Operating systems 1, Lecture 5
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File System

- is the component that **organizes** and **manages** all data on a storage device
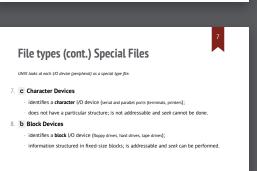
Unix characteristics

- the first OS that used the tree structure;
- current Unix systems extend it to the acyclic graph structure;
- Unix simultaneously supports multiple types of file systems (even if they belong to other OSs).
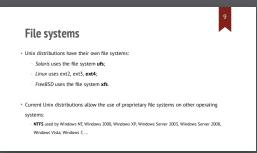

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OS UNIX structure

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The UNIX file system

- **Organization:**
    - files and folders

- **Management:**
    - set of operations: read, write, create, update, delete

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File types

Within a Unix file system there are 8 file types (file = byte sequence):

1. **-** **Ordinary files (regular)**
    - without a special logical organization;
    - sequential access;
    - can be text (ASCII) or binary.

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File types (cont.)

2. **d** **Directories**
    - structure: a table which contains an entry for every file that it houses;
    - offers the possibility of organizing the file system;
    - Each directory has two entries with special names:
        - **.** - generic name of the folder itself;
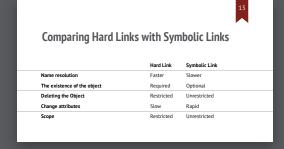   - **..** - generic name of the parent directory.

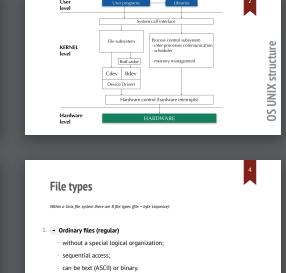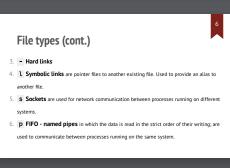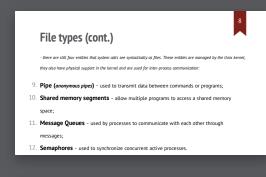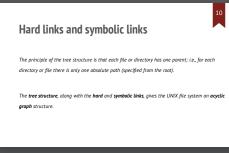Each file system contains a primary directory called `root` or `/`.

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File types (cont.)

3. **-** **Hard links**
4. **l** **Symbolic links** are pointer files to another existing file. Used to provide an alias to another file.
5. **s** **Sockets** are used for network communication between processes running on different systems.
6. **p** **FIFO - named pipes** in which the data is read in the strict order of their writing; are used to communicate between processes running on the same system.

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File types (cont.) Special Files

UNIX looks at each I/O device (peripheral) as a special type file.

7. **c** **Character Devices**
    - identifies a **character** I/O device (serial and parallel ports (terminals, printers);
    - does not have a particular structure; is not addressable and seek cannot be done.
8. **b** **Block Devices**
    - identifies a **block** I/O device (floppy drives, hard drives, tape drivers);
    - information structured in fixed-size blocks; is addressable and seek can be performed.

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File types (cont.)

- there are still four entities that unix system calls see syntactically as files. These entities are managed by the Unix kernel, they also have physical support in the kernel and are used for inter-process communication:

9. **Pipe (anonymous pipes)** - used to transmit data between commands or programs;
10. **Shared memory segments** - allow multiple programs to access a shared memory space;
11. **Message Queues** - used by processes to communicate with each other through messages;
12. **Semaphores** - used to synchronize concurrent active processes.

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File systems

- Unix distributions have their own file systems:
    - *Solaris* uses the file system **ufs**;
    - *Linux* uses ext2, ext5, and **ext4**;
    - *FreeBSD* uses the file system **xfs**.
- Current Unix distributions allow the use of proprietary file systems on other operating systems:
    - **NTFS** used by Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Server 2008, Windows Vista, Windows 7, ...

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Hard links and symbolic links

The principle of the tree structure is that each file or directory has one parent; i.e., for each directory or file there is only one absolute path (specified from the root).

The **tree structure**, along with the **hard** and **symbolic links**, gives the UNIX file system an **acyclic graph** structure.

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Hard links

- entries in a directory pointing to a file system substructure to which it already links its natural connection. Thus, the substructure is seen as descending from two different directories!

```
ln /bin/sh /usr/bin/sh # is old one
```

- is not distinguished from the original file;
- can not refer to directories;
- hard links between two distinct file systems can not be created.
- *can only be created by the system administrator.*

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Symbolic links

- special entries in a directory pointing (referring) to any file or directory in the file system structure. This entry behaves like a subdirectory of the directory in which it was created:

```
ln -s pathInTheFileSystemStructure symbolicName
```

- implemented as a (sub)directory containing a path;
- may refer to directories;
- symbolic links between two distinct file systems can be created.

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Comparing Hard Links with Symbolic Links

	Hard Link	Symbolic Link
Name resolution	Faster	Slower
The existence of the object	Required	Optional
Deleting the Object	Restricted	Unrestricted
Change attributes	Slow	Rapid
Scope	Restricted	Unrestricted

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Mounting concept

- connecting an "external" file system (e.g., from a HDD) to a folder in the default file system.


```
mount # displays all mounted file systems
mount /dev/cdrom /CD # mount [opt] fileSystem mountingDir
unmount /CD # unmount mountingDirectory
```

REMARK! DO NOT remove the peripheral from which the file system was mounted until after **unmount**.

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Mounting concept (cont.)

mount [options] **file_system** **directory**

unmount directory

Options:
- **-t fstip** specifies the type of file system we want to mount;
- **-r** or **-o ro** specifies that the new file system is mounted in read-only mode;
- **-w** or **-o rw** specifies that the new file system is mounted in read-write mode.

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Protection of Unix files. ls -l

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Protection of Unix files. Access rights (*mode*)

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Protection of Unix files. chmod

```
chmod 644 test_file # r-w-, w=ro
chmod go-w dir # deny w to g & o
chmod =rw,+X f # rw-default, keep x
```

	Octal	0	6	4	0
Binary:		000	110	100	000
Symbols:		S S T	r w x	r w x	r w x

Octal	Symbol	Permission	Octal	Symbol	Permission
0	---	No Permissions	4	r--	Read
1	--x	Execute	5	r-x	Read and Execute
2	-w-	Write	6	rw-	Read and Write
3	-wx	Write and Execute	7	rwx	Read, Write, and Execute

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Protection of Unix files. Default rights

When a user enters the system, they will be given default rights for the newly created files or folders. Fixing default rights or finding them can be done with the **umask** command.

```
umask # displays default rights
umask 027 # default rights: 777-027=750
```

The effect of this command will remain valid until a new **umask** or until the end of the session.

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Protection of Unix files. Launching rights

If for an executable file the **setuid** bit is 1, then a user executing this file receives the same resource access rights (files, semaphores, memory areas, etc.) as the executable file owner during execution

```
» ls -l examen
-rw-r--r-- 1 sanda cadre 20547 Dec 14 13:48 examen
» chmod +s examen
» ls -l
-rwSr-Sr-- 1 sanda cadre 20547 Dec 14 13:48 examen
```
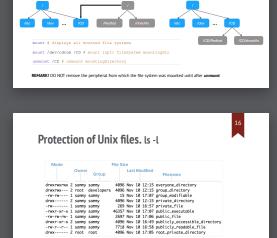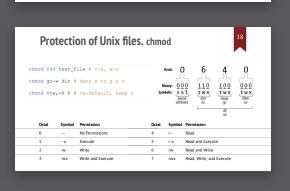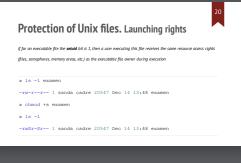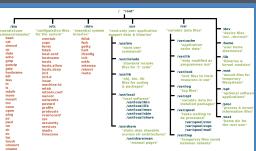

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The main directories of a UNIX file system

Each version of UNIX has a specific structure of the upper part of the file system. The differences between these structures are not too significant. Newer versions define additional hard links to ensure compatibility with older file systems.

The main ... UNIX directories

/bin/ commonly used executable commands

/boot/ contains the system kernel and the files needed for the boot process

contains device specific files; some of the most important are:

/dev/

hdx - IDE HDD, CD-ROM		**ttyx** - serial port entries (mouse, modem, etc.)	
sdx - SCSI HDD, card readers, flash drives		**lpx** - parallel port entries (printers, etc.)	
null - a black hole where data are send never to be seen again. Anything sent to /dev/null will disappear.			

```
» ls -D > /dev/null 2>&1; echo $? # error - ls: illegal option -- D
1
» rm /var/tmp/home_franky.tar.bz2 2> /dev/null
```

The main ... UNIX directories. /etc

- contains system configuration files; some of the most important are:

/etc/passwd - the user database, with fields giving information about each user

/etc/group - similar to /etc/passwd, but describes groups instead of users

/etc/fstab - configuration file for 'mount'; the the filesystems mounted automatically at startup

/etc/inittab - Boot-time system configuration/initialization script

/etc/httpd/ - directory containing Apache configuration files

```
» grep "sanda" /etc/passwd
sanda:x:2514:575:Sanda Avram:/home/cs/cadre/sanda:/bin/bash
» grep 575 /etc/group
cadre:x:575:
```

The main ... UNIX directories (cont.)

/home	contains the home directories for the users
/lib	(libraries) contains system libraries, and some critical files such as kernel modules or device drivers
/mnt	contains filesystem mount points
/proc	(procfs) virtual filesystem showing information about processes as files
/sbin	system binary files, being generally accessible to the system administrator
/tmp	storage for temporary files which are periodically removed from the filesystem

The main ... UNIX directories. /usr

- contains executables, libraries, and shared resources that are not system critical

/usr/bin - all binary programs distributed with the operating system not residing in /bin, /sbin

/usr/include - stores the development headers used throughout the system

/usr/lib - stores the required libraries and data files for programs

/usr/share/man - the manpages of various commands

/usr/share/doc - documentation for programs installed by users

/usr/src - the uncompiled source code of some programs

The main ... UNIX directories. /var

- contains files that may change often

/var/log/ - contains system log files

/var/log/apache2/ - contains access logs and web server errors

/var/log/spool/ - (spool directory) contains print jobs, mail spools and other queued tasks

/var/mail/ - where all the incoming mails are stored

/var/tmp - contains temporary files which should be preserved between system reboots.

The End