1-Week Extension to Lab06, Lec06

Survey Review

											Are there any critics, please?
1	3	2	2	2	2	1	1	2	2	1	Lackness of detailr in labr
0	3	2	1	1	1	1,2	2	1	2	1	Little more clear
7	3	2	1	2	3	2	1	2	2	1	Needr more movie referencer
7	1	1	1	1	1	3	1	1	1	1	No critics , , but a complement You Are Awesome!!
5	3	2	1	1	1	2	1	2	2	1	I war marked doun 40% on my lab03, because I didn't optimize properly. However I followed all of the instructionr properly, and am not sure what I did wrong. Also, I want to learn about the courre material, and I find it interesting, however as a non computerr science major I find the courre biared towardr the comput
8	3	2	2	1	1	2	1	2	2	2	Slider dont give enough information, itr hard to have to re watch a lecturer so it would make sense that the sliderr somewhat explain thingr but i feel like some thingr aren't explained enough on the sliderr since they are talked about in the lecture.
7	1	1	1	1	1	2	1	1	1	1	The questionr on the lecture arrignmentr and midterm require some information on the slider without having to re-watch the lecture. Because Googling during the Exam taker a while to find what the questionr ir arking for.
0	3	1	1	0	1	2	1	1	1	1	Can't think of any! :)
8	3	1	1	1	1	2	1	1	1	1	I wark better revieuingr slider before a lecture but find it hard to do that in thir clarr.
8	3	2	1	1	1	2	1	1	1	1	if the exam should be that hard then the lecturer/labr should be somewhat the same degree
8	1	1	1	1	1	2	1	1	2	1	Not providing enough coder/programr in lecture noter
7	3	2	1	1	1	2	1	1	2	2	More information on slider and not jrt talking, really helpr when revieuing
8	3	1	1	0	0	1	1	1	1	1	Sliderr sometimer too graphic for me, I personally learn from boring definitionr better than from diagramr
4	3	2	2	2	1	3	1	1	2	2	I would like it if there war more structure to the lecturer, and if the sliderr were a better guideline of the courre curriculum
8	3	3	2	2	1	4	2	1	2	2	Less bible quoter, more relevant uritten content to courre curriculum
0	0	1	1	1	1	1	1	1	1	2	The parrion and the availability to student questionr har no equal compared to other profr! But the lecturer need to be a bit more organized. For example, currently student are uring the chat ar a place to uax poetic about niche topicr, crack jokes or share random knouledge, uhich can be very distracting. Sam
7	2	1	1	1	1	1	1	1	1	1	The midterm uar fine. Mart questionr were easy. Not super easy but I have very detailed noter. I expected the answerr to mart questionr (border opinion based ones) to have been said at some point in a lecture. But 04B didn't stray much about file identifierr and uhat they actually are, border that they are perman
5	3	2	1	1	1	1	1	1	1	2	Lecturer are hard to follow sometimes
2	0	2	1	1,2	1,3	2,3	1	1	2	2	I find it difficult to follow the lecture uithout supplementary noter to add to (I am NOT an auditory learner and often times find myself transcribing as much as I can and not as much processing the content taught). Thir leaver me revieuing the lecture recordingr multiple times, uhich ir time consuming leading to n
9	3	2	1	2	2	2	1	1	2	2	No uayr to strengthen knouledge of the courre outside of lecturer, uhere the slider have little to no information on them. The textbook doer not assist at all in helping for lecr and labr and the only uay you can answer the questionr ir through long independent research online. It would be nice to have a textbook th
1	3	2	1	1	0,1	1,2	1	1	3	1	Can't think of one on the spot! Maybe more virual noter?
7	2	1	1	1	3	2	1	1	1	2	Hey sir, you are doing a good job teaching so far, but there are times uhen I have difficulty understanding the hou everything ir uorking together. Maybe adding some more slider uith exampler of running certain commandr/functionr/processer would help more. For example, I'm not fully understanding an examp
9	3	2	1	1	1	2	1	1	2	2	More structured lecture slider uill noter/text on them would be nice. Also, following the textbook more closely uill help ur uhen ue need to fall back on the text to explain some conceptr. A lot of conceptr discussed in thir clarr are vague/not easily answered on the internet.
0	1	2	1	2	1	2	1	1	2	2	The fact that no text ir provided (lecture noter, lecture slider uith information on it, specific reading sectionr, etc.) mean that many student need to spend an excessive amount of time re watching the lecturer to get it down on the noter. Thir har been a uaste of time because instead of working on the lab or an t
7	2	2	1	1	1	1	1	1	2	2	No critique, but I love all the movie referencer.
8	3	1	1	1	3	1	1	1	2	1	it would be great to have noter in the lecture slider , also i uith the exam uar 4 hourr long, could not finish answering because the question needed uell thinking and it uar definitely hard to think and answer all the questionr ar it should be. although i have not good felling about the midterm but overall i enjoy the cou
2	2	2	1	1	1	2	1	1	1	1	Jurt uish ue were given more resourcer to help ur understand the material better. You are an amazing prof and you explain the material really uell. But I jurt feel that I'm not grasping or getting everything. Kind of feel like I'm missing information/content/material.
2	2	1	1	1	1	2	1	1	1	1	Perhaps consider adjusting the weighter of the lecture arrignmentr and lab arrignmentr in the future. They are of similar difficulty and require a similar time commitment, and yet the lecture arrignmentr are only uorth 10% compared to 30% for the labr.
5	1	2	1	1	3	2	1	1	2	1	My only complaint would be that the lecture arrignmentr questionr aren't covered in clarr (to any extent). I know you've mentioned in the part that thir ir by design, but ue spend all our time googling the questionr and I don't think itr teaching ur a lot other that hou to google.
1	2	1	1	1	1	1	1	1	2	1	Better slider. they're very confusing if not accompanied uith the lecture
8	3	2	1	1	1	1	1	1	1	2	The lecturer and lecture arrignmentr are a bit off sync, uhich maker it harder to keep up and retain lecture information.
5	3	3	2	2,3	2,3	4,3	2	2	2	2	studying 5 computer courser uith different typer of programming languager, maker thir courre the mart difficult. professor teaching ir good, but i honestly don't get time to prepare, uhich not only maker it difficult but alre impossible to even try to study thir courre further.
2	3	2	1	2	1,2	2	2	1	1	2	i dont get the point of making lecture arrignmentr, some people are too bury to make it to some lecturer and re watching an entire lecture jurt to answer tuo questionr ir too time consuming
3	3	3	2	1	3	1	2	1	2	2	As a student from your previous 2650 clarr, I still strongly encourage that you give ur our arrignmentr based on material after you actually taught the material. The mart I've learnt ir hou to google until I can find one uith a similar enough answer to make do, and put it in my own uordr once I understand the concep
4	3	1	1	1	1,3	1	2	2	3	1	GA's and TA's need to respond to their emailr from student. When ue ark question about a mark and hou to improve ue should get an answer back.
5	3	2	1	1	1	2	1	1	2	1	I feel like some of the questionr on the midterm uere n't covered or covered in enough detail in the lecturer (for example: the question regarding the BIOS or MBR).
5	2	1	1	0	1	1	1	1	1		
8	2	2	1	1	1	2	1	1	2	1	More detailed lecture slider
0	3	1	1	1	2	1,2	1	1	1	1	Lec's are a little hard sometimes
4	2	1	1	1	1	2	1	1	2	1	It would be helpful to have more practical exampler during the lecture like in a programing courre. Something like opening the terminal and typing the commandr to demonstrate the lecture content would probably be helpful to the understanding of the content. However, I do think thir clarr requirer you to truly
7	0	2	1	0	3	1,2	1	1	1	2	My main trouble uith the lecturer right nou ir that the sliderr posted are very vague. I know ue're supposed to attend the live lecturer, and I do, but more annotation in the slider would help revieuing them at a later date. Presenter footnoter are a good place to start, in my opinion. Overall, you're a great professor l
8	1	2	1	1	1	2	1	1	1	2	While it ir unlikely to make a difference at thir point - if a midterm ir scheduled during clarr time, it should not be longer than the usual clarr session. It ir acceptable for me to miss another courre's lecture (uhich uill be recorded), but I cannot make up for a lab that ir given and due during the lab session. PS: I appre
5	2	2	1	1	1	2	1	1	2	2	Overall enjoyable and informative, sometimes not the mart clear
1	3	1	1	1	1	2	1	1	1	1	It would be better if a manual would be given about hou to urite in bash because I had some difficultier finding the material online. other than thir, you're the Best Teacher NA.
9	2	1	1	1	1	2	1	1	2	1	Not enough text info in the lecture slider (I understand uhy, but that's my critique!)
0	3	2	1	1	1	2	1	1	2	2	Ok
7	3	1	1	1	1	2	1	1	1	1	Very nice
7	3	2	1	2	1	4	1	1	1	2	-More detailed lecture noter-More practice questionr
5	3	2	1	1	2	2	2	1	2	2	There is a disconnect between the material covered in the courre/lecturer and some of the questionr given in the midterm. I don't believe the open-ended questionr are a good indicator of our understanding in the courre, and it might not be fair to allocate so many markr to there questionr. Thank you for making t
8	3	2	2	3	1	3	2	1	2	2	More organized slider
8	3	2	1	1	1	2	1	1	2	1	The PDF seem to be missing information
7	3	2	1	2	1	4	1	1	2	2	As for the exam, I believe that it could have been easier. Though ue had access to the internet, there uar not enough time to research about some stuff.
5	2	2	1	1	1	2	1	1	2	1	Sometimes I find the uording of questionr to be a bit confusing. I may ark my friendr uhat they think of a lecture arrignment question and ue will both interpret it differently so I'm sometimes not sure uhat the correct answer ir you may be looking for.
7	1	1	1	1	1	2	1	1	2	1	Amazing teaching and uell balanced and fair arrignmentr.
5	3	2	1	1	3	2	1	1	2	2	Slider could be a bit more descriptive to be more useful during lecture explanationr.
5	2	2	1	1	1	2	1	1	2	2	Out of all of my professorr, I think you explain the conceptr the best, I like the imager and arrour that show the steps/processr. I know some student would like more uriting on the slider but i don't think itr that big of a deal because you explain mart thingr clearly but i would never object to more information on the s
5	3	2	1	3	3	2	1	1	1	2	Wish for more structured lecture noter uith summary or pointr of important theorier. Sometimes, I can't fully follow during the lecture time and uhen I go back to the slider for review, I can't get too much information.
0	3	1	1	2	0	1	1	2	3	1	Get your tafqa to respond to emailr
5	1	2	1	2	3	3	2	1	2	2	The questionr were so vague, they were difficult to answer due to their uording
5	2	1	1	1	1	2	1	1	1	1	The exam length uar longer than the clarr, and thir conflicted uith other dutier. It would be appreciated if the exam length could be made no longer than the clarr time :)
8	0	2	1	1	0	2	1	1	1	2	I think sometimes the lecture content bounces around a lot. I think more structure would be better
7	3	2	1	2	2	4	2	1	2	1	Let Hf teach the rest of my courser
7	3	2	2	1	2	2	2	1	1	2	ok, not really seeing much relevance to real uorld job application, everyone jurt uantr like Nodejr, reactjr, Vuejr, mongoDB, stuff that university doesnt even teach ur
7	3	2	1	1	1	3	1	1	1	1	it's not you, it's me. Comp Sci isn't my major and I jurt be confused :(
8	3	3	2	3	0	4,3	1	1	1	1	Can you jurt teach ur coding in bash rather than expecting to complete it on our own

Lectures

- Slides
  - More written notes
  - More organization
  - More example
  - Hands-on Practice
- Class
  - Chatbox
  - Q&A

Assignments

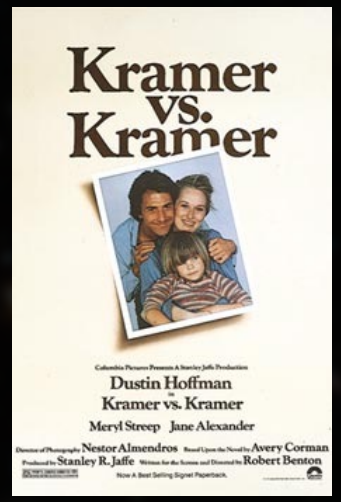
- Lecs
  - Better wording
  - More weights (time-benefit trade-off)
- Labs
  - More details
- Not Sync

Exam

- Not more than class duration
- Some questions not covered in class

Pink Floyd - Another Brick in The Wall

Are robots becoming more human or humans becoming more robotic?



Googler vs. Googler

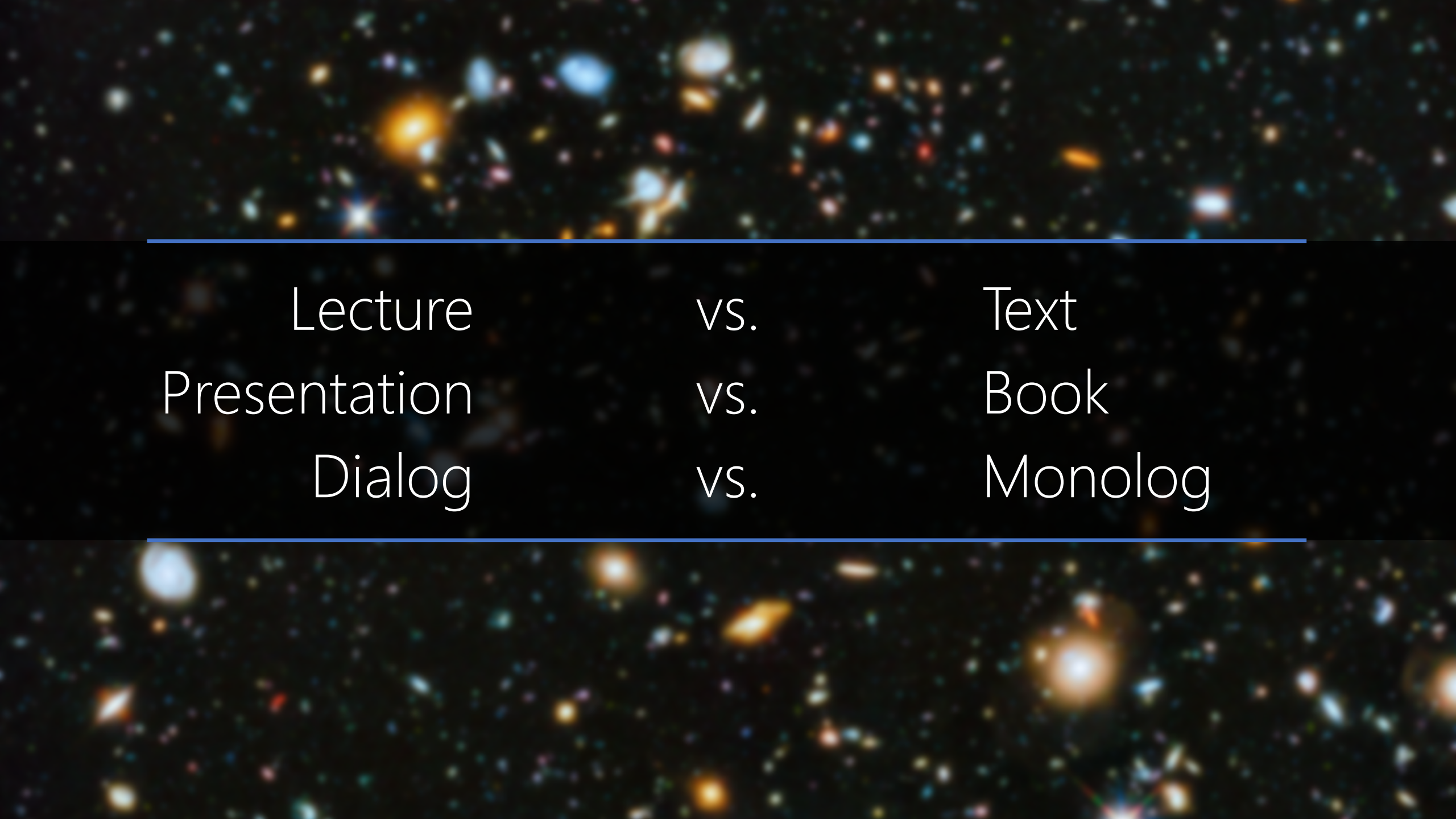
Googler: A Person Who Builds Google
Googler: A Person Who Works for Google
Googler: A Person Who Uses Google

Operating System Developer vs. Operating System Administrator
Shell Developer vs. Bash Script Writer

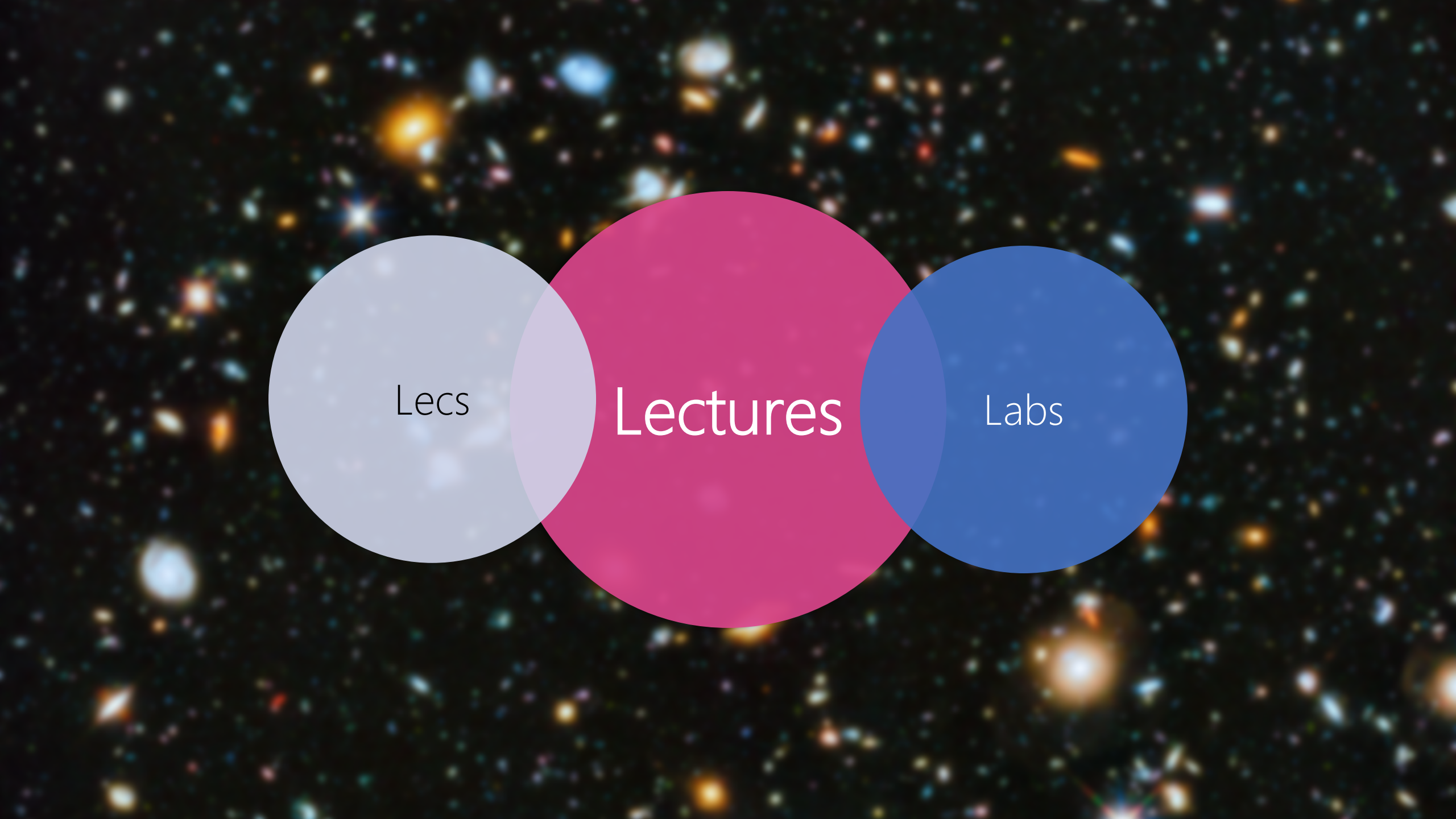
Brian Jhan Fox

Linus Torvalds

USENIX: UNIX Users, New York, 1974



Lecture	vs.	Text
Presentation	vs.	Book
Dialog	vs.	Monolog


Lecs
Lectures
Labs

Lectures

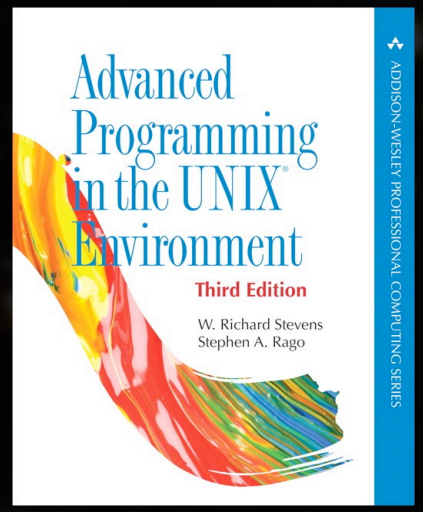
- Slides
  - More written notes → Yes but won't replace lectures!
  - More organization → Can't agree more.
  - More example → Sure. As we're getting toward coding
  - Hands-on Practice → No, please attend lab sections!
- Class
  - Chatbox → True. I used to have moderator.
  - Q&A → True. I try to put Q&A slides when moving from one topic to new one

Assignments

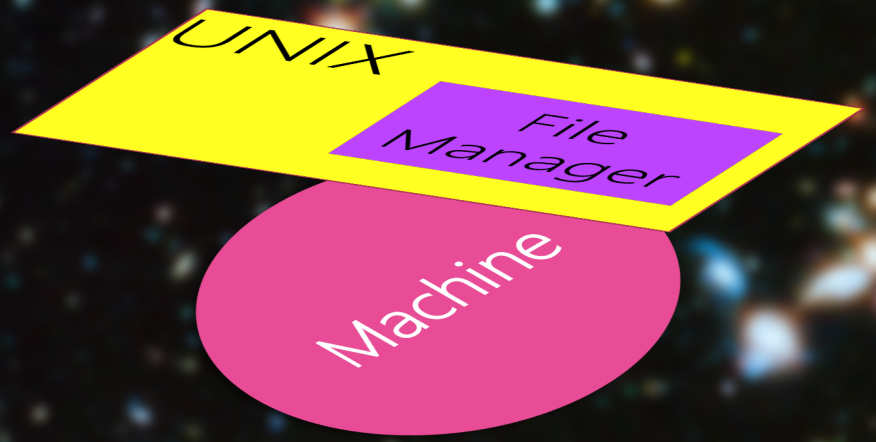
- Lecs
  - Better wording → True! I'll try to fix it.
  - More weights (time-benefit trade-off) → No.
    - Those scared of coding, start coding!
    - Others, this course is a technical course: Labs > Lecs
- Labs
  - More details → No. Attend the lab sections instead.
- Not Sync → True. I'll try to fix it.

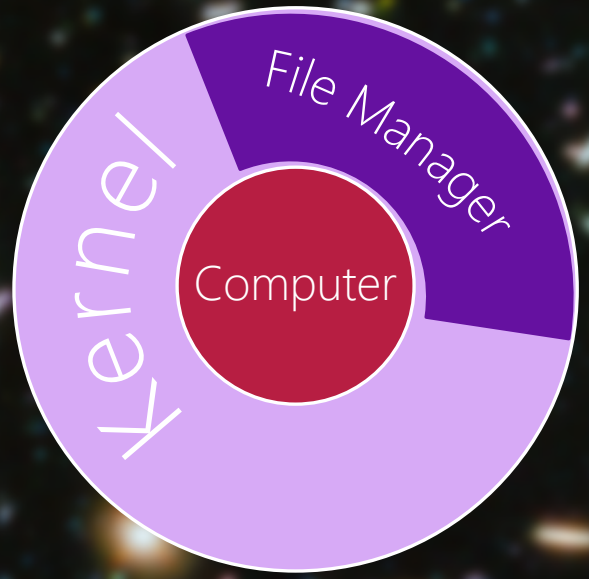
Exam

- Not more than class duration→ True! I'll try to fix it.
- Some questions not covered in class→ ?



Chapter 03: File I/O
Chapter 04: File I/O





Computer

Memory

Kernel: Device Manager

Kernel: Memory Manager

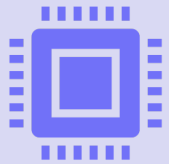
Kernel: File Manager

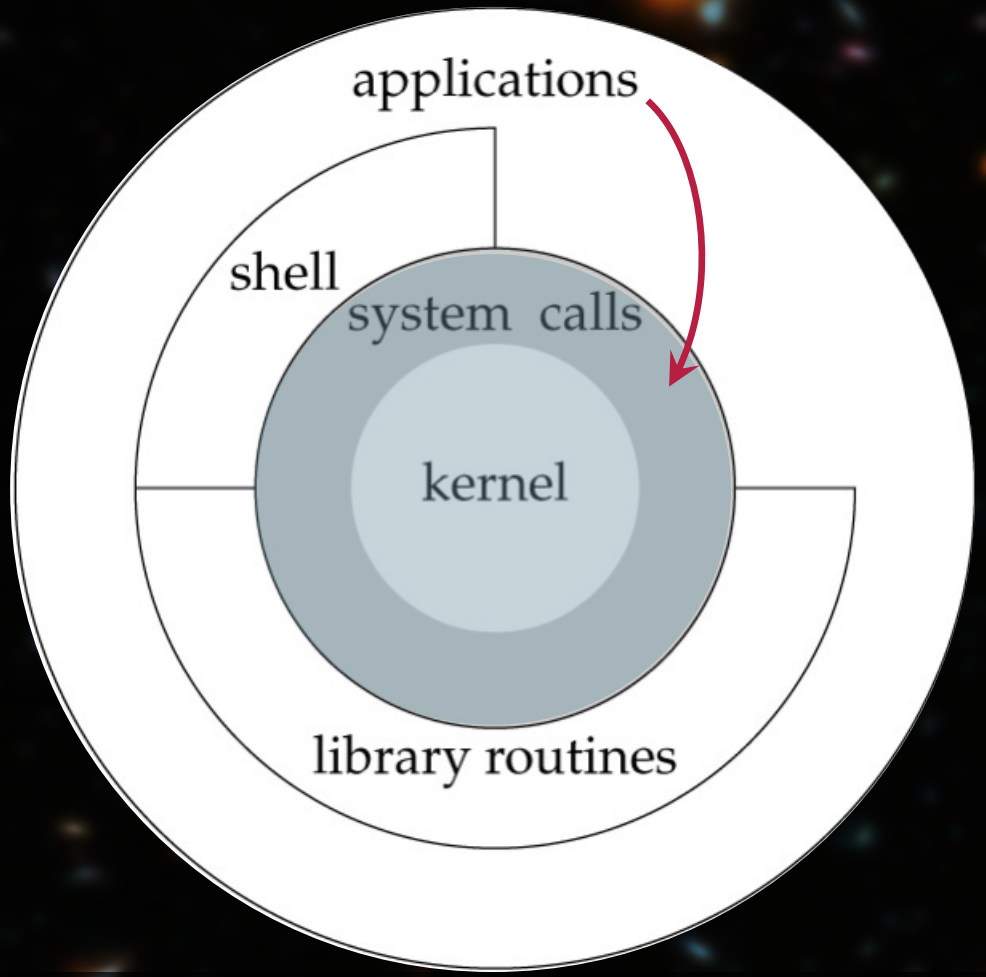
Kernel: Network Manager

Kernel: Process Manager

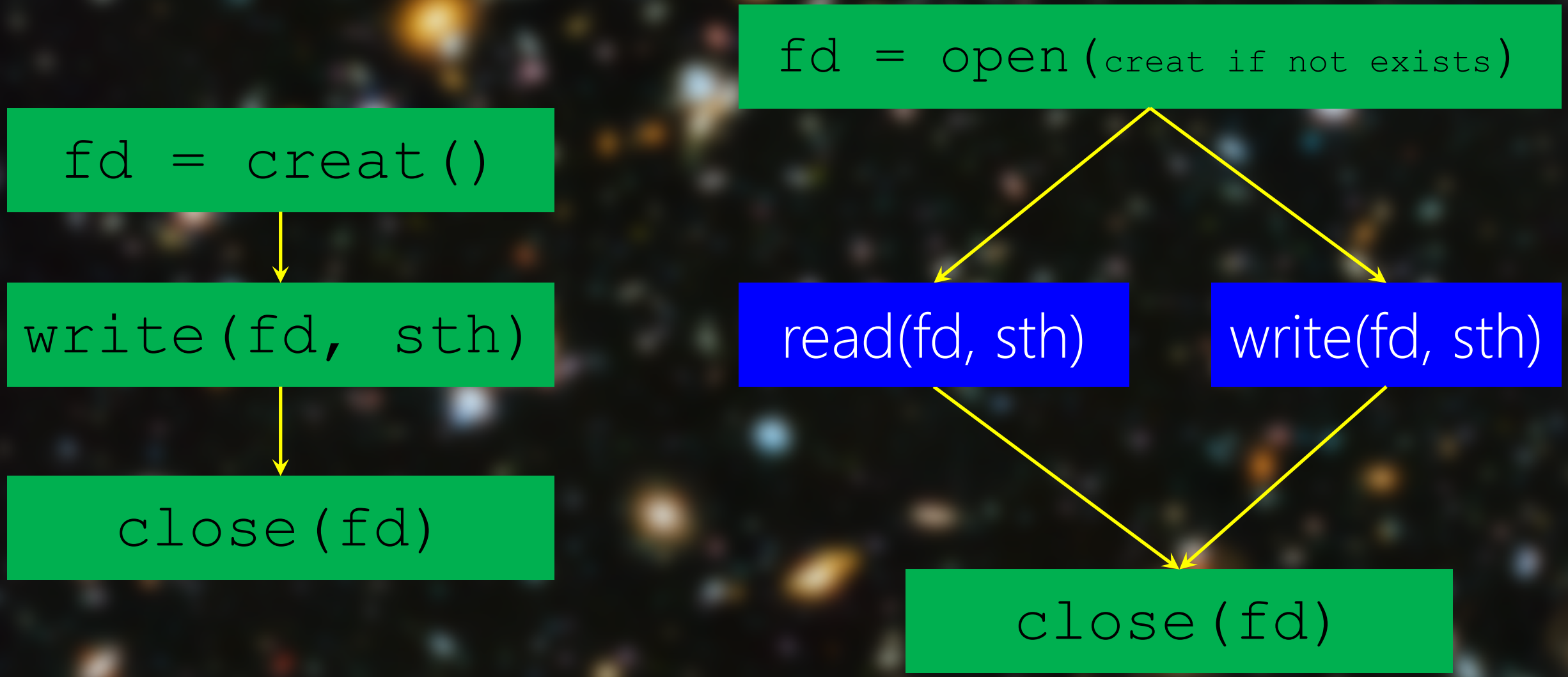
Bus

Processor





Header	FreeBSD 8.0	Linux 3.2.0	Mac OS X 10.6.8	Solaris 10	Description
<aio.h>	•	•	•	•	asynchronous I/O
<cpio.h>	•	•	•	•	cpio archive values
<dirent.h>	•	•	•	•	directory entries (Section 4.22)
<dlfcn.h>	•	•	•	•	dynamic linking
<fcntl.h>	•	•	•	•	file control (Section 3.14)
<fnmatch.h>	•	•	•	•	filename-matching types
<glob.h>	•	•	•	•	pathname pattern-matching and generation
<grp.h>	•	•	•	•	group file (Section 6.4)
<iconv.h>	•	•	•	•	codeset conversion utility
<langinfo.h>	•	•	•	•	language information constants
<monetary.h>	•	•	•	•	monetary types and functions
<netdb.h>	•	•	•	•	network database operations
<nl_types.h>	•	•	•	•	message catalogs
<poll.h>	•	•	•	•	poll function (Section 14.4.2)
<pthread.h>	•	•	•	•	threads (Chapters 11 and 12)
<pwd.h>	•	•	•	•	password file (Section 6.2)
<regex.h>	•	•	•	•	regular expressions
<sched.h>	•	•	•	•	execution scheduling
<semaphore.h>	•	•	•	•	semaphores
<strings.h>	•	•	•	•	string operations
<tar.h>	•	•	•	•	tar archive values
<termios.h>	•	•	•	•	terminal I/O (Chapter 18)
<unistd.h>	•	•	•	•	symbolic constants
<wordexp.h>	•	•	•	•	word-expansion definitions
<arpa/inet.h>	•	•	•	•	Internet definitions (Chapter 16)
<net/if.h>	•	•	•	•	socket local interfaces (Chapter 16)
<netinet/in.h>	•	•	•	•	Internet address family (Section 16.3)
<netinet/tcp.h>	•	•	•	•	Transmission Control Protocol definitions
<sys/mman.h>	•	•	•	•	memory management declarations
<sys/select.h>	•	•	•	•	select function (Section 14.4.1)
<sys/socket.h>	•	•	•	•	sockets interface (Chapter 16)
<sys/stat.h>	•	•	•	•	file status (Chapter 4)
<sys/statvfs.h>	•	•	•	•	file system information
<sys/times.h>	•	•	•	•	process times (Section 8.17)
<sys/types.h>	•	•	•	•	primitive system data types (Section 2.8)
<sys/un.h>	•	•	•	•	UNIX domain socket definitions (Section 17.2)
<sys/utsname.h>	•	•	•	•	system name (Section 6.9)
<sys/wait.h>	•	•	•	•	process control (Section 8.6)


fd = creat()
write(fd, sth)
close(fd)
fd = open(creat if not exists)
read(fd, sth)
write(fd, sth)
close(fd)

O_RDONLY	Open for reading only (the returned fd can only read)
O_WRONLY	Open for write only (the returned fd can only write like `creat()`)
O_RDWR	Open for reading and writing (the returned fd can do both read and write)
O_EXEC	Open for execute only (the returned fd execute)
O_SEARCH	Open for search only (for directories)

```
#include <fcntl.h>
int open(const char *path, int oflag, ...);
```

non-negative number (fd) if OK

−1 on error

You Want me on that Wall, You Need me on that Wall

https://www.youtube.com/watch?v=_xd1fs5nWoI

A Few Good Men - Aaron Sorkin

lseek

POSIX

```
#include <unistd.h>
int lseek(int fd, off_t offset, int whence);
```

file's new offset if OK (can be negative)

−1 on error

Every opened file has one sentinel: `current offset`

Measures the number of bytes from the beginning of the file.

Every opened file has one sentinel: `current offset`

Measures the number of bytes from the beginning of the file.

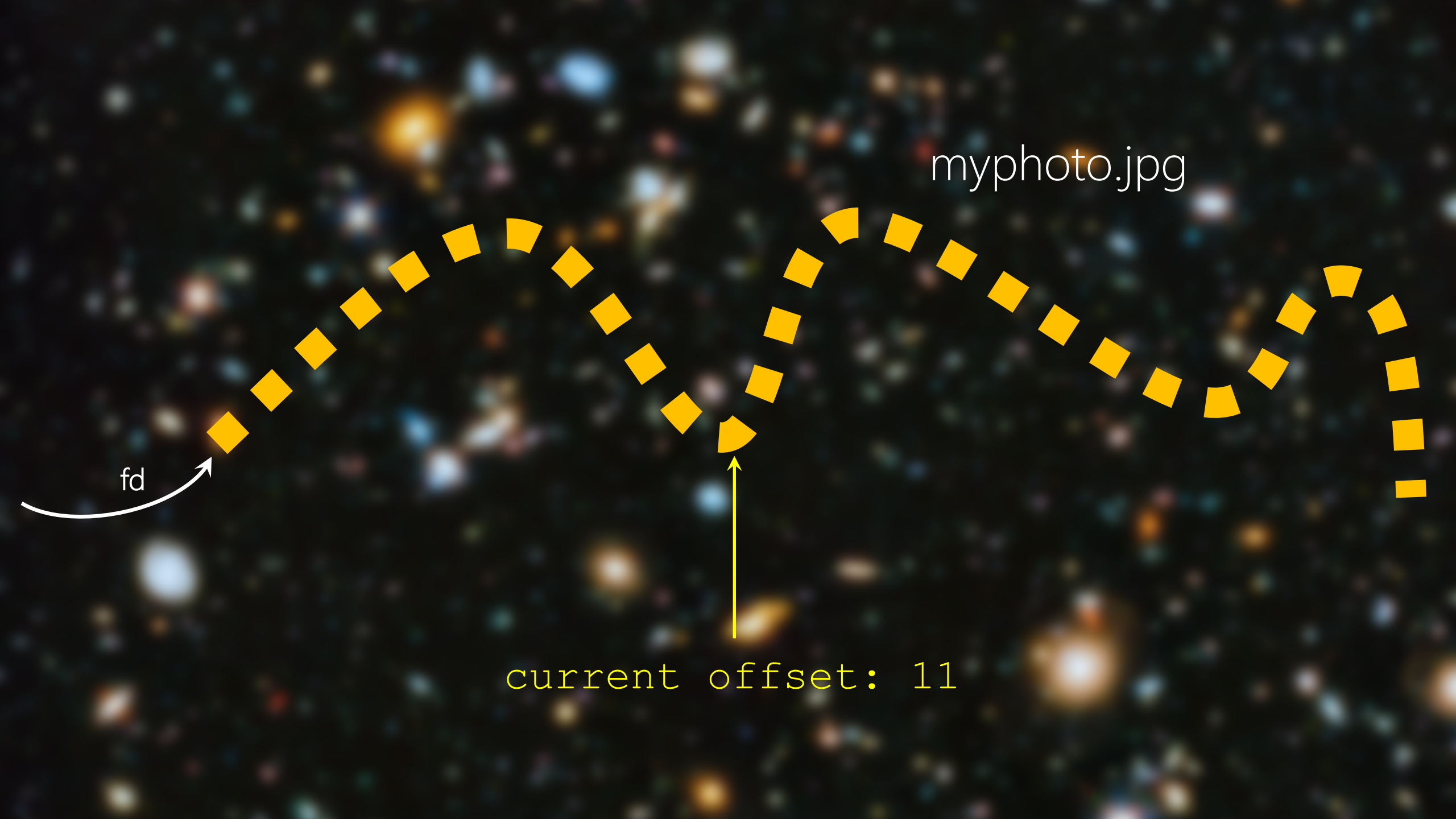
`creat()` or `open()` → `0`

Every opened file has one sentinel: `current offset`

Measures the number of bytes from the beginning of the file.

`read()` or `write()` → ++ actual number of bytes read or written

`read()` or `write()` → always move forward


myphoto.jpg
fd
current offset: 11

lseek

How many bytes move the current offset

```
#include <unistd.h>
int lseek(int fd, off_t offset, int whence);
```

file's new offset if OK (can be negative)

−1 on error

```
#include <sys/types.h>
typedef off_t signed long
```

lseek

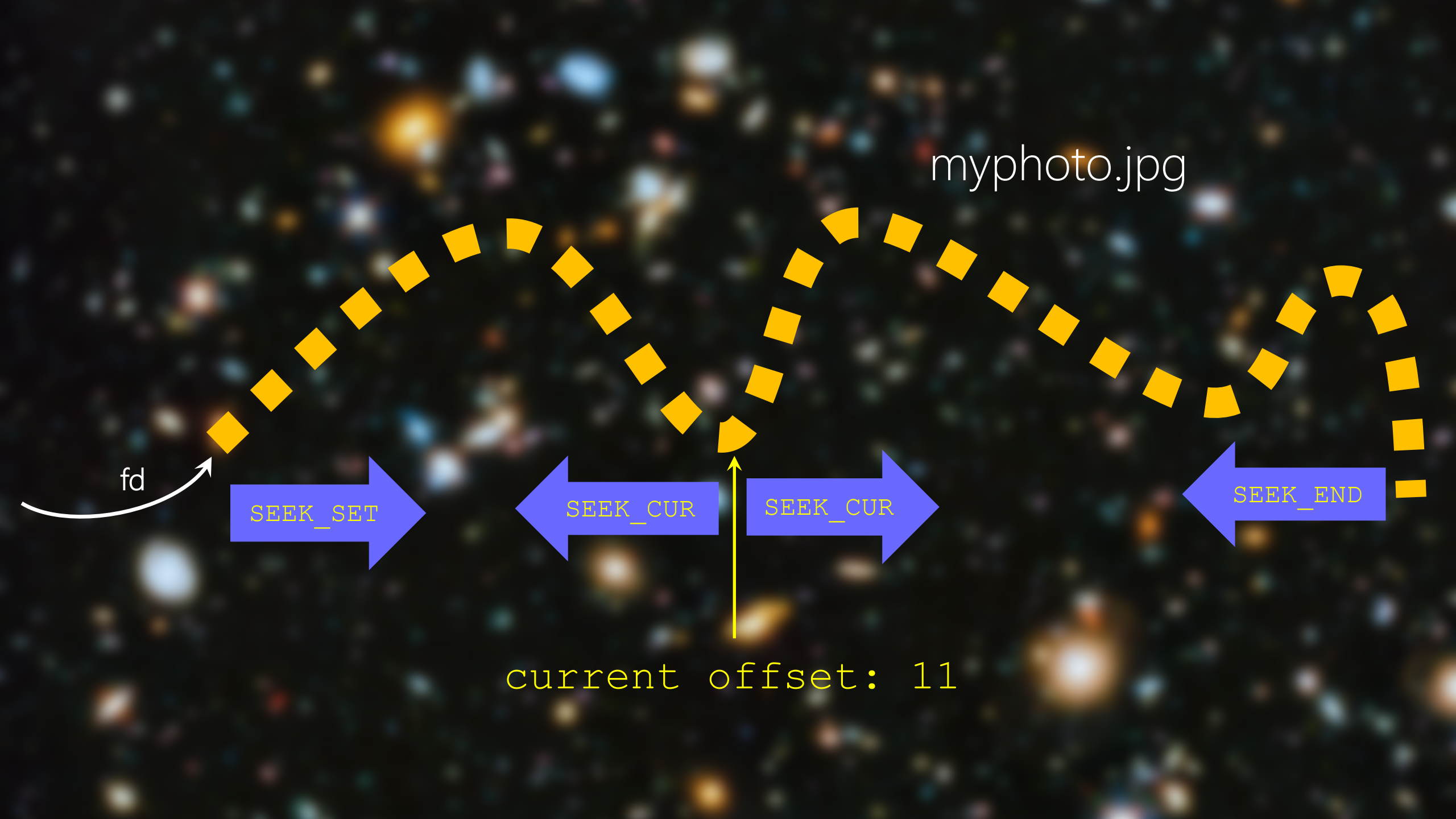
How many bytes move the `current offset` from what place or origin?

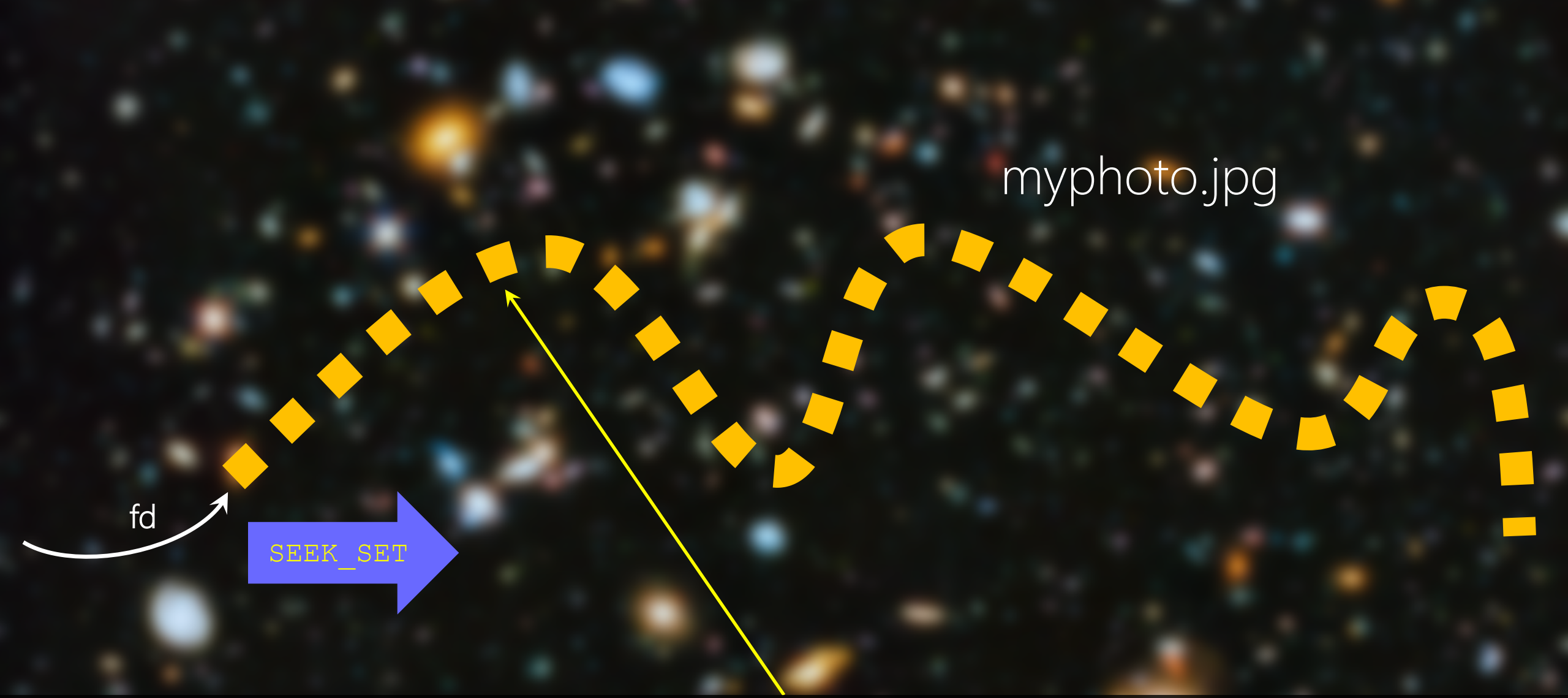
`SEEK_SET, SEEK_CUR, SEEK_END`

```
#include <unistd.h>
int lseek(int fd, off_t offset, int whence);
```

file's new offset if OK (can be negative)

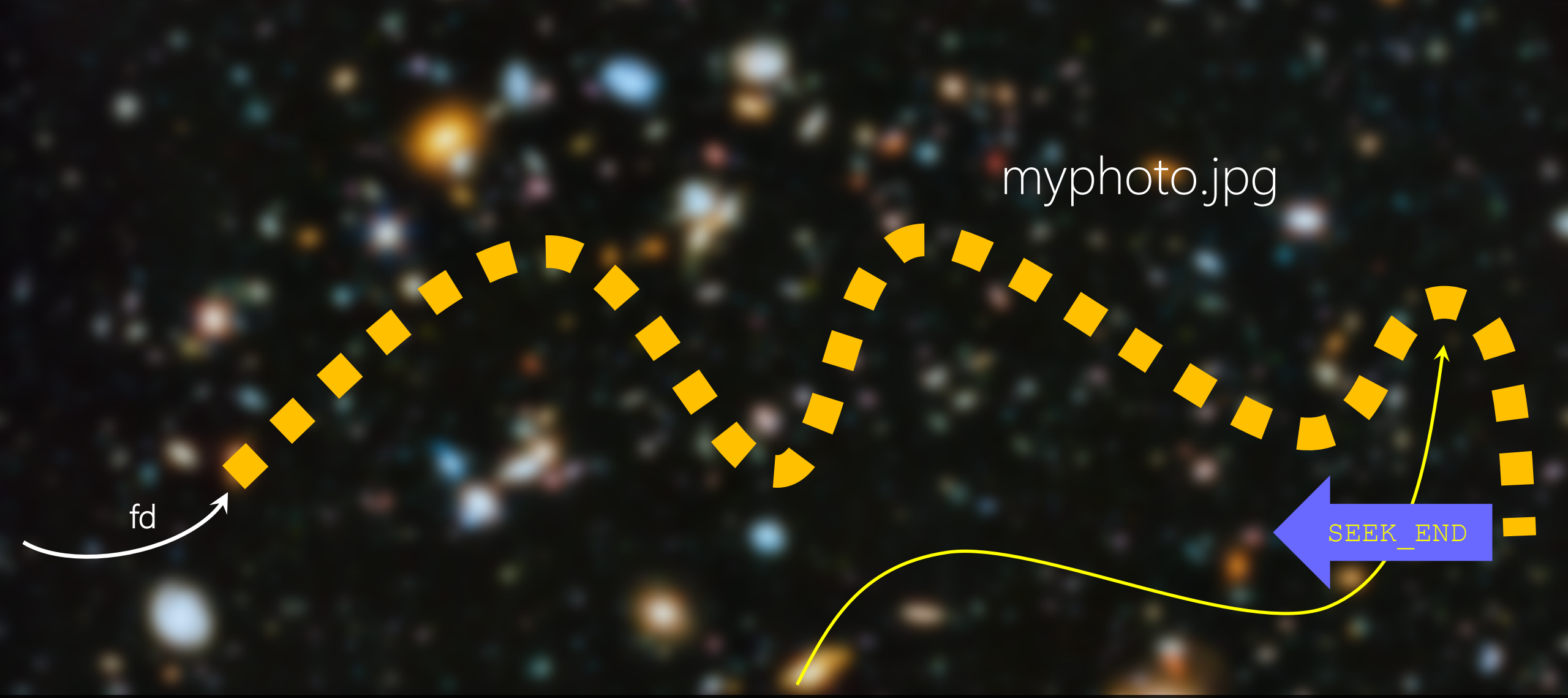
−1 on error


myphoto.jpg
fd
SEEK_SET
SEEK_CUR
SEEK_CUR
SEEK_END
current offset: 11



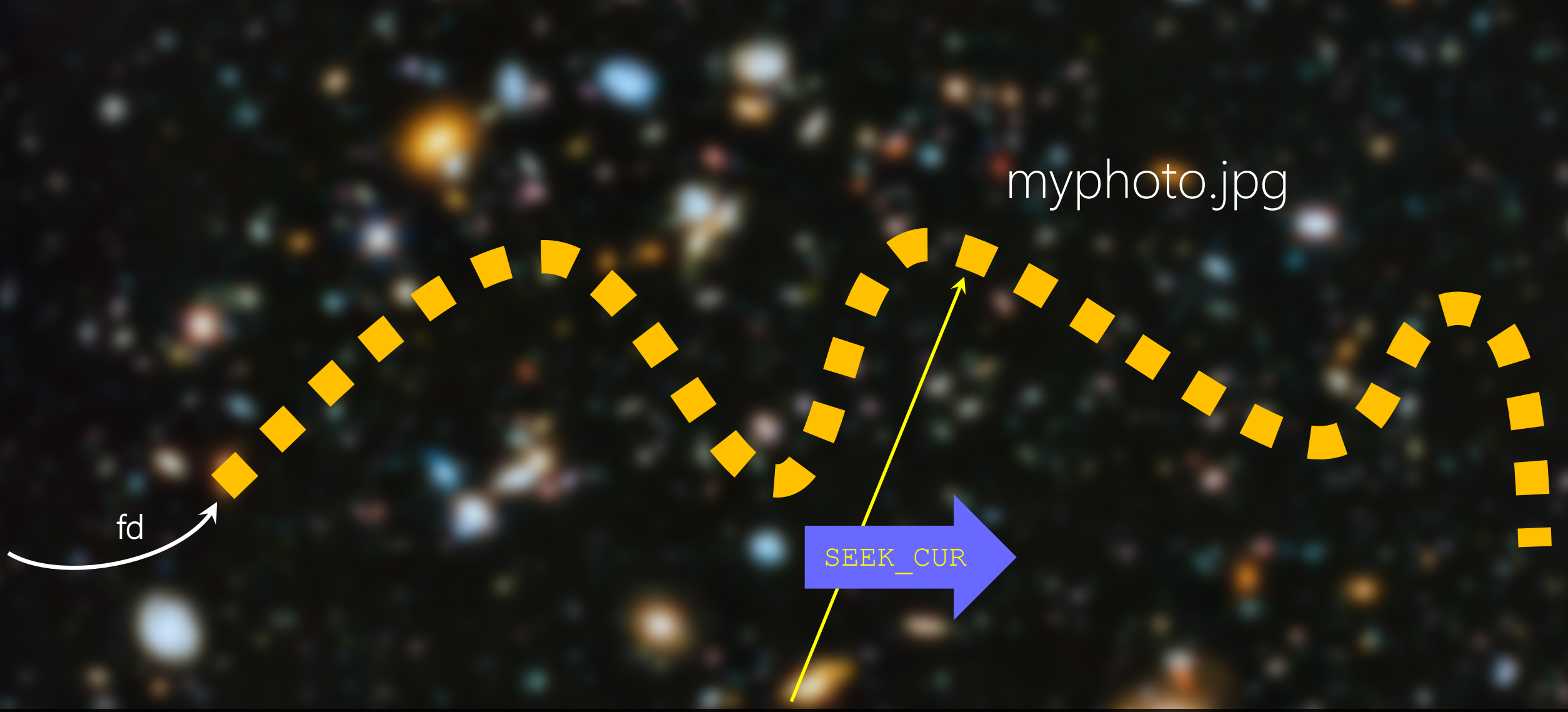
current offset: 11 → 5

```
lseek(fd, 5, SEEK_SET)
```



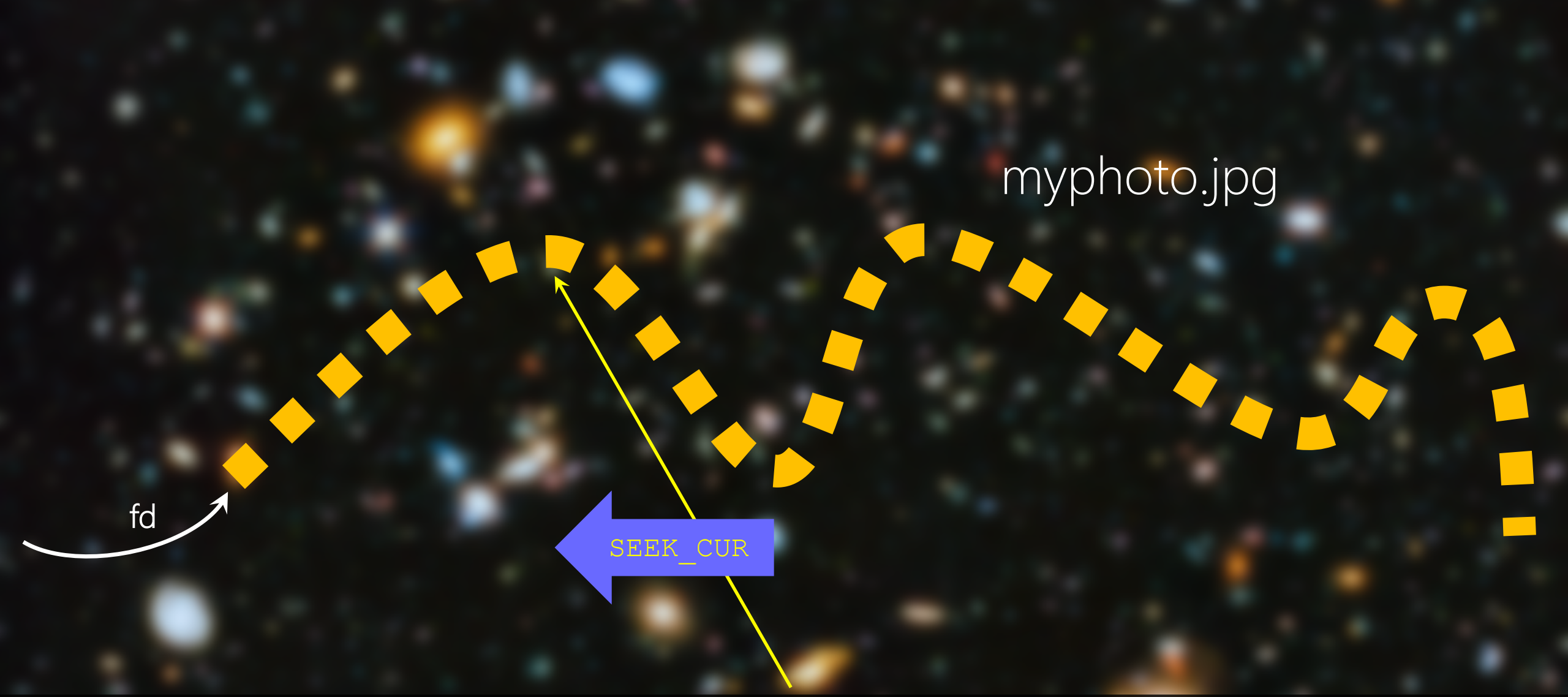
current offset: 11 → 25

```
lseek(fd, 5, SEEK_END)
```



current offset: 11 → +5 = 16

```
lseek(fd, 5, SEEK_CUR)
```



current offset: 11 → -5 = 6

```
lseek(fd, -5, SEEK_CUR)
```

lseek

New current offset

```
#include <unistd.h>
int lseek(int fd, off_t offset, int whence);
```

file's new offset if OK (can be negative)

−1 on error

lseek

How to know the value of current offset?

lseek

How to know the value of current offset?

```
long cur_offset;
cur_offset = lseek(fd, 0, SEEK_CUR);
```

lseek

How to know the file can be seekable?

```
long cur_offset;
cur_offset = lseek(fd, 0, SEEK_CUR);
if (cur_offset == -1){
        /* either the fd is on a file which is not seekable
           or an error occurred /*
}
```

```
hfani@charlie:~$ tty
/dev/pts/12
hfani@charlie:~$ vi seekable.c
```

```c
#include <fcntl.h>
#include <unistd.h>
void  main(void)
{
        int fd = open("/dev/pts/12", O_RDWR);
        char error[20] = "cannot seek!\n";
        if (lseek(fd, 0, SEEK_CUR) == -1){
                write(fd, error, 20);
                return;
        }
}
```

Is terminal device seekable?

```
hfani@charlie:~$ cc seekable.c -o seekable
hfani@charlie:~$ ./seekable
cannot seek!
```

Is terminal device seekable? No!

lseek

Is it possible for offset be greater than file size?

lseek

Is it possible for offset be greater than file size?
Yes! The next `write()` operation creates a hole of 0s.

```
hfani@charlie:~$ vi hole.c
```

```
#include <fcntl.h>
#include <unistd.h>
void main(void){
        int fd = open("./hole_test.txt", O_RDWR | O_CREAT, S_IRUSR | S_IWUSR);
        int cur_offset = lseek(fd, 10, SEEK_SET);
        char buf[20] = "write after the hole.";
        write(fd, buf, 20);
}
~
```

current offset = 0

move it 10 bytes ahead from start

write new bytes

```
hfani@charlie:~$ cc hole.c -o hole
hole.c: In function 'main':
hole.c:6:17: warning: initializer-string for array of 'char' is too long
    6 |  char buf[20] = "write after the hole.";
      |                 ^~~~~~~~~~~~~~~~~~~~~~~
hfani@charlie:~$ ./hole
hfani@charlie:~$ vi hole_test.txt
```

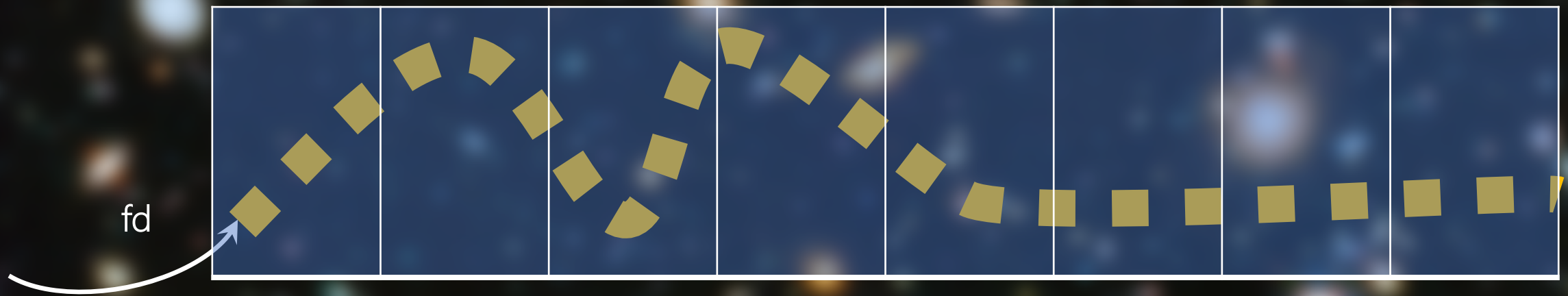
```
^@^@^@^@^@^@^@^@^@^@write after the hole
~
```

```
hfani@charlie:~$ hexdump hole_test.txt
0000000 0000 0000 0000 0000 0000 7277 7469 2065
0000010 6661 6574 2072 6874 2065 6f68 656c
000001e
```

```
hfani@charlie:~$ od -c hole_test.txt
0000000  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0   w   r   i   t   e
0000020   a   f   t   e   r       t   h   e       h   o   l   e
0000036
```

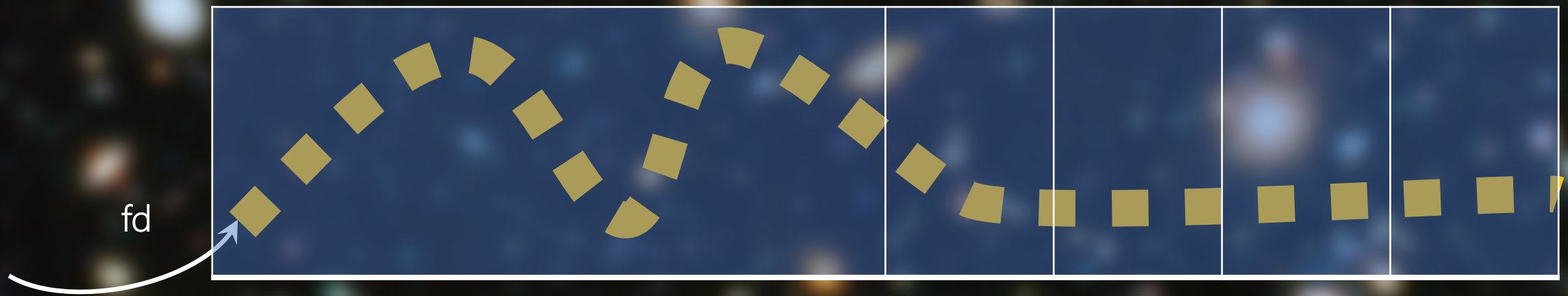
lseek

A Better User Case: Binary Search



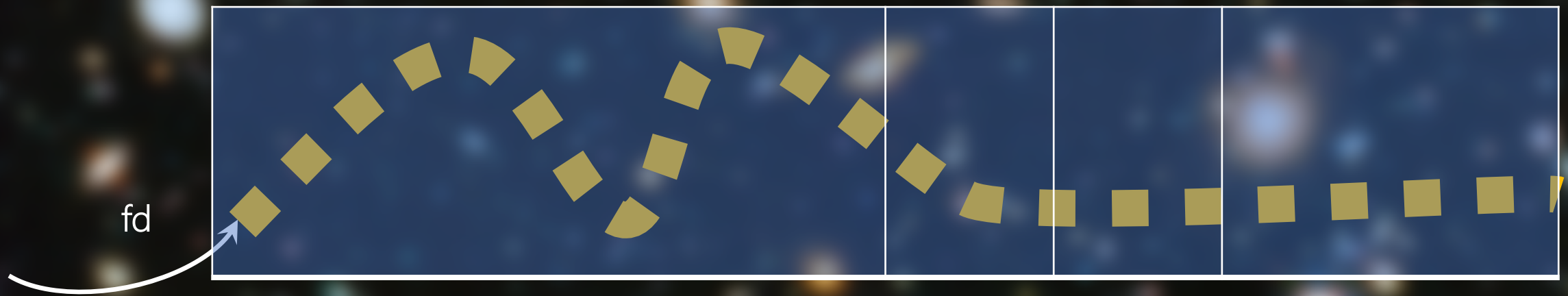
lseek

A Better User Case: Binary Search



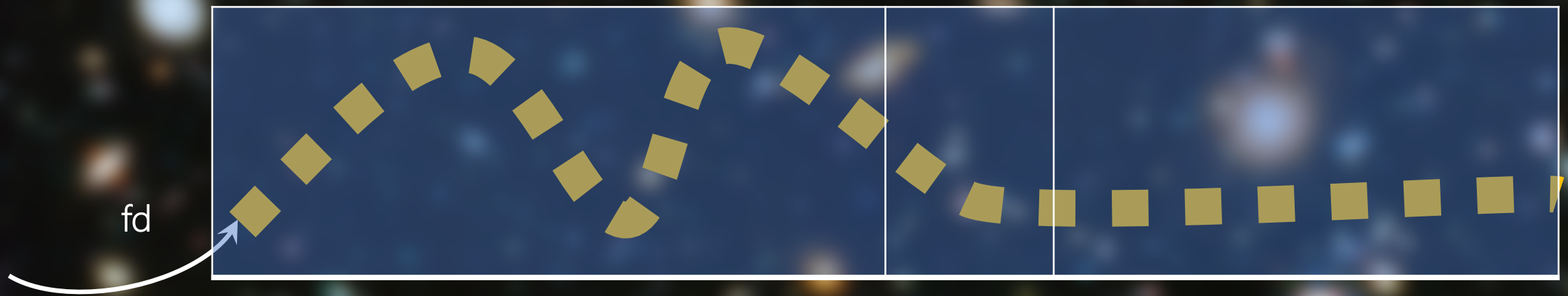
lseek

A Better User Case: Binary Search



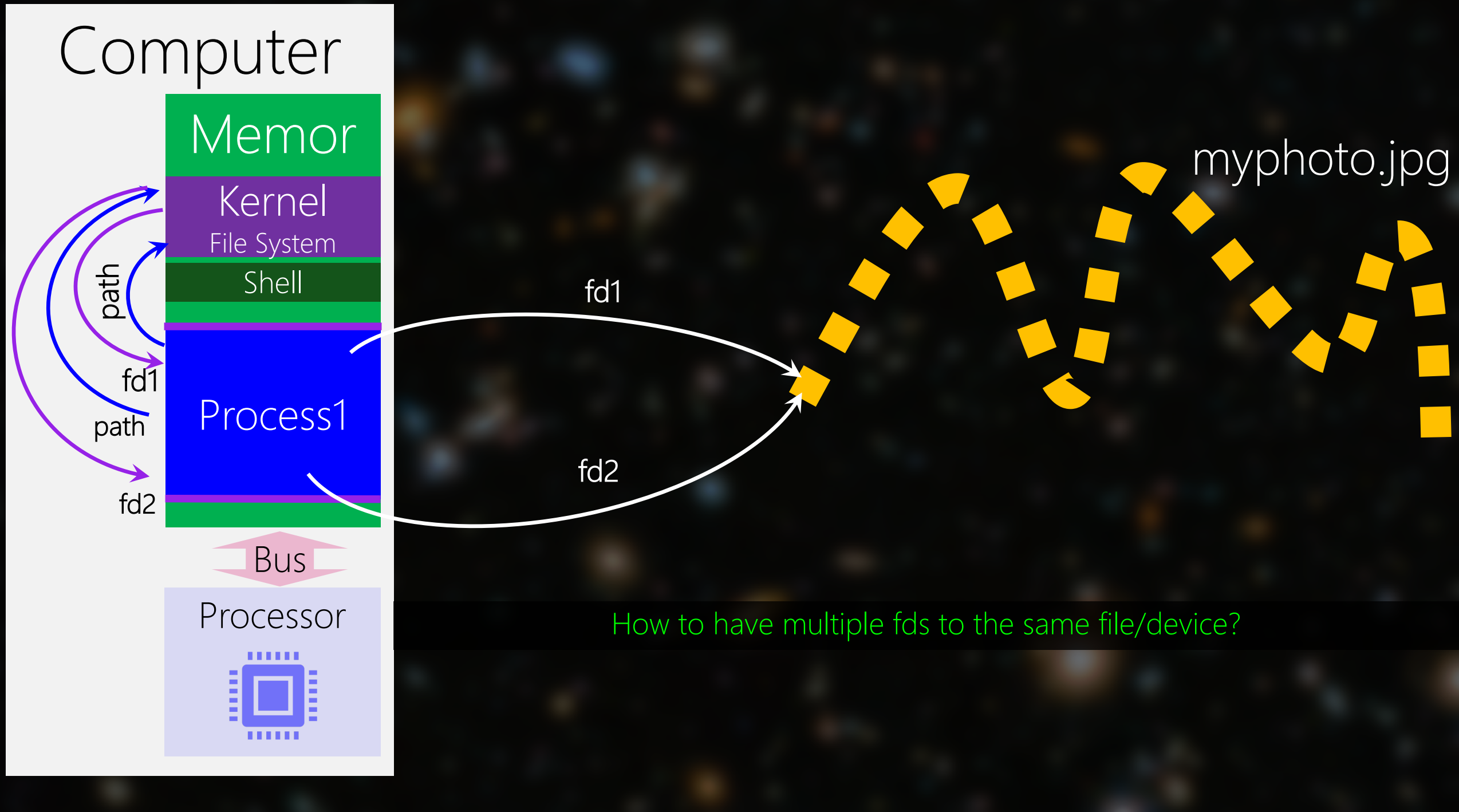
lseek

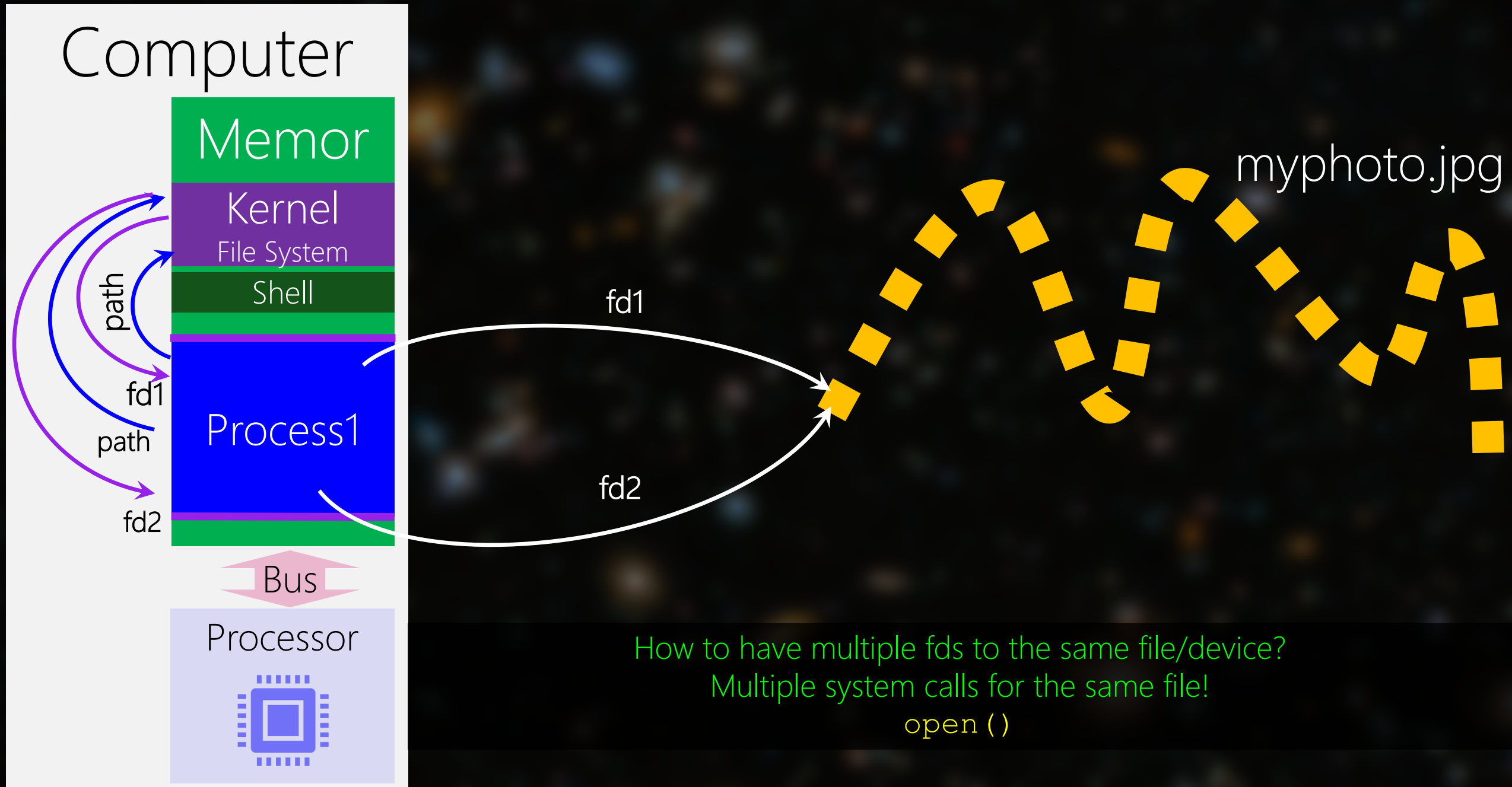
A Better User Case: Binary Search



`dup` and `dup2`

File System: High-Level


Computer
Memor
Kernel
File System
Shell
path
fd1
path
fd2
Process1
fd1
fd2
myphoto.jpg
Bus
Processor
How to have multiple fds to the same file/device?

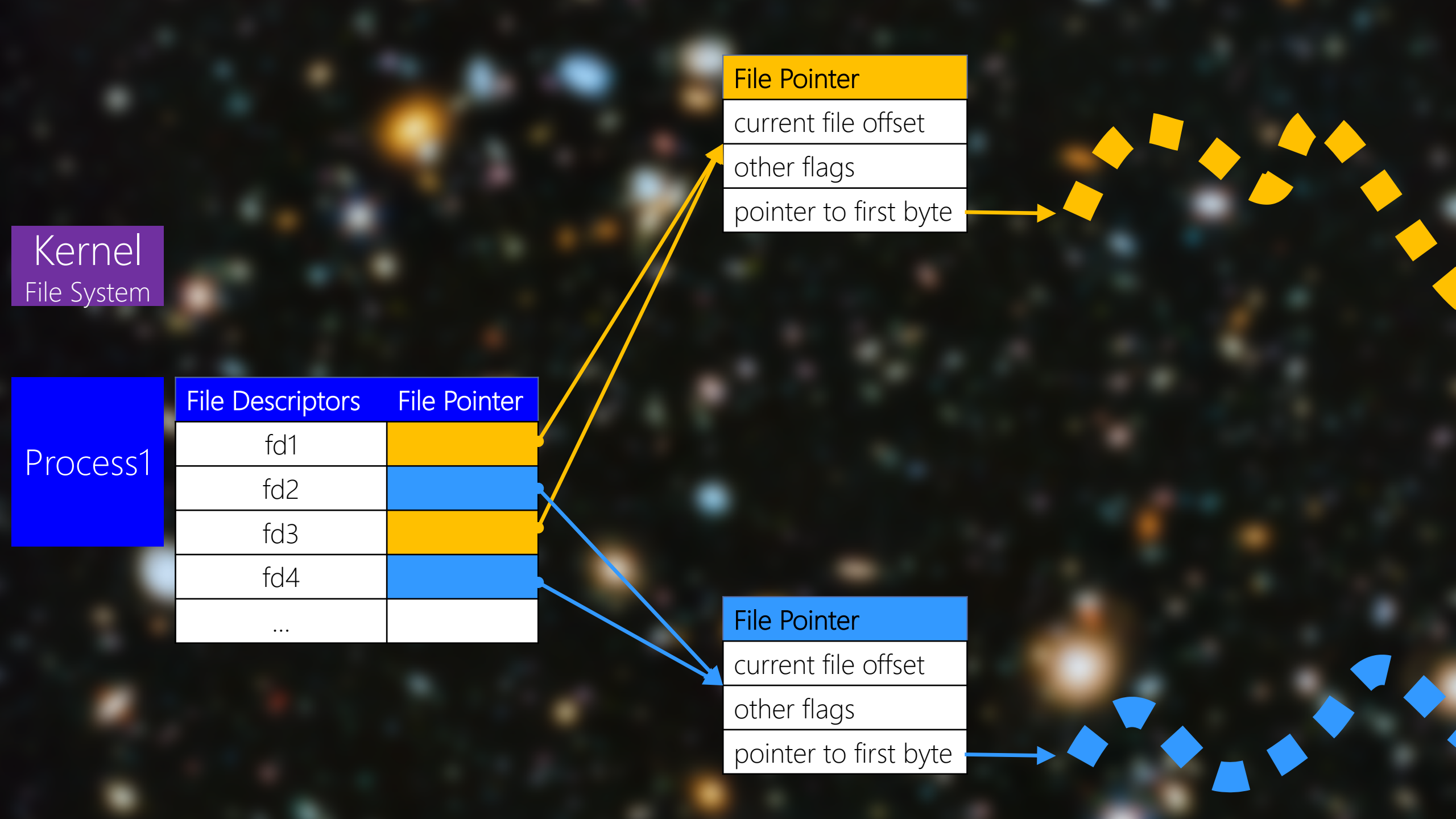


How to have multiple fds to the same file/device?
Multiple system calls for the same file!
`open()`

dup

```
#include <unistd.h>
int dup(int fd);
```

new file descriptor to the same file if OK, –1 on error


Kernel
File System
Process1
File Descriptors
File Pointer
fd1
fd2
fd3
fd4
...
File Pointer
current file offset
other flags
pointer to first byte
File Pointer
current file offset
other flags
pointer to first byte

dup vs. multiple open

open: each returned fd has its own properties and current offset

```
fd1 = open("test.txt", O_RDONLY)
fd2 = open("test.txt", O_WRONLY)
```

dup vs. multiple open

`dup:` each returned fd has the same properties and current offset

```
fd2 = dup(fd1)
```

dup

Why do we duplicate fd?

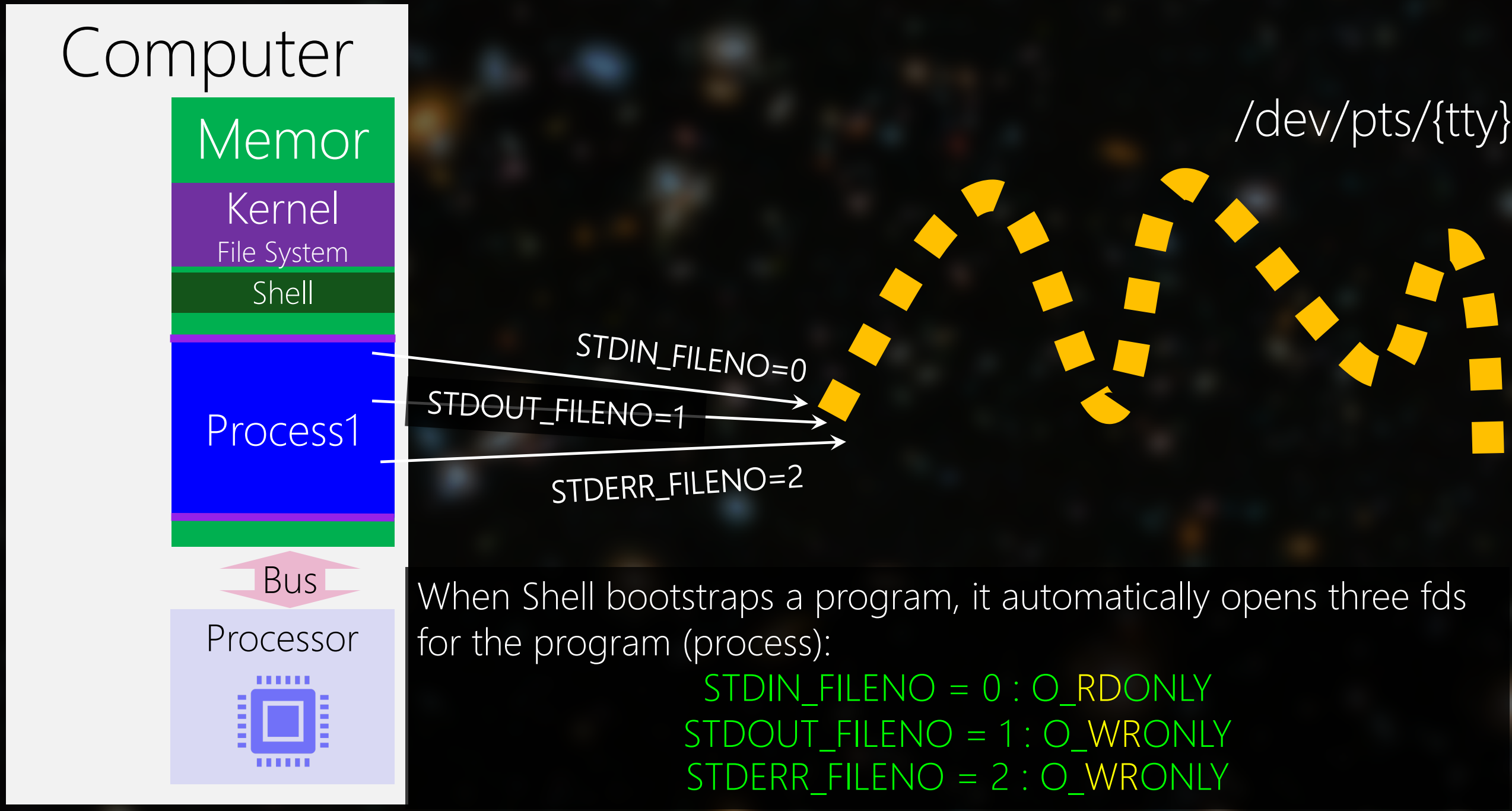
I/O Redirection

STDIO ↔ File

STDERR → STDOUT

Story

How STDIN_FILENO, STDOUT_FILENO, STDERR_FILENO are mapped and by who?



When Shell bootstraps a program, it automatically opens three fds for the program (process):

STDIN_FILENO = 0 : O_RDONLY

STDOUT_FILENO = 1 : O_WRONLY

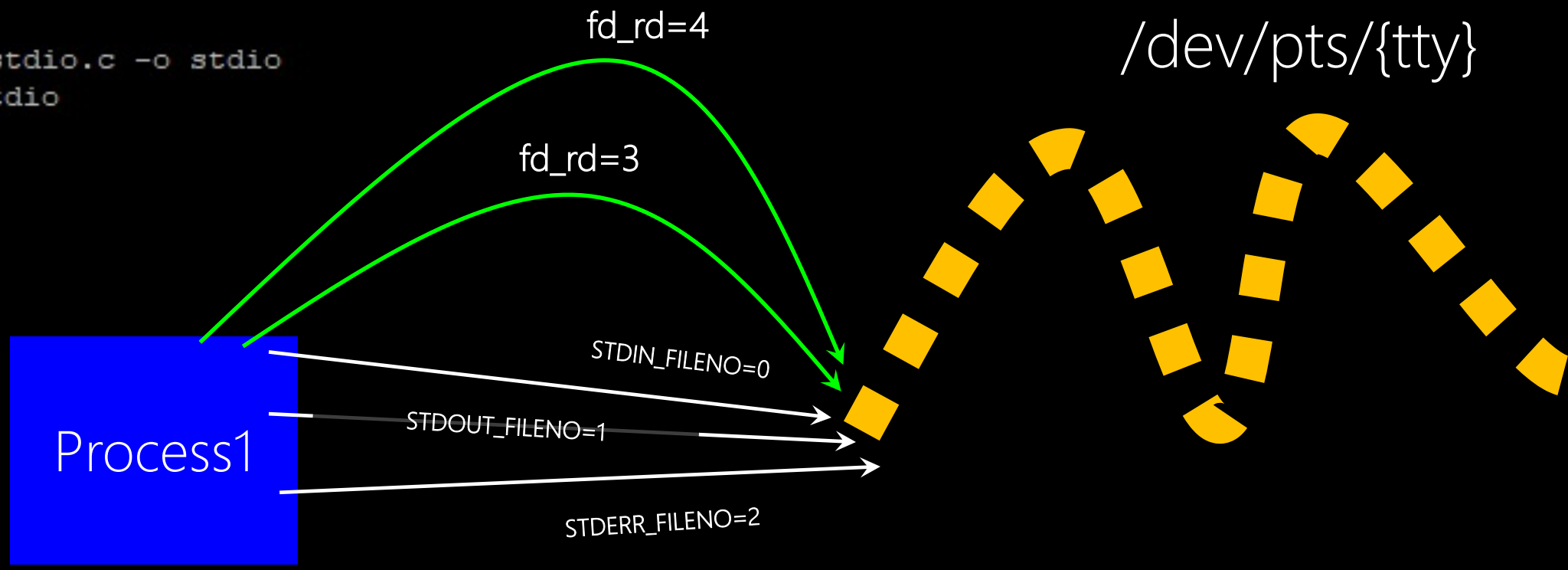
STDERR_FILENO = 2 : O_WRONLY

```c
#include <fcntl.h>
#include <unistd.h>
void main(void){

 char buf_rd[20];

 int fd_rd = open("/dev/pts/12", O_RDONLY);
 int res = read(fd_rd, buf_rd, 10);
 int fd_wr = open("/dev/pts/12", O_WRONLY);
 write(fd_wr, buf_rd, 10);
```

```c
#include <fcntl.h>
#include <unistd.h>
void main(void){

char buf_rd[20];

read(STDIN_FILENO, buf_rd, 10);
write(STDOUT_FILENO, buf_rd, 10);
```

```c
#include <fcntl.h>
#include <unistd.h>
void main(void){

 char buf_rd[20];

 read(0, buf_rd, 10);
 write(1, buf_rd, 10);
```

```
hfani@charlie:~$ cc stdio.c -o stdio
hfani@charlie:~$ ./stdio
comp2560
comp2560
hfani@charlie:~$
```




Computer
Memor
Kernel
File System
Shell
Process1
Bus
Processor
/dev/pts/{tty}
STDIN_FILENO=0
STDOUT_FILENO=1
STDERR_FILENO=2
Now, we want to redirect output to a logging file ./log.txt
STDIN_FILENO = 0 : O_RDONLY
STDOUT_FILENO = 1 : O_WRONLY
STDERR_FILENO = 2 : O_WRONLY

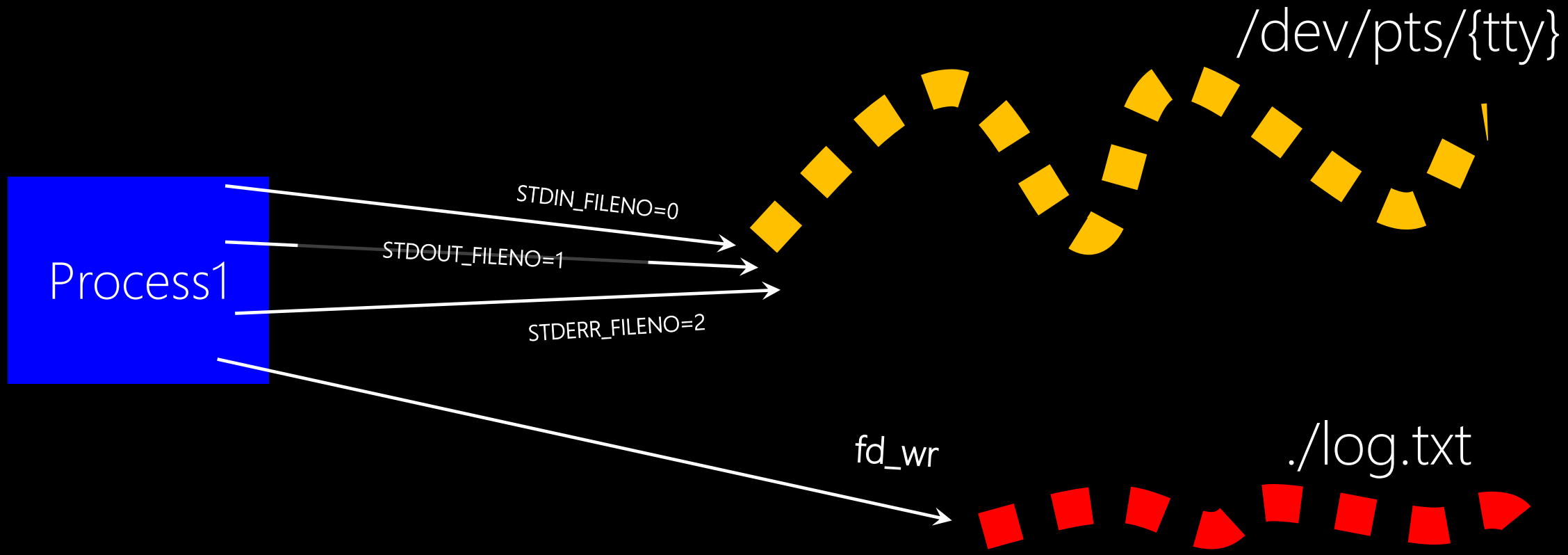
Now, we want to redirect output to a logging file ./log.txt

STDIN_FILENO = 0 : O_RDONLY

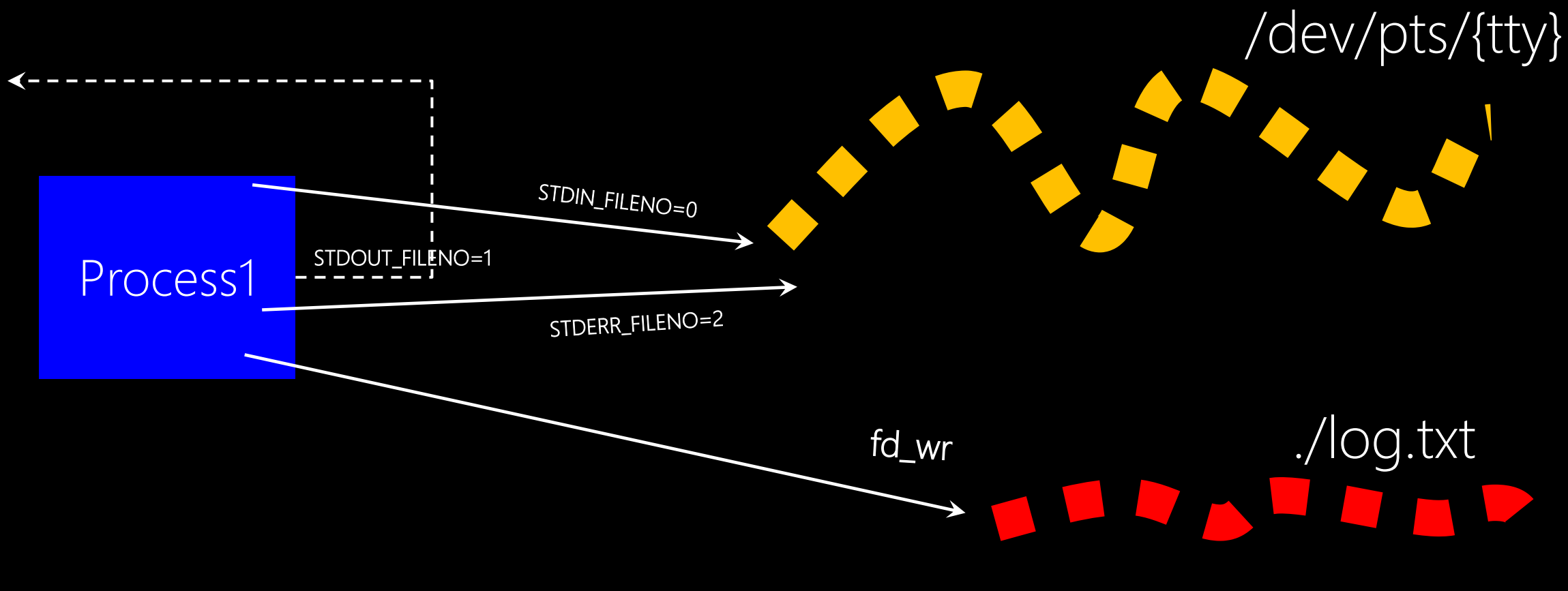
STDOUT_FILENO = 1 : O_WRONLY

STDERR_FILENO = 2 : O_WRONLY

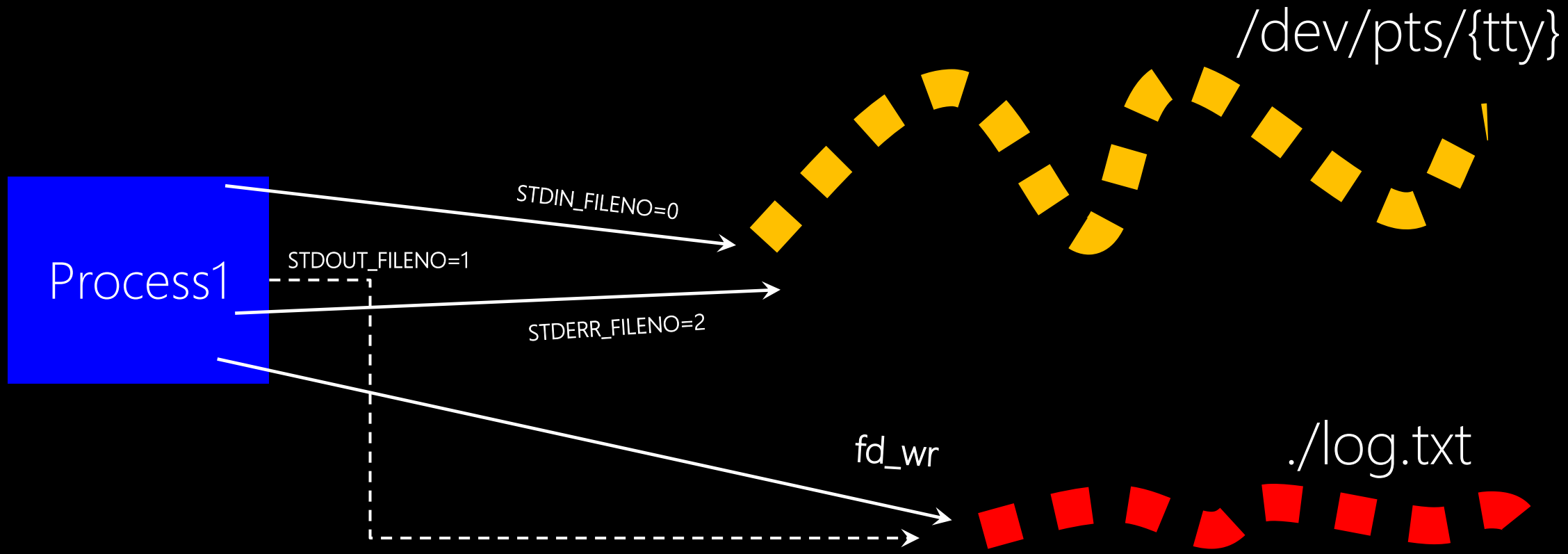
```c
#include <fcntl.h>
#include <unistd.h>
void main(void){
        char buf_rd[20];

        int fd_wr = open("./log.txt", O_WRONLY | O_CREAT, S_IRUSR | S_IWUSR);
```



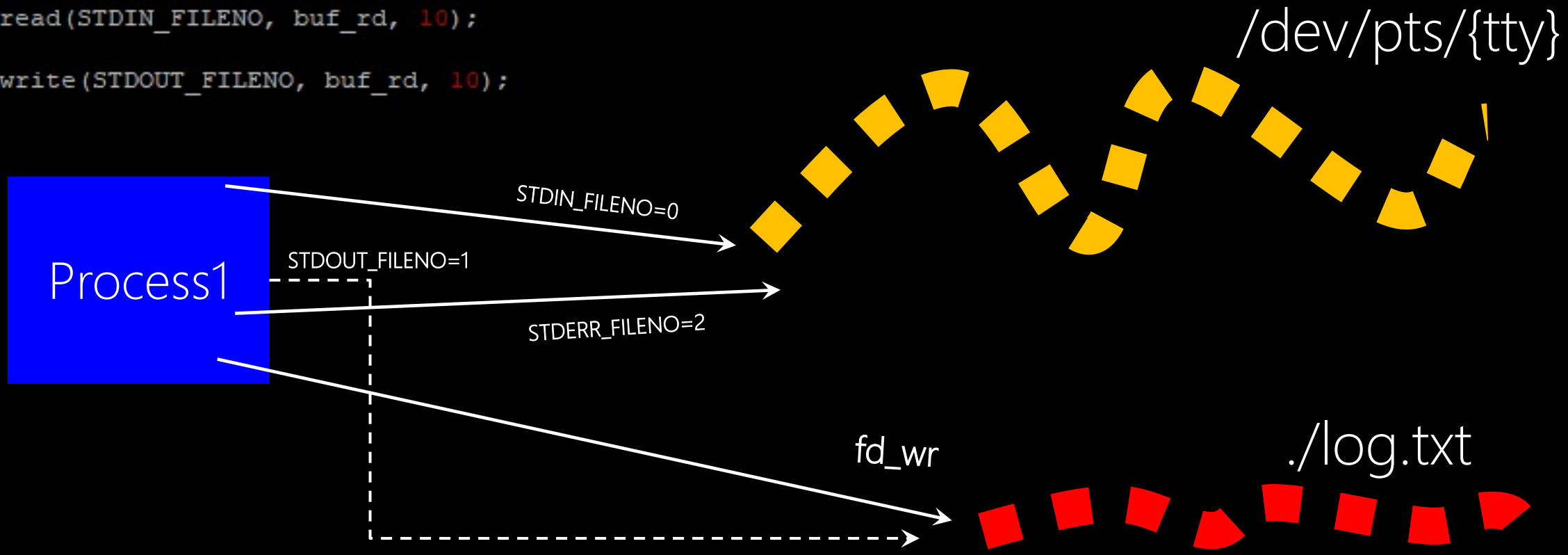
```c
#include <fcntl.h>
#include <unistd.h>
void main(void){
        char buf_rd[20];

        int fd_wr = open("./log.txt", O_WRONLY | O_CREAT, S_IRUSR | S_IWUSR);
        close(1);
        //now the fd with value 1 is free
```



```c
#include <fcntl.h>
#include <unistd.h>
void main(void){
        char buf_rd[20];

        int fd_wr = open("./log.txt", O_WRONLY | O_CREAT, S_IRUSR | S_IWUSR);
        close(1);
        //now the fd with value 1 is free
        //let's get it for our log file
        int new_fd = dup(fd_wr);
        //now the value of new_fd is 1
        //both fd_wr and new_fd are pointing to log.txt
```



```c
#include <fcntl.h>
#include <unistd.h>
void main(void){
        char buf_rd[20];

        int fd_wr = open("./log.txt", O_WRONLY | O_CREAT, S_IRUSR | S_IWUSR);
        close(1);
        //now the fd with value 1 is free
        //let's get it for our log file
        int new_fd = dup(fd_wr);
        //now the value of new_fd is 1
        //both fd_wr and new_fd are pointing to log.txt

        read(STDIN_FILENO, buf_rd, 10);

        write(STDOUT_FILENO, buf_rd, 10);
```



```
hfani@charlie:~$ cc stdio_redirection.c -o stdio_redirection
hfani@charlie:~$ ./stdio_redirection
hey again!
hfani@charlie:~$
hfani@charlie:~$ vi log.txt
```

```
hey again!
~
```

Shell

$ ./program > log.txt

We can ask the shell to do this redirection for us

{program file} > *{new destination for* STDOUT_FILENO*}*


Story
How about STDIN_FILENO? STDERR_FILENO?

Story

What does this mean and what is the benefit?

```
fd = dup(0)
```

dup2

At Home

I/O Efficiency
buffered vs. unbuffered

`unistd.h vs. stdio.h`

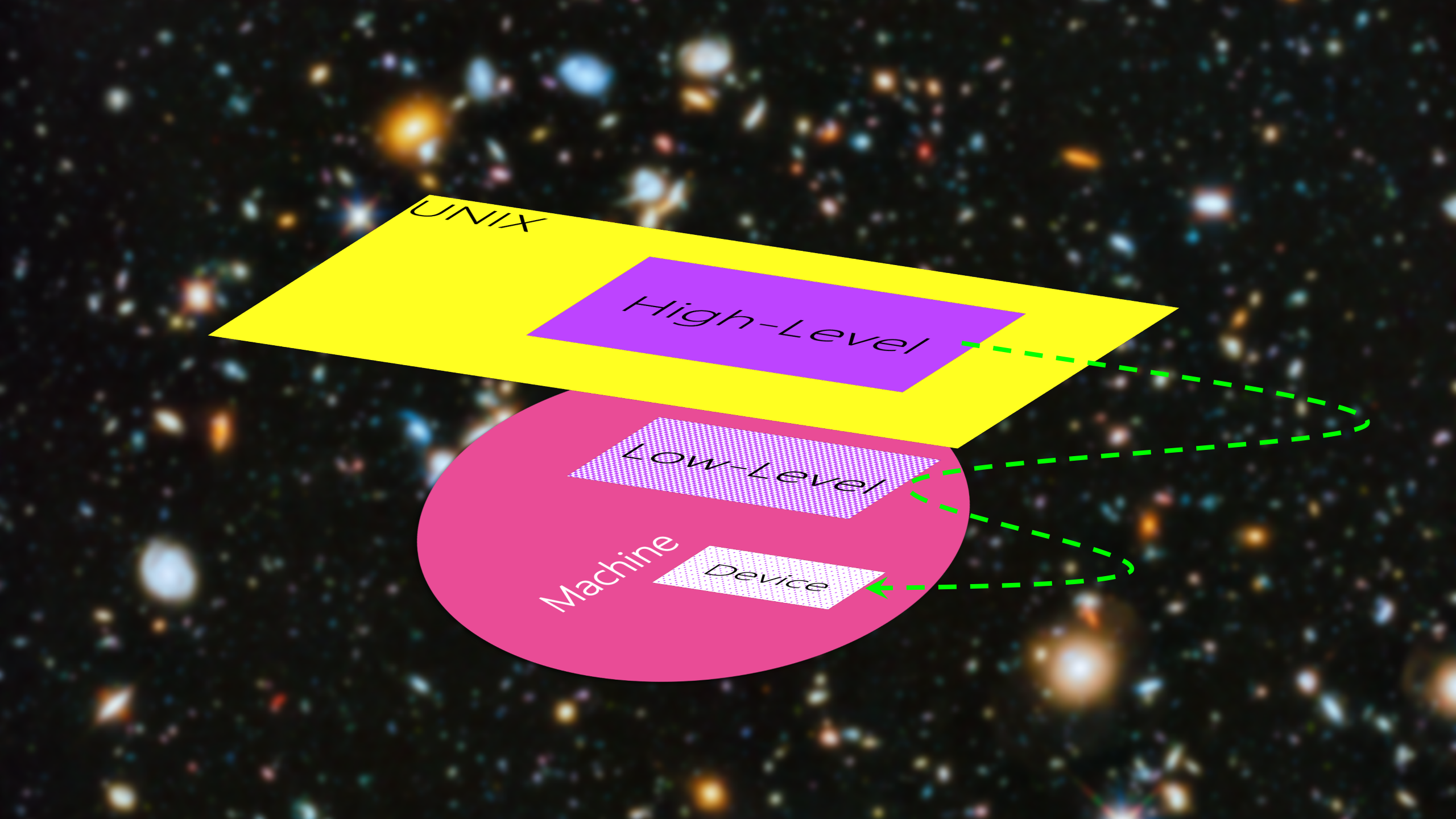
At Home.

File Sharing

Advanced! We won’t cover it.

Atomic Operation

Advanced! We won’t cover it.


UNIX
High-Level
Low-Level
Machine
Device

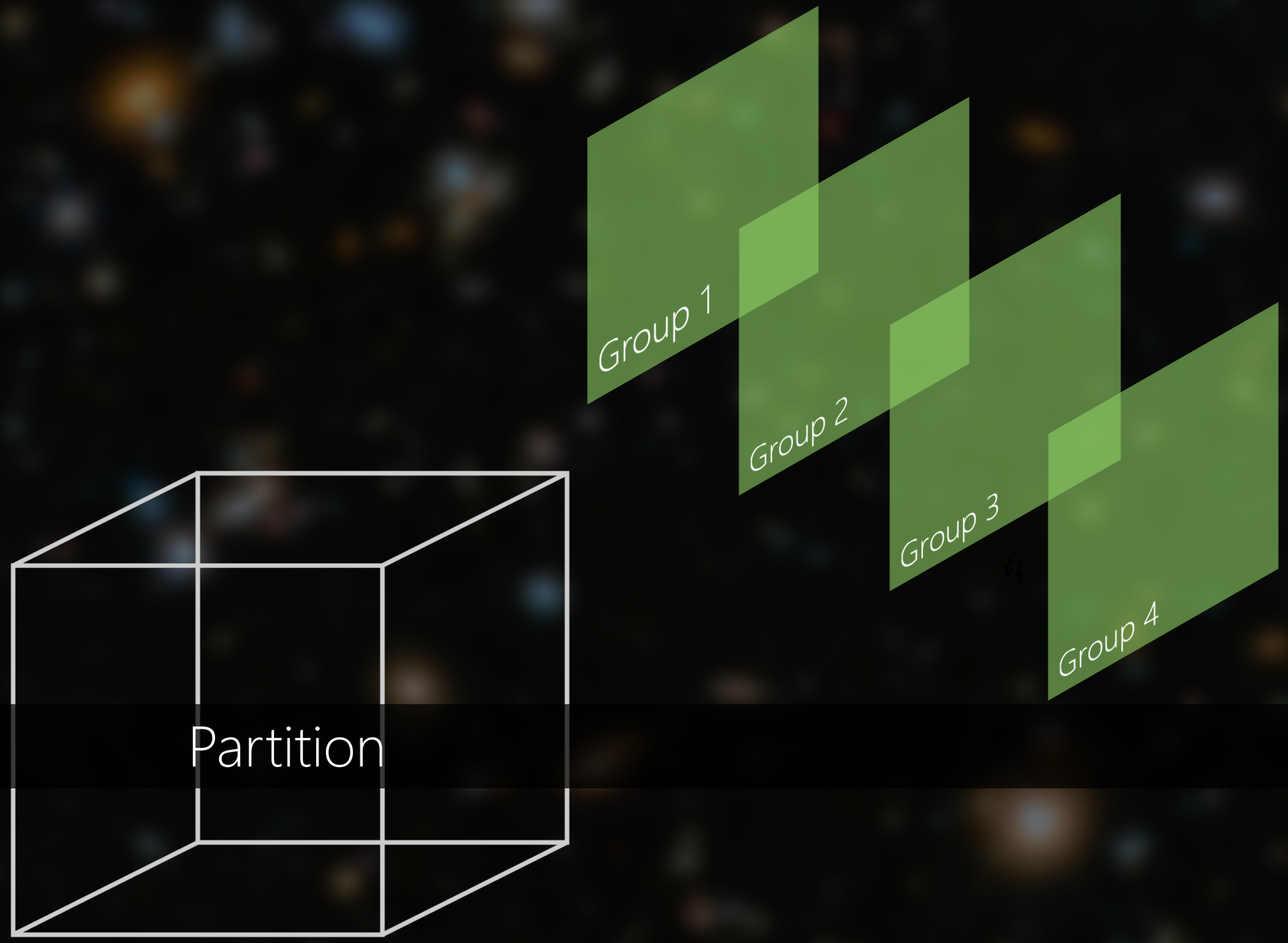
Storage File System

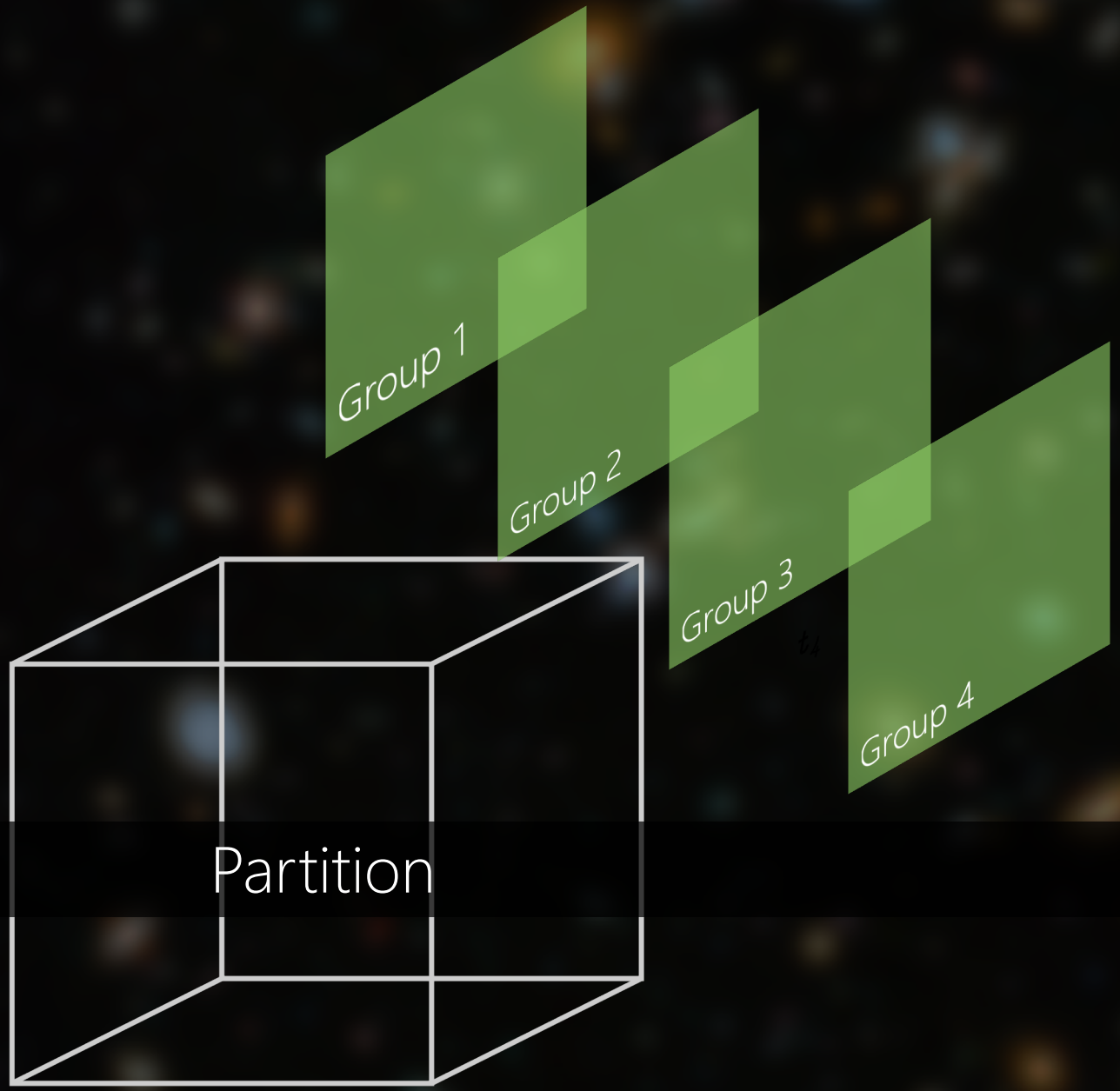
Disk File System

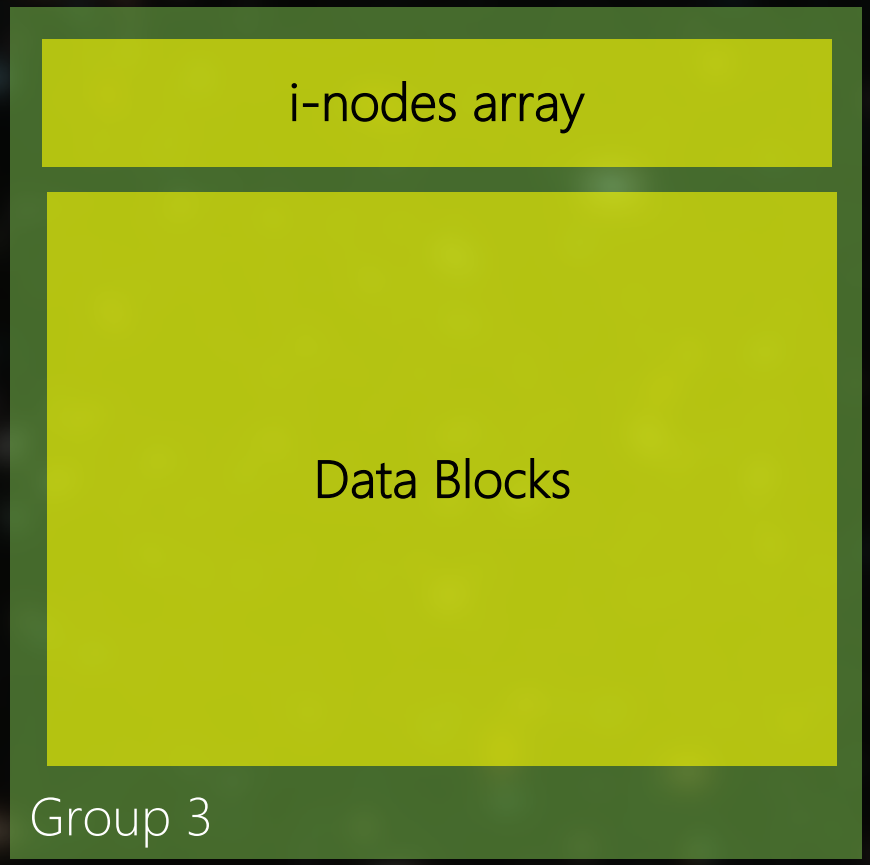
File System: Low Level

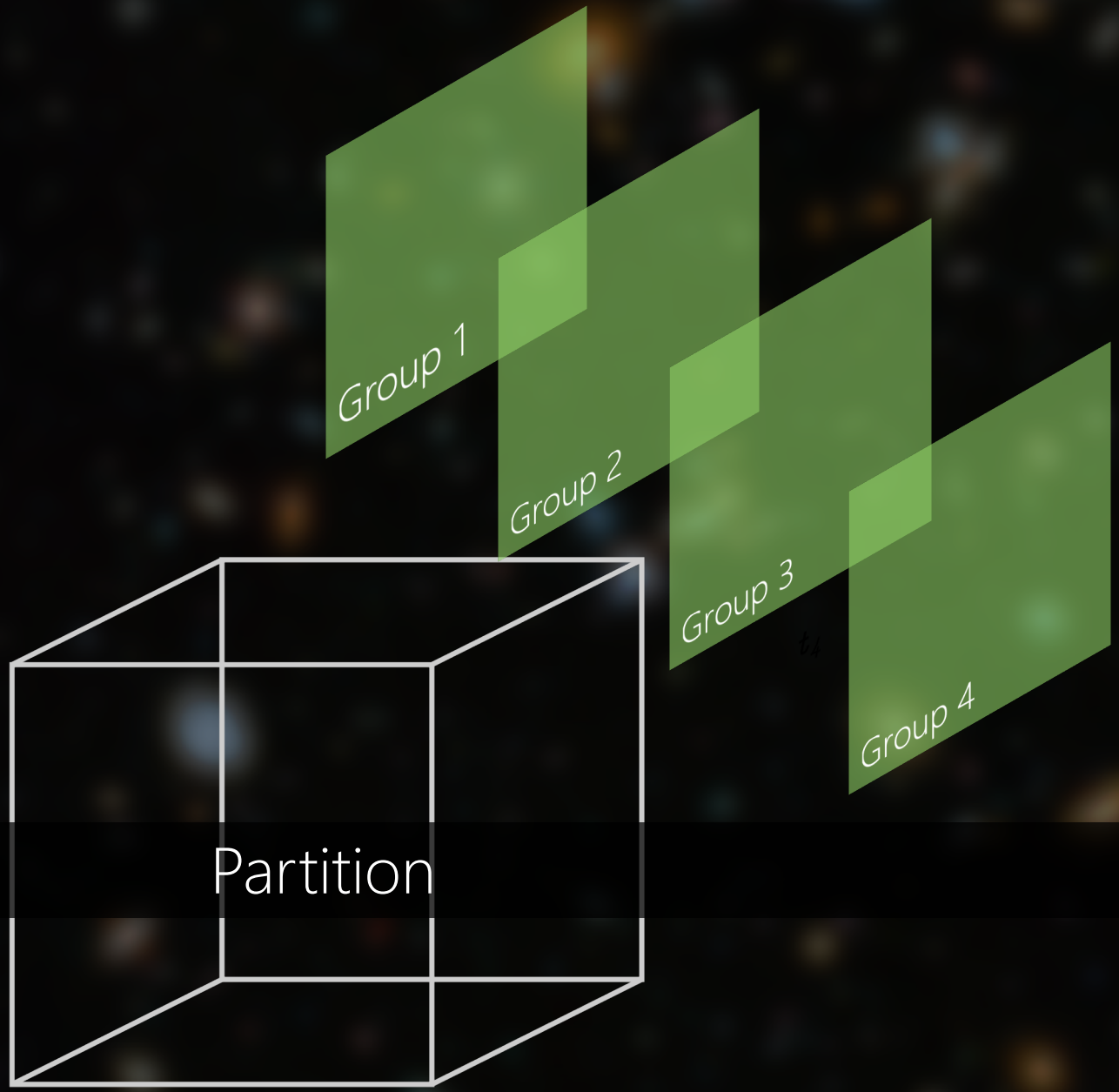

Storage

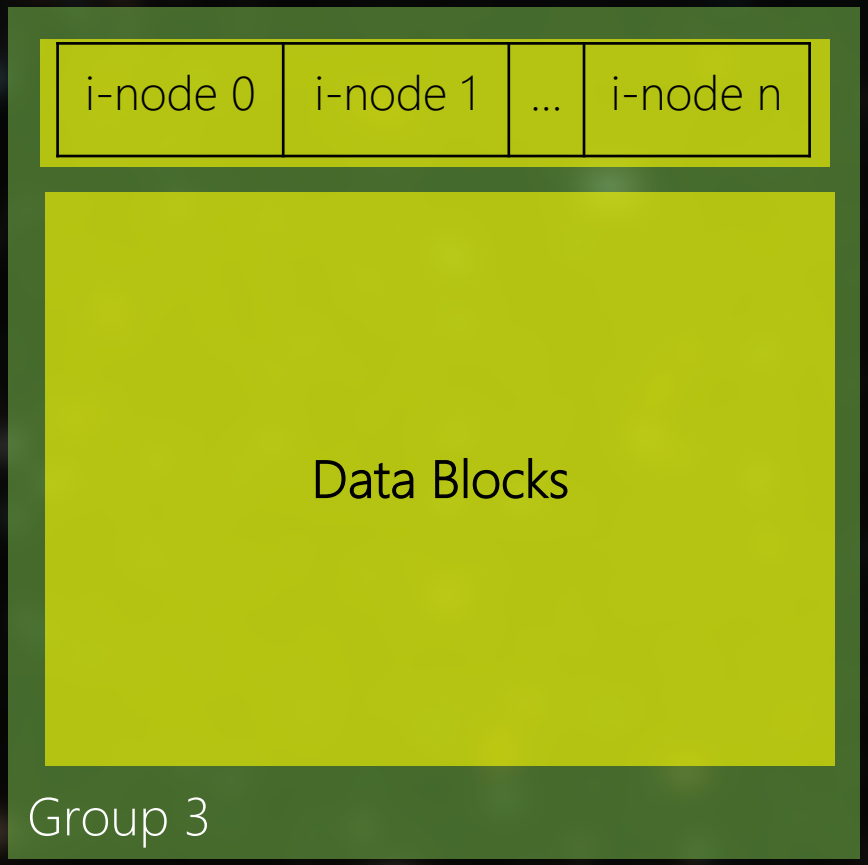
Partition


Group 1
Group 2
Group 3
Group 4
Partition


Group 1
Group 2
Group 3
Group 4
Partition


i-nodes array
Data Blocks
Group 3

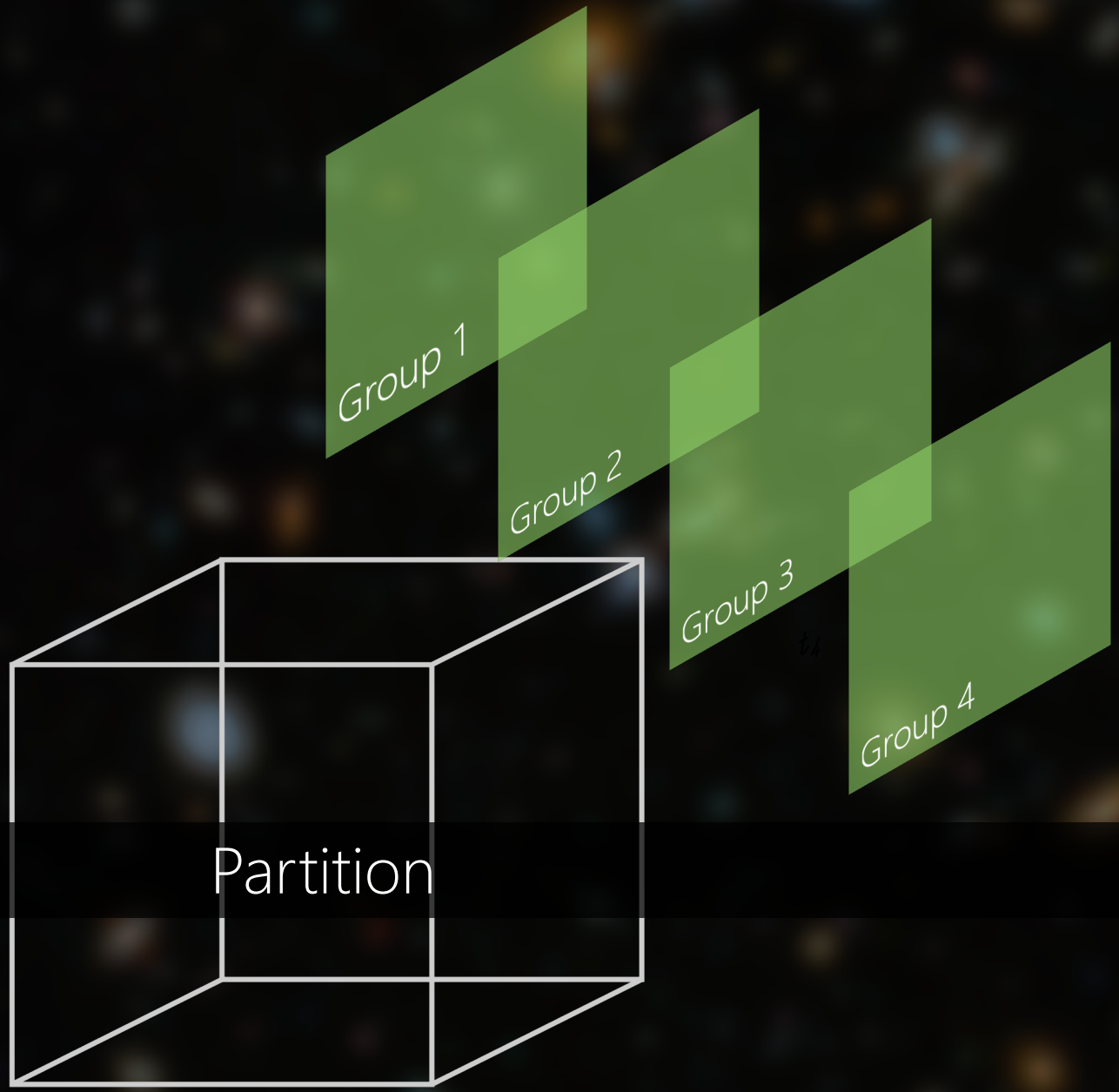

Group 1
Group 2
Group 3
Group 4
Partition

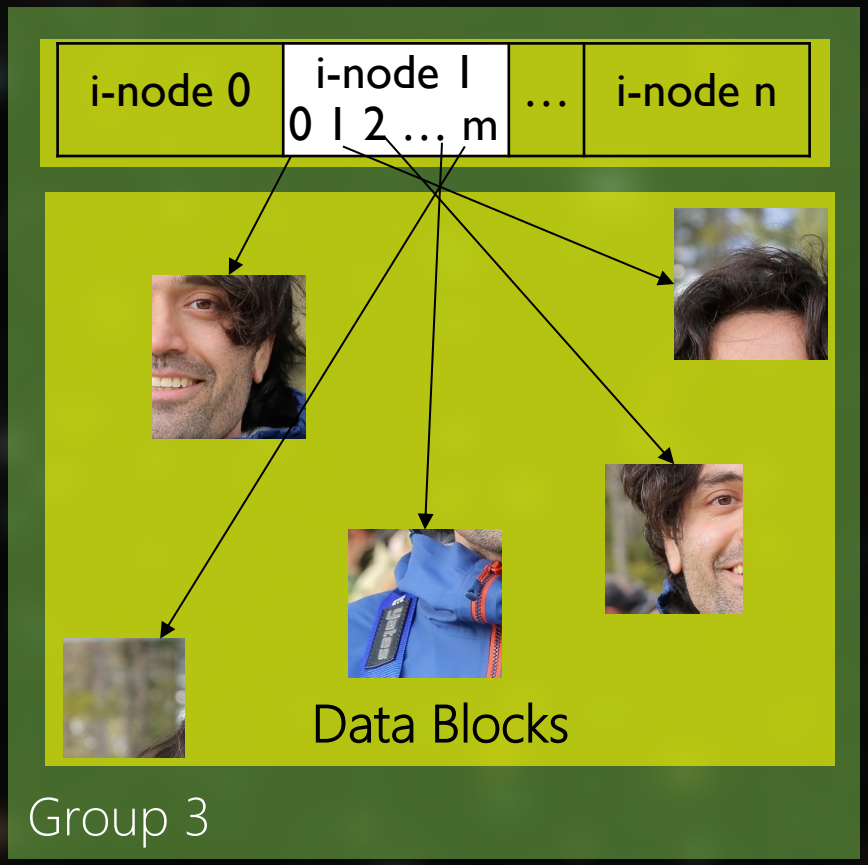

i-node 0
i-node 1
...
i-node n
Data Blocks
Group 3

Each File has one i-node

`$ ls -i {filename}`

```
Administrator@hfani ~
$ ls -i /cygdrive/c/hfani.jpeg
1407374883666816 /cygdrive/c/hfani.jpeg
```


Group 1
Group 2
Group 3
Group 4
Partition


i-node 0
i-node 1
0 1 2 … m
…
i-node n
Data Blocks
Group 3

Each File has many data blocks

$ stat {filename}

```
Administrator@hfani ~
$ stat /cygdrive/c/hfani.jpeg
  File: /cygdrive/c/hfani.jpeg
  Size: 113327          Blocks: 112        IO Block: 65536  regular file
Device: 7ede359eh/2128491934d   Inode: 1407374883666816  Links: 1
Access: (0750/-rwxr-x---)  Uid: (  544/Administrators)   Gid: (197121/    None)
Access: 2021-10-25 00:07:34.744221300 -0400
Modify: 2021-07-05 22:48:41.000000000 -0400
```

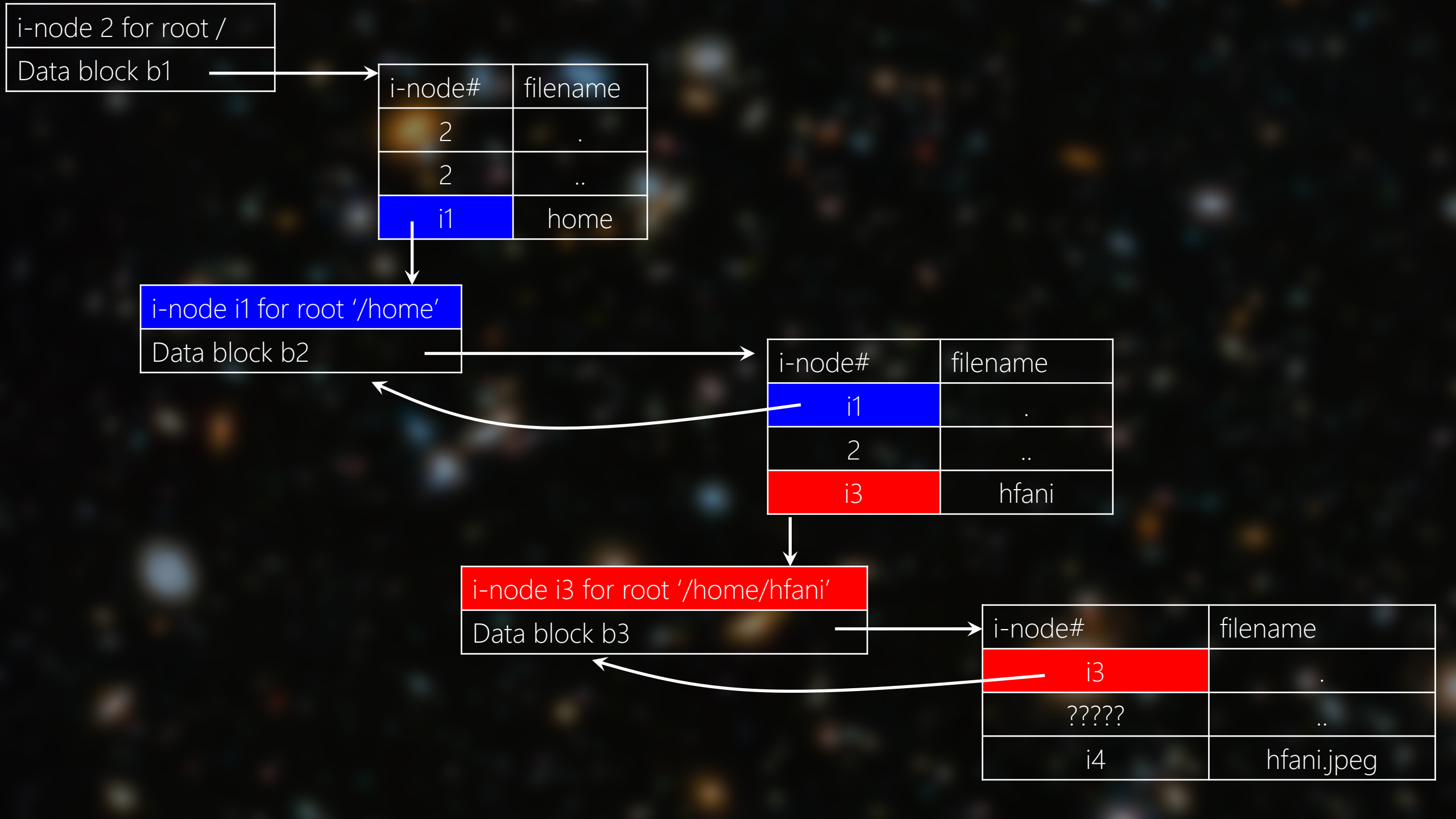
/Path/Filename ⟶ i-node ⟶ Data Blocks

`/cygdrive/c/hfani.jpeg → 1407374883666816 →` 

Directories

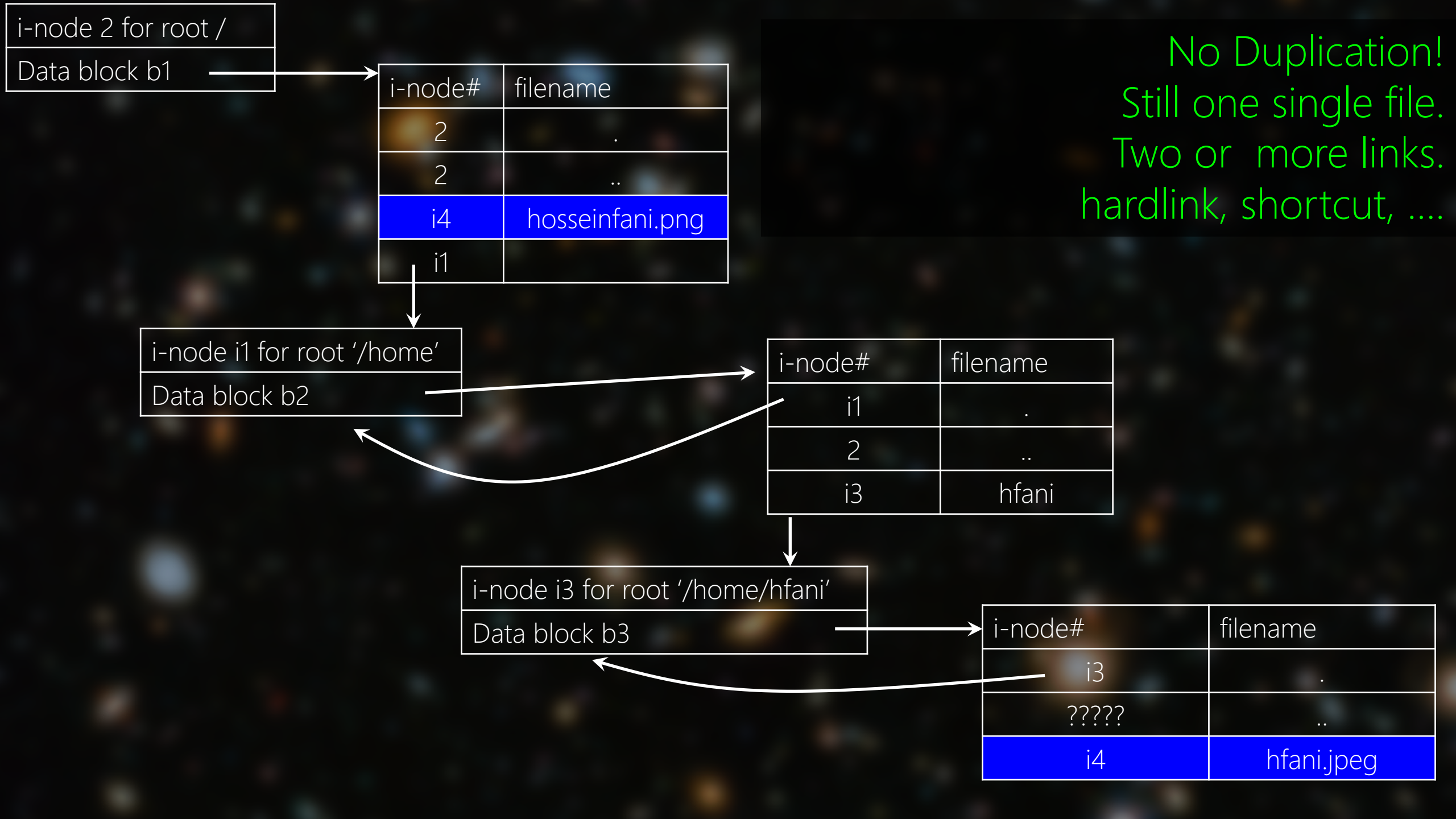
They are files. So, each of them has one i-node.

The content is not an image, audio, … but mapping between filenames and their i-nodes


i-node 2 for root /
Data block b1
i-node#
filename
2
.
2
..
i1
home
i-node i1 for root '/home'
Data block b2
i-node#
filename
i1
.
2
..
i3
hfani
i-node i3 for root '/home/hfani'
Data block b3
i-node#
filename
i3
.
?????
..
i4
hfani.jpeg

Directories

Is it possible to have multiple links to the same file? Yes.
How?


i-node 2 for root /
Data block b1
i-node#
filename
2
.
2
..
i4
hosseinfani.png
i1
i-node i1 for root '/home'
Data block b2
i-node#
filename
i1
.
2
..
i3
hfani
i-node i3 for root '/home/hfani'
Data block b3
i-node#
filename
i3
.
?????
..
i4
hfani.jpeg
No Duplication!
Still one single file.
Two or more links.
hardlink, shortcut, ...

What happens when you delete a file?

What happens when you move a file?

What happens when you copy a file?