

OS Online 2 Document

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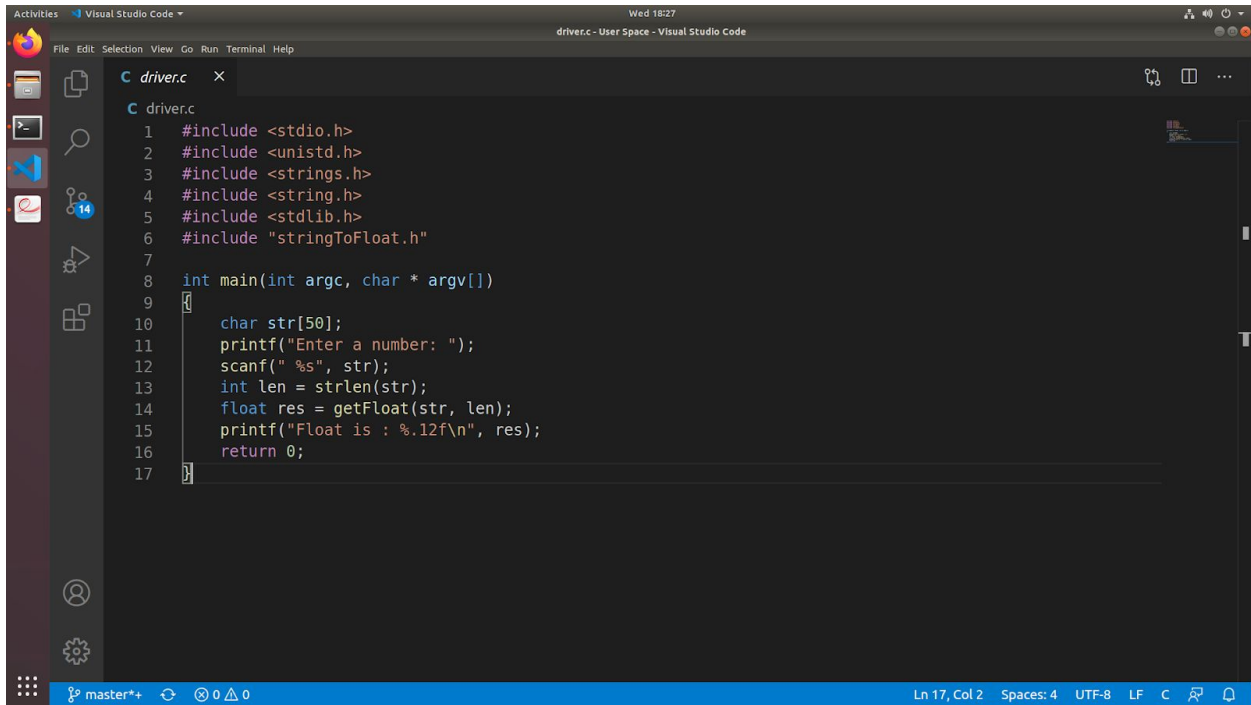
The IEEE Standard for Floating-Point Arithmetic (IEEE 754) was used for the conversion of string to long in system call `parse_float_syscall` in kernel mode.

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User Space

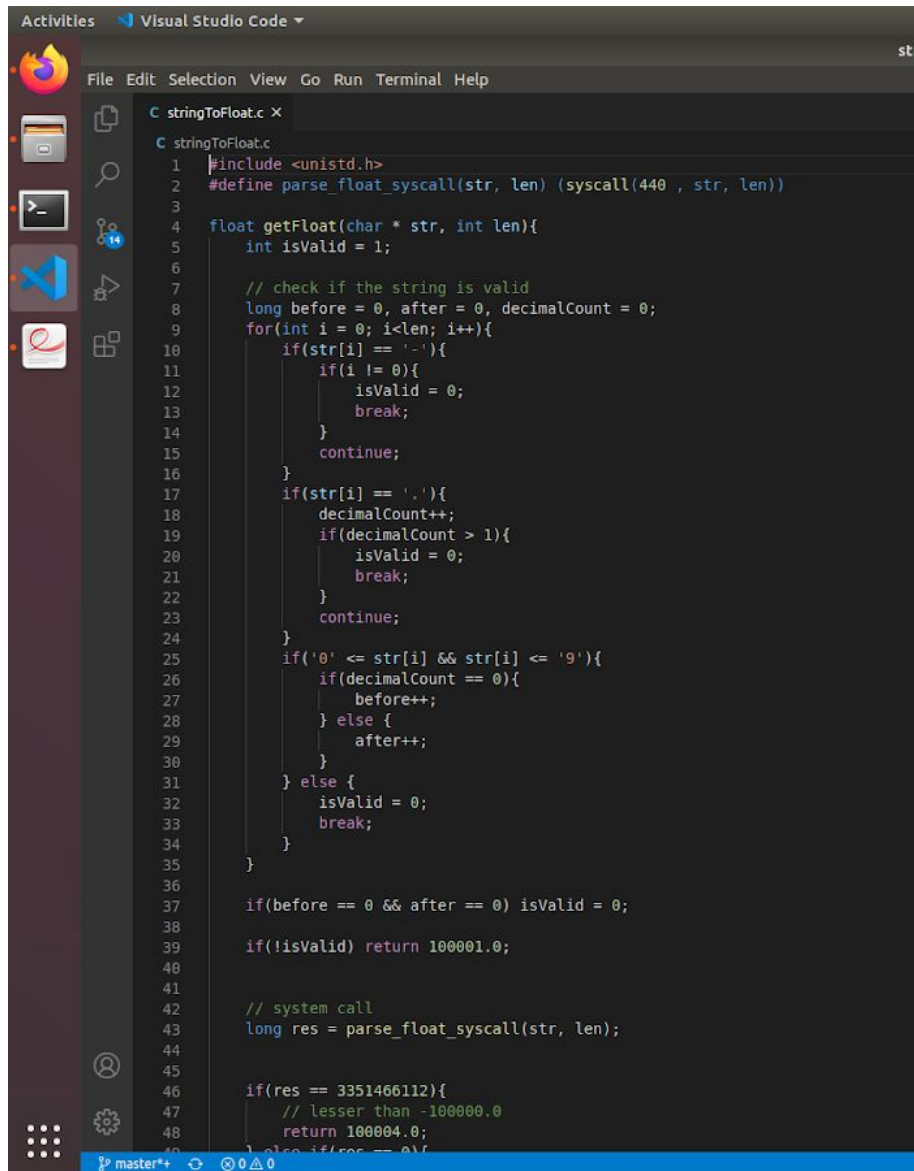
driver.c



```
1 #include <stdio.h>
2 #include <unistd.h>
3 #include <strings.h>
4 #include <string.h>
5 #include <stdlib.h>
6 #include "stringToFloat.h"
7
8 int main(int argc, char * argv[])
9 {
10     char str[50];
11     printf("Enter a number: ");
12     scanf(" %s", str);
13     int len = strlen(str);
14     float res = getFloat(str, len);
15     printf("Float is : %.12f\n", res);
16     return 0;
17 }
```

- Contains the given template for calling the wrapper function getFloat().
- Takes input form the user and prints the returned value from the wrapper function.

stringToFloat.c



```

1  #include <unistd.h>
2  #define parse_float_syscall(str, len) (syscall(440, str, len))
3
4  float getFloat(char * str, int len){
5      int isValid = 1;
6
7      // check if the string is valid
8      long before = 0, after = 0, decimalCount = 0;
9      for(int i = 0; i < len; i++){
10         if(str[i] == '-'){
11             if(i != 0){
12                 isValid = 0;
13                 break;
14             }
15             continue;
16         }
17         if(str[i] == '.'){
18             decimalCount++;
19             if(decimalCount > 1){
20                 isValid = 0;
21                 break;
22             }
23             continue;
24         }
25         if('0' <= str[i] && str[i] <= '9'){
26             if(decimalCount == 0){
27                 before++;
28             } else {
29                 after++;
30             }
31         } else {
32             isValid = 0;
33             break;
34         }
35     }
36
37     if(before == 0 && after == 0) isValid = 0;
38
39     if(!isValid) return 100001.0;
40
41     // system call
42     long res = parse_float_syscall(str, len);
43
44     if(res == 3351466112){
45         // lesser than -100000.0
46         return 100004.0;
47     } else if(res == 0){
48         return 0.0;
49     }
50 }

```

- Validates and checks if the string parameter is infact a valid float number.
- Returns 100001.0 if not valid
- Calls the system call 440 (parse_float_syscall)

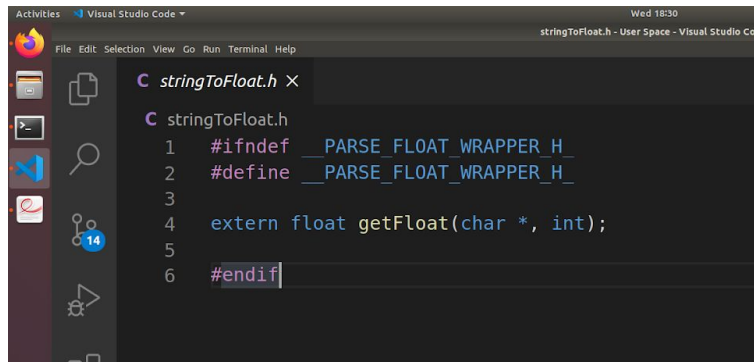
```

43     long res = parse_float_syscall(str, len);
44
45
46     if(res == 3351466112){
47         // lesser than -100000.0
48         return 100004.0;
49     } else if(res == 0){
50         // between 0.01 and 0.01
51         return 100003.0;
52     } else if(res == 1203982464){
53         // greater than 100000.0
54         return 100002.0;
55     }
56
57     // Converting IEEE 754 format to float
58
59     float num = 0;
60     float mantissa = 0;
61     long exponent = 0;
62
63     // extracting exponent
64     for(int i = 30; i>=23; i--){
65         exponent = exponent<<1;
66         exponent = (exponent | ((res>>i)&1));
67     }
68     exponent -= 127;
69
70     // extracting mantissa
71     for(int i = 22; i>=0; i--){
72         if((res>>i)&1) mantissa = mantissa + (((float)1.0)/(1<<(23-i)));
73     }
74
75     // obtaining float number
76     num = (1+mantissa);
77     if(exponent >= 0){
78         num = num*(1<<exponent);
79     } else {
80         exponent = -exponent;
81         num = num/(1<<exponent);
82     }
83
84     // assigning sign
85     if((res>>31)&1) num *= -1;
86
87
88
89     return num;
90 }

```

- If the number is less than -100000 (ret value = 3351466112) returns 100004.0
- If the number is between -0.01 and 0.01 (ret value = 0) returns 100003.0
- If the number is greater than 100000 (ret value = 1203982464) returns 100002.0
- Extracts sign, exponent and mantissa from the response of system call.
- Construct float number and return it.

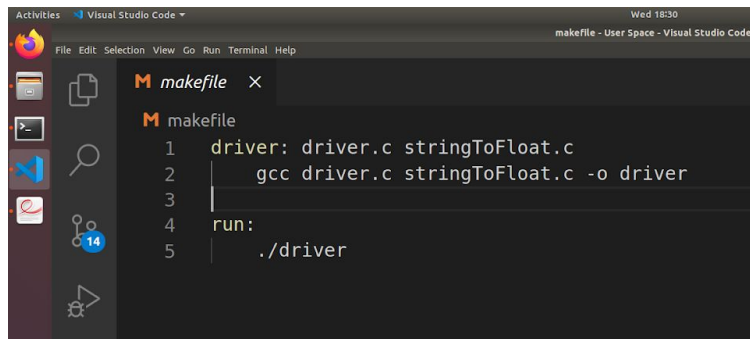
stringToFloat.h

A screenshot of the Visual Studio Code editor. The top bar shows 'Activities', 'Visual Studio Code', and 'Wed 18:30'. The title bar of the active window says 'stringToFloat.h - User Space - Visual Studio Code'. The editor is open to a file named 'stringToFloat.h'. The code in the file is as follows:

```
1  #ifndef __PARSE_FLOAT_WRAPPER_H__
2  #define __PARSE_FLOAT_WRAPPER_H__
3
4  extern float getFloat(char *, int);
5
6  #endif
```

- Declares the function getFloat()

makefile

A screenshot of the Visual Studio Code editor. The top bar shows 'Activities', 'Visual Studio Code', and 'Wed 18:30'. The title bar of the active window says 'makefile - User Space - Visual Studio Code'. The editor is open to a file named 'makefile'. The code in the file is as follows:

```
1  driver: driver.c stringToFloat.c
2  |
3  |   gcc driver.c stringToFloat.c -o driver
4
5  run:
6  |   ./driver
```

- makefile to run driver.c

Kernel Space

/usr/src/linux-5.8.12/parse_float_syscall/parse_float_syscall.c

```

C parse_float_syscall.c
parse_float_syscall > C parse_float_syscall.c
1 #include<linux/kernel.h>
2 #include<linux/types.h>
3 #include<linux/syscalls.h>
4 #include "parse_float_syscall.h"
5
6 /*
7  * Pre-condition:
8  *   num is a valid float number in string format
9  *
10  * Post-condition:
11  *   return float num in long format
12  */
13
14 SYSCALL_DEFINE2(parse_float_syscall, char __user *, num, int, len){
15     long res = 0, i = 0, j = 0, t, sign = 0, first = 0, firstBinaryLen = 0, second = 0, secondLen = 0, exponent = 0, mantissa = 0, mantissaBinaryLen = 0, capacity
16     char numBuffer[64];
17     unsigned long lengthLeft = len;
18     unsigned long chunkSize = sizeof(numBuffer);
19
20     while(lengthLeft > 0){
21         if(lengthLeft < chunkSize){
22             chunkSize = lengthLeft;
23         }
24         if(copy_from_user(numBuffer, num, chunkSize)){
25             return -EFAULT;
26         }
27         lengthLeft = lengthLeft - chunkSize;
28     }
29
30     if(len == 0) return res;
31
32     if(numBuffer[i] == '-') {
33         // setting sign bit
34         sign = (1<<31);
35         i++;
36     }
37
38     // IEEE 754 representation of floating point numbers
39
40     // seperating first and second half
41     // extracting first part
42     for(; i<len; i++){

```

- Receives the char __user * input from the user as parameter
- Converted to buffer to use in kernel space using copy_from_user() function
- Uses IEEE 754 format to convert the float in string to long value

```

C parse_float_syscall.c x
parse_float_syscall > C parse_float_syscall.c
38
39 // IEEE 754 representation of floating point numbers
40
41 // separating first and second half
42 // extracting first part
43 for(; i<len; i++){
44     if(numBuffer[i] == '.') break;
45     first = 10*first+(numBuffer[i] - '0');
46     if(first > 100000){
47         if(sign == 0) return 1203982464;
48         else return 3351466112;
49     }
50 }
51
52 i++;
53 // extracting second part
54 for(; i<len; i++){
55     second = 10*second+(numBuffer[i] - '0');
56     secondLen++;
57     if(first == 0 && second == 0 && secondLen > 1) return 0;
58 }
59
60 if(first == 0 && second == 0) return 0;
61 if(first == 100000 && second != 0){
62     if(sign == 0) return 1203982464;
63     else return 3351466112;
64 }
65
66 // calculating exponent
67 j = first;
68 while(j){
69     firstBinaryLen++;
70     j = (j>>1);
71 }
72 exponent = firstBinaryLen-1;
73
74 // calculating mantissa
75 mantissa = first;
76 mantissa = (mantissa&~(1<<(firstBinaryLen-1)));
77 mantissaBinaryLen = firstBinaryLen;
78
79
80 capacity = 32-1-8-(mantissaBinaryLen-1);

```

- Calculating the part before decimal point and after the decimal point.
- Using this to calculate the exponent and mantissa

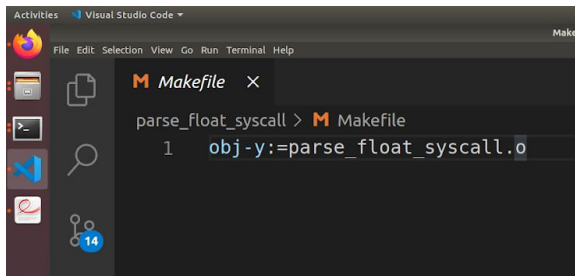
```

C parse_float_syscall.c X
parse_float_syscall > C parse_float_syscall.c
72     exponent = firstBinaryLen-1;
73
74     // calculating mantissa
75     mantissa = first;
76     mantissa = (mantissa & ~(1<<(firstBinaryLen-1)));
77     mantissaBinaryLen = firstBinaryLen;
78
79
80     capacity = 32-1-8-(mantissaBinaryLen-1);
81     den = 1;
82     for(t = 0; t<secondLen; t++){
83         den *= 10;
84     }
85     tempSecond = second;
86
87
88     for(j = capacity-1; j>=0; j--){
89         tempSecond *= 2;
90         mantissa = (mantissa<<1);
91         mantissa = (mantissa|(tempSecond/den));
92         if(first == 0){
93             if(tempSecond/den == 1){
94                 if(firstOne == 0){
95                     mantissa = (mantissa&(~1));
96                 }
97                 firstOne = 1;
98             }
99             if(firstOne == 0){
100                 zeroCountTillFirstOne++;
101                 j++;
102             }
103         }
104         tempSecond %= den;
105     }
106
107
108     if(first == 0){
109         exponent = -(zeroCountTillFirstOne+1);
110     }
111     exponent += 127;
112     exponent = (exponent<<23);
113
114
115     res = sign | exponent | mantissa ;
116     return res;
117 }

```

- Combine sign, exponent and mantissa using bitwise OR and return it

/usr/src/linux-5.8.12/parse_float_syscall/Makefile

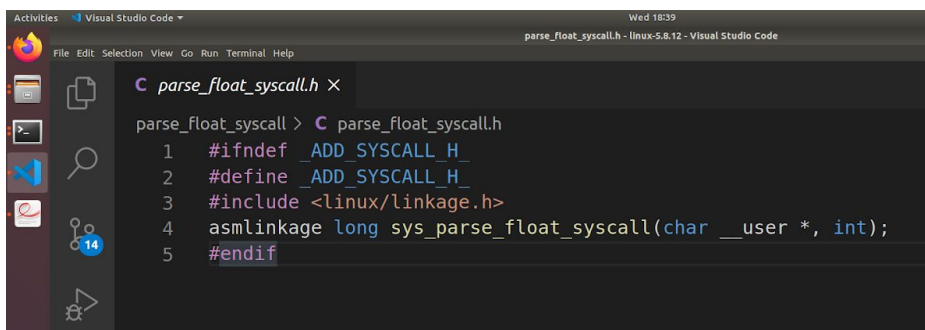


```

Makefile
parse_float_syscall > Makefile
1  obj-y:=parse_float_syscall.o

```

/usr/src/linux-5.8.12/parse_float_syscall/parse_float_syscall.h

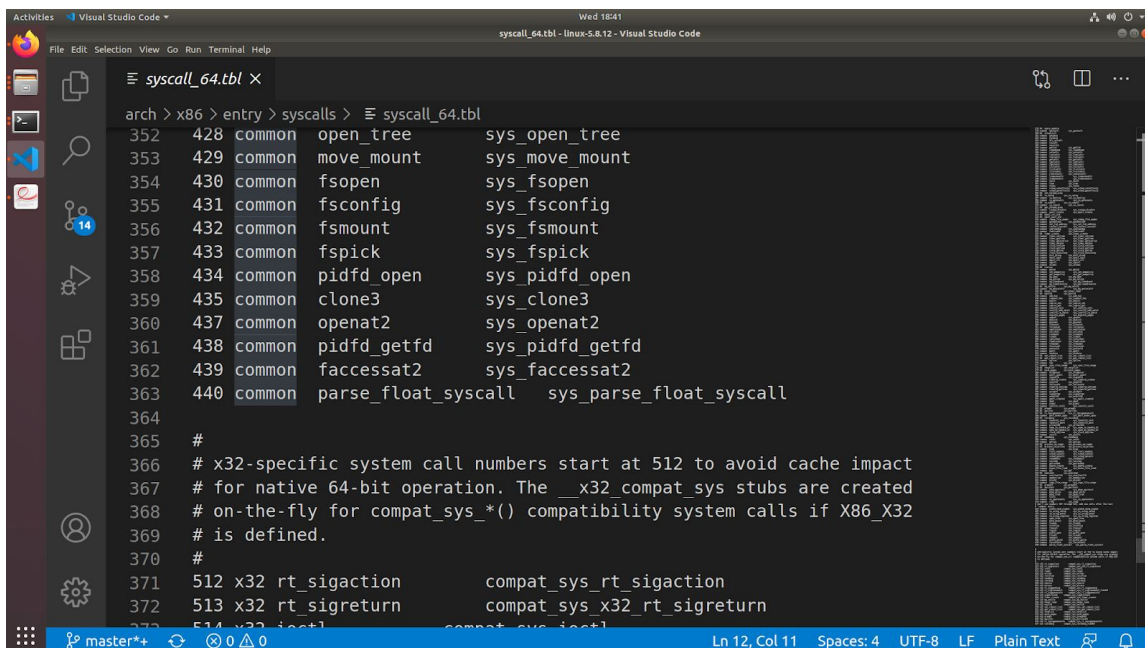


```

parse_float_syscall > parse_float_syscall.h
1  #ifndef _ADD_SYSCALL_H
2  #define _ADD_SYSCALL_H
3  #include <linux/linkage.h>
4  asmlinkage long sys_parse_float_syscall(char __user *, int);
5  #endif

```

/usr/src/linux-5.8.12/arch/x86/entry/syscalls/syscall_64.tbl



```

arch > x86 > entry > syscalls > syscall_64.tbl
352 428 common open_tree sys_open_tree
353 429 common move_mount sys_move_mount
354 430 common fsopen sys_fsopen
355 431 common fsconfig sys_fsconfig
356 432 common fsmount sys_fsmount
357 433 common fspick sys_fspick
358 434 common pidfd_open sys_pidfd_open
359 435 common clone3 sys_clone3
360 437 common openat2 sys_openat2
361 438 common pidfd_getfd sys_pidfd_getfd
362 439 common faccessat2 sys_faccessat2
363 440 common parse_float_syscall sys_parse_float_syscall
364
365 #
366 # x32-specific system call numbers start at 512 to avoid cache impact
367 # for native 64-bit operation. The __x32_compat_sys stubs are created
368 # on-the-fly for compat_sys_*() compatibility system calls if X86_X32
369 # is defined.
370 #
371 512 x32 rt_sigaction compat_sys_rt_sigaction
372 513 x32 rt_sigreturn compat_sys_x32_rt_sigreturn
373 514 x32 ioctl compat_sys_ioctl

```

- Add sys_parse_float_syscall entry at 440 [line 363]

/usr/src/linux-5.8.12/include/asm-generic/syscalls.h

```

19  include > asm-generic > C syscalls.h
20  #include sys_mmap
21  asmlinkage long sys_mmap(unsigned long addr, unsigned long len,
22  |         unsigned long prot, unsigned long flags,
23  |         unsigned long fd, off_t pgoff);
24
25  #ifndef sys_rt_sigreturn
26  asmlinkage long sys_rt_sigreturn(struct pt_regs *regs);
27  #endif
28
29  #ifndef sys_parse_float_syscall
30  asmlinkage long sys_parse_float_syscall(char __user * num, int len);
31  #endif
32
33  #endif /* __ASM_GENERIC_SYSCALLS_H */
34

```

- [line 29-32]

/usr/src/linux-5.8.12/include/linux/syscalls.h

```

1213  /* obsolete: ipc */
1214  asmlinkage long sys_ipc(unsigned int call, int first, unsigned long second,
1215  |         unsigned long third, void __user *ptr, long fifth);
1216
1217  /* obsolete: mm/ */
1218  asmlinkage long sys_mmap_pgoff(unsigned long addr, unsigned long len,
1219  |         unsigned long prot, unsigned long flags,
1220  |         unsigned long fd, unsigned long pgoff);
1221  asmlinkage long sys_old_mmap(struct mmap_arg_struct __user *arg);
1222
1223  /*parse_float_syscall: parse_float_syscall/parse_float_syscall.c */
1224  asmlinkage long sys_parse_float_syscall(char __user * num, int len);
1225
1226  /*
1227   * Not a real system call, but a placeholder for syscalls which are
1228   * not implemented -- see kernel/sys_ni.c
1229   */
1230  asmlinkage long sys_ni_syscall(void);
1231
1232  #endif /* CONFIG_ARCH_HAS_SYSCALL_WRAPPER */
1233

```

- [line 1223-1224]

/usr/src/linux-5.8.12/Makefile

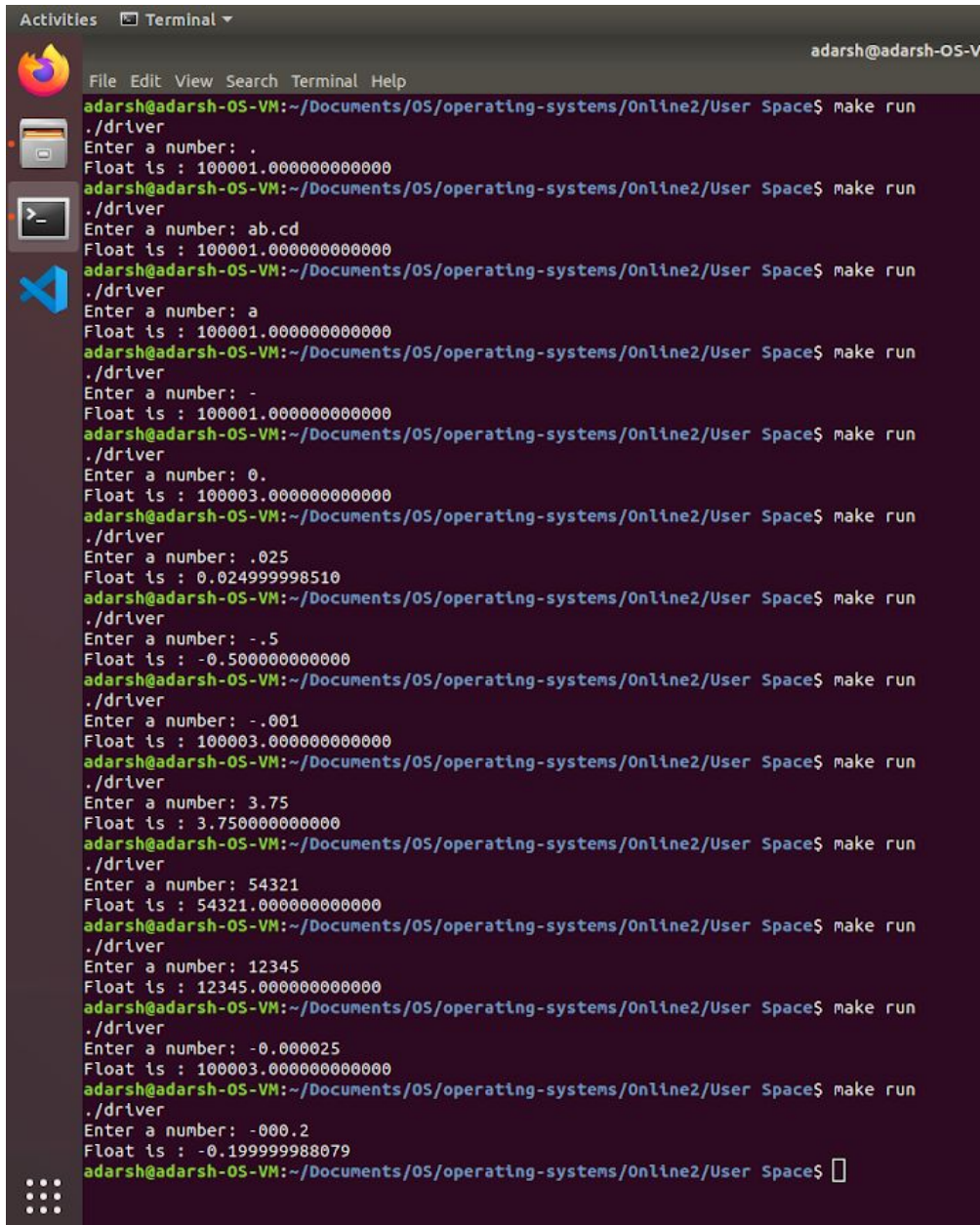
```

1060
1061
1062
1063 pare0
1064
1065 DER := $(extmod-prefix)modules.order
1066 ES_NSDEPS := $(extmod-prefix)modules.nsdeps
1067
1068 LD_EXTMOD,)
1069 += kernel/ certs/ mm/ fs/ ipc/ security/ crypto/ block/ parse_float_syscall/
1070
1071 := $(patsubst %/,%, $(filter %/, \
1072 $(core-y) $(core-m) $(drivers-y) $(drivers-m) \
1073 $(libs-y) $(libs-m)))
1074
1075 irs := $(sort $(vmlinux-dirs) Documentation \
1076 $(patsubst %/,%, $(filter %/, $(core-) \
1077 $(drivers-) $(libs-))))
1078
1079 der := $(addsuffix modules.order, $(filter %/, \
1080 $(core-y) $(core-m) $(libs-y) $(libs-m) \

```

- Append parse_float_syscall/
- [line 1069]

Test Cases



```

Activities  Terminal  adarsh@adarsh-OS-VM
File Edit View Search Terminal Help
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: .
Float is : 100001.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: ab.cd
Float is : 100001.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: a
Float is : 100001.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: -
Float is : 100001.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 0.
Float is : 100003.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: .025
Float is : 0.024999998510
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: -.5
Float is : -0.500000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: -.001
Float is : 100003.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 3.75
Float is : 3.750000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 54321
Float is : 54321.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 12345
Float is : 12345.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: -0.000025
Float is : 100003.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: -000.2
Float is : -0.199999988079
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$

```



```

Activities  Terminal  adarsh@adarsh-OS-V
File Edit View Search Terminal Help
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 0
Float is : 100003.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 0.09
Float is : 0.0899999996126
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 0.1
Float is : 0.0999999994040
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 1.25
Float is : 1.25000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 12.75
Float is : 12.75000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 12.34
Float is : 12.339999198914
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: -123.3
Float is : -123.299995422363
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: -234321.34
Float is : 100004.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 10000
Float is : 10000.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 100000
Float is : 100000.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 100000.01
Float is : 100002.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: -100000.1
Float is : 100004.000000000000
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: -0.01
Float is : -0.009999999776
adarsh@adarsh-OS-VM:~/Documents/OS/operating-systems/Online2/User Space$ make run
./driver
Enter a number: 

```