

NASA HW2

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Network Administration

1. Short Answer

1.

Reference:

<http://www.cs.nthu.edu.tw/~nfhuang/chap04.htm>

<https://zh.wikipedia.org/wiki/%E8%BD%BD%E6%B3%A2%E4%BE%A6%E5%90%AC%E5%A4%9A%E8%B7%AF%E8%AE%BF%E9%97%AE>

<https://www.geeksforgeeks.org/collision-avoidance-in-wireless-networks/>

CSMA/CD passively detects if a collision has happened. If it detects a collision, it will stop sending frames as soon as possible. CSMA/CA, on the other hand, will check if the medium is busy or not before sending anything. If it's busy, it will wait for a random time then continue the transmission. CSMA/CA also uses a three-way handshake called RTS/CTS.

In wireless network, it's really difficult to precisely detect a collision, because the two nodes that collides might not be within each other's range (a.k.a. hidden node). Therefore CSMA/CD won't work in a wireless condition, but CSMA/CA's RTS/CTS can fix this problem.

2.

References:

<http://ccna2012.weebly.com/24291257732131222495-30896257583893622495.html>

<https://www.geeksforgeeks.org/collision-domain-and-broadcast-domain-in-computer-network/>

Collision domain is the range where the frames transferred will collide with each other. Broadcast domain is the range where a broadcast message sent by any device will be received by every other devices in this domain.

(a) Hubs can't split either collision domains or broadcast domains. That's because hubs don't use MAC address table, and they will send the received packet to every connected device except the source.

(b) Each port on a switch is an individual collision domain, because switches use MAC address tables to achieve point-to-point transfer. But switches can't split broadcast domains, splitting them requires a network layer device.

(c) A router splits both collision domain and broadcast domain, because a router connects different networks, and those two domains are restricted to a local network.

3.

References:

https://en.wikipedia.org/wiki/Broadcast_storm

https://en.wikipedia.org/wiki/Spanning_Tree_Protocol

When many broadcast traffics accumulate on a network and consumes lots of resources, we called this broadcast storm. It's usually caused by loops in network topology. STP solve this problem by cutting excessive paths , breaking all loops in the network topology.

2. IPerf

1.

From R204 PC to CSIE Workstation

On R204 PC

```
nslookup linux12.csie.ntu.edu.tw # to get the IP address of workstation  
iperf -c 140.112.30.43
```

On CSIE Workstation

```
iperf -s -i 5
```

Result

```
(b09902004) linux12.csie.ntu.edu.tw — Konsole
b09902004@linux12 [~] iperf -s -i 5
-----
Server listening on TCP port 5001
TCP window size: 128 KByte (default)
-----
[ 4] local 140.112.30.43 port 5001 connected with 140.112.16.183 port 1704
[ ID] Interval      Transfer    Bandwidth
[ 4] 0.0- 5.0 sec   401 MBytes  672 Mbits/sec
[ 4] 5.0-10.0 sec   395 MBytes  662 Mbits/sec
[ 4] 10.0-15.0 sec   395 MBytes  663 Mbits/sec
[ 4] 15.0-20.0 sec   291 MBytes  488 Mbits/sec
[ 4] 20.0-25.0 sec   311 MBytes  522 Mbits/sec
[ 4] 25.0-30.0 sec   378 MBytes  634 Mbits/sec
[ 4] 30.0-35.0 sec   387 MBytes  649 Mbits/sec
[ 4] 35.0-40.0 sec   398 MBytes  668 Mbits/sec
[ 4] 40.0-45.0 sec   362 MBytes  607 Mbits/sec
[ 4] 45.0-50.0 sec   382 MBytes  642 Mbits/sec
[ 4] 50.0-55.0 sec   399 MBytes  670 Mbits/sec
[ 4] 55.0-60.0 sec   383 MBytes  642 Mbits/sec
[ 4] 0.0-60.0 sec   4.38 GBytes 626 Mbits/sec
```

From laptop (connected to **csie-5G**) to R204 PC

On R204 PC

```
ifconfig # to get the IP address of this system
iperf -s
```

On my laptop

```
iperf -c 192.168.204.36 -t 60 -i 5
```

Result

```
HW2 : zsh — Konsole
(base)
# frank @ Frank-UX425EA-Linux in ~/Github_Repos/NASA-2021/HW2 on git:main x [16:11:40]
$ iperf -c 192.168.204.36 -t 60 -i 5
-----
Client connecting to 192.168.204.36, TCP port 5001
TCP window size: 255 KByte (default)
-----
[ 3] local 10.5.0.147 port 53926 connected with 192.168.204.36 port 5001
[ ID] Interval      Transfer    Bandwidth
[ 3] 0.0- 5.0 sec   128 MBytes  214 Mbits/sec
[ 3] 5.0-10.0 sec   142 MBytes  239 Mbits/sec
[ 3] 10.0-15.0 sec   119 MBytes  199 Mbits/sec
[ 3] 15.0-20.0 sec   119 MBytes  199 Mbits/sec
[ 3] 20.0-25.0 sec   136 MBytes  229 Mbits/sec
[ 3] 25.0-30.0 sec   145 MBytes  243 Mbits/sec
[ 3] 30.0-35.0 sec   132 MBytes  222 Mbits/sec
[ 3] 35.0-40.0 sec   127 MBytes  213 Mbits/sec
[ 3] 40.0-45.0 sec   118 MBytes  197 Mbits/sec
[ 3] 45.0-50.0 sec   117 MBytes  196 Mbits/sec
[ 3] 50.0-55.0 sec   151 MBytes  253 Mbits/sec
[ 3] 55.0-60.0 sec   144 MBytes  241 Mbits/sec
[ 3] 0.0-60.0 sec   1.54 GBytes 220 Mbits/sec
(base)
# frank @ Frank-UX425EA-Linux in ~/Github_Repos/NASA-2021/HW2 on git:main x [16:12:45]
$
```

From R204 PC to laptop (connected to csie-5G)

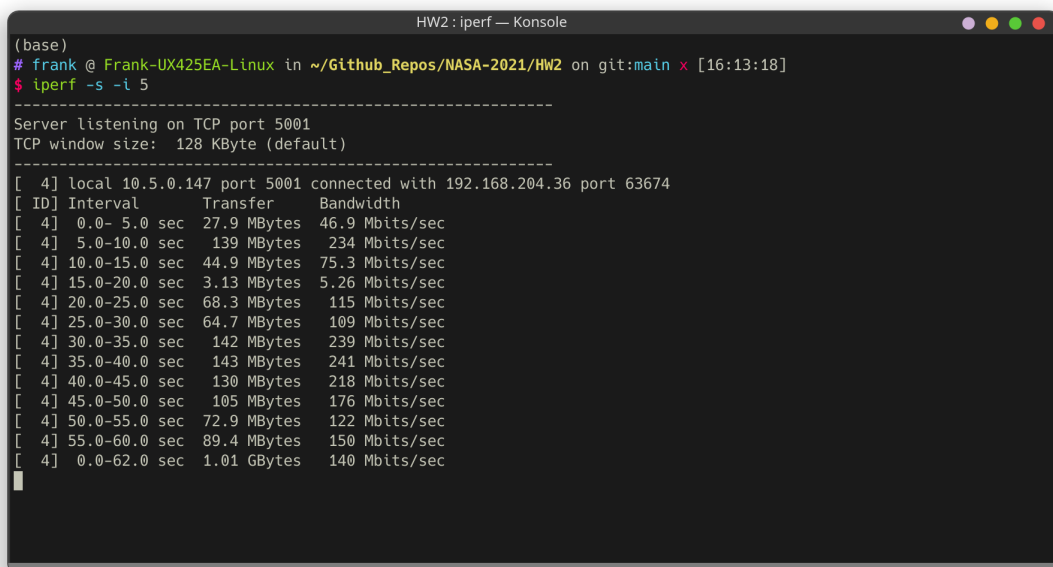
On my laptop

```
ifconfig # to get the IP address of this system  
iperf -s -i 5
```

On R204 PC

```
iperf -c 10.5.0.147 -t 60
```

Result



The screenshot shows a terminal window titled "HW2: iperf — Konsole". The user is logged in as "frank" on a system named "Frank-UX425EA-Linux". The terminal shows the execution of the command "iperf -s -i 5". The output indicates that the server is listening on TCP port 5001 with a window size of 128 KByte. It then shows a connection from a local IP 10.5.0.147 to a remote IP 192.168.204.36. The results are presented in a table with columns for ID, Interval, Transfer, and Bandwidth. The transfer increases over time, reaching 1.01 GBytes and 140 Mbits/sec by the 60-second mark.

```
(base)  
# frank @ Frank-UX425EA-Linux in ~/Github_Repos/NASA-2021/HW2 on git:main x [16:13:18]  
$ iperf -s -i 5  
-----  
Server listening on TCP port 5001  
TCP window size: 128 KByte (default)  
-----  
[ 4] local 10.5.0.147 port 5001 connected with 192.168.204.36 port 63674  
[ ID] Interval      Transfer      Bandwidth  
[ 4] 0.0- 5.0 sec   27.9 MBytes   46.9 Mbits/sec  
[ 4] 5.0-10.0 sec   139 MBytes   234 Mbits/sec  
[ 4] 10.0-15.0 sec   44.9 MBytes   75.3 Mbits/sec  
[ 4] 15.0-20.0 sec    3.13 MBytes    5.26 Mbits/sec  
[ 4] 20.0-25.0 sec   68.3 MBytes   115 Mbits/sec  
[ 4] 25.0-30.0 sec   64.7 MBytes   109 Mbits/sec  
[ 4] 30.0-35.0 sec   142 MBytes   239 Mbits/sec  
[ 4] 35.0-40.0 sec   143 MBytes   241 Mbits/sec  
[ 4] 40.0-45.0 sec   130 MBytes   218 Mbits/sec  
[ 4] 45.0-50.0 sec   105 MBytes   176 Mbits/sec  
[ 4] 50.0-55.0 sec   72.9 MBytes   122 Mbits/sec  
[ 4] 55.0-60.0 sec   89.4 MBytes   150 Mbits/sec  
[ 4] 0.0-62.0 sec   1.01 GBytes   140 Mbits/sec  
[ 4]
```

From laptop A to laptop B (both connected to csie-5G)

On laptop A

```
ifconfig # to get the IP address of this system  
iperf -s
```

On laptop B

```
iperf -c 10.5.6.200 -t 60 -i 5
```

Result

```
HW2 : zsh — Konsole
(base)
# frank @ Frank-UX425EA-Linux in ~/Github_Repos/NASA-2021/HW2 on git:main x [16:06:02]
$ iperf -c 10.5.6.200 -t 60 -i 5
-----
Client connecting to 10.5.6.200, TCP port 5001
TCP window size: 119 KByte (default)
-----
[ 3] local 10.5.0.147 port 46558 connected with 10.5.6.200 port 5001
[ ID] Interval      Transfer      Bandwidth
[ 3] 0.0- 5.0 sec  16.6 MBytes  27.9 Mbits/sec
[ 3] 5.0-10.0 sec  13.9 MBytes  23.4 Mbits/sec
[ 3] 10.0-15.0 sec  3.81 MBytes  6.39 Mbits/sec
[ 3] 15.0-20.0 sec  58.5 MBytes  98.1 Mbits/sec
[ 3] 20.0-25.0 sec  52.2 MBytes  87.7 Mbits/sec
[ 3] 25.0-30.0 sec  59.1 MBytes  99.2 Mbits/sec
[ 3] 30.0-35.0 sec  44.2 MBytes  74.2 Mbits/sec
[ 3] 35.0-40.0 sec  52.1 MBytes  87.5 Mbits/sec
[ 3] 40.0-45.0 sec  49.8 MBytes  83.5 Mbits/sec
[ 3] 45.0-50.0 sec  16.3 MBytes  27.3 Mbits/sec
[ 3] 50.0-55.0 sec  46.6 MBytes  78.2 Mbits/sec
[ 3] 55.0-60.0 sec  63.8 MBytes  107 Mbits/sec
[ 3] 0.0-60.1 sec  477 MBytes  66.6 Mbits/sec
(base)
# frank @ Frank-UX425EA-Linux in ~/Github_Repos/NASA-2021/HW2 on git:main x [16:07:03]
$
```

2.

From	To	Bandwidth Measured
R204 PC	CSIE Workstation	626 Mbps
Laptop (connected to csie-5G)	R204 PC	220 Mbps
R204 PC	Laptop (connected to csie-5G)	140 Mbps
Laptop A (connected to csie-5G)	Laptop B (connected to csie-5G)	66.6 Mbps

The highest bandwidth is between R204 PC and CSIE Workstation, and it's because the path is completely on wire, which is more robust than WiFi.

The difference between laptop to PC and PC to laptop is probably because more downstream bandwidth is occupied than upstream one, and becomes the bottleneck in transmission.

The lowest bandwidth occurs when both server and client are connected to WiFi, because wireless transmission could have more data loss than wired.

3. IPv6

Reference:

<https://unix.stackexchange.com/questions/457670/netcat-how-to-listen-on-a-tcp-port-using-ipv6-address>

<https://ithelp.ithome.com.tw/articles/10244029>

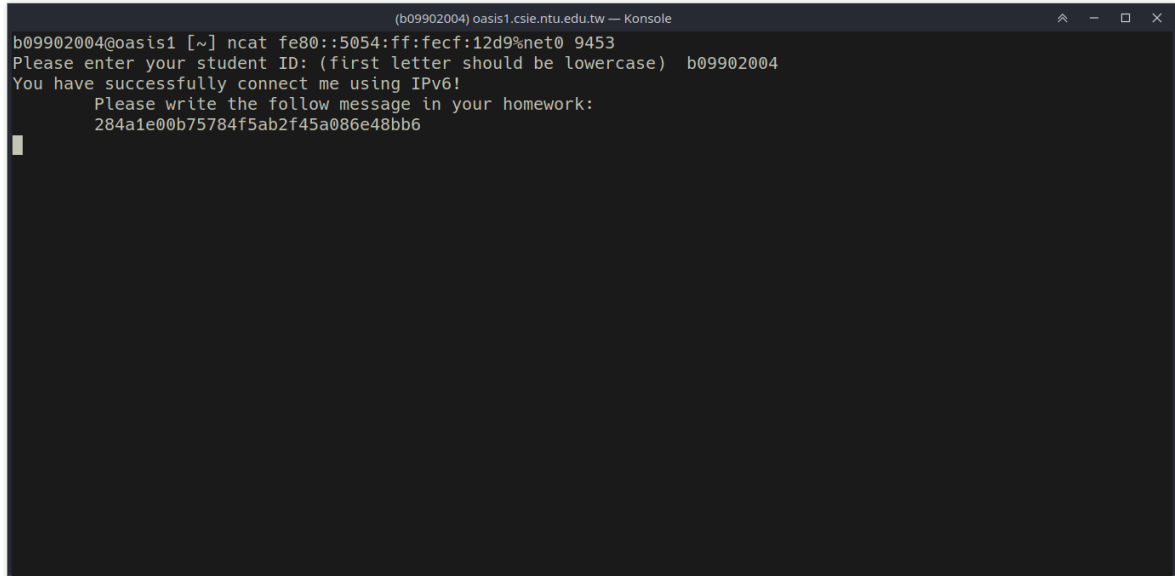
<https://stackoverflow.com/questions/24780404/python-tcp-socket-with-ipv6-address-failed>

Commands:

```
ifconfig  
ncat fe80::5054:ff:febf:12d9%net0 9453
```

Server message:

```
284a1e00b75784f5ab2f45a086e48bb6
```



```
(b09902004) oasis1.csie.ntu.edu.tw — Konsole  
b09902004@oasis1 [~] ncat fe80::5054:ff:febf:12d9%net0 9453  
Please enter your student ID: (first letter should be lowercase) b09902004  
You have successfully connect me using IPv6!  
Please write the follow message in your homework:  
284a1e00b75784f5ab2f45a086e48bb6
```

System Administration

1.

Reference:

Lab 3 slides

<https://zh.wikipedia.org/wiki/%E6%96%87%E4%BB%B6%E7%B3%BB%E7%BB%9F>

http://linux.vbird.org/linux_basic/0230filesystem.php

<https://askubuntu.com/questions/24027/how-can-i-resize-an-ext-root-partition-at-runtime>

<https://unix.stackexchange.com/questions/61209/create-and-format-exfat-partition-from-linux>

Commands:

```
sudo -i
```

```
lsblk # check current status
parted /dev/sda print # check if it's MBR or GPT
pacman -Syy
pacman -S gdisk # install gdisk bc it's GPT
umount /dev/sda3
e2fsck /dev/sda3
resize2fs /dev/sda3 5G
gdisk /dev/sda
# then follow the instructions in gdisk to:
# 1. delete partition3
# 2. create partition 3 with 5 GB
# 3. create partition 4 with rest of the space
partprobe
vim /etc/fstab
# in vim:
# find the line for mounting /home/nasa/documents
# change the original 'UUID=<some ID>' to '/dev/sda3'
reboot
# after reboot
sudo -i
lsblk
mkfs.exfat /dev/sda4
mount /dev/sda4 /home/nasa/share
vim /etc/fstab
# in vim:
# add a new line like this:
# /dev/sda4    /home/nasa/share    exfat    defaults    0 0
reboot
lsblk; df -hT
```

```
NASA21HW2 (Initial State (Audio Disabled)) [執行中] - Oracle VM VirtualBox
lnasa@nasahu2 ~$ lsblk; df -hT
NAME        MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda         8:0    0   20G  0 disk
l-sda1      8:1    0  256M  0 part /boot
l-sda2      8:2    0   9.1G  0 part /
l-sda3      8:3    0    5G  0 part /home/nasa/documents
l-sda4      8:4    0   5.7G  0 part /home/nasa/share
sdb         8:16   0    16G  0 disk
sdc         8:32   0    16G  0 disk
sdd         8:48   0    16G  0 disk
sde         8:64   0    8G  0 disk
l-sde1      8:65   0    8G  0 part /home/nasa/backup
Filesystem  Type      Size  Used Avail Use% Mounted on
dev         devtmpfs  2.0G   0    2.0G   0% /dev
run         tmpfs     2.0G  628K  2.0G   1% /run
/dev/sda2   ext4      8.8G 1016M  7.4G  12% /
tmpfs       tmpfs     2.0G   0    2.0G   0% /dev/shm
tmpfs       tmpfs     4.0M   0    4.0M   0% /sys/fs/cgroup
tmpfs       tmpfs     2.0G   0    2.0G   0% /tmp
/dev/sde1   btrfs     8.0G  3.6M  7.5G   1% /home/nasa/backup
/dev/sda4   exfat     5.7G   96K  5.7G   1% /home/nasa/share
/dev/sda3   ext4      4.9G   33M  4.6G   1% /home/nasa/documents
/dev/sda1   ufat     256M   46M  211M  18% /boot
tmpfs       tmpfs     392M   0   392M   0% /run/user/1000
lnasa@nasahu2 ~$ _
```

2.

Reference:

<https://www.cyberciti.biz/faq/linux-add-a-swap-file-howto/>

Commands:

```
sudo -i
dd if=/dev/zero of=/myswap bs=1024 count=2097152
chown root:root /myswap
chmod 0600 /myswap
mkswap /swapfile1
swapon /myswap
free -h
```



```
NASA21HW2 (p1 - solution) [執行中] - Oracle VM VirtualBox
[root@nasahu2 /]# free -h
              total        used        free      shared  buff/cache   available
Mem:           3.8Gi        90Mi        1.6Gi        1.0Mi        2.1Gi        3.5Gi
Swap:          2.0Gi          0B        2.0Gi
[root@nasahu2 /]#
```

3.

References:

<https://linuxhint.com/set-up-btrfs-raid/>

Commands:

```
sudo mkfs.btrfs -L p3 -d raid1 -m raid1 -f /dev/sdb /dev/sdc
sudo mount /dev/sdb /home/nasa/mnt
cd ~
ls -lah
sudo chown nasa:nasa ~/mnt
sudo btrfs filesystem show /home/nasa/mnt; sudo btrfs filesystem df /home/nasa/mnt
```

```
NASA21HW2 (p2 - solution) [執行中] - Oracle VM VirtualBox
[nasa@nasahu2 ~]$ sudo btrfs filesystem show /home/nasa/mnt: sudo btrfs filesystem df /home/nasa/mnt
Label: 'p3'  uuid: 7c7a7742-bcf0-478e-90c5-eb67ffc36cc2
    Total devices 2 FS bytes used 448.00KiB
    devid    1 size 16.00GiB used 1.26GiB path /dev/sdb
    devid    2 size 16.00GiB used 1.26GiB path /dev/sdc

Data, RAID1: total=1.00GiB, used=320.00KiB
System, RAID1: total=8.00MiB, used=16.00KiB
Metadata, RAID1: total=256.00MiB, used=112.00KiB
GlobalReserve, single: total=3.25MiB, used=0.00B
[nasa@nasahu2 ~]$ _
```

4.

References:

<https://linuxhint.com/create-mount-btrfs-subvolumes/>

Commands:

```
sudo mount /dev/sdb /home/nasa/mnt
sudo btrfs subvolume create /home/nasa/mnt/@
sudo btrfs subvolume create /home/nasa/mnt/@videos
sudo btrfs subvolume create /home/nasa/mnt/@documents
sudo mount /dev/sdb -o subvol=@ /home/nasa/courses
sudo mount /dev/sdb -o subvol=@videos /home/nasa/courses/videos
sudo mount /dev/sdb -o subvol=@documents /home/nasa/courses/documents
sudo blkid --match-token TYPE=btrfs # look for the UUID of /dev/sdb
sudo vim /etc/fstab
sudo reboot
```

```
NASA21HW2 (p3 - solution) [執行中] - Oracle VM VirtualBox
lnasa@nasahu2 ~]$ sudo btrfs subvolume list -p /home/nasa/courses
ID 263 gen 28 parent 5 top level 5 path @
ID 264 gen 23 parent 5 top level 5 path @videos
ID 265 gen 24 parent 5 top level 5 path @documents
lnasa@nasahu2 ~]$ cat /etc/fstab
# /dev/sda2 UUID=ade68796-6e1e-4a05-b443-fdc6be933014
PARTUUID=f80310f1-f90e-0144-b5b0-7a8ba789d8b7 / ext4 rw,relatime 0 1
tracefs /sys/kernel/tracing tracefs rw,nosuid,nodev,noexec 0 0
# /dev/sda3 UUID=3a8af8d5-7777-42e3-ba36-0266467029d5
/dev/sda3 /home/nasa/documents ext4 rw,relatime 0 2
# /dev/sda1 UUID=2177-52a4
PARTUUID=e1ca0f4c-a859-ab49-96b5-ed154009fbd4 /boot ufat rw,relatime,fmask=0022,dmask=0022,codepa
ge=437,iocharset=ascii,shortname=mixed,utf8,errors=remount-ro 0 2
# /dev/sdd1 UUID=b2d6670d-b2bb-4af3-ab47-7500a8e1520b LABEL=backup
PARTUUID=dfa995af-b842-ad4f-a3a4-c7ca47c83bb8 /home/nasa/backup btrfs rw,relatime,space_cache,subvolid=5,subvo
l=/ 0 0
/dev/sda4 /home/nasa/share exfat defaults 0 0
UUID=7c7a7742-bcf0-478e-90c5-eb67ffc36cc2 /home/nasa/courses btrfs subvol=@ 0
UUID=7c7a7742-bcf0-478e-90c5-eb67ffc36cc2 /home/nasa/courses/videos btrfs subvol=@videos 0
UUID=7c7a7742-bcf0-478e-90c5-eb67ffc36cc2 /home/nasa/courses/documents btrfs subvol=@documents 0
lnasa@nasahu2 ~]$
```

5.

References:

<https://linuxhint.com/use-btrfs-snapshots/>

Commands:

```
sudo btrfs subvolume snapshot -r /home/nasa/courses/documents
/home/nasa/courses/documents_backup
```

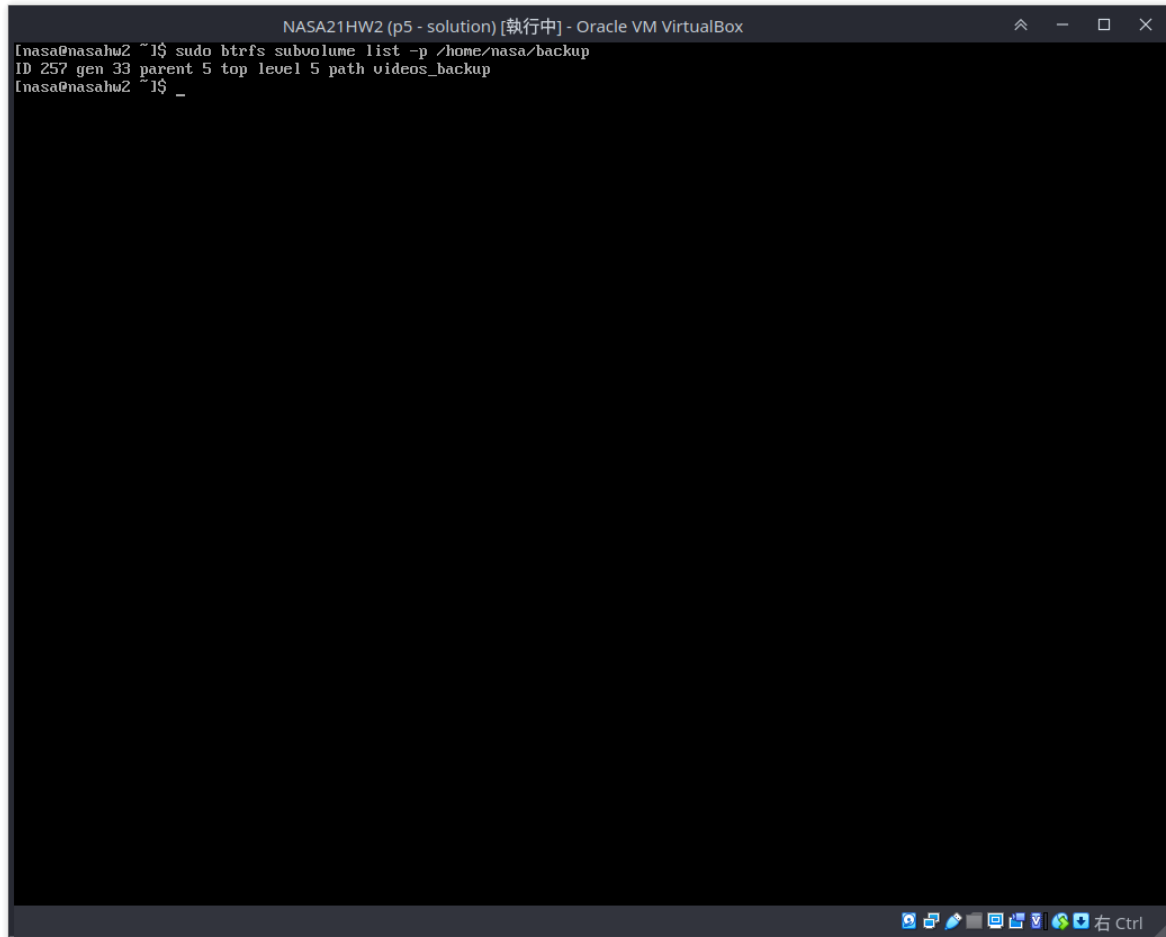
6.

References:

https://linuxhint.com/back_up_btrfs_snapshots_external_drives/

Commands:

```
sudo cp -R /home/nasa/videos/* /home/nasa/courses/videos
sudo btrfs subvolume snapshot -r /home/nasa/courses/videos
/home/nasa/courses/videos_backup
sudo btrfs send /home/nasa/courses/videos_backup | sudo btrfs receive
/home/nasa/backup
```



The screenshot shows a terminal window titled "NASA21HW2 (p5 - solution) [執行中] - Oracle VM VirtualBox". The terminal output shows the user running the command `sudo btrfs subvolume list -p /home/nasa/backup`, which returns the output: `ID 257 gen 33 parent 5 top level 5 path videos_backup`. The prompt then returns to the user's shell.

7.

References:

https://btrfs.wiki.kernel.org/index.php/Using_Btrfs_with_Multiple_Devices

<https://superuser.com/questions/901067/btrfs-convert-from-raid1-to-raid5>

Commands

```
sudo btrfs device add /dev/sdd /home/nasa/courses
sudo btrfs balance start -dconvert=raid5 -mconvert=raid5 /home/nasa/courses
```

```
NASA21HW2 (p6 - solution) [執行中] - Oracle VM VirtualBox
[nasa@nasahu2 ~]$ sudo btrfs filesystem df /home/nasa/courses; sudo btrfs filesystem show /home/nasa/courses
Data, RAID5: total=2.00GiB, used=54.73MiB
System, RAID5: total=128.00MiB, used=16.00KiB
Metadata, RAID5: total=512.00MiB, used=272.00KiB
GlobalReserve, single: total=3.25MiB, used=0.00B
Label: 'p3'  uuid: 7c7a7742-bcf0-478e-90c5-eb67ffc36cc2
Total devices 3 FS bytes used 55.02MiB
devid    1 size 16.00GiB used 1.31GiB path /dev/sdb
devid    2 size 16.00GiB used 1.31GiB path /dev/sdc
devid    3 size 16.00GiB used 1.31GiB path /dev/sdd

[nasa@nasahu2 ~]$
```

8.

References:

https://btrfs.wiki.kernel.org/index.php/Using_Btrfs_with_Multiple_Devices

Commands

```
sudo btrfs device delete /dev/sdc /home/nasa/courses
sudo btrfs balance start -dconvert=raid1 -mconvert=raid1 /home/nasa/courses
```

```
NASA21HW2 (p7 - solution) [執行中] - Oracle VM VirtualBox
[nasa@nasahu2 ~]$ sudo btrfs filesystem df /home/nasa/courses/; sudo btrfs filesystem show /home/nasa/courses
Data, RAID1: total=2.00GiB, used=54.48MiB
System, RAID1: total=32.00MiB, used=16.00KiB
Metadata, RAID1: total=512.00MiB, used=256.00KiB
GlobalReserve, single: total=3.25MiB, used=0.00B
Label: 'p3'  uuid: 7c7a7742-bcf0-478e-90c5-eb67ffc36cc2
Total devices 2 FS bytes used 54.75MiB
devid    1 size 16.00GiB used 2.53GiB path /dev/sdb
devid    3 size 16.00GiB used 2.53GiB path /dev/sdd

[nasa@nasahu2 ~]$ _
```

9.

(i)

References:

https://en.wikipedia.org/wiki/Comparison_of_file_systems

<https://linuxhint.com/btrfs-vs-ext4-filesystems-comparison/>

Btrfs has built-in RAID 1, RAID 0, and RAID 10 support, but ext4 doesn't have any RAID built-in. Btrfs supports online shrinking, but ext4 doesn't support it.

(ii)

References:

<https://zh.wikipedia.org/wiki/RAID>

In RAID 0, we parallelize reading and writing over all the disks in the array, thus increase performance. Files would have only a single copy and the data is distributed all over the disk array.

In RAID 1, the data on a disk would be mirrored to all the other disks in the array, thus the security is ensured, but waste lots of space.

RAID 5 is like a more secure RAID 0, the data is also distributed to all disks, but a parity data is calculated and stored in a disk different to where the corresponding data is stored. RAID 5 have slightly lower performance than RAID 0, but can allow a single disk failure.

RAID 10 is a combination of RAID 1 and RAID 0. Two disks are paired to build a RAID 1 array, and every RAID array is then combined to build a RAID 0 array. As long as not both disks in a pair are dead, the data is still secure and the system would still work.

(iii)

References:

<https://medium.com/@jain.sm/filesystem-in-userspace-5d1b398b04e>

<https://www.jianshu.com/p/c2b77d0bbc43>

FUSE is a feature that lets users define file operations and create their filesystems without having to deal with kernel-related stuff. One advantage is that it can be more portable because libraries would deal with the kernel. The obvious disadvantage is that efficiency is worse than those directly implemented in kernel.

(iv)

References:

<https://en.wikipedia.org/wiki/ZFS>

<https://zh.wikipedia.org/wiki/RAID>

https://www.reddit.com/r/homelab/comments/b4iz3w/zfs_vs_hardware RAID/

<https://superuser.com/questions/1134753/can-zfs-cope-with-sudden-power-loss-what-events-cause-a-pool-to-be-irrecoverab>

ZFS is a system that combines both file system and volume manager. It has control from physical layer to file system layer. ZFS uses many checksum mechanisms to secure data. It also has features like RAID, snapshots, and cloning.

Hardware RAID is a means to implement RAID. A RAID card is used in hardware RAID, and has dedicated processor, memory, and backup battery to handle reading and writing. Because it's implemented in hardware, it can be separated from the OS easily and it's almost plug-and-play.

In the case of a server, I would choose ZFS over hardware RAID. The first reason being hardware RAID relies heavily on the RAID card, which means that if the RAID card somehow dies, you probably would need to find the exact card. On the other hand, ZFS is completely a software solution, therefore doesn't have this problem.

Also, the resources ZFS might consume is becoming negligible as CPU performance is increasing a lot, making dedicated hardware just for RAID a bit excessive.

