

Genomics and Transcriptomics

Class 01 - Introduction to Linux



INSTRUCTOR:
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Università degli Studi di Milano

Outline of Topics

1. What is Linux?
 2. The terminal (or emulator)
 3. Files and directories
 4. Absolute and relative paths
 5. Basic command structure
 6. Users, groups and permissions
 7. Shortcuts
 8. Environmental variables
 9. Monitoring resources
 10. Networking
 11. Installing programs
-
1. Navigating in the terminal
 2. Working with files and directories



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Day 1

1. Navigating in the terminal
2. Working with files and directories



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1. Navigating in the terminal
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1. What is Linux?

A brief history of Unix

- UNICS—UNiplexed Information and Computing Service
- Developed in the 1970s
- Multiuser, multitasking computer OS

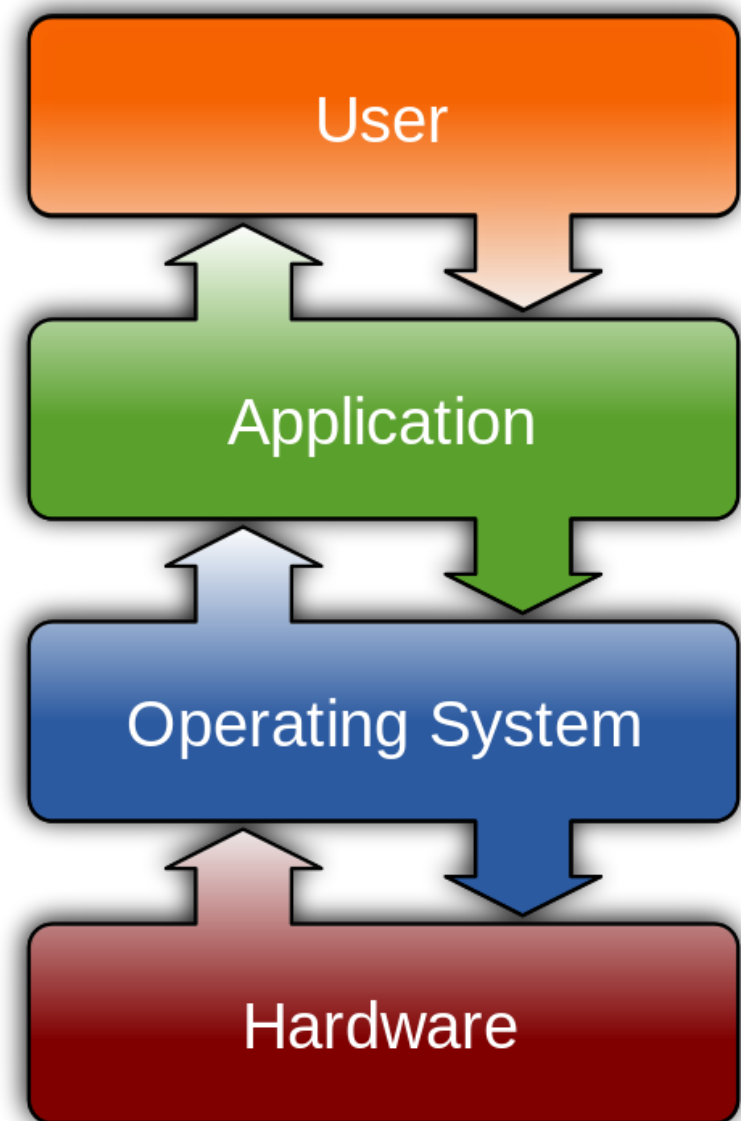


"Ken Thompson (sitting) and Dennis Ritchie at PDP-11 (2876612463)" by Peter Hamer - Licensed under CC BY-SA 2.0 via Commons - <https://commons.wikimedia.org/wiki/>

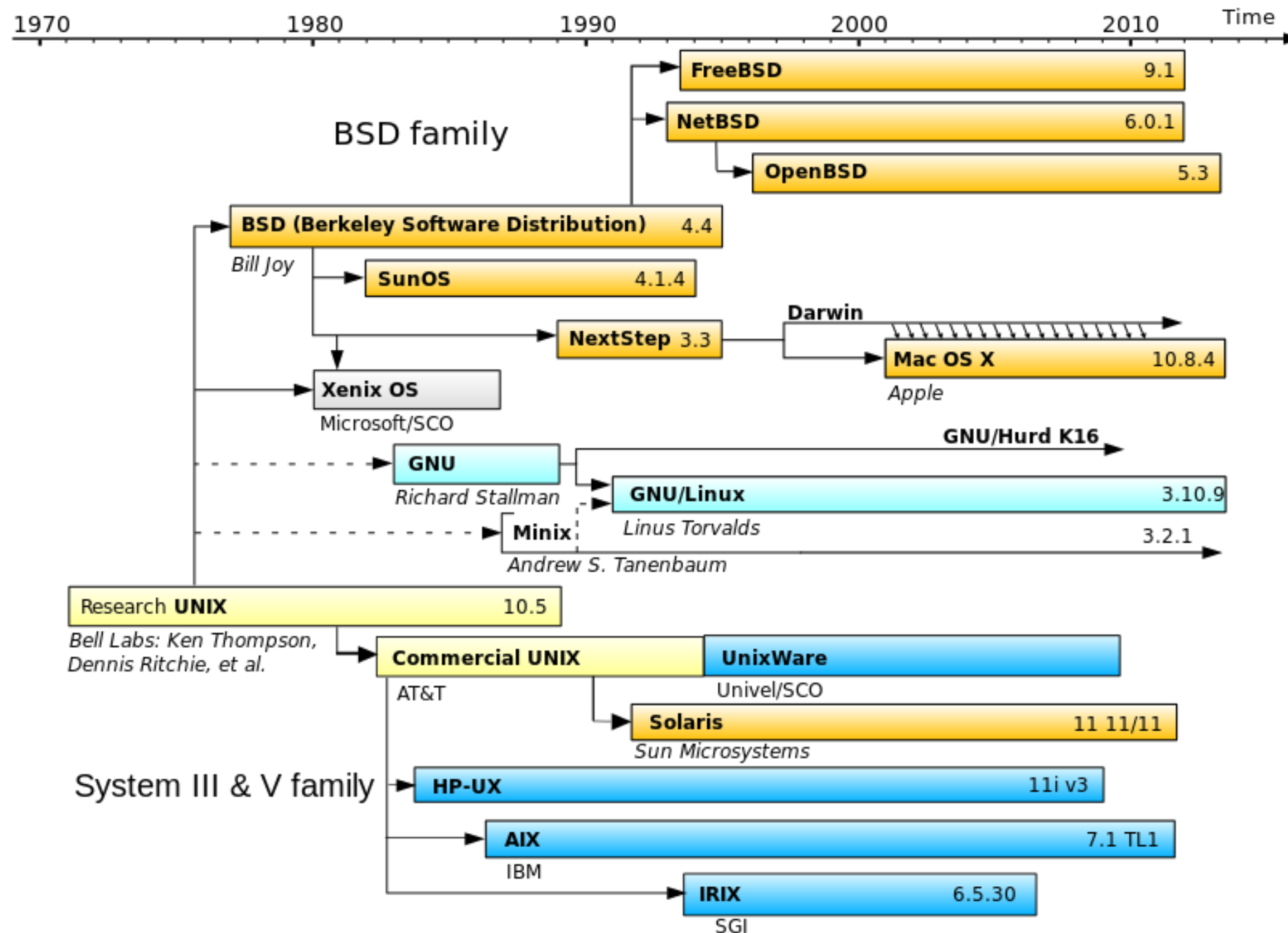
1. What is Linux?

A brief history of Unix

- Universal interaction with mainframe
- Simultaneous passing of instructions
- MULTIUSER!

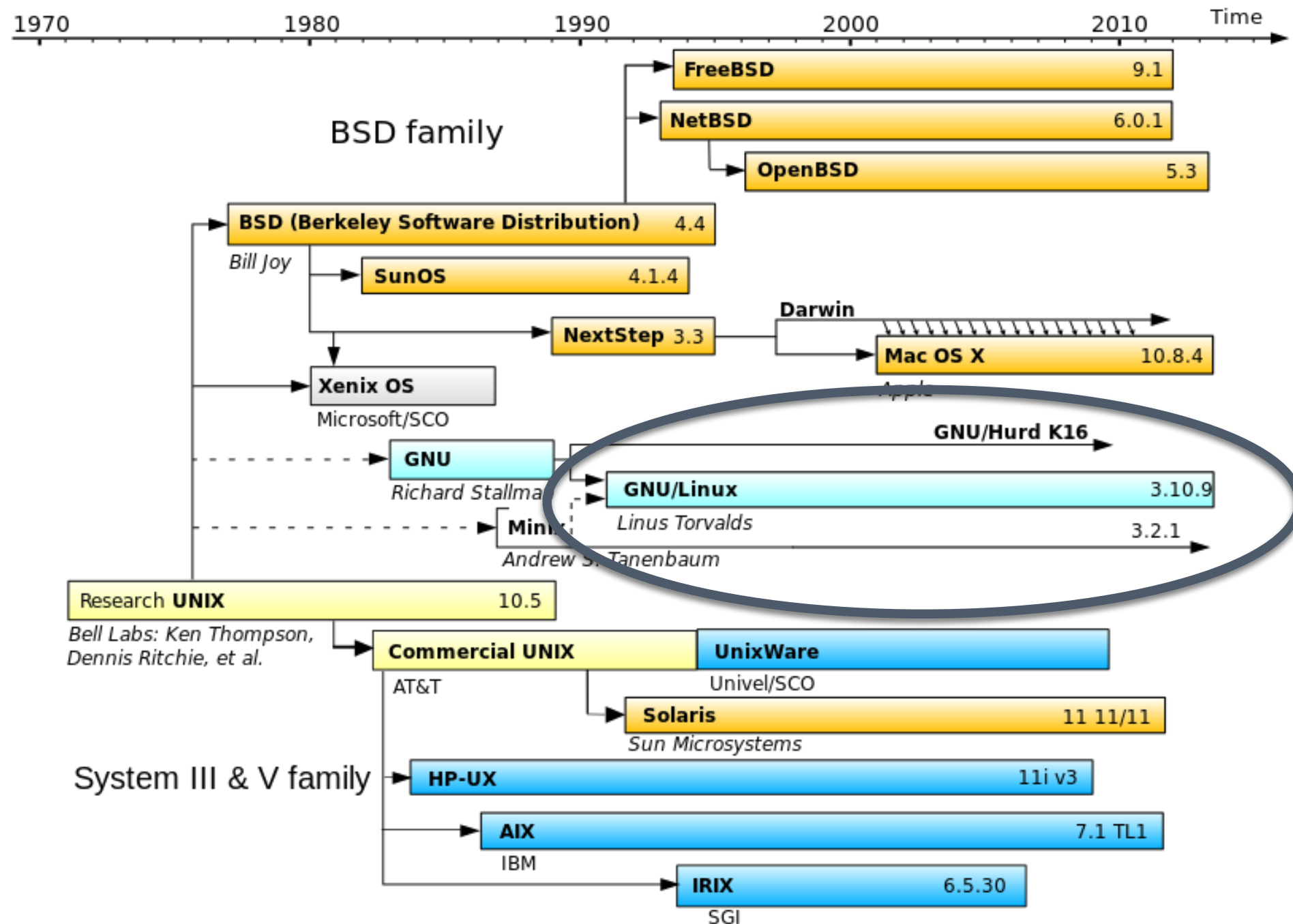


1. What is Linux?



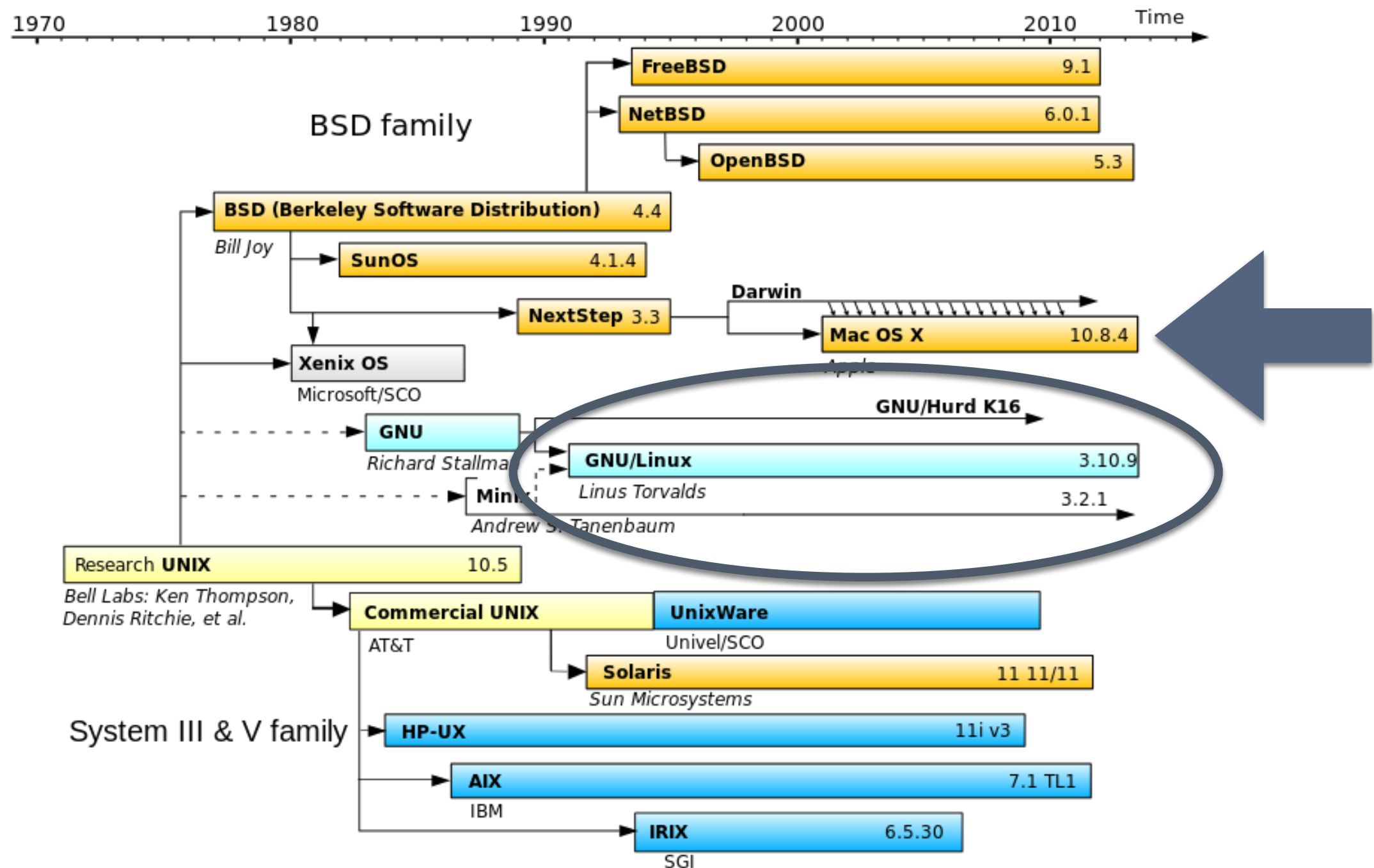
- "Unix timeline.en" by Guillem, Wereon, Hotmocha (copied from old version's history) Christoph S. (redrew the image with Inkscape) - Original image: Image:Unix.png. Licensed under Public Domain via Commons - https://commons.wikimedia.org/wiki/File:Unix_timeline.en.svg#/media/File:Unix_timeline.en.svg

1. What is Linux?



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1. What is Linux?



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1. What is Linux?

- Unix-like and POSIX compliant
- Free and open-source
- Designed for personal computers



"LinuxCon Europe Linus Torvalds 03" by Krd - Own work.
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1. What is Linux?

Linux Distribution:

Distributions (often called distros for short) are **Operating Systems** including a large **collection of software applications** such as word processors, spreadsheets, media players, and database applications.

The operating system will consist of the **Linux kernel** and, usually, a **set of libraries and utilities** from the GNU Project, with graphics support from the X Window System.

1. What is Linux?

Linux Distribution:

Different libraries and utilities.



Web Browser
installed by default



1. What is Linux?

Linux Distribution: ... more than 600 distributions



1. What is Linux?

Linux Distribution:

One can distinguish between:

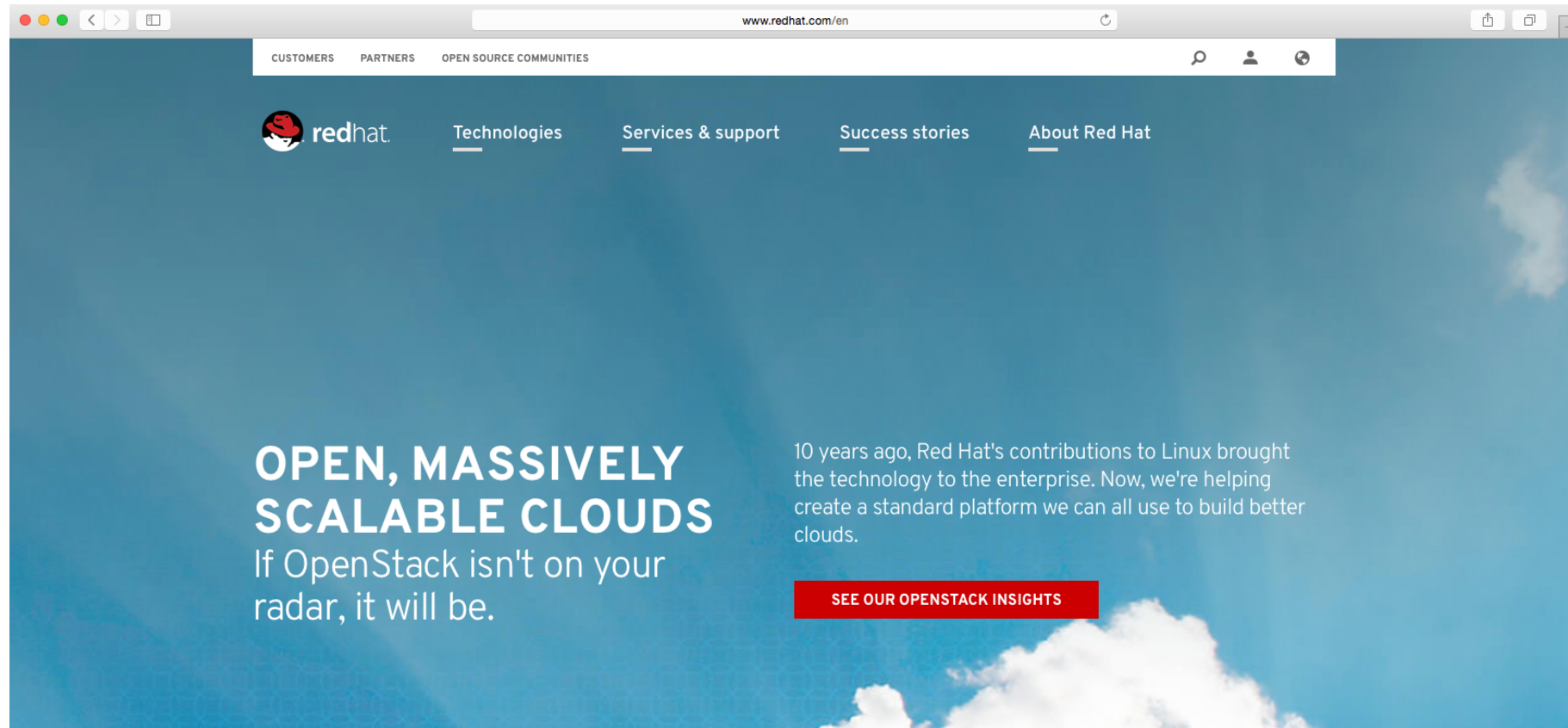
1) Commercially-backed distributions, such as:

Fedora (Red Hat),
OpenSUSE (Novell),
Ubuntu (Canonical Ltd.)
Mandriva Linux (Mandriva)

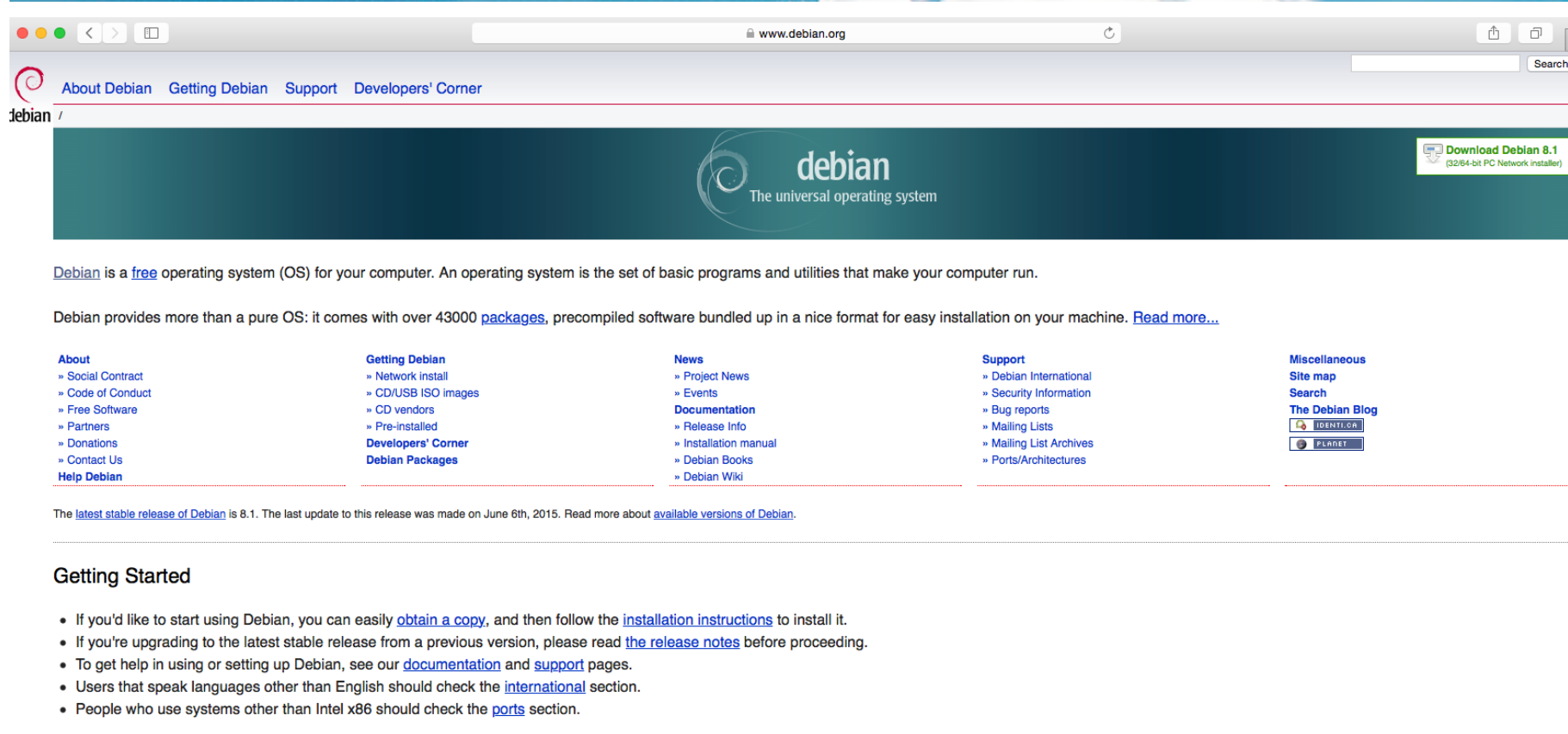
2) Entirely community-driven distributions, such as:

Debian.
Gentoo.

1. What is Linux?



The screenshot shows the Red Hat website (www.redhat.com/en) with a blue background featuring a cloud. The navigation bar includes links for CUSTOMERS, PARTNERS, OPEN SOURCE COMMUNITIES, and a search icon. The main content area has the Red Hat logo and a headline: "OPEN, MASSIVELY SCALABLE CLOUDS". Below the headline, it says "If OpenStack isn't on your radar, it will be." To the right, there is a paragraph: "10 years ago, Red Hat's contributions to Linux brought the technology to the enterprise. Now, we're helping create a standard platform we can all use to build better clouds." A red button labeled "SEE OUR OPENSTACK INSIGHTS" is positioned below the paragraph.



The screenshot shows the Debian website (www.debian.org) with a green background. The navigation bar includes links for About Debian, Getting Debian, Support, and Developers' Corner. The main content area features the Debian logo and the text "The universal operating system". A green button labeled "Download Debian 8.1 (32/64-bit PC Network installer)" is visible in the top right corner. Below the main content, there is a section titled "Getting Started" with a list of links: "If you'd like to start using Debian, you can easily [obtain a copy](#), and then follow the [installation instructions](#) to install it." "If you're upgrading to the latest stable release from a previous version, please read [the release notes](#) before proceeding." "To get help in using or setting up Debian, see our [documentation](#) and [support](#) pages." "Users that speak languages other than English should check the [international](#) section." "People who use systems other than Intel x86 should check the [ports](#) section."

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 - 2. The terminal (or emulator)**
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1. Navigating in the terminal
 2. Working with files and directories



2. The Terminal

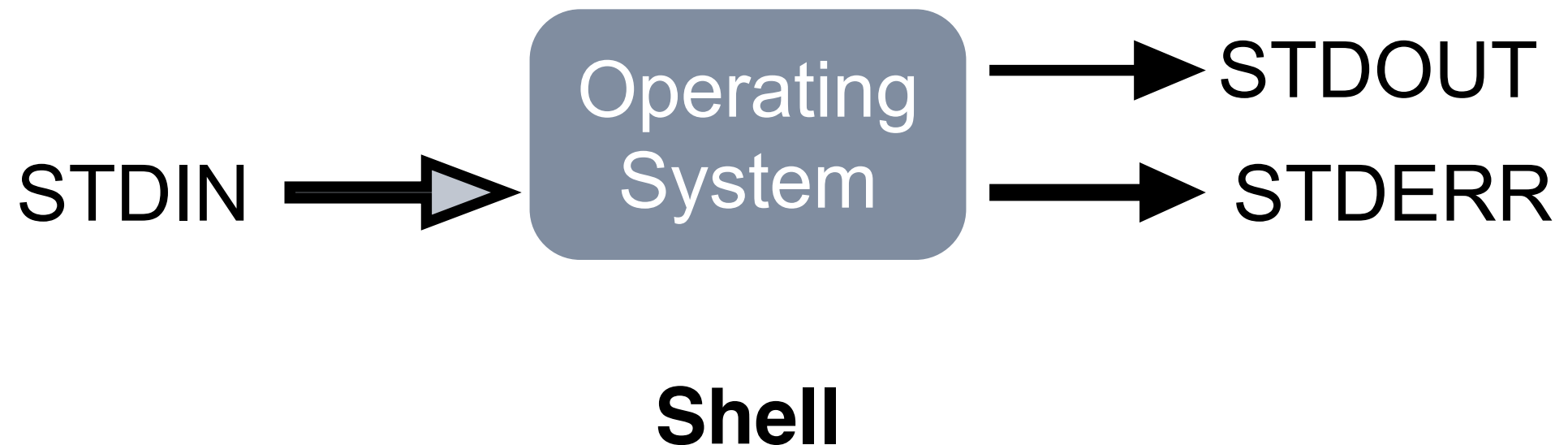
What is a console ?

Computer terminal or system consoles are the **text entry and display device** for system administration messages, particularly those from the BIOS or boot loader, the kernel, from the init system and from the system logger. It is a **physical device consisting of a keyboard and a screen.**



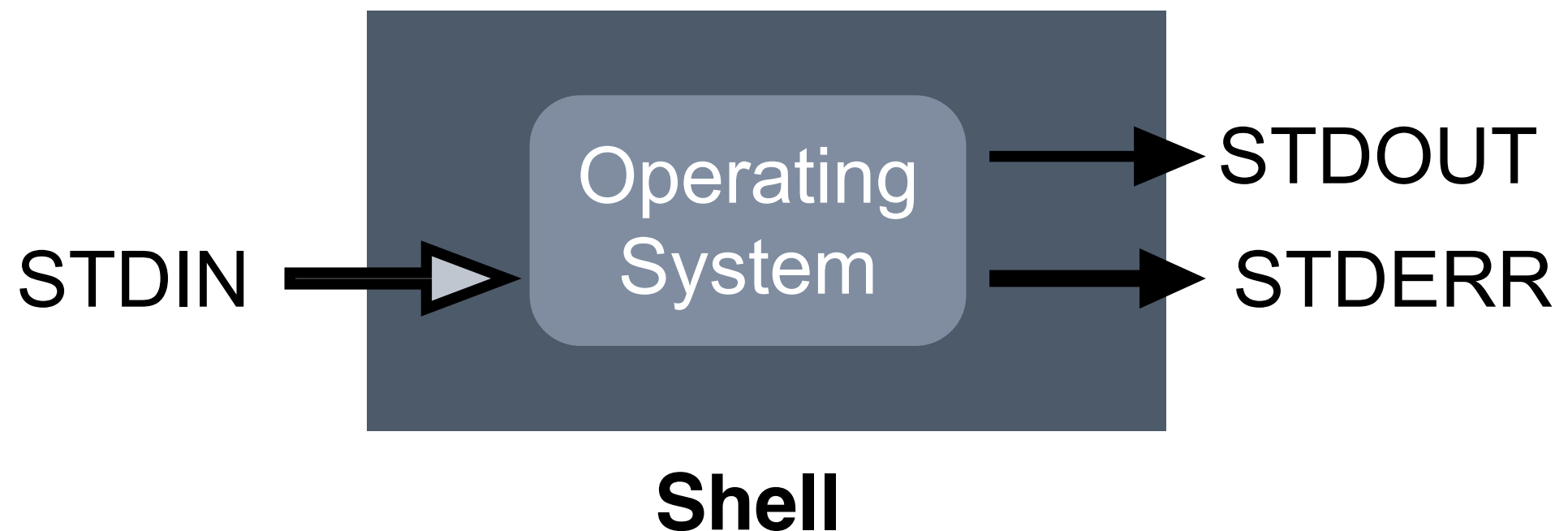
2. The Terminal

How do we interface with the operating system?



2. The Terminal

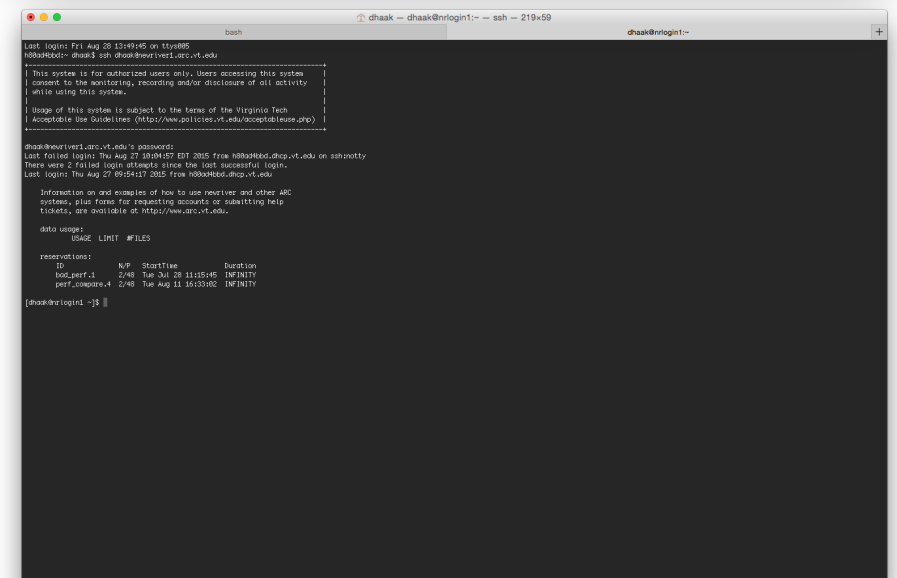
How do we interface with the operating system?



2. The Terminal

Shell: Software that provides an interface with the OS. There are two categories:

1. **Graphical User Interface (GUI):**
2. **Command-line interface (CLI):**

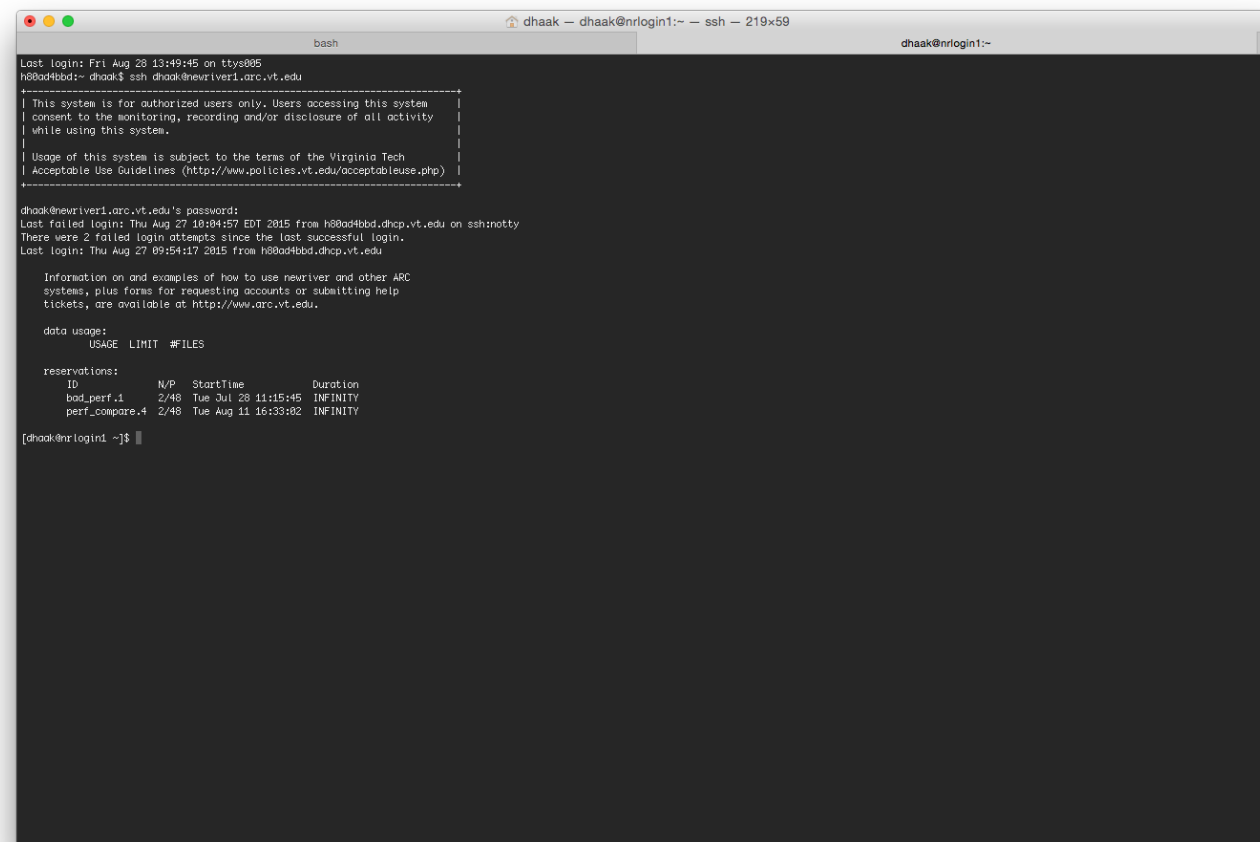


2. The Terminal

Command-line interface (CLI):

Mechanism for **interacting** with a computer operating system or software by typing **commands** to perform specific tasks.

The command-line interpreter may be run in a **text terminal** or in a **terminal emulator** window as a remote shell client such as PuTTY.



```
bash
Last login: Fri Aug 28 13:49:45 on ttys005
h00adHb0d:~ dhaak$ ssh dhaak@newriver1.arc.vt.edu
-----
| This system is for authorized users only. Users accessing this system |
| consent to the monitoring, recording and/or disclosure of all activity |
| while using this system. |
| Usage of this system is subject to the terms of the Virginia Tech |
| Acceptable Use Guidelines (http://www.policies.vt.edu/acceptableuse.php) |
-----
dhaak@newriver1.arc.vt.edu's password:
Last failed login: Thu Aug 27 18:04:57 EDT 2015 from h00adHb0d.dhcp.vt.edu on sshnotty
There were 2 failed login attempts since the last successful login.
Last login: Thu Aug 27 09:54:17 2015 from h00adHb0d.dhcp.vt.edu

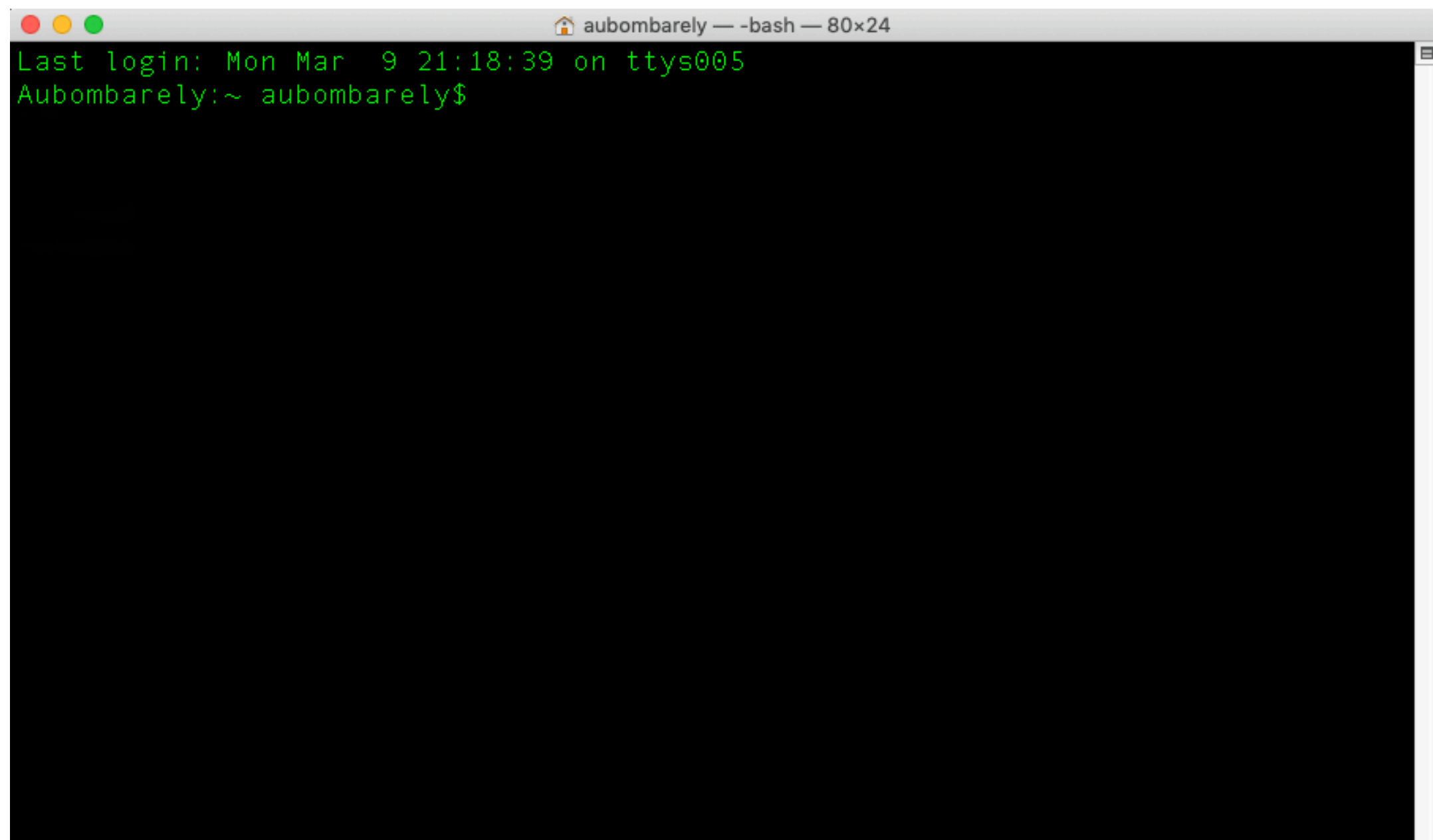
Information on and examples of how to use newriver and other ARC
systems, plus forms for requesting accounts or submitting help
tickets, are available at http://www.arc.vt.edu.

data usage:
  USAGE  LIMIT  #FILES
-----
reservations:
  ID      N/P  StartTime  Duration
  bad_perf.1  2/48  Tue Jul 28 11:15:45  INFINITY
  perf_compare.4  2/48  Tue Aug 11 16:33:02  INFINITY

[dhaak@nrlogin1 ~]$
```

2. The Terminal

Bash-Bourne again shell

A terminal window with a grey title bar containing three colored window control buttons (red, yellow, green) on the left and the text 'aubombarely — -bash — 80x24' on the right. The terminal area has a black background with green text. The first line shows the login message 'Last login: Mon Mar 9 21:18:39 on ttys005'. The second line shows the prompt 'Aubombarely:~ aubombarely\$' with a green cursor at the end.

```
aubombarely — -bash — 80x24
Last login: Mon Mar 9 21:18:39 on ttys005
Aubombarely:~ aubombarely$
```

2. The Terminal

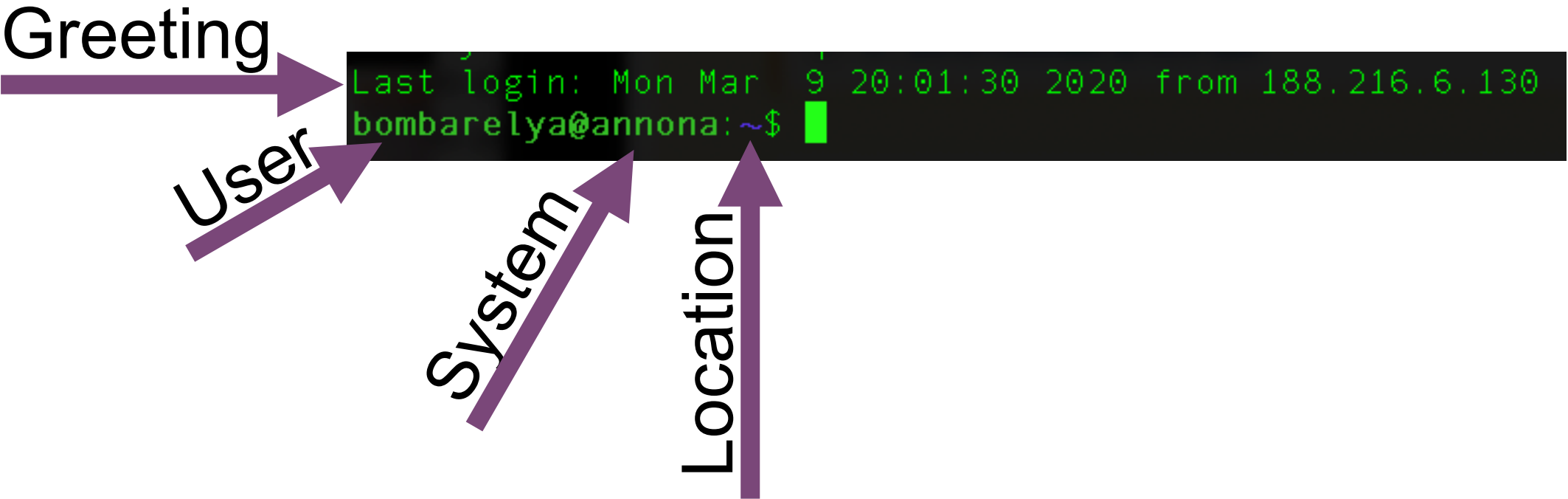
Bash-Bourne again shell

Greeting

User

System

Location



A terminal window with a black background and green text. The text shows a login message: "Last login: Mon Mar 9 20:01:30 2020 from 188.216.6.130" followed by a prompt "bombarelya@annona: ~\$". Four purple arrows point to different parts of the prompt: "Greeting" points to the login message, "User" points to "bombarelya", "System" points to "@annona", and "Location" points to "~\$".

```
Last login: Mon Mar 9 20:01:30 2020 from 188.216.6.130
bombarelya@annona: ~$
```

2. The Terminal

Bash-Bourne again shell

Check your shell type:

```
userid$ echo $SHELL
```

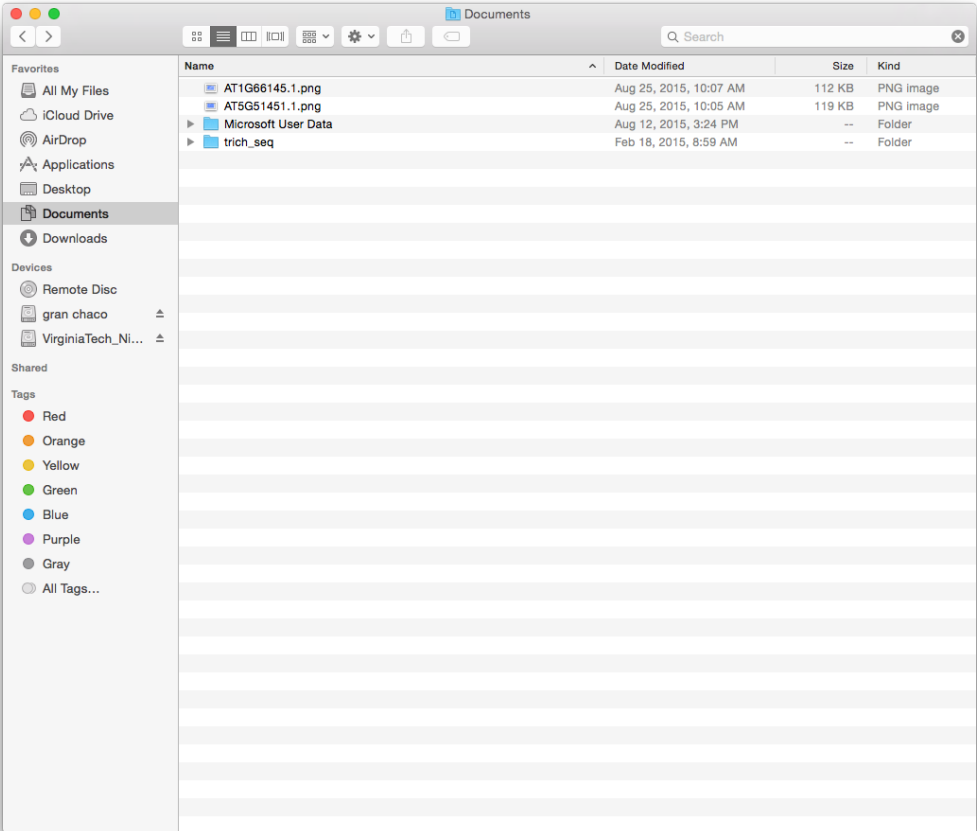
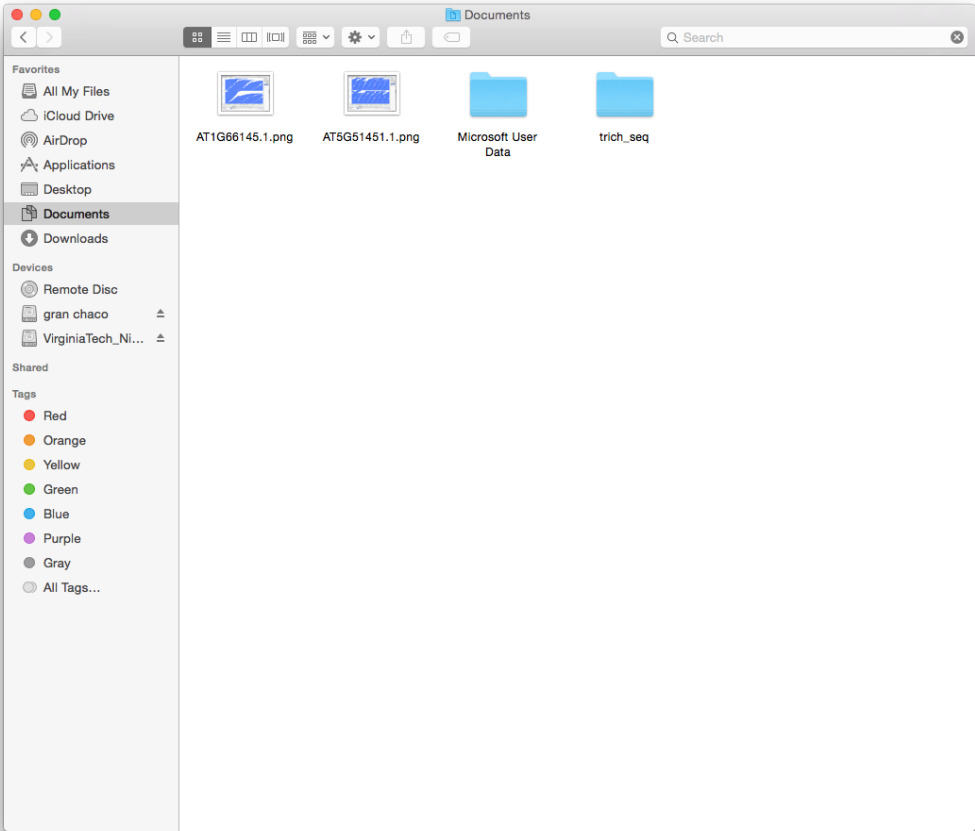
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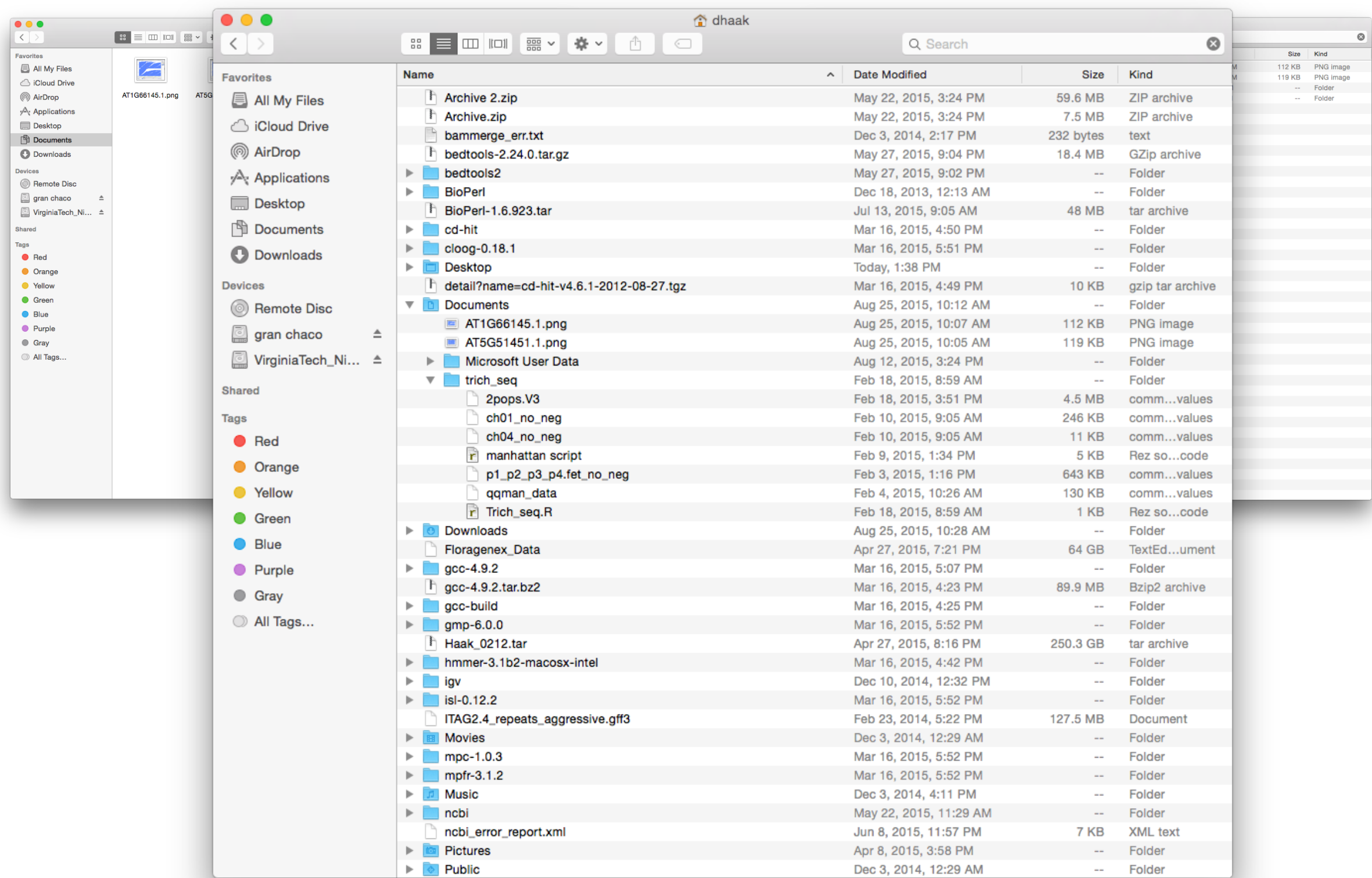
1. Navigating in the terminal
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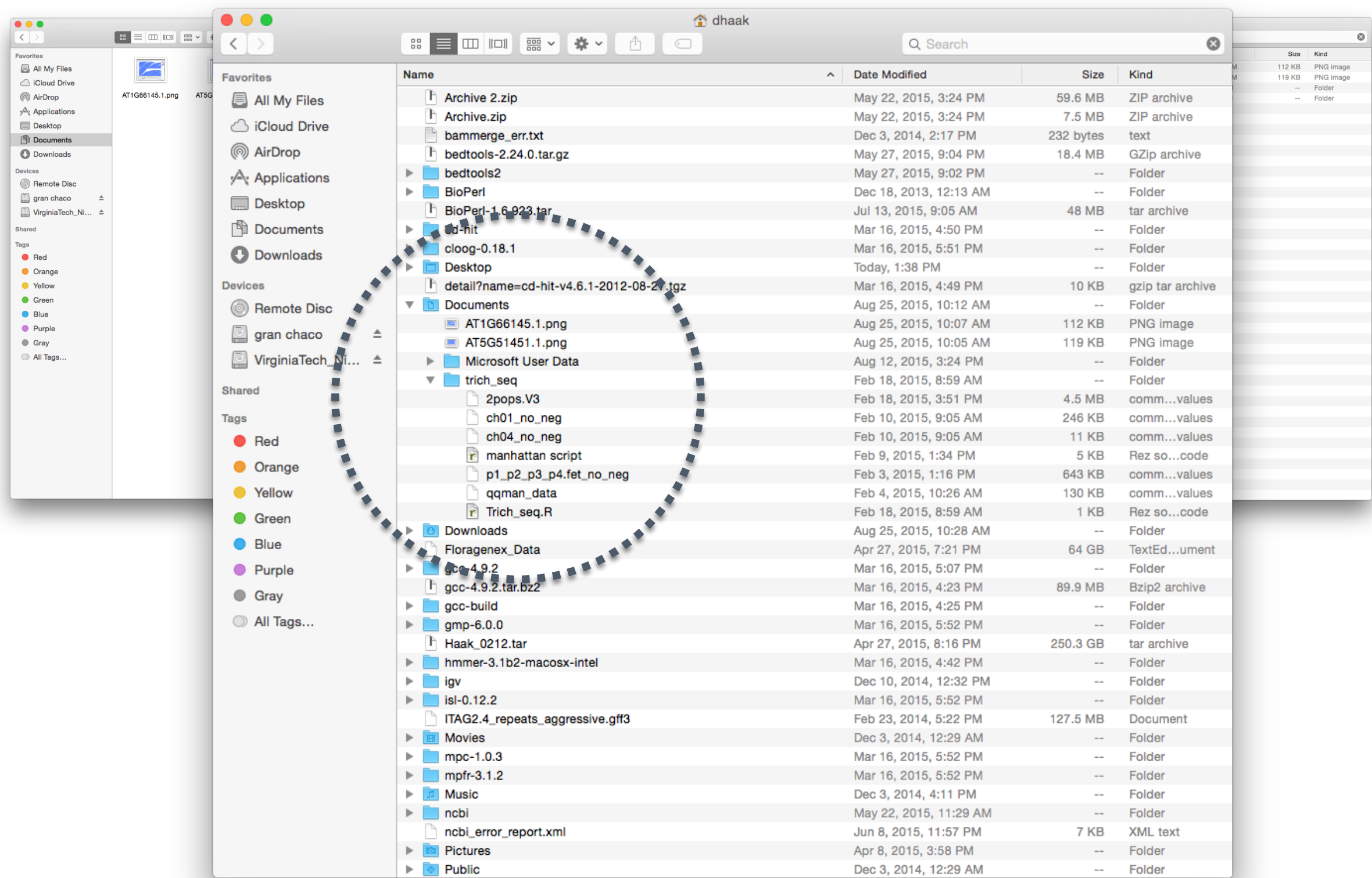
3. Files and Directories



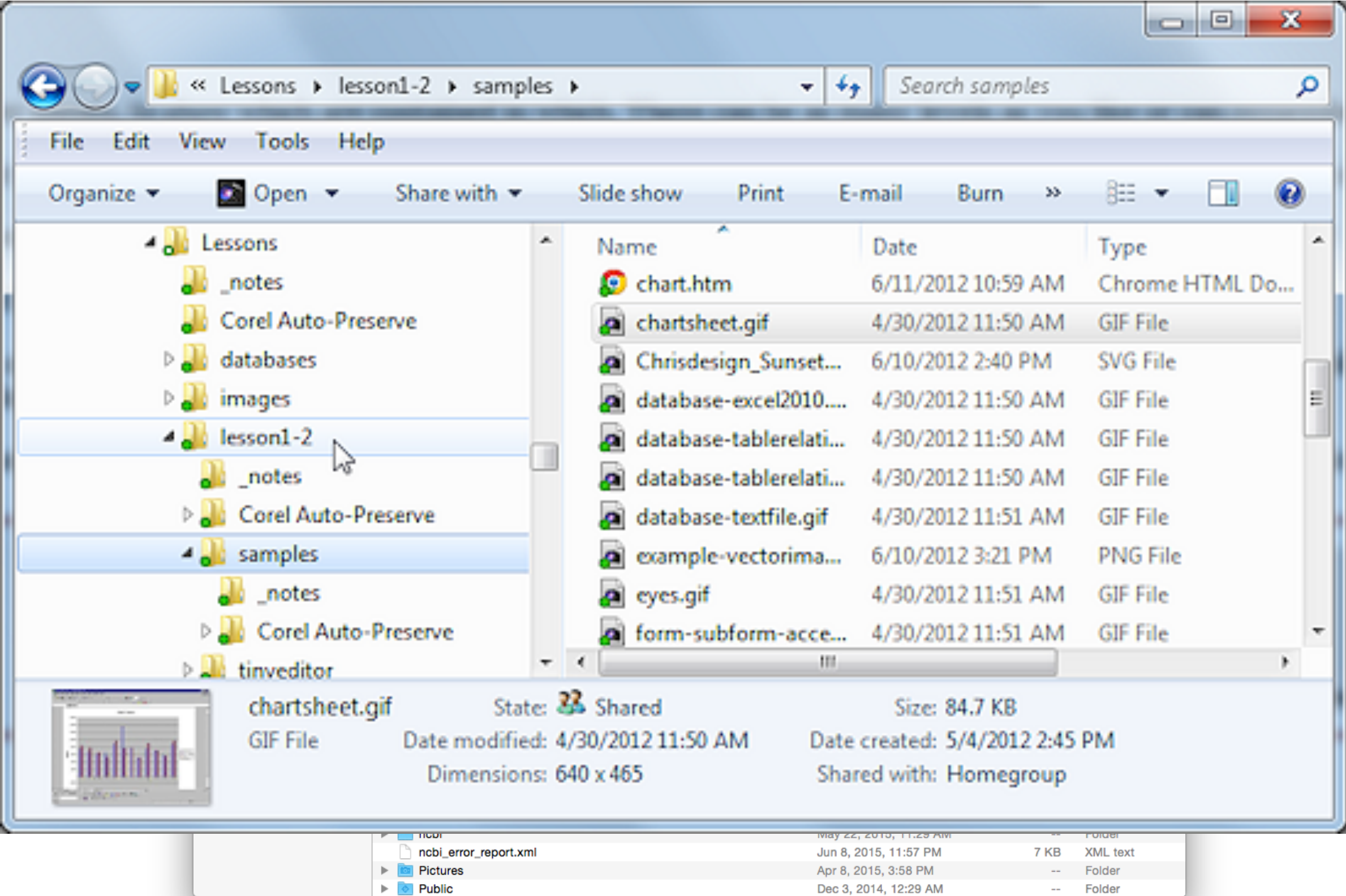
3. Files and Directories



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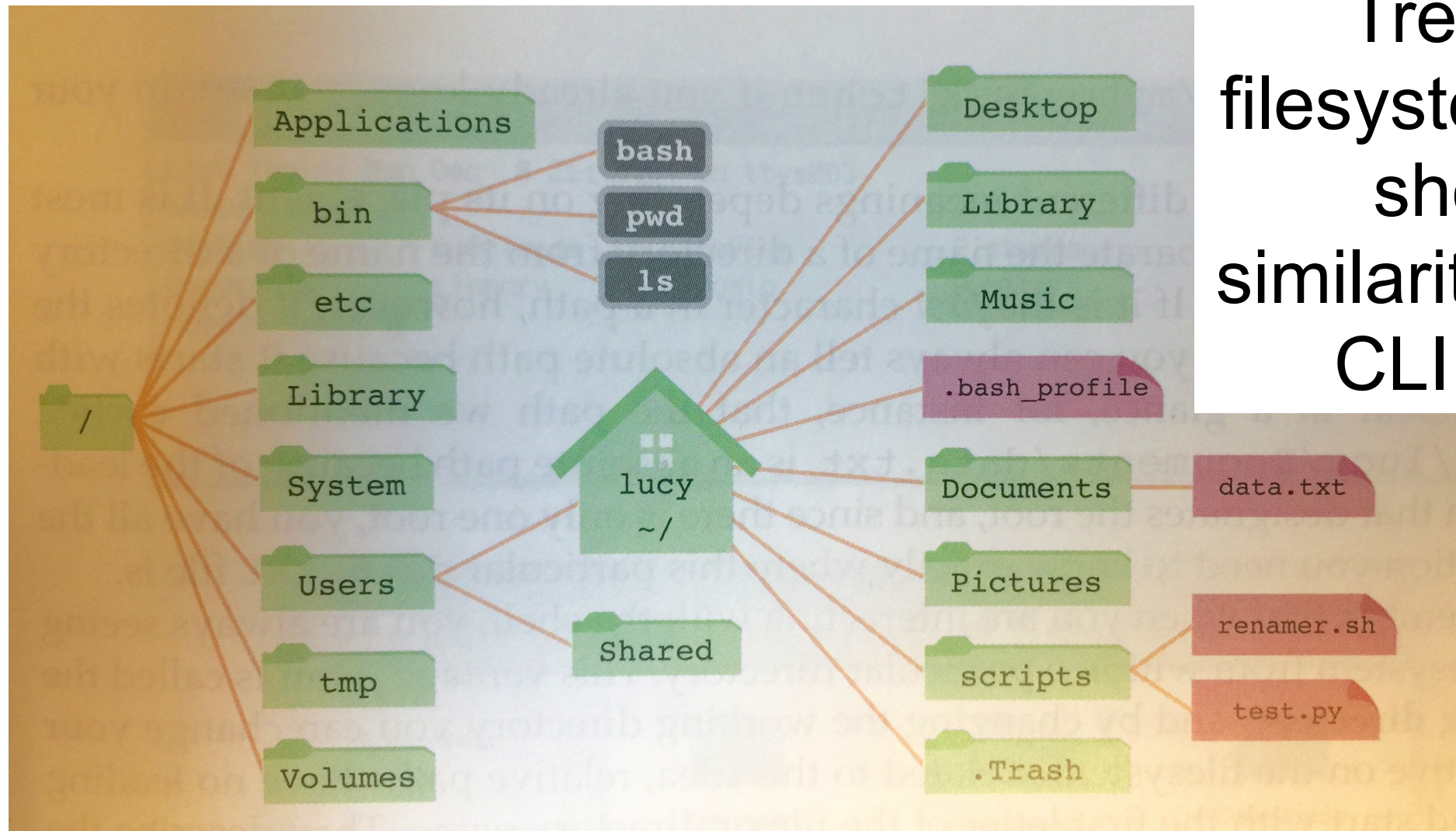
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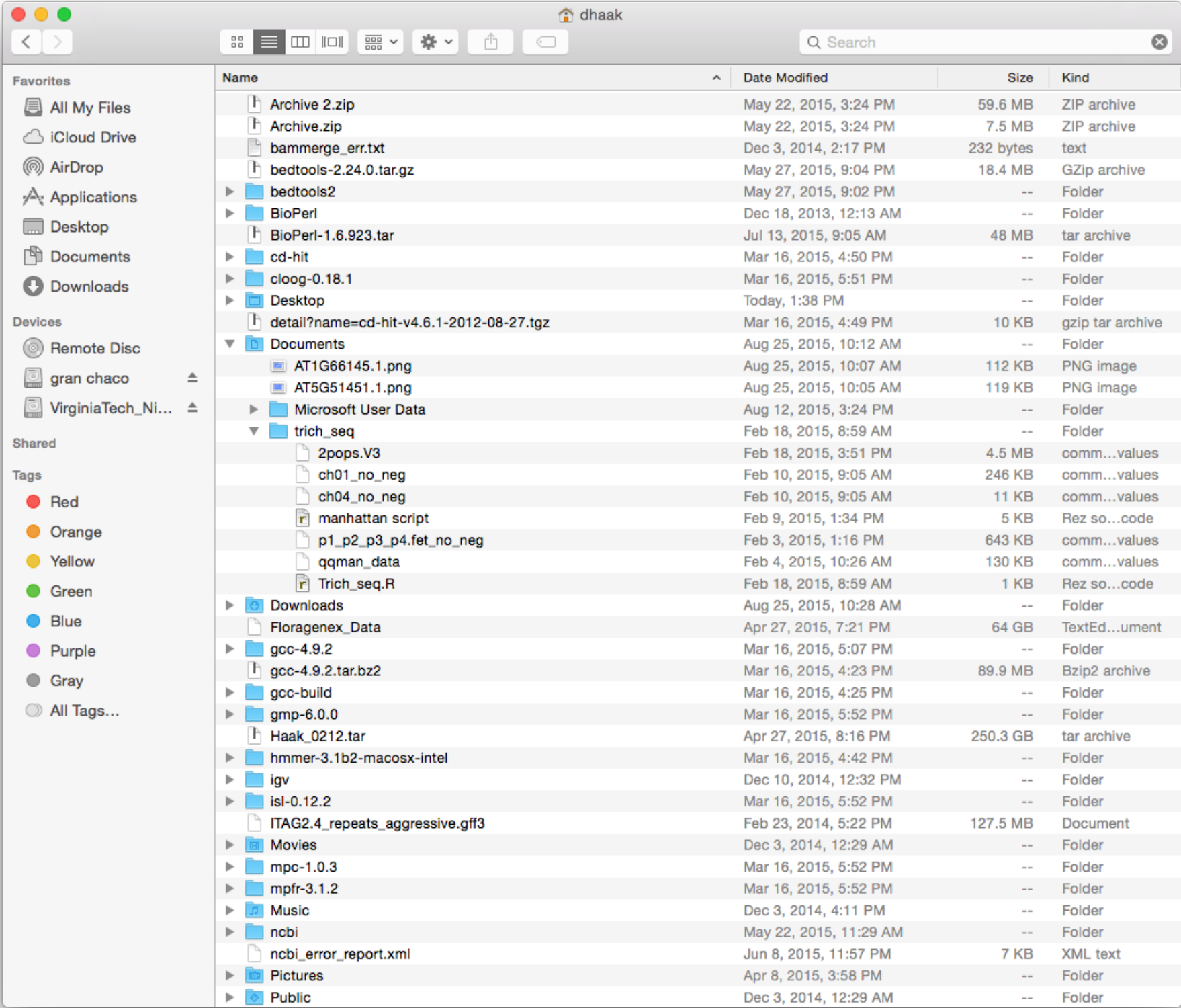
- Is file access convenient?
- What about repeated access?
- What about speed?
- Cross platform use?

3. Files and Directories



Tree format
filesystem structure
shows the
similarities between
CLI and GUI

3. Files and Directories



3. Files and Directories

Back/Forward

Path

View

Action

Group

Share

Edit Tags

Search

Favorites

AirDrop

Desktop

Applications

Recents

Documents

Google Drive

aubombarely

iCloud

iCloud Drive

Locations

Aubombarely

Macintosh HD

Remote Disc

AirPort Time...

Network

Tags

Green

Orange

Gray

Red

All Tags...

Name	Date Modified	Size	Kind
2015_SAFRON	26 Oct 2016 at 14:05	--	Folder
2015_SALAMANDERS	20 Dec 2018 at 23:12	--	Folder
2015_SWITCHGRASS	7 Oct 2016 at 17:50	--	Folder
2015_TOBACCO_PY	8 Jul 2015 at 05:27	--	Folder
2015_TOBACCO_SHENGMING	10 Oct 2017 at 16:42	--	Folder
2016_AFRICANVIOLET	7 Apr 2016 at 05:06	--	Folder
2016_ATHA_HDA19MUT	16 Aug 2016 at 15:46	--	Folder
2016_AVOCADO_GBS	27 Nov 2018 at 22:42	--	Folder
2016_BCUCULLATA_INVASIVE	11 May 2016 at 0	--	Folder
2016_BEGONIA_DOMESTICATION	19 Mar 2016 at 0	--	Folder
2016_FLOWEREVODEVO	3 Mar 2016 at 20	--	Folder
2016_GENOMARCHDB	16 Sep 2016 at 2	--	Folder
2016_MEDICAGO_GOMEZK	19 Aug 2019 at 2	--	Folder
2016_NZZ_UNIMI	5 Oct 2016 at 17	--	Folder
2016_OLIVEGBS	9 Dec 2019 at 18	--	Folder
2016_PETUNIA_HYBRIDA	22 Jan 2018 at 2	--	Folder
2016_RBRBINDINGDOM	14 Oct 2016 at 1	--	Folder
2016_SEQCAPTURE	12 Oct 2016 at 0	--	Folder
2016_SNAPDRAGON_ERAMOSA	20 Nov 2016 at 2	--	Folder
2016_SOLANACEAE_GENOMEARCH	10 Jun 2016 at 1	--	Folder
2016_THYMUS_EXPLOREGENOME	31 Aug 2018 at 1	--	Folder
2017_ALTERNATIVE_GBS	14 Nov 2018 at 1	--	Folder
2017_AVOCADO_GENOME	16 Apr 2019 at 2	--	Folder
2017_BENTHAMIANA_KVITKO	3 Apr 2018 at 18	--	Folder
2017_CHERIMOYA_GENOME	12 Feb 2020 at 2	--	Folder
2017_GUAVA_GENOME	16 Jul 2019 at 11	--	Folder
2017_PAWPAW_GENOME	29 Jan 2020 at 1	--	Folder
2017_PCINAMOMI_MANOSALVA	19 May 2018 at 1	--	Folder
2017_PETUNIA_DOMESTICATION	2 Mar 2020 at 10	--	Folder
2017_SINAPIS_MANZANEDA	4 Feb 2019 at 14	--	Folder
2017_SUAVEOLENTES	3 Mar 2020 at 22	--	Folder
2017_SWITCHGRASS_4x8x_LINKAI	19 May 2017 at 1	--	Folder
2017_WILD_PETUNIAS_FREITAS	6 Dec 2018 at 19	--	Folder
2017_WILD_SINNINGIAS_ROSSINI	14 Jun 2017 at 2	--	Folder
2018_AVOCADO_PLIEGO	13 Jan 2020 at 0	--	Folder
2018_MONOPTEROS	27 Apr 2019 at 0	--	Folder
2018_VANILLA	19 May 2018 at 1	--	Folder
2019_EGGPLANT_RESEQ	12 May 2019 at 1	--	Folder
2019_MANGO_GENOME	1 Mar 2020 at 20	--	Folder
2019_MIRACLE_FRUIT	6 Aug 2019 at 12	--	Folder
2019_OLIVE_KOUBOURIS	5 Feb 2020 at 18	--	Folder
2019_PEAR_MASIERO	5 Jul 2019 at 10:	--	Folder
2019_TOMATO_BENVENUTTO	15 Jul 2019 at 17	--	Folder

Macintosh HD > Users > aubombarely > Documents > USA_work > PROJECTS

78 items, 55.04 GB available

PROJECTS — -bash — 84x39

drwxr-xr-x	8	aubombarely	staff	256B	Apr	7	2016	2016_AFRICANVIOLET
drwxr-xr-x	4	aubombarely	staff	128B	Aug	16	2016	2016_ATHA_HDA19MUT
drwxr-xr-x	6	aubombarely	staff	192B	Nov	27	2018	2016_AVOCADO_GBS
drwxr-xr-x	14	aubombarely	staff	448B	May	11	2016	2016_BCUCULLATA_INVASIVE
drwxr-xr-x	4	aubombarely	staff	128B	Mar	19	2016	2016_BEGONIA_DOMESTICATION
drwxr-xr-x	10	aubombarely	staff	320B	Mar	3	2016	2016_FLOWEREVODEVO
drwxr-xr-x	4	aubombarely	staff	128B	Sep	16	2016	2016_GENOMARCHDB
drwxr-xr-x	10	aubombarely	staff	320B	Aug	19	2019	2016_MEDICAGO_GOMEZK
drwxr-xr-x	29	aubombarely	staff	928B	Oct	5	2016	2016_NZZ_UNIMI
drwxr-xr-x	23	aubombarely	staff	736B	Dec	9	18:11	2016_OLIVEGBS
drwxr-xr-x	8	aubombarely	staff	256B	Jan	22	2018	2016_PETUNIA_HYBRIDA
drwxr-xr-x	22	aubombarely	staff	704B	Oct	14	2016	2016_RBRBINDINGDOM
drwxr-xr-x	3	aubombarely	staff	96B	Oct	12	2016	2016_SEQCAPTURE
drwxr-xr-x	27	aubombarely	staff	864B	Nov	20	2016	2016_SNAPDRAGON_ERAMOSA
drwxr-xr-x	33	aubombarely	staff	1.0K	Jun	10	2016	2016_SOLANACEAE_GENOMEARCH
drwxr-xr-x	7	aubombarely	staff	224B	Aug	31	2018	2016_THYMUS_EXPLOREGENOME
drwxr-xr-x	6	aubombarely	staff	192B	Nov	14	2018	2017_ALTERNATIVE_GBS
drwxr-xr-x	13	aubombarely	staff	416B	Apr	16	2019	2017_AVOCADO_GENOME
drwxr-xr-x	37	aubombarely	staff	1.2K	Apr	3	2018	2017_BENTHAMIANA_KVITKO
drwxr-xr-x	9	aubombarely	staff	288B	Feb	12	21:47	2017_CHERIMOYA_GENOME
drwxr-xr-x	16	aubombarely	staff	512B	Jul	16	2019	2017_GUAVA_GENOME
drwxr-xr-x	17	aubombarely	staff	544B	Jan	29	10:00	2017_PAWPAW_GENOME
drwxr-xr-x	8	aubombarely	staff	256B	May	19	2018	2017_PCINAMOMI_MANOSALVA
drwxr-xr-x	15	aubombarely	staff	480B	Mar	2	10:04	2017_PETUNIA_DOMESTICATION
drwxr-xr-x	13	aubombarely	staff	416B	Feb	4	2019	2017_SINAPIS_MANZANEDA
drwxr-xr-x	16	aubombarely	staff	512B	Mar	3	22:41	2017_SUAVEOLENTES
drwxr-xr-x	9	aubombarely	staff	288B	May	19	2017	2017_SWITCHGRASS_4x8x_LINKAI
drwxr-xr-x	17	aubombarely	staff	544B	Dec	6	2018	2017_WILD_PETUNIAS_FREITAS
drwxr-xr-x	3	aubombarely	staff	96B	Jun	14	2017	2017_WILD_SINNINGIAS_ROSSINI
drwxr-xr-x	5	aubombarely	staff	160B	Jan	13	09:34	2018_AVOCADO_PLIEGO
drwxr-xr-x	23	aubombarely	staff	736B	Apr	27	2019	2018_MONOPTEROS
drwxr-xr-x	6	aubombarely	staff	192B	May	19	2018	2018_VANILLA
drwxr-xr-x	69	aubombarely	staff	2.2K	May	12	2019	2019_EGGPLANT_RESEQ
drwxr-xr-x	9	aubombarely	staff	288B	Mar	1	20:05	2019_MANGO_GENOME
drwxr-xr-x	4	aubombarely	staff	128B	Aug	6	2019	2019_MIRACLE_FRUIT
drwxr-xr-x	23	aubombarely	staff	736B	Feb	5	18:46	2019_OLIVE_KOUBOURIS
drwxr-xr-x	11	aubombarely	staff	352B	Jul	5	2019	2019_PEAR_MASIERO
drwxr-xr-x	27	aubombarely	staff	864B	Jul	15	2019	2019_TOMATO_BENVENUTTO

3. Files and Directories

Home versus root

```
bombarelya@annona:~$ ls -lh
total 24K
drwxrwxr-x 3 bombarelya bombarelya 4.0K Jan  9 17:09 Avocado
drwxrwxr-x 3 bombarelya bombarelya 4.0K Feb 11 21:37 Cherimola
drwxrwxr-x 3 bombarelya bombarelya 4.0K Nov  6 12:51 Mango
drwxrwxr-x 5 bombarelya bombarelya 4.0K Jan 17 16:12 perl5
drwxrwxr-x 3 bombarelya bombarelya 4.0K Feb 28 15:09 R
drwxrwxr-x 6 bombarelya bombarelya 4.0K Feb 19 10:58 Suaveolentes
```

Home directory
~/bombarelya
/data/bombarelya

```
bombarelya@annona:/$ ls -lh
total 8.1G
drwxr-xr-x  2 root root 4.0K Sep 20 14:55 altos
drwxr-xr-x  2 root root 4.0K Feb 11 09:23 bin
drwxr-xr-x  4 root root 4.0K Feb 20 06:40 boot
drwxr-xr-x  2 root root 4.0K Sep 20 14:23 cdrom
drwxr-xr-x 19 root root 4.0K Mar  9 09:30 data
drwxr-xr-x 20 root root 4.1K Feb 16 09:16 dev
drwxr-xr-x 116 root root 4.0K Mar  9 20:23 etc
drwxr-xr-x  3 root root 4.0K Sep 20 14:32 home
lrwxrwxrwx  1 root root   33 Feb 19 06:49 initrd.img -> boot/initrd.img-4.15.0-88-generic
lrwxrwxrwx  1 root root   33 Feb 19 06:49 initrd.img.old -> boot/initrd.img-4.15.0-76-generic
drwxr-xr-x 22 root root 4.0K Nov  6 12:57 lib
drwxr-xr-x  2 root root 4.0K Aug  5 2019 lib64
drwx----- 2 root root 16K Sep 20 14:23 lost+found
drwxr-xr-x  2 root root 4.0K Aug  5 2019 media
drwxr-xr-x  2 root root 4.0K Aug  5 2019 mnt
drwxr-xr-x  2 root root 4.0K Aug  5 2019 opt
dr-xr-xr-x 702 root root   0 Feb 16 09:14 proc
drwx----- 4 root root 4.0K Feb 11 08:18 root
drwxr-xr-x 26 root root 980 Mar  9 20:27 run
drwxr-xr-x  2 root root 12K Feb 11 09:23 sbin
drwxr-xr-x  4 root root 4.0K Sep 20 14:32 snap
drwxr-xr-x  2 root root 4.0K Aug  5 2019 srv
-rw-----  1 root root 8.0G Sep 20 14:24 swap.img
dr-xr-xr-x 13 root root   0 Feb 16 09:14 sys
drwxrwxrwt 16 root root 4.0K Mar  9 20:22 tmp
drwxr-xr-x 10 root root 4.0K Aug  5 2019 usr
drwxr-xr-x 13 root root 4.0K Aug  5 2019 var
lrwxrwxrwx  1 root root   30 Feb 19 06:49 vmlinuz -> boot/vmlinuz-4.15.0-88-generic
lrwxrwxrwx  1 root root   30 Feb 19 06:49 vmlinuz.old -> boot/vmlinuz-4.15.0-76-generic
```

Root directory
/bin, /sbin, /dev
/data, /home

3. Files and Directories

Home versus root



```
bombarelya@annona: ~$
```

Home directory
~/bombarelya
/data/bombarelya



```
bombarelya@annona: /$
```

Root directory
/bin, /sbin, /dev
/data, /home

Outline of Topics

1. What is Linux?
2. The terminal (or emulator)
3. Files and directories
- 4. Absolute and relative paths**
5. Basic command structure
6. Users, groups and permissions
7. Shortcuts
8. Environmental variables
9. Monitoring resources
10. Networking
11. Installing programs

1. Navigating in the terminal
2. Working with files and directories



4. Absolute and Relative Paths

ABSOLUTE PATH: Location of a file **from root (/)**



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RELATIVE PATH: Location of a file **from working dir**



Room 311

4. Absolute and Relative Paths

Relative filepath depends of the working directory

```
bombarelya@annona:~/Avocado$ ls RNASeq_PliegoC/
```

Absolute filepath starts at root

```
[bombarelya@annona:~/Avocado$ ls /data/bombarelya/Avocado/RNASeq_PliegoC/
```



4. Absolute and Relative Paths

Find the present working directory

```
pwd
```

Change the working directory

```
cd <directory>
```

Goes to the root

```
cd /
```

/home/user

```
cd ~
```

up one dir

```
cd ..
```

What does this do?

```
cd
```

4. Absolute and Relative Paths

Create a directory

```
mkdir dirname
```

Create an empty file

```
touch filename
```

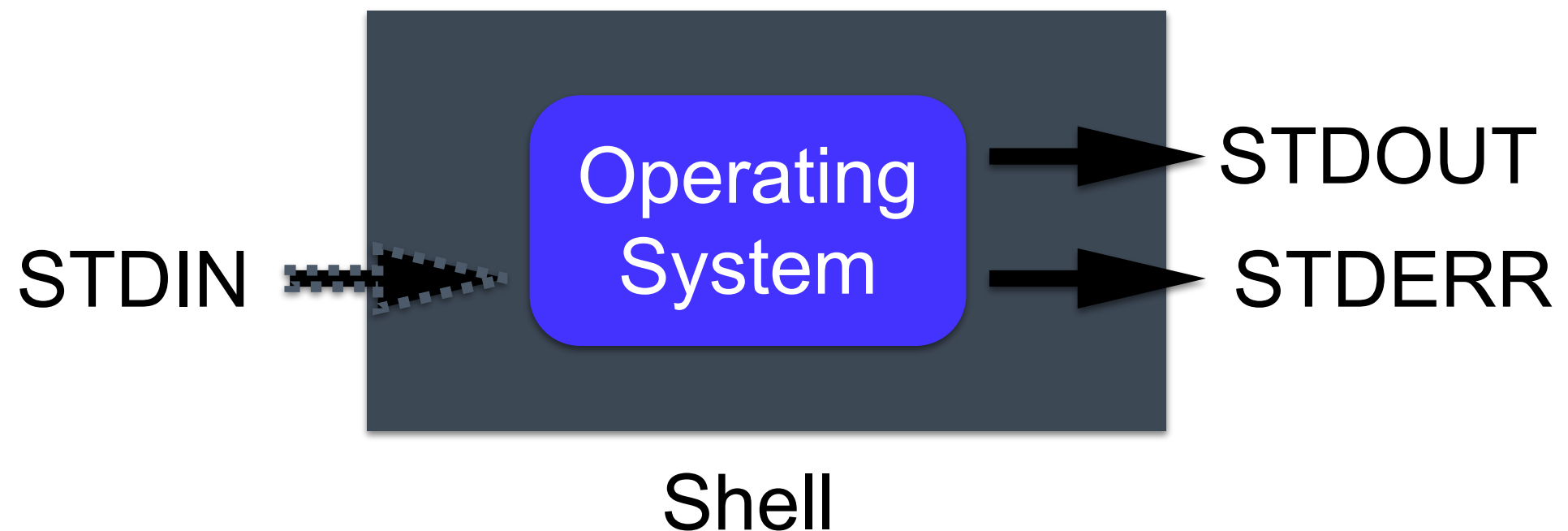
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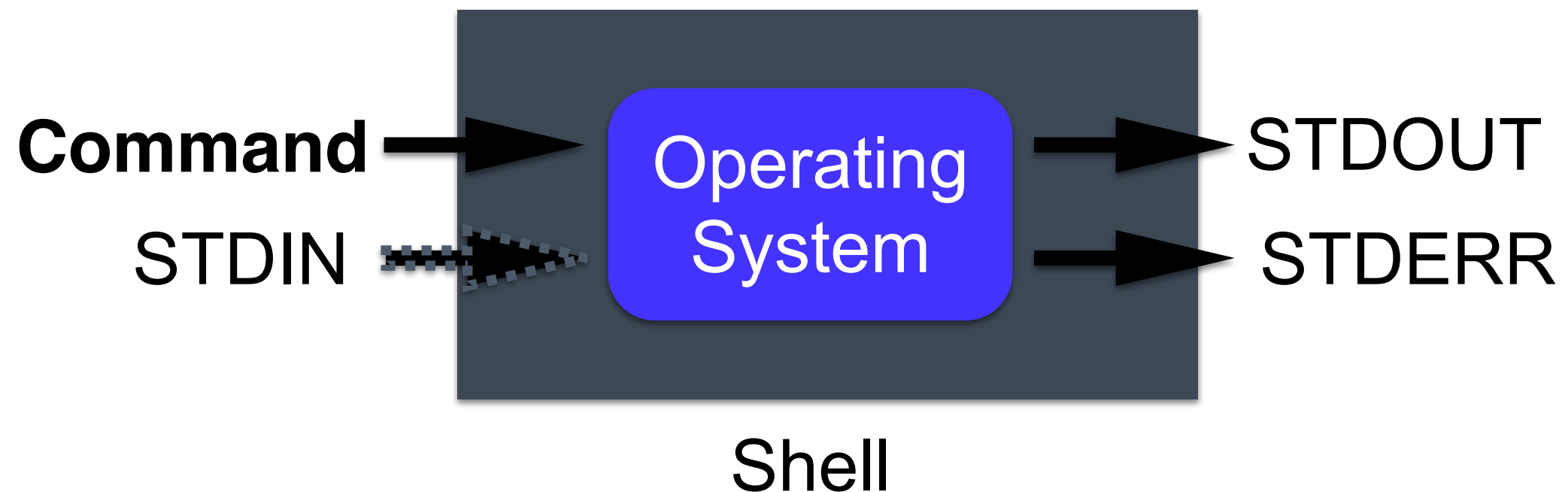
5. Basic Command Structure

How do we interface with the operating system?



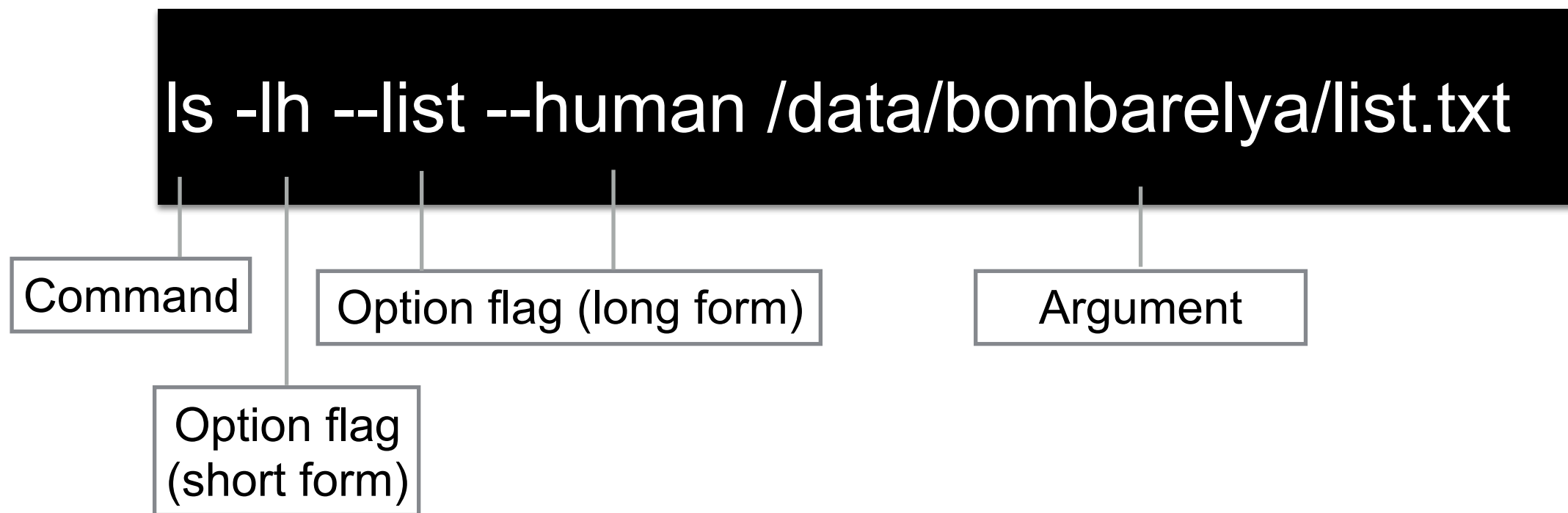
5. Basic Command Structure

How do we interface with the operating system?



5. Basic Command Structure

Anatomy of a UNIX command



5. Basic Command Structure

Exercise 1

The behavior of a command can be modified using **options** such as `-l` or `-a`.

1. Create a directory with the name
“exercise01”
2. Change the working directory to
“exercise01”
3. Create an empty file with the name
“test01.txt”.
4. Create another empty file with the name
“”test02.txt

5. Basic Command Structure

Exercise 1

5. Run **ls**, without options (1), with **-lh** (2), with **-l -h** (3) and with **-lha** (4).

What are the differences in the output?

5. Basic Command Structure

Special characters in bash:

Character	Meaning
SPACE	Separate commands and arguments
# HASH	Comment
; SEMICOLON	Command separator to run multiple commands
. DOT	Source command OR filename component OR current directory
.. DOUBLE DOTS	Parent directory
' SINGLE QUOTES	Use expression between quotes
, COMMA	Concatenate strings
\ BACKSLASH	Escape for single character
/ SLASH	Filename path separator
* ASTERISK	Wildcard for filename expansion
>, <, >> CHARACTERS	Redirection input/outputs
PIPE	Pipe outputs between commands
! BANG	Run a command

5. Basic Command Structure

Special characters in bash:

```
ls Solanum lycopersicum
```

Bash interprets spaces as separators

```
ls 'Solanum lycopersicum'  
ls Solanum\lycopersicum
```

Use single quotes or escape '\ ' for special characters

5. Basic Command Structure

Special characters in bash:

The wildcard '*' is your friend

```
ls ~/*txt
```

Lists all text files in your directory

```
ls ~/D*p
```

Lists files/directories in your home folder that start with D and end with p

Note: With great power comes great responsibility

5. Basic Command Structure

Getting more information for a command:

```
man <command>
```

```
man ls
```

note: use “q” to exit the interface.

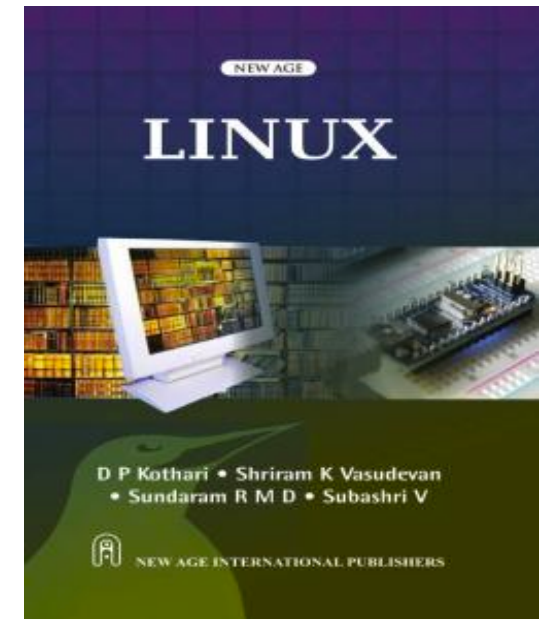
5. Basic Command Structure

Tracing your steps:

```
$ history
```

Recommended Reading

- Author: Shriram, K V
- Book: Linux
- Publisher: New Age International
- ISBN: 81-224-3438-X, 978-81-224-3438-5
- Date:12/01/2014
- Free ebook from lib.vt.edu
- Chapter 1, 2, 3



Recommended Reading

- Author: Shotts, William E
- Book: The Linux command line : a complete
- Publisher: No Starch Press
- ISBN: 1-59327-389-4, 978-1-59327-389-7
- Date: 2011
- Free ebook from lib.vt.edu
- Section 1.1, 1.2, 1.3, 1.4, 1.9

