

<https://github.com/deep6000/Advanced-Embedded-Software-Design.git>

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

Var/log/messages

```
# cat /var/log/messages | grep syslog | grep eth0
Jan 1 00:00:03 buildroot@DS daemon.info syslog[104]: eth0: waiting for carrier
Jan 1 00:00:03 buildroot@DS daemon.info syslog[104]: eth0: carrier acquired
Jan 1 00:00:03 buildroot@DS daemon.info syslog[104]: eth0: IAID 69:53:1f:d7
Jan 1 00:00:03 buildroot@DS daemon.info syslog[104]: eth0: adding address fe80::5e8a:9920:6a84:43cb
Jan 1 00:00:03 buildroot@DS daemon.info syslog[104]: eth0: carrier lost
Jan 1 00:00:03 buildroot@DS daemon.info syslog[104]: eth0: deleting address fe80::5e8a:9920:6a84:43cb
Jan 1 00:00:05 buildroot@DS daemon.info syslog[104]: eth0: carrier acquired
Jan 1 00:00:05 buildroot@DS daemon.info syslog[104]: eth0: IAID 69:53:1f:d7
Jan 1 00:00:05 buildroot@DS daemon.info syslog[104]: eth0: adding address fe80::5e8a:9920:6a84:43cb
Jan 1 00:00:05 buildroot@DS daemon.info syslog[104]: eth0: rebinding lease of 10.0.0.223
Jan 1 00:00:05 buildroot@DS daemon.info syslog[104]: eth0: soliciting an IPv6 router
Jan 1 00:00:05 buildroot@DS daemon.info syslog[104]: eth0: probing address 10.0.0.223/24
Jan 1 00:00:06 buildroot@DS daemon.info syslog[104]: eth0: Router Advertisement from fe80::3e04:61ff:fedd:a66c
Jan 1 00:00:06 buildroot@DS daemon.info syslog[104]: eth0: adding address 2601:281:8000:552e:42ac:595d:cb67:30c7/64
Jan 1 00:00:06 buildroot@DS daemon.info syslog[104]: eth0: adding route to 2601:281:8000:552e::/64
Jan 1 00:00:06 buildroot@DS daemon.info syslog[104]: eth0: adding default route via fe80::3e04:61ff:fedd:a66c
Jan 1 00:00:06 buildroot@DS daemon.info syslog[104]: eth0: confirming prior DHCPv6 lease
Jan 1 00:00:07 buildroot@DS daemon.info syslog[104]: eth0: REPLY6 received from fe80::3e04:61ff:fedd:a66c
Jan 1 00:00:07 buildroot@DS daemon.info syslog[104]: eth0: adding address 2601:281:8000:552e::84ab/128
Jan 1 00:00:07 buildroot@DS daemon.info syslog[104]: eth0: renew in 302400, rebind in 483840, expire in 604800 seconds
Jan 1 00:00:10 buildroot@DS daemon.info syslog[104]: eth0: leased 10.0.0.223 for 604800 seconds
Jan 1 00:00:10 buildroot@DS daemon.info syslog[104]: eth0: adding route to 10.0.0.0/24
Jan 1 00:00:10 buildroot@DS daemon.info syslog[104]: eth0: adding default route via 10.0.0.1
```

SSH

```
deepesh@UbuntuVB:~$ ssh root@10.0.0.223
root@10.0.0.223's password:
# cd /usr/bin/exec/
```

SCP_COPY to /usr/bin/exec

```
deepesh@UbuntuVB: ~/buildroot/buildroot/SCP_FOLDER
File Edit View Search Terminal Help

deepesh@UbuntuVB:~/buildroot/buildroot/SCP_FOLDER$ scp myname root@192.168.0.2:/usr/bin/exec
root@192.168.0.2's password:
myname                               100% 7252    851.3KB
/s  00:00
deepesh@UbuntuVB:~/buildroot/buildroot/SCP_FOLDER$
```

Output of the file

```
deepesh@UbuntuVB: ~
File Edit View Search Terminal Help

# pwd
/usr/bin/exec
# ls
myname
# ./myname
My name is Deepesh Sonigra
#
```

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

1) GDB

sysroot

```
deepesh@UbuntuVB:~$ cd buildroot/buildroot/  
deepesh@UbuntuVB:~/buildroot/buildroot$ set sysroot /home/deepesh/buildroot/buildroot/output/staging/  
deepesh@UbuntuVB:~/buildroot/buildroot$
```

Start the host GDB session with the program name to debug

```
# gdbserver --multi localhost:5555  
Listening on port 5555  
Remote debugging from host 10.0.0.207  
□
```

Show the host commands connecting to the target

```
(gdb) target extended-remote 10.0.0.223:5555  
Remote debugging using 10.0.0.223:5555  
(gdb) □
```

Pushing your out-of-tree executable to the target

```
(gdb) remote put /home/deepesh/buildroot/buildroot/SCP_FOLDER/mean /usr/bin/exec  
/mean  
Successfully sent file "/home/deepesh/buildroot/buildroot/SCP_FOLDER/mean".  
(gdb) □
```

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

```
(gdb) set remote exec-file /usr/bin/exec/mean  
(gdb) file mean  
Reading symbols from mean...done.  
(gdb) □
```

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

```
(gdb) i b  
No breakpoints or watchpoints.  
(gdb) b main  
Breakpoint 6 at 0x104f8  
(gdb) b 15  
Breakpoint 7 at 0x103e0: file libc/sysdeps/linux/arm/crt1.S, line 15.  
(gdb) b 18  
Note: breakpoint 7 also set at pc 0x103e0.  
Breakpoint 8 at 0x103e0: file libc/sysdeps/linux/arm/crt1.S, line 18.  
(gdb) i b  
Num      Type           Disp Enb  Address      What  
6         breakpoint       keep y   0x000104f8  <main>  
7         breakpoint       keep y   0x000103e0  libc/sysdeps/linux/arm/crt1.S:15  
8         breakpoint       keep y   0x000103e0  libc/sysdeps/linux/arm/crt1.S:18  
(gdb) □
```

Single stepping through your code and continuing execution

- Step and next

```
Breakpoint 1, main () at mean.c:5  
5      int i,n,sum=0,numbers;  
(gdb) s  
8      printf("\nPlease Enter How many Number you want?\n");  
(gdb) next  
9      scanf("%d",&n);  
(gdb) next  
11     printf("\nPlease Enter the elements one by one\n");
```

- Continue

```
(gdb) next
11      printf("\nPlease Enter the elements one by one\n");
(gdb) c
Continuing.

Breakpoint 2, main () at mean.c:15
15      Sum = Sum +numbers;
(gdb) c
Continuing.

Breakpoint 2, main () at mean.c:15
15      Sum = Sum +numbers;
(gdb) print Sum
$7 = 1
(gdb) c
Continuing.

Breakpoint 2, main () at mean.c:15
15      Sum = Sum +numbers;
(gdb) print Sum
$8 = 3
(gdb) c
Continuing.

Breakpoint 2, main () at mean.c:15
15      Sum = Sum +numbers;
(gdb) print Sum
$9 = 8
(gdb) c
Continuing.

Breakpoint 3, main () at mean.c:18
18      Average = Sum/n;
(gdb) print Sum
$10 = 15
(gdb)
```

7) Manually showing (print) variable values at the command line

- Print command

```
Breakpoint 3, main () at mean.c:18
18      Average = Sum/n;
(gdb) print Average
$11 = 0
(gdb) next
20      printf("\nSum of the %d Numbers = %d",n, Sum);
(gdb) print Average
$12 = 3
(gdb) info locals
i = 4
n = 4
Sum = 15
numbers = 7
Average = 3
(gdb)
```

- Printing locals variables

```
(gdb) info locals
i = 4
n = 4
Sum = 15
numbers = 7
Average = 0
```

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

```
Please Enter the elements one by one
1
2
5
7

Sum of the 4 Numbers = 15
Average of the 4 Numbers = 3.00
```

2) GDBINIT

Start the host GDB session with the program name to debug

```
deepesh@UbuntuVB:~/buildroot/buildroot/SCP_FOLDER$ gdb-multiarch -x gdbinit
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".
Breakpoint 1 at 0x10504: file mean.c, line 5.
Breakpoint 2 at 0x10558: file mean.c, line 15.
Breakpoint 3 at 0x10584: file mean.c, line 18.
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 instead.
Reading /lib/ld-uClibc.so.0 from remote target...
Reading /lib//libc.so.0 from remote target...

Breakpoint 1, main () at mean.c:5
5      int i,n,Sum=0,numbers;
(gdb) c
```

Continuing execution

```

Breakpoint 1, main () at mean.c:5
5      int i,n,Sum=0,numbers;
(gdb) c
Continuing.
(gdb)
Breakpoint 2, main () at mean.c:15
15      Sum = Sum +numbers;
(gdb) c
Continuing.

Breakpoint 2, main () at mean.c:15
15      Sum = Sum +numbers;
(gdb) c
Continuing.

Breakpoint 2, main () at mean.c:15
15      Sum = Sum +numbers;
(gdb) c
Continuing.

Breakpoint 2, main () at mean.c:15
15      Sum = Sum +numbers;
(gdb) c
Continuing.

Breakpoint 3, main () at mean.c:18
18      Average = Sum/n;
(gdb) c
Continuing.
[Inferior 1 (process 13902) exited normally]

```

Gdbinit output console

```

# gdbserver --multi localhost:5560
Listening on port 5560
Remote debugging from host 10.0.0.207
Process /usr/bin/exec/mean created; pid = 13902

Please Enter How many Number you want?
4

Please Enter the elements one by one
1
2
3
7

Sum of the 4 Numbers = 13
Average of the 4 Numbers = 3.00
Child exited with status 0

```

GDBINIT file

```
File Edit View Search Terminal Help
target extended-remote 10.0.0.223:5560
remote put /home/deepesh/buildroot/buildroot/SCP_FOLDER/mean /usr/bin/exec/mean
set remote exec-file /usr/bin/exec/mean
file mean
b main
b 15
b 18
run
```

[Problem 3 - 20 Pts] Create a Kernel Module

1) Parameters: TimerName="Deepesh" TimerTimeout= 500

Screenshots of the install and successful load of the module

```
#
# insmod TimerModule.ko TimerName="Deepesh" TimerTimeout=500
#
#
#
```

Output print buffer (dmesg log) of your count printing your name and the count and timestamps

```
[ 1837.611847] TIMER MODULE INITIALIZING: Deepesh
[ 1837.611847] Timeout: 500 milliseconds
[ 1838.128125] Name: Deepesh Counts: 1
[ 1838.637684] Name: Deepesh Counts: 2
[ 1839.147679] Name: Deepesh Counts: 3
[ 1839.657677] Name: Deepesh Counts: 4
[ 1840.167696] Name: Deepesh Counts: 5
[ 1840.677679] Name: Deepesh Counts: 6
[ 1841.187675] Name: Deepesh Counts: 7
[ 1841.697677] Name: Deepesh Counts: 8
[ 1842.207675] Name: Deepesh Counts: 9
[ 1842.717682] Name: Deepesh Counts: 10
[ 1843.227691] Name: Deepesh Counts: 11
[ 1843.737679] Name: Deepesh Counts: 12
[ 1844.247681] Name: Deepesh Counts: 13
[ 1844.757679] Name: Deepesh Counts: 14
[ 1845.267681] Name: Deepesh Counts: 15
[ 1845.777677] Name: Deepesh Counts: 16
[ 1846.287685] Name: Deepesh Counts: 17
[ 1846.797739] Name: Deepesh Counts: 18
[ 1847.307688] Name: Deepesh Counts: 19
[ 1847.817722] Name: Deepesh Counts: 20
[ 1848.327682] Name: Deepesh Counts: 21
[ 1848.837683] Name: Deepesh Counts: 22
[ 1849.347682] Name: Deepesh Counts: 23
[ 1849.857687] Name: Deepesh Counts: 24
[ 1850.367678] Name: Deepesh Counts: 25
[ 1850.877686] Name: Deepesh Counts: 26
[ 1851.387686] Name: Deepesh Counts: 27
[ 1851.897685] Name: Deepesh Counts: 28
[ 1852.407687] Name: Deepesh Counts: 29
[ 1852.917710] Name: Deepesh Counts: 30
```

Screenshots of the module info showing you as the author

```
# modinfo TimerModule.ko
filename:      /KerMod/TimerModule.ko
description:   Timer Module logging Name and Counts
author:       Deepesh Mahendra
license:      GPL
srcversion:    98AE0C32D9E07517E9F95D8
depends:
name:         TimerModule
vermagic:     4.14.40 SMP mod_unload modversions ARMv6 p2v8
parm:         TimerName:charp
parm:         TimerTimeout:ulong
#
#
#
```

Screenshots of the module remove

```
#
# rmmod TimerModule.ko
#
#
```

```
[ 1985.007699] Name: Deepesh   Counts: 289
[ 1985.517682] Name: Deepesh   Counts: 290
[ 1986.027699] Name: Deepesh   Counts: 291
[ 1986.101326] Deleting Timer Module: Deepesh.
[ 1986.105825] Exiting Timer Module: Deepesh.
█
```

2) Parameters: TimerName="Deso6761" TimerTimeout= 1000

Screenshots of the install and successful load of the module

```
TimerModule.ko
# insmod TimerModule.ko TimerName="Deso6761" TimerTimeout=1000
█
```

Output print buffer (dmesg log) of your count printing your name and the count and timestamps


```
[ 1379.388442] TIMER MODULE INITIALIZING: Deso6761
[ 1379.388442] Timeout: 1000 milliseconds
[ 1380.408140] Name: Deso6761 Counts: 1
[ 1381.447688] Name: Deso6761 Counts: 2
[ 1382.487682] Name: Deso6761 Counts: 3
[ 1383.527684] Name: Deso6761 Counts: 4
[ 1384.567685] Name: Deso6761 Counts: 5
[ 1385.607709] Name: Deso6761 Counts: 6
[ 1386.647684] Name: Deso6761 Counts: 7
[ 1387.687683] Name: Deso6761 Counts: 8
[ 1388.727681] Name: Deso6761 Counts: 9
[ 1389.767685] Name: Deso6761 Counts: 10
[ 1390.807683] Name: Deso6761 Counts: 11
[ 1391.847686] Name: Deso6761 Counts: 12
[ 1392.887689] Name: Deso6761 Counts: 13
[ 1393.927681] Name: Deso6761 Counts: 14
[ 1394.967683] Name: Deso6761 Counts: 15
[ 1396.007676] Name: Deso6761 Counts: 16
[ 1397.047685] Name: Deso6761 Counts: 17
[ 1398.087689] Name: Deso6761 Counts: 18
[ 1399.127686] Name: Deso6761 Counts: 19
[ 1400.167699] Name: Deso6761 Counts: 20
[ 1401.207681] Name: Deso6761 Counts: 21
[ 1402.247678] Name: Deso6761 Counts: 22
[ 1403.287682] Name: Deso6761 Counts: 23
[ 1404.327688] Name: Deso6761 Counts: 24
[ 1405.367676] Name: Deso6761 Counts: 25
[ 1406.407683] Name: Deso6761 Counts: 26
[ 1407.447719] Name: Deso6761 Counts: 27
[ 1408.487684] Name: Deso6761 Counts: 28
[ 1409.527682] Name: Deso6761 Counts: 29
[ 1410.567689] Name: Deso6761 Counts: 30
[ 1411.607683] Name: Deso6761 Counts: 31
[ 1412.647680] Name: Deso6761 Counts: 32
[ 1413.687680] Name: Deso6761 Counts: 33
[ 1414.727710] Name: Deso6761 Counts: 34
[ 1415.767686] Name: Deso6761 Counts: 35
[ 1416.807779] Name: Deso6761 Counts: 36
[ 1417.847687] Name: Deso6761 Counts: 37
```

Screenshots of the module info showing you as the author


```
# lsmod | grep TimerModule
TimerModule                16384  0
#
#
#
#
#
#
# modinfo TimerModule.ko
filename:                   /KerMod/TimerModule.ko
description:                Timer Module logging Name and Counts
author:                     Deepesh Mahendra
license:                    GPL
srcversion:                 98AE0C32D9E07517E9F95D8
depends:
name:                       TimerModule
vermagic:                   4.14.40 SMP mod_unload modversions ARMv6 p2v8
parm:                       TimerName:charp
parm:                       TimerTimeout:ulong
#
#
#
#
#
#
```

Screenshots of the module remove

```
#
# rmmod TimerModule.ko
#
# lsmod | grep TimerModule
#
#
#
#
```

```
[ 1698.647703] Name: Deso6761 Counts: 307
[ 1699.687714] Name: Deso6761 Counts: 308
[ 1700.727694] Name: Deso6761 Counts: 309
[ 1701.767699] Name: Deso6761 Counts: 310
[ 1702.768689] Deleting Timer Module: Deso6761.
[ 1702.773276] Exiting Timer Module: Deso6761.
```

[Problem 4 - 20 Pts] Data Structures

Init module

```
[ 458.816445] Entering Sorting Module
[ 458.824825] This is Implemented Using Linked List Data Structure
[ 458.831247] Duplicate Entry: toad
[ 458.834712] Duplicate Entry: toad
[ 458.838227] Duplicate Entry: spider
[ 458.841874] Duplicate Entry: spider
[ 458.845517] Duplicate Entry: spider
[ 458.849225] Duplicate Entry: spider
[ 458.852868] Duplicate Entry: spider
[ 458.856518] Duplicate Entry: spider
[ 458.860212] Duplicate Entry: spider
[ 458.863864] Duplicate Entry: spider
[ 458.867547] Duplicate Entry: shark
[ 458.871096] Duplicate Entry: shark
[ 458.874645] Duplicate Entry: shark
[ 458.878246] Duplicate Entry: mouse
[ 458.881800] Duplicate Entry: mouse
```

Unique Ecosystem

```
[ 641.039517] Animals Name List
[ 641.042614] Animal: [cat] Count: [4]
[ 641.046622] Animal: [dog] Count: [5]
[ 641.050722] Animal: [elephant] Count: [6]
[ 641.055180] Animal: [fish] Count: [4]
[ 641.059328] Animal: [frog] Count: [7]
[ 641.063415] Animal: [mouse] Count: [8]
[ 641.067648] Animal: [shark] Count: [4]
[ 641.071834] Animal: [spider] Count: [9]
[ 641.076104] Animal: [toad] Count: [3]
[ 641.080247] The Size of Ecosystem 1 is [9]
[ 641.080259] Dynamically Allocated Memory for nodes in Ecosystem 1 is : [144]
```

No filter

```
[ 641.092658] Printing All Animal List as no filter selected
[ 641.098476] Animal: toad Count : [3]
[ 641.102566] Animal: spider Count : [9]
[ 641.106846] Animal: shark Count : [4]
[ 641.111080] Animal: mouse Count : [8]
[ 641.115261] Animal: frog Count : [7]
[ 641.119404] Animal: fish Count : [4]
[ 641.123493] Animal: elephant Count : [6]
[ 641.127998] Animal: dog Count : [5]
[ 641.132005] Animal: cat Count : [4]
[ 641.136004] Size of Ecosystem 2 is : 9
[ 641.136015] Memory Allocated to nodes in Ecosystem 2 is : {144 bytes}
[ 641.146680] Init Module Time Taken :[139443 us]
[ 644.794010] Memory Freed from Unique Ecosystem : [144 bytes]
[ 644.805015] Memory Freed from Filtered Ecosystem: [144 bytes]
[ 644.811121] Exiting Module
```

Animal type

```
#
[ 948.176619] Filter Chosen : Animal Type = dog.
[ 948.181408] Animal Selected: [dog]          Count: [5]
[ 948.186228] Size of Ecosystem Animal Type: 1
[ 948.186238] Memory Allocated in Animal Type Filter: [16 bytes]
[ 948.196830] Init Module Time Taken :[189594 us]
[ 953.471209] Memory Freed from Unique Ecosystem : [144 bytes]
[ 953.482221] Memory Freed from Filtered Ecosystem: [16 bytes]
[ 953.488231] Exiting Module
#
```

Count Greater than

```
#
[ 1746.070819] Filter Chosen : Count Greater Than =[ 8].
[ 1746.076193] Animal: [spider]              Count: [9]
[ 1746.080511] Size of Ecosystem Count Greater Than [8] : [1]
[ 1746.080521] Memory Allocated in Animal Type Filter:[ 16 bytes]
[ 1746.092390] Init Module Time Taken :[85157 us]
[ 1748.200871] Memory Freed from Unique Ecosystem : [144 bytes]
[ 1748.211759] Memory Freed from Filtered Ecosystem: [16 bytes]
[ 1748.217769] Exiting Module
#
```

Animal type and Count Greater Than

```
#
[ 1802.333883] Filter Chosen Count Greater Than [2] and Animal Type = cat.
[ 1802.341116] Animals :[cat]/t/t Count: [4]
[ 1802.345397] Ecosystem Size Both Filters [1]
[ 1802.345406] Memory Allocated : [16 bytes]
[ 1802.349825] Init Module Time Taken :[342590 us]
[ 1804.752192] Memory Freed from Unique Ecosystem : [144 bytes]
[ 1804.763168] Memory Freed from Filtered Ecosystem: [16 bytes]
[ 1804.769173] Exiting Module
#
```

Exit

```
#
[ 1866.589199] Memory Freed from Unique Ecosystem : [144 bytes]
[ 1866.600162] Memory Freed from Filtered Ecosystem: [16 bytes]
[ 1866.606077] Exiting Module
#
```