REPORT

PLAGIARISM STATEMENT

I certify that this assignment/report is my own work, based on my personal study and/or research and that

I have acknowledged all material and sources used in its preparation, whether they be books, articles, reports, lecture notes, and any other kind of document, electronic or personal communication. I also certify that this assignment/report has not previously been submitted for assessment in any other course, except where specific permission has been granted from all course instructors involved, or at any other time in this course, and that I have not copied in part or whole or otherwise plagiarised the work of other students and/or persons. I pledge to uphold the principles of honesty and responsibility at CSE@IITH. In addition, I understand my responsibility to report honour violations by other students if I become aware of it.

Name: Siddharth Saini

Date: Oct 31, 2020

Signature: Siddharth Saini

- **Text with green colour is input in the console.**
- **Text with blue colour is the answer to various questions asked in the assignment.**

TASK 1

siddharth@debian:~$ gcc -o helloWorld.o helloWorld.c

LTRACE

siddharth@debian:~$ ltrace ./helloWorld.o
puts("Hello Siddharth, It's Debain her"...Hello Siddharth, It's Debain here!
)   = 35

+++ exited (status 0) +++

siddharth@debian:~$ ltrace -c ./helloWorld.o
Hello Siddharth, It's Debain here!
% time   seconds usecs/call   calls   function
------ ----------- ----------- --------- --------------------
100.00 0.000297   297   1 puts
------ ----------- ----------- --------- --------------------
100.00 0.000297   1 total

siddharth@debian:~$ ltrace -S ./helloWorld.o
SYS_brk(0)   = 0x55b1c7d93000
SYS_access("/etc/ld.so.preload", 04)   = -2
SYS_openat(0xffffff9c, 0x7fc86ca8f90f, 0x80000, 0) = 3
SYS_fstat(3, 0x7ffdc7cd7c20)   = 0
SYS_mmap(0, 0x166e1, 1, 2)   = 0x7fc86ca58000
SYS_close(3)   = 0
SYS_openat(0xffffff9c, 0x7fc86ca98df0, 0x80000, 0) = 3
SYS_read(3, "\177ELF\002\001\001\003", 832)   = 832
SYS_fstat(3, 0x7ffdc7cd7c80)   = 0
SYS_mmap(0, 8192, 3, 34)   = 0x7fc86ca56000
SYS_mmap(0, 0x1c0800, 1, 2050)   = 0x7fc86c895000
SYS_mprotect(0x7fc86c8b7000, 1658880, 0)   = 0
SYS_mmap(0x7fc86c8b7000, 0x148000, 5, 2066) = 0x7fc86c8b7000
SYS_mmap(0x7fc86c9ff000, 0x4c000, 1, 2066)   = 0x7fc86c9ff000
SYS_mmap(0x7fc86ca4c000, 0x6000, 3, 2066)   = 0x7fc86ca4c000
SYS_mmap(0x7fc86ca52000, 0x3800, 3, 50)   = 0x7fc86ca52000
SYS_close(3)   = 0
SYS_arch_prctl(4098, 0x7fc86ca57500, 0x7fc86ca57e30, 144) = 0
SYS_mprotect(0x7fc86ca4c000, 16384, 1)   = 0
SYS_mprotect(0x55b1c750a000, 4096, 1)   = 0
SYS_mprotect(0x7fc86ca96000, 4096, 1)   = 0
SYS_munmap(0x7fc86ca58000, 91873)   = 0
puts("Hello Siddharth, It's Debain her"... <unfinished ...>
SYS_fstat(1, 0x7ffdc7cd88a0)   = 0
SYS_brk(0)   = 0x55b1c7d93000
SYS_brk(0x55b1c7db4000)   = 0x55b1c7db4000
SYS_write(1, "Hello Siddharth, It's Debain her"..., 35Hello Siddharth, It's Debain here!
) = 35
<... puts resumed>)   = 35
SYS_exit_group(0 <no return ...>
+++ exited (status 0) +++

siddharth@debian:~$ ltrace -t ./helloWorld.o

16:45:14 puts("Hello Siddharth, It's Debain her"...Hello Siddharth, It's Debain here!
) = 35
16:45:14 +++ exited (status 0) +++

siddharth@debian:~$ ltrace -T ./helloWorld.o
puts("Hello Siddharth, It's Debain her"...Hello Siddharth, It's Debain here!
)   = 35 <0.001047>
+++ exited (status 0) +++

STRACE

siddharth@debian:~$ strace ./helloWorld.o
execve("./helloWorld.o", ["./helloWorld.o"], 0x7ffea7de4750 /* 39 vars */) = 0
brk(NULL)   = 0x55e4aa46f000
access("/etc/ld.so.preload", R_OK)   = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=91873, ...}) = 0
mmap(NULL, 91873, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f0fd1b2c000
close(3)   = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\260A\2\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=1824496, ...}) = 0
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7f0fd1b2a000
mmap(NULL, 1837056, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f0fd1969000
mprotect(0x7f0fd198b000, 1658880, PROT_NONE) = 0
mmap(0x7f0fd198b000, 1343488, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x22000) = 0x7f0fd198b000
mmap(0x7f0fd1ad3000, 311296, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x16a000) = 0x7f0fd1ad3000
mmap(0x7f0fd1b20000, 24576, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1b6000) = 0x7f0fd1b20000
mmap(0x7f0fd1b26000, 14336, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f0fd1b26000
close(3)   = 0
arch_prctl(ARCH_SET_FS, 0x7f0fd1b2b500) = 0
mprotect(0x7f0fd1b20000, 16384, PROT_READ) = 0
mprotect(0x55e4aa405000, 4096, PROT_READ) = 0
mprotect(0x7f0fd1b6a000, 4096, PROT_READ) = 0
munmap(0x7f0fd1b2c000, 91873)   = 0
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0), ...}) = 0
brk(NULL)   = 0x55e4aa46f000
brk(0x55e4aa490000)   = 0x55e4aa490000

write(1, "Hello Siddharth, It's Debain her"..., 35Hello Siddharth, It's Debain here!
) = 35
exit_group(0)   = ?
+++ exited with 0 +++

siddharth@debian:~$ strace -c ./helloWorld.o
Hello Siddharth, It's Debain here!
% time   seconds usecs/call   calls   errors syscall
------ ----------- ----------- --------- --------- ----------------
  0.00 0.000000   0   1   read
  0.00 0.000000   0   1   write
  0.00 0.000000   0   2   close
  0.00 0.000000   0   3   fstat
  0.00 0.000000   0   7   mmap
  0.00 0.000000   0   4   mprotect
  0.00 0.000000   0   1   munmap
  0.00 0.000000   0   3   brk
  0.00 0.000000   0   1   1 access
  0.00 0.000000   0   1   execve
  0.00 0.000000   0   1   arch_prctl
  0.00 0.000000   0   2   openat
------ ----------- ----------- --------- --------- ----------------
100.00 0.000000   27   1 total

siddharth@debian:~$ strace -C ./helloWorld.o
execve("./helloWorld.o", ["./helloWorld.o"], 0x7fff915eac58 /* 39 vars */) = 0
brk(NULL)   = 0x560da4ede000
access("/etc/ld.so.preload", R_OK)   = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=91873, ...}) = 0
mmap(NULL, 91873, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f2344ccc000
close(3)   = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\260A\2\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=1824496, ...}) = 0
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7f2344cca000
mmap(NULL, 1837056, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f2344b09000
mprotect(0x7f2344b2b000, 1658880, PROT_NONE) = 0
mmap(0x7f2344b2b000, 1343488, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x22000) = 0x7f2344b2b000
mmap(0x7f2344c73000, 311296, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x16a000) = 0x7f2344c73000

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mmap(0x7f2344cc0000, 24576, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1b6000) = 0x7f2344cc0000
mmap(0x7f2344cc6000, 14336, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f2344cc6000
close(3)                        = 0
arch_prctl(ARCH_SET_FS, 0x7f2344ccb500) = 0
mprotect(0x7f2344cc0000, 16384, PROT_READ) = 0
mprotect(0x560da404d000, 4096, PROT_READ) = 0
mprotect(0x7f2344d0a000, 4096, PROT_READ) = 0
munmap(0x7f2344ccc000, 91873)           = 0
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0), ...}) = 0
brk(NULL)                       = 0x560da4ede000
brk(0x560da4eff000)             = 0x560da4eff000
write(1, "Hello Siddharth, It's Debain her"..., 35Hello Siddharth, It's Debain here!
) = 35
exit_group(0)                   = ?
+++ exited with 0 +++
% time         seconds  usecs/call   calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 0.00  0.000000       0      1         read
 0.00  0.000000       0      1         write
 0.00  0.000000       0      2         close
 0.00  0.000000       0      3         fstat
 0.00  0.000000       0      7         mmap
 0.00  0.000000       0      4         mprotect
 0.00  0.000000       0      1         munmap
 0.00  0.000000       0      3         brk
 0.00  0.000000       0      1       1 access
 0.00  0.000000       0      1         execve
 0.00  0.000000       0      1         arch_prctl
 0.00  0.000000       0      2         openat
------ ----------- ----------- --------- --------- ----------------
100.00 0.000000             27       1 total
```

siddharth@debian:~$ strace -t ./helloWorld.o
16:48:28 execve("./helloWorld.o", ["./helloWorld.o"], 0x7ffc6c5342a8 /* 39 vars */) = 0
16:48:28 brk(NULL)   = 0x55d14b510000
16:48:28 access("/etc/ld.so.preload", R_OK) = -1 ENOENT (No such file or directory)
16:48:28 openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
16:48:28 fstat(3, {st_mode=S_IFREG|0644, st_size=91873, ...}) = 0
16:48:28 mmap(NULL, 91873, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7fd7a3f58000
16:48:28 close(3)   = 0
16:48:28 openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
16:48:28 read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\260A\2\0\0\0\0\0"..., 832) = 832

16:48:28 fstat(3, {st_mode=S_IFREG|0755, st_size=1824496, ...}) = 0
16:48:28 mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7fd7a3f56000
16:48:28 mmap(NULL, 1837056, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7fd7a3d95000
16:48:28 mprotect(0x7fd7a3db7000, 1658880, PROT_NONE) = 0
16:48:28 mmap(0x7fd7a3db7000, 1343488, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x22000) = 0x7fd7a3db7000
16:48:28 mmap(0x7fd7a3eff000, 311296, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x16a000) = 0x7fd7a3eff000
16:48:28 mmap(0x7fd7a3f4c000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1b6000) = 0x7fd7a3f4c000
16:48:28 mmap(0x7fd7a3f52000, 14336, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7fd7a3f52000
16:48:28 close(3)   = 0
16:48:28 arch_prctl(ARCH_SET_FS, 0x7fd7a3f57500) = 0
16:48:28 mprotect(0x7fd7a3f4c000, 16384, PROT_READ) = 0
16:48:28 mprotect(0x55d14a203000, 4096, PROT_READ) = 0
16:48:28 mprotect(0x7fd7a3f96000, 4096, PROT_READ) = 0
16:48:28 munmap(0x7fd7a3f58000, 91873) = 0
16:48:28 fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0), ...}) = 0
16:48:28 brk(NULL)   = 0x55d14b510000
16:48:28 brk(0x55d14b531000)   = 0x55d14b531000
16:48:28 write(1, "Hello Siddharth, It's Debain her"..., 35Hello Siddharth, It's Debain here!
) = 35
16:48:28 exit_group(0)   = ?
16:48:28 +++ exited with 0 +++

siddharth@debian:~$ strace -w ./helloWorld.o
strace: -w must be given with (-c or -C)
Try 'strace -h' for more information.

siddharth@debian:~$ strace -c -w ./helloWorld.o
Hello Siddharth, It's Debain here!

% time	seconds	usecs/call	calls	errors	syscall
35.34	0.000132	131	1		execve
20.09	0.000075	75	1		write
12.16	0.000045	6	7		mmap
9.58	0.000036	8	4		mprotect
5.14	0.000019	19	1		munmap
3.83	0.000014	7	2		openat
3.65	0.000014	4	3		fstat
3.57	0.000013	4	3		brk

2.13	0.000008	3	2		close
2.03	0.000008	7	1	1	access
1.45	0.000005	5	1		read
1.05	0.000004	3	1		arch_prctl
------	-----------	-----------	---------	---------	----------------
100.00	0.000373		27	1	total

TIME

siddharth@debian:~$ time ./helloWorld.o
Hello Siddharth, It's Debain here!

real   0m0.018s
user   0m0.002s
sys   0m0.000s

siddharth@debian:~$ /usr/bin/time -v ./helloWorld.o
Hello Siddharth, It's Debain here!
    Command being timed: "./helloWorld.o"
    User time (seconds): 0.00
    System time (seconds): 0.00
    Percent of CPU this job got: 20%
    Elapsed (wall clock) time (h:mm:ss or m:ss): 0:00.00
    Average shared text size (kbytes): 0
    Average unshared data size (kbytes): 0
    Average stack size (kbytes): 0
    Average total size (kbytes): 0
    Maximum resident set size (kbytes): 1236
    Average resident set size (kbytes): 0
    Major (requiring I/O) page faults: 0
    Minor (reclaiming a frame) page faults: 68
    Voluntary context switches: 3
    Involuntary context switches: 37
    Swaps: 0
    File system inputs: 304
    File system outputs: 0
    Socket messages sent: 0
    Socket messages received: 0
    Signals delivered: 0
    Page size (bytes): 4096
    Exit status: 0

CPU Bound OR I/O Bound

helloWorld.c is CPU Bound as the Percent of CPU used is 20%.

Converting to I/O Bound

To convert it to I/O Bound, we add some "scanf" statement so that the program asks for an input from the user.

siddharth@debian:~$ gcc -o helloWorld.o helloWorld.c

siddharth@debian:~$ /usr/bin/time -v ./helloWorld.o
3
Hello Siddharth, It's Debain here!
    Command being timed: "./helloWorld.o"
    User time (seconds): 0.00
    System time (seconds): 0.00
    Percent of CPU this job got: 0%
    Elapsed (wall clock) time (h:mm:ss or m:ss): 0:02.93
    Average shared text size (kbytes): 0
    Average unshared data size (kbytes): 0
    Average stack size (kbytes): 0
    Average total size (kbytes): 0
    Maximum resident set size (kbytes): 1300
    Average resident set size (kbytes): 0
    Major (requiring I/O) page faults: 0
    Minor (reclaiming a frame) page faults: 69
    Voluntary context switches: 2
    Involuntary context switches: 0
    Swaps: 0
    File system inputs: 0
    File system outputs: 0
    Socket messages sent: 0
    Socket messages received: 0
    Signals delivered: 0
    Page size (bytes): 4096
    Exit status: 0

-> Here the job becomes I/O Bound as the CPU usage reduces to 0%.

TASK 2

I have used a linkedList program which makes a linkedList and then asks the user to search for an element in the list, it also asks the user to enter a new element in the list and then prints the final list.

siddharth@debian:~$ gcc -o linkedList.o LinkedList.c

siddharth@debian:~$ ltrace ./linkedList.o
puts("The linked list is: "The linked list is:
)   = 21
printf(" %d ", 2)   = 3
printf(" %d ", 3)   = 3
printf(" %d ", 4)   = 3
printf(" %d ", 5)   = 3
printf(" %d ", 6)   = 3
putchar(10, 0x55acdbb93097, 0x7fbd544598c0, 0 2 3 4 5 6
) = 10
printf("Enter the Number to search in th"...)   = 40
__isoc99_scanf(0x55acdbb93049, 0x7ffdf6a164ac, 0x7fbd544598c0, 0Enter the Number to
search in the list: 2
) = 1
putchar(89, 2, 2, 16)   = 89
putchar(10, 89, 0x7fbd544598c0, 0xfbad2a84Y
)   = 10
printf("Enter the new number you want to"...)   = 38
__isoc99_scanf(0x55acdbb93049, 0x7ffdf6a164a8, 0x7fbd544598c0, 0Enter the new number
you want to add: 5
) = 1
malloc(24)   = 0x55acdd719a80
puts("The updated linked list is: "The updated linked list is:
)   = 29
printf(" %d ", 5)   = 3
printf(" %d ", 2)   = 3
printf(" %d ", 3)   = 3
printf(" %d ", 4)   = 3
printf(" %d ", 5)   = 3
printf(" %d ", 6)   = 3
putchar(10, 0x55acdbb93097, 0x7fbd544598c0, 0 5 2 3 4 5 6
) = 10
+++ exited (status 0) +++

siddharth@debian:~$ strace ./linkedList.o
execve("./linkedList.o", ["./linkedList.o"], 0x7ffe2e400bc0 /* 39 vars */) = 0
brk(NULL)   = 0x55a301262000
access("/etc/ld.so.preload", R_OK)   = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=91873, ...}) = 0
mmap(NULL, 91873, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f48a08c7000
close(3)   = 0

```
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\260A\2\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=1824496, ...}) = 0
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7f48a08c5000
mmap(NULL, 1837056, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f48a0704000
mprotect(0x7f48a0726000, 1658880, PROT_NONE) = 0
mmap(0x7f48a0726000, 1343488, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x22000) = 0x7f48a0726000
mmap(0x7f48a086e000, 311296, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x16a000) = 0x7f48a086e000
mmap(0x7f48a08bb000, 24576, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1b6000) = 0x7f48a08bb000
mmap(0x7f48a08c1000, 14336, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f48a08c1000
close(3)                        = 0
arch_prctl(ARCH_SET_FS, 0x7f48a08c6500) = 0
mprotect(0x7f48a08bb000, 16384, PROT_READ) = 0
mprotect(0x55a2ffeae000, 4096, PROT_READ) = 0
mprotect(0x7f48a0905000, 4096, PROT_READ) = 0
munmap(0x7f48a08c7000, 91873)           = 0
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0), ...}) = 0
brk(NULL)                       = 0x55a301262000
brk(0x55a301283000)             = 0x55a301283000
write(1, "The linked list is: \n", 21The linked list is:
) = 21
write(1, " 2  3  4  5  6 \n", 16 2  3  4  5  6
)       = 16
fstat(0, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0), ...}) = 0
write(1, "Enter the Number to search in th"..., 40Enter the Number to search in the list: ) = 40
read(0, 3
"3\n", 1024)          = 2
write(1, "Y\n", 2Y
)               = 2
write(1, "Enter the new number you want to"..., 38Enter the new number you want to add: ) = 38
read(0, 5
"5\n", 1024)          = 2
write(1, "The updated linked list is: \n", 29The updated linked list is:
) = 29
write(1, " 5  2  3  4  5  6 \n", 19 5  2  3  4  5  6
)      = 19
lseek(0, -1, SEEK_CUR)          = -1 ESPIPE (Illegal seek)
exit_group(0)                   = ?
```

+++ exited with 0 +++

time ./linkedList.o
The linked list is:
 2 3 4 5 6
Enter the Number to search in the list: 3
Y
Enter the new number you want to add: 7
The updated linked list is:
 7 2 3 4 5 6

real   0m11.093s
user   0m0.001s
sys   0m0.000s

siddharth@debian:~$ /usr/bin/time -v ./linkedList.o
The linked list is:
 2 3 4 5 6
Enter the Number to search in the list: 3
Y
Enter the new number you want to add: 7
The updated linked list is:
 7 2 3 4 5 6
    Command being timed: "./linkedList.o"
    User time (seconds): 0.00
    System time (seconds): 0.00
    Percent of CPU this job got: 0%
    Elapsed (wall clock) time (h:mm:ss or m:ss): 0:03.33
    Average shared text size (kbytes): 0
    Average unshared data size (kbytes): 0
    Average stack size (kbytes): 0
    Average total size (kbytes): 0
    Maximum resident set size (kbytes): 1408
    Average resident set size (kbytes): 0
    Major (requiring I/O) page faults: 0
    Minor (reclaiming a frame) page faults: 73
    Voluntary context switches: 3
    Involuntary context switches: 5
    Swaps: 0
    File system inputs: 0
    File system outputs: 0
    Socket messages sent: 0
    Socket messages received: 0
    Signals delivered: 0

Page size (bytes): 4096
Exit status: 0

strace -c ./linkedList.o
The linked list is:
 2 3 4 5 6
Enter the Number to search in the list: 3
Y
Enter the new number you want to add: 7
The updated linked list is:
 7 2 3 4 5 6

% time	seconds	usecs/call	calls	errors	syscall
0.00	0.000000	0	3		read
0.00	0.000000	0	7		write
0.00	0.000000	0	2		close
0.00	0.000000	0	4		fstat
0.00	0.000000	0	1	1	lseek
0.00	0.000000	0	7		mmap
0.00	0.000000	0	4		mprotect
0.00	0.000000	0	1		munmap
0.00	0.000000	0	3		brk
0.00	0.000000	0	1	1	access
0.00	0.000000	0	1		execve
0.00	0.000000	0	1		arch_prctl
0.00	0.000000	0	2		openat
------	-----------	-----------	---------	---------	---------
100.00	0.000000		37	2	total

strace -w -c ./linkedList.o
The linked list is:
 2 3 4 5 6
Enter the Number to search in the list: 3
Y
Enter the new number you want to add: 7
The updated linked list is:
 7 2 3 4 5 6

% time	seconds	usecs/call	calls	errors	syscall
99.98	3.061286	1020428	3		read
0.01	0.000260	37	7		write
0.00	0.000118	117	1		execve
0.00	0.000041	5	7		mmap
0.00	0.000031	7	4		mprotect

0.00	0.000018	17	1		munmap
0.00	0.000018	4	4		fstat
0.00	0.000013	6	2		openat
0.00	0.000013	4	3		brk
0.00	0.000007	3	2		close
0.00	0.000007	6	1	1	access
0.00	0.000004	3	1	1	lseek
0.00	0.000004	3	1		arch_prctl
------	-----------	-----------	---------	---------	----------------
100.00	3.061817		37	2	total

- It is an I/O Bound job since the CPU usage is 0%.
  This happened because we have used 2 "scanf" statements that waits for the user to input the data.
- "Read" system call is called most frequently as visible from the above data.
  This happens because the system has to read the input data everytime we enter that.
- "Read" system call consumes the maximum amount of time as clear from the above data. It consumes about "99.98%" of time.

TASK 3

- Example 2 is named as example2.c and Example 2' is named as example3.c, which are compiled into example2.o and example3.o respectively.
- I have used the printf statements to print "This is Example X", where X is 2 and 3 in Example2 and Example3 respectively.

Example2:

siddharth@debian:~$ gcc -o example2.o example2.c
siddharth@debian:~$ ltrace ./example2.o
syscall(90, 0x5571e93dc004, 292, 0x7f2f2db5f718) = -1
__errno_location()   = 0x7f2f2db66480
fprintf(0x7f2f2db60680, "chmod failed, errno = %d\n", 1chmod failed, errno = 1
) = 24
printf("This is Example2")   = 16
This is Example2+++ exited (status 0) +++

siddharth@debian:~$ strace ./example2.o
execve("./example2.o", ["./example2.o"], 0x7fff9f5bd610 /* 39 vars */) = 0
brk(NULL)   = 0x55f47ba81000

```
access("/etc/ld.so.preload", R_OK)    = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=91873, ...}) = 0
mmap(NULL, 91873, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f04b0fdc000
close(3)                           = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\260A\2\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=1824496, ...}) = 0
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7f04b0fda000
mmap(NULL, 1837056, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f04b0e19000
mprotect(0x7f04b0e3b000, 1658880, PROT_NONE) = 0
mmap(0x7f04b0e3b000, 1343488, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x22000) = 0x7f04b0e3b000
mmap(0x7f04b0f83000, 311296, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x16a000) = 0x7f04b0f83000
mmap(0x7f04b0fd0000, 24576, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1b6000) = 0x7f04b0fd0000
mmap(0x7f04b0fd6000, 14336, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f04b0fd6000
close(3)                           = 0
arch_prctl(ARCH_SET_FS, 0x7f04b0fdb500) = 0
mprotect(0x7f04b0fd0000, 16384, PROT_READ) = 0
mprotect(0x55f47b473000, 4096, PROT_READ) = 0
mprotect(0x7f04b101a000, 4096, PROT_READ) = 0
munmap(0x7f04b0fdc000, 91873)           = 0
chmod("/etc/passwd", 0444)          = -1 EPERM (Operation not permitted)
write(2, "chmod failed, errno = 1\n", 24chmod failed, errno = 1
) = 24
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0), ...}) = 0
brk(NULL)                   = 0x55f47ba81000
brk(0x55f47baa2000)              = 0x55f47baa2000
write(1, "This is Example2", 16This is Example2)     = 16
exit_group(0)               = ?
+++ exited with 0 +++

siddharth@debian:~$ time ./example2.o
chmod failed, errno = 1
This is Example2
real    0m0.001s
user    0m0.001s
sys    0m0.000s
```

siddharth@debian:~$ /usr/bin/time -v ./example2.o
chmod failed, errno = 1
This is Example2   Command being timed: "./example2.o"
    User time (seconds): 0.00
    System time (seconds): 0.00
    Percent of CPU this job got: ?%
    Elapsed (wall clock) time (h:mm:ss or m:ss): 0:00.00
    Average shared text size (kbytes): 0
    Average unshared data size (kbytes): 0
    Average stack size (kbytes): 0
    Average total size (kbytes): 0
    Maximum resident set size (kbytes): 1372
    Average resident set size (kbytes): 0
    Major (requiring I/O) page faults: 0
    Minor (reclaiming a frame) page faults: 72
    Voluntary context switches: 1
    Involuntary context switches: 3
    Swaps: 0
    File system inputs: 0
    File system outputs: 0
    Socket messages sent: 0
    Socket messages received: 0
    Signals delivered: 0
    Page size (bytes): 4096
    Exit status: 0

siddharth@debian:~$ ltrace -c ./example2.o
chmod failed, errno = 1
This is Example2% time   seconds usecs/call   calls   function

------ ----------- ----------- --------- --------------------
 39.45 0.000172   172   1 fprintf
 28.90 0.000126   126   1 printf
 20.41 0.000089   89   1 syscall
 11.24 0.000049   49   1 __errno_location
------ ----------- ----------- --------- --------------------
100.00 0.000436   4 total

siddharth@debian:~$ strace -c ./example2.o
chmod failed, errno = 1
This is Example2% time   seconds usecs/call   calls   errors syscall

------ ----------- ----------- --------- --------- ----------------
  0.00 0.000000   0   1   read
  0.00 0.000000   0   2   write
  0.00 0.000000   0   2   close

0.00	0.000000	0	3		fstat
0.00	0.000000	0	7		mmap
0.00	0.000000	0	4		mprotect
0.00	0.000000	0	1		munmap
0.00	0.000000	0	3		brk
0.00	0.000000	0	1	1	access
0.00	0.000000	0	1		execve
0.00	0.000000	0	1	1	chmod
0.00	0.000000	0	1		arch_prctl
0.00	0.000000	0	2		openat

```
------ ----------- ----------- --------- --------- ----------------
```

100.00	0.000000		29	2	total

- Procedure Calls: fprintf, printf, syscall, __errno_location
- System Calls: read, write, close, fstat, mmap, mprotect, munmap, brk, execve, chmod, openat

Example3:

siddharth@debian:~$ gcc -o example3.o Example3.c
siddharth@debian:~$ ltrace ./example3.o
chmod("/etc/passwd", 0444)   = -1
__errno_location()   = 0x7f184a2c1480
fprintf(0x7f184a2bb680, "chmod failed, errno = %d\n", 1chmod failed, errno = 1
) = 24
printf("This is Example3")   = 16
This is Example3+++ exited (status 0) +++

siddharth@debian:~$ strace ./example3.o
execve("./example3.o", ["./example3.o"], 0x7fffd50b5f20 /* 39 vars */) = 0
brk(NULL)   = 0x561cfe1ab000
access("/etc/ld.so.preload", R_OK)   = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=91873, ...}) = 0
mmap(NULL, 91873, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f96ac555000
close(3)   = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0\260A\2\0\0\0\0\0"..., 832) = 832
fstat(3, {st_mode=S_IFREG|0755, st_size=1824496, ...}) = 0
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0)
= 0x7f96ac553000
mmap(NULL, 1837056, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) =
0x7f96ac392000
mprotect(0x7f96ac3b4000, 1658880, PROT_NONE) = 0

```
mmap(0x7f96ac3b4000, 1343488, PROT_READ|PROT_EXEC,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x22000) = 0x7f96ac3b4000
mmap(0x7f96ac4fc000, 311296, PROT_READ,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x16a000) = 0x7f96ac4fc000
mmap(0x7f96ac549000, 24576, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1b6000) = 0x7f96ac549000
mmap(0x7f96ac54f000, 14336, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f96ac54f000
close(3)                        = 0
arch_prctl(ARCH_SET_FS, 0x7f96ac554500) = 0
mprotect(0x7f96ac549000, 16384, PROT_READ) = 0
mprotect(0x561cfdfac000, 4096, PROT_READ) = 0
mprotect(0x7f96ac593000, 4096, PROT_READ) = 0
munmap(0x7f96ac555000, 91873)           = 0
chmod("/etc/passwd", 0444)          = -1 EPERM (Operation not permitted)
write(2, "chmod failed, errno = 1\n", 24chmod failed, errno = 1
) = 24
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0), ...}) = 0
brk(NULL)                       = 0x561cfe1ab000
brk(0x561cfe1cc000)                     = 0x561cfe1cc000
write(1, "This is Example3", 16This is Example3)     = 16
exit_group(0)                   = ?
+++ exited with 0 +++


siddharth@debian:~$ time ./example3.o
chmod failed, errno = 1
This is Example3
real    0m0.003s
user    0m0.001s
sys    0m0.000s
siddharth@debian:~$ /usr/bin/time -v example3.o
/usr/bin/time: cannot run example3.o: No such file or directory
Command exited with non-zero status 127
    Command being timed: "example3.o"
    User time (seconds): 0.00
    System time (seconds): 0.00
    Percent of CPU this job got: ?%
    Elapsed (wall clock) time (h:mm:ss or m:ss): 0:00.00
    Average shared text size (kbytes): 0
    Average unshared data size (kbytes): 0
    Average stack size (kbytes): 0
    Average total size (kbytes): 0
    Maximum resident set size (kbytes): 1144
    Average resident set size (kbytes): 0
```

Major (requiring I/O) page faults: 0
Minor (reclaiming a frame) page faults: 30
Voluntary context switches: 1
Involuntary context switches: 4
Swaps: 0
File system inputs: 0
File system outputs: 0
Socket messages sent: 0
Socket messages received: 0
Signals delivered: 0
Page size (bytes): 4096
Exit status: 127

siddharth@debian:~$ ltrace -c ./example3.o
chmod failed, errno = 1
This is Example3% time   seconds usecs/call   calls   function
------ ----------- ----------- --------- --------------------
 38.93 0.000160   160   1 fprintf
 30.17 0.000124   124   1 printf
 19.71 0.000081   81   1 chmod
 11.19 0.000046   46   1 __errno_location
------ ----------- ----------- --------- --------------------
100.00 0.000411   4 total

siddharth@debian:~$ strace -c ./example3.o
chmod failed, errno = 1
This is Example3% time   seconds usecs/call   calls   errors syscall
------ ----------- ----------- --------- --------- ----------------
  0.00 0.000000   0   1   read
  0.00 0.000000   0   2   write
  0.00 0.000000   0   2   close
  0.00 0.000000   0   3   fstat
  0.00 0.000000   0   7   mmap
  0.00 0.000000   0   4   mprotect
  0.00 0.000000   0   1   munmap
  0.00 0.000000   0   3   brk
  0.00 0.000000   0   1   1 access
  0.00 0.000000   0   1   execve
  0.00 0.000000   0   1   1 chmod
  0.00 0.000000   0   1   arch_prctl
  0.00 0.000000   0   2   openat
------ ----------- ----------- --------- --------- ----------------
100.00 0.000000   29   2 total

- Procedure Calls: fprintf, printf, chmod, __errno_location
- System Calls: read, write, close, fstat, mmap, mprotect, munmap, brk, execve, chmod, openat