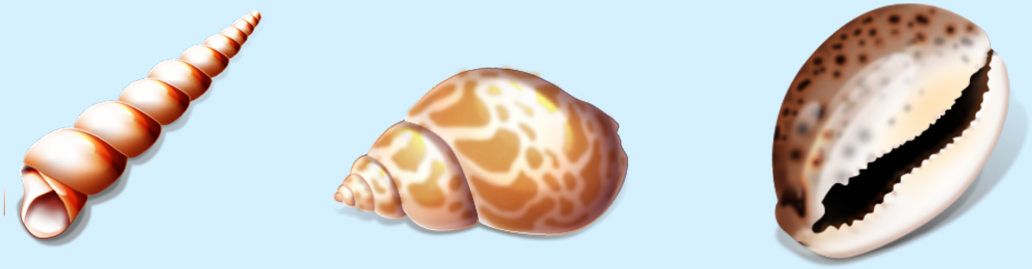
CS 33

Shells and Files

Shells

- Command and scripting languages for Unix
- First shell: Thompson shell
  - sh, developed by Ken Thompson
  - released in 1971
- Bourne shell
  - also sh, developed by Steve Bourne
  - released in 1977
- C shell
  - csh, developed by Bill Joy
  - released in 1978
  - tcsh, improved version by Ken Greer

More Shells



- Bourne-Again Shell
  - bash, developed by Brian Fox
  - released in 1989
  - found to have a serious security-related bug in 2014
    - shellshock
- Almquist Shell
  - ash, developed by Kenneth Almquist
  - released in 1989
  - similar to bash
  - dash (debian ash) used for scripts in Debian and Ubuntu Linux
    - faster than bash
    - less susceptible to shellshock vulnerability

The File Abstraction

- A file is a simple array of bytes
- A file is made larger by writing beyond its current end
- Files are named by paths in a naming tree
- System calls on files are synchronous

Naming

- (almost) everything has a path name
  - files
  - directories
  - devices (known as *special files*)
    - keyboards
    - displays
    - disks
    - etc.

I/O System Calls

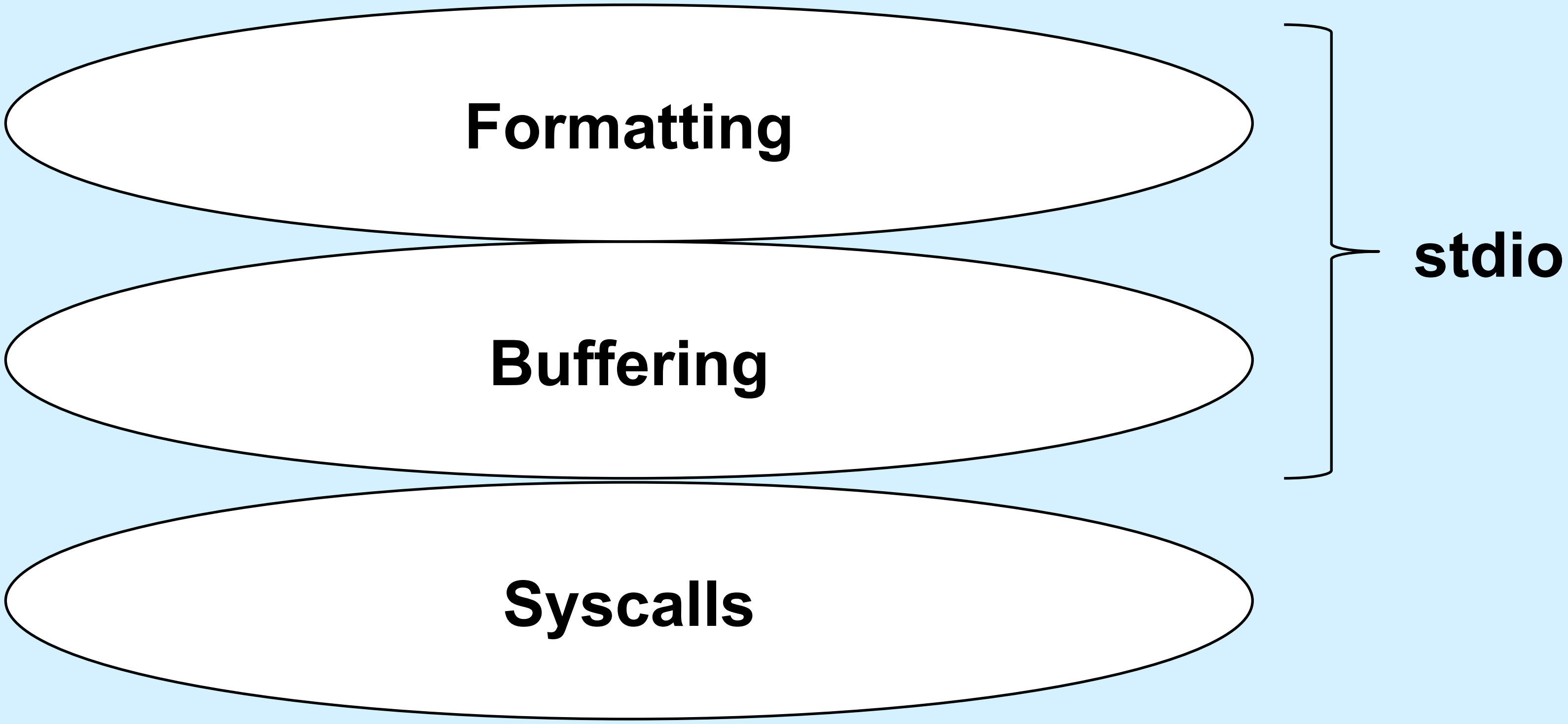
- **int** file_descriptor = open(pathname, mode [, permissions])
- **int** close(file_descriptor)
- **int** count = read(file_descriptor, buffer_address, buffer_size)
- **int** count = write(file_descriptor, buffer_address, buffer_size)

Uniformity

```
int filefd = open("/home/twd/data", O_RDWR);
      // opening a normal file
int devicefd = open("/dev/tty", O_RDWR);
      // opening a device (one’s terminal
      // or window)
// file and device are file descriptors

int bytes = read(filefd, buffer, sizeof(buffer));
write(devicefd, buffer, bytes);
```

Standard I/O Library



Standard File Descriptors

```
int main( ) {
  char buf[BUFSIZE];
  int n;
  const char *note = "Write failed\n";

  while ((n = read(0, buf, sizeof(buf))) > 0)
    if (write(1, buf, n) != n) {
          write(2, note, strlen(note));
          exit(1);
    }
  return(0);
}
```

A Program

```
int main(int argc, char *argv[]) {
  if (argc != 2) {
    fprintf(stderr, "Usage: echon reps\n");
    exit(0);
  }
  int reps = atoi(argv[1]);
  if (reps > 2) {
    fprintf(stderr, "reps too large, reduced to 2\n");
    reps = 2;
  }
  char buf[256];
  while (fgets(buf, 256, stdin) != NULL)
    for (int i=0; i<reps; i++)
      fputs(buf, stdout);
  return(0);
}
```

From the Shell ...

```
$ echon 1
```

- *stdout* and *stderr* go to the display
- *stdin* comes from the keyboard

```
$ echon 1 > Output
```

- *stdout* goes to the file “Output” in the current directory
- *stderr* goes to the display
- *stdin* comes from the keyboard

```
$ echon 1 < Input
```

- *stdin* comes from the file “Input” in the current directory

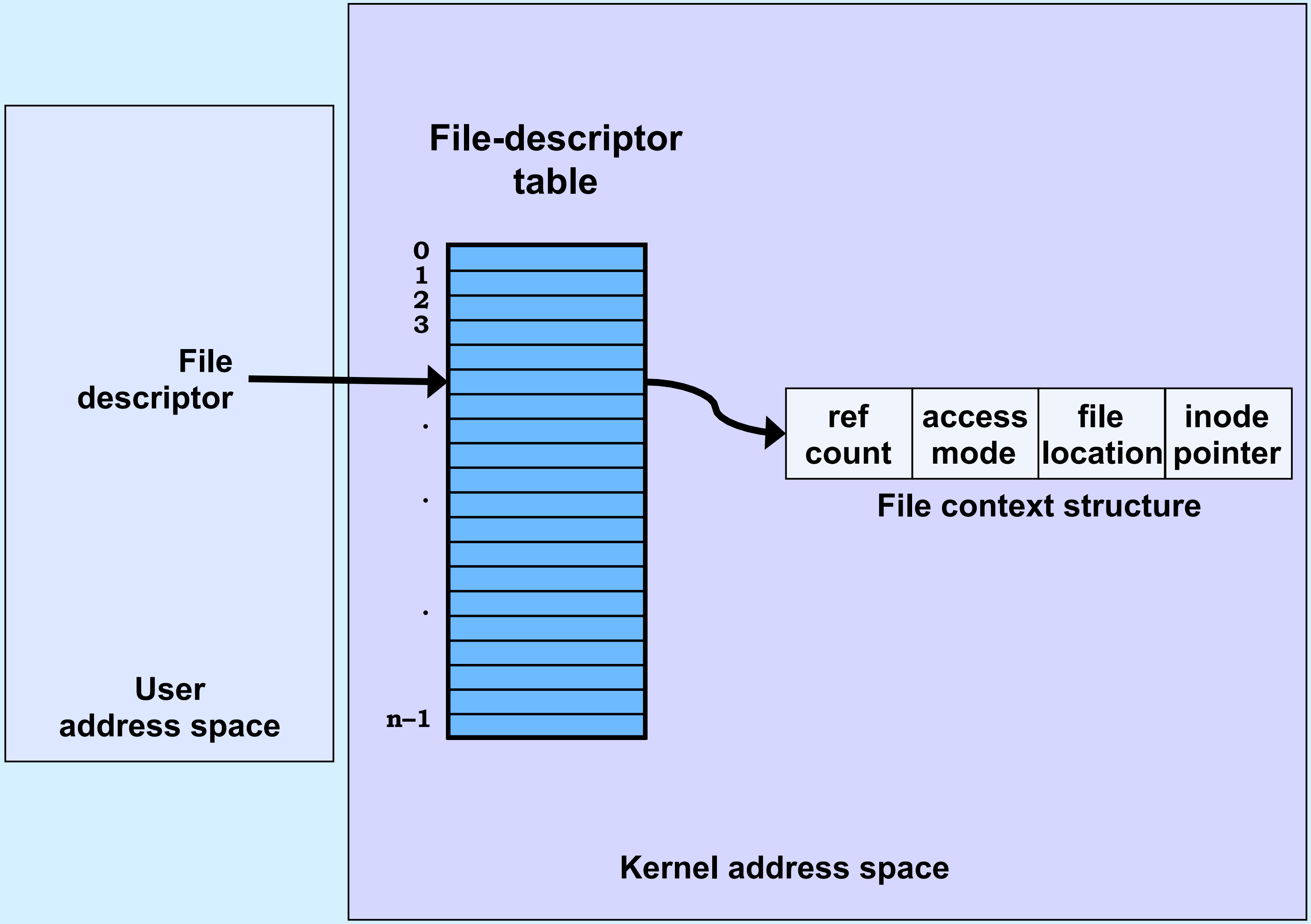
Running It

```
if (fork() == 0) {
   /* set up file descriptor 1 in the child process */
   close(1);
   if (open("/home/twd/Output", O_WRONLY) == -1) {
      perror("/home/twd/Output");
      exit(1);
   }
   char *argv[] = {"echon", "2", 0};
   execv("/home/twd/bin/echon", argv);
   exit(1);
}

/* parent continues here */

while(pid != wait(0))      /* ignore the return code */
   ;
```

File-Descriptor Table



Allocation of File Descriptors

- **Whenever a process requests a new file descriptor, the lowest-numbered file descriptor not already associated with an open file is selected; thus**

```
#include <fcntl.h>
#include <unistd.h>

close(0);
fd = open("file", O_RDONLY);
```

  - **will always associate *file* with file descriptor 0 (assuming that the *open* succeeds)**

Redirecting Output … Twice

```
if (fork() == 0) {
   /* set up file descriptors 1 and 2 in the child process */
   close(1);
   close(2);
   if (open("/home/twd/Output", O_WRONLY) == -1) {
      exit(1);
   }
   if (open("/home/twd/Output", O_WRONLY) == -1) {
      exit(1);
   }
   char *argv[] = {"echon", 2};
   execv("/home/twd/bin/echon", argv);
   exit(1);
}
/* parent continues here */
```

From the Shell ...

```
$ echon 1 >Output 2>Output
```

- both stdout and stderr go to Output file

Quiz 1

- **Suppose we run**

```
% echon 3 >Output 2>Output
```

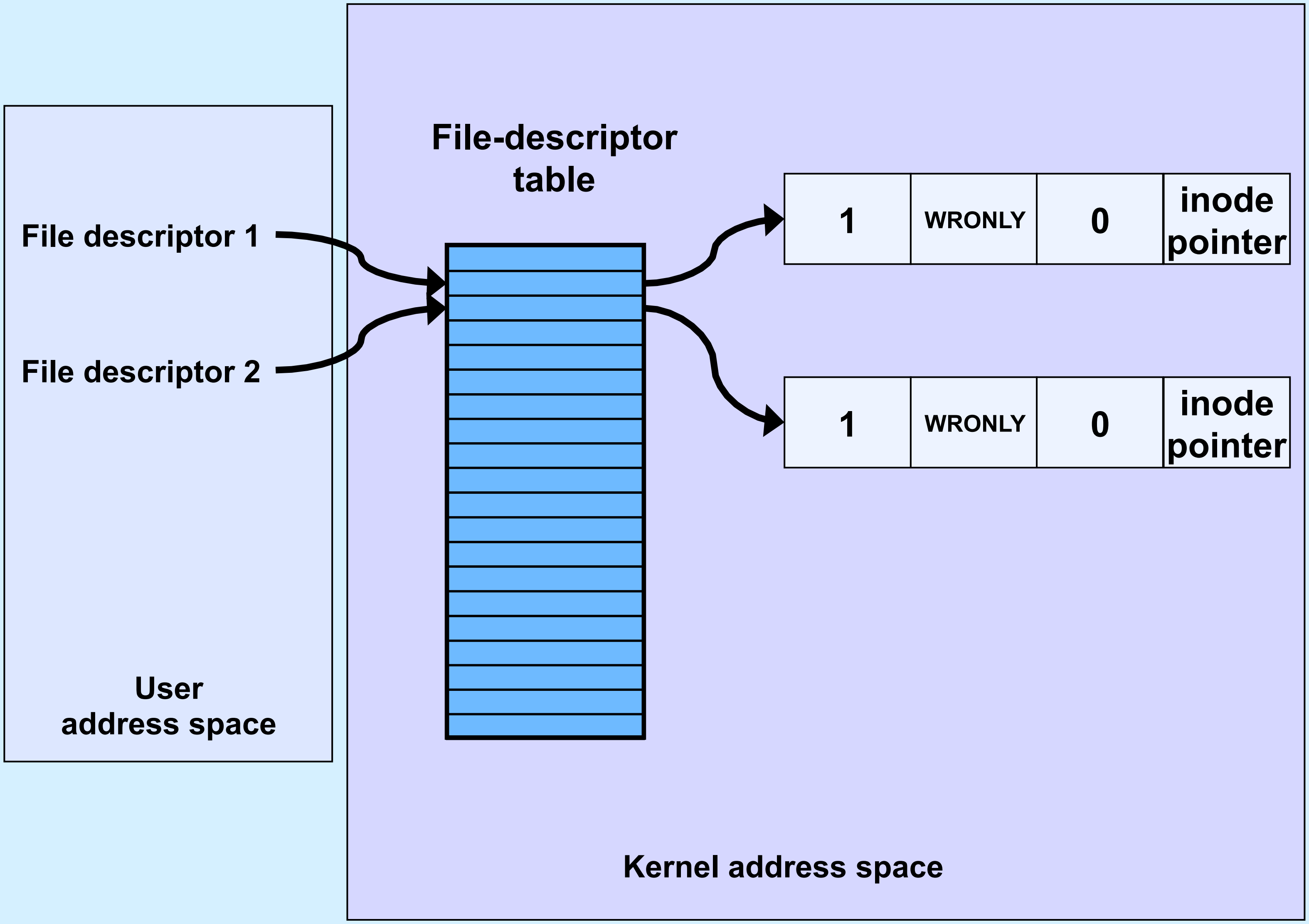
- **The input line is**

```
X
```

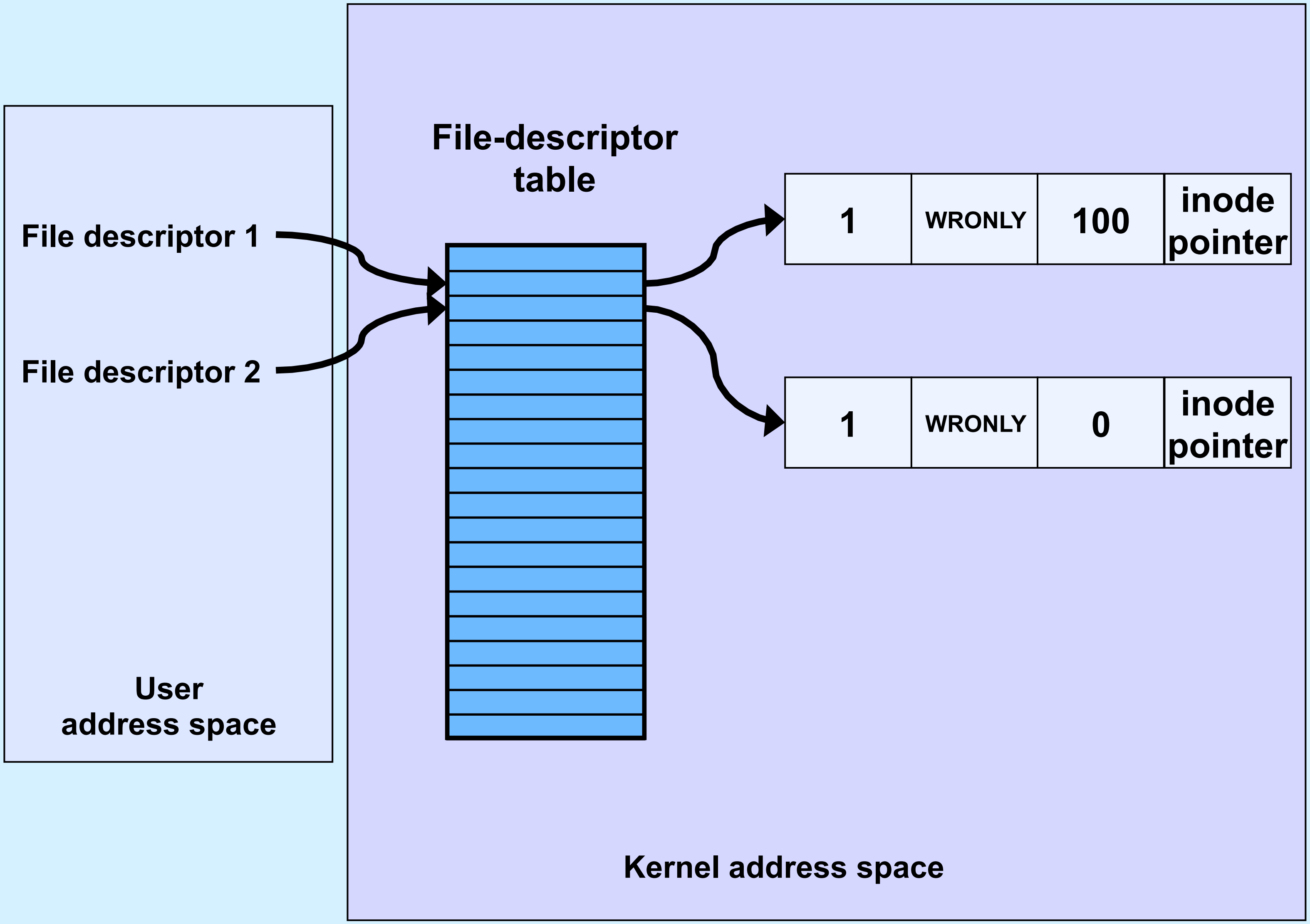
- **What is the final content of Output?**

```
a) reps too large, reduced to 2\nX\nX\n
b) X\nX\nreps too large, reduced to 2\n
c) X\nX\n too large, reduced to 2\n
```

Redirected Output



Redirected Output After Write



File descriptor 1

File descriptor 2

User address space

File-descriptor table

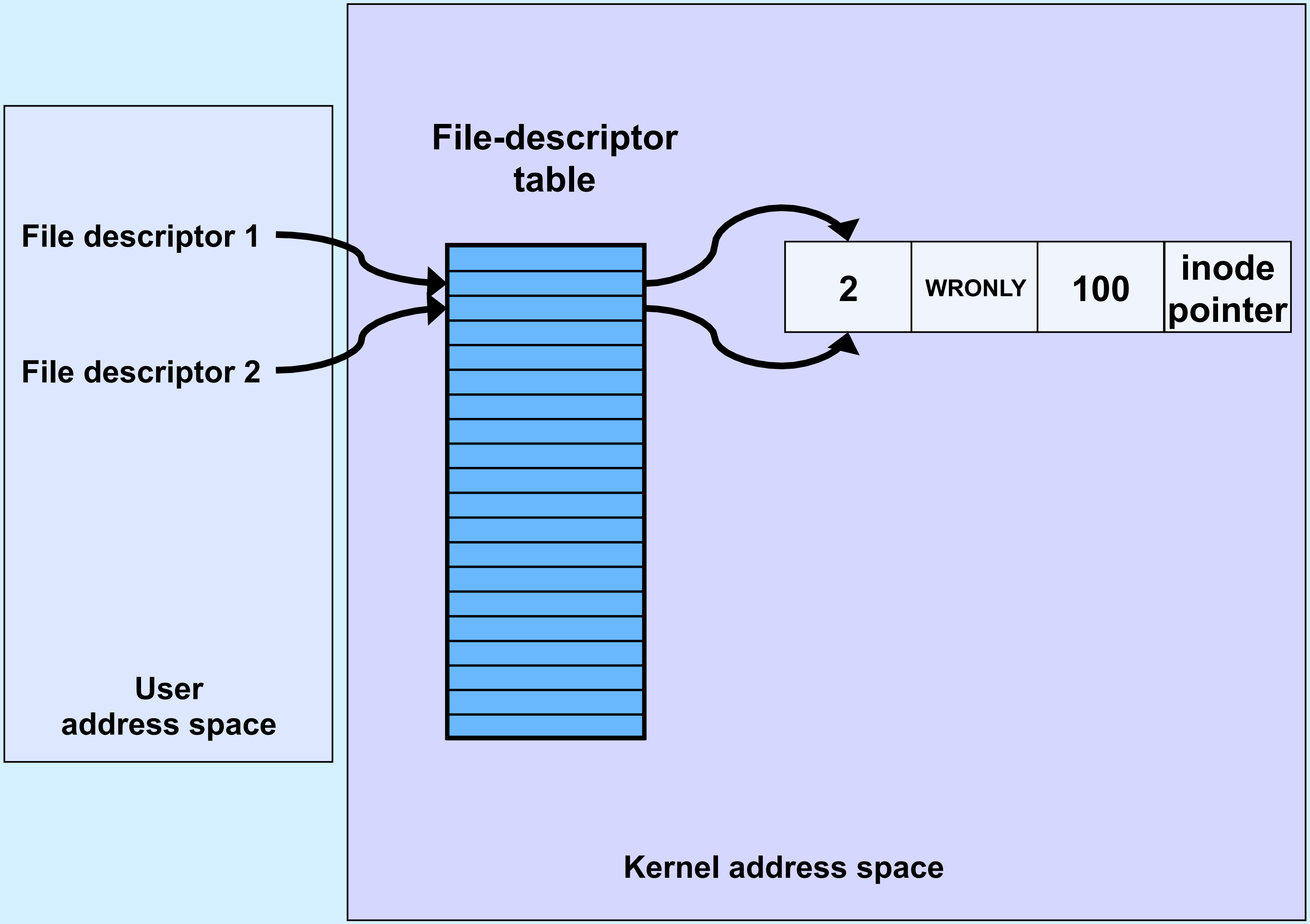
1	WRONLY	100	inode pointer
1	WRONLY	0	inode pointer

Kernel address space

Sharing Context Information

```
if (fork() == 0) {
   /* set up file descriptors 1 and 2 in the child process */
   close(1);
   close(2);
   if (open("/home/twd/Output", O_WRONLY) == -1) {
      exit(1);
   }
   dup(1); /* set up file descriptor 2 as a duplicate of 1 */
   char *argv[] = {"echon", 2};
   execv("/home/twd/bin/echon", argv);
   exit(1);
}
/* parent continues here */
```

Redirected Output After Dup



From the Shell ...

```
$ echon 3 >Output 2>&1
```

- stdout goes to Output file, stderr is the dup of fd 1

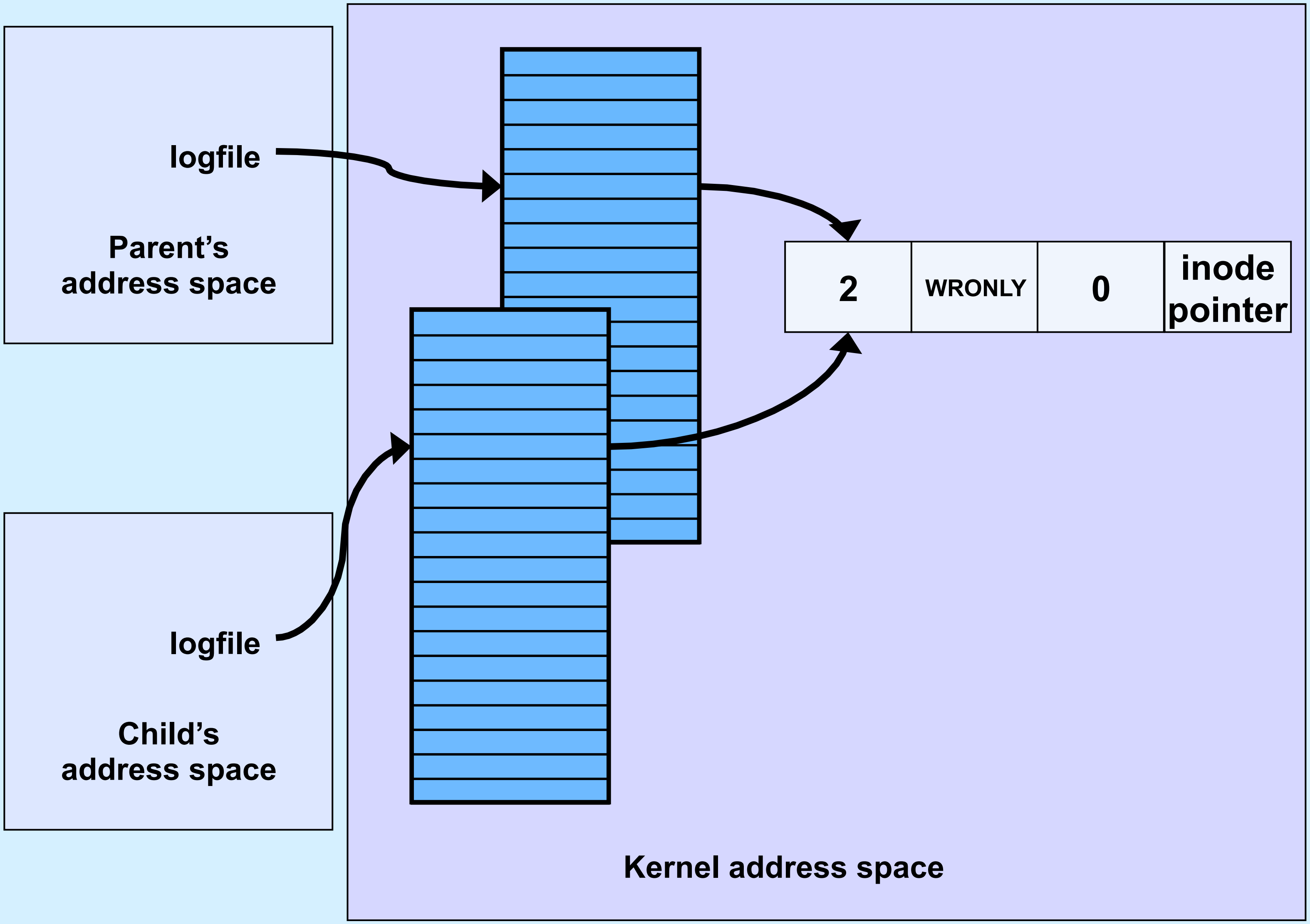
Fork and File Descriptors

```
int logfile = open("log", O_WRONLY);
if (fork() == 0) {
   /* child process computes something, then does: */
   write(logfile, LogEntry, strlen(LogEntry));
   …
   exit(0);
}

/* parent process computes something, then does: */

write(logfile, LogEntry, strlen(LogEntry));
…
```

File Descriptors After Fork



Quiz 2

```
int main() {
  if (fork() == 0) {
    fprintf(stderr, "Child");
    exit(0);
  }
  printf("Parent");
}
```

Suppose the program is run as:

```
% prog >file 2>&1
```

What is the final content of file?

a) either “ChildParent” or “ParentChild”

b) either “Childt” or “Parent”

c) either “Child” or “Parent”