Design and Engineering of Computer Systems
Professor Mythili Vutukuru
Computer Science and Engineering
Indian Institute of Technology, Bombay
Lecture 29 (Week - 4, Tutorial - 1)
File I/O in C

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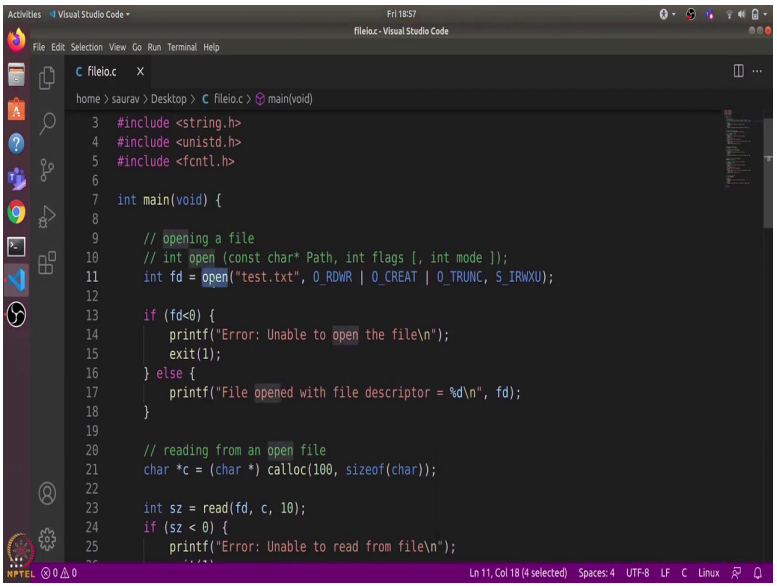

Hi everyone. In this video, we will learn about file I/O in C programming language. So, I have written this fileio.c program. Let us open it with visual code. So, this is the overall code. Let us go over the code. So, here is the main program. The very first system call that we use is the open system call, which is used to open a new file. So, what all argument does it take?

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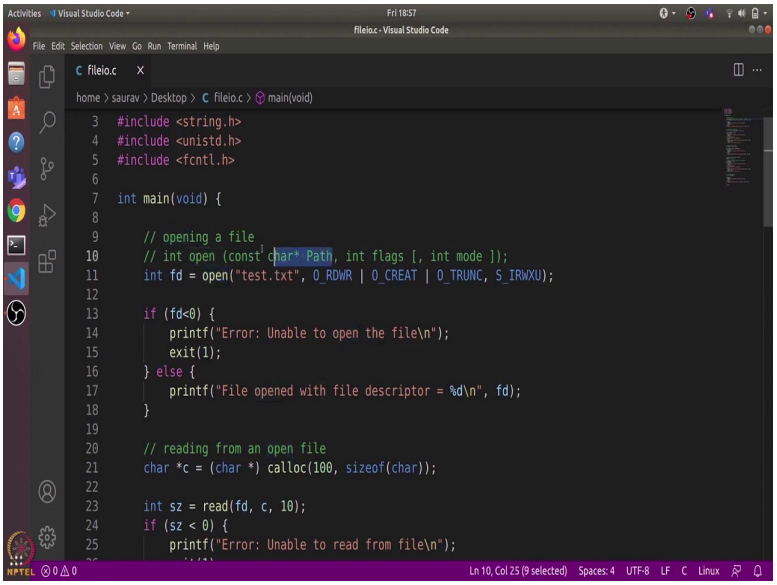
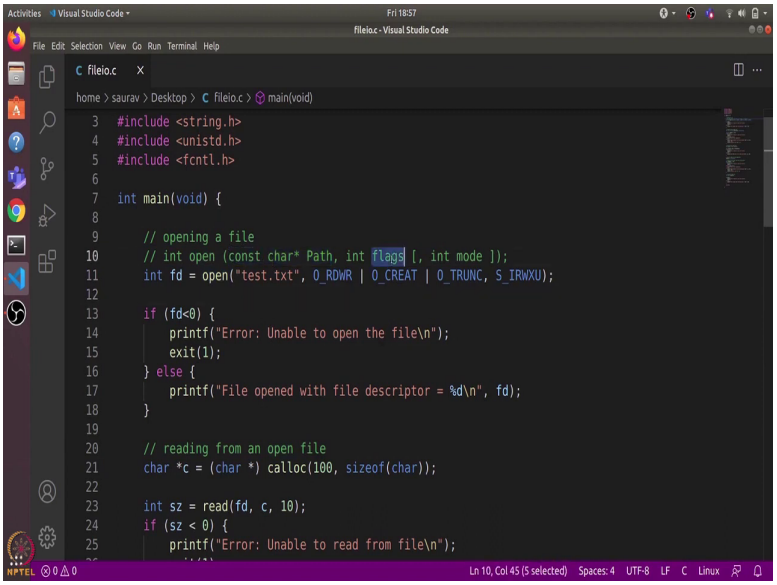

Activities
Visual Studio Code
Fri 18:57
fileio.c - Visual Studio Code
File Edit Selection View Go Run Terminal Help
fileio.c
home > saurav > Desktop > fileio.c > main(void)
#include <string.h>
#include <unistd.h>
#include <fcntl.h>
int main(void) {
// opening a file
// int open (const char* Path, int flags [, int mode]);
int fd = open("test.txt", O_RDWR | O_CREAT | O_TRUNC, S_IRWXU);
if (fd<0) {
printf("Error: Unable to open the file\n");
exit(1);
} else {
printf("File opened with file descriptor = %d\n", fd);
}
// reading from an open file
char *c = (char *) calloc(100, sizeof(char));
int sz = read(fd, c, 10);
if (sz < 0) {
printf("Error: Unable to read from file\n");
Ln 10, Col 25 (9 selected)
Spaces: 4
UTF-8
LF
C
Linux


Activities
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File Edit Selection View Go Run Terminal Help
fileio.c
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int main(void) {
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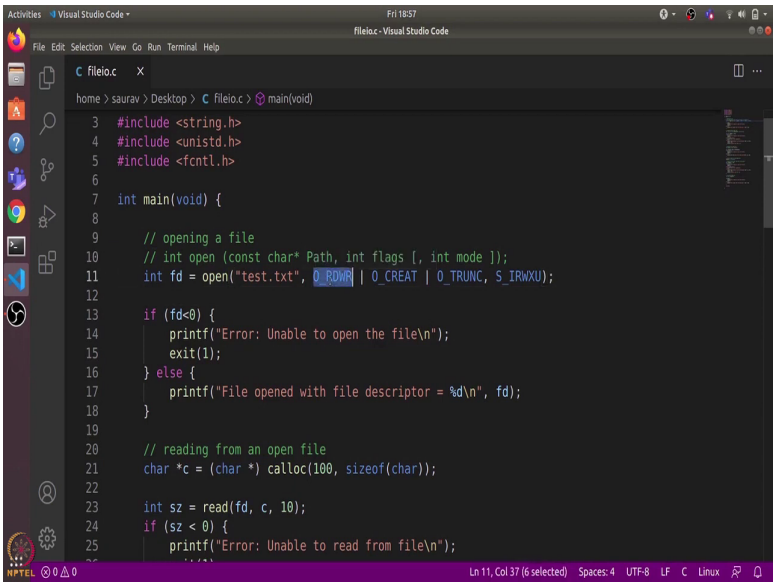
int fd = open("test.txt", O_RDWR | O_CREAT | O_TRUNC, S_IRWXU);
if (fd<0) {
printf("Error: Unable to open the file\n");
exit(1);
} else {
printf("File opened with file descriptor = %d\n", fd);
}
// reading from an open file
char *c = (char *) calloc(100, sizeof(char));
int sz = read(fd, c, 10);
if (sz < 0) {
printf("Error: Unable to read from file\n");
Ln 10, Col 45 (5 selected)
Spaces: 4
UTF-8
LF
C
Linux


Activities
Visual Studio Code
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fileio.c
home > saurav > Desktop > fileio.c > main(void)
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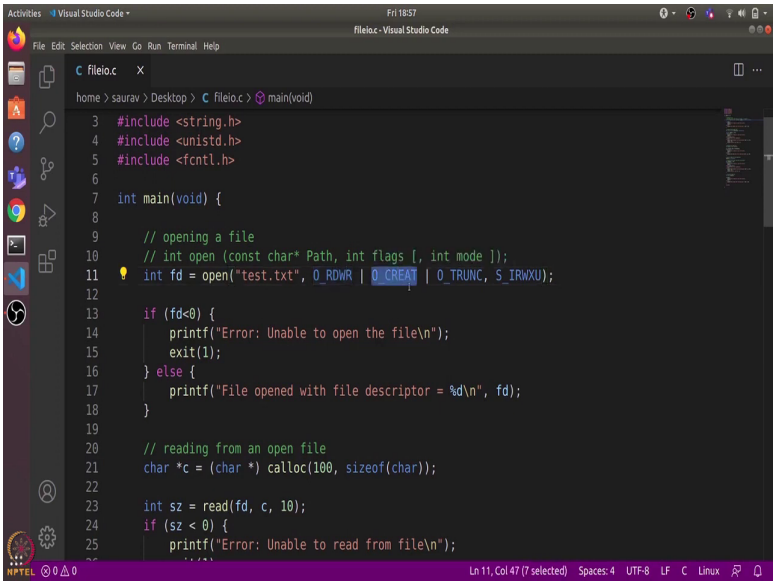
#include <unistd.h>
#include <fcntl.h>
int main(void) {
// opening a file
// int open (const char* Path, int flags [, int mode]);
int fd = open("test.txt", O_RDWR | O_CREAT | O_TRUNC, S_IRWXU);
if (fd<0) {
printf("Error: Unable to open the file\n");
exit(1);
} else {
printf("File opened with file descriptor = %d\n", fd);
}
// reading from an open file
char *c = (char *) calloc(100, sizeof(char));
int sz = read(fd, c, 10);
if (sz < 0) {
printf("Error: Unable to read from file\n");
Ln 11, Col 37 (6 selected)
Spaces: 4
UTF-8
LF
C
Linux



The first argument that it takes is the path to the file, then it takes certain flags. For instance, here we have used this RDWR flag, which means we want to both read and write using this file descriptor and second flag that we use is O_CREATE, which means if the file does not already exist, then we want to create the file.

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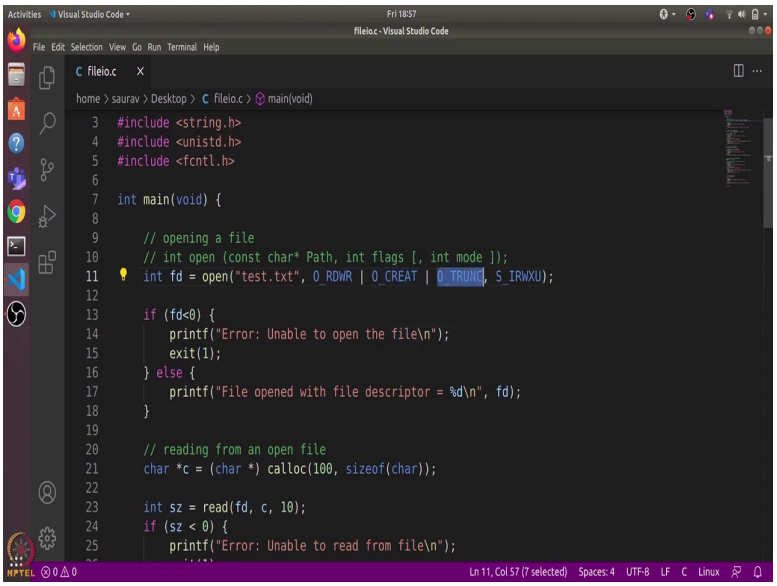

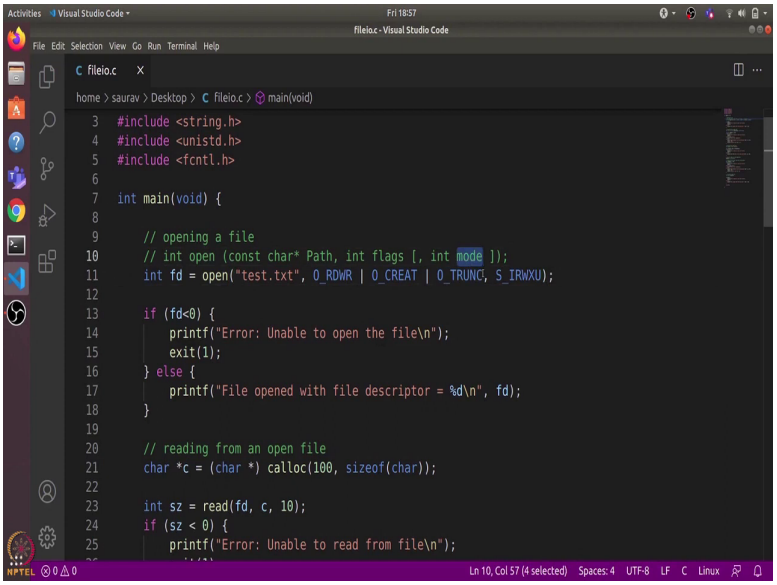

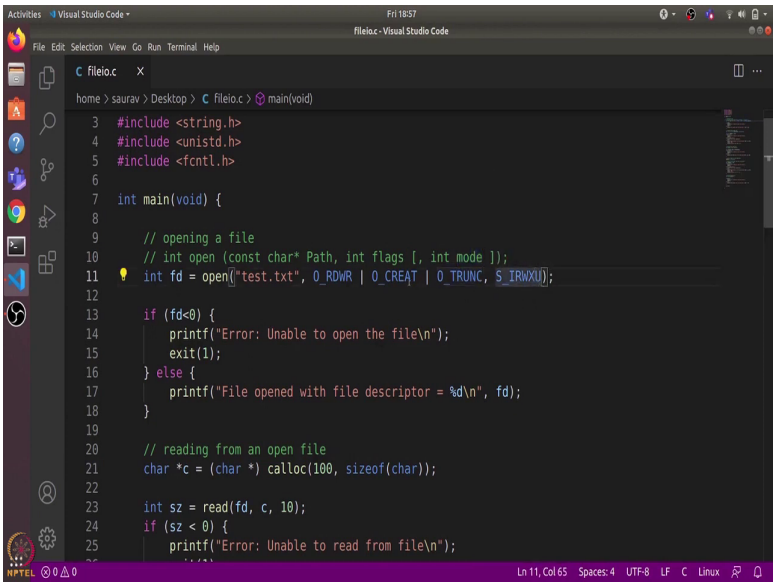

And the last flag is the truncate flag, which means if the file already exists, then we want to clear all its contents. And finally, the last argument is an optional argument. And it is used only when we create a file, it is used to set the permissions of the file. So, here we have given read, write and execute permission to the user.

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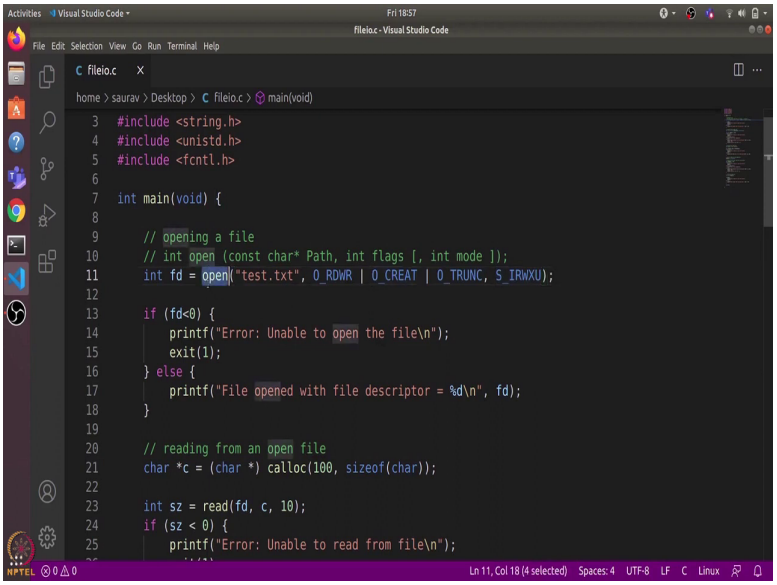

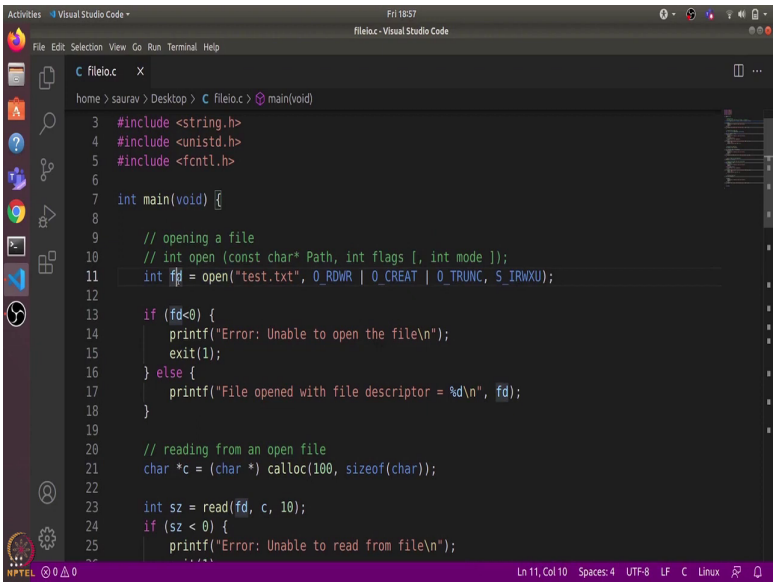

And this open system call returns a file descriptor, which we store in this fd variable. So, what happens when we make this open system call, the process will create the new file, it will allocate a new inode and add a mapping from the file name to this new inode number in the parent directory. And then it will copy this inode into memory from the disk. So, now that we have inode in the memory, it will create a new entry in the open file table, which will point to this in memory inode.

And it will also add a new entry in the file descriptor array for this process. And that file descriptor array entry will point to this open file table entry. And then it will return the index in that file descriptor array as the file descriptor. So, if it returns a negative value, that means that there was some error and we print out unable to open the file.

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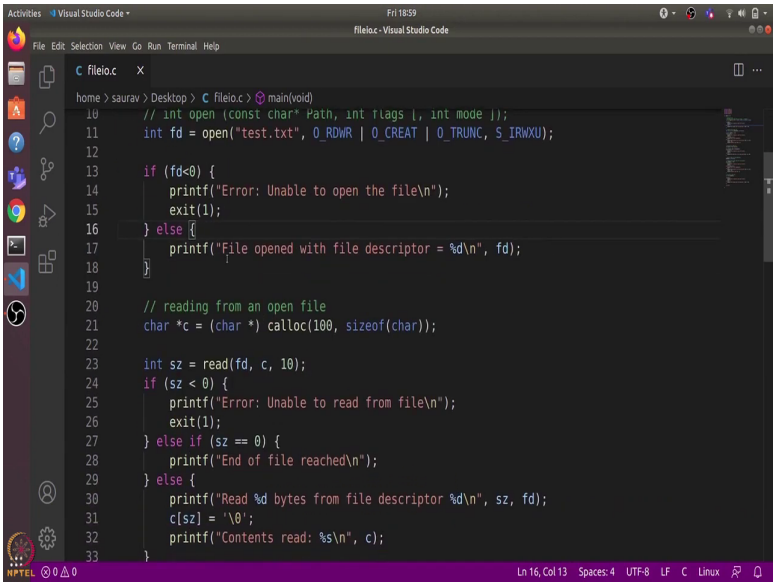

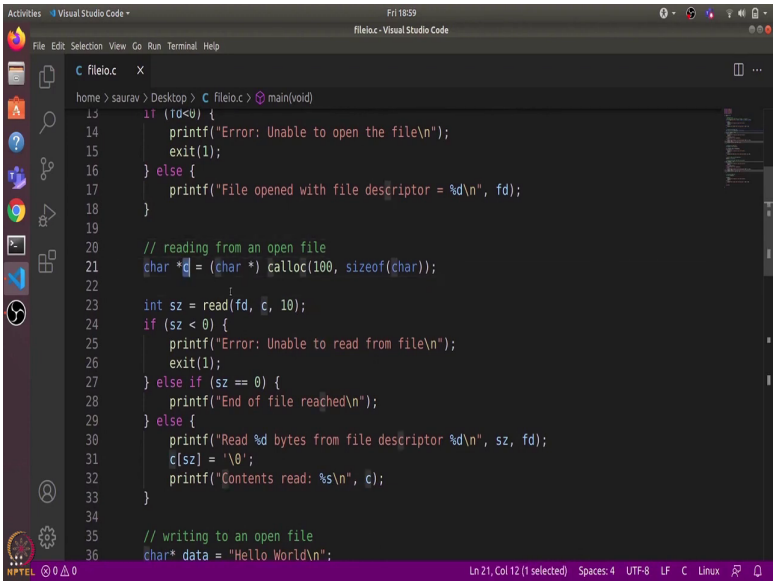

Otherwise, we print out file open with this as file descriptor. Now, we use the read system call to read from an open file. Firstly, we allocate some region where we can read the contents.

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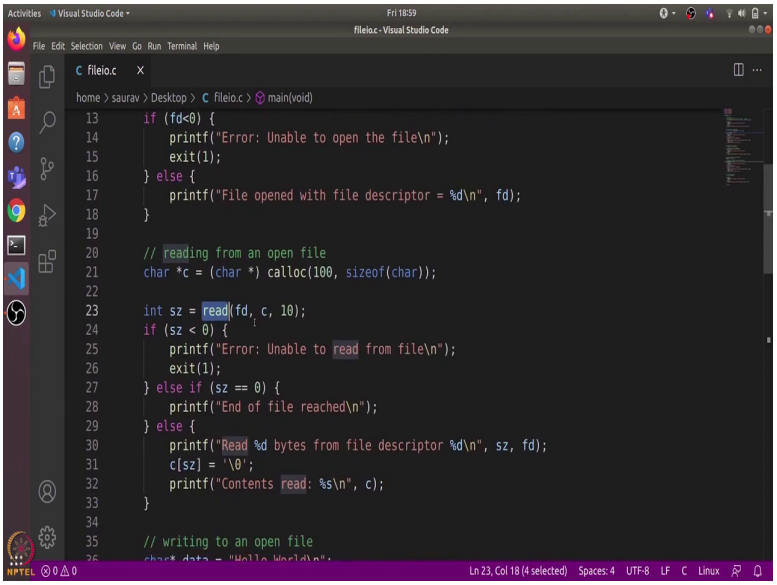
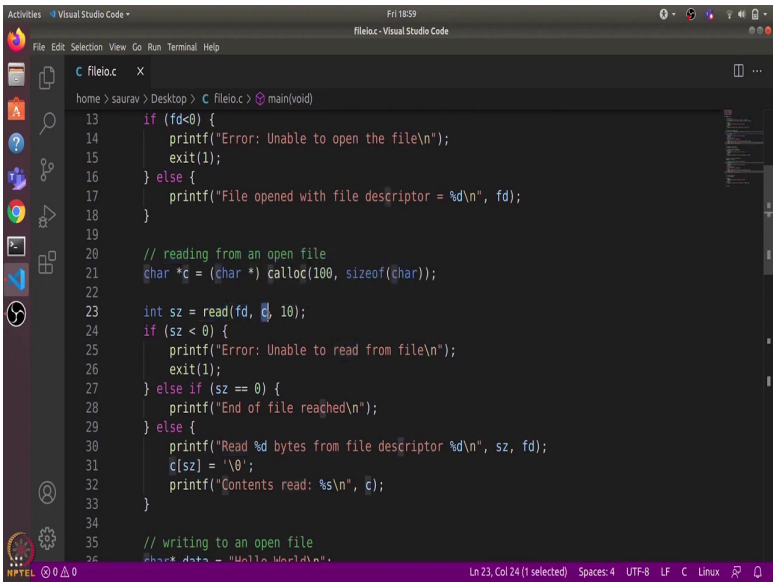
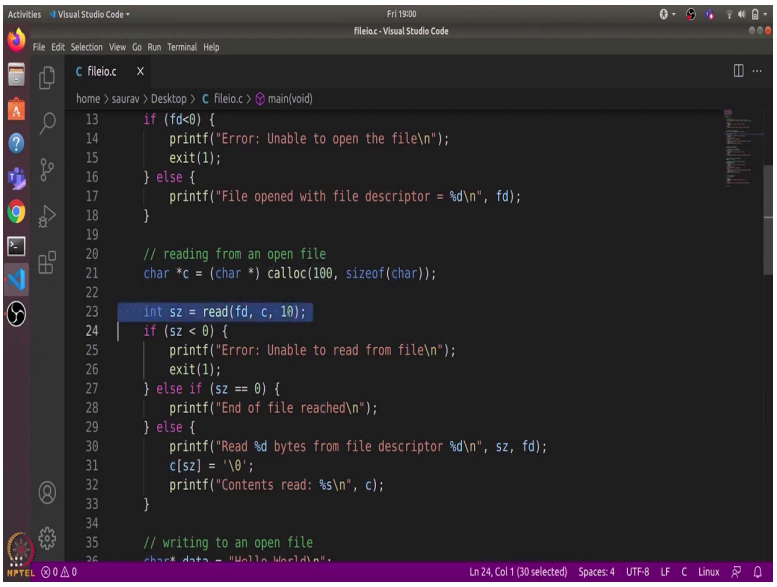
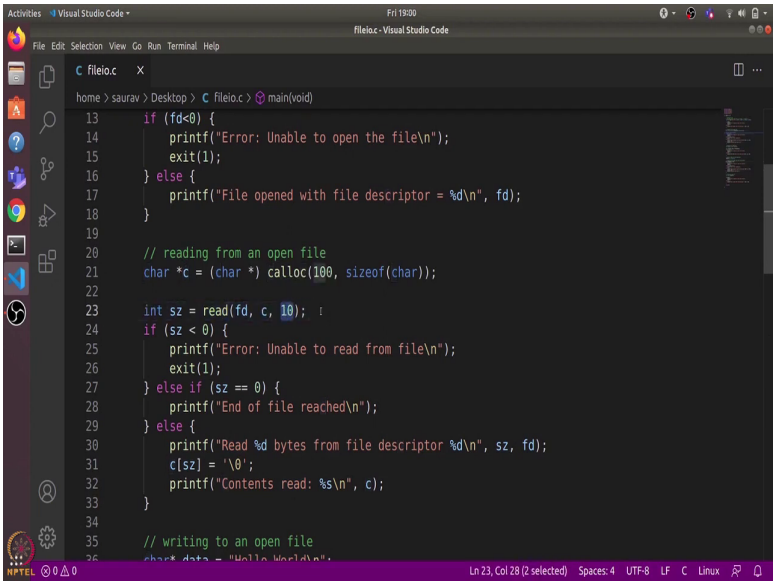

Activities
Visual Studio Code
Fri 18:59
fileio.c - Visual Studio Code
File Edit Selection View Go Run Terminal Help
fileio.c
home > saurav > Desktop > fileio.c > main(void)
13 if (fd<0) {
14 printf("Error: Unable to open the file\n");
15 exit(1);
16 } else {
17 printf("File opened with file descriptor = %d\n", fd);
18 }
19
20 // reading from an open file
21 char *c = (char *) calloc(100, sizeof(char));
22
23 int sz = read(fd, c, 10);
24 if (sz < 0) {
25 printf("Error: Unable to read from file\n");
26 exit(1);
27 } else if (sz == 0) {
28 printf("End of file reached\n");
29 } else {
30 printf("Read %d bytes from file descriptor %d\n", sz, fd);
31 c[sz] = '\0';
32 printf("Contents read: %s\n", c);
33 }
34
35 // writing to an open file
NPTEL
0 0
Ln 23, Col 18 (4 selected)
Spaces: 4
UTF-8
LF
C
Linux


Activities
Visual Studio Code
Fri 18:59
fileio.c - Visual Studio Code
File Edit Selection View Go Run Terminal Help
fileio.c
home > saurav > Desktop > fileio.c > main(void)
13 if (fd<0) {
14 printf("Error: Unable to open the file\n");
15 exit(1);
16 } else {
17 printf("File opened with file descriptor = %d\n", fd);
18 }
19
20 // reading from an open file
21 char *c = (char *) calloc(100, sizeof(char));
22
23 int sz = read(fd, c, 10);
24 if (sz < 0) {
25 printf("Error: Unable to read from file\n");
26 exit(1);
27 } else if (sz == 0) {
28 printf("End of file reached\n");
29 } else {
30 printf("Read %d bytes from file descriptor %d\n", sz, fd);
31 c[sz] = '\0';
32 printf("Contents read: %s\n", c);
33 }
34
35 // writing to an open file
NPTEL
0 0
Ln 23, Col 24 (1 selected)
Spaces: 4
UTF-8
LF
C
Linux


Activities
Visual Studio Code
Fri 19:00
fileio.c - Visual Studio Code
File Edit Selection View Go Run Terminal Help
fileio.c
home > saurav > Desktop > fileio.c > main(void)
13 if (fd<0) {
14 printf("Error: Unable to open the file\n");
15 exit(1);
16 } else {
17 printf("File opened with file descriptor = %d\n", fd);
18 }
19
20 // reading from an open file
21 char *c = (char *) calloc(100, sizeof(char));
22
23 int sz = read(fd, c, 10);
24 if (sz < 0) {
25 printf("Error: Unable to read from file\n");
26 exit(1);
27 } else if (sz == 0) {
28 printf("End of file reached\n");
29 } else {
30 printf("Read %d bytes from file descriptor %d\n", sz, fd);
31 c[sz] = '\0';
32 printf("Contents read: %s\n", c);
33 }
34
35 // writing to an open file
NPTEL
0 0
Ln 24, Col 1 (30 selected)
Spaces: 4
UTF-8
LF
C
Linux



And then we use this read system call to read the content from the file descriptor. So, read system call takes three arguments. First is the file descriptor itself. Second is a pointer to the region where it can store the data. So, we have used this c variable here. And finally, the number of bytes which we want to read.

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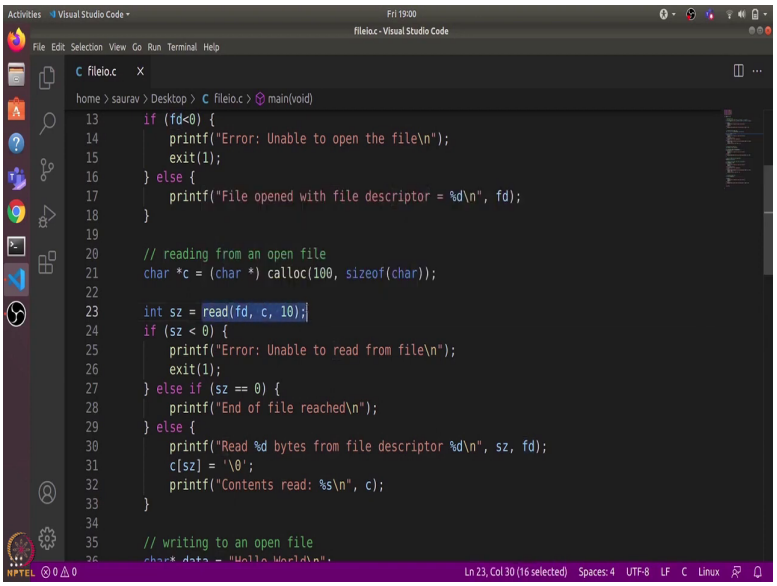
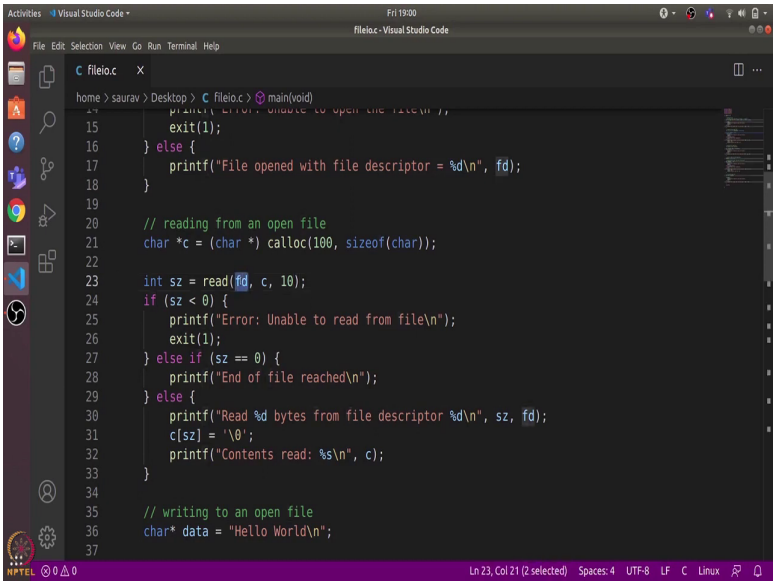
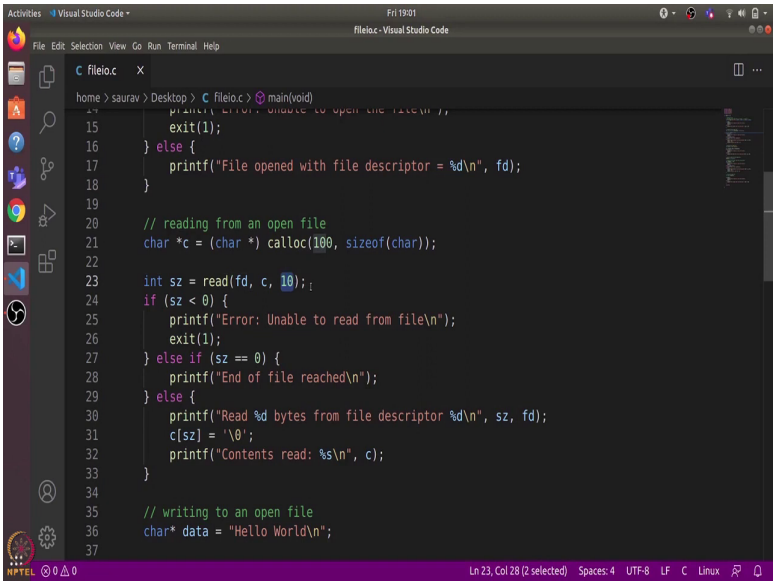
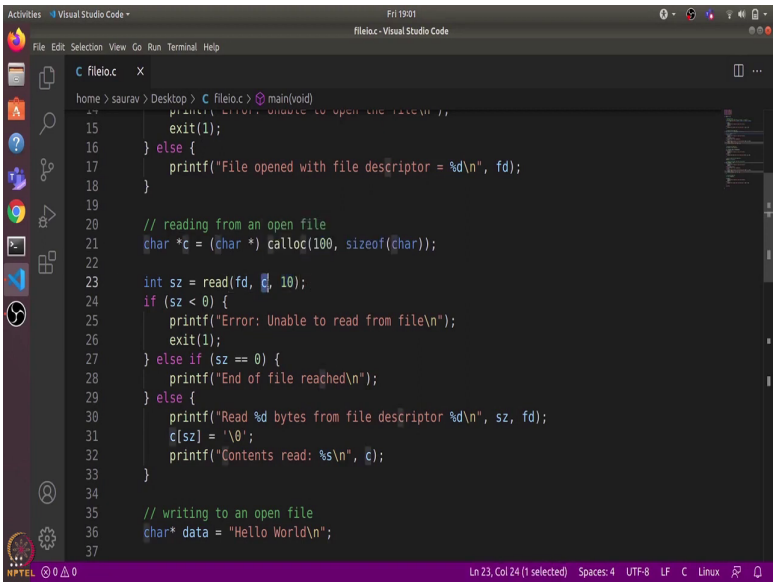
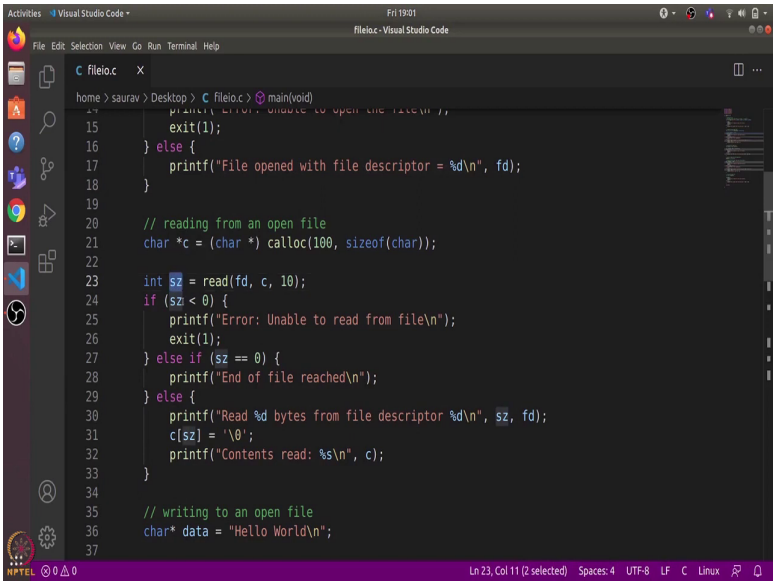



Activities
Visual Studio Code
Fri 19:00
fileio.c - Visual Studio Code
File Edit Selection View Go Run Terminal Help
fileio.c
home > saurav > Desktop > fileio.c > main(void)
exit(1);
} else {
printf("File opened with file descriptor = %d\n", fd);
}
// reading from an open file
char *c = (char *) calloc(100, sizeof(char));
int sz = read(fd, c, 10);
if (sz < 0) {
printf("Error: Unable to read from file\n");
exit(1);
} else if (sz == 0) {
printf("End of file reached\n");
} else {
printf("Read %d bytes from file descriptor %d\n", sz, fd);
c[sz] = '\0';
printf("Contents read: %s\n", c);
}
// writing to an open file
char* data = "Hello World\n";
Ln 23, Col 21 (2 selected) Spaces: 4 UTF-8 LF C Linux


Activities
Visual Studio Code
Fri 19:01
fileio.c - Visual Studio Code
File Edit Selection View Go Run Terminal Help
fileio.c
home > saurav > Desktop > fileio.c > main(void)
exit(1);
} else {
printf("File opened with file descriptor = %d\n", fd);
}
// reading from an open file
char *c = (char *) calloc(100, sizeof(char));
int sz = read(fd, c, 10);
if (sz < 0) {
printf("Error: Unable to read from file\n");
exit(1);
} else if (sz == 0) {
printf("End of file reached\n");
} else {
printf("Read %d bytes from file descriptor %d\n", sz, fd);
c[sz] = '\0';
printf("Contents read: %s\n", c);
}
// writing to an open file
char* data = "Hello World\n";
Ln 23, Col 28 (2 selected) Spaces: 4 UTF-8 LF C Linux


Activities
Visual Studio Code
Fri 19:01
fileio.c - Visual Studio Code
File Edit Selection View Go Run Terminal Help
fileio.c
home > saurav > Desktop > fileio.c > main(void)
exit(1);
} else {
printf("File opened with file descriptor = %d\n", fd);
}
// reading from an open file
char *c = (char *) calloc(100, sizeof(char));
int sz = read(fd, c, 10);
if (sz < 0) {
printf("Error: Unable to read from file\n");
exit(1);
} else if (sz == 0) {
printf("End of file reached\n");
} else {
printf("Read %d bytes from file descriptor %d\n", sz, fd);
c[sz] = '\0';
printf("Contents read: %s\n", c);
}
// writing to an open file
char* data = "Hello World\n";
Ln 23, Col 24 (1 selected) Spaces: 4 UTF-8 LF C Linux



And this read system call returns the number of bytes that were actually read. So, for instance, if a file has just 5 bytes, then it will return 5 instead of 10. So, what happens when we make a read system call? On making this read system call, the process will use the file descriptor array index and access the open file table entry. And based on that open file table entry, it will access the inode. From that inode, it will see what all are the data blocks that stores the corresponding data that you want.

And it will check if that data block is already there in disk buffer cache. If it is not there in this buffer cache, then it will issue commands to the hard disk to pull the relevant data blocks into the disk buffer cache. And then it will copy the relevant contents from the data block to the region pointed by this address. And finally, it will return the number of bytes which were read.

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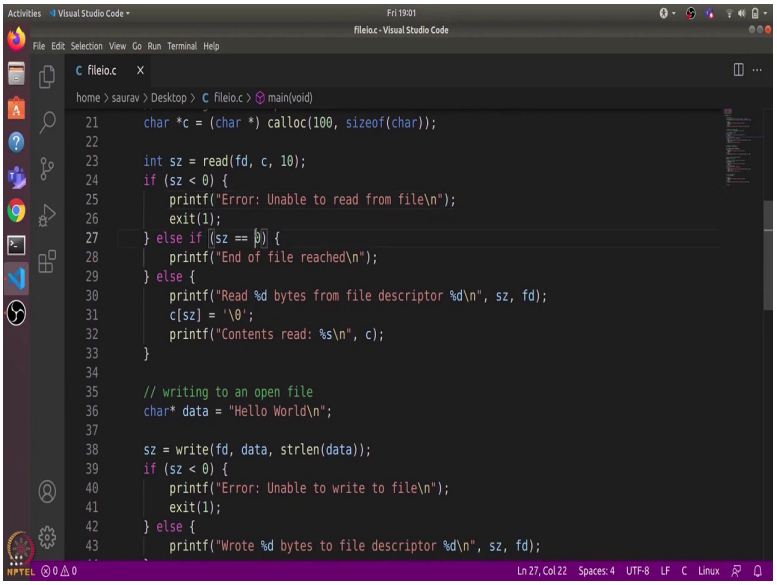

So, if it returns a negative value, that means there was some error. And if it returns 0, that means that we have reached the end of file, so we print out end of file reached. Otherwise, we print out these many bytes were read, and we print out the contents which are actually read.

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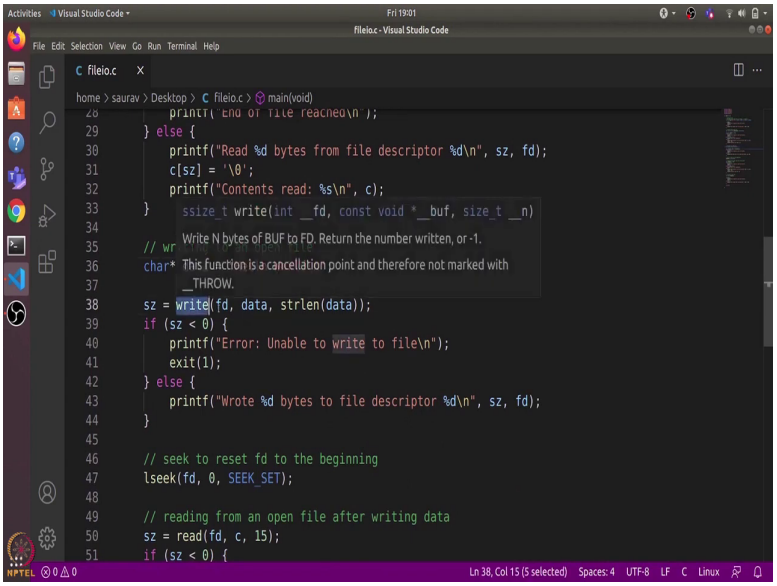

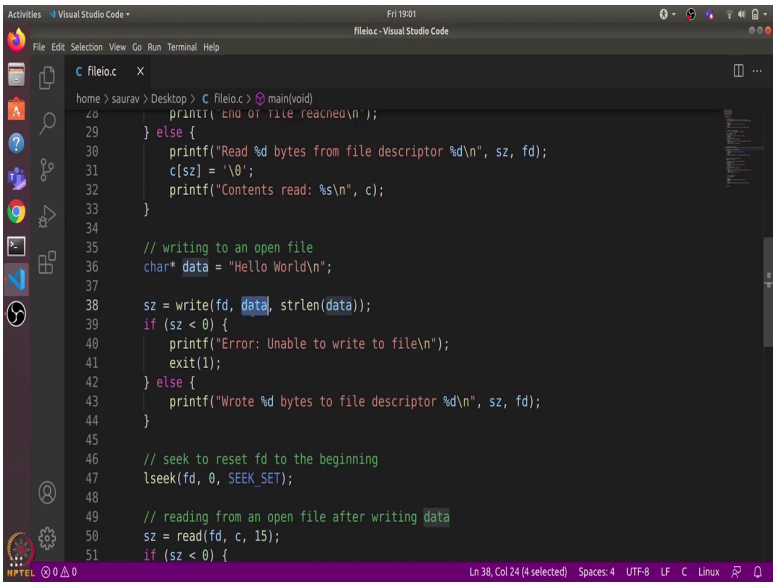

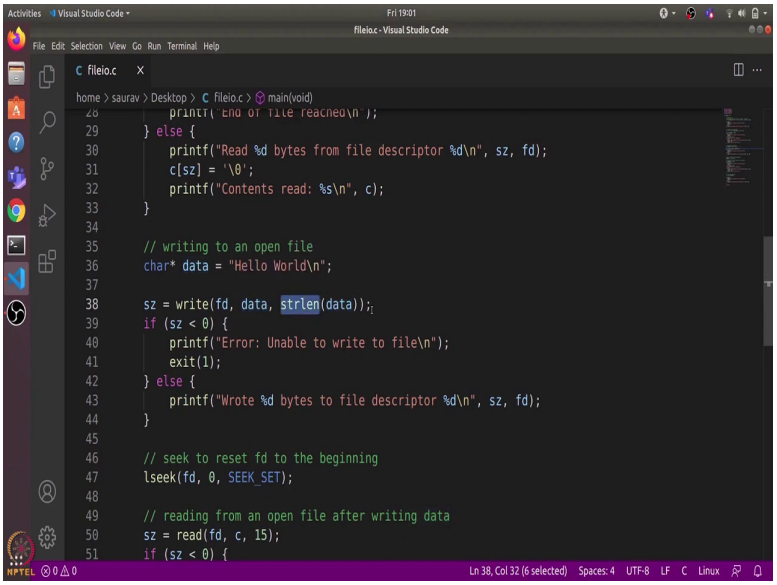

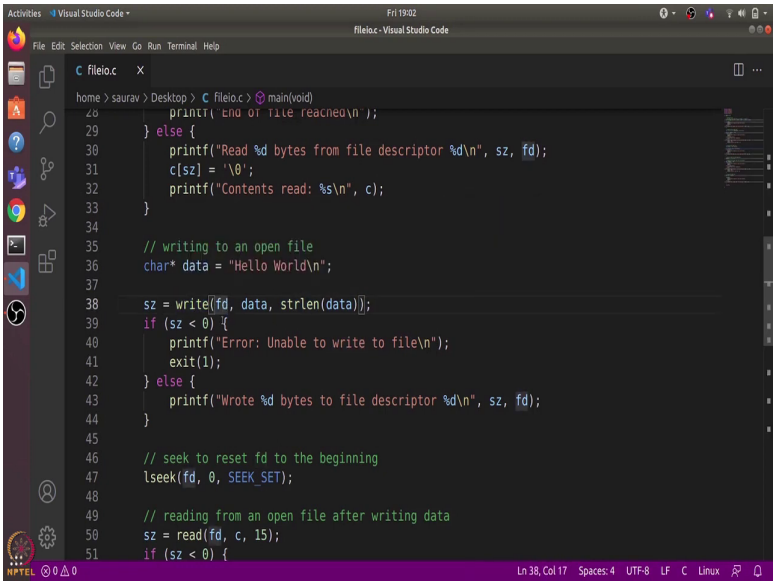

Now we use the write system call to write this Hello World in this file. So, write system call also takes first argument as the file descriptor. Second is the pointer to memory location from where we want to copy the data and write to the file. And the last argument says what is the size of data that we want to write.

So, this write system call also returns the number of bytes which were actually return to the file. And what happens when we make this write system call based on the file descriptor, the system will access the relevant data block where we want to write the data. And in case, we want to write beyond the end of file, it will allocate a new data block and add its number to the file inode. And then it will pull this data block into the disk buffer cache.

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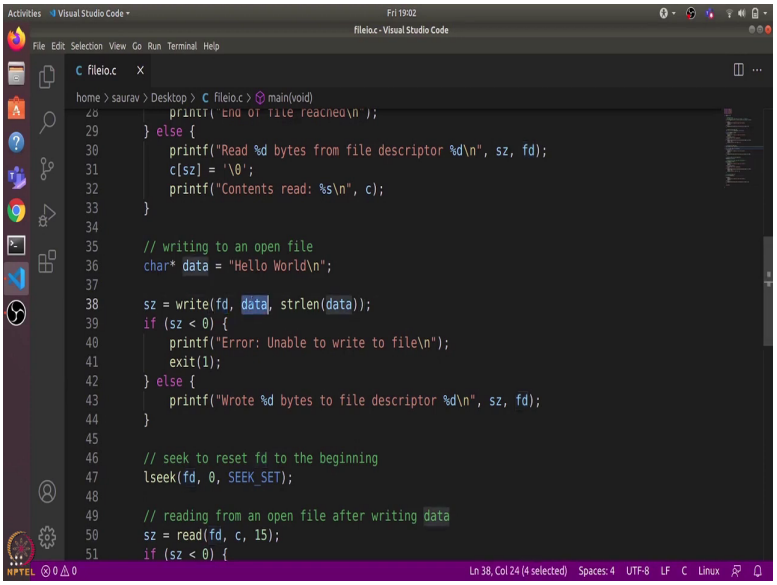

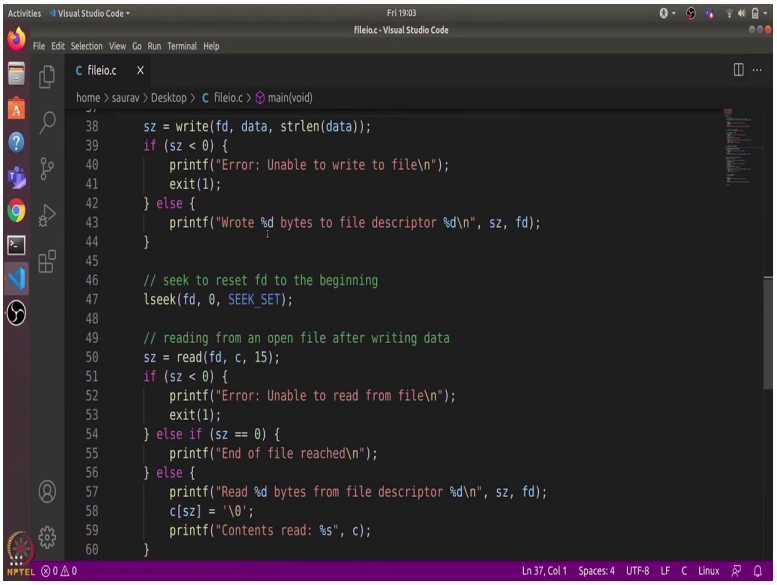

And then copy the data from this location to the data block. And finally return the number of bytes which are written, so if it returns a negative value that means that there was some error otherwise we print out that it has written these many bytes to the file descriptor.

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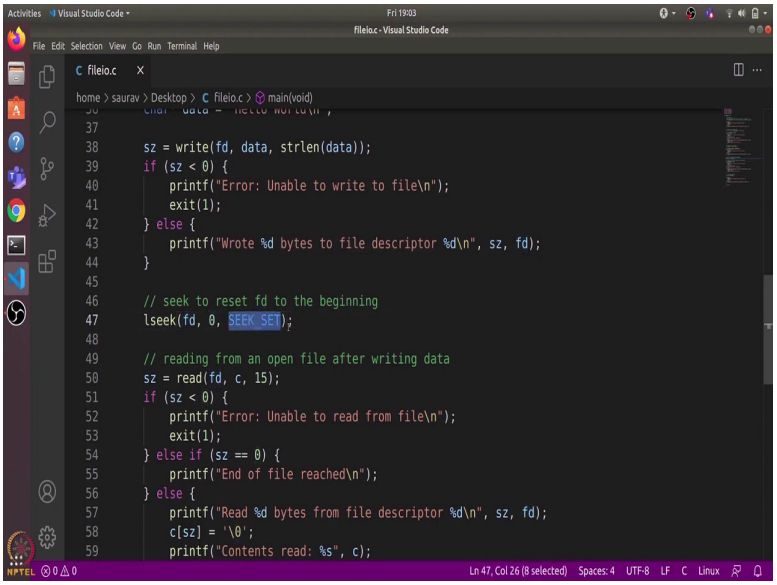

Now after writing to the file descriptor, the offset inside the inode will point to the end of file. And if you want to read the data again, we need to use the seek system call to again reset the offset to 0. So, we use the lseek function which takes in the file descriptor, the offset that we want to set. And if you want to set this offset in absolute way, or we want to set it related to the current offset position.

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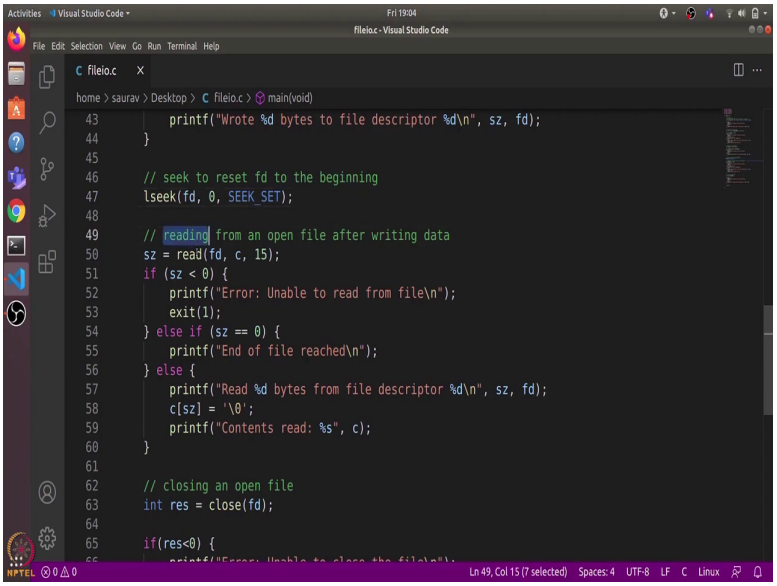

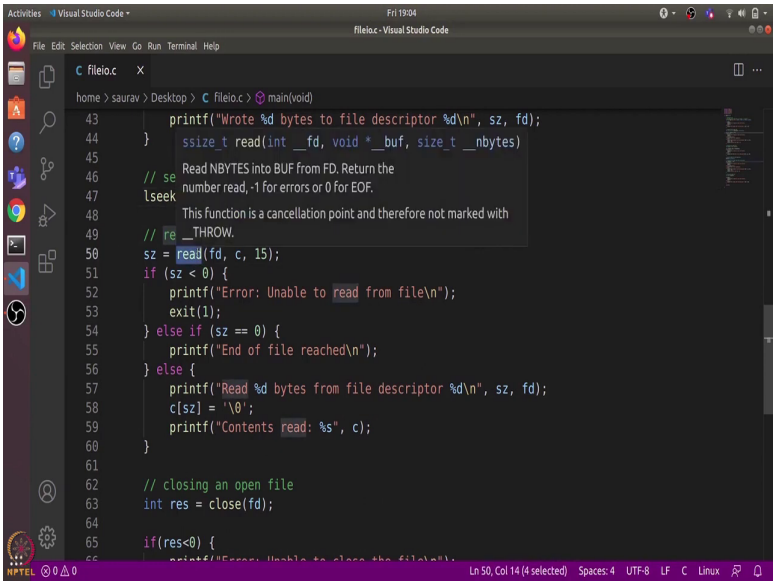

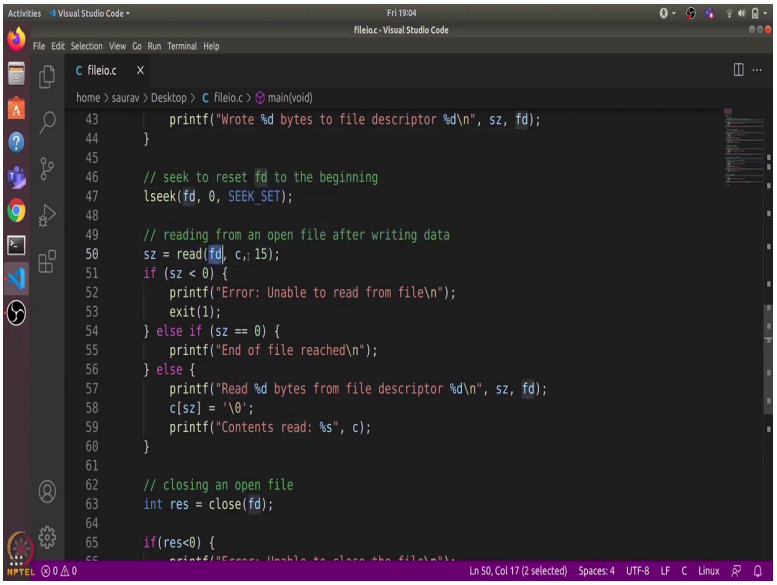

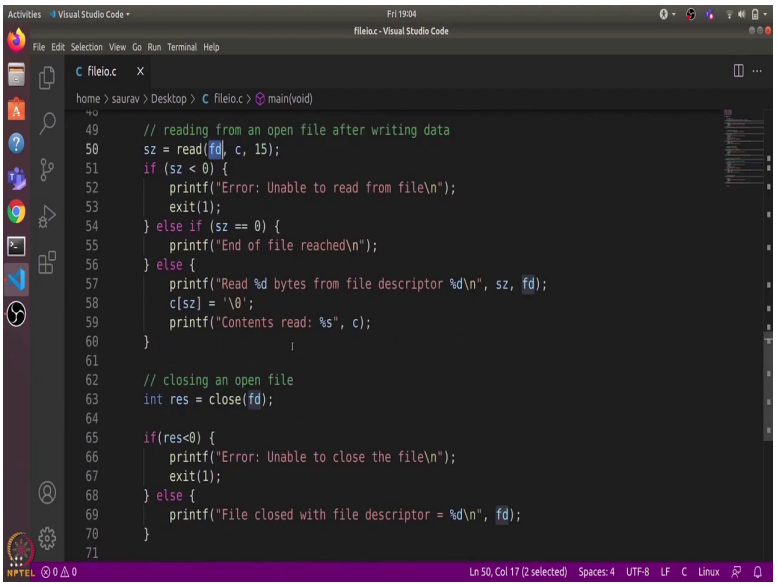

After setting the offset back to 0, we use the read system call to again read contents from this file descriptor, we try to read 15 bytes, but because we have just written 12 bytes, it will just read these many bytes, and it will print out the contents.

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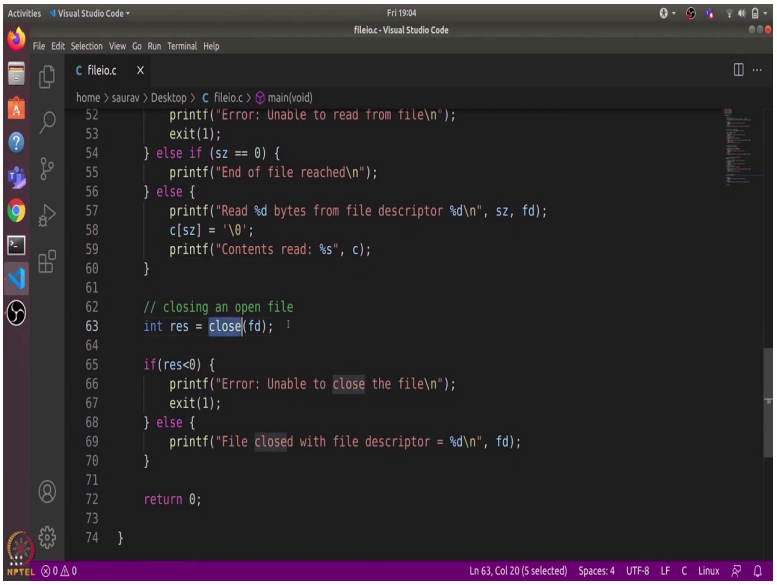

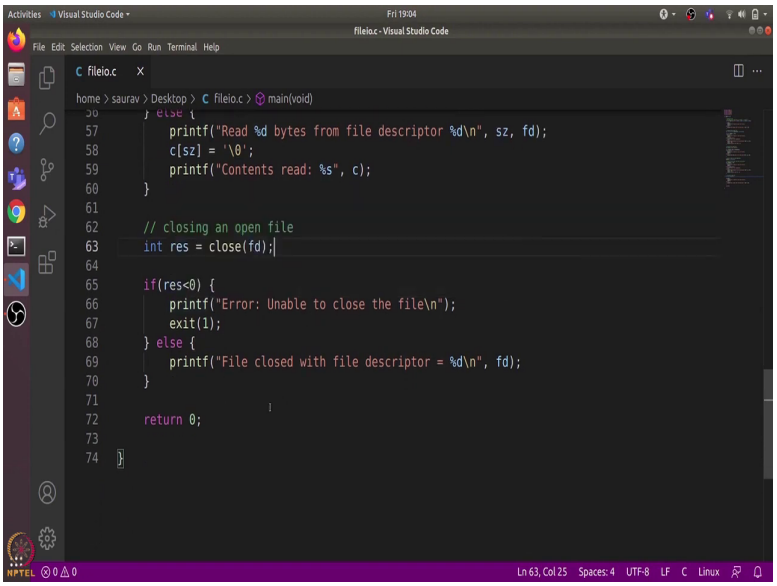

Finally, we use this closed system call to close the file descriptor. This will remove all the entries which are made in the open file table and the file descriptor array. And it will return 0 in case of success. Otherwise, if it returns a negative value, that means there were some error, and that would end the program.

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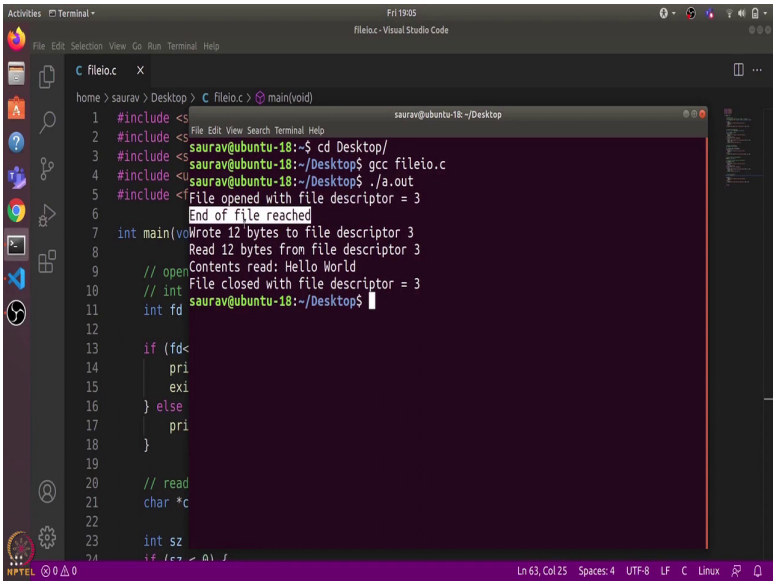
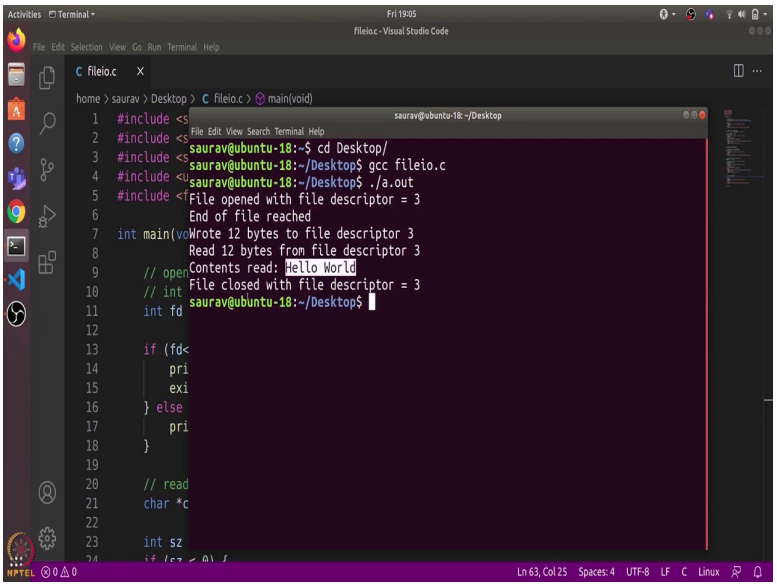

Activities
Terminal
Fri 19:05
fileio.c - Visual Studio Code
File Edit Selection View Go Run Terminal Help
fileio.c
home > saurav > Desktop > fileio.c > main(void)
saurav@ubuntu-18: ~/Desktop
File Edit View Search Terminal Help
saurav@ubuntu-18:~$ cd Desktop/
saurav@ubuntu-18:~/Desktop$ gcc fileio.c
saurav@ubuntu-18:~/Desktop$ ./a.out
File opened with file descriptor = 3
End of file reached
Wrote 12 bytes to file descriptor 3
Read 12 bytes from file descriptor 3
Contents read: Hello World
File closed with file descriptor = 3
saurav@ubuntu-18:~/Desktop$
Ln 63, Col 25
Spaces: 4
UTF-8
LF
C
Linux


Activities
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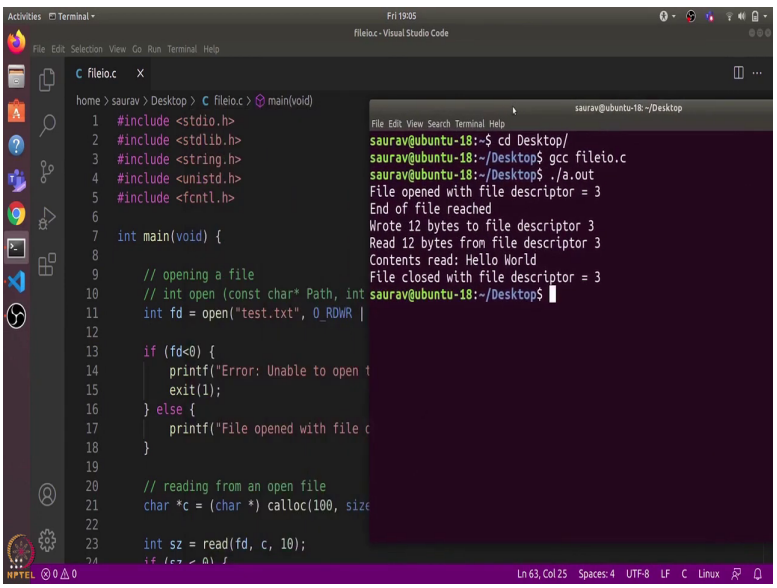
Activities
Terminal
Fri 19:05
fileio.c - Visual Studio Code
File Edit Selection View Go Run Terminal Help
fileio.c
home > saurav > Desktop > fileio.c > main(void)
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <fcntl.h>
int main(void) {
// opening a file
// int open (const char* Path, int
int fd = open("test.txt", O_RDWR |
if (fd<0) {
printf("Error: Unable to open
exit(1);
} else {
printf("File opened with file
}
// reading from an open file
char *c = (char *) calloc(100, size
int sz = read(fd, c, 10);
saurav@ubuntu-18: ~/Desktop
File Edit View Search Terminal Help
saurav@ubuntu-18:~$ cd Desktop/
saurav@ubuntu-18:~/Desktop$ gcc fileio.c
saurav@ubuntu-18:~/Desktop$ ./a.out
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End of file reached
Wrote 12 bytes to file descriptor 3
Read 12 bytes from file descriptor 3
Contents read: Hello World
File closed with file descriptor = 3
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Ln 63, Col 25
Spaces: 4
UTF-8
LF
C
Linux

So, let us compile and run this program. So, we will open a terminal and compile this program gcc fileio.c, and it creates the a.out executable let us run that executable. So, we can see that it opened a new file with file descriptor 3. And why is it 3? Because 0, 1, 2 are already used for standard in, standard out and standard error. And as expected, it prints out end of file reached, because there is no data initially in this new file.

Then it writes 12 bytes to the file descriptor. And finally, again reads that 12 bytes which were written there, and the contents are Hello World. And then it closes this file descriptor. So, let us see if we have that test.txt file here. So, we have this test.txt file. And if we check its contents, we can use cat text.txt. So the contents are Hello World. So, that is it for this video. Thanks and have a nice day.