Introduction to the Linux OS

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November 16, 2023

Overview and Organization

Introduction to the Operation system Linux, focus on the command line, scripting, basic services and tools used in (not only) physics: tasks automation in data processing and modeling

Organization

- Graded Assessment (KZ): attendance to the lectures, worked out homeworks

Literature

- C. Herborth: Unix a Linux - Názorný průvodce, Computer Press, Praha, 2006
- D. J. Barrett: Linux - Kapesní přehled, Computer Press, Praha, 2006
- M. Sobell: Mistrovství v RedHat a Fedora Linux, Computer Press, Praha, 2006
- M. Sobell: Linux - praktický průvodce, Computer Press, Praha, 2002
- E. Siever: Linux v kostce, Computer Press, Praha, 1999
- Number of online sources...

Study materials and homeworks

- http://kfa.mff.cuni.cz/linux

Syllabus

1. UNIX systems, history, installation, basic applications
2. Structure of the Linux OS, file systems, hierarchy of the file system
3. Command line, shells, remote access (ssh, ftp)
4. Processes and their administration, basic system commands, packages, printing
5. Users, file and directory permissions
6. Work with files and directories, file compression, links, partition
7. Text-file processing commands, redirection, pipeline
8. Regular expressions
9. Command line based text editors
10. User and system variables, output processing
11. Scripts: basic construction, conditionals, loops, functions, automation
12. Networking, server-client services: http, (s)ftp, scp, ssh, sshfs, nfs
13. Programming in Linux (examples of Fortran, C/C++, Python), version control systems, documents in Latex

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File and directory (de)compression

File and directory (de)compression

Prupose: creating one file to replace many files and to reduce the size of files/directories Commands to be learnt: zip, tar, gzip, bzip2, 7z ...

- ZIP - similar to WinZIP

```
# Compression
zip [options] zipfile files_list
zip myfile.zip  my_files
zip -r student_home.zip /home/student
zip -P password zipfile files_list # zipping with "password"
# Decompression
unzip myfiles.zip
unzip -l myfiles.zip # shows the zip content without unzipping
```

- TAR - create a tar archive (originally tape archive = tar). Merges whole directories into one file called 'tarball'. No compression!!!

```
# "Compression" - no compression in fact
tar -cvf myfilesdirs.tar /my/dirs /and/files # make a tarball from dirs and files
                                             # -c means compress
# Uncompress - untar
tar -xvf myfilesdirs.tar # -x means eXtract
# does not compresses
tar -cvf downloads.tar Downloads/
ls -l downloads.tar
976005120
du -cb Downloads
975353493
```

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Tar can be combined with compression to reduce the size of the tarball file. Using compression algorithms from GZIP and BZIP2 utilities

- TAR with GZIP

```
# Compression
tar -zcvf myfiles.tar.gz /my/files /and/my/dirs # the extension is .tar.gz or .tgz
# Decompression
tar -zxvf  myfiles.tar.gz
tar -tvf myfiles.tar.gz # view contents
```

- TAR with BZIP2

```
# Compression
tar -jcvf myfiles.tar.bz2 /my/files /and/my/dirs # the extension is .tar.bz2 or .tbz2
# Decompression
tar -jxvf  myfiles.tar.bz2
tar -tvf myfiles.tar.bz2 # view contents
```

- gzip and bzip2 can be used directly for files

```
# Compression
gzip /my/file # creates file.gz
bzip2 /my/file # creates file.bz2
# Decompression
gunzip file.gz
bunzip2 file.bz2
```

File and directory (de)compression

- 7z - From man pages "7-Zip is a file archiver with the highest compression ratio. Supports LZMA, LZMA2, XZ, ZIP, Zip64, CAB, RAR (if the non-free p7zip-rar package is installed), ARJ, GZIP, BZIP2, TAR, CPIO, RPM, ISO, most filesystem images and DEB formats. Compression ratio in the new 7z format is 30-50% better than ratio in ZIP format."

```
# Compression
7z a dir.7z  /my/dir
# Decompression
7z e dir.7z
```

- RAR and UNRAR

```
# Compression
rar a myfiles.rar /my/files /my/dirs
# Decompression
unrar x myfiles.rar
```

- XZ - general-purpose data compression tool with command line syntax similar to gzip and bzip2, contained by 7z

```
# Compression
xz /my/files
# Decompression
xz -dk files.xz
```

- Excercise 1: Archive all files and directories in your home folder starting with . (dot) with tar+gzip
- Excercise 2: make a tarball from /etc directory - will it work for all the files
- Excercise 3: Compare the sizes of gzip, bzip2, zip, 7z, rar and xz for this file http://meop3.troja.mff.cuni.cz:8010/linux/netcdf/PHA03_STS.2007-2011DJF.nc
- Excercise 4: How to use 7z with password? Is it safe?

Disk/partition/filesystem handling utilities

Basic disk/partition handling utilities

Files/directories are structures physically or virtually written into harddrives/flashdrives, cdrom/dvdroms, tapes, virtual memory etc. These are usually divided into partitions which enables to separate logically distinct parts of the filesystem hierarchy structure. For example /home will be placed on different partition than /.

- Each parition has its own filesystem (FS)
- Partitions are 'mounted' to directories
- df – report file system disk space usage. It shows which partition is 'mounted' to which directory.
  - /dev/sda, /dev/sdb, /dev/sdc are 'device' files corresponding to individual devices
  - /dev/sda1, sda2 mean the partition number on the disk (i.e. each partition has a separate device file in /dev)
  - tmpfs is a temporal filesystem created in the RAM, so it behaves as a normal hraddisk, but when the computer is turned off, it is gone.
  - df -Th shows the type of the filesystems mounted (ext2, ext3, ext4, reiserfs, vfat, ntfs etc).
- lsblk – very useful utility to show the disk/partitions structure/filesystems and IDs of partitions
- hdparm – get/set SATA/IDE device parameters. Tool to use when it comes to tuning your hard disk or DVD drive, but it can also measure read speed, deliver valuable information about the device, change important drive settings, and even erase SSDs securely.

```
lsblk -f # get complete information about the disks/partitions/filesystems and disk UUIDs (see /etc/fstab)
hdparm -I /dev/sda # For all kind of information about the SATA/IDE disk
```

- FDISK - manipulate disk partition table. A very powerful utility to create,modify and delete partitions on a disk. USE WITH CAUTION AS YOU CAN EASILY DAMAGE YOUR EXISTING FILES/DIRECTORIES!!! More info on: https://www.tldp.org/HOWTO/Partition/fdisk_partitioning.html or man fdisk.

```
fdisk -l # shows all disks connected to the computer (needs root privileges)
fdisk /dev/sdb # prompt to manipulate with disk /dev/sdb, press m to get all the commands
```

- Once partitions are created on a disk, we can create different filesystems (Linux File System list https://static.javatpoint.com/linux/images/linux-file-system2.png, https://en.wikipedia.org/wiki/List_of_file_systems mkfs.filesystem

```
mkfs.ext4 /dev/sdb1 # create Ext4 filesystem on disk /dev/sdb and partition 1.
```

- fsck - check and repair a Linux filesystem

```
fsck.ext4 /dev/sdb1 # check and repairs the ext4 filesystem on disk /dev/sdb and partition 1.
```

Basic disk/partition handling utilities

In order to access the files/directories on the partitions, this partition has to be 'mounted'.

- mount - mount a filesystem

```
mount -t type device dir # The standard form of the mount command
# type is the filesystem type, device is the device file in /dev and dir is the directory where to mount
mount /dev/sdb1 /data # -t type may be omitted as the system will find it out automatically
mount -o ro /dev/sdb1 /data # "-o" = adding mount options, ro = read-only
```

- mounting ISO filesystem (CD/DVD *.iso image)

```
mount /path/to/image.iso /media/iso -o loop
```

- Mounting NFS - network filesystem

```
mount -t nfs 10.76.120.40:/volume1/d01 /home/nas01
```

- tmpfs - temporal/virtual filesystem represented in the RAM

```
mount -F tmpfs -o size=1G swap /mount/tmp # this takes 1G from the RAM and allocate it to /mnt/tmp
```

- unmounting filesystems

```
umount /mount/point
```

Basic disk/partition handling utilities

The `/etc/fstab` file is a system configuration file that contains all available disks, disk partitions, virtual disks and their options. Each file system is described on a separate line. Each line contains six fields separated by one or more spaces or tabs.

The `mount` command reads each line at system boot and mounts the disks according to the options given on the lines.

```
# <file system><mount point><type><options><dump><pass>
# filesystem root disk
UUID=f3b12014-faea-49c8-9e9a-f397b002454d / ext4 errors=remount-ro 0 1
# boot partitions
UUID=515B-6053 /boot/efi vfat umask=0077 0 1
UUID=141ad68b-b7f4-4074-a89d-43801222d5fb none       swap sw 0        0
# 2T data disk
UUID=6f3ffadf-418f-4e15-baaf-93ca06ffaf54 /data    ext4  errors=remount-ro 0       0
# NAS1 and NAS2
10.76.120.40:/volume1/d01 /home/nas01 nfs defaults 0 0
10.76.120.40:/volume2/d02 /home/nas02 nfs rw 0 0
# cesnet high capacity storage center Jihlava
sshfs#huszarpet@ssh.du4.cesnet.cz:/tape_tape/archive/VO_cuni_mff_meteo/home/huszarpet \
        /mnt/cesnet fuse defaults,idmap=user,IdentityFile=/home/huszi/.ssh/id_rsa,allow_other 0 0
```

- Disks can be specified either by the device file e.g. `/dev/sda2`, however, this is not uniq and can change if disk are connected to the computer in a different order.
- A much safer option is to specify the disks by their UUID number (`lsblk -f /dev/sda2`)
- Further options: type = FS type; options = mount options (like ro for read only); dump = backup operation with 'dump' (0/1); pass = FS check with fsck (root always 1, other 2, nocheck = 0)
- to mount the "lines" of fstab (when changes made) use `mount -a`.

Excercise - disk/partition handling utilities

A simple but frequent example

Suppose we got an old (or new) disk and want to format it as a single partition to the `ext4` filesystem, then mount it to /mnt/mydisk.

- fdisk to repartition (delete old partitions)
- mkfs.ext4 to create a FS
- mount it (for one time use) and permanently via fstab