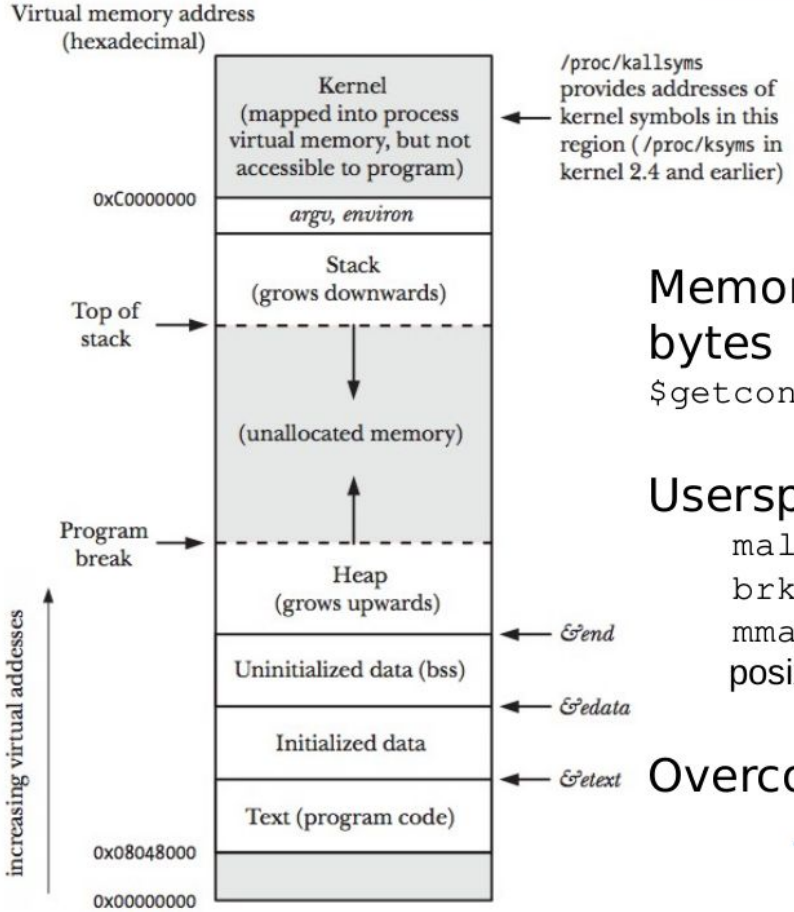
Linux Kernel Basecamp

Memory Management
Apr 2023

Agenda

- Memory layout
- Dynamic memory allocation
- SLAB allocators
- Mempools

Memory Layout



Memory page frame size on x86-32 is 4096 bytes

```
$getconf PAGESIZE
```

Userspace functions

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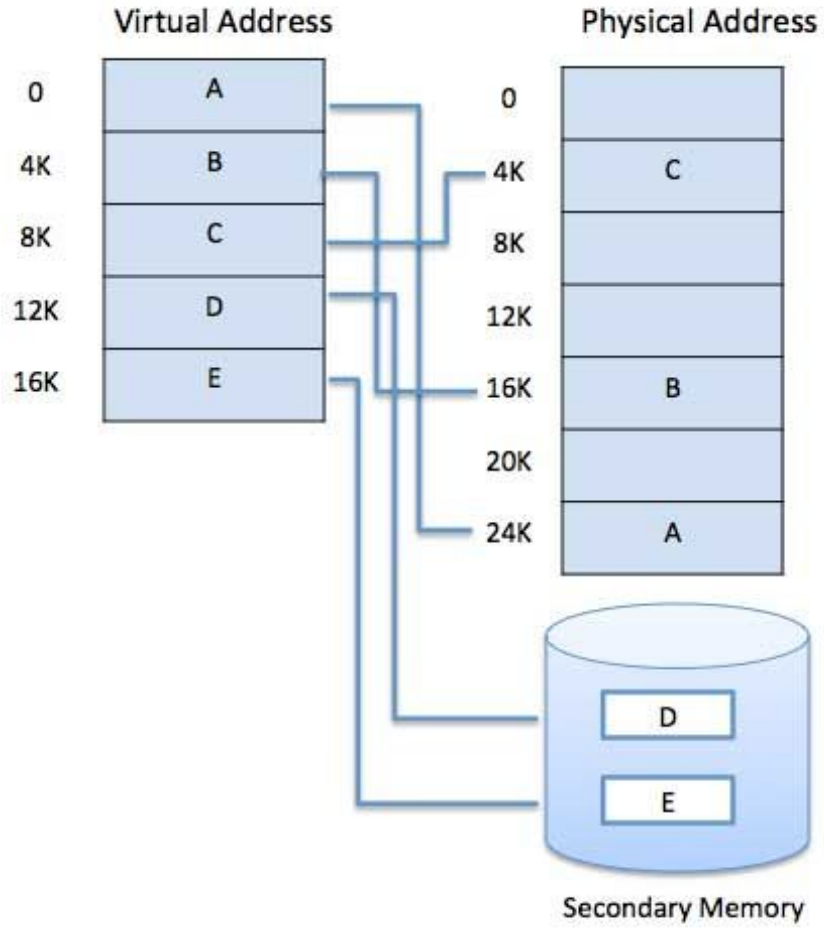
malloc()/calloc()/realoc()/free()
brk()/sbrk()
mmap()
```

posix_memalign()

Overcommiting and OOM

Virtual memory



Userspace memory allocation

Internal and external fragmentation are the common issues

Glibc allocates memory via

✔ buddy memory allocation scheme

✔ anonymous memory mapping

MMAP_THRESHOLD is 128 kB (malopt() to change)

Memory Management

#include <include/linux/gfp.h> or/and

#include <include/linux/types.h>

void ***kmalloc**(size_t size, gfp_t flags);

gfp_t: is a bitmask. The most popular predefined values are:

GFP_ATOMIC, GFP_KERNEL, GFP_USER

void **kfree**(const void *);

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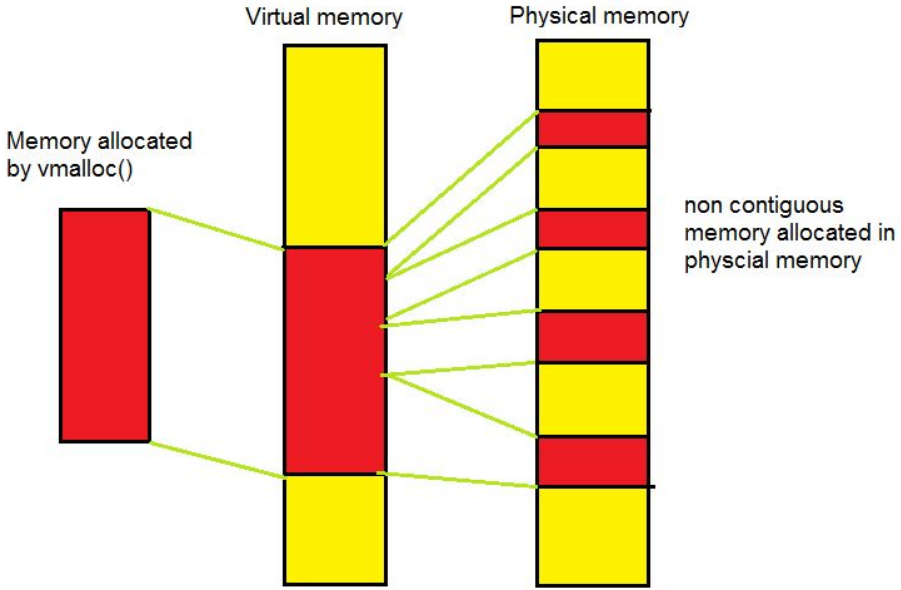
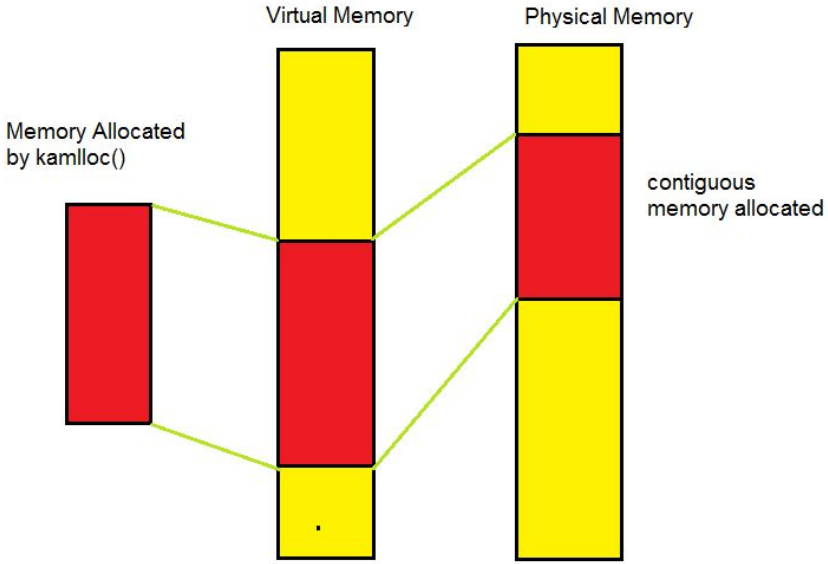
#include/linux/vmalloc.h

void ***vmalloc**(unsigned long size);

void **vfree**(const void *addr);

Vmalloc vs kmalloc





Low level memory management

#include/linux/gfp.h

struct_page ***alloc_pages**(gfp_t gfp_mask, unsigned int order);

struct page * **alloc_page**(gfp_t gfp_mask);

void ***page_address**(struct_page * page);

unsigned long **get_zeroed_page**(unsigned int gfp_mask);

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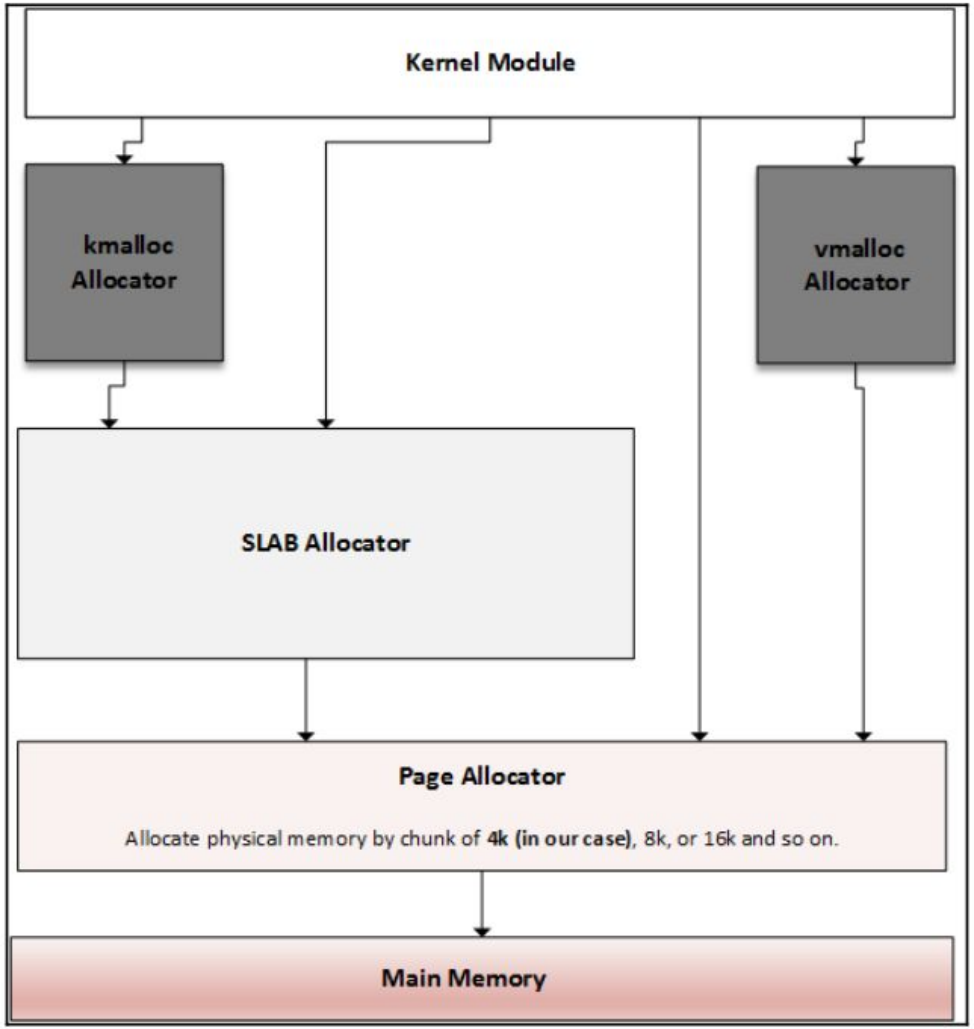
void **free_pages**(unsigned long addr, unsigned int order);

void **free_page**(unsigned long addr);



Kernel memory allocation

MemPool

#include/linux/mempool.h

typedef void *(**mempool_alloc_t**)(int gfp_mask, void *pool_data);

typedef void (**mempool_free_t**)(void *element, void *pool_data);

mempool_t ***mempool_create**(int min_nr, mempool_alloc_t *alloc_fn, mempool_free_t *free_fn, void pool_data);

void ***mempool_alloc**(mempool_t *pool, gfp_t gfp_mask);

void **mempool_free**(void *element, mempool_t *pool);

mempool_alloc_slab()

mempool_kmalloc()

mempool_alloc_pages()

Interface SLAB

File system point: /proc/slabinfo

include/linux/slab.h

struct kmem_cache ***kmem_cache_create**(const char *name, size_t size, size_t align, unsigned long flags, void (*ctor)(void *));

void **kmem_cache_destroy**(struct kmem_cache *s);

void ***kmem_cache_alloc**(struct kmem_cache *, gfp_t flags);

void **kmem_cache_free**(struct kmem_cache *, void *);

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• SLAB

• SLUB

• SLOB

cat /boot/<path_to_config> | grep "CONFIG_SL[AOU]B"