

Homework 3

File server & Backup

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Outline

- HW 3-1: File server
- HW 3-2: SFTP auditing with RC
- HW 3-3: ZFS & Backup

HW 3-1: File server (24%)

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HW 3-1: Requirement (1/4)

Use **SFTP** to build a file server; create 2 directories under */home/sftp*

1. */home/sftp/public*:

- Everyone can **download & upload** files except for anonymous, sftp-u1 and sftp-u2
- Everyone can **mkdir** except anonymous
- Everyone can only **delete & rmdir** their **own** file or directory
- sysadm can **download, upload, delete, mkdir, rmdir** all content

2. */home/sftp/hidden*:

- Create a directory called “**treasure**” inside hidden directory
- Create a file called “secret” inside *hidden/treasure*
- Everyone **except sysadm** can't list */home/sftp/hidden* but **can enter *hidden/treasure*** and **show *hidden/treasure/secret***
- sysadm can **download, upload, delete, mkdir, rmdir** all content

HW 3-1: Requirement (2/4)

Create users

1. Create a **system user** “sysadm”
 - Can log in by **SSH**
 - Full access to *public* and *hidden*
2. Create **two users** “sftp-u1”, “sftp-u2”
 - Can **not** log in by **SSH**
 - Can **only** delete files in */home/sftp/public* **which are created by themselves**
 - Other permissions are the same as sysadm
3. Create a user “anonymous”
 - Can **not** log in by **SSH**
 - Read-Only permission (enter directory */home/sftp/{public,hidden}* and read file)

HW 3-1: Requirement (3/4)

Other requirements

- All accounts except **sysadm** are **chrooted** to */home/sftp*
- Everyone should support login to sftp with ssh key (same public key of judge)
- remaining users, “sftp-u1”, “sftp-u2”, “anonymous”
 - can only be used by **SFTP (can't login by SSH)**
 - every uploaded file should remove other's **read/write/execute** DAC permission

HW 3-1: Requirement (4/4)

	<u>sysadm</u>		<u>sftp-u{1..2}</u>		<u>anonymous</u>	
	<i>public/</i>	<i>hidden/</i>	<i>public/</i>	<i>hidden/</i>	<i>public/</i>	<i>hidden/</i>
list dir	✓	✓	✓	✓	✓	✗
mkdir	✓	✓	✓	✓	✗	✗
rmdir	✓	✓	▲	✓	✗	✗
upload	✓	✓	✓	✓	✗	✗
download	✓	✓	✓	✓	✓	✓
delete	✓	✓	▲	✓	✗	✗

✓: full access ▲: only the owner has permission ✗: permission denied

HW 3-1: Grading (24%)

- sysadm
 - Login from ssh and sftp (2%)
 - Full access to “*public*” (2%), “*hidden*” (2%)
- sftp-u1, sftp-u2
 - disable SSH login, only accept SFTP, Chrooted (*/home/sftp*)(3%)
 - Full access to “*public*”, can only delete files and directories they **owned**. (2%)
 - Full access to “*hidden*” (2%)
 - adjust DAC (2%)
 - remove all permission (rwx) of others when uploading
- anonymous
 - disable SSH login, only accept SFTP, Chrooted (*/home/sftp*) (3%)
 - can enter “*hidden*” (2%) and “*public*” (2%)
 - operations are read-only(even the file is writable to anonymous) (2%)

HW 3-1: Hint

- README (sftp config)
 - [sshd_config](#)
 - [sftp-server](#)
- If `ssh` or `sftp` run unexpectedly
 - Check your ssh log `/var/log/auth.log` first

HW 3-2: SFTP auditing with RC (22%)

HW 3-2: Requirements (1/6)

- Enable SFTP logging, aggregate all SFTP log to “`/var/log/sftp.log`”
 - SFTP log should only contain pure SFTP log, can't blend with other log (SSH, sudo...)

```
csjhuang@freebsd-132:~ $ sudo cat /var/log/sftp.log
Oct  9 23:48:35 freebsd-132 internal-sftp[48981]: session opened for local user sftp-u1 from
[10.113.52.12]
Oct  9 23:48:35 freebsd-132 internal-sftp[48981]: open "/public/test.exe" flags
WRITE,CREATE,TRUNCATE mode 0666
Oct  9 23:48:35 freebsd-132 internal-sftp[48981]: set "/public/test.exe" size 0
Oct  9 23:48:35 freebsd-132 internal-sftp[48981]: set "/public/test.exe" modtime
20231008-15:11:01
Oct  9 23:48:35 freebsd-132 internal-sftp[48981]: close "/public/test.exe" bytes read 0 written
0
Oct  9 23:48:40 freebsd-132 internal-sftp[48981]: session closed for local user sftp-u1 from
[10.113.52.12]
```

HW 3-2: Requirements (2/6)

- Create an executable stand-alone program (called “**sftp_watchd**”) that would filter every file uploaded.
 - “**sftp_watchd**” should reside in your system’s PATH
 - “sftp_watchd” can be written at **any** language (Python, Lua, Rust...)
 - The file name with extension **.exe** is violated
 - Move these files to **/home/sftp/hidden/.exe/**

```
csjhuang@freebsd-132:~ $ sudo ls /home/sftp/hidden/.exe/  
test.exe
```

HW 3-2: Requirements (3/6)

- Log violation of our sftp_watchd program policy into

`/var/log/sftp_watchd.log`

- Format -

timestamp hostname programname: filename violate file detected.

Uploaded by **upload_user**.

```
csjhuang@freebsd-132:~ $ sudo cat /var/log/sftp_watchd.log
Oct  9 17:47:25 freebsd-132 sftp_watchd[3256]: /usr/home/sftp/public/test.exe violate file
detected. Uploaded by sysadm.
Oct  9 17:47:25 freebsd-132 sftp_watchd[3256]: /usr/home/sftp/public/test.exe violate file
detected. Uploaded by sysadm.
```

HW 3-2: Requirements (4/6)

- You should write an **rc script** “**sftp_watchd**” as a daemon to start the sftp_watchd program
- Your service must support these operation:
 - `$ service sftp_watchd start`
 - `$ service sftp_watchd stop`
 - `$ service sftp_watchd restart`
 - `$ service sftp_watchd status`

HW 3-2: Requirements (5/6)

- Requires a **pid file** to indicate which process to stop

```
csjhuang@freebsd-132:~ $ cat /var/run/sftp_watchd.pid
3209
```

- You should display as following format while using each command
 - Service start

```
csjhuang@freebsd-132:~ $ sudo service sftp_watchd start
Starting sftp_watchd.
```

- Service stop

```
csjhuang@freebsd-132:~ $ sudo service sftp_watchd stop
Kill: 3209
```

HW 3-2: Requirements (6/6)

- Service restart

```
csjhuang@freebsd-132:~ $ sudo service sftp_watchd restart  
Kill: 3204  
Starting sftp_watchd.
```

- Service status

```
csjhuang@freebsd-132:~ $ sudo service sftp_watchd status  
sftp_watchd is running as pid 3204.
```


HW 3-2: Grading (22%)

- sftp_watchd
 - SFTP logging (3%)
 - aggregate only SFTP log to “/var/log/sftp.log” (3%)
 - violation file should moved to /home/sftp/hidden/.exe/ (4%)
 - logging after the violation file upload (4%)
- Service operation works correctly
 - sftp_watchd should be auto-start (2%)
 - start/status/stop/restart (6%)
 - sftp_watchd should be run in the background, and pid file is **not required** when using Linux

HW 3-2: Hint

- [sftp-server\(8\)](#)
 - On some systems, sftp-server **must be able to access** `/dev/log` for logging to work, and use of sftp-server in a chroot configuration therefore requires that syslogd(8) establish a `logging socket inside the chroot directory`.
- [syslogd\(8\)](#)
 - if log files didn't get the logs, try to restart syslogd
 - [logger\(1\)](#)
- [daemon\(8\)](#)
- [nohup\(1\)](#)

HW 3-3: ZFS & Backup (55%)

HW 3-3: Requirement (1/14)

- Add four new hard disks and create a **raid10** pool called “**mypool**”
 - You should partition each disk with GPT partition scheme, and label it as “mypool-1”, “mypool-2”, “mypool-3”, “mypool-4”
 - initialize ZFS pool using vdev with **GPT label** (under “/dev/gpt”)
 - Mount **mypool** on */home/sftp*
- Enable ZFS service
 - Reboot and everything is fine (ZFS still mounted)
- Create ZFS datasets
 - Set **lz4 compression**, **atime=off** to all datasets
 - Create **mypool/public**, **mypool/hidden** dataset

HW 3-3: Requirement (2/14)

- Automatic Snapshot Script: **zfsbak**
 - Add your script to \$PATH
 - Allow to execute zfsbak with command “zfsbak”, not “./zfsbak”
 - Usage:
 - Create: zfsbak DATASET [ROTATION_CNT]
 - List: zfsbak -l|--list [DATASET|ID|DATASET ID...]
 - Delete: zfsbak -d|--delete [DATASET|ID|DATASET ID...]
 - Export: zfsbak -e|--export DATASET [ID]
 - Import: zfsbak -i|--import FILENAME DATASET

```
csjhuang@freebsd-132:~$ zfsbak
Usage:
- create: zfsbak DATASET [ROTATION_CNT]
- list: zfsbak -l|--list [DATASET|ID|DATASET ID...]
- delete: zfsbak -d|--delete [DATASET|ID|DATASET ID...]
- export: zfsbak -e|--export DATASET [ID]
- import: zfsbak -i|--import FILENAME DATASET
```

HW 3-3: Requirement (3/14)

- Specification - Create (Default)
 - Must specify **dataset**
 - If no rotation count is specified, use 12 as default
 - No more than rotation count snapshots per dataset
 - If rotation count is reached, delete the oldest one
 - Your snapshot should include the dataset name and date
 - Every snapshot should **prefix with “zfsbak_”** to avoid collision with other on-demand snapshot

```
csjhuang@freebsd-132:~ $ sudo zfsbak -l
ID  DATASET  TIME
csjhuang@freebsd-132:~ $ sudo zfsbak mypool/public
Snap mypool/public@zfsbak_2023-10-09-16:22:25
csjhuang@freebsd-132:~ $ sudo zfsbak mypool/public
Snap mypool/public@zfsbak_2023-10-09-16:22:32
csjhuang@freebsd-132:~ $ sudo zfsbak mypool/public 1
Snap mypool/public@zfsbak_2023-10-09-16:22:38
Destroy mypool/public@zfsbak_2023-10-09-16:22:25
Destroy mypool/public@zfsbak_2023-10-09-16:22:32
```

HW 3-3: Requirement (4/14)

- Specification - List

- List snapshots created by zfs. **Sorted by time.**
- Ignored the snapshot that doesn't have the prefix “zfsbak_”
- If only **ID** is specified, list only the snapshot with that **id**
- If only **DATASET** is specified, list all snapshots of that dataset
- If **DATASET** and **ID** are specified, list only the snapshot with that **id** of the **dataset**
- Otherwise, list all snapshots

```
csjhuang@freebsd-132:~ $ sudo zfs create
mypool/public@not_zfsbak_target
csjhuang@freebsd-132:~ $ sudo zfsbak -l
```

ID	DATASET	TIME
1	mypool/public	2023-10-09-16:22:38
2	mypool/public	2023-10-09-16:24:22
3	mypool/hidden	2023-10-09-16:24:28
4	mypool/hidden	2023-10-09-16:24:30

```
csjhuang@freebsd-132:~ $ sudo zfsbak -l 3
```

ID	DATASET	TIME
3	mypool/hidden	2023-10-09-16:24:28

```
csjhuang@freebsd-132:~ $ sudo zfsbak -l mypool/public
```

ID	DATASET	TIME
1	mypool/public	2023-10-09-16:22:38
2	mypool/public	2023-10-09-16:24:22

```
csjhuang@freebsd-132:~ $ sudo zfsbak -l mypool/public 2
```

ID	DATASET	TIME
2	mypool/public	2023-10-09-16:24:22

HW 3-3: Requirement (5/14)

- Specification - Delete
 - Delete snapshots created by zfs
 - If only **ID** is specified, delete the snapshot with that **id**
 - If only **DATASET** is specified, delete all snapshots of that dataset
 - If **DATASET** and **ID...** are specified, delete snapshots with those **id** of the **dataset**
 - Otherwise, delete all snapshots

```
csjhuang@freebsd-132:~ $ sudo zfsbak -l
```

ID	DATASET	TIME
1	mypool/public	2023-10-09-16:32:30
2	mypool/hidden	2023-10-09-16:32:34
3	mypool/public	2023-10-09-16:32:36
4	mypool/hidden	2023-10-09-16:32:37
5	mypool/public	2023-10-09-16:32:38
6	mypool/public	2023-10-09-16:32:40
7	mypool/hidden	2023-10-09-16:32:41

```
csjhuang@freebsd-132:~ $ sudo zfsbak -d 1
```

```
Destroy mypool/public@zfsbak_2023-10-09-16:32:30
```

```
csjhuang@freebsd-132:~ $ sudo zfsbak -d mypool/hidden 2
```

```
Destroy mypool/hidden@zfsbak_2023-10-09-16:32:37
```

```
csjhuang@freebsd-132:~ $ sudo zfsbak -d mypool/hidden
```

```
Destroy mypool/hidden@zfsbak_2023-10-09-16:32:34
```

```
Destroy mypool/hidden@zfsbak_2023-10-09-16:32:41
```

```
csjhuang@freebsd-132:~ $ sudo zfsbak -d mypool/public 1 2 3
```

```
Destroy mypool/public@zfsbak_2023-10-09-16:32:36
```

```
Destroy mypool/public@zfsbak_2023-10-09-16:32:38
```

```
Destroy mypool/public@zfsbak_2023-10-09-16:32:40
```


HW 3-3: Requirement (6/14)

- Log
 - Must contain the action (e.g. snap), dataset name and time
 - Print “**Snap `dataset@zfsbak_create_time`**” after creating the new snapshot, e.g.,
 - Snap mypool/public@zfsbak_2023-10-09-16:32:30
 - Print “**Destroy `dataset@zfsbak_create_time`**” after destroying the deleted snapshot, e.g.,
 - mypool/public@zfsbak_2023-10-09-16:32:30
 - For any undefined operation, just print the error message and exit

HW 3-3: Requirement (7/14)

- Specification - Export
 - Must specify **dataset**
 - **ID** defaults to **1**
 - Compress with **zstd**
 - Encrypt with **aes-256-cbc (with password-based key derivation function 2)**
 - Encrypt with the environment we specified (EXPORT_PASS)
 - A filename example: ``mypool_public@zfsbak_2023-10-09-17:29:56.zst.aes``
 - Put the export file at the user's home directory

```
csjhuang@freebsd-132:~$ export ZFSBAK_PASS=secure_password
csjhuang@freebsd-132:~$ sudo -E zfsbak -e mypool/public 1
Export mypool/public@zfsbak_2023-10-09-17:29:56 to
~/mypool_public@zfsbak_2023-10-09-17:29:56.zst.aes
```

HW 3-3: Requirement (8/14)

- Specification - Import
 - Must specify **filename** and **dataset**
 - **filename** is the decrypted file exported by zfsbak
 - Load the snapshot to the dataset

```
csjhuang@freebsd-132:~$ sudo zfsbak -i "~/mypool_public@zfsbak_2023-10-09-17:29:56.zst"
mypool/public2
Import /home/csjhuang/mypool_public@zfsbak_2023-10-09-17:29:56.zst to mypool/public2
csjhuang@freebsd-132:~$ zfsbak -l
ID  DATASET          TIME
1   mypool/public    2023-10-09-17:29:56
2   mypool/public2   2023-10-09-17:29:56
csjhuang@freebsd-132:~$ ls /home/sftp/
dev/      hidden/  public/  public2/
```

HW 3-3: Requirement (9/14)

- Specification - **recursively Create**
 - should create the snapshot recursively, and do rotation properly

```
csjhuang@freebsd-132:~$ sudo zfs create -p mypool/demo/demo1
csjhuang@freebsd-132:~$ sudo zfs create -p mypool/demo/demo2
```

```
csjhuang@freebsd-132:~$ sudo zfsbak mypool/demo
Snap mypool/demo@zfsbak_2023-10-16-22:10:25
csjhuang@freebsd-132:~$ sudo zfsbak mypool/demo
Snap mypool/demo@zfsbak_2023-10-16-22:14:47
csjhuang@freebsd-132:~$ sudo zfsbak mypool/demo 2
Snap mypool/demo@zfsbak_2023-10-16-22:15:11
Destroy mypool/demo@zfsbak_2023-10-16-22:10:25
```

```
csjhuang@freebsd-132:~$ zfs list -t snapshot -r mypool/demo
```

NAME	USED	AVAIL	REFER	MOUNTPOINT
mypool/demo@zfsbak_2023-10-16-22:14:47	0B	-	96K	-
mypool/demo@zfsbak_2023-10-16-22:15:11	0B	-	96K	-
mypool/demo/demo1@zfsbak_2023-10-16-22:14:47	0B	-	96K	-
mypool/demo/demo1@zfsbak_2023-10-16-22:15:11	0B	-	96K	-
mypool/demo/demo2@zfsbak_2023-10-16-22:14:47	0B	-	96K	-
mypool/demo/demo2@zfsbak_2023-10-16-22:15:11	0B	-	96K	-

HW 3-3: Requirement (10/14)

- Specification - **recursively List**
 - should merge snapshots that have the same “**name**” and “**timestamp**” into one snapshot

```
csjhuang@freebsd-132:~$ zfs list -t snapshot -r mypool/demo
```

NAME	USED	AVAIL	REFER	MOUNTPOINT
mypool/demo@zfsbak_2023-10-16-22:14:47	0B	-	96K	-
mypool/demo@zfsbak_2023-10-16-22:15:11	0B	-	96K	-
mypool/demo/demo1@zfsbak_2023-10-16-22:14:47	0B	-	96K	-
mypool/demo/demo1@zfsbak_2023-10-16-22:15:11	0B	-	96K	-
mypool/demo/demo2@zfsbak_2023-10-16-22:14:47	0B	-	96K	-
mypool/demo/demo2@zfsbak_2023-10-16-22:15:11	0B	-	96K	-

```
csjhuang@freebsd-132:~$ sudo zfsbak --list mypool/demo
```

ID	DATASET	TIME
1	mypool/demo	2023-10-16-22:14:47
2	mypool/demo	2023-10-16-22:15:11

HW 3-3: Requirement (11/14)

- Specification - **recursively Export**
 - should export recursively
 - other requirements are the same as previous version

```
csjhuang@freebsd-132:~$ sudo zfsbak --list mypool/demo
```

ID	DATASET	TIME
1	mypool/demo	2023-10-16-22:14:47
2	mypool/demo	2023-10-16-22:15:11

```
csjhuang@freebsd-132:~$ export ZFSBAK_PASS=1
```

```
csjhuang@freebsd-132:~$ sudo -E zfsbak -e mypool/demo
```

```
Export mypool/demo@zfsbak_2023-10-16-22:14:47 to  
~/mypool_demo@zfsbak_2023-10-16-22:14:47.zst.aes
```

HW 3-3: Requirement (12/14)

- Specification - **recursively Import**
 - should export recursively and import recursively
 - **mypool/demo/demo3** is **part of** the first mypool/demo snapshot (the same timestamp and snapshot name)

```
csjhuang@freebsd-132:~$ sudo zfsbak -i ~/mypool_demo\@zfsbak_2023-10-16-22\:14\:47.zst mypool/demo/demo3
Import /home/csjhuang/mypool_demo\@zfsbak_2023-10-16-22:14:47.zst to mypool/demo/demo3
csjhuang@freebsd-132:~$ zfs list -t snapshot -r mypool
```

NAME	USED	AVAIL	REFER	MOUNTPOINT
mypool/demo@zfsbak_2023-10-16-22:14:47	0B	-	96K	-
mypool/demo@zfsbak_2023-10-16-22:15:11	0B	-	96K	-
mypool/demo/demo1@zfsbak_2023-10-16-22:14:47	0B	-	96K	-
mypool/demo/demo1@zfsbak_2023-10-16-22:15:11	0B	-	96K	-
mypool/demo/demo2@zfsbak_2023-10-16-22:14:47	0B	-	96K	-
mypool/demo/demo2@zfsbak_2023-10-16-22:15:11	0B	-	96K	-
mypool/demo/demo3@zfsbak_2023-10-16-22:14:47	0B	-	96K	-
mypool/demo/demo3/demo1@zfsbak_2023-10-16-22:14:47	0B	-	96K	-
mypool/demo/demo3/demo2@zfsbak_2023-10-16-22:14:47	0B	-	96K	-

```
csjhuang@freebsd-132:~$ sudo zfsbak --list mypool/demo
```

ID	DATASET	TIME
1	mypool/demo	2023-10-16-22:14:47
2	mypool/demo	2023-10-16-22:15:11

HW 3-3: Requirement (13/14)

- Specification - **recursively Import**
 - mypool/demo1 is new entries of mypool

```
csjhuang@freebsd-132:~$ sudo zfsbak -i ~/mypool_demo\@zfsbak_2023-10-16-22\:14\:47.zst mypool/demo1
Import /home/csjhuang/mypool_demo@zfsbak_2023-10-16-22:14:47.zst to mypool/demo1
```

```
csjhuang@freebsd-132:~$ zfs list -t snapshot -r mypool/demo1
```

NAME	USED	AVAIL	REFER	MOUNTPPOINT
mypool/demo1@zfsbak_2023-10-16-22:14:47	64K	-	96K	-
mypool/demo1/demo1@zfsbak_2023-10-16-22:14:47	0B	-	96K	-
mypool/demo1/demo2@zfsbak_2023-10-16-22:14:47	0B	-	96K	-

```
csjhuang@freebsd-132:~$ sudo zfsbak --list mypool
```

ID	DATASET	TIME
1	mypool/demo	2023-10-16-22:14:47
2	mypool/demo1	2023-10-16-22:14:47
3	mypool/demo	2023-10-16-22:15:11

HW 3-3: Requirement (14/14)

- Specification - **recursively remove**
 - snapshot should remove snapshots recursively

```
csjhuang@freebsd-132:~$ zfs list -t snapshot -r mypool/demo1
NAME                                     USED  AVAIL    REFER  MOUNTPOINT
mypool/demo1@zfsbak_2023-10-16-22:14:47  64K   -        96K   -
mypool/demo1/demo1@zfsbak_2023-10-16-22:14:47  0B   -        96K   -
mypool/demo1/demo2@zfsbak_2023-10-16-22:14:47  0B   -        96K   -

csjhuang@freebsd-132:~$ sudo zfsbak -d mypool/demo1
Destroy mypool/demo1@zfsbak_2023-10-16-22:14:47

csjhuang@freebsd-132:~$ zfs list -t snapshot -r mypool/demo1
no datasets available
```

HW 3-3: Grading (55%)

- Disk Setup (Add 4 new disks)
 - Enable kernel to show gpt label in /dev/gpt/ (FreeBSD), /dev/disk/by-partlabel (Linux) (3%)
 - partition with GPT scheme with correct label (3%)
- ZFS
 - Create a raid10 pool using block device at /dev/gpt as vdev (3%)
 - Create all datasets and set up correctly mountpoint, atime, compression (3%)
- zfsbak
 - Usage (2%)
 - Create, List, Delete (5% / each)
 - Export, Import (include log) (3% / each)
 - Recursive Create/List/Delete/Import/Export (4% each)

HW 3-3: Hint

- It will be much easier if you implement `Delete`, `Export`, `Import` with a well coding `List`
- If you make use of `zfs-list` sorting, you would easily handle zfsbak's recursive operations
- If you thinks shell script is hard to implement the function we wants, try [awk\(8\)](#)
- Check handbook first
 - <https://www.freebsd.org/doc/en/books/handbook/zfs-zfs.html>
 - <https://www.freebsd.org/doc/en/books/handbook/zfs-term.html>

HW 3: Grading(Bonus)

- You can choose whatever OS you want to use
 - OJ does **NOT** guarantee **Linux** can pass all test cases, so we only make it work with our **best effort**
- The grading is calculated by your highest score + (your less higher score * 20%)
 - if your freebsd get **70pt**, ubuntu get **30pt**, total you would get $70\text{pt} + (30\text{pt} * 20\%) = \mathbf{76\text{pt}}$
 - if your freebsd get **60pt**, ubuntu get **80pt**, total you would get $80\text{pt} + (60\text{pt} * 20\%) = \mathbf{92\text{pt}}$

Attention!

- Your work will be tested by Online Judge system.
 - You can submit multiple judge requests. However, OJ will cool down for several minutes after each judge.
 - **We will take the last submitted score** instead of the highest score.
 - Late submissions will not be accepted.
- **BACKUP your server before judge EVERY TIME**
 - **We may do something bad when judging.**
- Make sure everything is fine after reboot.



Attention!

- TAs reserve the right of final explanations. Specs and the points of each sub-judges are subject to change in any time.
- We might randomly pick some students to demo after end of HW3.
- Start from **Wed, 2023/10/26 21:00**
- **Deadline Wed, 2023/11/15 23:59**



Help me!

Questions about this homework

- Ask them on <https://groups.google.com/g/nctunasa>
- We MIGHT give out hints on Google Groups
 - Be sure to join the group :D
 - When posting a question, be sure to include all information you think others would need
 - including but not limiting to your ID, setups, configurations and / or what you have done to trace the error / problem
- Do not email us
- Do not use E3 to email us

Good Luck!

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