

Assignment 1

Advances in Operating Systems Design (CS60038)

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(Part A) Objective: To configure, build, and install a Linux kernel from the source.

Setting different configurations

1. Remove NUMA memory allocation, scheduler, and emulation

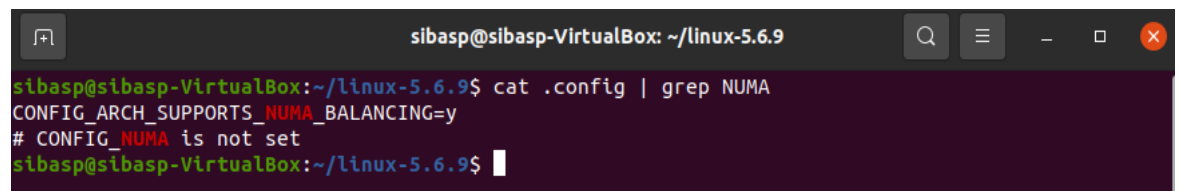
NUMA support was removed from the `menuconfig` file of Linux Kernel 5.6.9 by unselecting it from `Processor Types and Features --> NUMA Memory Allocation and Scheduler Support`.

Changes after removal of NUMA memory allocation, scheduler, and emulation

After building the kernel, the following checks were performed to ensure that NUMA support has been removed. These checks also highlight the changes that were observed in the system.

a. In `.config`

Checked the `.config` file to see if `CONFIG_NUMA` is set or not. The snapshot attached below shows that it is not set.



```
sibasp@sibasp-VirtualBox: ~/linux-5.6.9
sibasp@sibasp-VirtualBox:~/linux-5.6.9$ cat .config | grep NUMA
CONFIG_ARCH_SUPPORTS_NUMA_BALANCING=y
# CONFIG_NUMA is not set
sibasp@sibasp-VirtualBox:~/linux-5.6.9$
```

b. With `numactl --hardware`

Since the `numactl` command was not found, it was installed with `sudo apt install numactl`. After successful installation of `numactl`, `numactl --hardware` was executed which displayed **"No NUMA available on this system"**. This again confirmed that NUMA support has been removed.

```
sibasp@sibasp-VirtualBox:~/linux-5.6.9$ sudo apt install numactl
[sudo] password for sibasp:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  linux-headers-5.8.0-43-generic linux-hwe-5.8-headers-5.8.0-43 linux-image-5.8.0-43-generic
  linux-modules-5.8.0-43-generic linux-modules-extra-5.8.0-43-generic
Use 'sudo apt autoremove' to remove them.
The following NEW packages will be installed:
  numactl
0 upgraded, 1 newly installed, 0 to remove and 220 not upgraded.
Need to get 38.5 kB of archives.
After this operation, 150 kB of additional disk space will be used.
Get:1 http://in.archive.ubuntu.com/ubuntu focal/main amd64 numactl amd64 2.0.12-1 [38.5 kB]
Fetched 38.5 kB in 0s (79.0 kB/s)
Selecting previously unselected package numactl.
(Reading database ... 228270 files and directories currently installed.)
Preparing to unpack .../numactl_2.0.12-1_amd64.deb ...
Unpacking numactl (2.0.12-1) ...
Setting up numactl (2.0.12-1) ...
Processing triggers for man-db (2.9.1-1) ...
sibasp@sibasp-VirtualBox:~/linux-5.6.9$ numactl --hardware
No NUMA available on this system
sibasp@sibasp-VirtualBox:~/linux-5.6.9$
```

2. Remove Kyber I/O Scheduler

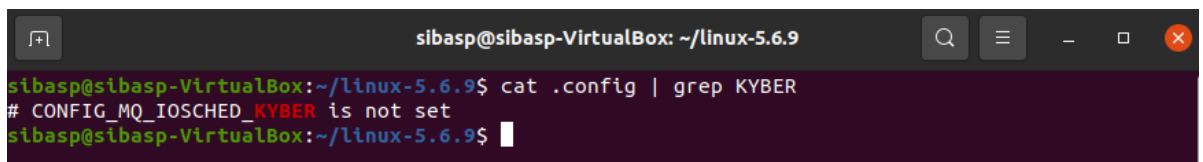
Kyber I/O Scheduler support was removed from the `menuconfig` file of Linux Kernel 5.6.9 by unselecting it from `IO Scheduler --> Kyber I/O Scheduler`.

Changes after removal of Kyber I/O scheduler

After building the kernel, the following checks were performed to ensure that the Kyber I/O scheduler has been removed. These checks also highlight the changes that were observed in the system.

a. In `.config`

Checked the `.config` file to see if `CONFIG_MQ_IOSCHED_KYBER` is set or not. The snapshot attached below shows that it is not set.



```
sibasp@sibasp-VirtualBox: ~/linux-5.6.9
sibasp@sibasp-VirtualBox:~/linux-5.6.9$ cat .config | grep KYBER
# CONFIG_MQ_IOSCHED_KYBER is not set
sibasp@sibasp-VirtualBox:~/linux-5.6.9$
```

b. In `/lib/modules/5.6.9/kernel/block/`

The absence of Kyber I/O Scheduler was confirmed by listing the files and directories inside `/lib/modules/5.6.9/kernel/block/`. The

absence of `kyber-iosched.ko` confirmed the removal of the Kyber I/O Scheduler.

```
sibasp@sibasp-VirtualBox:~/linux-5.6.9$ cd /lib/modules/5.6.9/kernel/block/
sibasp@sibasp-VirtualBox:/lib/modules/5.6.9/kernel/block$ ls
bfq.ko
sibasp@sibasp-VirtualBox:/lib/modules/5.6.9/kernel/block$
```

3. Include multipath TCP (MPTCP)

MPTCP was supported in the menuconfig file of Linux Kernel 5.6.9 by selecting it in the following fashion: `Networking support -->`

`Networking options --> MPTCP: Multipath TCP` and `MPTCP: IPv6 support for Multipath TCP`

Linux kernel 5.6.9 supports MPTCP v1

(<https://github.com/multipath-tcp/mptcp/issues/397>), hence `dmesg | grep MPTCP` and `curl http://www.multipath-tcp.org` did not indicate presence of MPTCP.

Changes after inclusion of MPTCP

After building the kernel, the following checks were performed to ensure the inclusion of MPTCP. These checks also highlight the changes that were observed in the system.

a. In .config

Checked the .config file to see if `CONFIG_MPTCP`, `CONFIG_MPTCP_IPV6`, and `CONFIG_MPTCP_HMAC_TEST` are `y` or not. The snapshot attached below shows that they are set.

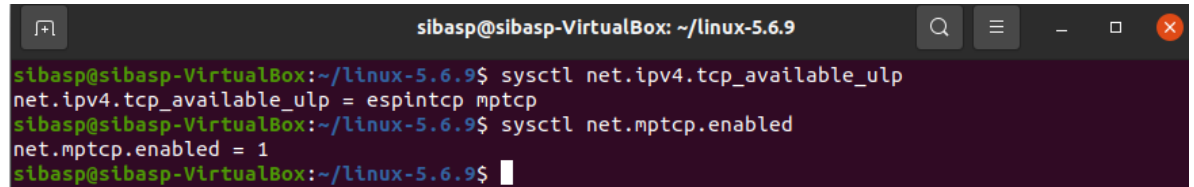
```
sibasp@sibasp-VirtualBox:~/linux-5.6.9$ cat .config | grep MPTCP
CONFIG_MPTCP=y
CONFIG_MPTCP_IPV6=y
CONFIG_MPTCP_HMAC_TEST=y
sibasp@sibasp-VirtualBox:~/linux-5.6.9$
```

b. With sysctl

`sysctl net.ipv4.tcp_available_ulp` and `sysctl net.mptcp.enabled` are executed, and the following outputs confirm that MPTCP is supported.

The output of `sysctl net.ipv4.tcp_available_ulp`:
`net.ipv4.tcp_available_ulp = espintcp mptcp`

The output of running `sysctl net.mptcp.enabled`:
`net.mptcp.enabled = 1`

A terminal window titled 'sibasp@sibasp-VirtualBox: ~/linux-5.6.9' with standard window controls. The terminal shows two commands being executed. The first command is 'sysctl net.ipv4.tcp_available_ulp', which outputs 'net.ipv4.tcp_available_ulp = espintcp mptcp'. The second command is 'sysctl net.mptcp.enabled', which outputs 'net.mptcp.enabled = 1'. The prompt 'sibasp@sibasp-VirtualBox:~/linux-5.6.9\$' is visible at the end of the second line.

```
sibasp@sibasp-VirtualBox:~/linux-5.6.9$ sysctl net.ipv4.tcp_available_ulp
net.ipv4.tcp_available_ulp = espintcp mptcp
sibasp@sibasp-VirtualBox:~/linux-5.6.9$ sysctl net.mptcp.enabled
net.mptcp.enabled = 1
sibasp@sibasp-VirtualBox:~/linux-5.6.9$
```