Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Distributed Computing

FS 2019 Prof. R. Wattenhofer

Computer Engineering II

Exercise Sheet Chapter 6

We categorize questions into four different categories:

Quiz Short questions which we will solve rather interactively at the start of the exercise sessions.

Basic Improve the basic understanding of the lecture material.

Advanced Test your ability to work with the lecture content. This is the typical style of questions which appear in the exam.

Mastery Beyond the essentials, more interesting, but also more challenging. These questions are **optional**, and we do not expect you to solve such exercises during the exam.

Questions marked with $^{(g)}$ may need some research on Google.

Basic

1 HDDs

a) Which tracks are favored if SSTF is used for disk scheduling, assuming a random access workload?

b) Explain how starvation can occur for SSTF, SCAN, C-SCAN, SPTF; how does F-SCAN solve the problem?

c) If we always serve disk requests in the order they occur, we avoid starvation. Which disadvantages does this have?

d) Assume you have two HDDs, one with 5ms average seek and 9000 rounds per minute, and one with 3ms average seek and 5400 rounds per minute. Both disks have a peak transfer rate of 120 MB/s. Which offers a better rate of I/O for a random access workload, assuming a 4KB sector size? How long is the total I/O time for a 200MB random access workload? Assume 1MB = 1000KB.

2 SSDs

Block	0				1			
Page	0	1	2	3	4	5	6	7
Content								
State	i	i	i	i	i	i	i	i

Perform the following writes and erases for an SSD, once for a direct mapped SSD, once for a page-level mapped one. Assume that a block consists of 4 pages, and each write is exactly the size of one page. By "garbage collect" we mean "pick the oldest block to erase, issue necessary writes, update validity information".

- write(0) content A
- write(6) content B
- write(4) content C
- write(1) content D
- write(0) content E
- garbage collect (only page-level mapped)
- write(4) content F
- garbage collect (only page-level mapped)

Below you'll find templates for the exercise. Show the SSD after each set of writes as well as after each block erasure.

Direct mapped SSD:

write(0) content A

Content								
State								

write(6) content B

Content								
State								

write(4) content C

Content								
State								

write(1) content D

Content								
State								

write(0) content E

Content								
State								

Content								
State								

write(4) content F

Content								
State								

Content								
State								

Page-level mapped SSD:

write(0) content A

Table								
Content								
State								

write(6) content B

Table								
Content								
State								

write(4) content C

Table								
Content								
State								

write(1) content D

Table								
Content								
State								

write(0) content E

Table								
Content								
State								

garbage collection

Table								
Content								
State								

Table								
Content								
State								

write(4) content F

Table								
Content								
State								

garbage collection

Table								
Content								
State								

Table								
Content								
State								

Advanced

3 Disk Scheduling

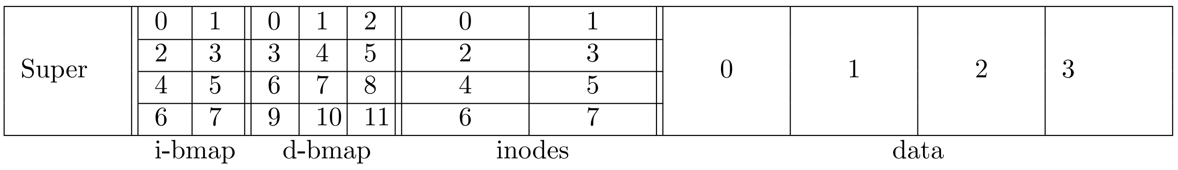
In this exercise, we compare the performance of FCFS and SSTF, under different scenarios. Assume that the disk platter consists of N tracks. It takes unit time for the read/write head to position itself on the adjacent track. A request is a tuple (t, p), where t is the time of arrival of the request, and $p \in \{1, 2, \dots, N\}$ is the track number addressed. The rotational delay is negligible and the time to serve a request is the time to seek the appropriate track.

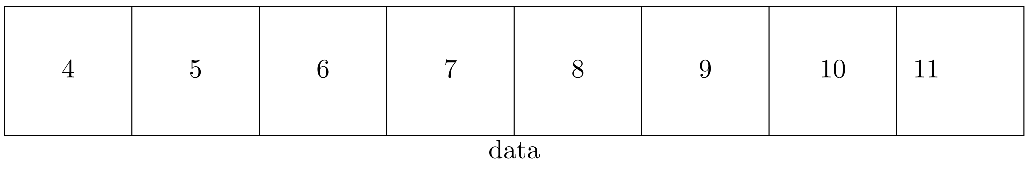
a) Consider a sequence of following $2k$ requests: the i^{th} request arrives at $i/2k$ time, and it addresses track 1 if i is odd, and track N if i is even. Assume that the head is at track $N/2$ initially and $N \geq 4$ is even. What is the time taken by FCFS and SSTF algorithms to serve all the requests. Which is better?

b) Give a request sequence for which FCFS is better than SSTF. Assume that the disk platter has 15 tracks and the head is at track 8 initially. Compare the total time taken by FCFS and SSTF to serve all the requests in the sequence.

c) Now, consider the following sequence of k requests: the i^{th} request arrives at $i \cdot N$ time, and every track is equally likely to be addressed by each request. What is the expected total seek time taken by $FCFS$ to serve the k requests. Is SSTF better at handling these requests? You can use the following approximate formulae: $\Sigma_{i=1}^{N} i = N^2/2$ and $\Sigma_{i=1}^{N} i^2 = N^3/3$.

4 File System





Assume we have a file system as depicted above with an inode table consisting of two blocks that can hold a total of 8 inodes, a data region that can hold 12 blocks, and uses bitmaps as allocation structures.

a) Starting with only the root directory /, the following actions are performed:

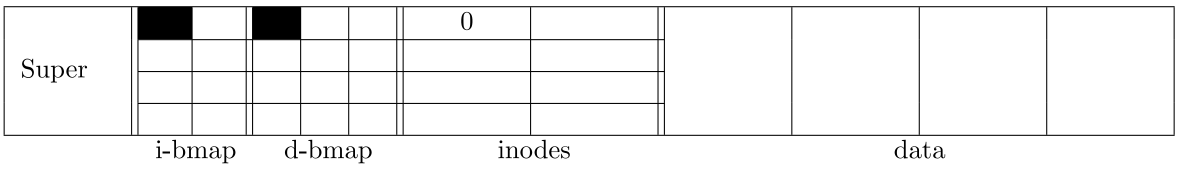
- Create directory /a
- Create directory /b
- Create file /b/a.txt, containing ”This is a long text file”. Assume that this file needs two blocks.
- Create file /a/b.txt, containing ”This is another long text file”. Assume that this file needs two blocks.
- Delete file /b/a.txt
- Create file /a/a.txt, containing ”Hi”. Assume that this file needs one block.

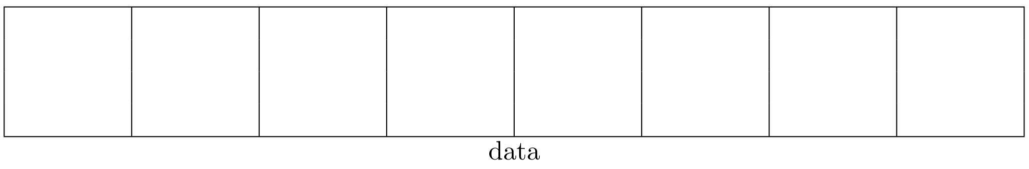
List the commands you can use in a UNIX terminal to perform these actions and show the state of the file system after each of these. For the inodes, list the indices of the referenced data blocks; for the directory blocks, list names and inode indices of the contained files. You find templates below.

b) How does the file system resolve the address /a/b.txt?

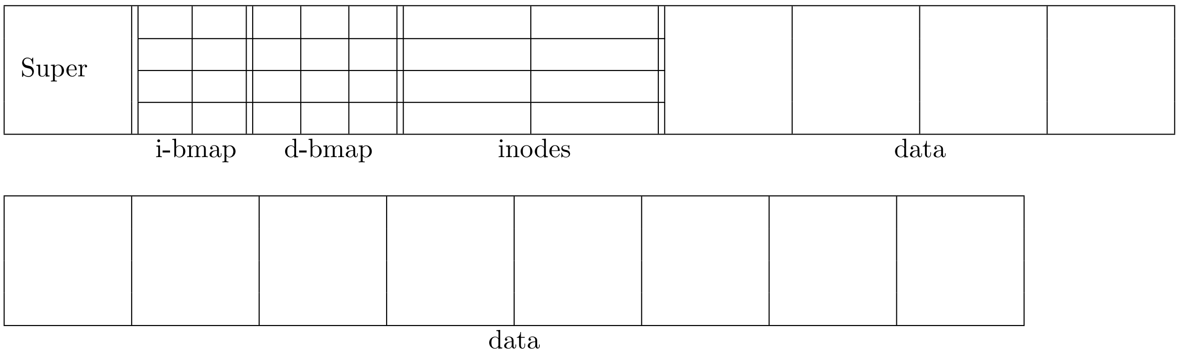
c) What is the difference between soft and hard links from an implementation view?

Starting state

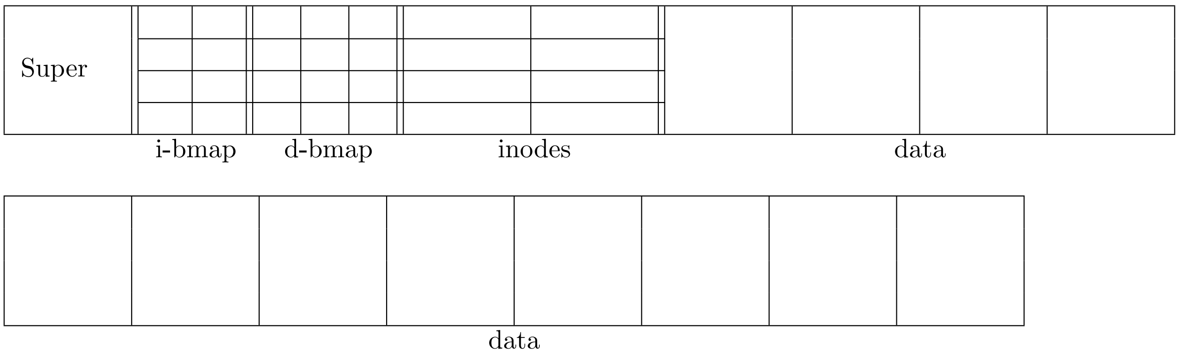




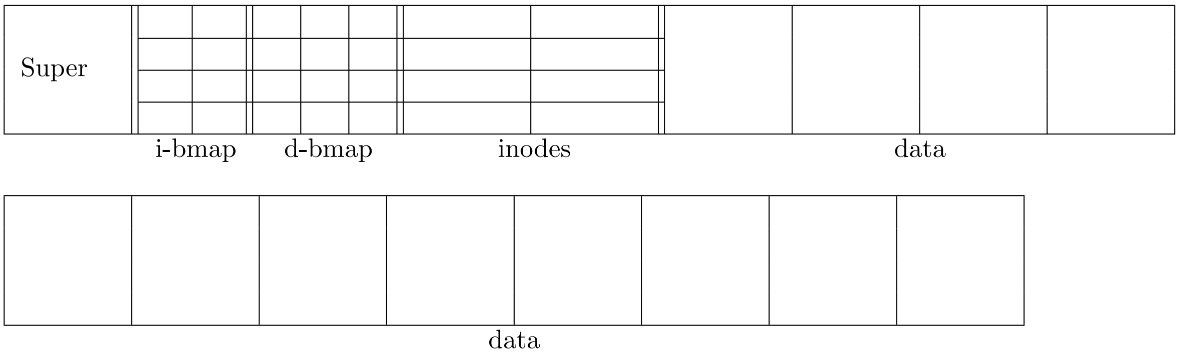
Command:



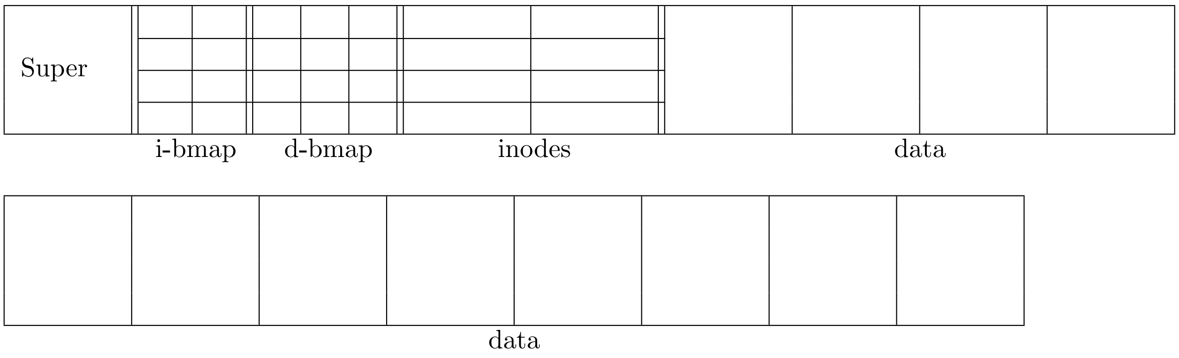
Command:



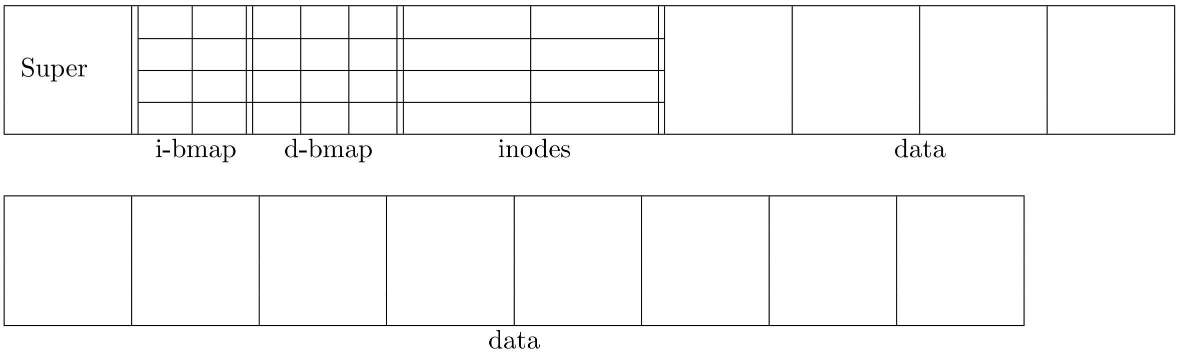
Command:



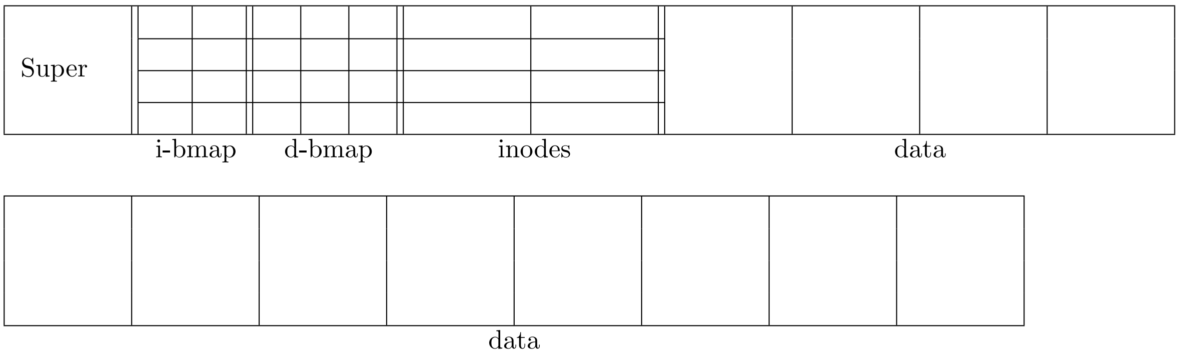
Command:



Command:



Command:



5 Permissions

Consider the following directory tree:

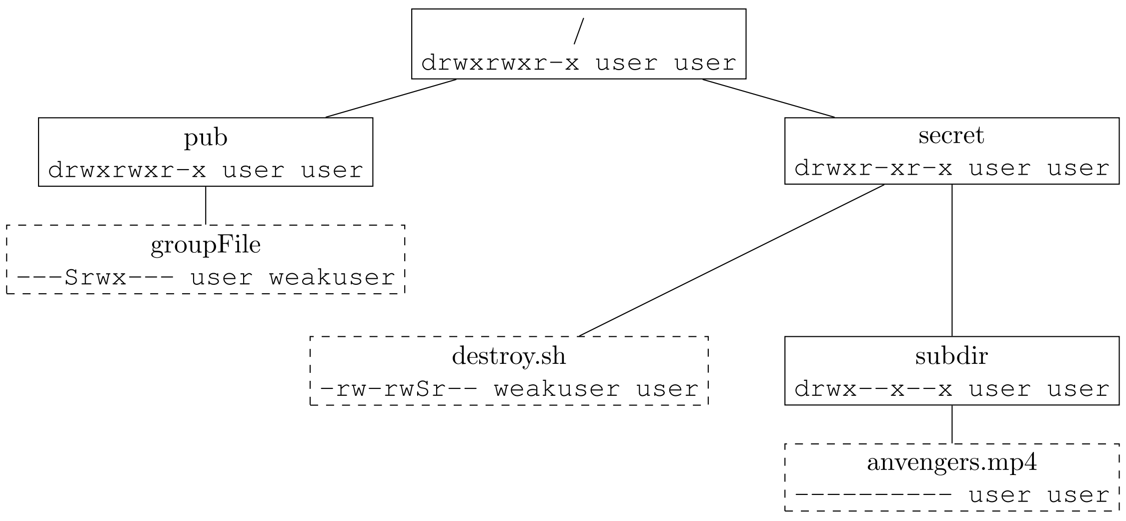


Figure 1: A small directory tree with ownership and permissions. The top line is the name of the file, the bottom line is the *permissions string*, then owner, then group owner.

Each letter in a permission string is also called a "bit" since it is implemented as a single bit (1 for "permission is granted", 0 for "not granted"). To explain the permissions strings:

- The first letter tells us which type of file it is; `-` means "normal file", `d` means "directory". See `https://en.wikipedia.org/wiki/Unix_file_types` for the other available UNIX file types.
- The three letters after that (the *first triad*) specify the permissions of the owner of the file. The first letter of the triad is "read", the second "write", the third "execute" permissions. For example, `-r-x------` means the owner has read and execute permissions, but not write.
- The second and third triad specify permissions for *group owner* and *other.*
- An execute bit of `s` means the suid/sgid bit and the respective execute bit are set, while `S` means only the suid/sgid bit but not the respective execute bit is set.

Assume for the following tasks that `user` is only in the group `user`, and `weakuser` is only in the group `weakuser`.

a) `weakuser` wants to execute `/secret/destroy.sh`, but the OS says `Permission denied`. How would the permissions string have to be different so he can execute it? What about `user`?

b) Can `weakuser` read, write, or execute `/pub/groupFile`?

c) The command `ls -l /secret/subdir` should list the contents of that directory. Why doesn't it when `weakuser` runs that command?

d) We want to make it possible for `weakuser` to play `/secret/subdir/avengers.mp4`. What are the minimal required changes to the permission strings such that this is possible? Who can set the respective bits in the permission strings?

$^{(g)}$**e)** Try to rebuild a directory structure like this on a UNIX machine. To change permissions, use the command `chmod` with the appropriate parameters; to see the contents of a directory with permission strings and owner/group owner, use `ls -l` or `ll`.