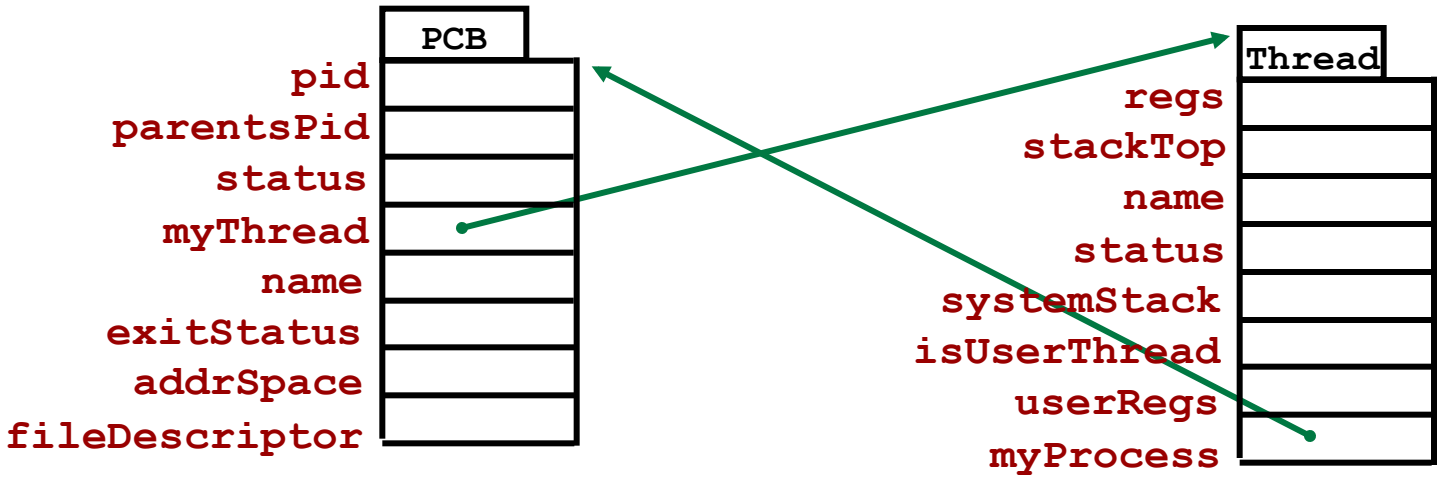
Project 5 Discussion

Threads and Processes - Design Options



class ProcessControlBlock

...

myThread: ptr to Thread

class Thread

...

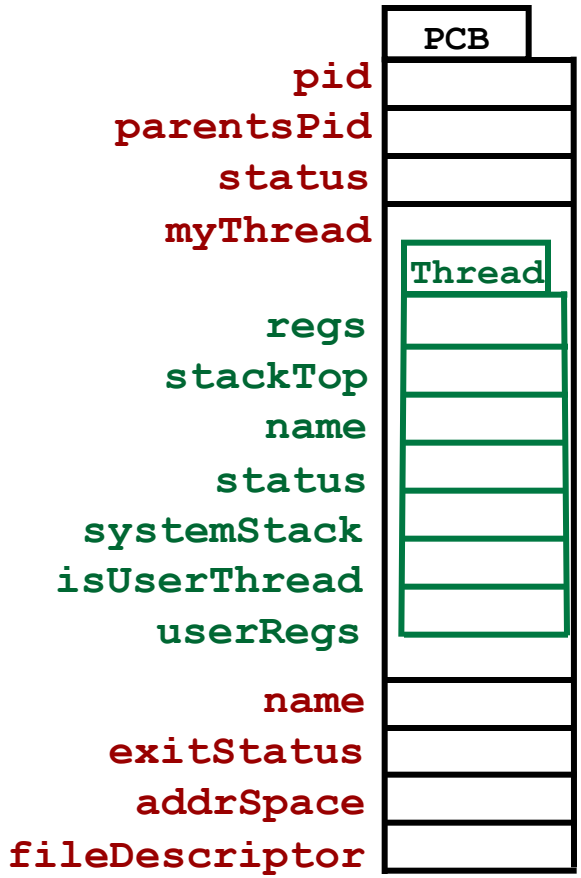
myProcess: ptr to ProcessControlBlock

Threads and Processes - Design Options

class ProcessControlBlock

...

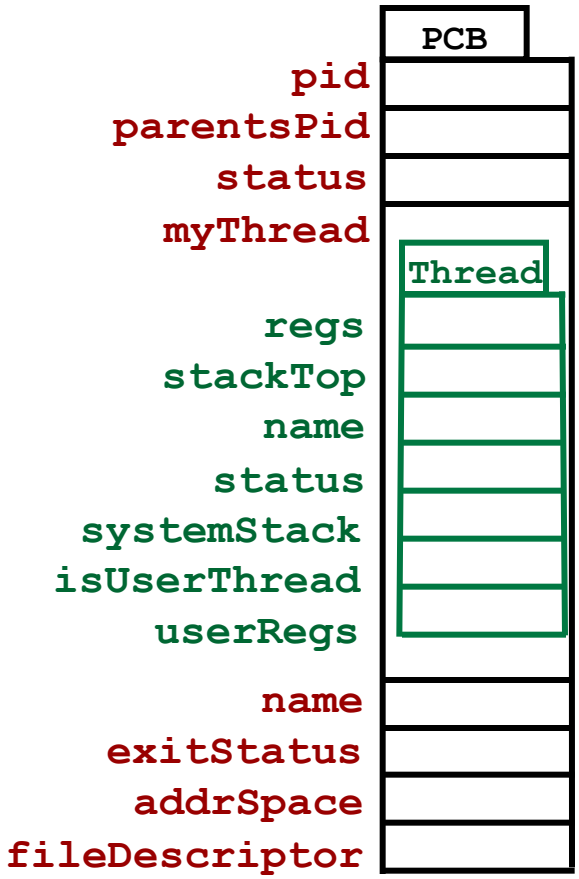
myThread: Thread



Threads and Processes - Design Options

```
class ProcessControlBlock
    ...
    myThread: Thread

pcb = ...
... = pcb.myThread.stackTop
```

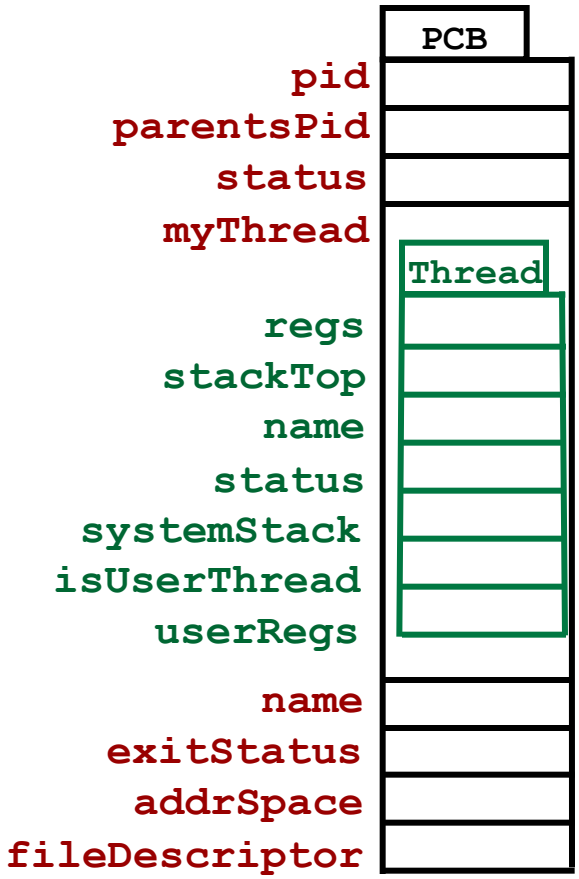


Threads and Processes - Design Options

```
class ProcessControlBlock
    ...
    myThread: Thread

pcb = ...
... = pcb.myThread.stackTop

var th: Thread
    th = pcb.myThread
    ... = th.stackTop
```



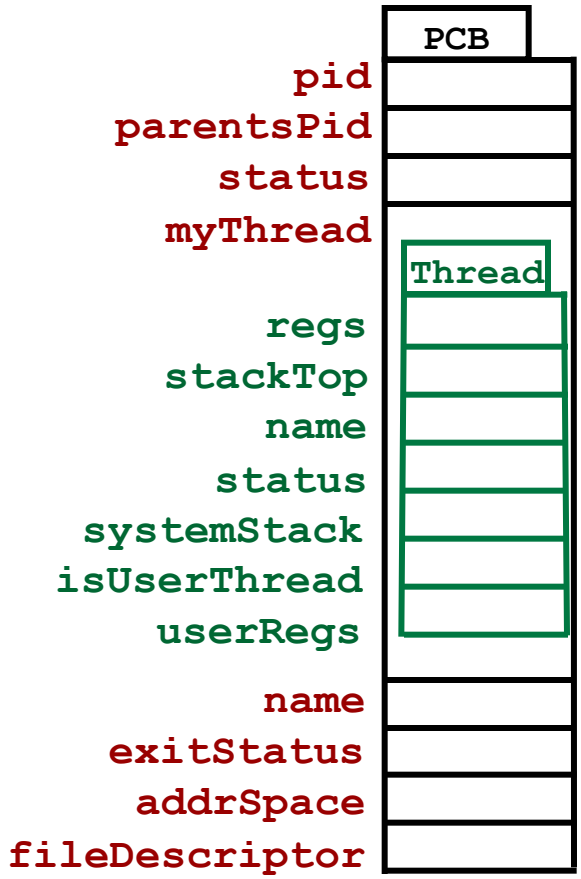
Threads and Processes - Design Options

```
class ProcessControlBlock
    ...
    myThread: Thread

pcb = ...
... = pcb.myThread.stackTop

var th: Thread
    th = pcb.myThread
    ... = th.stackTop

var th: ptr to Thread
    th = & pcb.myThread
    ... = th.stackTop
```



Threads and Processes - Design Options

```
class ProcessControlBlock
    ...
    myThread: Thread

pcb = ...
... = pcb.myThread.stackTop

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    th = pcb.myThread
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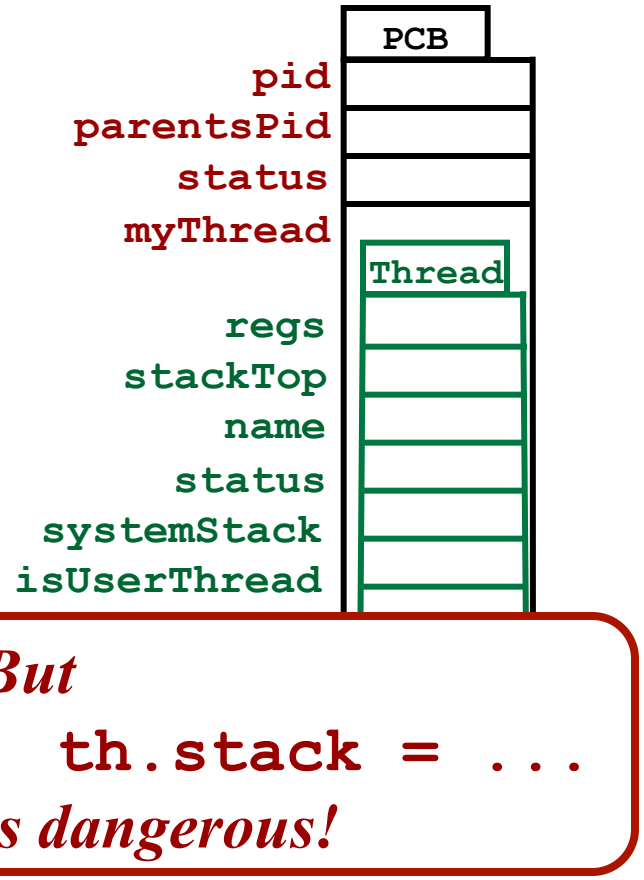
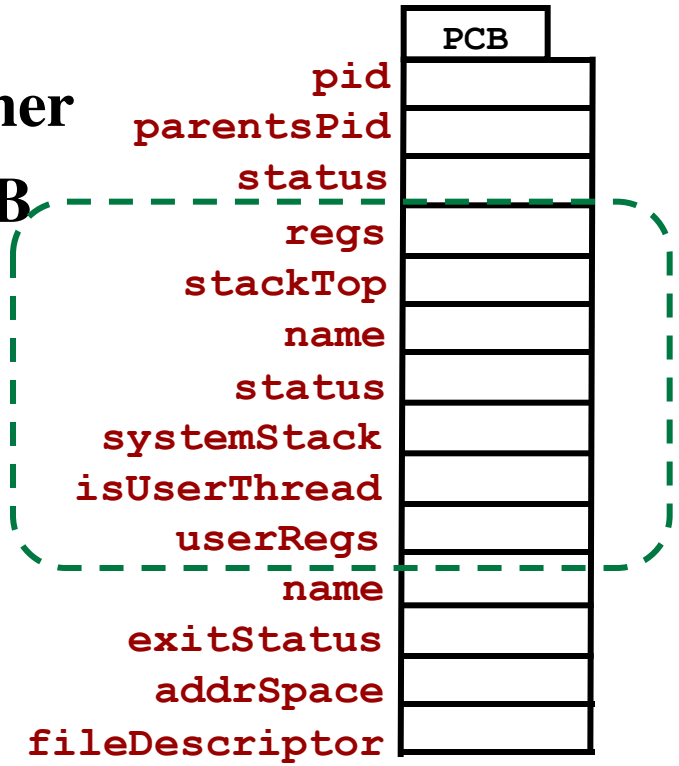


Threads and Processes - Design Options

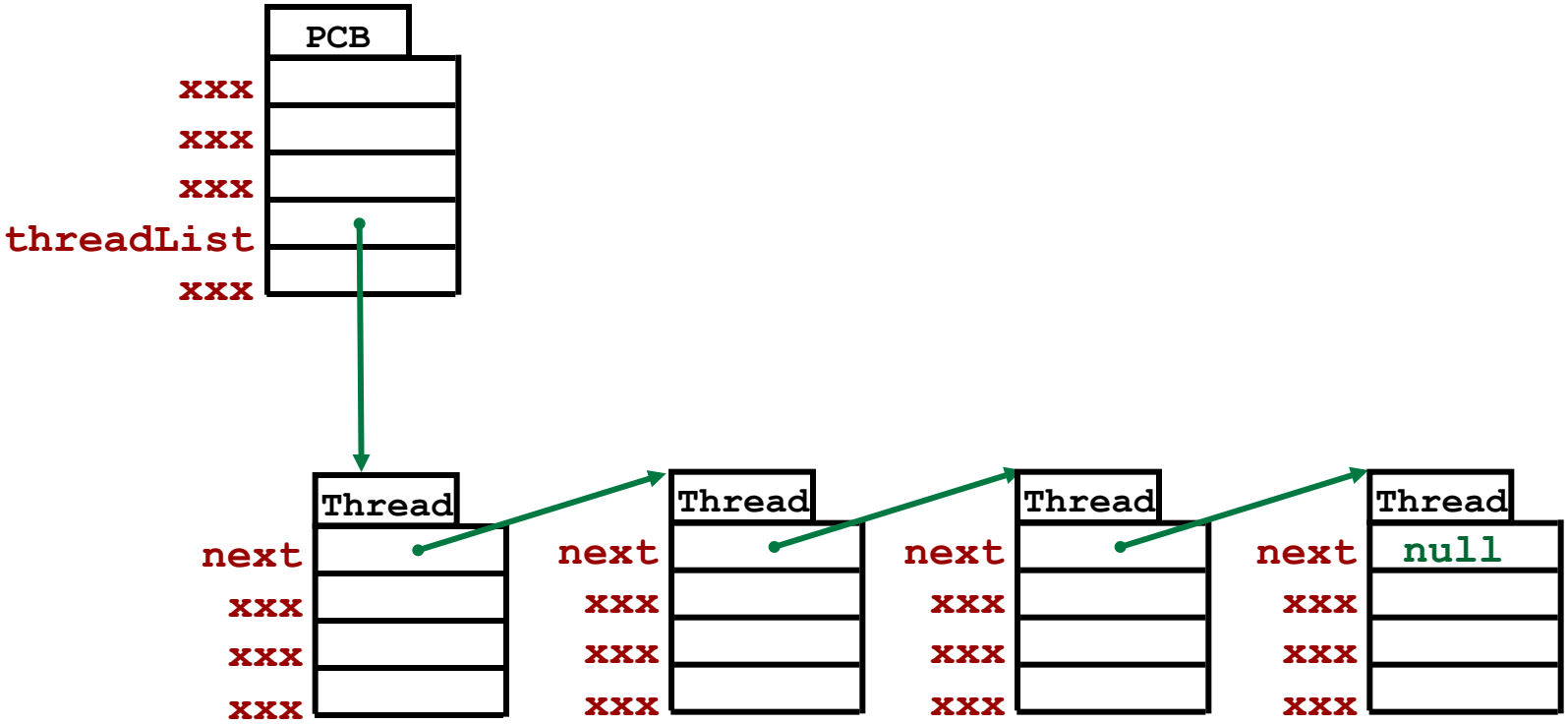
Another Option:

- **Get rid of class Thread altogether**
- **Include all Thread fields in PCB**



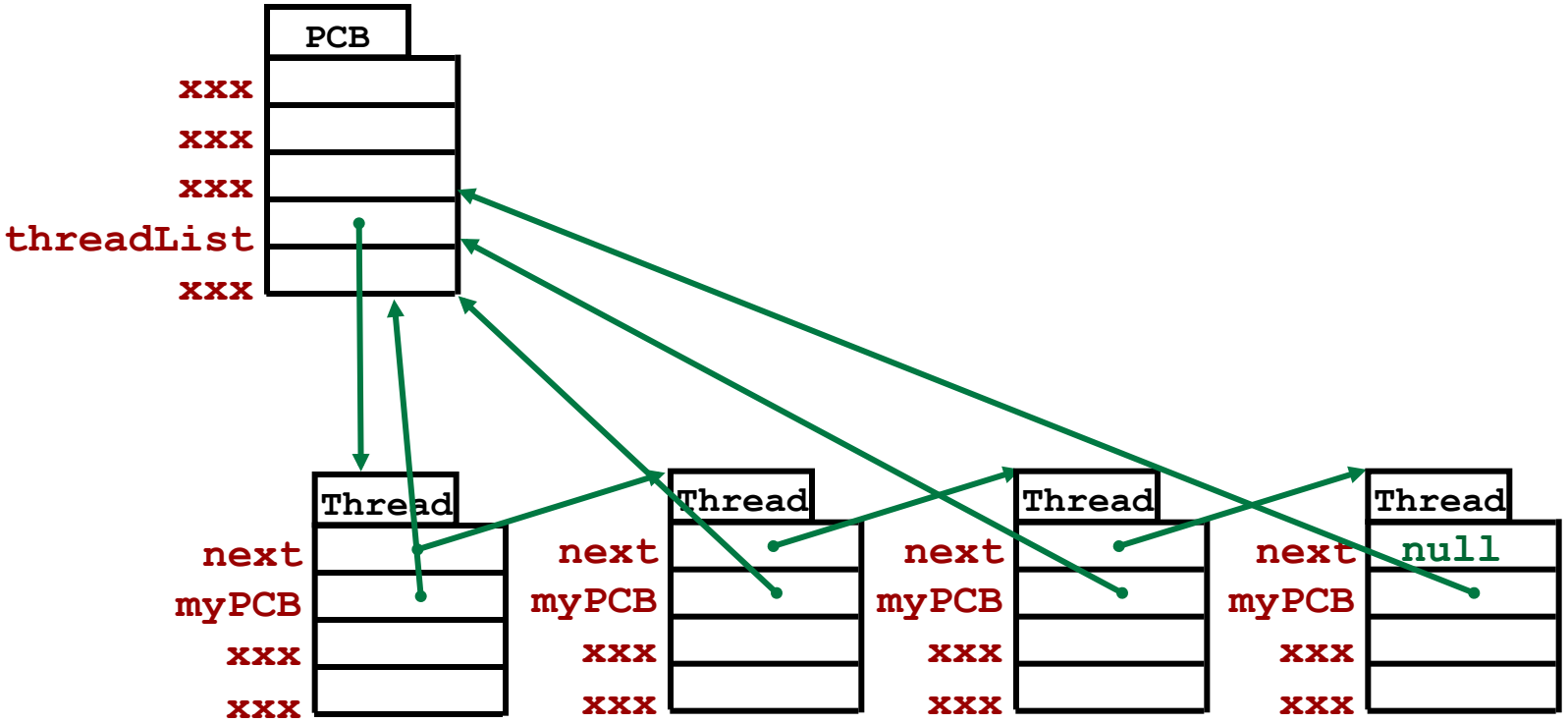
Threads and Processes - Design Options

Multiple Threads per Process



Threads and Processes - Design Options

Multiple Threads per Process



Class Thread

fields

```
    regs: array [13] of int      -- Space for r2..r14
    stackTop: ptr to void        -- Current system stack top ptr
    name: ptr to array of char
    status: int                  -- JUST_CREATED, READY,
                                 -- RUNNING, BLOCKED, UNUSED
    initialFunction: ptr to function (int)
    initialArgument: int
    systemStack: array [SYSTEM_STACK_SIZE] of int
    isUserThread: bool
    userRegs: array [15] of int      -- Space for r1..r15
    myProcess: ptr to ProcessControlBlock
```

Class Thread

methods

- **Init** (n: ptr to array of char)
- **Fork** (fun: ptr to function (int), arg: int)
- **Yield** ()
- **Sleep** ()
- **CheckOverflow** ()
- **Print** ()

Class ProcessControlBlock

fields

- **pid: int** -- The process ID
- **parentsPid: int** -- The pid of the parent of this process
- **status: int** -- ACTIVE, ZOMBIE, or FREE
- **myThread: ptr to Thread** -- Each process has one thread
- **exitStatus: int** -- The value passed to Sys_Exit
- **addrSpace: AddrSpace** -- The logical address space
- **fileDescriptor: array [MAX_FILES_PER_PROCESS] of ptr to OpenFile**

Class ProcessControlBlock

methods

Init ()

Print ()

Class ThreadManager

```
fields
    threadTable: array [MAX_NUMBER_OF_PROCESSES]
                                        of Thread
    freeList: List [Thread]
    threadManagerLock: Mutex
                        -- These synchronization objects
    aThreadBecameFree: Condition
                        --     apply to the "freeList"
```

Class ThreadManager

methods

- **Init** ()
- **Print** ()
- **GetANewThread** () **returns ptr to Thread**
- **FreeThread** (**th: ptr to Thread**)

Class ProcessManager

```
fields
    processTable: array [MAX_NUMBER_OF_PROCESSES]
                                    of ProcessControlBlock
    processManagerLock: Mutex
                                    -- These synchronization objects
    aProcessBecameFree: Condition
                                    --     apply to the "freeList"
    freeList: List [ProcessControlBlock]
    aProcessDied: Condition
                                    -- Signalled for new ZOMBIEs
    nextPid: int
```

Class ProcessManager

methods

Init ()

Print ()

GetANewProcess () returns ptr to ProcessControlBlock

FreeProcess (p: ptr to ProcessControlBlock)

-- TurnIntoZombie (p: ptr to ProcessControlBlock)

-- WaitForZombie (proc: ptr to ProcessControlBlock)
returns int

The “Stub” File System

Model of disk

- **Sequence of sectors**

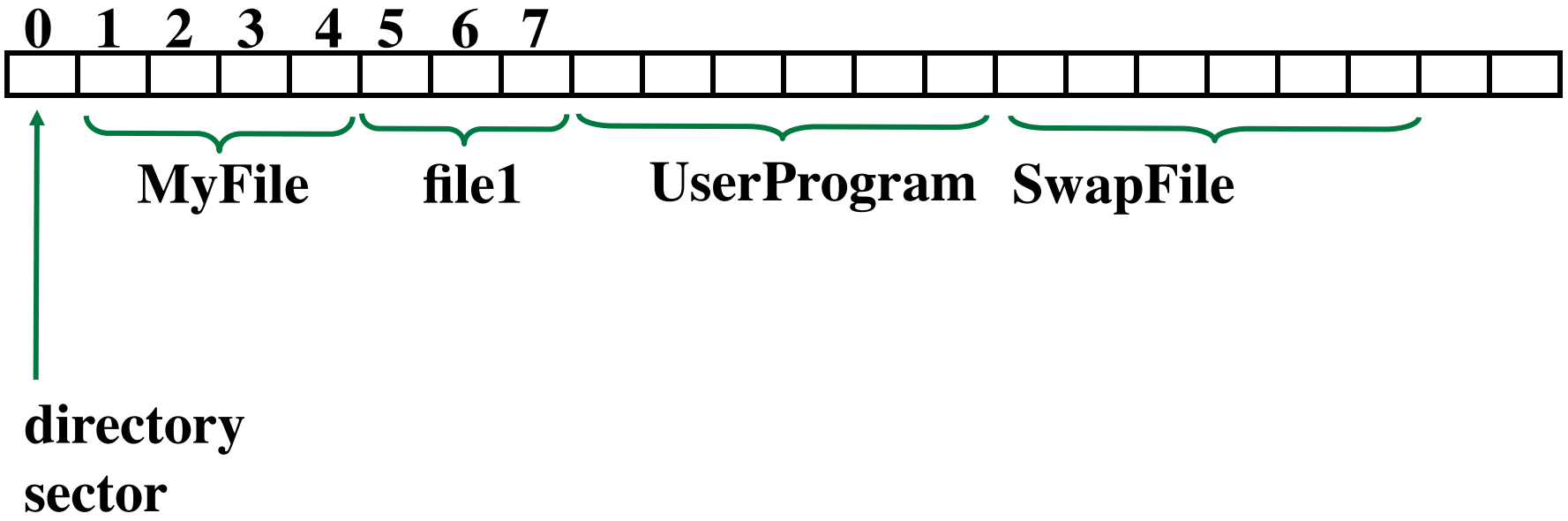
The File System

- **Sector zero contains the directory**
- **Only one directory (a “flat” file system)**

Files:

- **Name**
- **Starting sector**
- **Size (number of bytes)**
- **All sectors for a file are contiguous**

The "Stub" File System



The “diskUtil” Utility

Another BLITZ tool

Initialize the file system, create empty directory...

diskUtil -i

List the directory of the BLITZ “DISK”...

diskUtil -l

Copy a file from Unix to the BLITZ “DISK”...

diskUtil -a *UnixFileName* *BlitzFileName*

Get help info...

diskUtil -h

File-Related Classes

Class "FileControlBlock" (FCB)

- Contains info kernel needs to read/write to a file
  - Where on disk
  - A buffer area to use
  - Length of file
- Must have only one FCB per file

Class "FileManager"

- A monitor
- Where all the methods are

Class FileControlBlock

fields

fcbID: int
numberOfUsers: int
-- count of OpenFiles pointing here
startingSectorOfFile: int -- or -1 if FCB not in use
sizeOfFileInBytes: int
bufferPtr: ptr to void -- ptr to a page frame
relativeSectorInBuffer: int -- or -1 if none
bufferIsDirty: bool -- Set to true when buffer is modified

Class FileControlBlock

methods

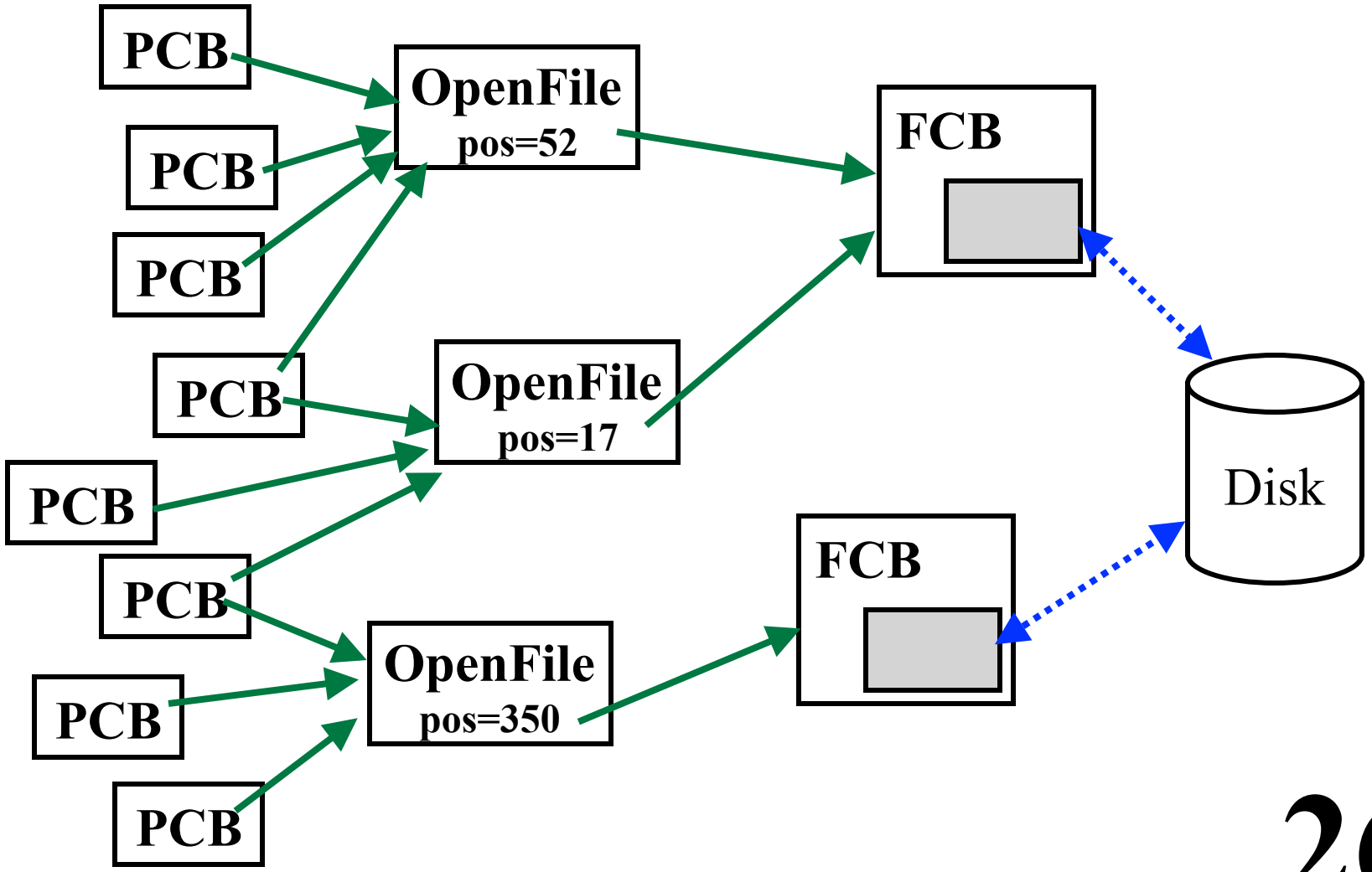
- **Init** ()
- **Print** ()

Class OpenFile

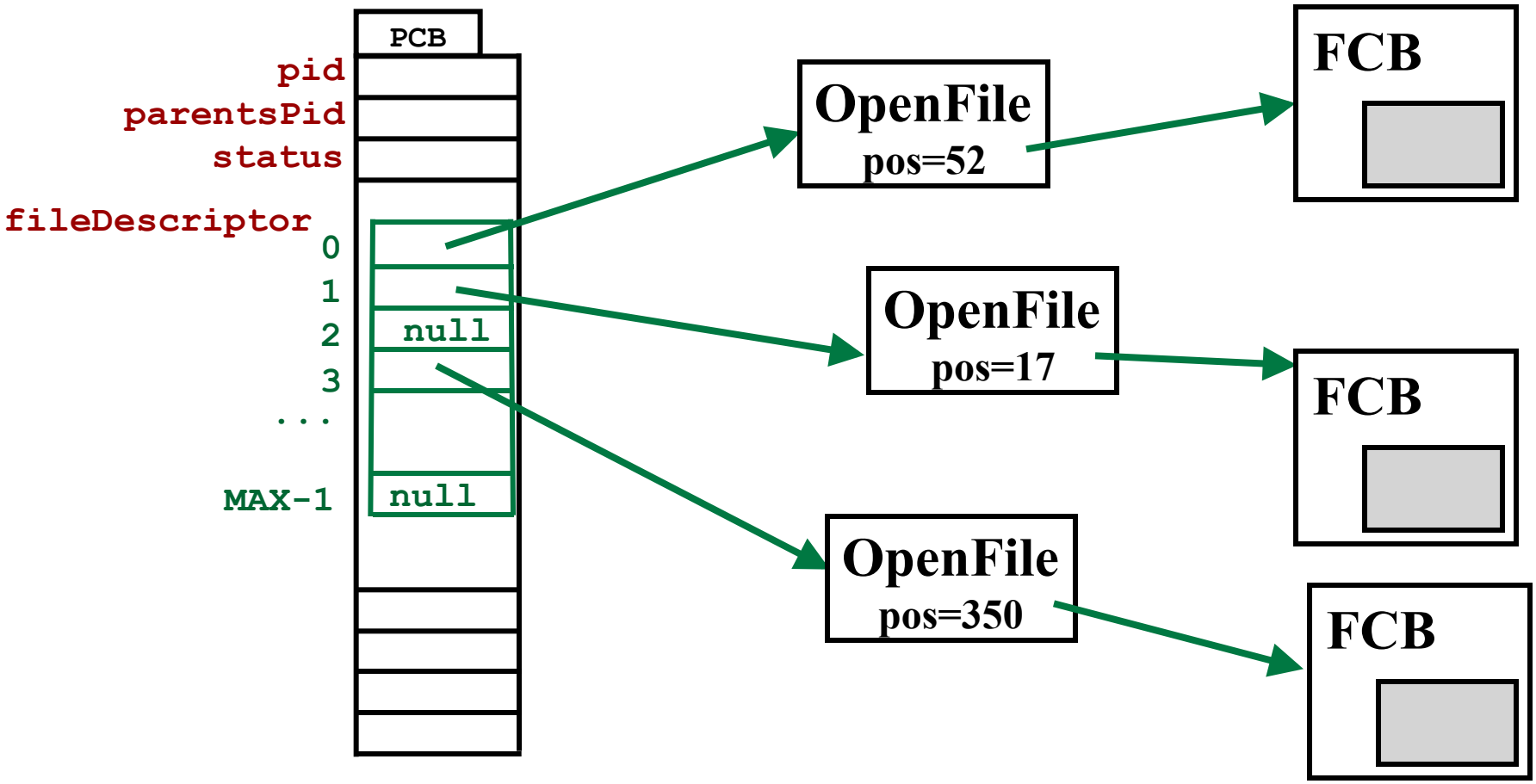
Contains:

- **Ptr to the FCB for this file**
- **The “current position”**
- **Processes point to “OpenFile”s, not “FCB”s**

The Unix Open-File Model



File Descriptors



Class OpenFile

fields

```
    currentPos: int                     -- 0 = first byte of file
    fcb: ptr to FileControlBlock        -- null = not open
    numberOfUsers: int      -- count of Processes pointing here
```

Class OpenFile

methods

Print ()

ReadBytes (targetAddr, numBytes: int) returns bool
-- returns true if all okay

ReadInt () returns int

LoadExecutable (addrSpace: ptr to AddrSpace) returns int
-- returns -1 if problems

Class FileManager

fields

fileManagerLock: Mutex

fcbTable: array [MAX_NUM_FILE_CONTROL_BLKS]
of FileControlBlock
anFCBBecameFree: Condition
fcbFreeList: List [FileControlBlock]

openFileTable: array [MAX_NUM_OPEN_FILES]
of OpenFile
anOpenFileBecameFree: Condition
openFileFreeList: List [OpenFile]

directoryFrame: ptr to void

Class FileManager

```
methods
    Init ()
    Print ()
    FindFCB (filename: String) returns
                    ptr to FileControlBlock       -- null if errors
    Open (filename: String) returns ptr to OpenFile
                                                  -- null if errors
    Close (open: ptr to OpenFile)
    Flush (open: ptr to OpenFile)
    SynchRead (open: ptr to OpenFile,
        targetAddr, bytePos, numBytes: int) returns bool
    SynchWrite (open: ptr to OpenFile,
        targetAddr, bytePos, numBytes: int) returns bool
```

Class DiskDriver

fields

DISK_STATUS_WORD_ADDRESS: ptr to int
DISK_COMMAND_WORD_ADDRESS: ptr to int
DISK_MEMORY_ADDRESS_REGISTER: ptr to int
DISK_SECTOR_NUMBER_REGISTER: ptr to int
DISK_SECTOR_COUNT_REGISTER: ptr to int
semToSignalOnCompletion: ptr to Semaphore
semUsedInSynchMethods: Semaphore
diskBusy: Mutex

DiskInterruptHandler

```
currentInterruptStatus = DISABLED
-- print ("DiskInterruptHandler invoked!\n")
if diskDriver.semToSignalOnCompletion
  diskDriver.semToSignalOnCompletion.Up()
endIf
```

Class DiskDriver

methods

Init ()

SynchReadSector

(sectorAddr, numberOfSectors, memoryAddr: int)

StartReadSector

(sectorAddr, numberOfSectors, memoryAddr: int,
whoCares: ptr to Semaphore)

SynchWriteSector

(sectorAddr, numberOfSectors, memoryAddr: int)

StartWriteSector

(sectorAddr, numberOfSectors, memoryAddr: int,
whoCares: ptr to Semaphore)

Building a User-level Program

UserSystem.h
UserSystem.c
UserRuntime.s

MyProgram.h
MyProgram.c

```
%asm  UserRuntime.s
%kpl  UserSystem -unsafe
%asm  UserSystem.s
%kpl  MyProgram -unsafe
%asm  MyProgram.s
%lddd UserRuntime.o UserSystem.o MyProgram.o
                                   -o MyProgram
```

Put Executable on the BLITZ Disk

```
% diskUtil –i
% diskUtil -a temp1 MyFileA
% diskUtil -a temp2 MyFileB
% diskUtil -a MyProgram MyProgram
% diskUtil –l
   StartingSector   SizeInSectors    SizeInBytes        FileName
   ==============   ============     ===========    ====================
        0               1              8192           < directory >
        1               1              8192           MyFileA
        2               3              17000          MyFileB
        5               8              60264          MyProgram
```

The disk is emulated with a Unix file. The filename ("DISK") is implicit.

The First User-Level Program

MyProgram.h

```
header MyProgram
  uses UserSystem
  functions
    main ()
endHeader
```

MyProgram.c

```
code MyProgram
  function main ()
      print ("My user-level program is
                                    running!\n")
      Sys_Shutdown ()
    endFunction
endCode
```

System Calls (Wrapper functions)

function Sys_Exit (returnStatus: int)
function Sys_Shutdown ()
function Sys_Yield ()
function Sys_Fork () returns int
function Sys_Join (processID: int) returns int
function Sys_Exec (filename: String) returns int
function Sys_Create (filename: String) returns int
function Sys_Open (filename: String) returns int
function Sys_Read (fileDesc: int, buffer: ptr to char, sizeInBytes: int)
    returns int
function Sys_Write (fileDesc: int, buffer: ptr to char, sizeInBytes: int)
    returns int
function Sys_Seek (fileDesc: int, newCurrentPosition: int) returns int
function Sys_Close (fileDesc: int)

Wrapper Function

```
function Sys_Read (fileDesc: int,
                   buffer: ptr to char,
                   sizeInBytes: int) returns int
    return DoSyscall (SYSCALL_READ,
                      fileDesc,
                      buffer asInteger,
                      sizeInBytes,
                      0)
    endFunction
```

DoSyscall

external DoSyscall (funCode, arg1, arg2, arg3, arg4: int) returns int

```
DoSyscall:
      load   [r15+8],r1   ! Move arg1 into r1
      load   [r15+12],r2  ! Move arg2 into r2
      load   [r15+16],r3  ! Move arg3 into r3
      load   [r15+20],r4  ! Move arg4 into r4
      load   [r15+4],r5   ! Move funcCode into r5
      syscall  r5         ! Do the syscall
      store r1,[r15+4]    ! Move result from r1 onto stack
      ret                 ! Return
```

Two copies (User, Kernel) must match!

```
enum
    SYSCALL_EXIT = 1,
    SYSCALL_SHUTDOWN,
    SYSCALL_YIELD,
    SYSCALL_FORK,
    SYSCALL_JOIN,
    SYSCALL_EXEC,
    SYSCALL_CREATE,
    SYSCALL_OPEN,
    SYSCALL_READ,
    SYSCALL_WRITE,
    SYSCALL_SEEK,
    SYSCALL_CLOSE
```

Virtual Address Space

- A Page for “environment” data
- Pages for the text segment
- Pages for the data segment
- Pages for the BSS segment
- Pages for the user’s stack

Typical:

0 environment pages
2 text pages
1 data page
0 BSS pages
1 stack page

4 pages → 32Kbyte Virtual Address Space