Lecture Agenda and Notes Draft: Unix on Local Machine

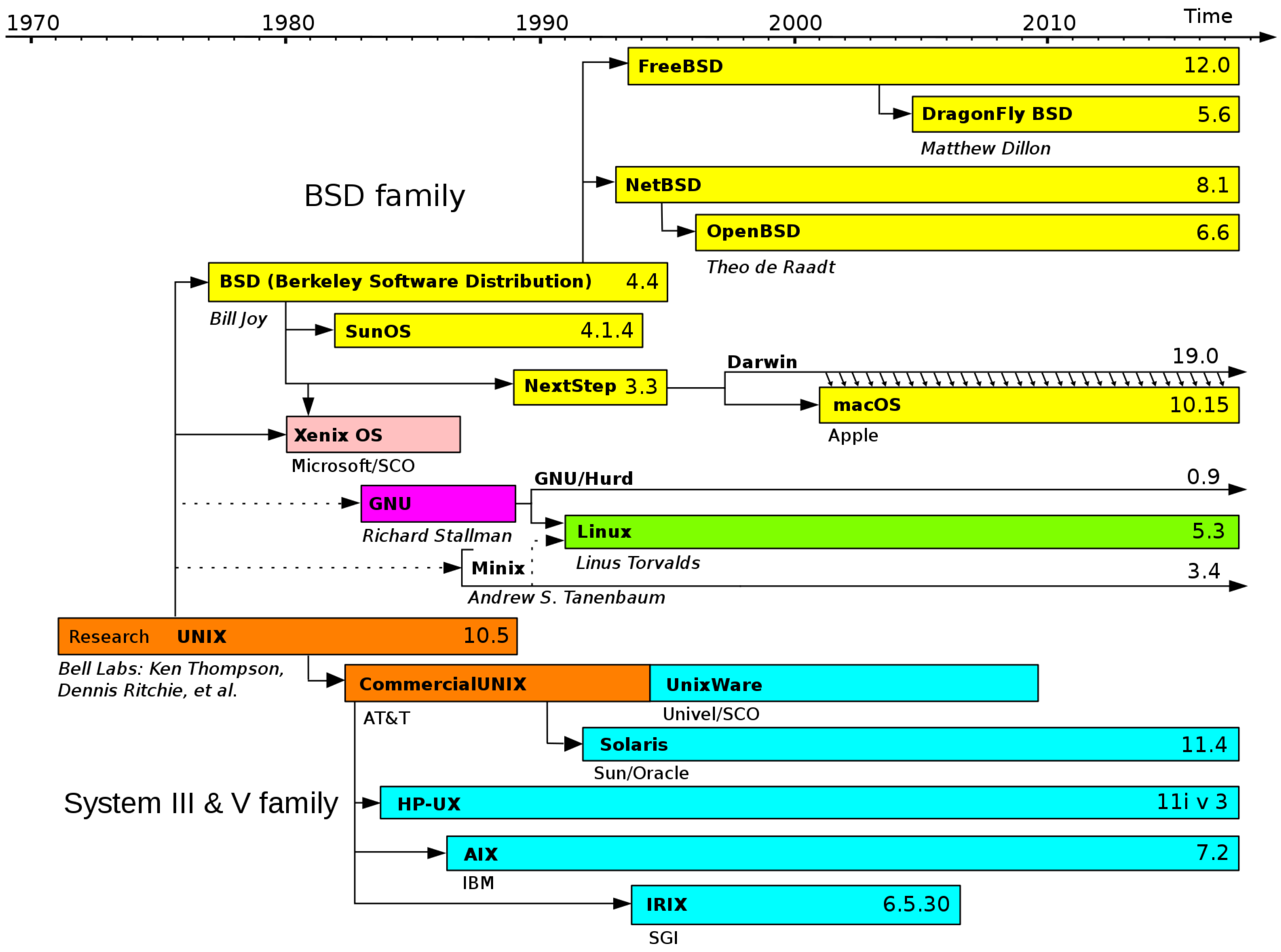
The following represents a very brief overview of the topics covered during the demonstration (lecture) part of the class. This material is publicly released to the students.

Course Overview [20 min]

This material is in the external slides.

What is Unix [20 min]

1. What is Linux? - Linux Explained is a great introduction and overview of the Linux, which is among the most popular Unix distributions.
2. Difference between UNIX and Windows Operating System
3. Unix vs. Windows
4. Below is a figure illustrating the evolution of Unix systems from the Darwin wiki page.



5. A Linux distribution contains a particular version of the Linux kernel and a set of open-source and proprietary applications. There are quite a few Linux distros out there.
   a. Open-source software (OSS) is computer software that is released under a license in which the copyright holder grants users the rights to use, study, change, and distribute the software and its

source code to anyone and for any purpose.[1][2] Open-source software may be developed in a collaborative public manner. Read more

   b. Proprietary software, also known as non-free software or closed-source software, is computer software for which the software's publisher or another person reserves some rights from licenses to use, modify, share modifications, or share the software. Read more
   c. Comparison of open-source and closed-source software - Wikipedia

6. Popular Linux distro families include Debian (e.g., Ubuntu), Fedora (RHEL, CentOS, Fedora), openSUSE, etc.
   a. Differences between Debian and RedHat include using different package managers (dpkg, yum).
   b. Various licensing options are there (e.g. RHEL is paid, while Fedora Core is not)
   c. Updates are released on a different time schedule, which leads to varying security .
7. Each distro has its own set of pre-installed applications and package managers.
   a. Examples for the Debian (Ubuntu, Mint): `dpkg`, `apt.` For Redhat (CentOS, Fedora) - это `rpm`, `yum`, `dnf.` The comparison of commands can be useful for your system.
      ```
      apt-cache search package_name.
      apt-get install
      apt-get remove
      ```

8. Getting info on your OS :

   `uname -s` — OS name
   `uname -r` — kernel version
   `cat /etc/os-release` — Distribution name

Unix Shells & Command-Line Interface (CLI) [20 min]

1. A Unix shell is a command-line interpreter or shell that provides a command line user interface for Unix-like operating systems. The shell is both an interactive command language and a scripting language, and is used by the operating system to control the execution of the system using shell scripts. Read more
2. Unix shells provide filename wildcarding (this class), piping, here documents, command substitution, variables and control structures for condition-testing and iteration (next class).
3. The most popular interpreters (shells) are: sh, bash, csh, zsh.
   ```
   username@hostname~$
         ~=current_directory
         $=shell_type (for common user $, root #)
   ```

4. Structure of the typical command:
   ```
   command  [option(s)/parameter(s)...]  [argument(s)...]
   ls --all --format=long
   ls -al
   ```
   symbols: `$, ?`

   These commands above are equivalent.

5. To get help on the command, use the man program present in most Unix distros out of the box, e.g.
   ```
   man ls
   ```

6. Two types of commands exist:
   internal/built-in - `cd`, `set`, `export`, `ls`
   external - stored in a binary file located in a certain list of default locations, e.g. `/bin, /usr/bin, /usr/local/bin`.

To invoke a command, the shell uses an environment variable named PATH, to search for binary files referenced by the external commands.
To check if the command is a built-in, internal, or an alias, use `which`:

```
which cd
which bash
```

Unix Filesystem [20 min]

1. Folders and file listing:
   `.dotfiles` - hidden and shell session customization;
   `cd`, `pwd`, `ls`, `tree` (should be installed).

   You can print a long list of the contents of the current directory using `ls -l`

```
        $ ls -l
-rw-r--r-- 1 user staff      3606 Jan 13  2017 report2018.txt
```

   `-rw-r--r-- -` This shows access permissions to a file or directory (first d or -), for owner, (`-rw-`), owner's group (`r--`) and the user (`r--`).
   `1 -` number of links to this file (soft and hard links exist, we'll get to that later today).
   `user -` owner name;
   `staff -` owner group;
   `3606 -` filesize
   `Jan 13 2017 -` date of last change;
   `report2018.txt -` filename.

2. Creating and removing files and directories:
   `touch,`
   `mkdir,`
   `rm,`
   `rm -r,`
   `wc,`
   `find --delete -` differs from rm -r. What is better for removing large number of files?
   Что лучше использовать при удалении большого кол-ва файлов? (ответ: find --delete - будет быстрее, он батчами удаляет)
   `brace extention: touch text1 text2 text5`
   `ls text{1..2}`

3. The inode (index node) is a data structure in a Unix-style file system that describes a file-system object such as a file or a directory. Each inode stores the attributes and disk block locations of the object's data. Read more

   Each file is assigned an inode ID. To view the inode information, use the stat command:
   Индексный узел `2678726` каждый inode ссылается на 1 файл раздела дискового пространства, и имеет информацию о файле. Inodes для директорий ссылается на структуру директорий.

```
2678726 -rw-r--r-- 1 user staff      3606 Jan 13  2017 report2018.txt
```

   `ln test.sh test_link.sh -` Creates a Hard link. A hard link lets you have multiple "file names" (for lack of a better description) that point to the same inode. This only works if those hard links are on the same file system.

   `ln -s test.sh test_slink.sh` - Create a symlink with the new inodes.

Changing a name or the permissions on the symlink does not affect the original file.

4. umask - user mask. When creating a file or a folder, the OS assigns default access permissions. By default, directory access permissions are 0777 (rwx r-x r-x), and for a file 0666 (rw-rw-rw).

```
User permissions = 0777 - umask
```

umask, for a normal user,

```
umask 0002
touch test_root.sh = 664
-rw-rw-r--
```

For a root user (a sudoer)

```
umask 0022
touch test_regular.sh = 644
-rw-r--r--
```

5. Changing permissions is possible with `chmod`:

   `chmod a+rw test.sh` - give write execute read permission to file;
   `chmod a-rw test.sh -` permissions to noone;
   `chmod 0777` - apply umask;

   for dir apply permission umask for all files in dir:

```
mkdir -p test & touch ./test/test1.sh ./test/test2.sh
chmod -R 0557 ./test
```

6. Special permissions:
   a. Sticky bit - forbidden to remove the directory except by the owner (бит t):

```
mkdir sticky_dir
chmod 1755 sticky_dir
```
      drwxr-xr-t

   b. SUID
   e.g. a directory

```
-rwsr-xr-x 1 root root 54256 Mar 26  2019 /usr/bin/passwd,
```

   allows to change passwords not only for a root user
   `SUID` allows users to run an executable with the file system permissions of the executable's owner or group respectively and to change behaviour in directories.

```
mkdir test.sh
chmod 6755 test.sh
```

   c. The **`SGID`** bit is analogous to **`SUID`**, but not the user but an owner group is set. Used with +s

```
chmod g+s /test.sh
```

7. File descriptors. A file descriptor is a number that uniquely identifies an open file in a computer's operating system. It describes a data resource, and how that resource may be accessed.
   In Linux, libc opens for each launched application 3 unique file descriptors by default, numbering them as 0,1,2. man stdio / man stdout:

Name	File descriptor	Description	Abbreviation
Standard input	**0**	The default data stream for input, for example in a command pipeline. In the terminal, this defaults to keyboard input from the user.	**stdin**
Standard output	**1**	The default data stream for output, for example when a command prints text. In the terminal, this defaults to the user's screen.	**stdout**
Standard error	**2**	The default data stream for output that relates to an error occurring. In the terminal, this defaults to the user's screen.	**stderr**

`ls -lah /proc/$$/fd/ -` prints the file descriptors

Piping 1 [20 min]

1. I/O redirection:
   redirect to file >
   redirect and append >>
   ```
   echo "Hello!" > text
   cat /proc/cpu_info 2>>/tmp/error.txt
   ```

   a. Redirect standard output:
   ```
   find /usr games 2> text-error
   ```

   b. Redirect standard input:
   ```
   uniq -c </tmp/error.txt
   ```
   < - input of the file contents into the stdin of the process

   c. Combination of output (channel 1) and error (channel 2) with &> (&>>):
   ```
   find /usr admin &> newfile
   (output input and error find: `admin': No such file or
   directory
   ```
   d. Commands:
   ```
   less,
   sort,
   head,
   ```

```
tail,
grep;
tr,
tar,
```

2. Pipes:
    i. `pv package` – pipe viewer
    ii. `cat /etc/passwd | grep root`
        The first command's output automatically becomes the second command's input
    iii. `xargs` works as an iterator over its input feeding through pipe. It is useful when you need to modify output of the pipe line-wise. E.g.
        ```
        cat /etc/passwd | cut -d: -f1 | xargs -I'{}'
        echo '{}@skoltech.ru'
        ```
3. standard filesystem contents & conventions.
    a. /bin - executable binaries (cat, kill), shipped with the system.
        `ls /bin | grep cat`
    b. /var - journal and log files /var/log; /var/log/messages
    c. /etc - editable configuration files;
    d. /usr - system resources,
        i. /usr/bin - user executable binaries that can be invoked by all users (sed, awk, curl)
        ii. /usr/local/bin - external compiled commands
    e. /dev - directory with device files for reading and writing
        i. /dev/sd* hard drives
        ii. /dev/null - an empty device where you can redirect output of stdout or any other stream
    f. /dev/urandom - random num generator
    g. /proc - virtual filesystem
        `ls -llt /proc` - each folder corresponds to a process identifier (PID) of each process currently running on a system.
        with /proc one can view the filesystem and file descriptors of various processes /proc:
        `echo $$` – which PID called echo
        `ls -lah /proc/$$/fd/` – shows file descriptors for stdin stdout stderr of the echo process
        `echo "hello world" > /proc/$$/fd/0` – shows hello world, which redirects to stdin (does not work on Darwin)

Find Utility

1. The *find* utility is a utility for traversing the hierarchy of files. Its used to search for files, directories and perform operations on them. The search can be performed by file, directory, name, date of creation/modification, owner and access rights

2. Find files by name

    a. *find ./foo -name foo.txt*

3. Find and remove file by name

    a. *find ./foo -name foo.txt -delete*

4. Find directory

   a. *find ./foo -type d -name bar*

5. Find by modification date
   a. *find ./foo -mtime -1* --- changed less then a day ago
   b. *find ./foo -mtime +1* --- changed more then a day ago
6. Find files by permissions
   a. *find ./foo -perm 777* --- find all files with rwxrwxrwx rights
7. Find provides interface to sequentially execute another command on found files
   a. *find ./foo -type f -name bar -exec chmod 777 {} \;*
   b. *find ./ -type f -name "*.md" -exec grep 'foo' {} \;*
   c. \; --- this ending is crucial

Reading

- Carinhas, Philip. "Linux Fundamentals." (2000). PDF version
- Ceruzzi, Paul E., E. Paul, and William Aspray. A history of modern computing. MIT press, 2003. (https://mitpress.mit.edu/books/history-modern-computing)
- https://www.softcover.io/read/fc6c09de/unix_commands

Problemsheet: Unix on Local Machine

Basics:

1. Using system package manager, install package `figlet`, run command `figlet hello ubuntu`, remove package figlet

2. Create 10 files with template file{number} within one command. Search within the tree for all files that end with a number and delete files from 4-6 files (Don't Use rm command). touch{1..10} (`touch{1..10}` `find ~ -name "*[4-6]" --delete`)

3. List the contents of your current directory, including the ownership and permissions, and redirect the output to a file called `contents.txt` within your home directory. (`ls -l > contents.txt`)

4. Count the number of files called `test` within the `/usr/share` directory and its subdirectories. Note: each line output from the `find` command represents a file. (`find /usr/share -name test | wc -l`)

5. permissions, io redirect, piping:
   a. How would you create a directory named `Box` where all the files are automatically owned by the group `users`, and can only be deleted by the user who created them?

      ```
      (mkdir Box
      chown :users Box/
      chmod g+wxs Box/
      chmod o+t Box/ (o - for others)
      ```
      or one command: specify SGID and the sticky bit
      ```
      chmod g+wxs,o+t Box/
      )
      ```

   b. Sort the /etc/passwd file, place the results in a file called foo.txt, and trap any errors in a file called err.txt:

      (`sort < /etc/passwd > foo.txt 2> err.txt`)

6. In the provided data practical_1_unix_local_machine_1.zip, count the number of txt files residing at the first depth level (e.g. at practical_1_unix_local_machine_1/ but not deeper) (`find . -maxdepth 1 -type f -name "*__stats.txt"`).

7. In the provided data practical_1_unix_local_machine_1.zip, count the number of txt files residing at any depth level and with the prefix "00221" (`find . -type f -name "00221*"`).

8. In the provided data practical_1_unix_local_machine_1.zip, count the number of lines in each txt file (`find . -maxdepth 2 -type f -name "*__stats.txt" -exec sh -c "wc -l {} " \;`).

9. Calculate the size of each root directory and sort them **by size** (`du -s /* | sort -nr`).
10. Calculate the size of all directories located at filesystem root (`/`) except the `/sys` and print the results for the largest one.

(`ls / | grep -v sys | xargs -I@ du -s /@ | sort -nr  | head -1`).

11. Calculate the size of all directories located at filesystem root (`/`) except the `/sys` and excluding zero-sized directories, and print all results.
(`ls / | grep -v sys | xargs -I@ du -s /@ | sort -nr | grep -vE '^0'`).