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exec syscall I

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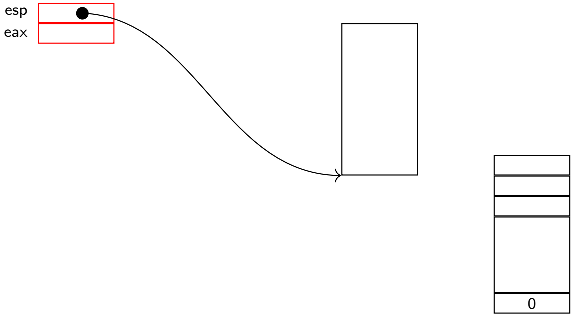
sys_exec arguments



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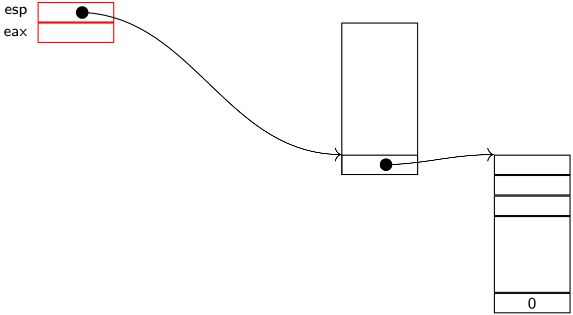

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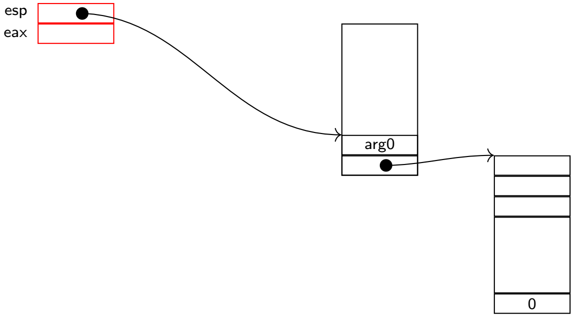

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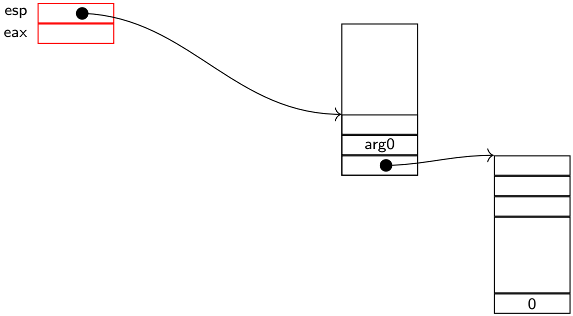

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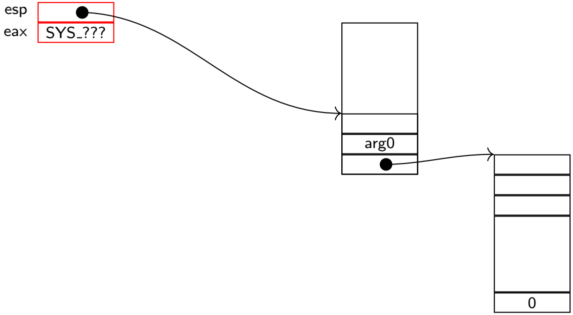

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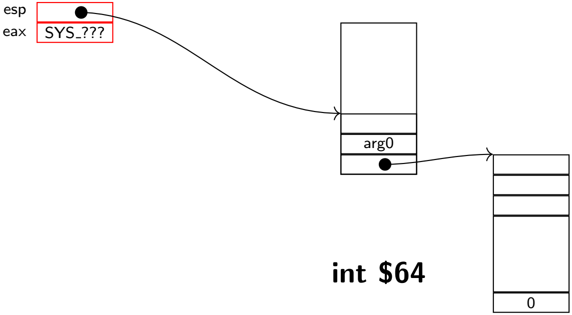
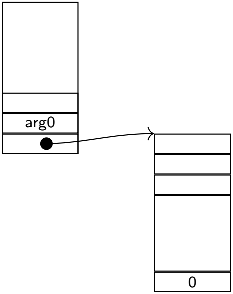


sys_exec arguments

esp	??
eax	??



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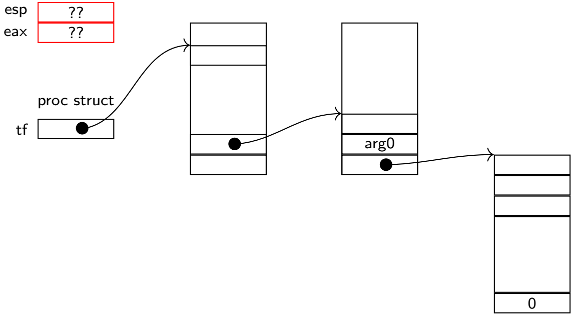

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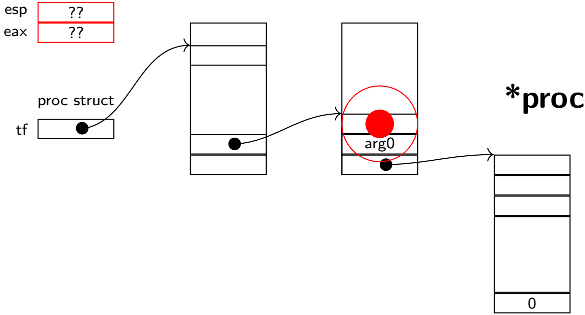
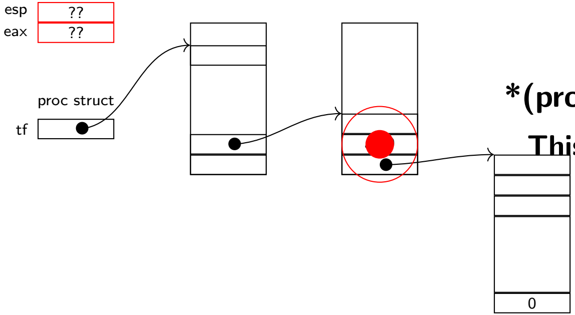


***proc->tf->esp**

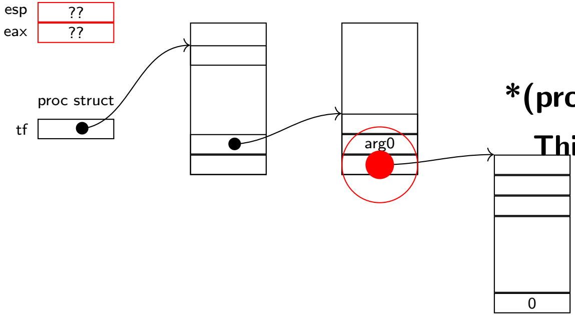
sys_exec arguments



***(proc->tf->esp +4)**

This is argument 0!

sys_exec arguments



***(proc->tf->esp + 8)**

This is argument 1!

sys_exec

```
6526  int sys_exec(void) {
       char *path, *argv[MAXARG];
       int i;
       uint uargv, uarg;
       if (argstr(0,&path)<0 || argint(1,(int*)&uargv)<0)
        return -1;
       memset(argv, 0, sizeof(argv));
       for (i=0; ; i++) {
        if (i >= NELEM(argv)) return -1;
        if (fetchint(uargv+4*i,(int*)&uarg)<0) return -1;
        if (uarg == 0) {
         argv[i] = 0;
         break;
        }
        if (fetchstr(uarg, &argv[i]) < 0) return -1;
       }
       return exec(path, argv);
      }
```

exec

```
exec(char *elf, char *argv[]);
```

There are four steps in **exec**'s implementation:

1. ELF file loading.
2. Allocating user stack and guard page.
3. Passing `argv[]` from the old address space to the new one.
4. Switching address spaces and fixing `trapframe`.

exec: step 1.

- We hold the knowldge to implement steps 2–4 above.
- What knowledge is crucially missing in order to implement step 1?
    - How to read from files.
    - The ELF.

Reading from file in kernel mode

Kernel file system interface for reading file

For now we use this kpi, just as user mode programmers use cluelessly the **open/read/close** api

```
void begin_op(void);
struct inode *namei(char *name);
void          ilock(struct inode *ip);

int           readi(struct inode *ip,
                        char *buf, uint len,
                        uint pos);

void          iunlockput(struct inode *ip);
void end_op(void);
```

Open/Read loop/Close

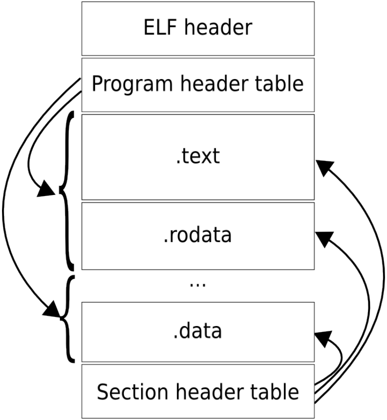
```
begin_op();
ip = namei(filename);

ilock(ip);
for (...) {
 error = readi(ip,buf,bufsiz,pos);
 if (error <= 0) ...
⋮
}

iunlockput(ip);
end_op();
```

(static) Executlabe and Linkable Format (ELF)

ELF components

1. ELF header. Must begin at byte zero of the file.
2. PROGHDR vector.
3. Program segments.

ELF file, very abstract



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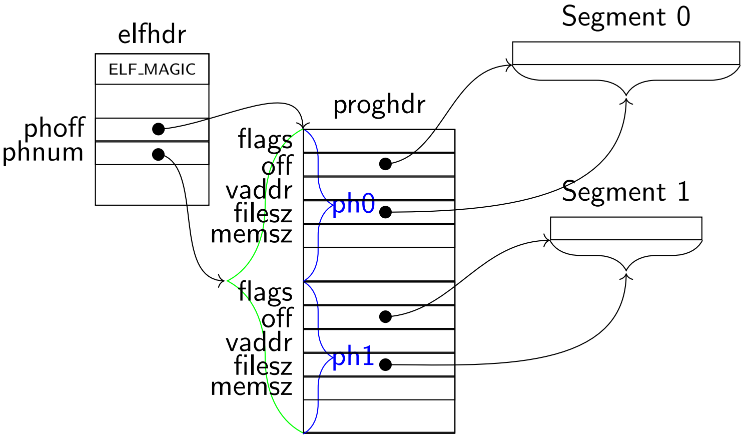
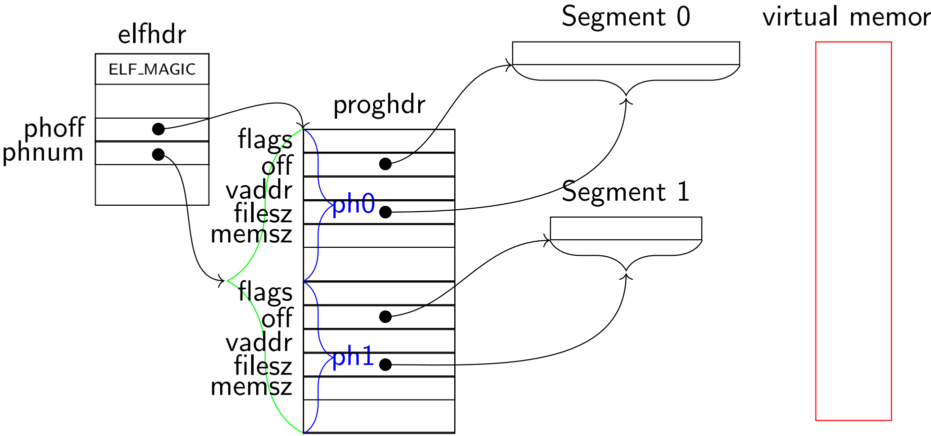
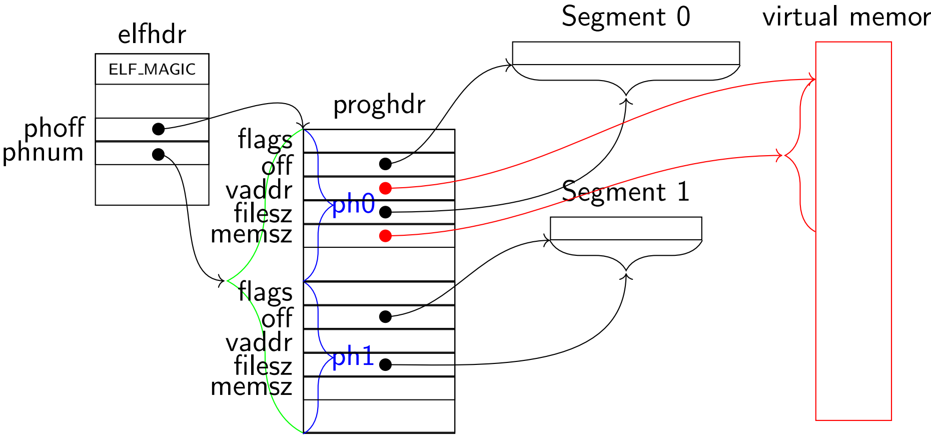
ELF, more detailed



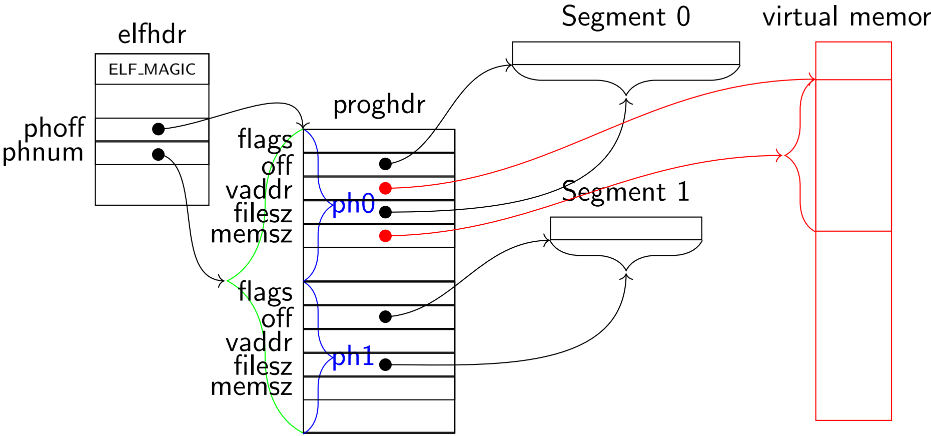
ELF, more detailed



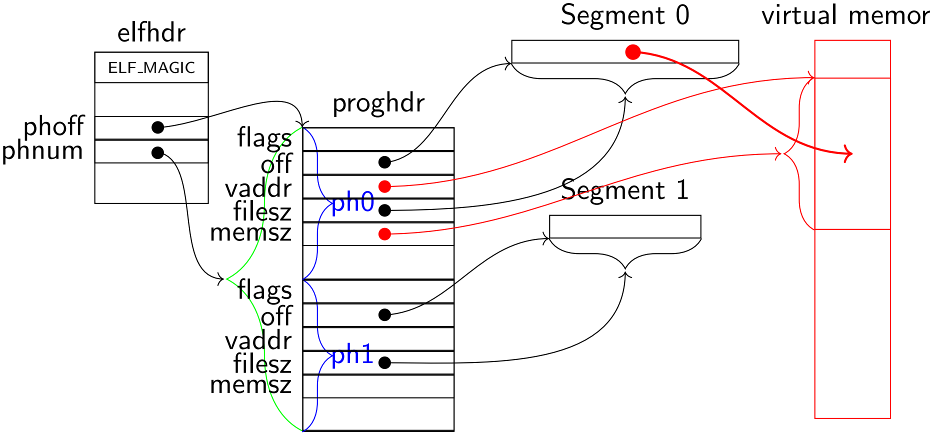
ELF, more detailed



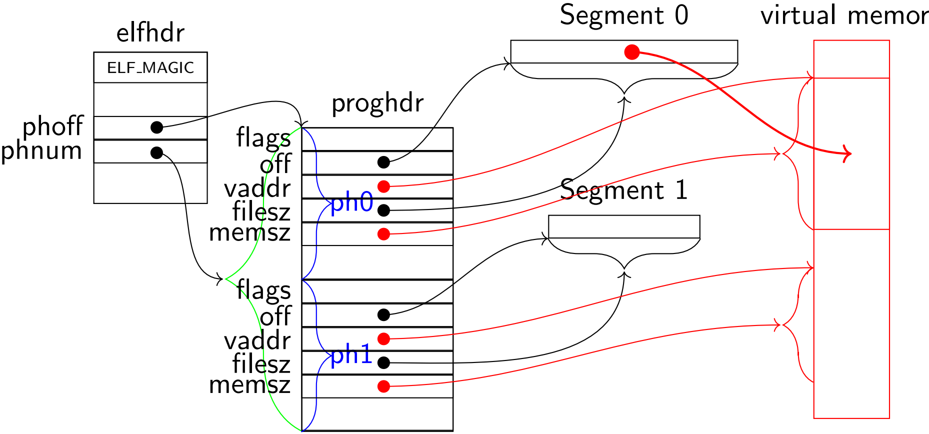
ELF, more detailed



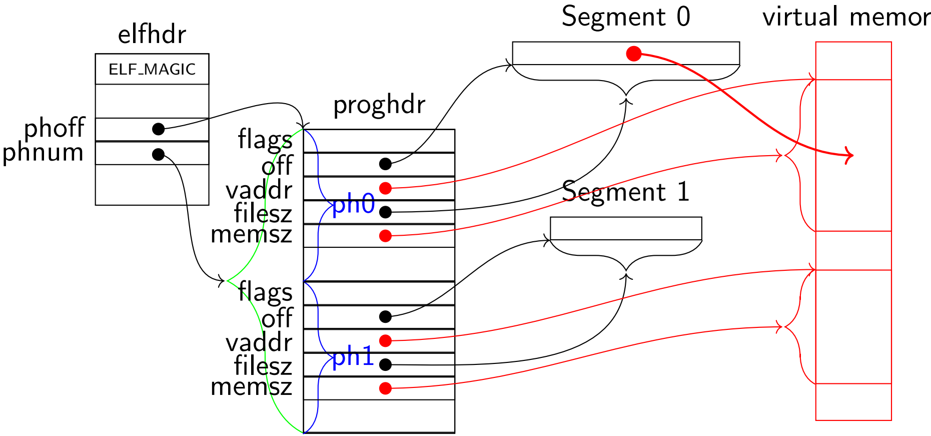
ELF, more detailed



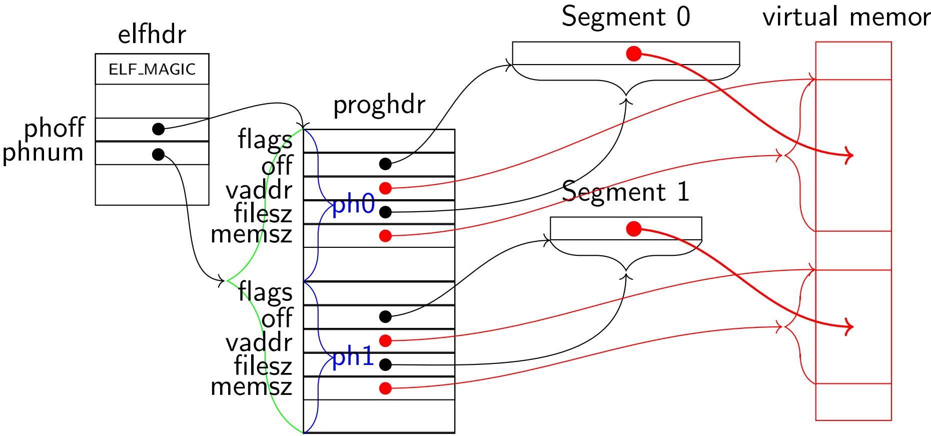
ELF, more detailed



ELF, more detailed



ELF, more detailed



ELFHDR

```
struct elfhdr {
  uint magic; // must equal ELF_MAGIC
  uchar elf[12];
  ushort type;
  ushort machine;
  uint version;
  uint entry;  // Entry point
  uint phoff;  // (File) Location of PROGHDR vectors
  uint shoff;
  uint flags;  // flag
  ushort ehsize;
  ushort phentsize;
  ushort phnum; // Length of PROGHDR vector
  ushort shentsize;
  ushort shnum;
  ushort shstrndx;
};
```

ELFHDR fields we are interested in

- **magic**: Should be ELF_MAGIC (0x464C457F).
- **entry**: Virtual address the program is starting at.
- **phoff**: File offset the Program segments Headers vector begins at.
- **phnum**: Number of elements in the Program segments Headers vector.

For each segment there is PROGHDR

```
struct proghdr {
 uint type;  // Only PROG_LOAD matters to us
 uint off;   // Section location in file
 uint vaddr; // Virtual address of section
 uint paddr; // Physical address of section
 uint filesz;// Section size in file
 uint memsz; // Section size in memory
 uint flags;
 uint align;
};
```

ELF file loading

1. Create a new address space.
2. For each segment with a PROG_LOAD type do the following:
    - 2.1 If necessary, allocate memory and add mapping rules so that address `vaddr` up to `vaddr + memsz - 1` will be legal in the new address space.
    - 2.2 Read the file from position `off` to `off + filesz - 1` into memory addresses `vaddr` up to `vaddr + memsz - 1`.
        - Observe: The new address space is not active. Hence we have to read page after page.

allocuvm(): Mission 2.1 above

```
allocuvm(pde_t *pgdir, uint oldsz, uint newsz) {
 char *mem;
 uint a;
 if (newsz >= KERNBASE) return 0;
 if (newsz < oldsz) return oldsz;
 a = PGROUNDUP(oldsz);
 for (; a < newsz; a += PGSIZE) {
  mem = kalloc();
  if (mem == 0) {
   deallocuvm(pgdir, newsz, oldsz);
   return 0;
  }
  memset(mem, 0, PGSIZE);
  mappages(pgdir, a, PGSIZE, v2p(mem), PTE_W|PTE_U);
 }
 return newsz;
}
```

loaduvm: Mission 2.2 above

```
loaduvm(pde_t *pgdir, char *addr,
        struct inode *ip, uint offset, uint sz) {
 uint i, pa, n;
 pte_t *pte;
 if ((uint) addr % PGSIZE != 0) panic("loaduvm:␣addr
 for (i = 0; i < sz; i += PGSIZE) {
  if ((pte = walkpgdir(pgdir, addr+i, 0)) == 0) pani
  pa = PTE_ADDR(*pte);
  if (sz - i < PGSIZE)
   n = sz - i;
  else
   n = PGSIZE;
  if (readi(ip, p2v(pa), offset+i, n) != n) return -
 }
 return 0;
}
```

loaduvm vs. readi

```
loaduvm(pde_t *pgdir, char *addr,
        struct inode *ip, uint offset, uint sz);

readi(struct inode *ip, char *buf,uint len,uint pos)
```

- **loaduvm** is not tied at all to ELF loading!
- It is a generalized **readi**.
- It allows reading into non-active virtual address spaces!

exec: ELFHDR loading

```
6610  int exec(char *path, char **argv) {
      struct elfhdr elf;
      struct inode *ip;
      begin_op()
      if ((ip = namei(path)) == 0) {end_op();
       return -1;}
      ilock(ip);
      pde_t *pgdir pgdir = 0;

      if (readi(ip, (char*)&elf, 0, sizeof(elf)) !=
                                     sizeof(elf))
       goto bad;
      if (elf.magic != ELF_MAGIC) goto bad;

      if ((pgdir = setupkvm()) == 0) goto bad;
      sz=0;
```

exec: Program segments loading

```
struct proghdr ph;
for (i=0, off=elf.phoff; i < elf.phnum; i++,
                                        off += sizeof(ph)) {
 if (readi(ip, (char*)&ph, off, sizeof(ph)) !=
                                     sizeof(ph)) goto bad;
 if (ph.type != ELF_PROG_LOAD) continue;
 if (ph.memsz < ph.filesz) goto bad;
 if (ph.vaddr + ph.memsz < ph.vaddr) goto bad;
 if ((sz = allocuvm(pgdir, sz,
              ph.vaddr + ph.memsz)) == 0) goto bad;
 if (ph.vaddr % PGSIZE != 0) goto bad;
 if (loaduvm(pgdir, (char*)ph.vaddr, ip,
                 ph.off, ph.filesz) < 0) goto bad;
}
iunlockput(ip);
end_op(); ip = 0;
```