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AESD Assignment 03
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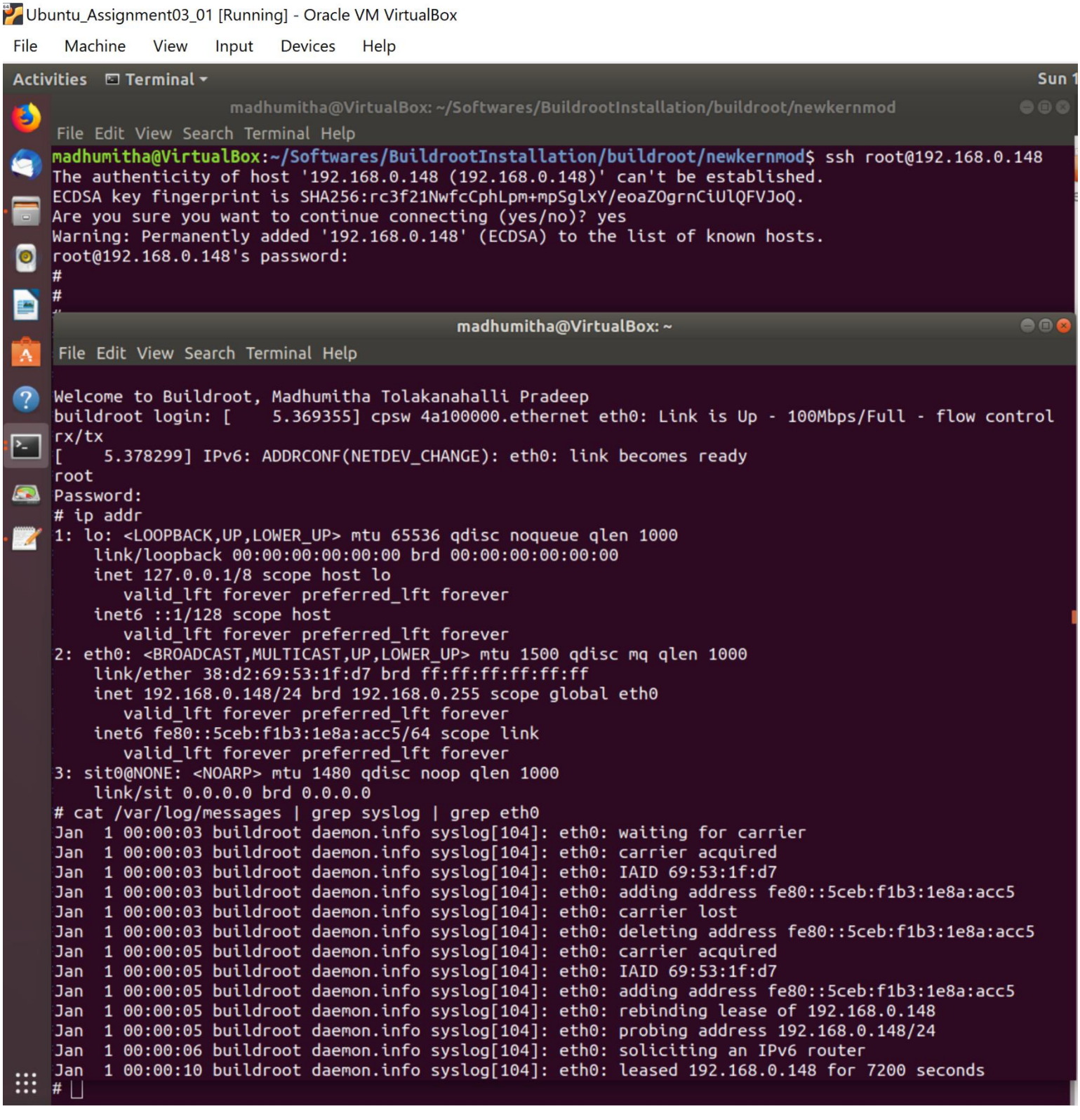
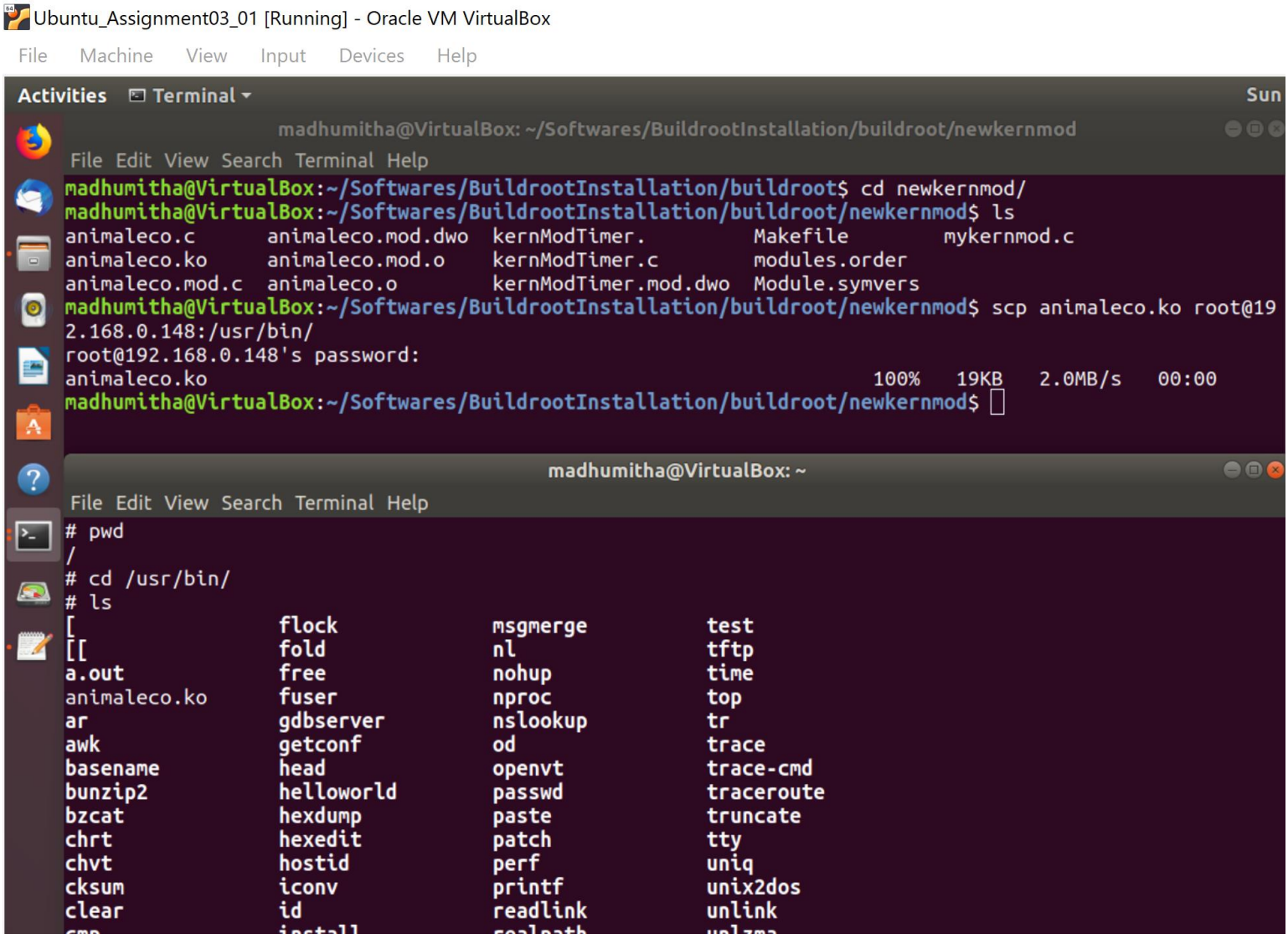
GITHUB - https://github.com/madhumithatp/aesd-assignment3

[Problem 1 – 2 pts] Set up BBG ethernet networking

Screen capture and report the console boot sequence/dmesg log showing the BBG getting an ethernet address from the network.

Screen capture and report a (scp) copy of a file from your host to the BBG to the /usr/bin directory.





[Problem 2 - 20 Pts] Remote debugging your application with GBD

Write/port, compile and add your own application (e.g. from Assignment 2 Problem 2) out-of-tree from the Buildroot Linux directories, yet using the Buildroot target tool chain. Make sure the symbols haven't been stripped. Let's run it on the BBG using GDB and exercise debugging skills with it.

Next set up your BBG and host for remote debugging. We're going to use Buildroot (i.e. make menuconfig) to configure and rebuild the BBG target Linux image as well as create host executables so you can do rudimentary remote command-line debugging of code running on the BBG. This method will utilize the ethernet interface for debugging connectivity.

Figure 1 - Recommended GDB connectivity

The high-level items needed via Buildroot are:

- Enable running GDB on the host
- Enable inclusion of GDB Server on the target
- Enabling debugging with symbols

Besides our MELP textbook, utilize the GDB manual for assistance in executing remote debugging commands. Key points to consider are SYSROOT settings to allow the host access to code symbols and compiling the target code to include them.

On the BBG console via the serial cable (or ssh to the BBG in another terminal), start gdbserver without supplying an initial command to run or process ID to attach by using the '--multi' command line option.

```
root@bbg# gdbserver --multi comm &
```

Sample Program to find number of upper and lower case characters in the input string

```c
#include <stdio.h>

#include <stdint.h>
#include <stdlib.h>
#include <string.h>
#include <sys/stat.h>

int main()
{
    char    str[100];
    int countL,countU;
    int counter;

    //assign all counters to zero
    countL=countU=0;

    printf("Enter a string: ");
    gets(str);

    for(counter=0;str[counter]!=NULL;counter++){

        if(str[counter]>='A' && str[counter]<='Z')
            countU++;
        else if(str[counter]>='a' && str[counter]<='z')
            countL++;
    }

    printf("Total Upper case characters: %d, Lower Case characters: %d",countU,countL);

    return 0;
}
```

Capture your host debugging session using the “manual” configuration command method

1) Start the host GDB session with the program name to debug

2) Show the host commands connecting to the target

e.g. `(gdb) target extended-remote 192.168.0.8:5555`

```
madhumitha@VirtualBox:~/Softwares/BuildrootInstallation/buildroot/board/beaglebone_m/rootfs-overlay/usr/bin$ gdb-multiarch
GNU gdb (Ubuntu 8.1-0ubuntu3) 8.1.0.20180409-git
Copyright (C) 2018 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.  Type "show copying"
and "show warranty" for details.
This GDB was configured as "x86_64-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word".
(gdb) target extended-remote 192.168.0.2:2222
Remote debugging using 192.168.0.2:2222
(gdb)
```

```
madhumitha@VirtualBox: ~
File  Edit  View  Search  Terminal  Help
# gdbserver --multi localhost:2222
Listening on port 2222
[  200.407932] random: crng init done
Remote debugging from host 192.168.0.1
```

3) Pushing your out-of-tree executable to the target

e.g. `(gdb) remote put …`

```
(gdb) remote put strmanip /usr/bin/strmanip
Successfully sent file "strmanip".
```

4) Select the file to debug. This should be set to the filename on the target system.

e.g. `(gdb) set remote exec-file filename`

```
(gdb) set remote exec-file strmanip
(gdb) file strmanip
Reading symbols from strmanip...done.
```

5) Set breakpoints (e.g. main and others) and any other commands necessary, then run your program

```
Reading symbols from strmanip...done.
(gdb) b main
Breakpoint 1 at 0x104a8: file strmanip.c, line 15.
(gdb) b 20
Breakpoint 2 at 0x104d0: file strmanip.c, line 20.
(gdb) b 28
Breakpoint 3 at 0x1057c: file strmanip.c, line 28.
(gdb) i b
Num     Type           Disp Enb Address    What
1       breakpoint     keep y   0x000104a8 in main at strmanip.c:15
2       breakpoint     keep y   0x000104d0 in main at strmanip.c:20
3       breakpoint     keep y   0x0001057c in main at strmanip.c:28
(gdb) run
Starting program: /home/madhumitha/Softwares/BuildrootInstallation/buildroot/board/beaglebone_m/rootfs
-overlay/usr/bin/strmanip
Reading /lib/ld-uClibc.so.0 from remote target...
warning: File transfers from remote targets can be slow. Use "set sysroot" to access files locally ins
tead.
Reading /lib/ld-uClibc.so.0 from remote target...
Reading /lib//libc.so.0 from remote target...
```

6) Single stepping through your code and continuing execution
7) Manually showing (print) variable values at the command line

```
Starting program: /home/madhumitha/Softwares/BuildrootInstallation/buildroot/board/beaglebone_m/rootfs
-overlay/usr/bin/strmanip
Reading /lib/ld-uClibc.so.0 from remote target...
Reading /lib/ld-uClibc.so.0 from remote target...
Reading /lib//libc.so.0 from remote target...

Breakpoint 1, main () at strmanip.c:15
15          countL=countU=0;
(gdb) n
17          printf("Enter a string: ");
(gdb) n
18          gets(str);
(gdb) n

Breakpoint 2, main () at strmanip.c:20
20          for(counter=0;str[counter]!=NULL;counter++){
(gdb) n
22              if(str[counter]>='A' && str[counter]<='Z')
(gdb) n
23                  countU++;
(gdb) print str
$1 = "This is a test STRING", '\000' <repeats 19 times>, "t/\365\266\070\v\365\266t/\365\266X?\362\266
\220\004\365\266\000\000\000\000\000\000\000\000t/\365\266\274L\v\b\361\363\266\000\000\000\000\000\000
\000\000\204\003\001\000\070<\362\266\000\000\000"
(gdb) print countU
$2 = 0
(gdb) print str[counter]
$3 = 84 'T'
(gdb) n
20          for(counter=0;str[counter]!=NULL;counter++){
(gdb) n
22              if(str[counter]>='A' && str[counter]<='Z')
(gdb) n
24              else if(str[counter]>='a' && str[counter]<='z')
(gdb) print counterU
No symbol "counterU" in current context.
(gdb) print countU
$4 = 1
(gdb) print countL
$5 = 0
(gdb) c
Continuing.

Breakpoint 3, main () at strmanip.c:28
28          printf("Total Upper case characters: %d, Lower Case characters: %d",countU,countL);
(gdb) n
30          return 0;
(gdb)
```

8) Capture the “console” printouts from the BBG output of your program.

```
# gdbserver --multi localhost:2222
Listening on port 2222
[  200.407932] random: crng init done
Remote debugging from host 192.168.0.1
```

```
Process /root/strmanip created; pid = 144
Enter a string: This is a test STRING
Total Upper case characters: 7, Lower Case characters: 10
Child exited with status 0
```

Capture and repeat the above steps using a host initialization file i.e. -x gdbinit , and repeat some debugging steps. Show the contents of your gdbinit file.

```
madhumitha@VirtualBox: ~/Softwares/BuildrootInstallation/buildroot/board/beaglebone_m/rootfs-overlay/usr/bin
File  Edit  View  Search  Terminal  Help
target extended-remote 192.168.0.2:2222
remote put strmanip /usr/bin/strmanip
set remote exec-file strmanip
file strmanip
b main
b 20
b 28
run
n
n
n
n
n
print str
print countU
n
n
n
print countU
print countL
c
n
~
```

[Problem 3 - 20 Pts] Create a Kernel Module

Create your own “external” (not in the tree) kernel module that use a kernel timer to periodically wake up (fire) every 500msec by default. Each time the timer wakes up you should call a function that prints to the kernel log buffers

- Your name
- a count of how many times the timer has fired

Submit your code to your Git repo and record it’s the location (link) in your Canvas assignment submittal.
Install and run your kernel module 2 times, each time with a different set of command line parameters. For each run get screenshots of the following items to include in your report:

Run 1: Default (Timer wakeup – 500ms)

- Screenshots of the install and successful load of the module & Output print buffer (dmesg log) of your count printing your name and the count and timestamps

```
[  847.387982] Initializing Kernel Timer Module...
[  848.407913] | Kernal Timer Fire Count : [1]   | Kernel Owner : [Madhumitha] |
[  849.447448] | Kernal Timer Fire Count : [2]   | Kernel Owner : [Madhumitha] |
[  850.487432] | Kernal Timer Fire Count : [3]   | Kernel Owner : [Madhumitha] |
[  851.527432] | Kernal Timer Fire Count : [4]   | Kernel Owner : [Madhumitha] |
[  852.567434] | Kernal Timer Fire Count : [5]   | Kernel Owner : [Madhumitha] |
[  853.607436] | Kernal Timer Fire Count : [6]   | Kernel Owner : [Madhumitha] |
[  854.647449] | Kernal Timer Fire Count : [7]   | Kernel Owner : [Madhumitha] |
[  855.687430] | Kernal Timer Fire Count : [8]   | Kernel Owner : [Madhumitha] |
[  856.727429] | Kernal Timer Fire Count : [9]   | Kernel Owner : [Madhumitha] |
[  857.767435] | Kernal Timer Fire Count : [10]          | Kernel Owner : [Madhumitha] |
[  858.807430] | Kernal Timer Fire Count : [11]          | Kernel Owner : [Madhumitha] |
[  859.847440] | Kernal Timer Fire Count : [12]          | Kernel Owner : [Madhumitha] |
[  860.887432] | Kernal Timer Fire Count : [13]          | Kernel Owner : [Madhumitha] |
[  861.927434] | Kernal Timer Fire Count : [14]          | Kernel Owner : [Madhumitha] |
[  862.967431] | Kernal Timer Fire Count : [15]          | Kernel Owner : [Madhumitha] |
[  864.007434] | Kernal Timer Fire Count : [16]          | Kernel Owner : [Madhumitha] |
[  865.047439] | Kernal Timer Fire Count : [17]          | Kernel Owner : [Madhumitha] |
[  866.087437] | Kernal Timer Fire Count : [18]          | Kernel Owner : [Madhumitha] |
```

• Screenshots of the module info showing you as the author

```
# modinfo kernModTimer.ko
filename:       /kern/kernModTimer.ko
description:    Kernel Timer Module with confugurable wake-up period (default 500ms). Owner Name and T
ime-Out values are input as parameters
author:         Madhumitha Tolakanahalli Pradeep
license:        GPL
srcversion:     A0AD5BAE48EF70EC9B8B196
depends:
name:           kernModTimer
vermagic:       4.14.40 SMP mod_unload modversions ARMv6 p2v8
parm:           ownerName:charp
parm:           timerWakeUp:ushort
#
```

• Screenshots of the module remove

```
# rmmod kernModTimer.ko
[ 1091.305981] Exiting Kernel Timer Module...
```

Run 2: ownerName=”Sample1” Timer wakeup = 1s

• Screenshots of the install and successful load of the module & Output print buffer (dmesg log) of your count printing your name and the count and timestamps

```
[ 1312.195737] Initializing Kernel Timer Module...
[ 1313.207932] | Kernal Timer Fire Count : [1]   | Kernel Owner : [Sample1] |
[ 1314.247466] | Kernal Timer Fire Count : [2]   | Kernel Owner : [Sample1] |
[ 1315.287469] | Kernal Timer Fire Count : [3]   | Kernel Owner : [Sample1] |
[ 1316.327465] | Kernal Timer Fire Count : [4]   | Kernel Owner : [Sample1] |
[ 1317.367465] | Kernal Timer Fire Count : [5]   | Kernel Owner : [Sample1] |
[ 1318.407496] | Kernal Timer Fire Count : [6]   | Kernel Owner : [Sample1] |
[ 1319.447468] | Kernal Timer Fire Count : [7]   | Kernel Owner : [Sample1] |
[ 1320.487464] | Kernal Timer Fire Count : [8]   | Kernel Owner : [Sample1] |
```

• Screenshots of the module info showing you as the author

```
# modinfo kernModTimer.ko
filename:       /kern/kernModTimer.ko
description:    Kernel Timer Module with confugurable wake-up period (default 500ms). Owner Name and T
ime-Out values are input as parameters
author:         Madhumitha Tolakanahalli Pradeep
license:        GPL
srcversion:     A0AD5BAE48EF70EC9B8B196
depends:
name:           kernModTimer
vermagic:       4.14.40 SMP mod_unload modversions ARMv6 p2v8
parm:           ownerName:charp
parm:           timerWakeUp:ushort
#
```

• Screenshots of the module remove

```
# rmmod kernModTimer.ko
[ 1091.305981] Exiting Kernel Timer Module...
```

Run 3: ownerName=”Sample2” Timer wakeup = 2s

• Screenshots of the install and successful load of the module & Output print buffer (dmesg log) of your count printing your name and the count and timestamps

```
[ 1385.732425] Initializing Kernel Timer Module...
[ 1387.767916] | Kernal Timer Fire Count : [1]   | Kernel Owner : [Sample2] |
[ 1389.847435] | Kernal Timer Fire Count : [2]   | Kernel Owner : [Sample2] |
[ 1391.927445] | Kernal Timer Fire Count : [3]   | Kernel Owner : [Sample2] |
[ 1394.007433] | Kernal Timer Fire Count : [4]   | Kernel Owner : [Sample2] |
[ 1396.087426] | Kernal Timer Fire Count : [5]   | Kernel Owner : [Sample2] |
```

• Screenshots of the module info showing you as the author

```
# modinfo kernModTimer.ko
filename:       /kern/kernModTimer.ko
description:    Kernel Timer Module with confugurable wake-up period (default 500ms). Owner Name and T
ime-Out values are input as parameters
author:         Madhumitha Tolakanahalli Pradeep
license:        GPL
srcversion:     A0AD5BAE48EF70EC9B8B196
depends:
name:           kernModTimer
vermagic:       4.14.40 SMP mod_unload modversions ARMv6 p2v8
parm:           ownerName:charp
parm:           timerWakeUp:ushort
#
```

• Screenshots of the module remove

```
# rmmod kernModTimer.ko
[ 1091.305981] Exiting Kernel Timer Module...
```

[Problem 4 - 20 Pts] Data Structures

```
# modinfo animaleco.ko
filename:       /kern/animaleco.ko
description:    Kernel Module sorts string array and processes it into two linked lists. Input parameters are Animal Types and Count
author:         Madhumitha Tolakanahalli Pradeep
license:        GPL
srcversion:     633CF46E146EE1790F70672
depends:
name:           animaleco
vermagic:       4.14.40 SMP mod_unload modversions ARMv6 p2v8
parm:           animalType:charp
parm:           animalCount:int
#
```

Filter Criterion 1 : No filters

- Insert Module

```
# insmod animaleco.ko
#
```

-
- Initialization

```
[ 1997.872712] Initializing animaleco kernel module...
[ 1997.883024] [ant] : Duplicate Entry Found
[ 1997.887295] [ant] : Duplicate Entry Found
[ 1997.891664] [ant] : Duplicate Entry Found
[ 1997.895946] [ant] : Duplicate Entry Found
[ 1997.900271] [bat] : Duplicate Entry Found
[ 1997.904555] [bat] : Duplicate Entry Found
[ 1997.908898] [bat] : Duplicate Entry Found
[ 1997.913177] [bat] : Duplicate Entry Found
[ 1997.917503] [cat] : Duplicate Entry Found
[ 1997.921777] [cat] : Duplicate Entry Found
[ 1997.926058] [cat] : Duplicate Entry Found
[ 1997.930380] [cat] : Duplicate Entry Found
[ 1997.934662] [cat] : Duplicate Entry Found
[ 1997.938981] [cat] : Duplicate Entry Found
[ 1997.943252] [cat] : Duplicate Entry Found
[ 1997.947574] [cat] : Duplicate Entry Found
[ 1997.951847] [cat] : Duplicate Entry Found
[ 1997.956120] [cat] : Duplicate Entry Found
[ 1997.960442] [cat] : Duplicate Entry Found
[ 1997.964718] [cat] : Duplicate Entry Found
[ 1997.969044] [cat] : Duplicate Entry Found
```

- Ecosystem Linked List and Filtered Linked List

```
[ 1998.073729] List of animals in the Ecosystem of Size [6]
[ 1998.079322] Animal : [rhino] | Number : [10]
[ 1998.079332] Animal : [rat] | Number : [5]
[ 1998.083794] Animal : [dog] | Number : [10]
[ 1998.088057] Animal : [cat] | Number : [15]
[ 1998.092333] Animal : [bat] | Number : [5]
[ 1998.096610] Animal : [ant] | Number : [5]
[ 1998.100841] No Filter Criteria input. List of animal ecosystem consisting of 6 animals
[ 1998.113421]  List of animals in the Ecosystem of Size [6]
[ 1998.119188] Animal : [ant] Count : [5]
[ 1998.119198] Animal : [bat] Count : [5]
[ 1998.123110] Animal : [cat] Count : [15]
[ 1998.127024] Animal : [dog] Count : [10]
[ 1998.131072] Animal : [rat] Count : [5]
[ 1998.135075] Animal : [rhino] Count : [10]
```

- Size of Ecosystem and Memory Allocated & Time calculated to execute init function

```
[ 1998.139037] ECOSYSTEM SIZE : [6] MEMORY ALLOCATED FOR FILTERED LIST : [96]
[ 1998.150521] Time taken to insert Kernel Module : [1894531585 ns]
#
```

- Removing kernel Module, Time taken to exit & memory freed during exit

```
[ 2561.427342] Exiting animaleco kernel module...
[ 2561.432282] Ecosystem Linked List Memory Freed : [96 B]
[ 2561.432294] Filtered Ecosystem Linked List Memory Freed : [96 B]
```

Filter Criteria 2: Animal Type

- Insert Module

```
# insmod animaleco.ko animalType="rhino"
```

- Initialization

```
[ 2718.692240] Initializing animaleco kernel module...
[ 2718.702544] [ant] : Duplicate Entry Found
[ 2718.706824] [ant] : Duplicate Entry Found
[ 2718.711192] [ant] : Duplicate Entry Found
[ 2718.715468] [ant] : Duplicate Entry Found
[ 2718.719803] [bat] : Duplicate Entry Found
[ 2718.724080] [bat] : Duplicate Entry Found
[ 2718.728418] [bat] : Duplicate Entry Found
[ 2718.732702] [bat] : Duplicate Entry Found
[ 2718.736980] [cat] : Duplicate Entry Found
[ 2718.741303] [cat] : Duplicate Entry Found
[ 2718.745580] [cat] : Duplicate Entry Found
[ 2718.749900] [cat] : Duplicate Entry Found
[ 2718.754174] [cat] : Duplicate Entry Found
[ 2718.758493] [cat] : Duplicate Entry Found
```

- Ecosystem Linked List and Filtered Linked List

```
[ 2718.893199] List of animals in the Ecosystem of Size [6]
[ 2718.898800] Animal : [rhino] | Number : [10]
[ 2718.898810] Animal : [rat] | Number : [5]
[ 2718.903264] Animal : [dog] | Number : [10]
[ 2718.907496] Animal : [cat] | Number : [15]
[ 2718.911769] Animal : [bat] | Number : [5]
[ 2718.916047] Animal : [ant] | Number : [5]
[ 2718.920269] FILTER BASED ON ANIMAL TYPE : rhino
[ 2718.929212] [10] OF ANIMAL TYPE [rhino] FOUND
```

- Size of Ecosystem and Memory Allocated & Time calculated to execute init function

```
[ 2718.933848] ECOSYSTEM SIZE : [1] MEMORY ALLOCATED FOR FILTERED LIST : [16]
[ 2718.941159] Time taken to insert Kernel Module : [1039555072 ns]
```

- Removing kernel Module, Time taken to exit & memory freed during exit

```
[ 4242.566422] Exiting animaleco kernel module...
[ 4242.571355] Ecosystem Linked List Memory Freed : [96 B]
[ 4242.571370] Filtered Ecosystem Linked List Memory Freed : [96 B]
[ 4242.571370]  Time taken to exit : 15917 ns
#
```

Filter 3: Animal Count

- Insert Module

```
# insmod animaleco.ko animalCount=4
#
```

- Init

```
[ 4421.516322] Initializing animaleco kernel module...
[ 4421.523652] [ant] : Duplicate Entry Found
[ 4421.528033] [ant] : Duplicate Entry Found
[ 4421.532312] [ant] : Duplicate Entry Found
[ 4421.536582] [ant] : Duplicate Entry Found
[ 4421.540904] [bat] : Duplicate Entry Found
[ 4421.545184] [bat] : Duplicate Entry Found
[ 4421.549515] [bat] : Duplicate Entry Found
[ 4421.553794] [bat] : Duplicate Entry Found
[ 4421.558127] [cat] : Duplicate Entry Found
[ 4421.562411] [cat] : Duplicate Entry Found
[ 4421.566685] [cat] : Duplicate Entry Found
[ 4421.571005] [cat] : Duplicate Entry Found
[ 4421.575281] [cat] : Duplicate Entry Found
[ 4421.579601] [cat] : Duplicate Entry Found
[ 4421.583875] [cat] : Duplicate Entry Found
[ 4421.588188] [cat] : Duplicate Entry Found
[ 4421.592457] [cat] : Duplicate Entry Found
```

- Ecosystem and Filtered Ecosystem Linked Lists

```
[ 4421.714381] List of animals in the Ecosystem of Size [6]
[ 4421.719990] Animal : [rhino] | Number : [10]
[ 4421.720000] Animal : [rat] | Number : [5]
[ 4421.724459] Animal : [dog] | Number : [10]
[ 4421.728690] Animal : [cat] | Number : [15]
[ 4421.732968] Animal : [bat] | Number : [5]
[ 4421.737240] Animal : [ant] | Number : [5]
[ 4421.741465] FILTER BASED ON ANIMAL COUNT : 4
[ 4421.750133] ANIMAL TYPE [rhino] GREATER THAN 4 FOUND
[ 4421.755406] ANIMAL TYPE [rat] GREATER THAN 4 FOUND
[ 4421.760545] ANIMAL TYPE [dog] GREATER THAN 4 FOUND
[ 4421.765636] ANIMAL TYPE [cat] GREATER THAN 4 FOUND
[ 4421.770777] ANIMAL TYPE [bat] GREATER THAN 4 FOUND
[ 4421.775869] ANIMAL TYPE [ant] GREATER THAN 4 FOUND
```

- Time taken to init and memory occupied

```
[ 4421.781006] ECOSYSTEM SIZE : [6] MEMORY ALLOCATED FOR FILTERED LIST : [96]
[ 4421.788319] Time taken to insert Kernel Module : [4203641344 ns]
```

- Exit : Time taken to exit and memory freed

```
[ 4425.801612] Exiting animaleco kernel module...
[ 4425.806304] Ecosystem Linked List Memory Freed : [96 B]
[ 4425.806315] Filtered Ecosystem Linked List Memory Freed : [96 B]
[ 4425.806315]  Time taken to exit : 13958 ns
```

Filter 4: Animal Count && Animal Type

- Insert Module

```
# insmod animaleco.ko animalType="dog" animalCount=8
```

- Init

```
[ 4718.472023] Initializing animaleco kernel module...
[ 4718.479341] [ant] : Duplicate Entry Found
[ 4718.483622] [ant] : Duplicate Entry Found
[ 4718.488005] [ant] : Duplicate Entry Found
[ 4718.492285] [ant] : Duplicate Entry Found
[ 4718.496558] [bat] : Duplicate Entry Found
[ 4718.500880] [bat] : Duplicate Entry Found
[ 4718.505153] [bat] : Duplicate Entry Found
[ 4718.509487] [bat] : Duplicate Entry Found
[ 4718.513761] [cat] : Duplicate Entry Found
[ 4718.518126] [cat] : Duplicate Entry Found
[ 4718.522406] [cat] : Duplicate Entry Found
[ 4718.526680] [cat] : Duplicate Entry Found
[ 4718.531003] [cat] : Duplicate Entry Found
```

- Ecosystem and Filtered Ecosystem Linked Lists

```
[ 4718.670060] List of animals in the Ecosystem of Size [6]
[ 4718.675609] Animal : [rhino] | Number : [10]
[ 4718.675618] Animal : [rat] | Number : [5]
[ 4718.680128] Animal : [dog] | Number : [10]
[ 4718.684311] Animal : [cat] | Number : [15]
[ 4718.688630] Animal : [bat] | Number : [5]
[ 4718.692900] Animal : [ant] | Number : [5]
[ 4718.697090] FILTER BASED ON ANIMAL COUNT > 8 & ANIMAL TYPE : dog
[ 4718.707631] ANIMAL TYPE [dog] WITH COUNT GREATER THAN 8 FOUND
```

- Time taken to init and memory occupied

```
[ 4718.713722] ECOSYSTEM SIZE : [1] MEMORY ALLOCATED FOR FILTERED LIST : [16]
[ 4718.721025] Time taken to insert Kernel Module : [516490752 ns]
```

- Exit : Time taken to exit and memory freed

```
[ 4719.977112] Exiting animaleco kernel module...
[ 4719.982055] Ecosystem Linked List Memory Freed : [96 B]
[ 4719.982069] Filtered Ecosystem Linked List Memory Freed : [16 B]
[ 4719.982069]  Time taken to exit : 10750 ns
```