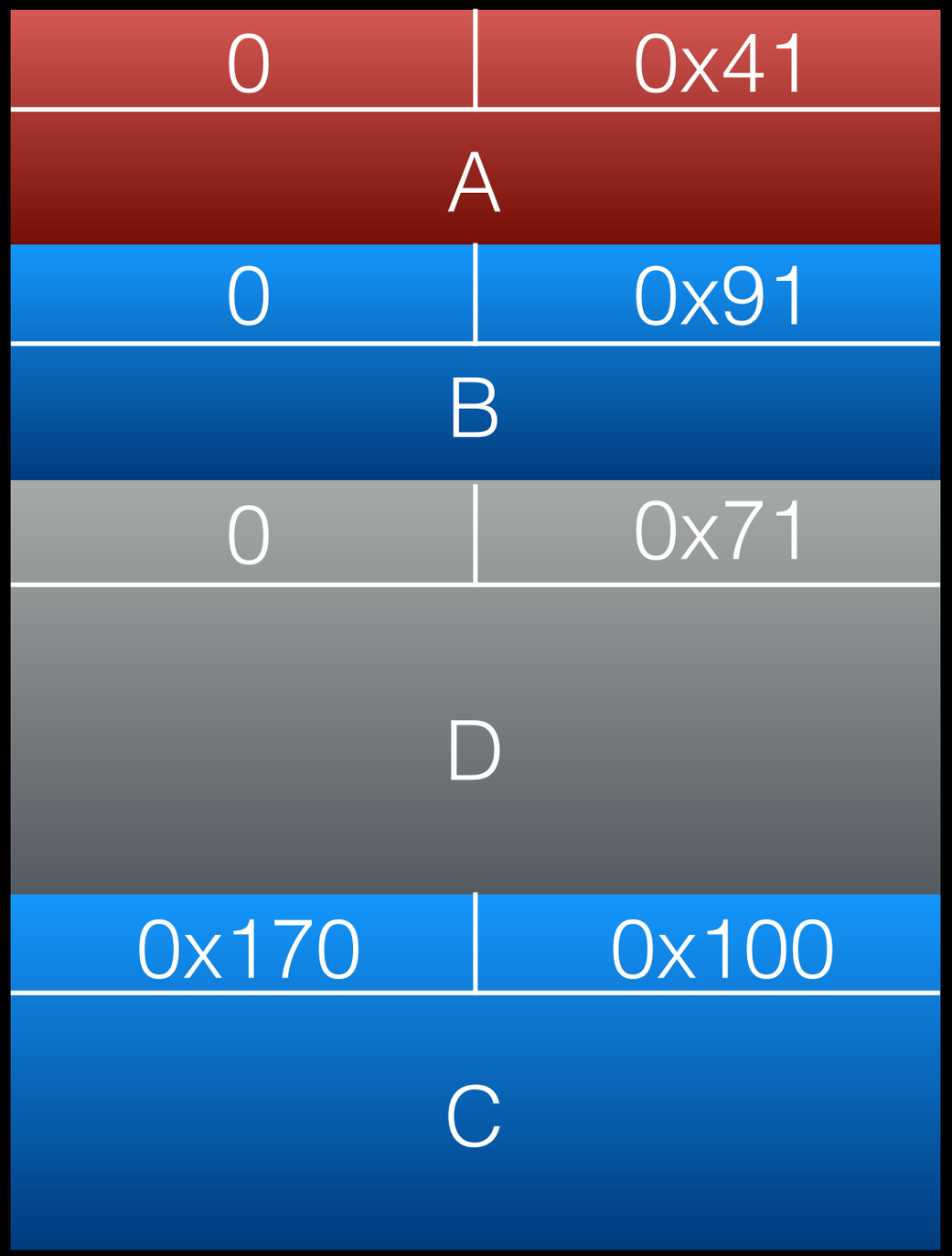
# Shrink the chunk

- malloc(0x80)



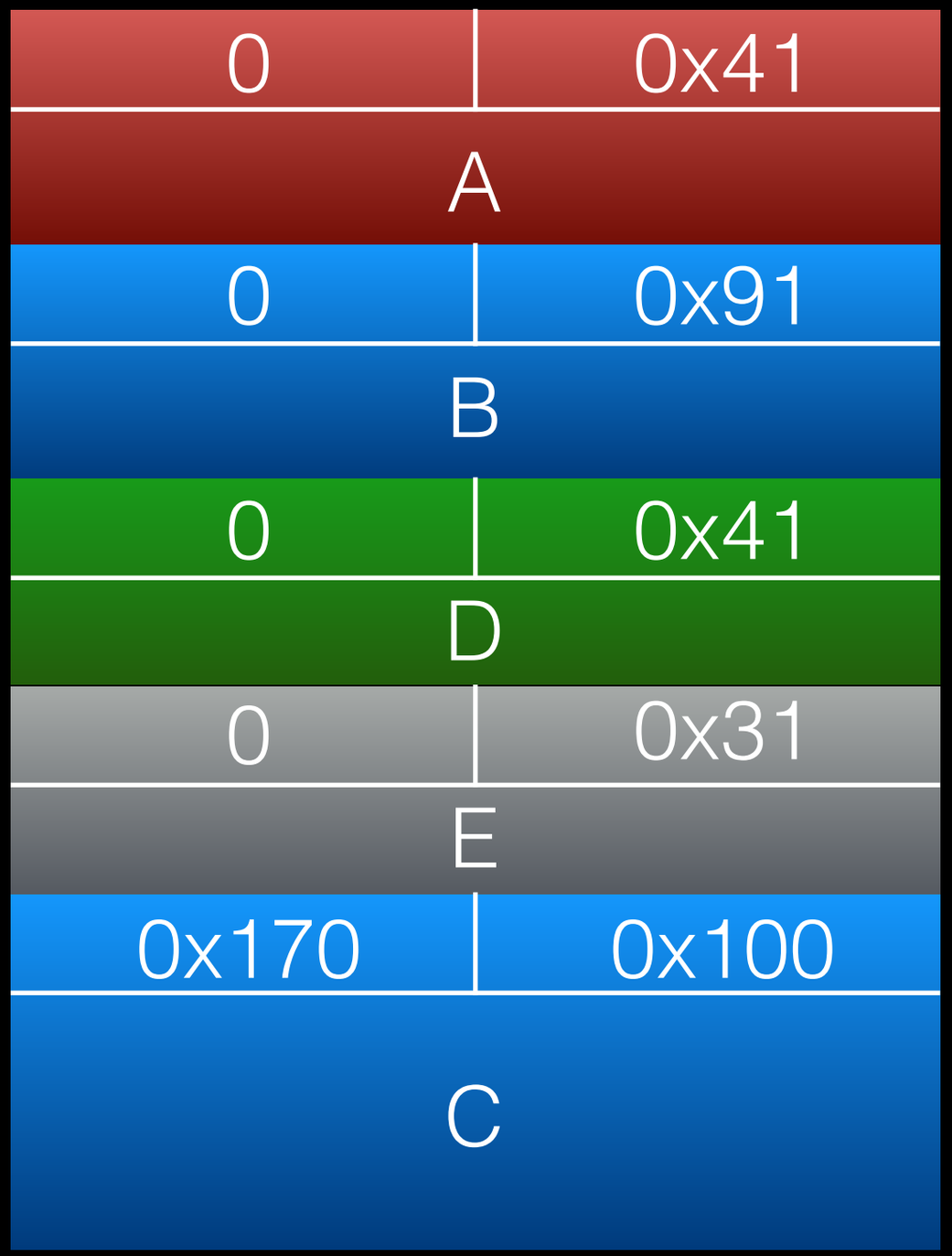
# Shrink the chunk

- malloc(0x30)



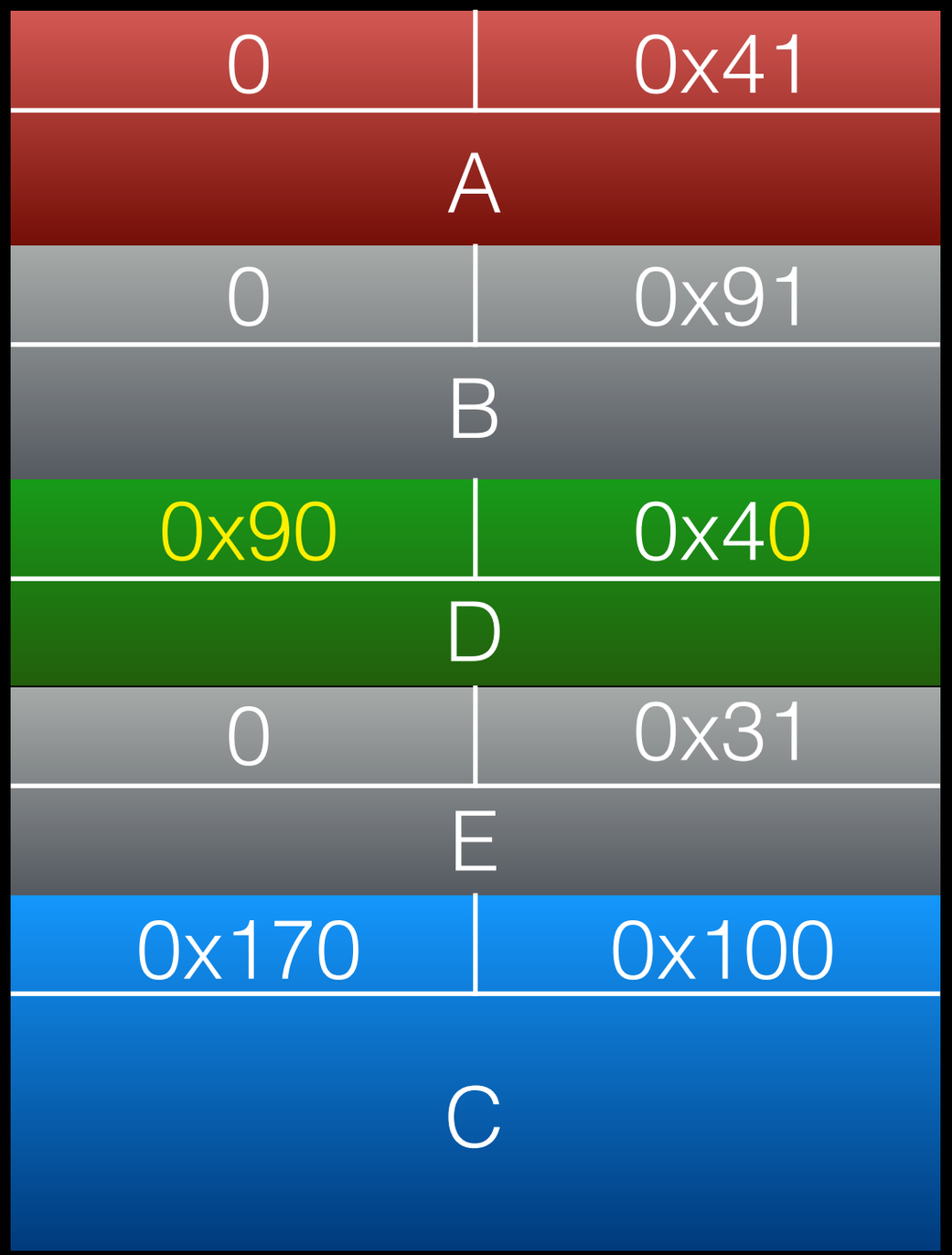
# Shrink the chunk

- free(B)



# Shrink the chunk

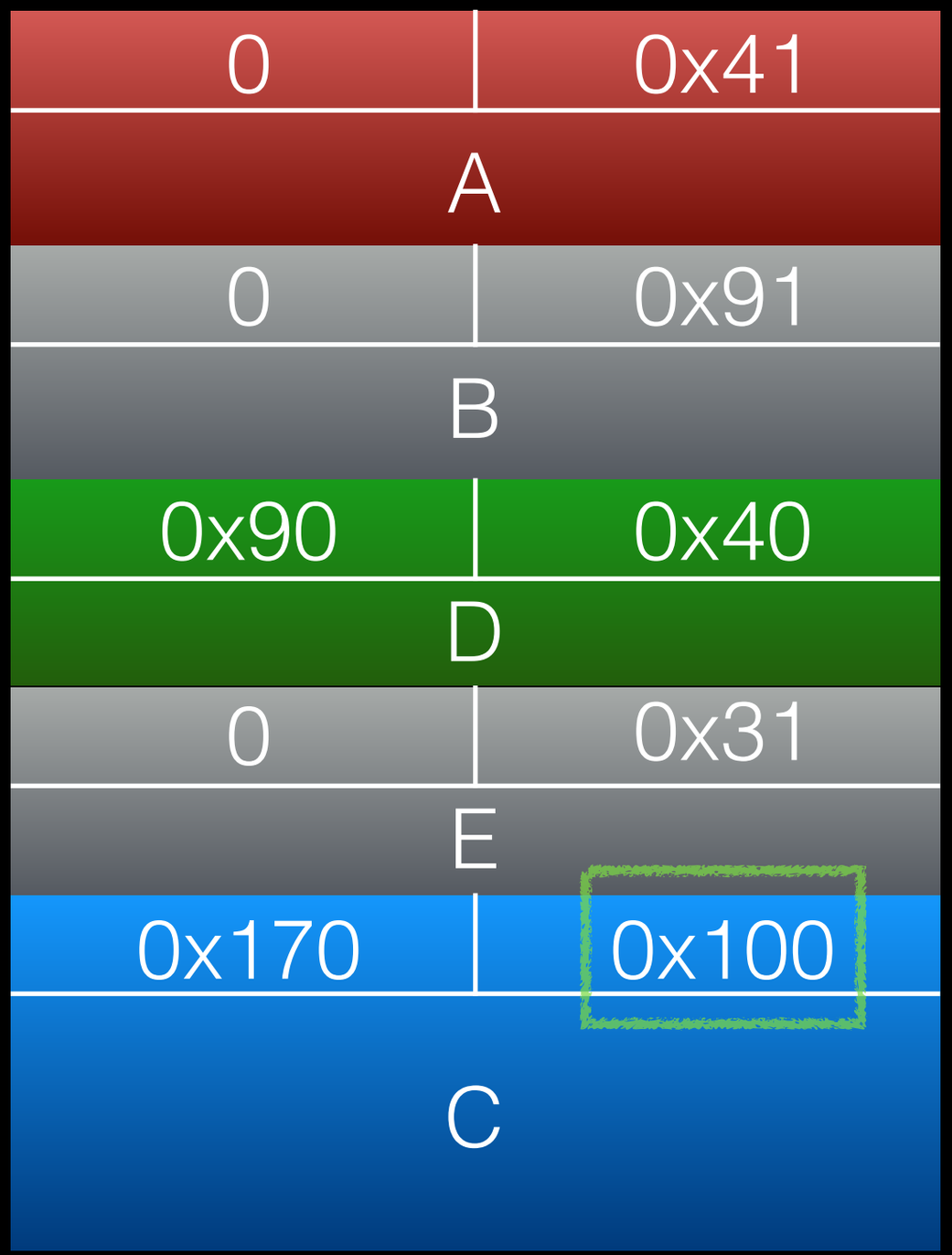
- free(C)



# Shrink the chunk

- free(C)

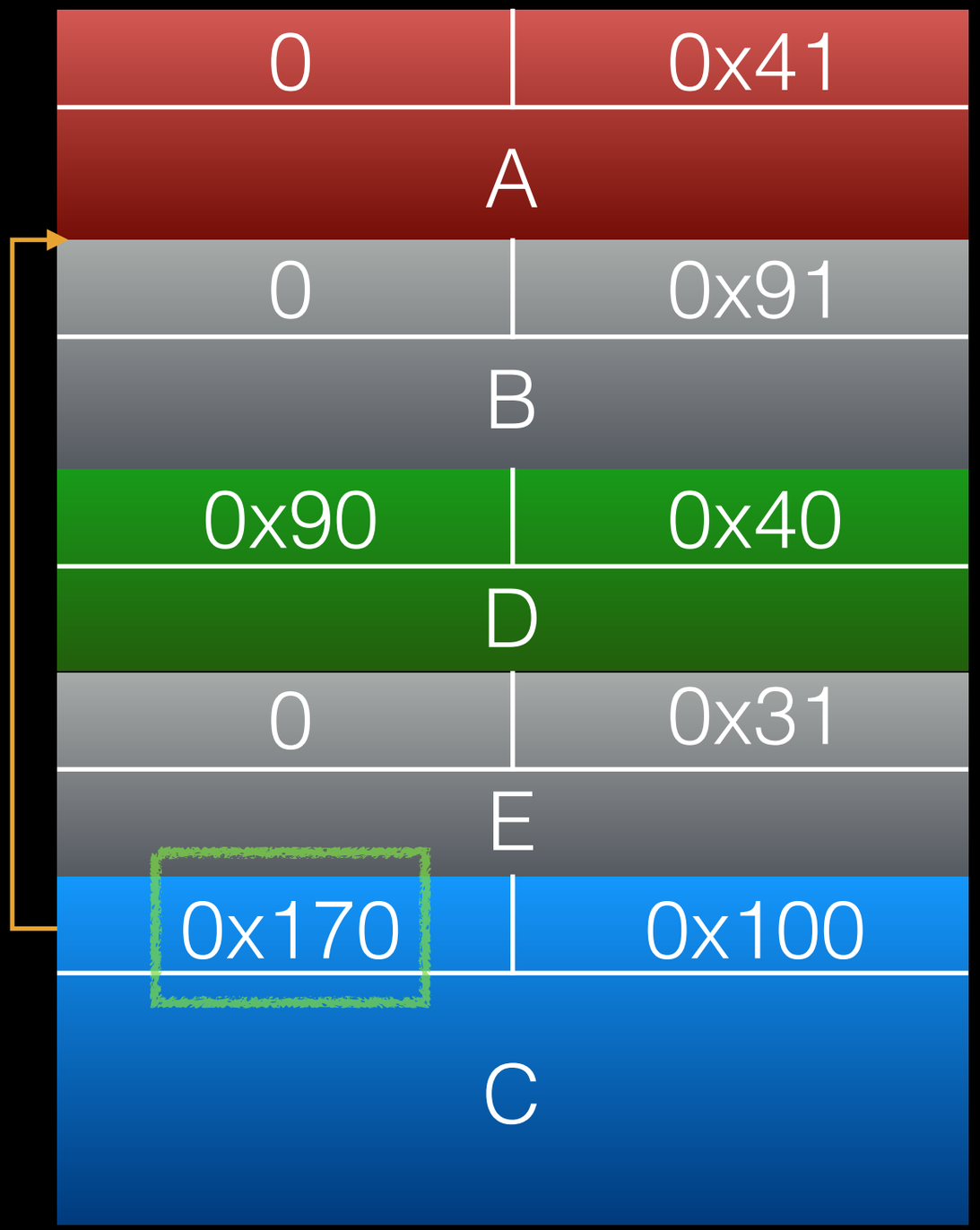
此時會因為 C 是 smallbin
的大小的關係，
所以會檢測上一塊是否 inused



# Shrink the chunk

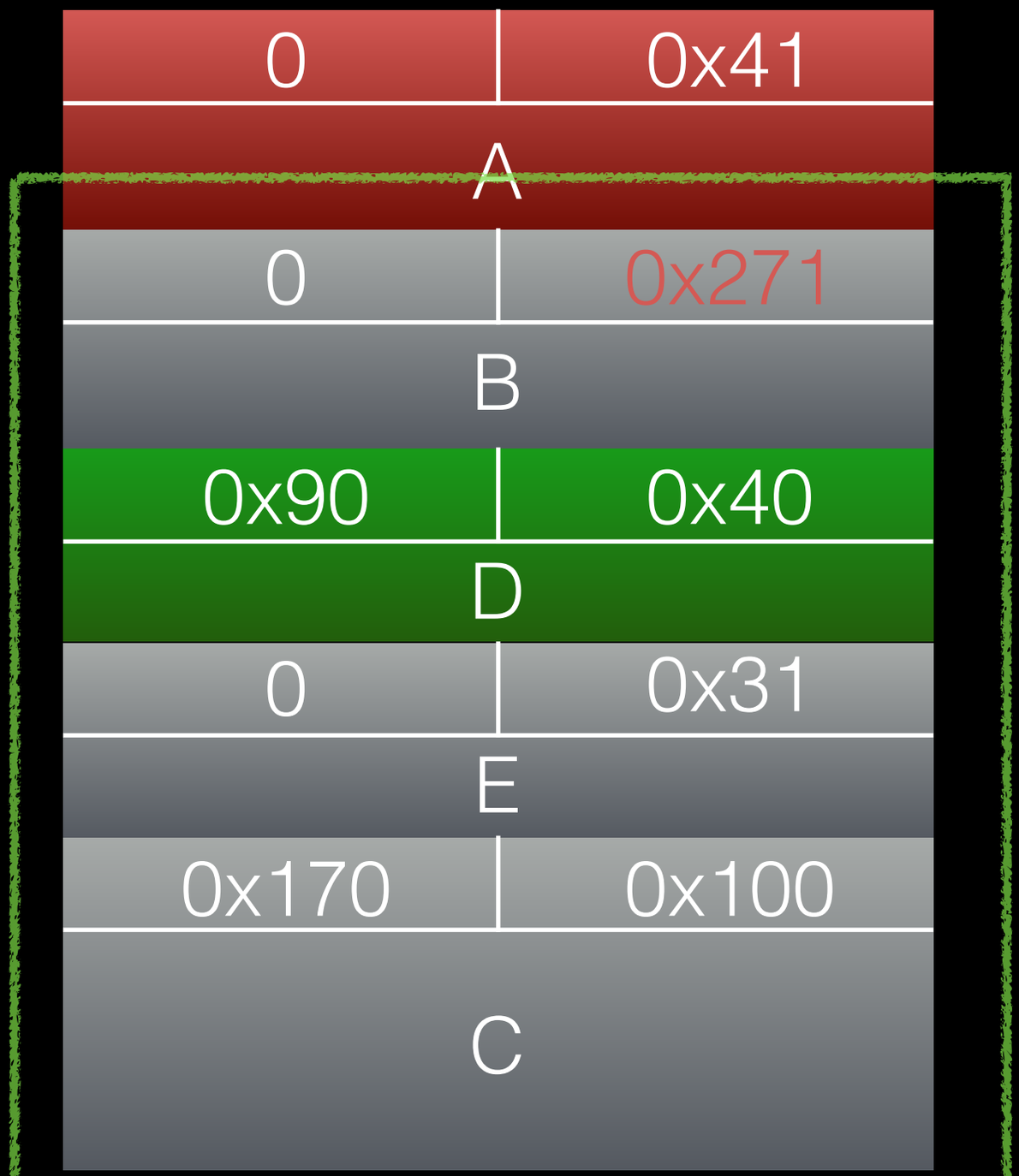
- free(C) - merge

如果上一塊是 freed 就會
根據prev_size
去找上一塊 chunk
的 header 做
合併及 unlink



# Shrink the chunk

此時 unsortbin 存這
這塊大 chunk ，
所以下次
malloc 會用這一塊
先份配給 user



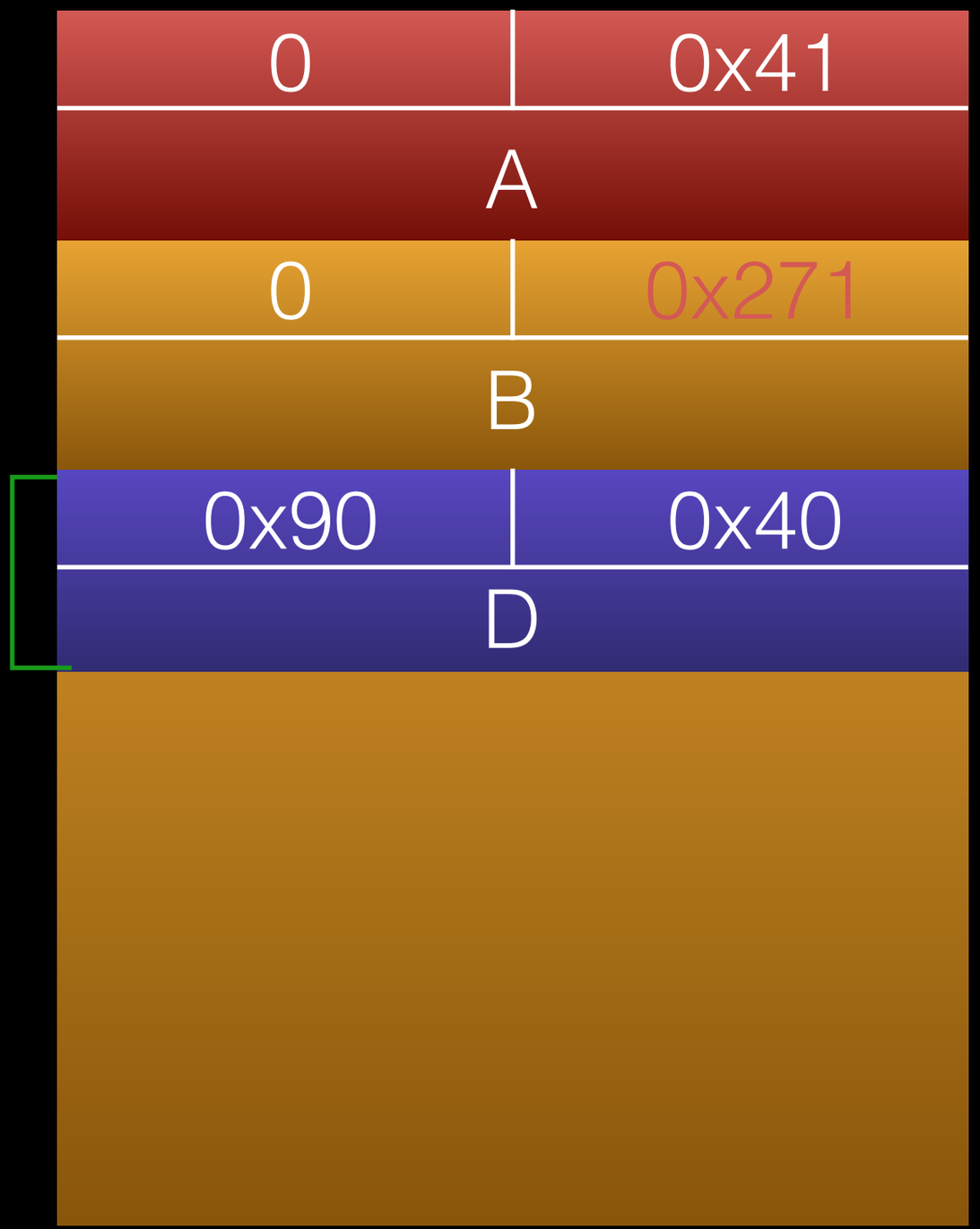
# Shrink the chunk

- malloc(0x260)

# Shrink the chunk

- 此時可任意改 D

overlap chunk



# Shrink the chunk

- overlap 的情況其實還蠻 powerful 的，如果中間 overlap 部分有 function pointer 或者是其他有用的 struct 可間接控制程式流程
- 也可以配合 fastbin freed chunk 更改 fd

# Outline

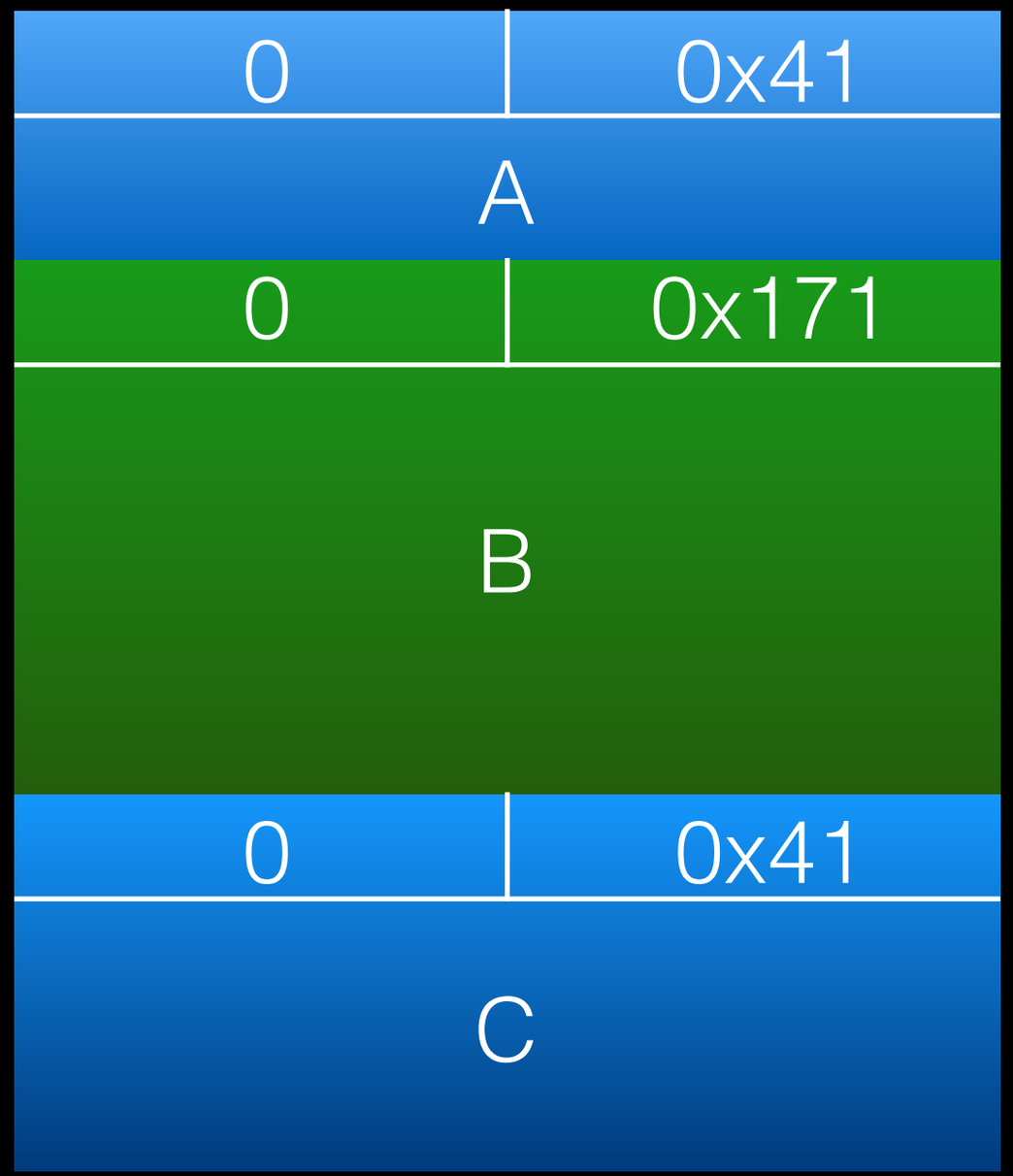
- Fastbin corruption
- Shrink the chunk
- Extend the chunk

# Extend the chunk

- 假設存在一個 off-by-one 的漏洞
- 目的：
  - 一樣是創造出 overlap chunk ，進而更改其他 chunk 中的內容
- 跟 shrink 很像，但主要是加大 size 直接吃掉後面的 chunk ，只要後面的 chunk header 有對上就好

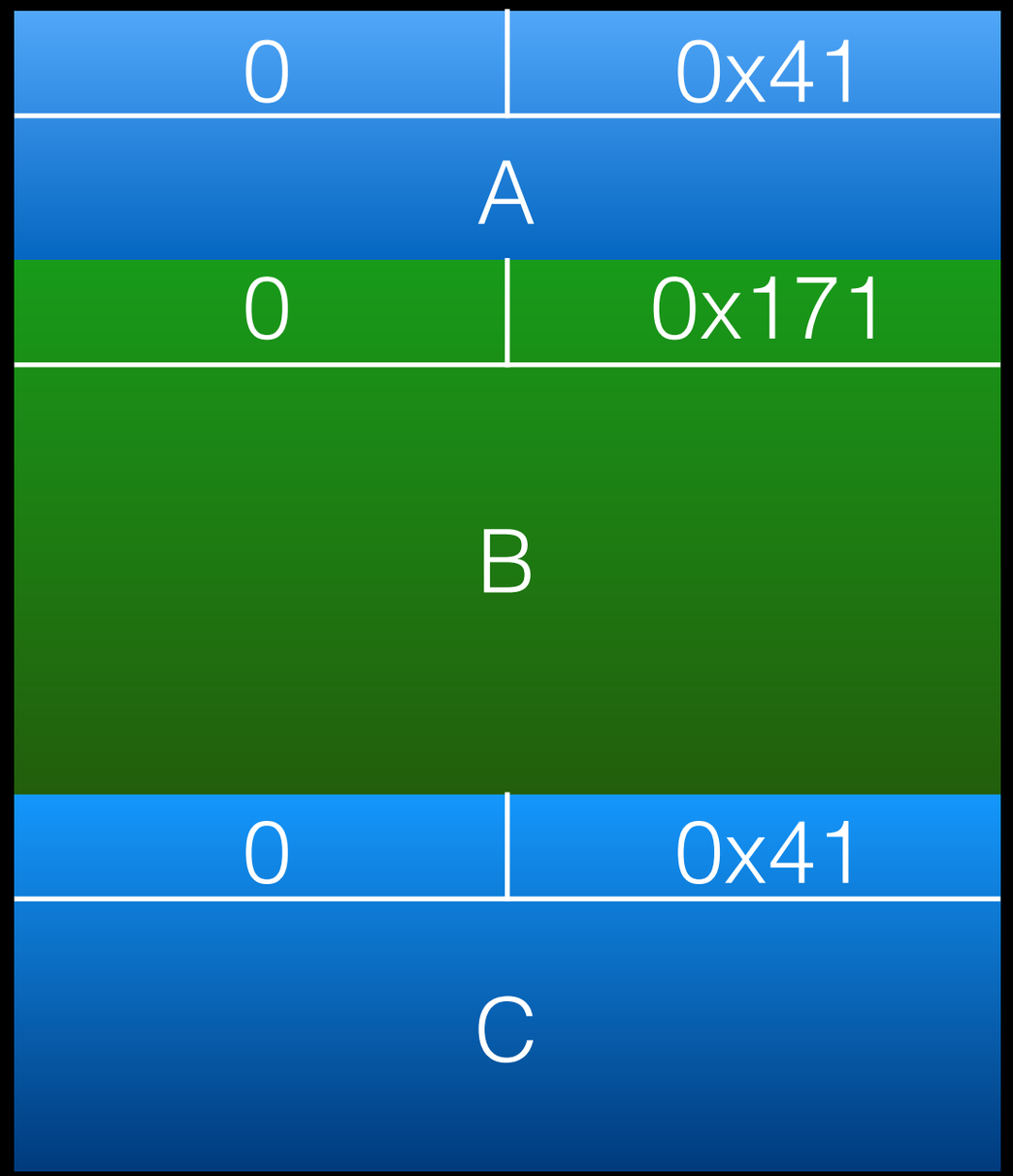
# Extend the chunk

- 一開始先 malloc 3 塊 chunk 至 heap 段



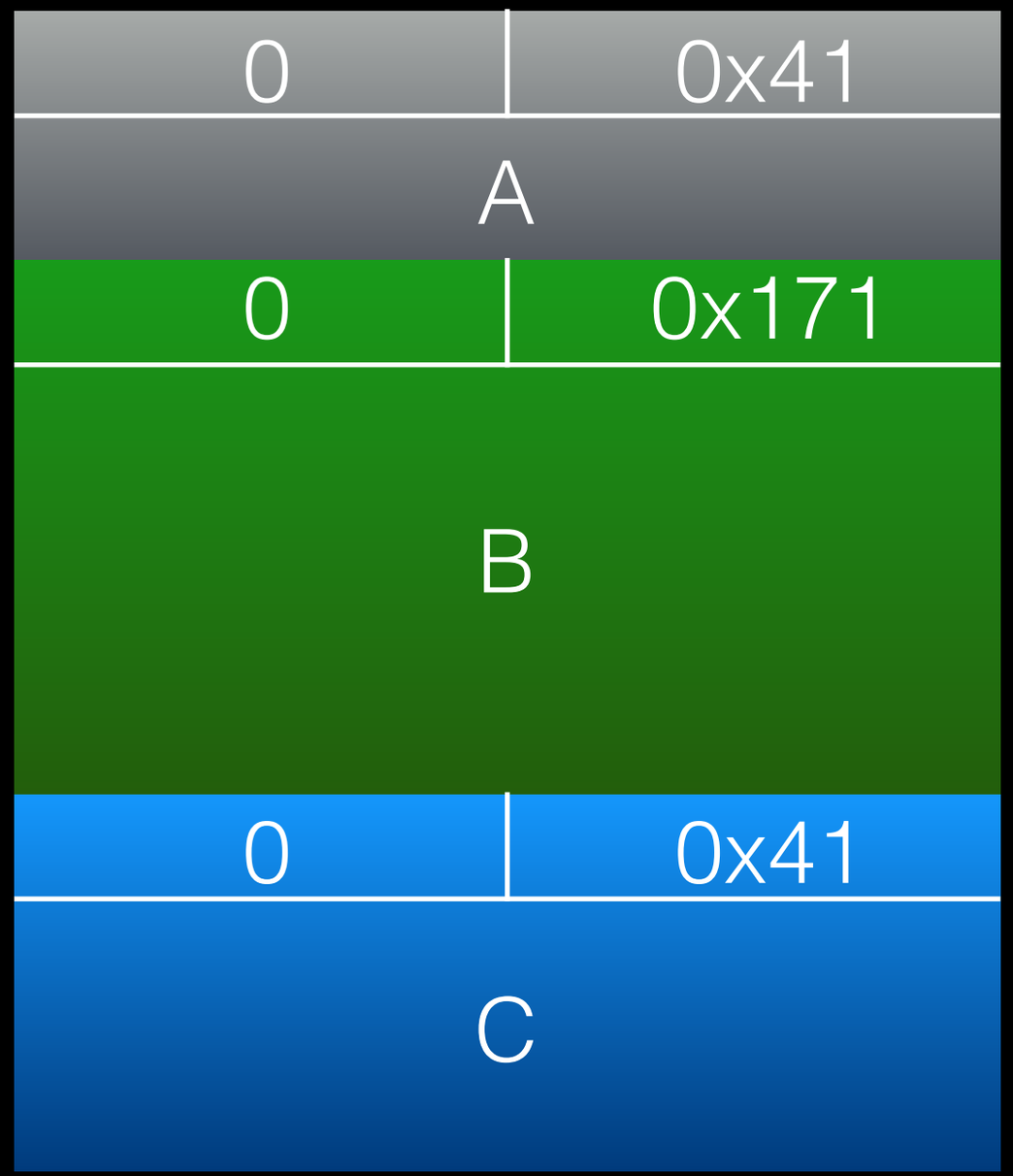
# Extend the chunk

- free(A)



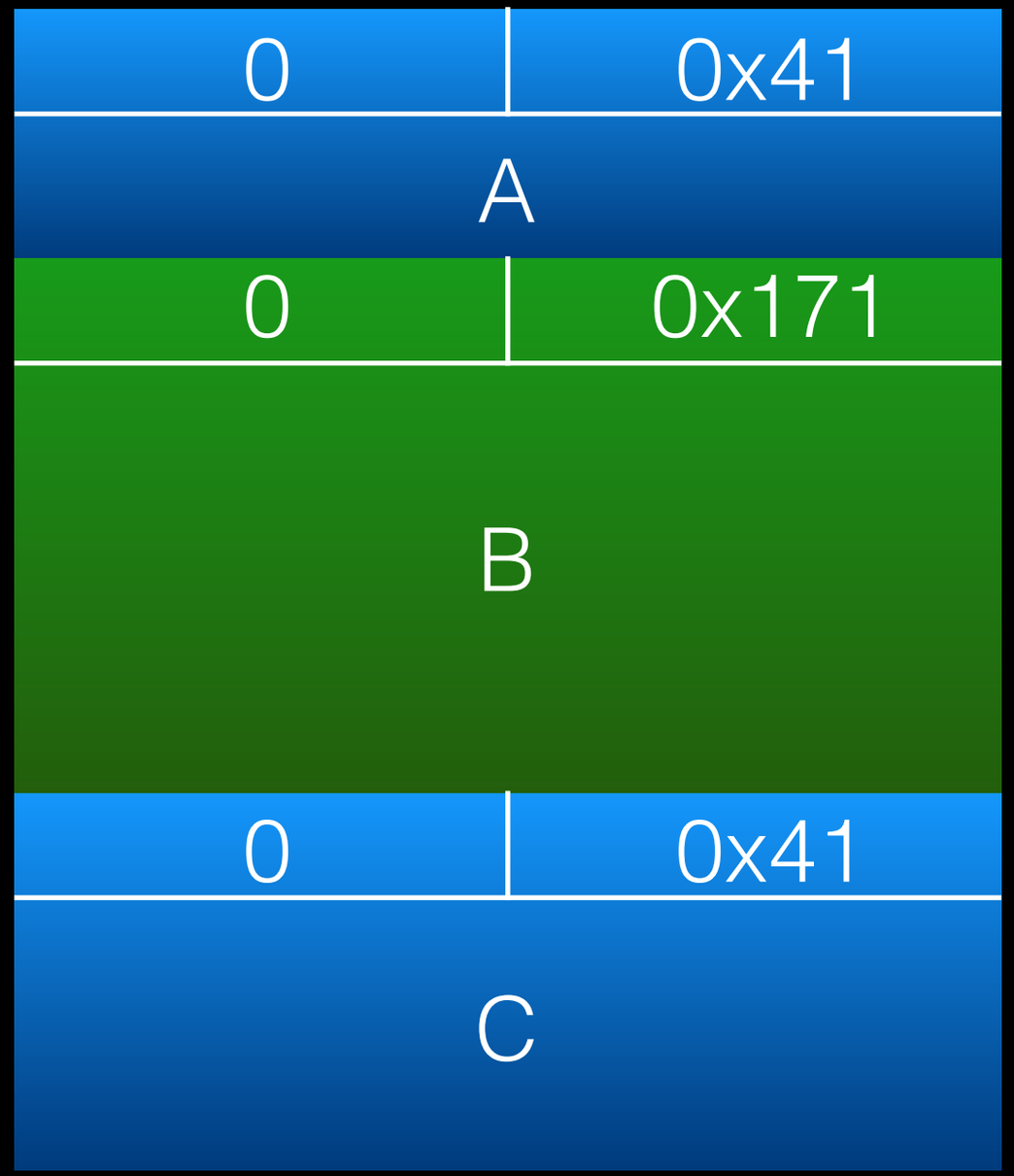
# Extend the chunk

- malloc(0x38)



# Extend the chunk

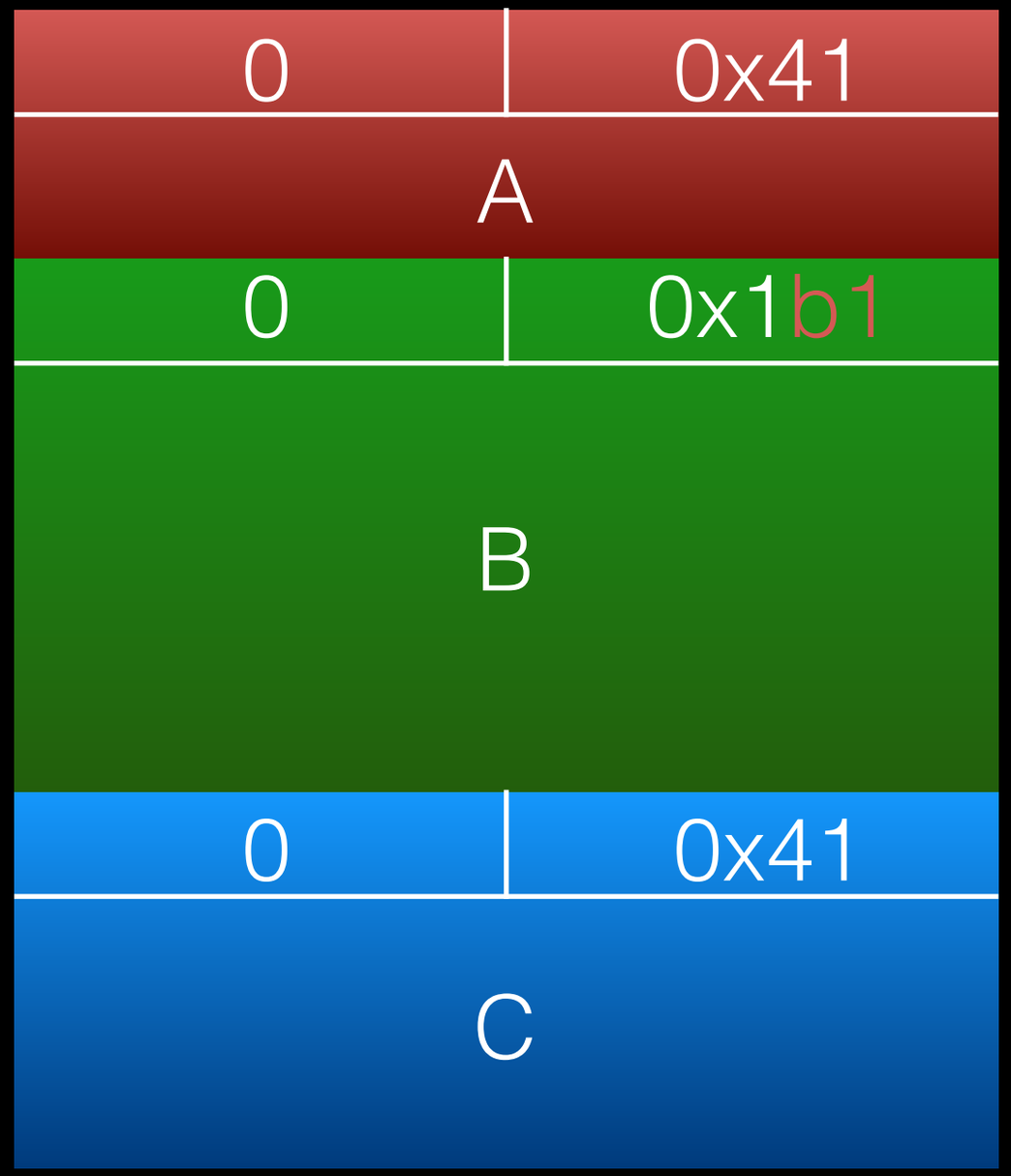
- read data to A and off-by-one overflow



# Extend the chunk

- free(B)

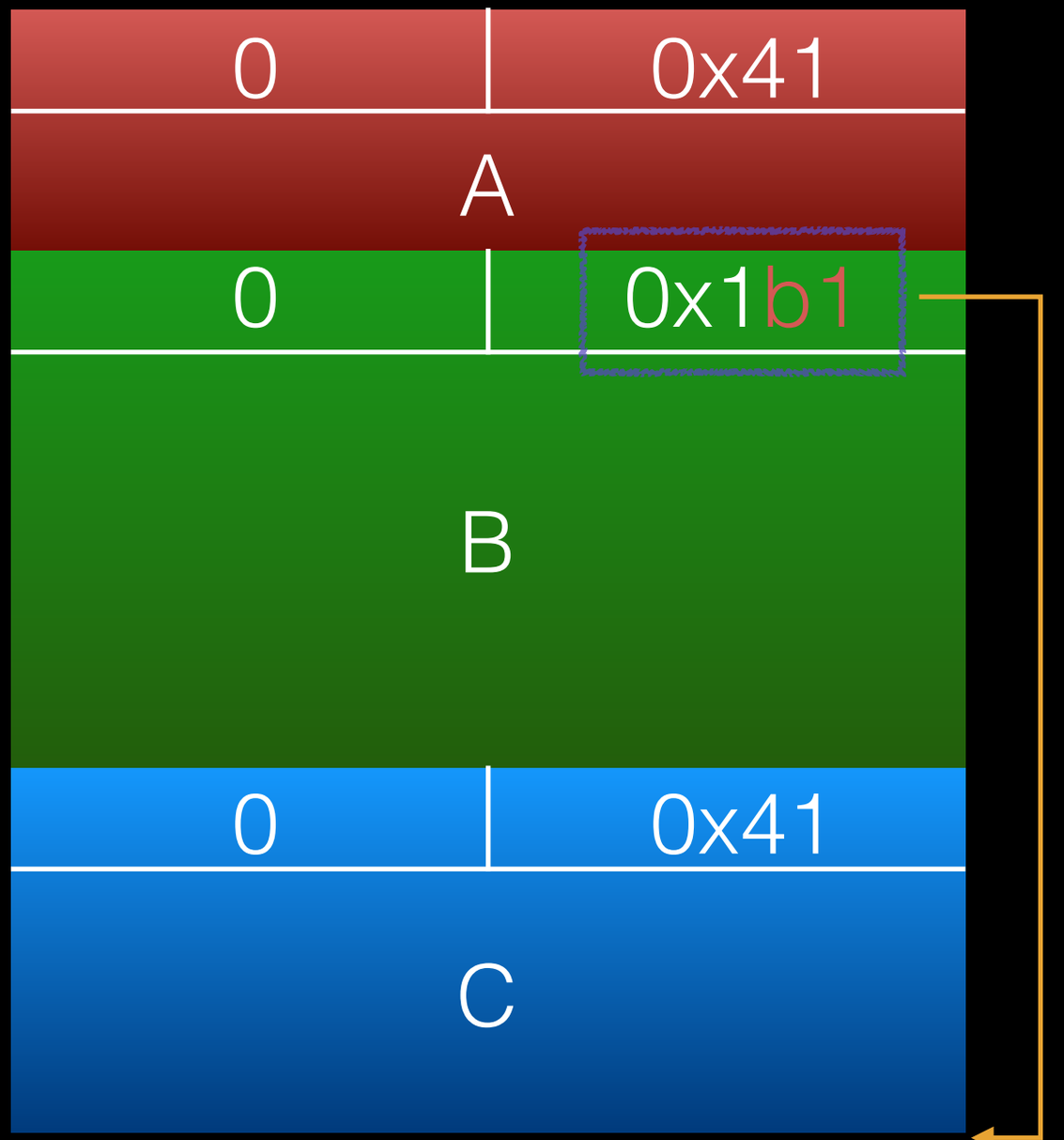
0x1b1 = 0x171 + 0x40
為了之後要把 C 吃進去



# Extend the chunk

- free(B)

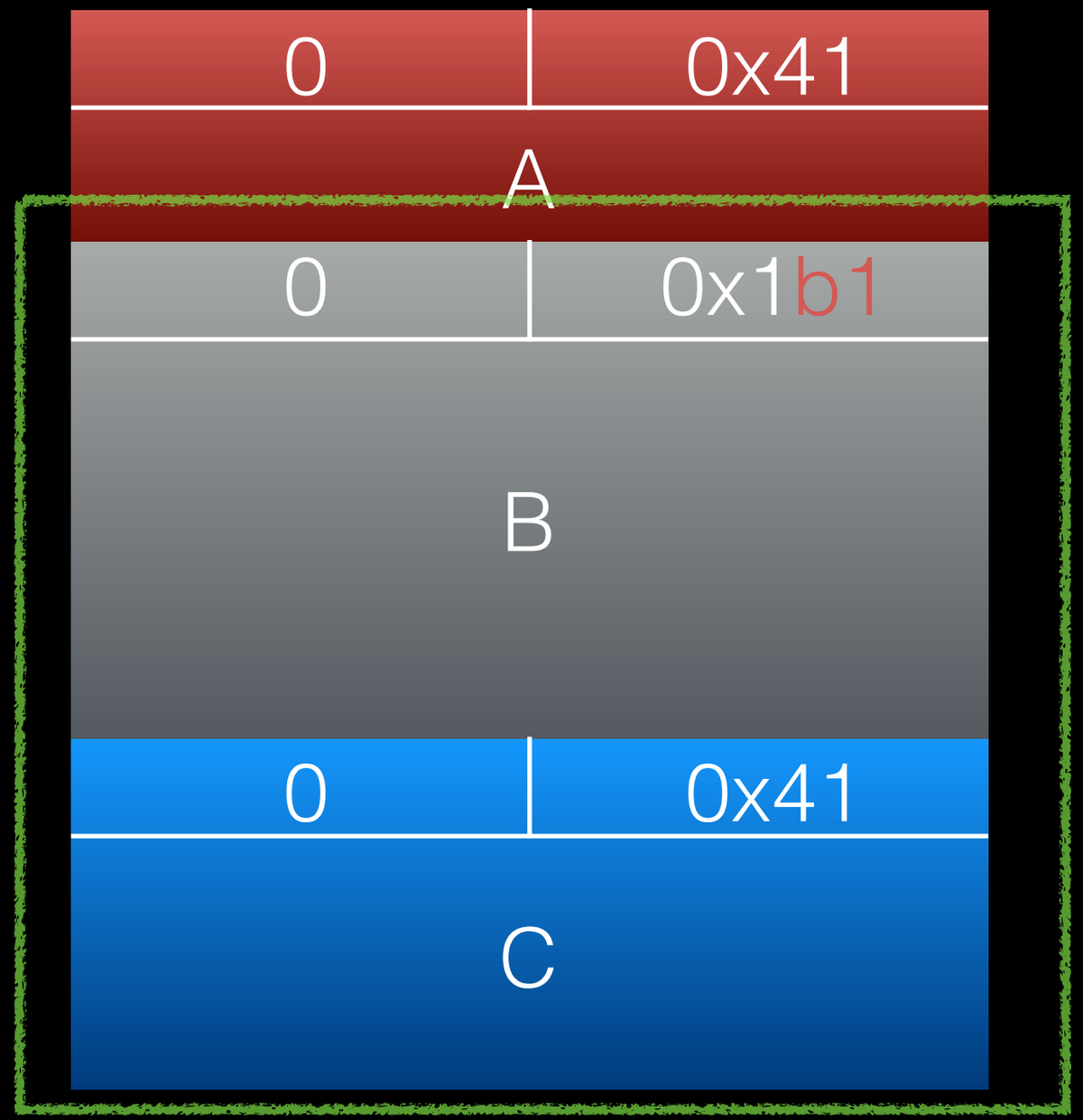
在此時會根據 B 的 size
去找下一塊 chunk 的 header
因剛剛偽造的 size 會去抓到
C 的下一塊 chunk header
做 inused bit 檢查
但 C 是 inused 所以會通過



# Extend the chunk

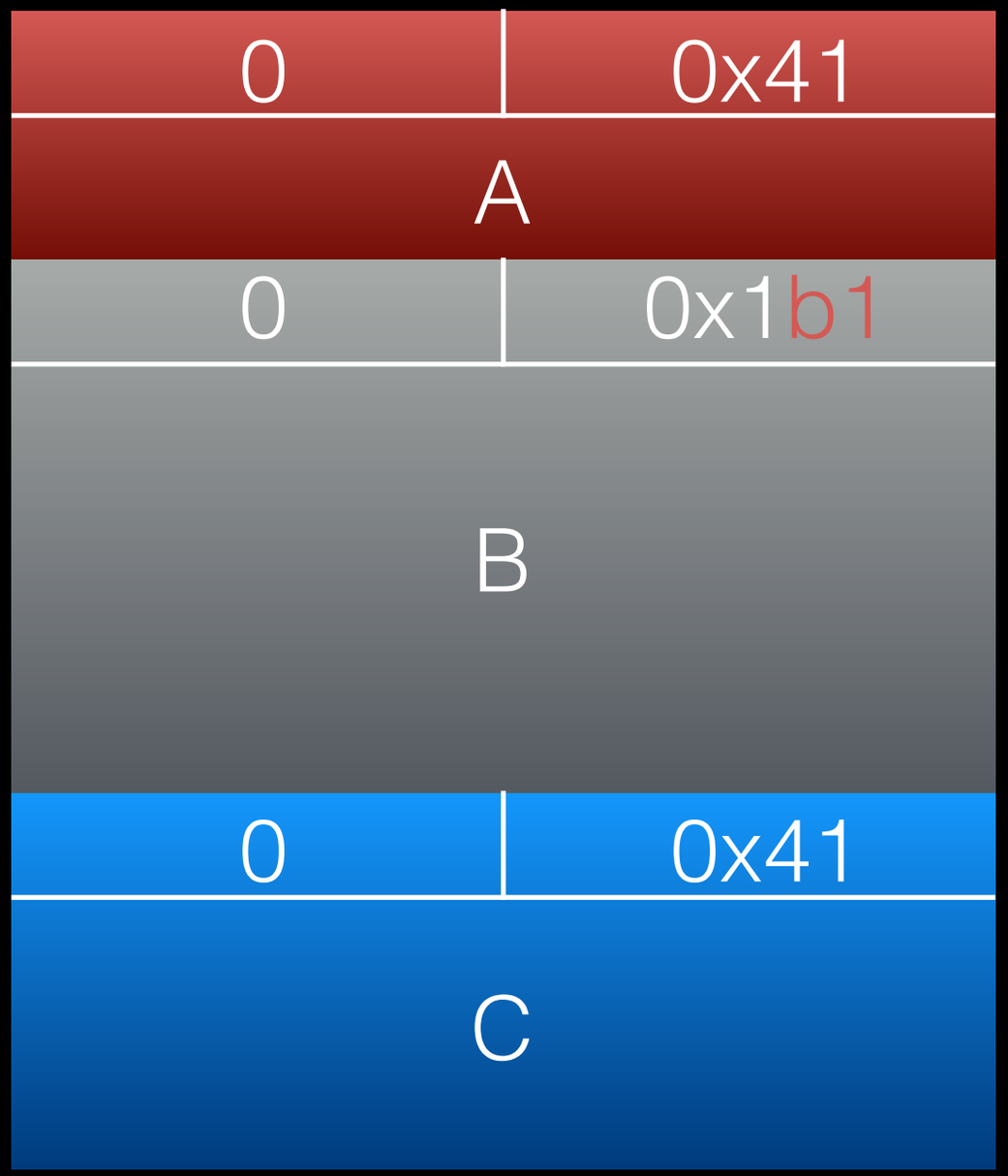
- free(B)

此時這塊 chunk
會被合併到 top
（如果 C 後面是 top）
或是加到 unsortbin 中



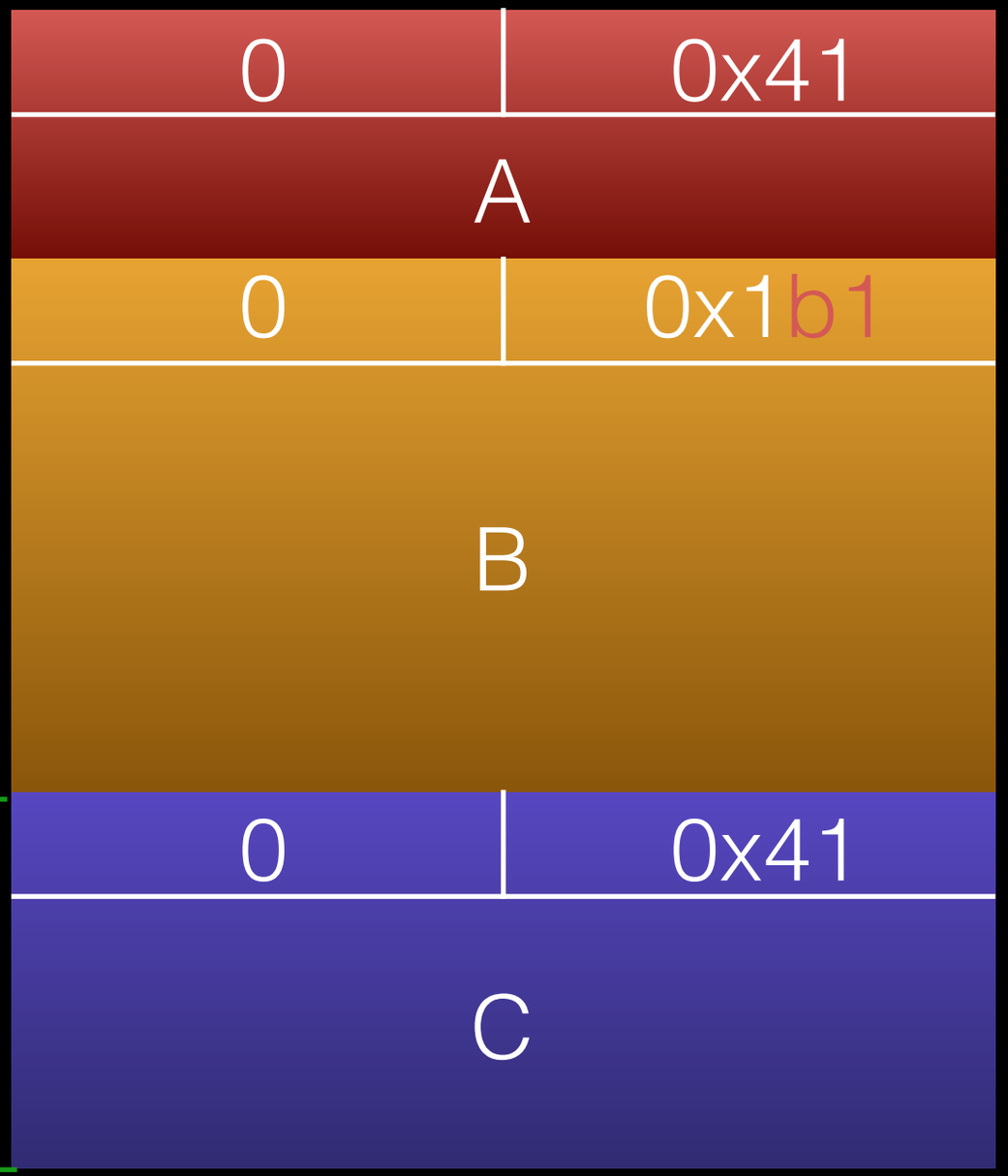
# Extend the chunk

- malloc(0x1a0)



# Extend the chunk

- 此時可以任意更改 C




overlap chunk

# Extend the chunk

- 不過跟 Shrink 比起來相對限制比較多一點，必須要可控 off-by-one 的那個 byte ，Shrink 只要是 null byte 即可，相對比較常見，但也不好發現就是了

# Summary

- Heap exploitation 雖然已利用來說會難一點，但常常在 Full mitigation 的情況下都可以利用，畢竟針對 heap 來說相對應的保護較少，也較難去實作
- Heap 就是門藝術

# Reference

- Glibc Adventures: The Forgotten Chunks
- google project zero
- glibc cross reference