# Programming in shell 1

## Filesystem. Basic file/directory commands.

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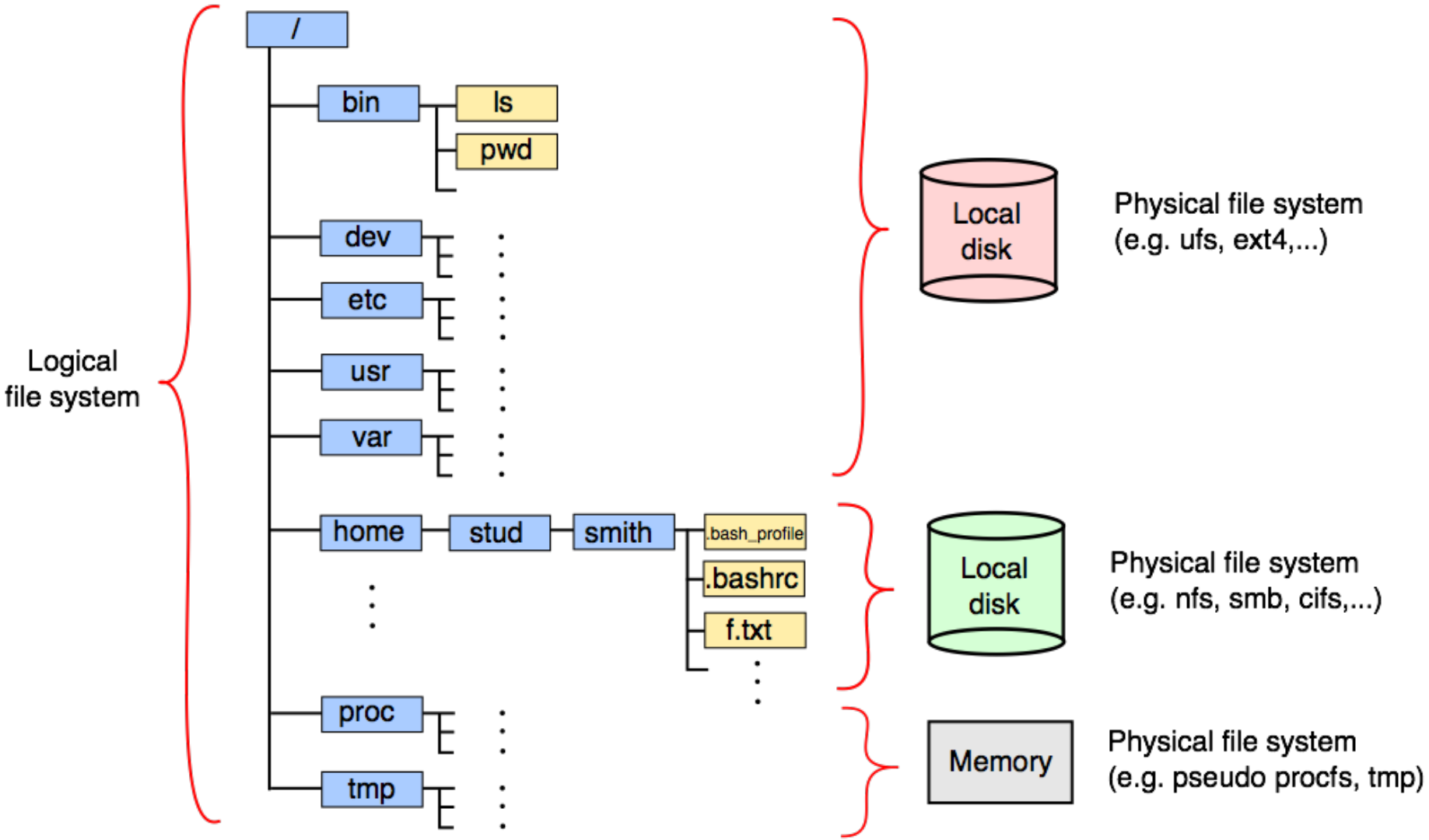
# Content

# File system (FS)



# File system

- Logical FS
  - It is arranged as a tree of directories, that starts at the root directory `/`.
  - For users, logical FS appears to be a homogeneous structure.
  - User can use commands like `cd`, `pwd`, `ls`, ... to change current working directory, to get info about path to directory, ...
  - Logical file system can consist of several physical file systems (use commands `df`, `mount`).

- Physical FS
  - Subtree of directories that is saved on one physical devices (e.g. local disk, remote disk, or memory).
    - Disk FS (ext4, ufs, btrfs, zfs, ...).
    - Remote FS (nfs, smb, cifs, ..).
    - Pseudo FS (procfs, tmpfs, fdfs, ...).

# Some important directories

| | |
|---|---|
| `/home` | Directory for user home directories, which store user files. |
| `/tmp` | Directory that contains temporary files. |
| `/bin` | Symbolic link to the `/usr/bin` directory. |
| `/sbin` | Symbolic link to the `/usr/sbin` directory. |
| `/usr` | Directory that contains system binaries and files. |
| `/usr/bin` | Directory that contains contains system exe-cutables and scripts. |
| `/usr/sbin` | Contains system administrative exe-cutables and scripts. |
| `/lib` | Directory that contains core system libraries. |
| `/dev` | Directory that contains special device files. |
| `/etc` | Directory that contains administrative and configuration files |
| `/opt` | Directory for unbundled application packages. |
| `/var` | Directory or file system that contains varying files that are unique to a system but can grow to an arbitrary or variable size. |

# File

File = path/name + attributes + data (contents)

- In Unix, the term file is much more general than in other OS.
- The file can represent a regular file, a directory, a special file, a symbolic link, ...
- Name
  - Maximal length is file system dependent.
  - Code depends on implementation (ASCII, UTF8,...).
  - Any characters is allowed except of character `/`.
  - Hidden file
    - File name beginning with dot.
    - It is not substituted by symbols `*` and `?`.
    - Command `ls` doesn't list them by default (use option `-a`).
  - File names dot (`.`) and double dots (`..`) are reserved for
    - `.` – working directory,
    - `..` – parent directory.

# File

- Attributes
  - They can be display by command `ls -l`.
  - Type:

| | |
|---|---|
| `d` | directory |
| `--` | regular file |
| `l` | symbolic link |
| `c` | special character device file |
| `d` | special block device file |

  - Owner: user and group.
  - Access permissions: read, write, execution, ACL,...).
  - Times: time of data modification, time of data access, time of attributes change.
- Data (contents)
  - Sequence/stream of bytes stored in data blocks.
- Access to file
  - By system calls: `open()`, `read()`, `write()`, `stat()`, ..., `close()`.
  - By OS commands: `less`, `cp`, `rm`, `mv`, `ln`,...

# Path

- Absolute path
  - It is a path beginning in the root directory `/`.
  - It contains the hierarchy of directories between root directory / and given file

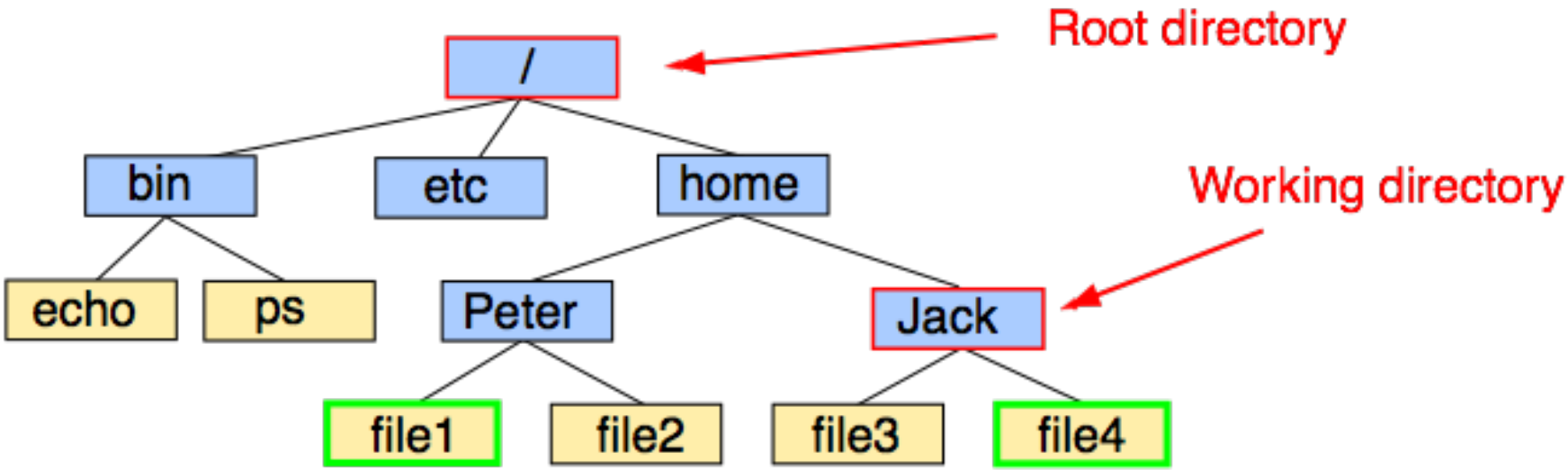
    `/home/stud/smith` or `/etc/passwd`
- Working directory
  - Its value is saved in the shell variable `PWD`.
  - It can be change by command `cd`.
  - Every process can have different working directory.
- Relative path
  - It is a path relative to the working directory.
  - It contains the hierarchy of directories between working directory and given file.
  - If PWD=/home, then

    `./stud/smith` or `../etc/passwd`

# Path

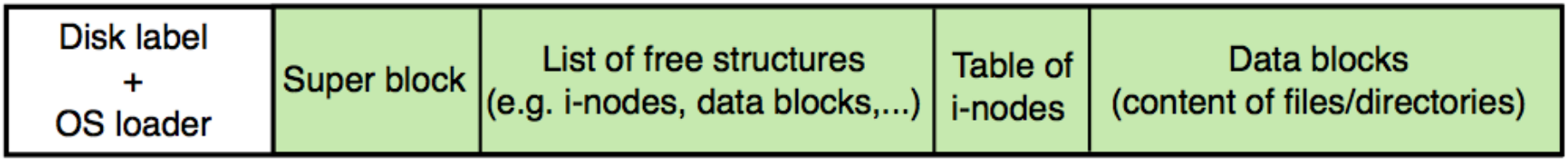
- Home directory
  - Every user has his home directory.
  - During login process working directory is set to the home directory.
  - Its value is saved in the shell variable `HOME`.

# Path – example



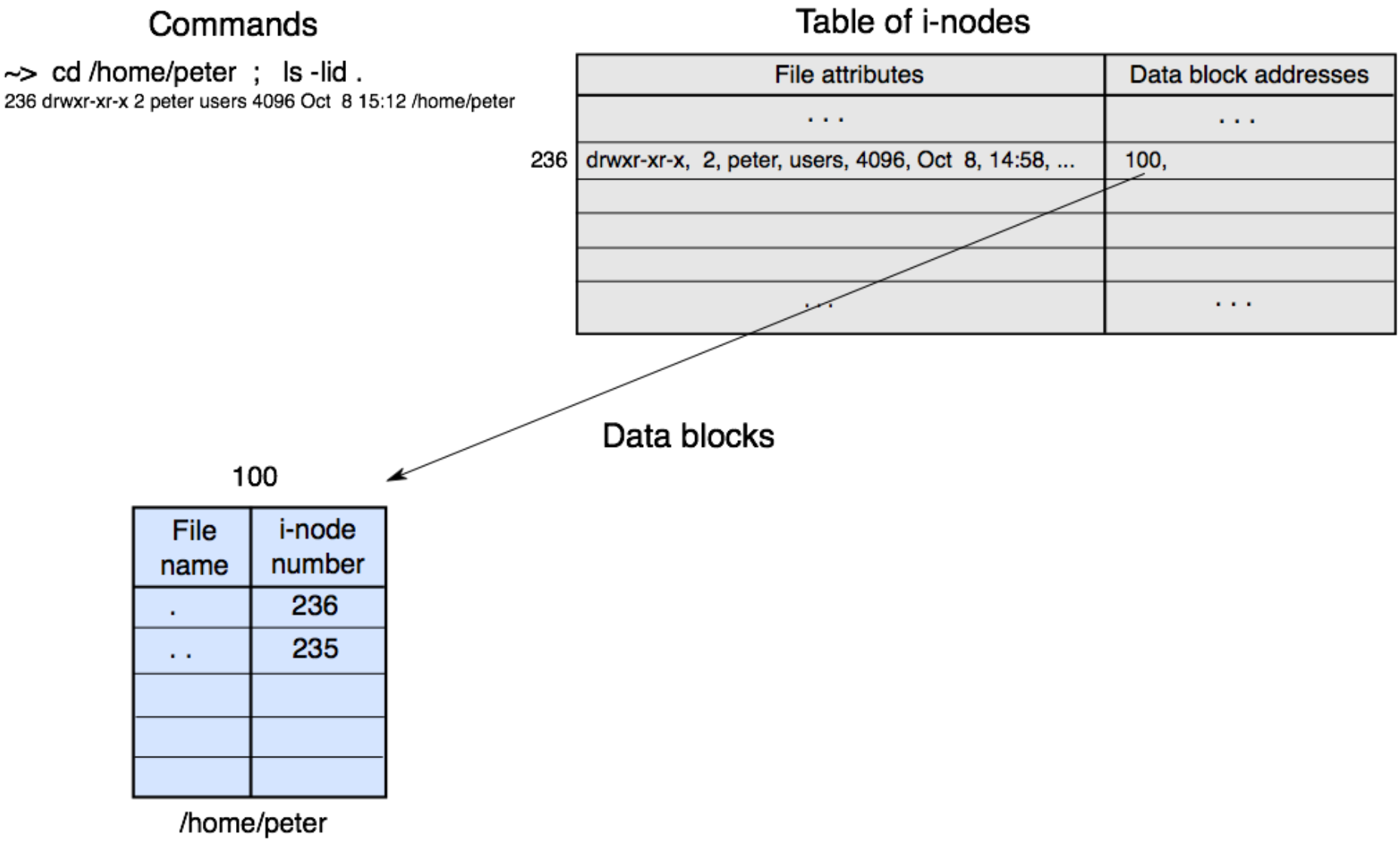

| | |
|---|---|
| `/home/Peter/file1` | absolute path to the file `file1` |
| `./../Peter/file1` | relative path to the file `file1` |
| `../Peter/file1` | relative path to the file `file1` |
| | |
| `/home/Jack/file4` | absolute path to the file `file4` |
| `./file4` | relative path to the file `file4` |
| `file4` | relative path to the file `file4` |

# Disk layout

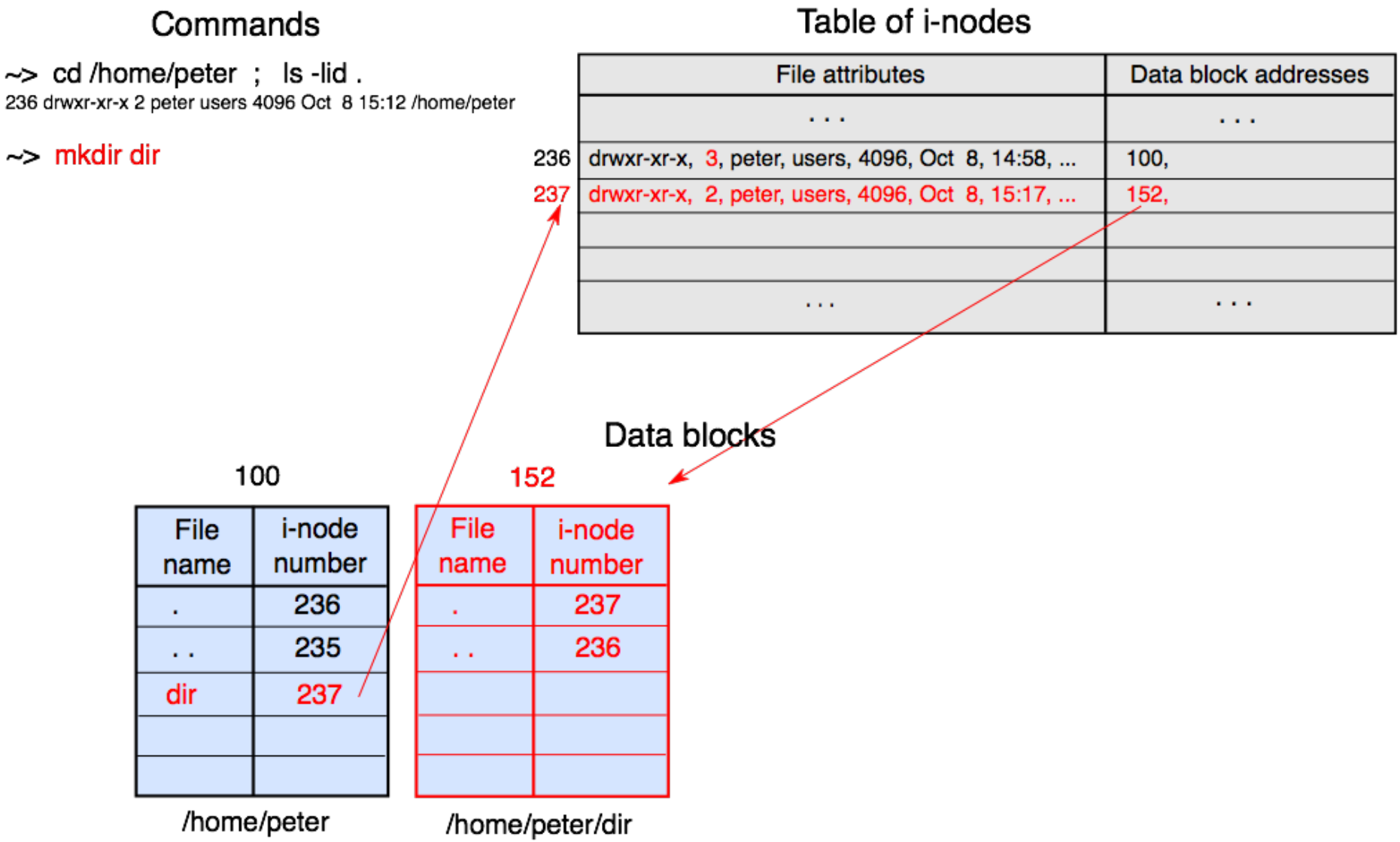



- Physical disk layout
  - Disk label
    - Table of disk partitions.
    - OS loader (it loads kernel and its modules into the main memory).
  - Disk partitions
    - Every partition can contain different file system.
- Unix file system
  - Super blok
    - File system specific information.
  - List of free structures
  - Table of i-nodes
    - It contains file attributes and disk addresses of data blocks where the file content is saved.
  - Data blocks.

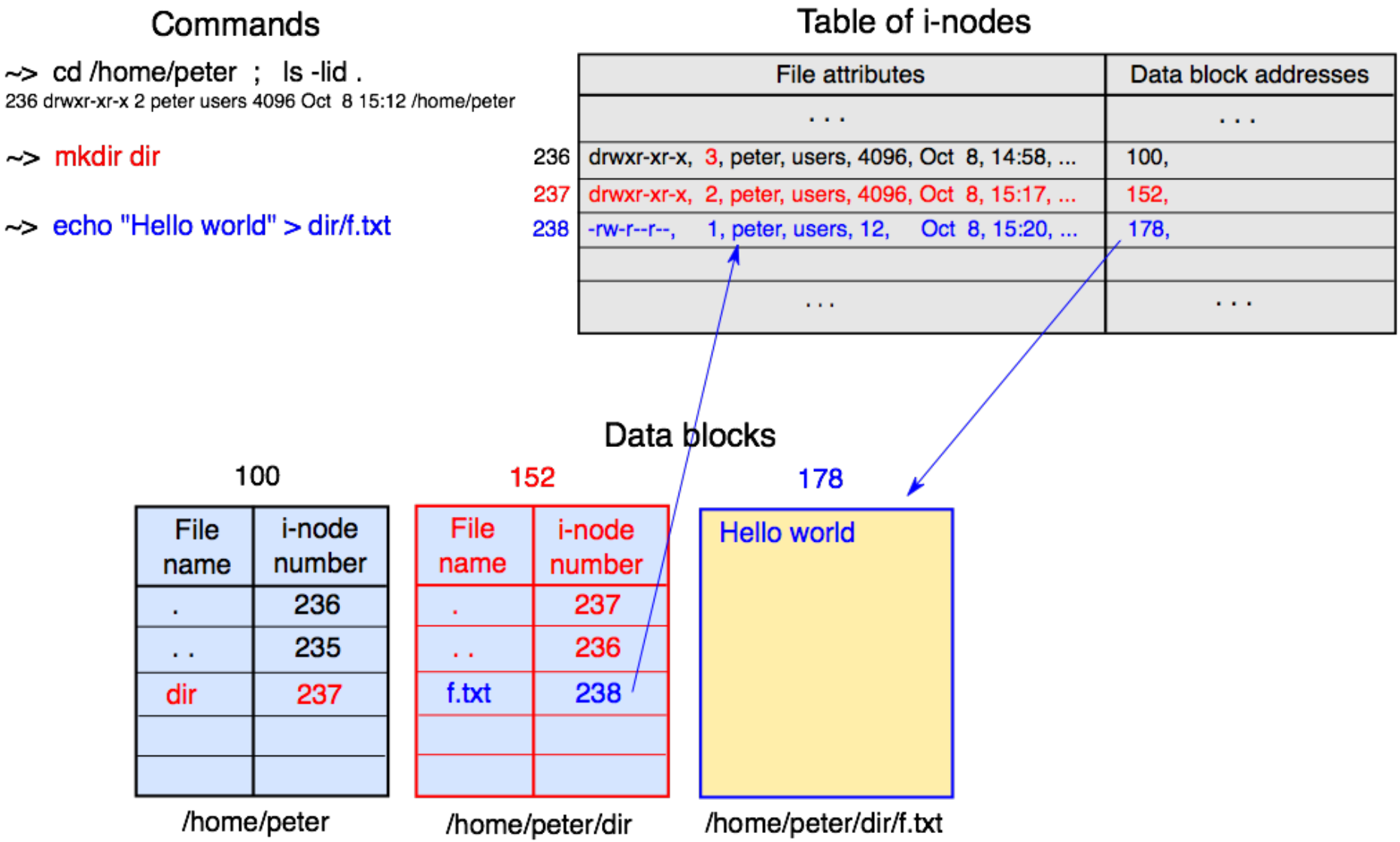
# FS implementation



# FS implementation – directory



# FS implementation – regular file

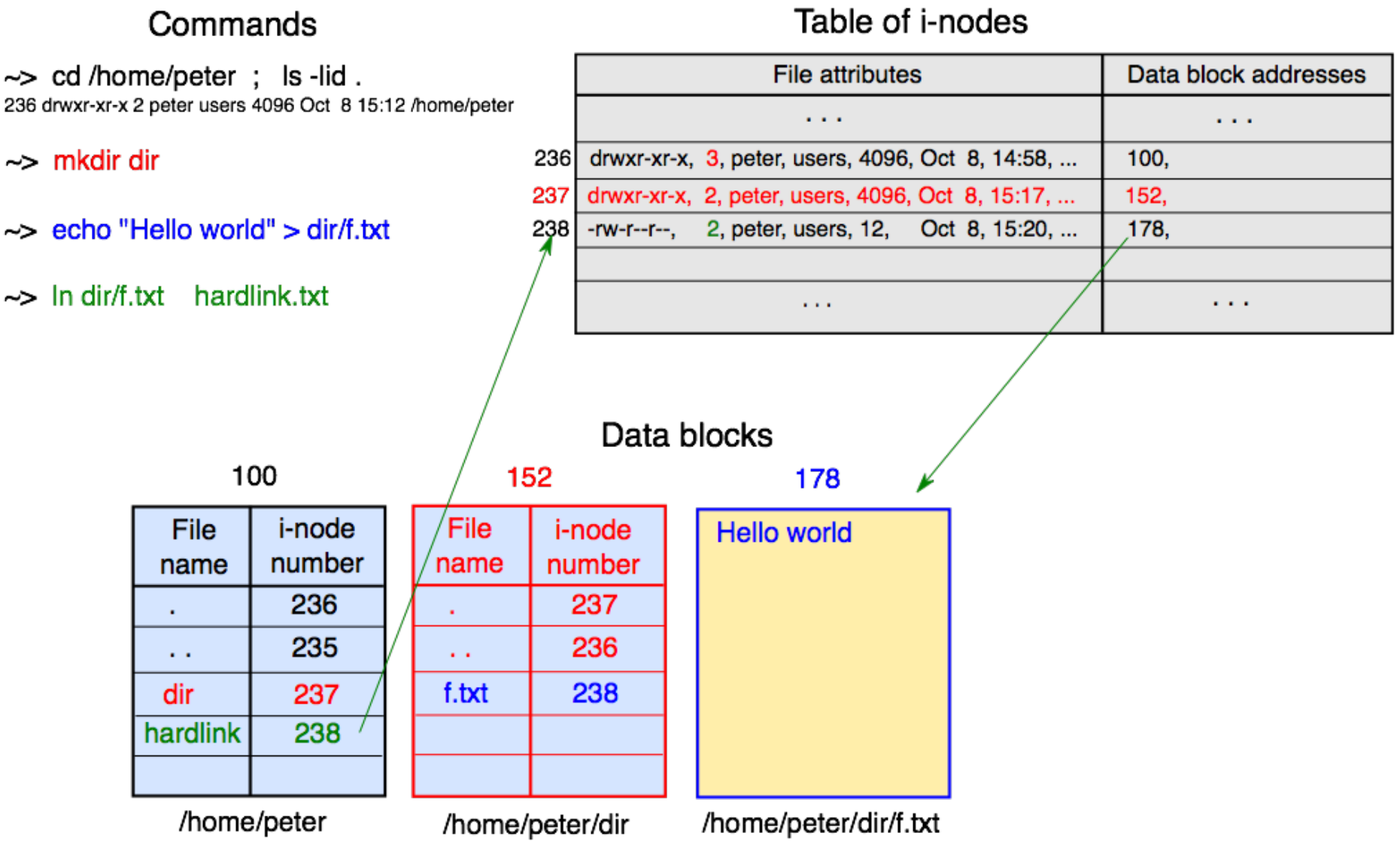


# FS implementation – hard link

```
ln original_file_name new_file_name
```

- Attributes and data of one file are accessible though several file names.
- It can be created only inside one physical file system.
- It can not point to
  - directory,
  - non existing file.
- After creation of hard link, it is not possible to distinguish between original and new file name.
- Removing
  - i-node and data are removed when the last name are removed.

# FS implementation – hard link

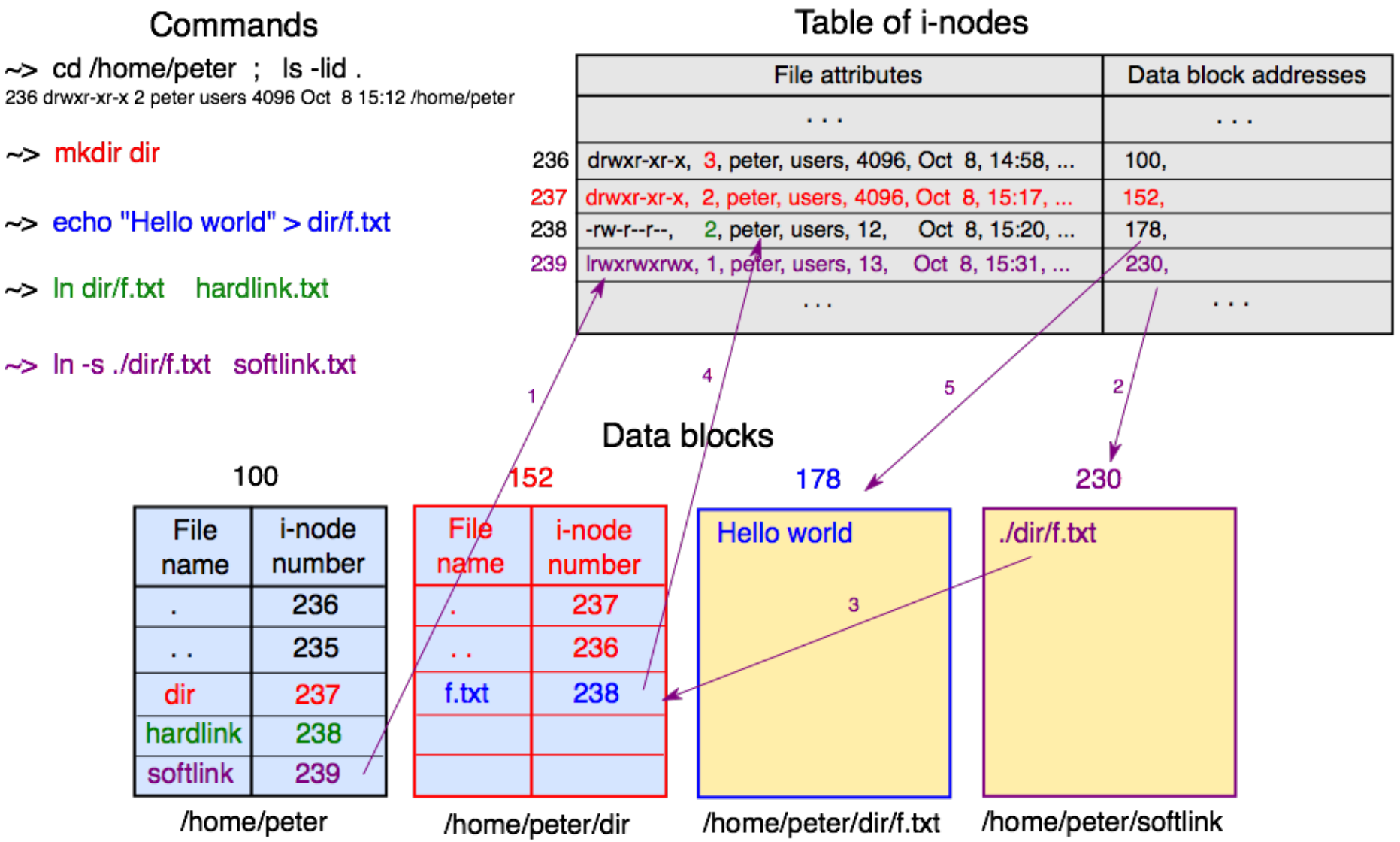


# FS implementation – soft link

```
ln -s original_file_name new_file_name
```

- Link contains original file name in its data block or in its i-node.
- It is possible create soft link
  - between different physical file systems,
  - to the directory,
  - to non existing files (error during usage of the soft link).
- Some operations are made directly with soft link (`rm`), another ones with the file on which the soft link points (`vi`).

# FS implementation – soft link



# FS implementation – file removing

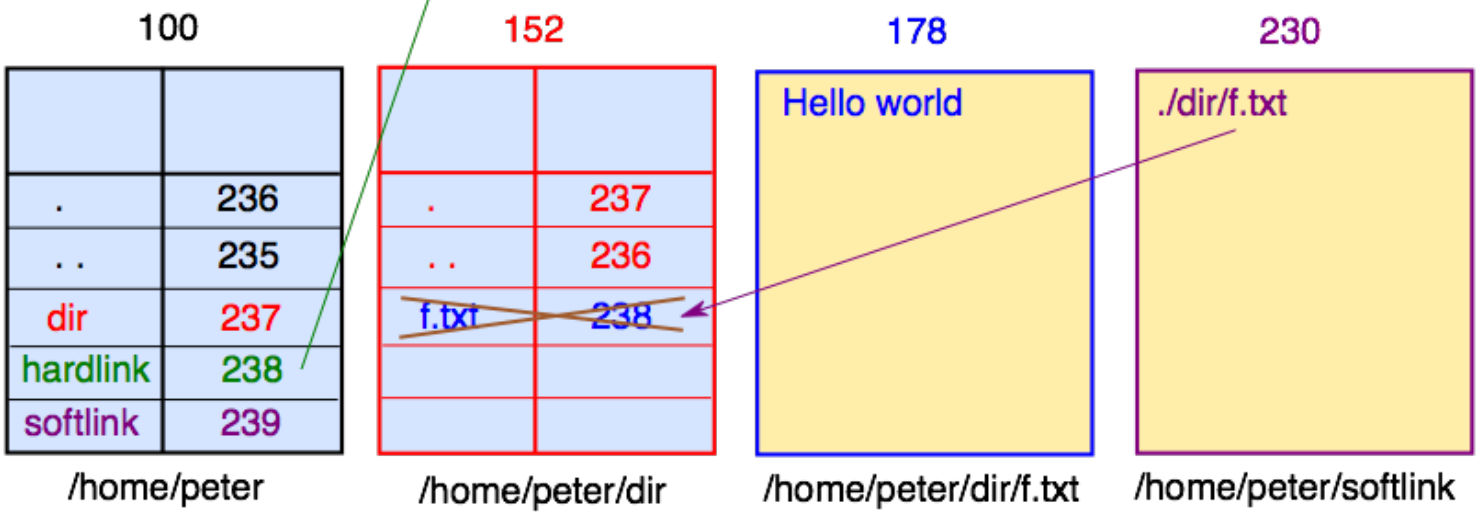
## Commands

```
~> cd /home/peter ; ls -lid .
236 drwxr-xr-x 2 peter users 4096 Oct  8 15:12 /home/peter
~> mkdir dir
~> echo "Hello world" > dir/f.txt
~> ln dir/f.txt hardlink.txt
~> ln -s ./dir/f.txt softlink.txt
~> rm dir/f.txt
```

## Table of i-nodes

| | File attributes | Data block addresses |
|---|---|---|
| | . . . | . . . |
| 236 | drwxr-xr-x, 3, peter, users, 4096, Oct 8, 14:58, ... | 100, |
| 237 | drwxr-xr-x, 2, peter, users, 4096, Oct 8, 15:17, ... | 152, |
| 238 | -rw-r--r--, 1, peter, users, 12, Oct 8, 15:20, ... | 178, |
| 239 | lrwxrwxrwx, 1, peter, users, 13, Oct 8, 15:31, ... | 230, |
| | . . . | . . . |

## Data blocks



# Basic commands – directory

| | |
|---|---|
| `cd [dir \| -]` | Change working directory. |
| `ls [aldL] [dir]` | List contents of directory |
| `mkdir [-p] dir` | Make new diectory. |
| `rm -r dir` | Remove dorectory (includinhg its contents). |
| `cp -r dir1 dir2` | `dir2` doesn't exist: create copy of `dir1` by name `dir2`.<br>`dir2` exists: create copy of `dir1` in directory `dir2` (`dir2/dir1`). |
| `mv dir1 dir2` | `dir2` doesn't exist: rename `dir1` to `dir2`.<br>`dir2` exists: move `dir1` to `dir2` (`dir2/dir1`). |

- Be careful on recursion copy.

```
cp -r dir1 dir1
```

# Basic commands – file

| | |
|---|---|
| `cp f1 f2 dir` | Copy files `f1` and `f2` to directory `dir` |
| `cp f1 f2` | `f2` doesn't exist: copy file `f1` to file `f2`.<br>`f2` exists: overwrite file `f2` by file `f1` |
| `mv f1 f2` | Move/rename file `f1` to `f2`. |
| `rm f1` | Remove `f1`. |
| `stat f1` | Display attributes of file `f1`. |
| `file f1` | Determine type of file `f1`. |
| `cat f1 f2` | Concatenate and display contents of text files `f1` and `f2`. |
| `less f1` | Browse or page through a contents of text file `f1`. |
| `od [-c] f1` | Octal dump (print contents of file `f1`). |
| `strings f1` | Display printable strings in file `f1`. |