xv6©-rev10

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Initialization, Dynamic Allocation Subsystem

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Our context

```
extern char end[];
kinit1(end, P2V(4*1024*1024)); // phys page alloc
kvmalloc();      // kernel page table
  ⋮
seginit();       // set up segments
  ⋮
pinit();         // process table
  ⋮
  ⋮
kinit2(P2V(4*1024*1024), P2V(PHYSTOP)); // must c
userinit();      // first user process
mpmain();
```

Why dynamic memory subsystem first?

- Many initialization routines uses utility kernel routines.
- The utility routines use the dynamic allocation subsystem.
- Ergo...

Prerequisites

- **freerange**
- **kfree**.

It will be clearer to explain first the dynamic allocation system, and then explain the initialization.

Services supplied by the dynamic allocation

- void *kalloc(void): Returns a pointer to a non-used **page**.
- kfree(void *p): Marks the **page** pointed to by p as unused.

Implementation

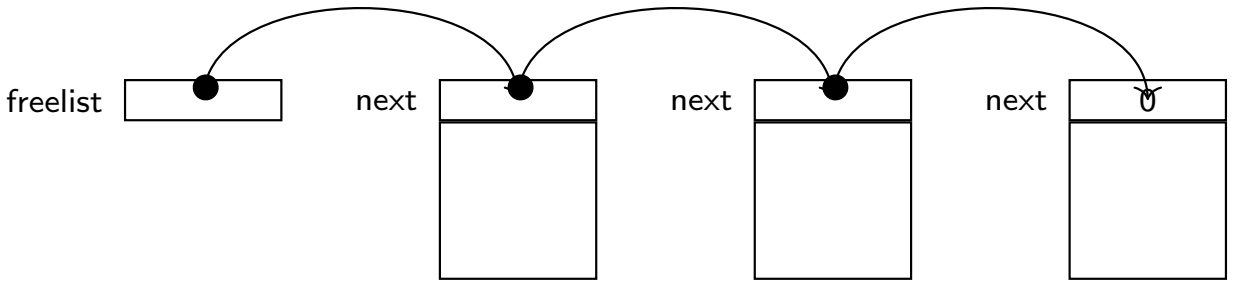
The unused pages are in a linked list headed by **kmem**:

```
3115  struct run {
        struct run *next;
      };

      struct {
        struct spinlock lock;
        int use_lock;
        struct run *freelist;
      } kmem;
```

The first longword in each page points to the next free page.

The freelist



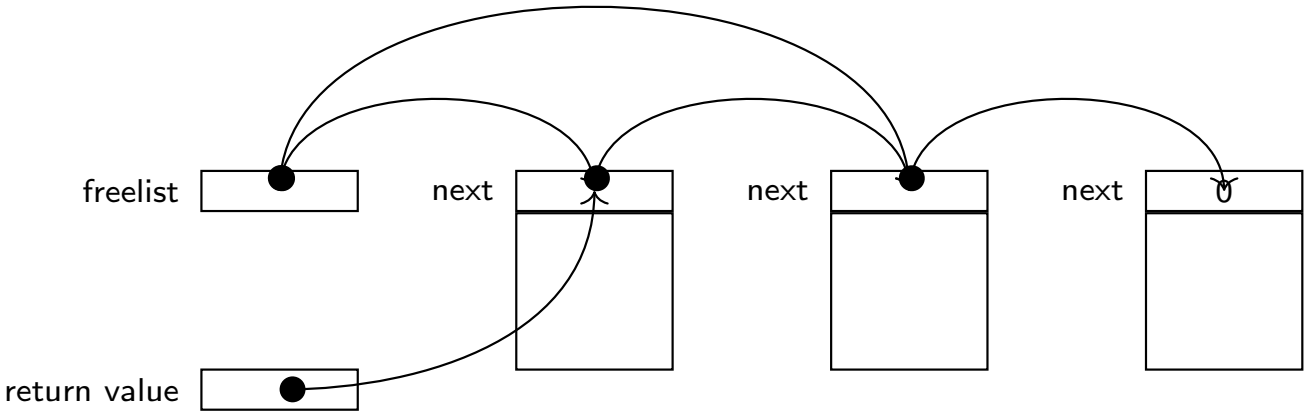
- **kalloc** removes from the head of the list.
- **kfree** inserts at the begining of the list.

kalloc

```
3187  char *kalloc(void) {
        struct run *r;

        acquire(&kmem.lock);
        r = kmem.freelist;
        if (r)
          kmem.freelist = r->next;
        release(&kmem.lock);
        return (char*)r;
      }
```

kalloc in action



Logically we mean this, of course!

kfree

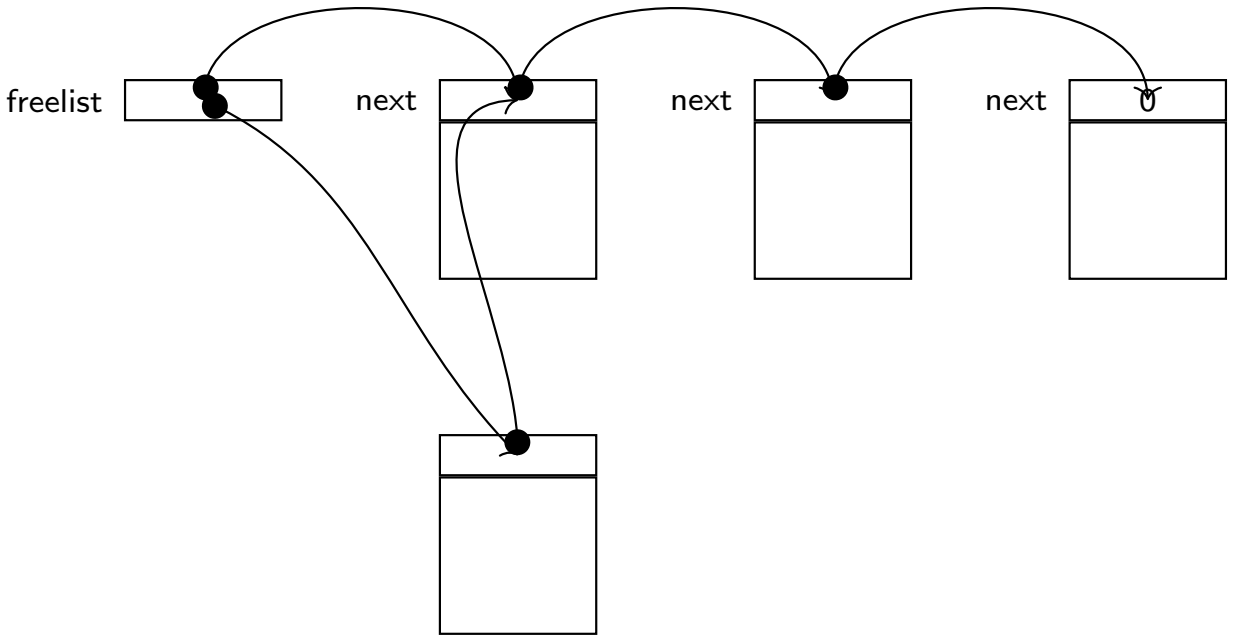
```
3163  void kfree(char *v) {
        struct run *r;

        if ((uint)v % PGSIZE || v < end || v2p(v)>=PHYSTOP)
          panic("kfree");

        memset(v, 1, PGSIZE);

        acquire(&kmem.lock);
        r = (struct run*)v;
        r->next = kmem.freelist;
        kmem.freelist = r;
        release(&kmem.lock);
      }
```

kfree in action



Loading **freelist**

- What is in the **freelist** when entering main?
  - The empty list.
- What addresses can be considered free?
  - Not valid addresses are, well, not valid!
  - Thus addresses in [0x80000000,0x80400000) without kernel addresses.
- xv6 is linked to address 0x80100000.
- The linker defines **_end** to where the kernel ends.
- Thus the following two ranges are free:
  - [0x80000000,0x800A0000).
  - [**_end**,0x80400000).
- xv6 'frees' only the range [**_end**,0x80400000).
- Since we work with pages, **_end** should be rounded up.
- (elective) There is info we need at the first 64KB.

freerange

- Is it legal,in user mode C, to **free** a block not **malloc**'ed?
  - No. Why?
- Can we, in the xv6 kernel, **kfree** a page not **kalloc**'ed?
  - Yes. Why?

```
#define PGROUNDUP(sz)  (((sz)+PGSIZE-1) &
                                    ~(PGSIZE-1))

3151 void freerange(void *vstart, void *vend) {
  char *p;
  p = (char*)PGROUNDUP((uint)vstart);
  for(; p + PGSIZE <= (char*)vend; p += PGSIZE)
    kfree(p);
}

3131 void kinit1(void *vstart, void *vend) {
  initlock(&kmem.lock, "kmem");
  freerange(vstart, vend);
}
```

Dynamic allocation initialization

- Step 1:

```
#define KERNBASE 0x80000000
#define PHYSTOP  0x0E000000
#define P2V(a) (((void *) (a)) + KERNBASE)

extern char end[];

  kinit1(end, P2V(4*1024*1024));
```

- Step 2:

```
  kinit2(P2V(4*1024*1024), P2V(PHYSTOP));
```