Project 3: Design and Implementation of File System

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Objectives

- Design and implement a basic disk-like secondary storage server.
- Design and implement a basic file system to act as a client using the disk services provided by the server designed above.
- Use socket API.

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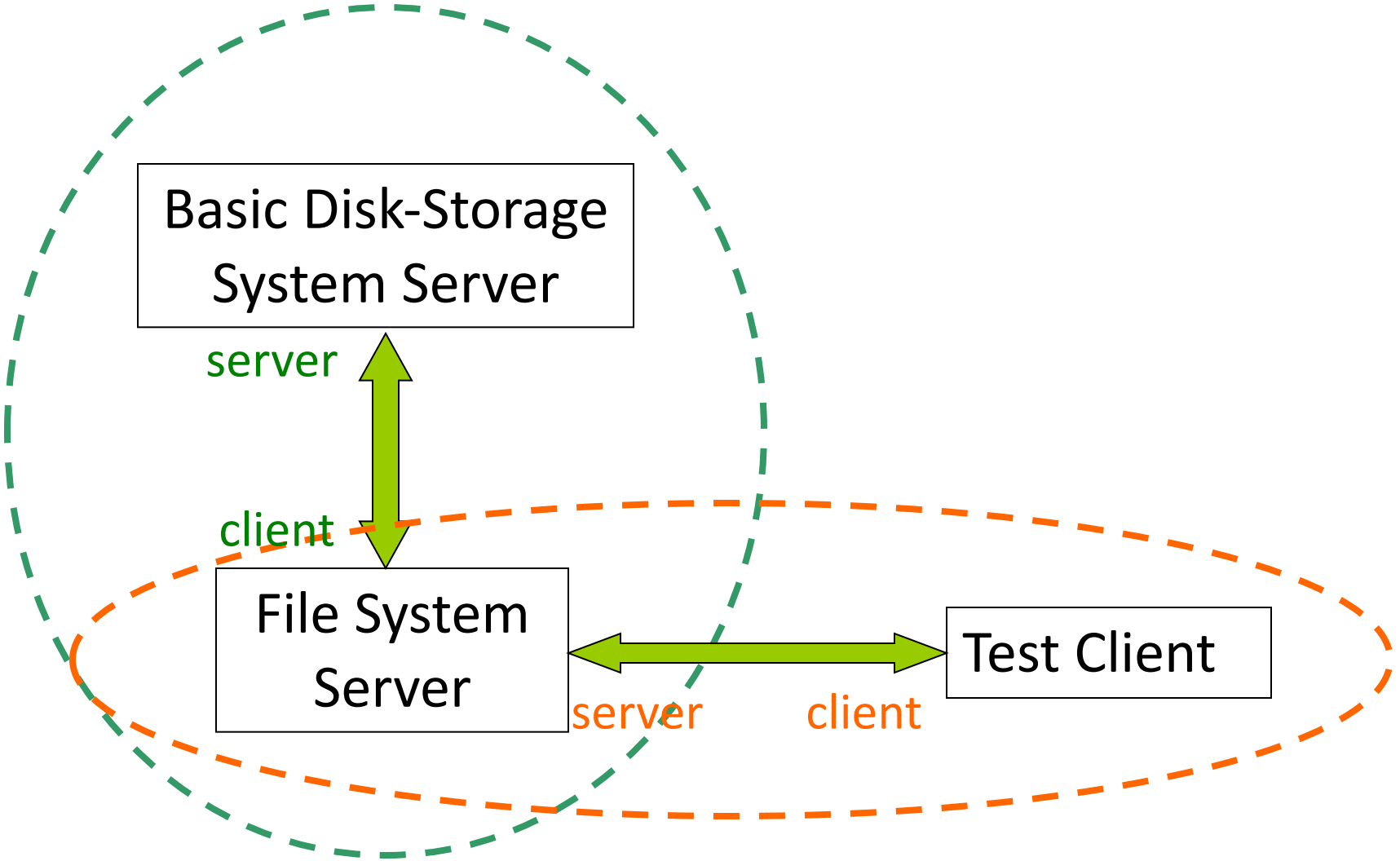
File System Architecture



Content

- Step 1: Design a basic disk-storage system
- Step 2: Design a basic file system
- Step 3: Work together

Enviroment

- VitrualBox/VMWare (optional)
- Ubuntu Linux (recommended)

What to Submit

- A“tar” file of your DIRECTORY, containing:
  - Your makefile
  - Any “.cc”, “.c”, and “.h” files
  - Any “readme” or “.pdf” files asked for in the project
  - A text file containing the runs of your programs for each of the project parts “typescript”
    - Do not submit ALL runs you have done, just the output required to demonstrate a successful (or unsuccessful) run
    - If you cannot get your program to work, submit a run of whatever you can get to work as you can get partial credit
    - Copy & paste, or use “>” to redirect output to a file
- DO NOT SUBMIT your object or executable files, remove them before you pack your directory

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How to Submit

- Remove your ".o" files and executables

```
rm  *.o
rm  basic_server
rm  basic_client
```

- Pack your entire directory (including the directory)

```
tar –cvf  Prj3+StudentID.tar  project3
```

- Send your Prj3+StudentID.tar file to Canvas

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Project organized structure

- Prj3+StudentID.tar
  - step1
    - disk.c
    - makefile
    - …
  - step2
    - fs.c
    - makefile
    - …
  - step3
    - disk.c
    - fs.c
    - client.c
    - makefile
    - …
  - report.pdf
  - Prj3README

Demo and Presentation

- Deadline
  - May 26, 2023
- Demo slot
  - May 27-28, 2023, SEIEE 3-East 309
- Presentation (Optional)
  - May 30, 2023

Step 1: Overview

- Implement a simulation of a physical disk.
- cylinders and sectors
- track-to-track time
- sector size = 256bytes
- Store the actual data in a real disk file.

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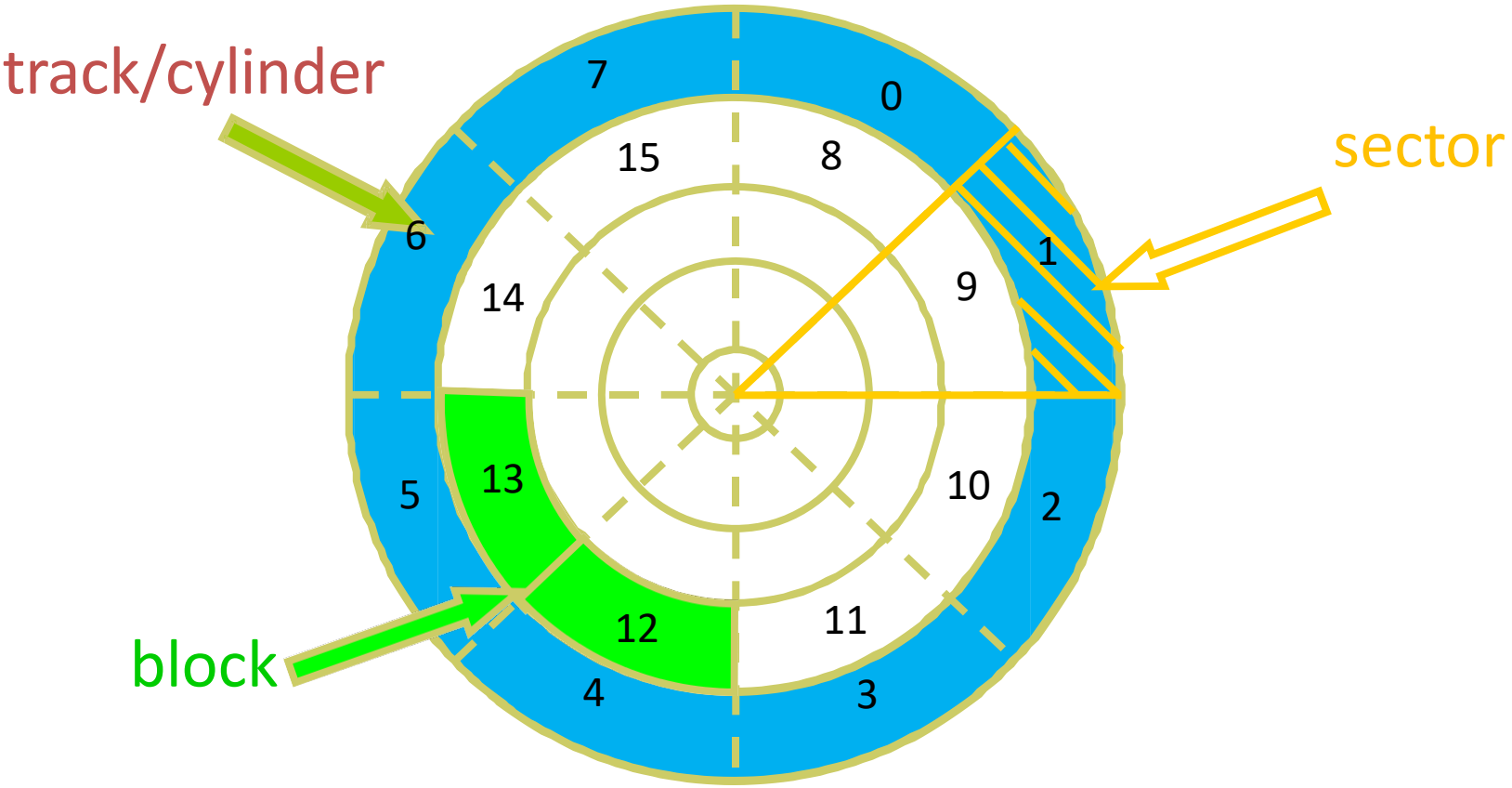
Disk Structure



0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	.....

Command

- Command line
  - ./disk <#cylinders> <#sector per cylinder> <track-to-track delay> <#disk-storage-filename>

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Protocol

- **I**: Information request. The disk returns two integers representing the disk geometry: the number of cylinders, and the number of sectors per cylinder.
- **R c s**: Read request for the contents of cylinder *c* sector *s*. The disk returns **Yes** followed by a writespace and those 256 bytes of information, or **No** if no such block exists.
- **W c s data**: Write request for cylinder *c* sector *s*. The disk returns **Yes** and writes the data to cylinder *c* sector *s* if it is a valid write request, or returns **No** otherwise.
- **E**: Exit the disk-storage system.

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Calculations

- Given:
  - c: track/cylinder number (0, 1, 2, …)
  - s: sector number (0, 1, 2, …)
  - n: number of sectors per track/cylinder
  - b: block size（256 bytes）
- Block start location (offset) in the file
  - l = b * (n * c + s)

Calculations (cont'd)

- Given
  - c1: current cylinder number
  - c2: next cylinder number
  - t: cylinder-to-cylinder / track-to-track time
- Disk arm moving delay
  - d = t * abs(c1 – c2)
- Useful function
  - usleep (unsigned long microseconds)
  - E.g., usleep(100000);

Manipulating Storage Space

- file system call
  - fseek(), fread(), fwrite(), …

```
int fseek( FILE *stream, long offset, int origin );

fseek(diskfile, (cylinder * sector_number + sector)*Sector_size, 0)
```


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Manipulating Storage Space

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```

- mmap() system call
  - create a mapping between a memory space and a file

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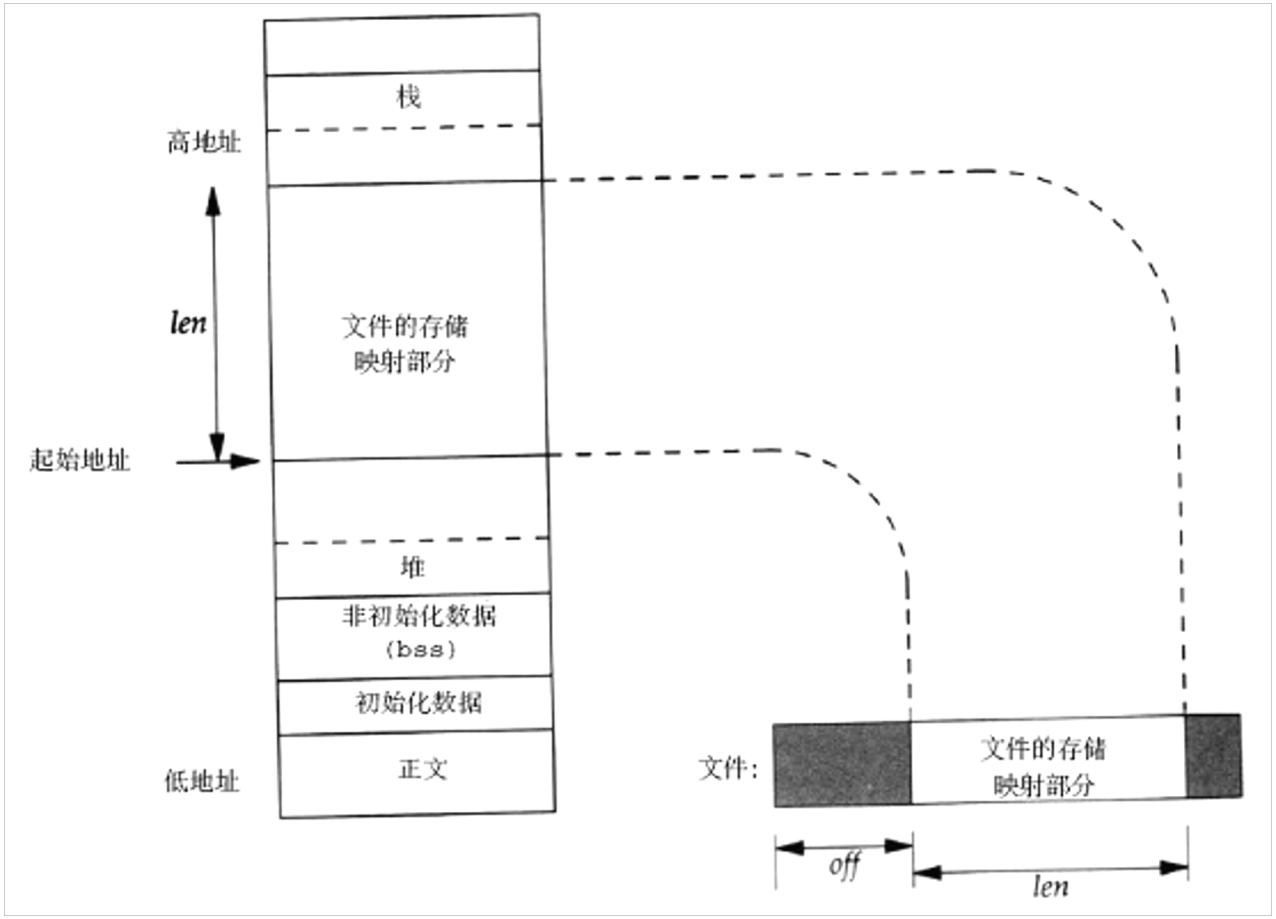
mmap


栈
高地址
len
文件的存储
映射部分
起始地址
堆
非初始化数据
(bss)
初始化数据
正文
低地址
文件:
文件的存储
映射部分
off
len

Using mmap()

- Header
  - #include <sys/mman.h>

- Open a file

```
int fd = open (filename, O_RDWR | O_CREAT, 0);
if (fd < 0) {
    printf("Error: Could not open file '%s'.\n", filename);
    exit(-1);
}
```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Using mmap() (cont'd)

- Stretch the file size to the size of the simulated disk

  off_t lseek(int filedes, off_t offset, int whence);

```
long FILESIZE = BLOCKSIZE * SECTORS * CYLINDERS;
int result = lseek (fd, FILESIZE-1, SEEK_SET);
if (result == -1) {
    perror ("Error calling lseek() to 'stretch' the file");
    close (fd);
    exit(-1);
}
```


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Using mmap() (cont'd)

- Write something at the end of the file to ensure the file actually have the new size.

```
result = write (fd, "", 1);
if (result != 1) {
    perror("Error writing last byte of the file");
    close(fd);
    exit(-1);
}
```


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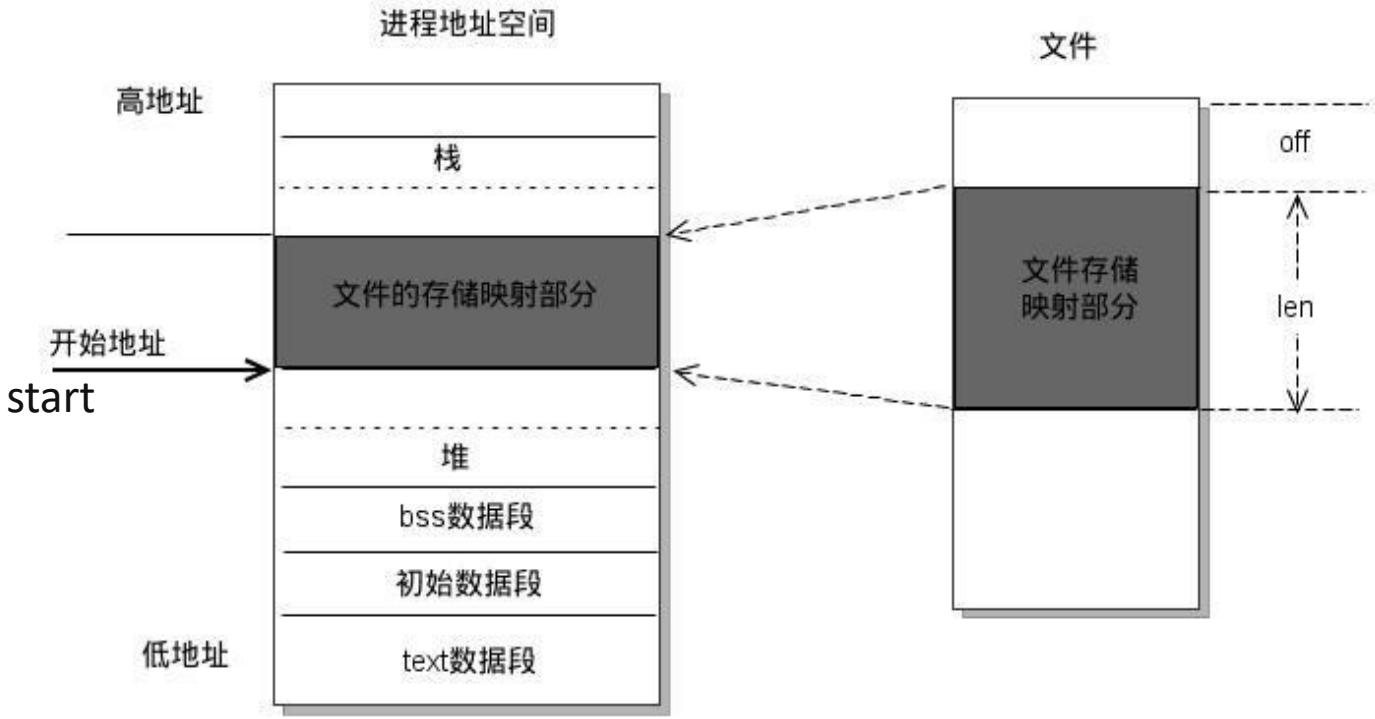
Using mmap() (cont'd)

- Map the file

void *mmap(void *start, size_t len, int prot, int flags, int fd, off_t off);



Using mmap() (cont'd)

- Map the file

void *mmap(void *start, size_t len, int prot, int flags, int fd, off_t off);

```
char* diskfile;
diskfile = (char *) mmap (NULL, FILESIZE,
            PROT_READ | PROT_WRITE,
            MAP_SHARED, fd, 0);
if (diskfile == MAP_FAILED){
   close(fd);
   printf("Error: Could not map file.\n");
   exit(-1);
}
```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Using mmap() (cont'd)

void *memcpy(void *dest, const void *src, size_t count);

- Write to the file

```
memcpy (&diskfile[BLOCKSIZE * (c * SECTORS + s)]
        , buf, len);
```

- Read from the file

```
memcpy (buf, &diskfile[BLOCKSIZE * (c * SECTORS + s)]
        , BLOCKSIZE);
```


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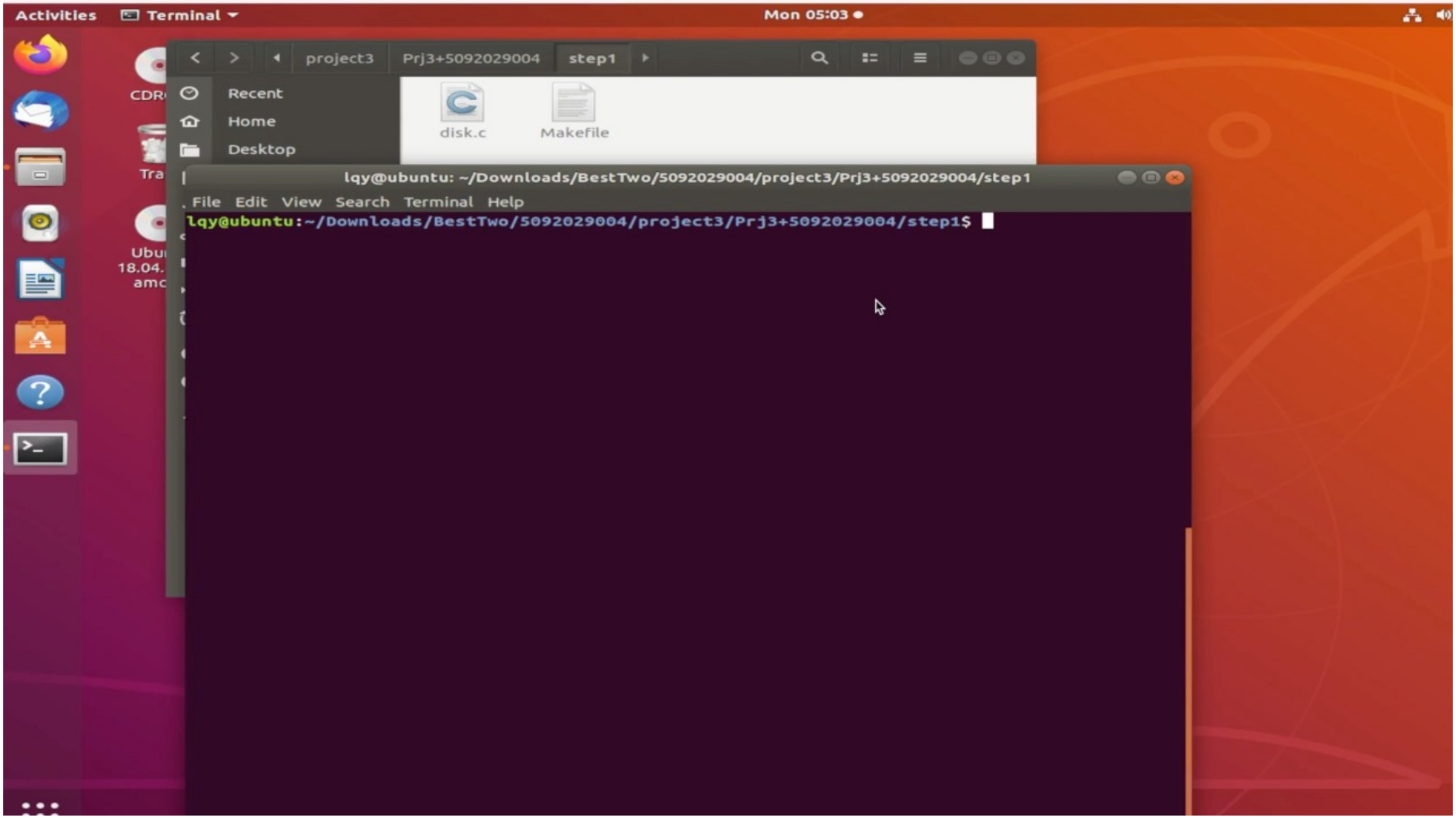
Test your disk-storage system

- Read requests from STDIN and write a log file (disk.log)
- For each request, output one line.
- For **I**, output two integers, separate by a writespace, which denote the number of cylinders and the number of sectors per cylinder.
- For **R c s**, output **No** if no such block exists, otherwise, output **Yes** followed by a writespace and those 256 bytes of information.
- For **W c s data**, Write **Yes** or **No** to show whether it is a valid write request or not.
- For **E**, output **Goodbye!**.

Demo


Activities
Terminal
Mon 05:03
project3
Prj3+5092029004
step1
Recent
Home
Desktop
disk.c
Makefile
lqy@ubuntu: ~/Downloads/BestTwo/5092029004/project3/Prj3+5092029004/step1
File Edit View Search Terminal Help
lqy@ubuntu:~/Downloads/BestTwo/5092029004/project3/Prj3+5092029004/step1$

Step 2: Overview

- Implement a file system
- files and directories
- store information in memory

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Protocal I

- **f**: Format. This will format the file system on the disk, by initializing any/all of tables that the file system relies on.
- **mk f**: Create file. This will create a file named *f* in the file system.
- **mkdir d**: Create directory. This will create a subdirectory named *d* in the current directory.
- **rm f**: Delete file. This will delete the file named *f* from current directory.
- **cd path**: Change directory. This will change the current working directory to the path. The path is in the format in Linux, which can be relative path or absolute path. When the file system starts, the initial working path is /. You need to handle . and ..

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Protocol II

- **rmdir d**: Delete directory. This will delete the directory named *d* in the current directory.
- **ls**: Directory listing. This will return a listing of the files and directories in the current directory. You are also required to output some other information, such as file size, last update time, etc.
- **cat f**: Catch file. This will read the file named *f* , and return the data that came from it.
- **w f l data**: Write file. This will overwrite the contents of the file named *f* with the *l* bytes of data. If the new data is longer than the data previously in the file, the file will be made longer. If the new data is shorter than the data previously in the file, the file will be truncated to the new length.

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Protocol III

- **i f pos l data**: Insert to a file. This will insert to the file at the position before the *pos*th character(0-indexed), with the *l* bytes of data. If the *pos* is larger than the size of the file. Just insert at the end of the file.

- **d f pos l**: Delete in the file. This will delete contents from the *pos* character (0-indexed), delete *l* bytes or till the end of the file.

- **e**: Exit the file system.

Something you may use

- read()
- write()
- <string.h>
  - strcpy()
  - strcat()
  - strlen()
  - memcpy()

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Test your file system

- For each request, output one line.
- For **f**, output Done.
- For **mk f**, **mkdir d**, **rm f**, **rmdir d**, **w f l data**, **i f pos l data**, **cd path**, and **d f pos l**, output **Yes**, if successful, or **No** otherwise.
- For **cat f**, if the file **f** exists, output its contents, otherwise output **No**.
- For **ls**, output all the files and directories in current directory. First output all the files, separate by a space, in lexicography order. Then output all the directories, separate by a space, in lexicography order. Output an '&' between the files and directories.
- For **e**, output **Goodbye!**.

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Step 3: Connecting a client to a server

```
1  int sockfd;
2  sockfd = socket(AF_INET, SOCK_STREAM,
               0);
3  struct sockaddr_in serv_addr;
4  struct hostent *host;
5  serv_addr.sin_family = AF_INET;
6  host = gethostbyname(argv[1]);
7  memcpy(&serv_addr.sin_addr.s_addr, host
               ->h_addr,
         host->h_length);
8
9  serv_addr.sin_port = htons(
               BASIC_SERVER_PORT);
10 connect(sockfd, (sockaddr *) &serv_addr
               , sizeof(serv_addr))
```


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