

Lab02

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Part01

- Github Link
- make

```
siradj@siradj:~/os-archi-tp$ make
make -C /lib/modules/6.8.0-48-generic/build M=/home/siradj/os-archi-tp modules
make[1]: Entering directory '/usr/src/linux-headers-6.8.0-48-generic'
warning: the compiler differs from the one used to build the kernel
The kernel was built by: x86_64-linux-gnu-gcc-13 (Ubuntu 13.2.0-23ubuntu4) 13.2.0
You are using:      gcc-13 (Ubuntu 13.2.0-23ubuntu4) 13.2.0
CC [M]  /home/siradj/os-archi-tp/hello_world.o
MODPOST /home/siradj/os-archi-tp/Module.symvers
CC [M]  /home/siradj/os-archi-tp/hello_world.mod.o
LD [M]  /home/siradj/os-archi-tp/hello_world.ko
BTF [H]  /home/siradj/os-archi-tp/hello_world.ko
Skipping BTF generation for /home/siradj/os-archi-tp/hello_world.ko due to unavailability of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-6.8.0-48-generic'
siradj@siradj:~/os-archi-tp$ _
```

Figure 1: make command

- `sudo insmod hello_world.ko` then `sudo dmesg | tail`

```

siradj@siradj:~/os-arch1-tp$ sudo insmod hello_world.ko
siradj@siradj:~/os-arch1-tp$ sudo dmesg | tail
dmesg: read kernel buffer failed: operation not permitted
siradj@siradj:~/os-arch1-tp$ sudo dmesg | tail
[ 3.794045] Loaded X.509 cert 'user: 61c930851aabd194bd0ac7fff6c7240db10c600'
[ 3.811308] e1000: e1000 NIC Link is Up 1000 Mbps Full Duplex, Flow Control: RX
[ 3.840905] snd_intel8x0 0000:00:05:0: allow list rate for 1028:0177 is 48000
[ 4.172575] NET: Registered PF_QIPCRTR protocol family
[ 4.216625] loop0: detected capacity change from 0 to 0
[ 14.023228] systemd-journal[344]: /var/log/journal/3eb00aafc5f4320a94e6ecd88cae96c/user-1000.Journal: Journal file uses a different sequence number ID, rotating.
[ 1318.840058] clocksource: Long readout interval, skipping watchdog check: cs_nsec: 1022933167 wd_nsec: 1022932586
[ 1568.114103] hello_world: loading out-of-tree module taints kernel.
[ 1568.114114] hello_world: module verification failed: signature and/or required key missing - tainting kernel
[ 1568.114683] Hello, World!
siradj@siradj:~/os-arch1-tp$

```

Figure 2: inject the module on the kernel then show the log message

- `sudo rmmod hello_world` then `sudo dmesg | tail`

```
slradj@slradj:~/os-arch1-tp$ sudo rmmod hello_world
slradj@slradj:~/os-arch1-tp$ sudo dmesg | tail
[ 3.811398] e1000: enp0s3 NIC Link is Up 1000 Mbps Full Duplex, Flow Control: RX
[ 3.848985] snd_intel8x0 0000:00:05:0: allow list rate for 1028:0177 is 48000
[ 4.172575] NET: Registered PF_QIPCRTR protocol family
[ 4.216525] loop0: detected capacity change from 0 to 8
[ 14.823228] systemd-journal[344]: /var/log/journal/3eb80aa5cf5f4328a94e6ecda8caea6c/user-1000.Journal: Journal file uses a different sequence number ID, rotating.
[ 1318.040056] clocksource: Long readout interval, skipping watchdog check: cs_nsec: 1022933167 wd_nsec: 1022932586
[ 1568.114193] hello_world: loading out-of-tree module taints kernel.
[ 1568.114114] hello_world: module verification failed: signature and/or required key missing - tainting kernel
[ 1568.114663] Hello, World!
[ 1676.153393] Goodbye, World!
slradj@slradj:~/os-arch1-tp$ _
```

Figure 3: Remove the module from the kernel then show the log

Part02

- Github Link
- make

```
sradi@sradi:~/os-archi-tp2$ make
make -C /lib/modules/6.8.0-48-generic/build M=/home/sradi/os-archi-tp2 modules
make[1]: Entering directory '/usr/src/linux-headers-6.8.0-48-generic'
warning: the compiler differs from the one used to build the kernel
The kernel was built by: x86_64-linux-gnu-gcc-13 (Ubuntu 13.2.0-23ubuntu4) 13.2.0
You are using:      gcc-13 (Ubuntu 13.2.0-23ubuntu4) 13.2.0
CC [M]  /home/sradi/os-archi-tp2/param_example.o
MODPOST /home/sradi/os-archi-tp2/Module.symvers
CC [M]  /home/sradi/os-archi-tp2/param_example.mod.o
LD [M]  /home/sradi/os-archi-tp2/param_example.ko
BTF [M]  /home/sradi/os-archi-tp2/param_example.ko
Skipping BTF generation for /home/sradi/os-archi-tp2/param_example.ko due to unavailability of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-6.8.0-48-generic'
sradi@sradi:~/os-archi-tp2$
```

Figure 4: make command

- `sudo insmod hello_world.ko` then `sudo dmesg | tail`

```

siradj@siradj:~/os-arch1-tp2$ sudo insmod param_example.ko param_value=155
(sudo) password for siradj:
siradj@siradj:~/os-arch1-tp2$ sudo dmesg | tail
[ 5.438215] audit: type=1400 audit(1732773867.390:114): apparmor="STATUS" operation="profile_replace" info="same as current profile, skipping" profile="unconfi
ined" name="syslogd" pid=778 comm="apparmor_parser"
[ 5.627845] loop0: detected capacity change from 0 to 8
[ 5.662701] NET: Registered PF_QIPCRTR protocol family
[ 5.818633] audit: type=1400 audit(1732773867.771:115): apparmor="STATUS" operation="profile_replace" profile="unconfined" name="/usr/lib/snapd/snap-confine"
pid=871 comm="apparmor_parser"
[ 5.828212] audit: type=1400 audit(1732773867.780:116): apparmor="STATUS" operation="profile_replace" profile="unconfined" name="/usr/lib/snapd/snap-confine/
/mount-namespace-capture-helper" pid=871 comm="apparmor_parser"
[ 34.432247] systemd-journald[343]: File /var/log/journal/3eb80aafc5f4328a94e6ecda8ca5a6c/user-1000: Journal corrupted or uncleanly shut down, renaming and re
placing.
[ 640.469642] param_example: loading out-of-tree module taints kernel.
[ 640.469665] param_example: module verification failed: signature and/or required key missing - tainting kernel
[ 640.469942] param_example: Module initialized.
[ 640.469943] param_example: param_value = 155
siradj@siradj:~/os-arch1-tp2$

```

Figure 5: inject the module on the kernel then show the log message

- `sudo rmmod hello_world` then `sudo dmesg | tail`

```

sradj@esirad:~/os-arch1-tp2$ sudo rmmod param_example
sradj@esirad:~/os-arch1-tp2$ sudo dmesg | tail
[ 5.627345] loop0: detected capacity change from 0 to 8
[ 5.662781] NET: Registered PF_QIPCRTR protocol family
[ 5.618633] audit: type=1400 audit(1732773867.771:115): apparmor="STATUS" operation="profile_replace" profile="unconfined" name="/usr/lib/snapd/snap-confine"
pid=871 comm="apparmor_parser"
[ 5.828212] audit: type=1400 audit(1732773867.780:116): apparmor="STATUS" operation="profile_replace" profile="unconfined" name="/usr/lib/snapd/snap-confine/
/mount-namespace-capture-helper" pid=871 comm="apparmor_parser"
[ 34.432247] systemd-journal[343]: File /var/log/journal/3eb0aa9cf5f4328a34e6ecd8c8a6c/user-1000.journal corrupted or uncleanly shut down, renaming and re
placing.
[ 640.469642] param_example: loading out-of-tree module taints kernel.
[ 640.469655] param_example: module verification failed: signature and/or required key missing - tainting kernel
[ 640.469942] param_example: Module initialized.
[ 640.469943] param_example: param_value = 155
[ 720.014592] param_example: Module exiting.
sradj@esirad:~/os-arch1-tp2$

```

Figure 6: Remove the module from the kernel then show the log

Part03: Linked List Module

Linked list C code

```
1 #include <linux/kernel.h>
2 #include <linux/module.h>
3 #include <linux/slab.h> // For kmalloc and kfree
4 #include <linux/list.h> // For linked list functions
5
6 MODULE_LICENSE("GPL");
7 MODULE_AUTHOR("Devv");
8 MODULE_DESCRIPTION("A kernel module demonstrating linked list
   management.");
9
10 // Define the structure for each node in the linked list
11 typedef struct node {
12     int data;
13     struct list_head list;
14 } node_t;
15
16 // Declare the list head
17 static LIST_HEAD(my_list);
18
19 static int __init linked_list_init(void) {
20     printk(KERN_INFO "Linked List Module: Initialized\n");
21
22     // Add some nodes to the list
23     int i;
24     for (i = 1; i <= 5; i++) {
25         node_t *new_node = kmalloc(sizeof(node_t), GFP_KERNEL);
26         if (!new_node) {
27             printk(KERN_ERR "Failed to allocate memory for
   node\n");
28             return -ENOMEM; // Return appropriate error code
29         }
30         new_node->data = i * 10;
31         list_add_tail(&new_node->list, &my_list);
32     }
33
34     // Traverse and print the list
35     printk(KERN_INFO "Linked List contents:\n");
36     node_t *current_node;
37     list_for_each_entry(current_node, &my_list, list) {
38         printk(KERN_INFO "Data: %d\n", current_node->data);
39     }
40
41     return 0;
42 }
43
44 static void __exit linked_list_exit(void) {
45     // Safely traverse and free the list
46     node_t *current_node, *temp_node;
47     list_for_each_entry_safe(current_node, temp_node, &my_list,
   list) {
48         list_del(&current_node->list);
49         kfree(current_node);
50     }
```

```

51     printk(KERN_INFO "Linked List Module: Exited, memory freed\n");
52 }
53
54
55 module_init(linked_list_init);
56 module_exit(linked_list_exit);

```

Listing 1: C Code

Makefile

```

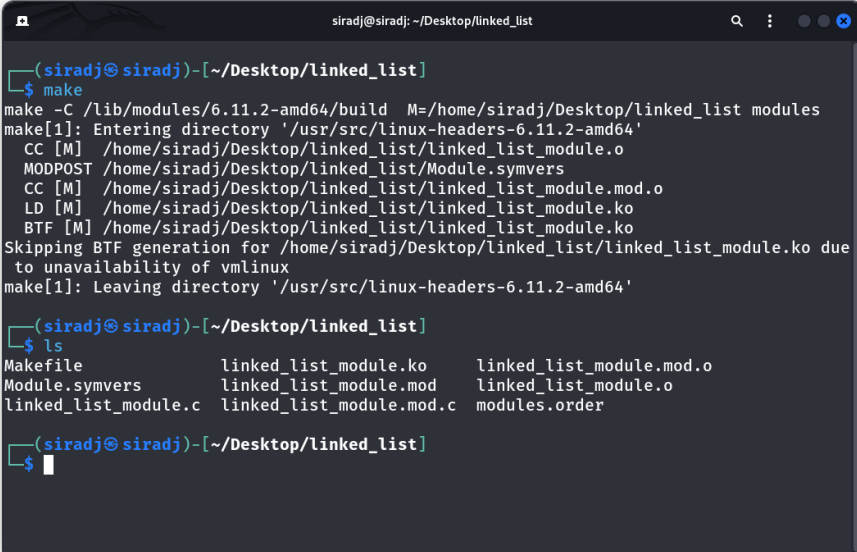
1 obj-m += linked_list_module.o
2 KDIR := /lib/modules/$(shell uname -r)/build
3 all:
4     make -C $(KDIR) M=$(PWD) modules
5 clean:
6     make -C $(KDIR) M=$(PWD) clean

```

Listing 2: Makefile

Execution

Building:



```

siradj@siradj: ~/Desktop/linked_list

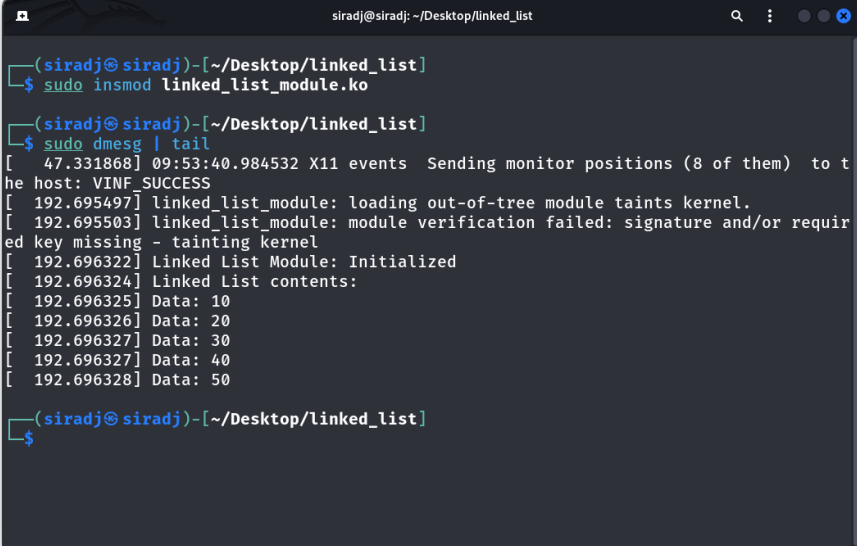
(siradj@siradj)~-[~/Desktop/linked_list]
$ make
make -C /lib/modules/6.11.2-amd64/build M=/home/siradj/Desktop/linked_list modules
make[1]: Entering directory '/usr/src/linux-headers-6.11.2-amd64'
CC [M] /home/siradj/Desktop/linked_list/linked_list_module.o
MODPOST /home/siradj/Desktop/linked_list/Module.symvers
CC [M] /home/siradj/Desktop/linked_list/linked_list_module.mod.o
LD [M] /home/siradj/Desktop/linked_list/linked_list_module.ko
BTF [M] /home/siradj/Desktop/linked_list/linked_list_module.ko
Skipping BTF generation for /home/siradj/Desktop/linked_list/linked_list_module.ko due
to unavailability of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-6.11.2-amd64'

(siradj@siradj)~-[~/Desktop/linked_list]
$ ls
Makefile                linked_list_module.ko    linked_list_module.mod.o
Module.symvers          linked_list_module.mod   linked_list_module.o
linked_list_module.c    linked_list_module.mod.c modules.order

(siradj@siradj)~-[~/Desktop/linked_list]
$

```


Install the module:

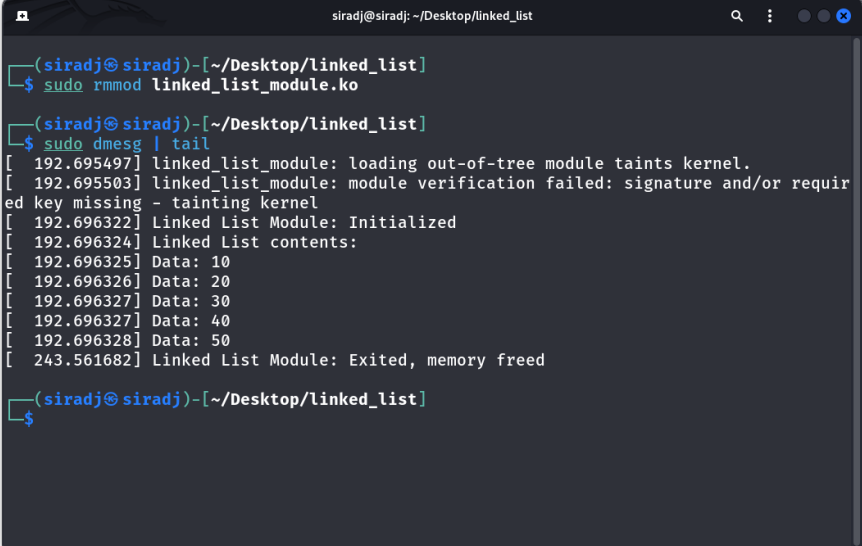


```
(siradj@siradj)-[~/Desktop/linked_list]
$ sudo insmod linked_list_module.ko

(siradj@siradj)-[~/Desktop/linked_list]
$ sudo dmesg | tail
[ 47.331868] 09:53:40.984532 X11 events Sending monitor positions (8 of them) to the host: VINF_SUCCESS
[ 192.695497] linked_list_module: loading out-of-tree module taints kernel.
[ 192.695503] linked_list_module: module verification failed: signature and/or required key missing - tainting kernel
[ 192.696322] Linked List Module: Initialized
[ 192.696324] Linked List contents:
[ 192.696325] Data: 10
[ 192.696326] Data: 20
[ 192.696327] Data: 30
[ 192.696327] Data: 40
[ 192.696328] Data: 50

(siradj@siradj)-[~/Desktop/linked_list]
$
```

Remove the module:



```
(siradj@siradj)-[~/Desktop/linked_list]
$ sudo rmmod linked_list_module.ko

(siradj@siradj)-[~/Desktop/linked_list]
$ sudo dmesg | tail
[ 192.695497] linked_list_module: loading out-of-tree module taints kernel.
[ 192.695503] linked_list_module: module verification failed: signature and/or required key missing - tainting kernel
[ 192.696322] Linked List Module: Initialized
[ 192.696324] Linked List contents:
[ 192.696325] Data: 10
[ 192.696326] Data: 20
[ 192.696327] Data: 30
[ 192.696327] Data: 40
[ 192.696328] Data: 50
[ 243.561682] Linked List Module: Exited, memory freed

(siradj@siradj)-[~/Desktop/linked_list]
$
```