[301] Program I/O

Tyler Caraza-Harter

Learning Objectives

Understand role of operating system in I/O

Use storage

- How do storage drives appear in Windows/UNIX?
- How are files named?

Work from the command line

- What is a terminal emulator?
- What is a shell?

PowerShell and bash

- How to navigate
- Run programs
- Redirect/pipe output
- Save scripts

Today's Topics

Program Input/Output

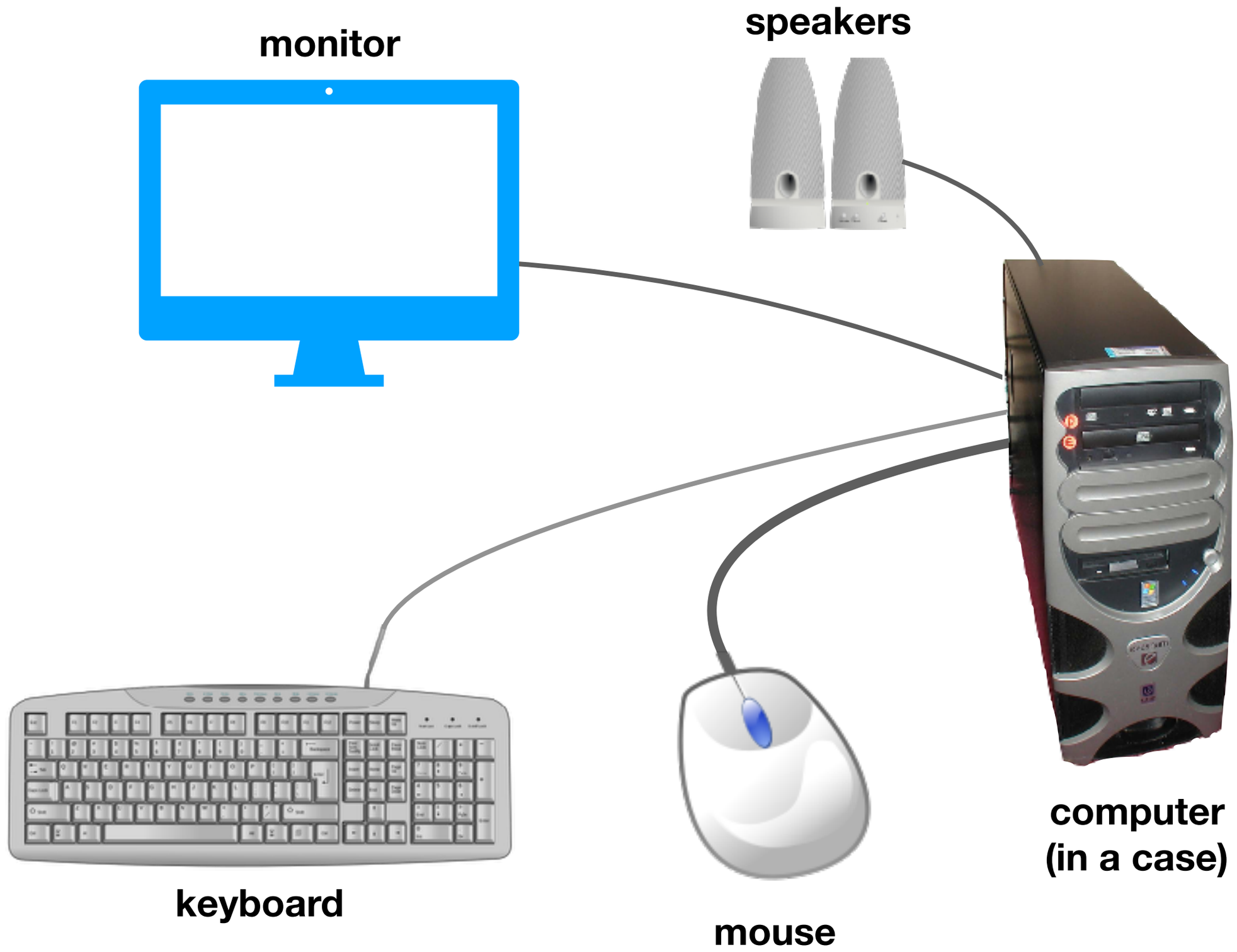
- Review Computer I/O
- Program I/O and the Operating System

File Systems

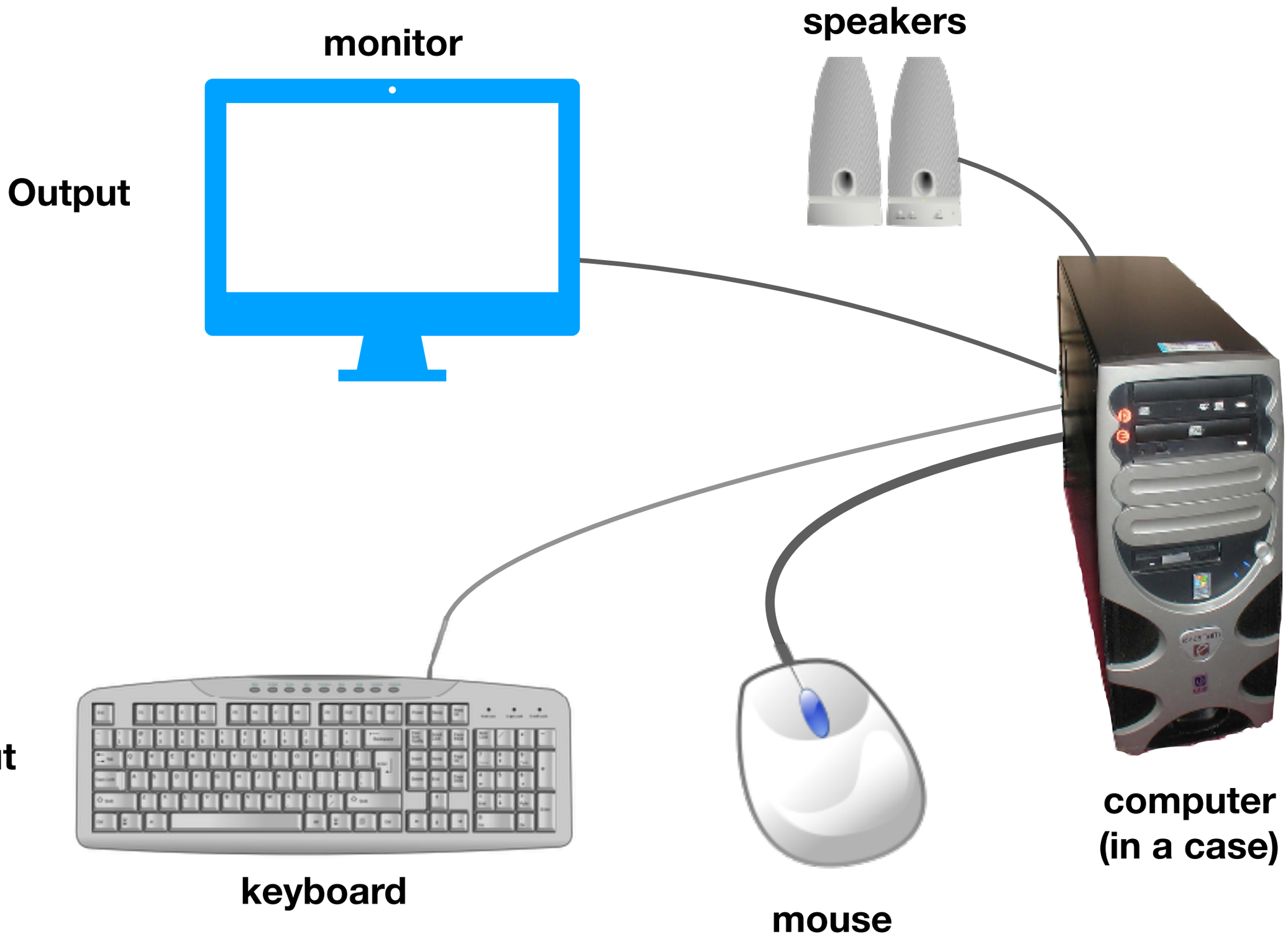
Terminal Emulators and Shells

Tutorials

Computer Input/Output



Computer Input/Output



Computer Input/Output

Are NICs and storage drives input devices or output devices?

computer (in a case)

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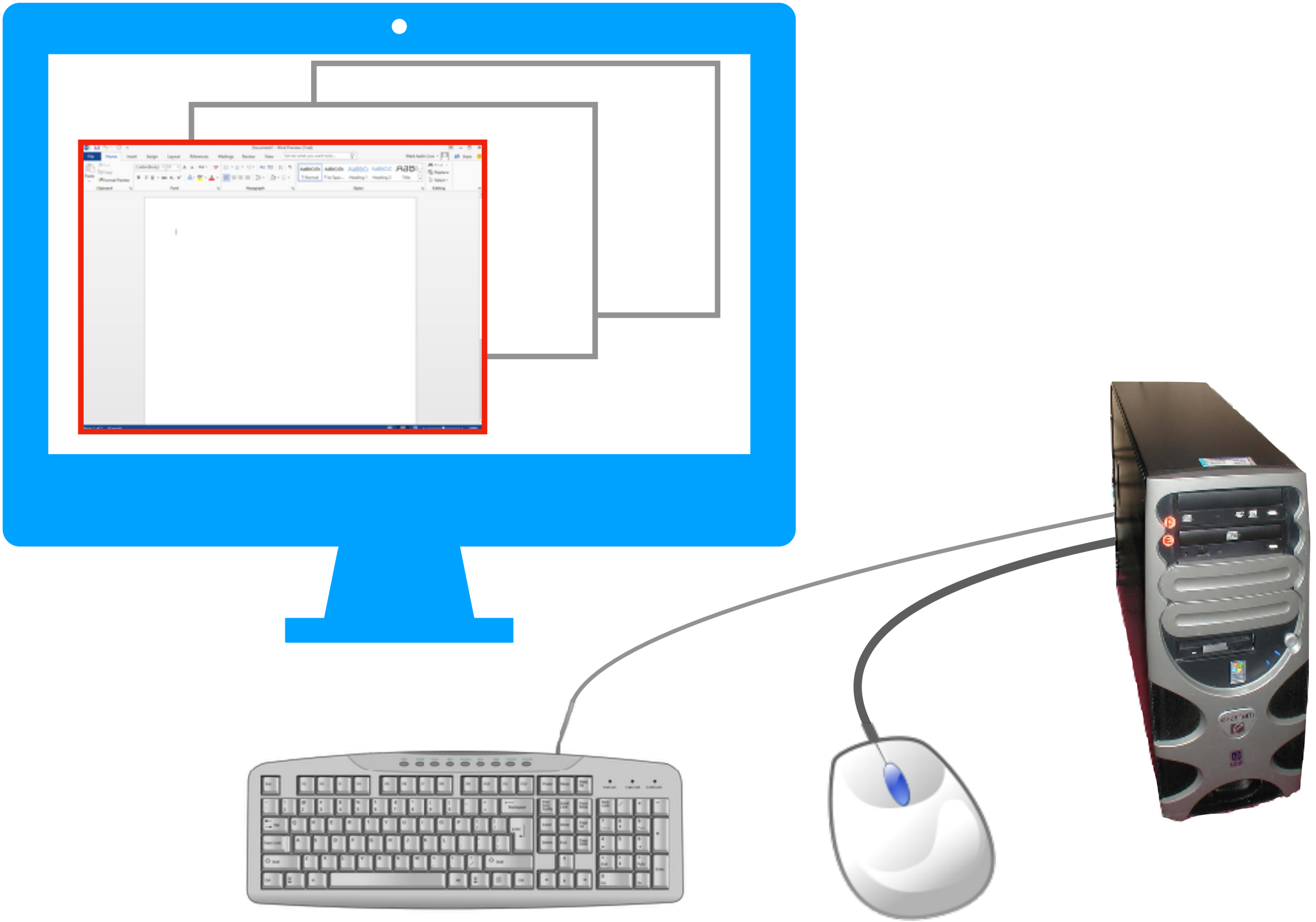
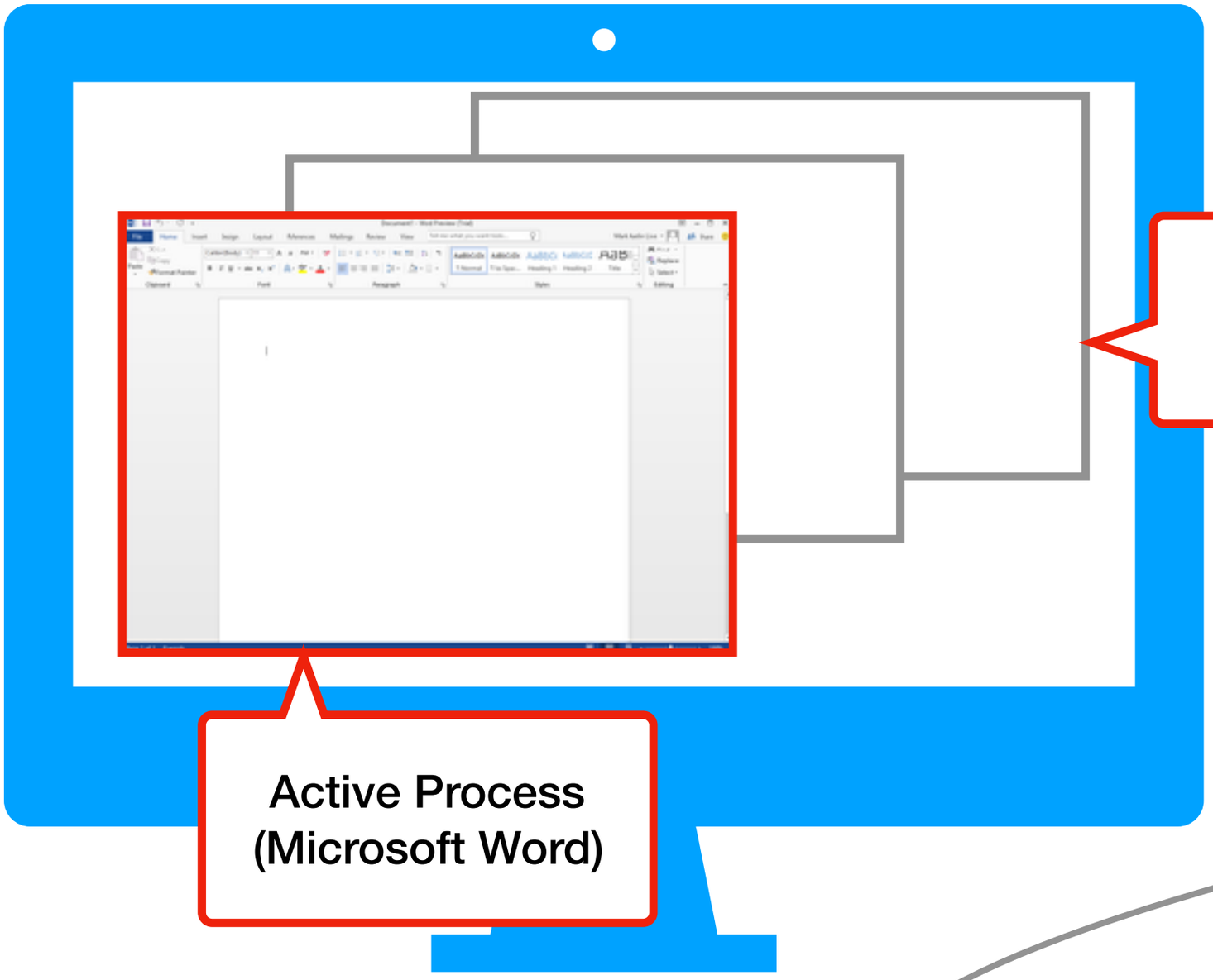
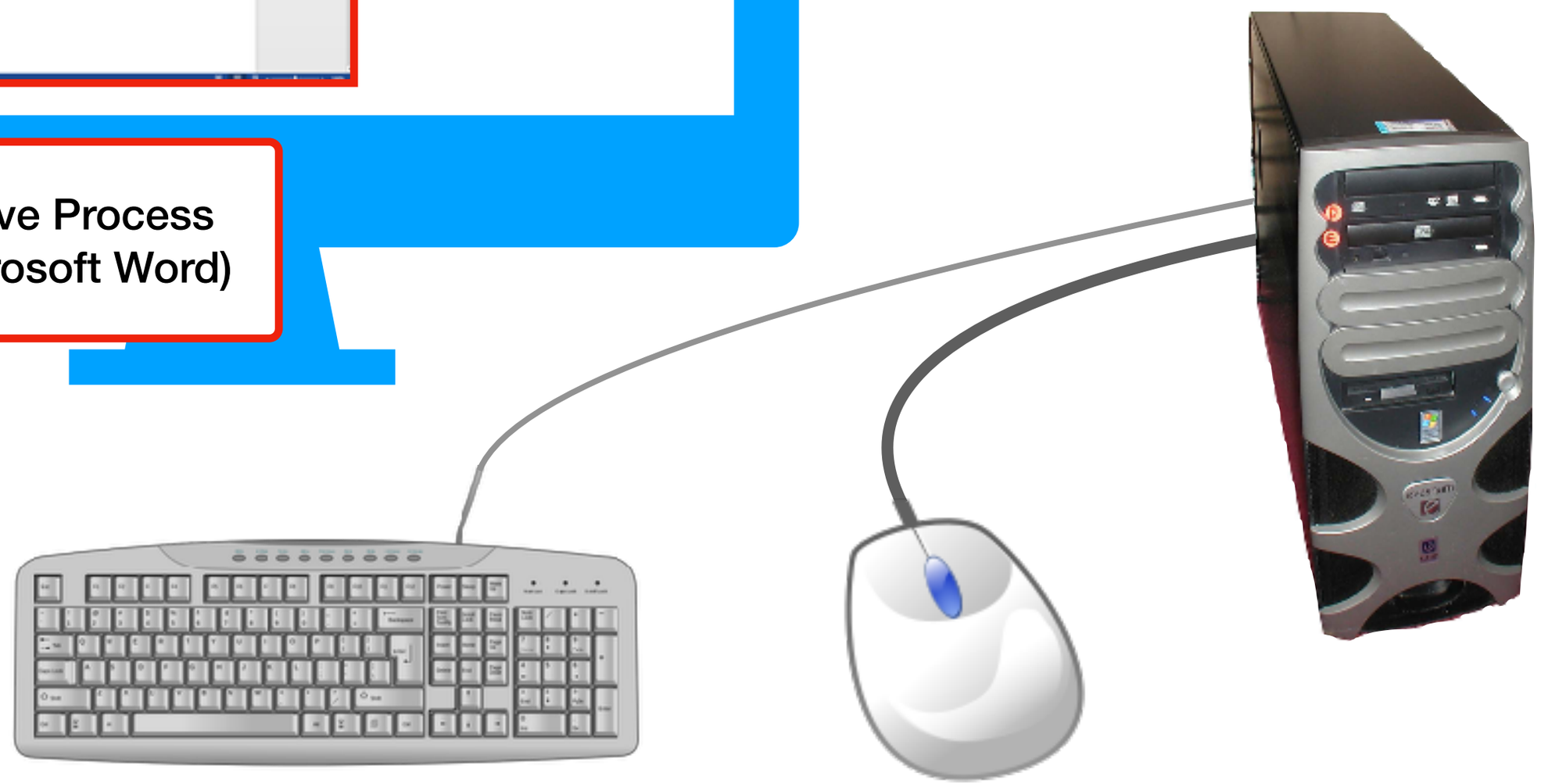
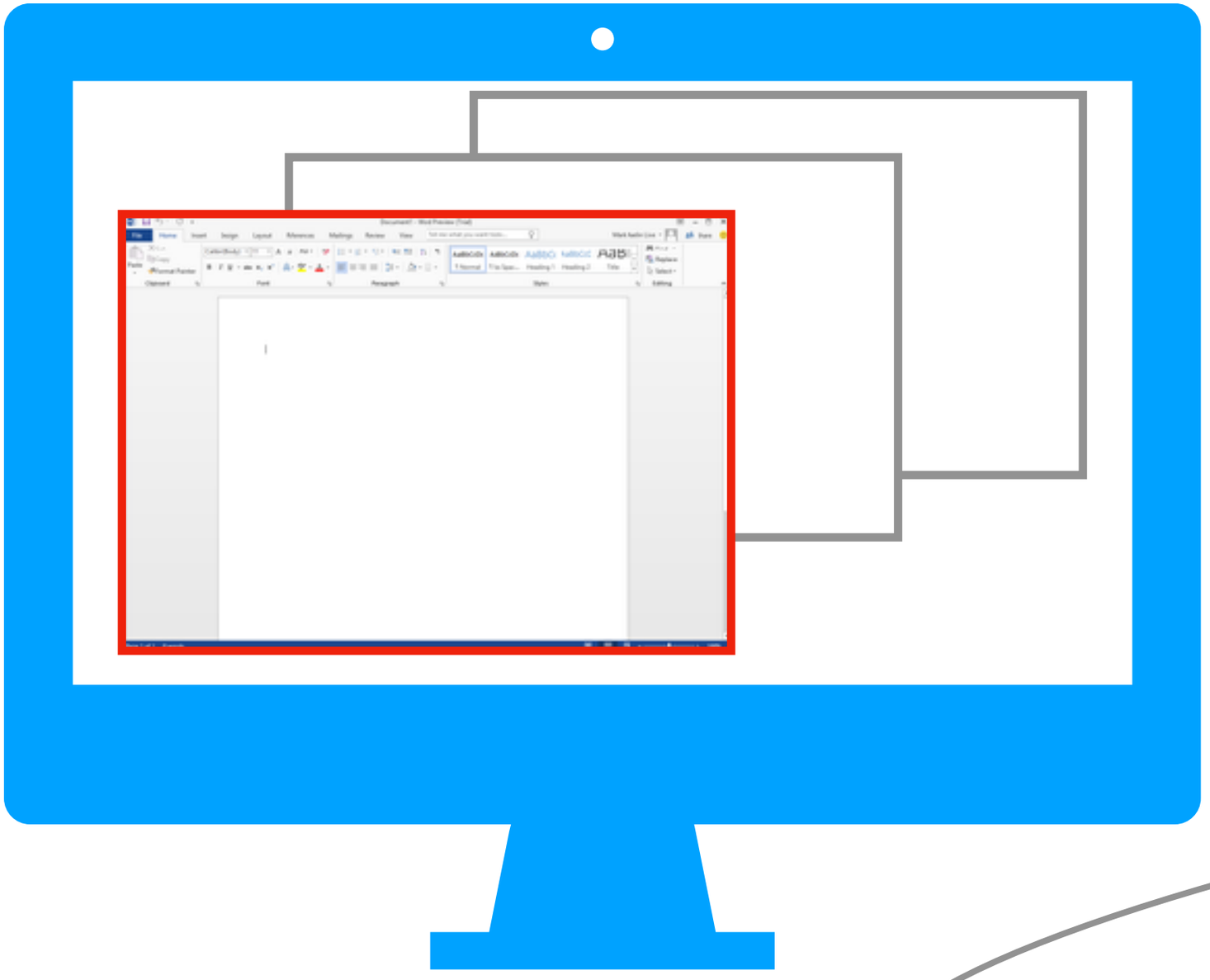
Tutorial



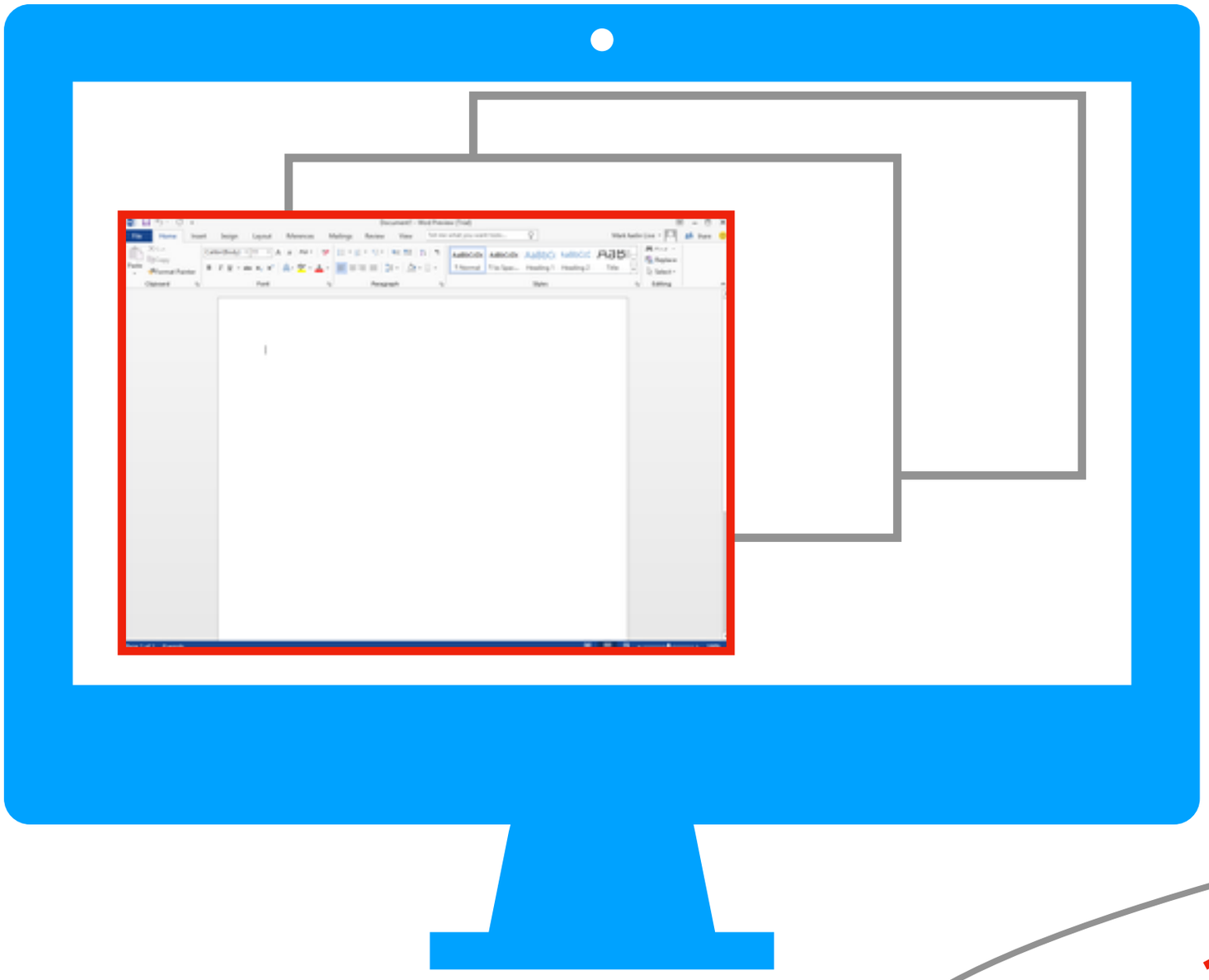
Terminology: a “process” is just a running “program”







Operating System



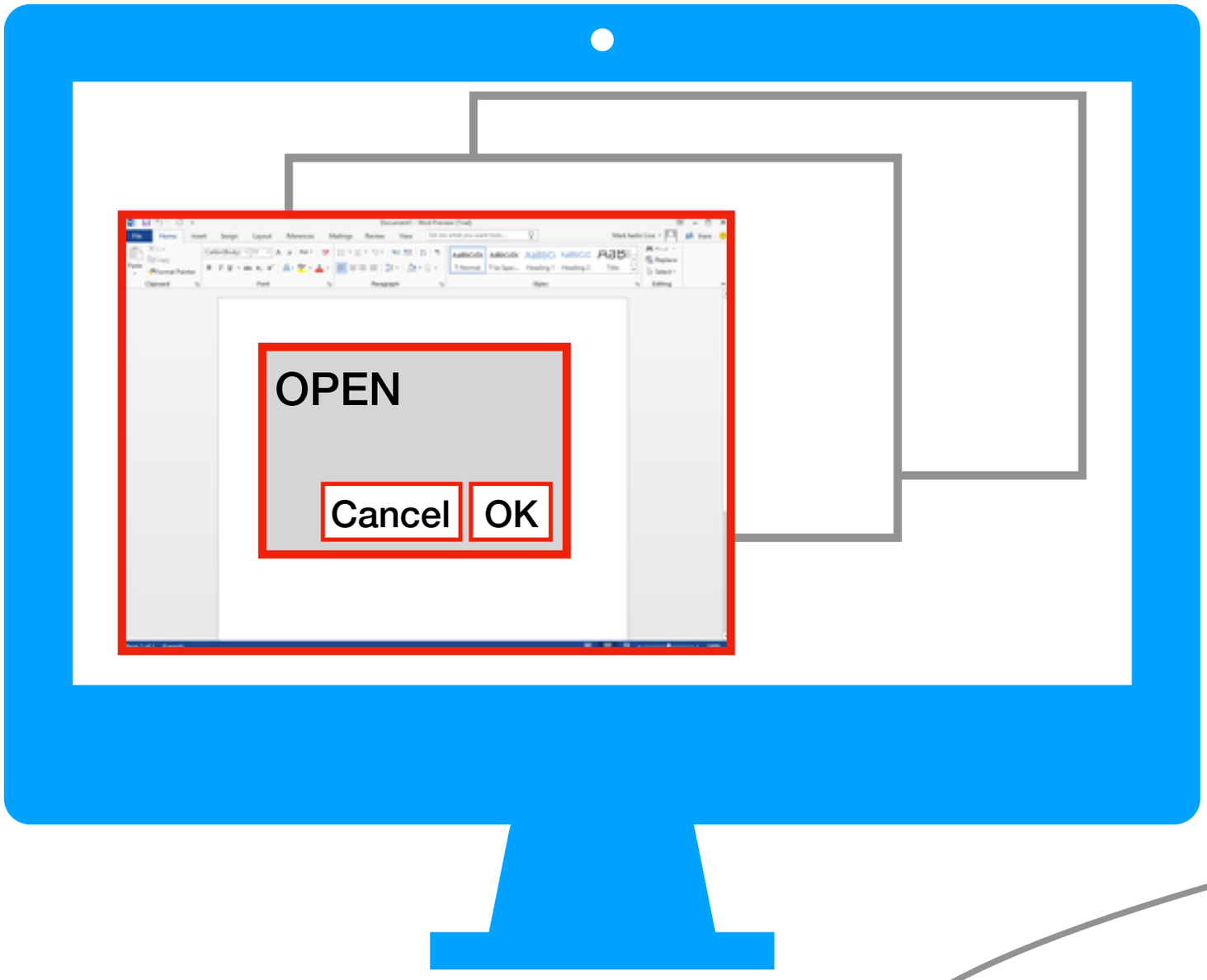
Operating System

Click!
(input)

Click!
(input)

Operating System

Click!
(input)



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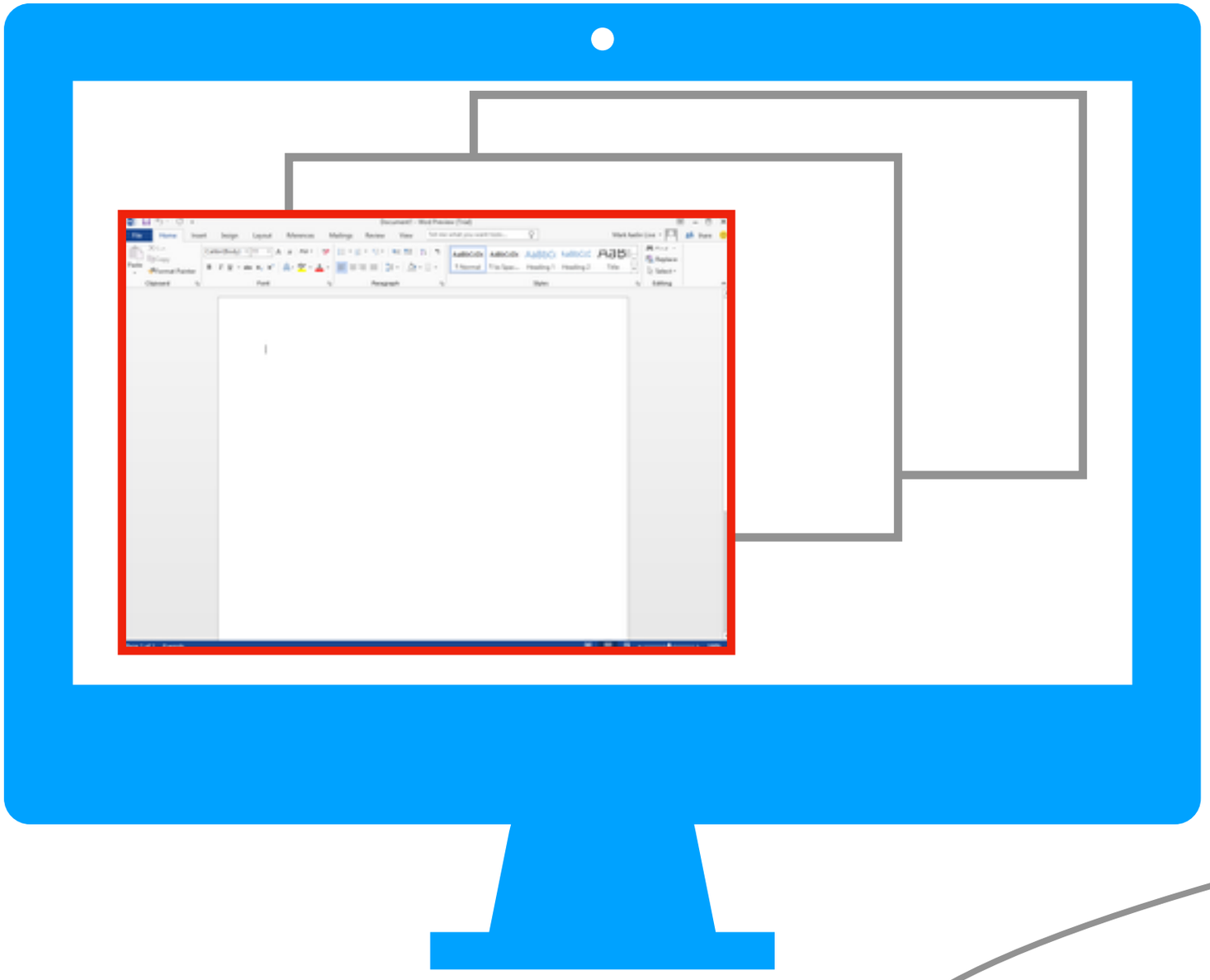
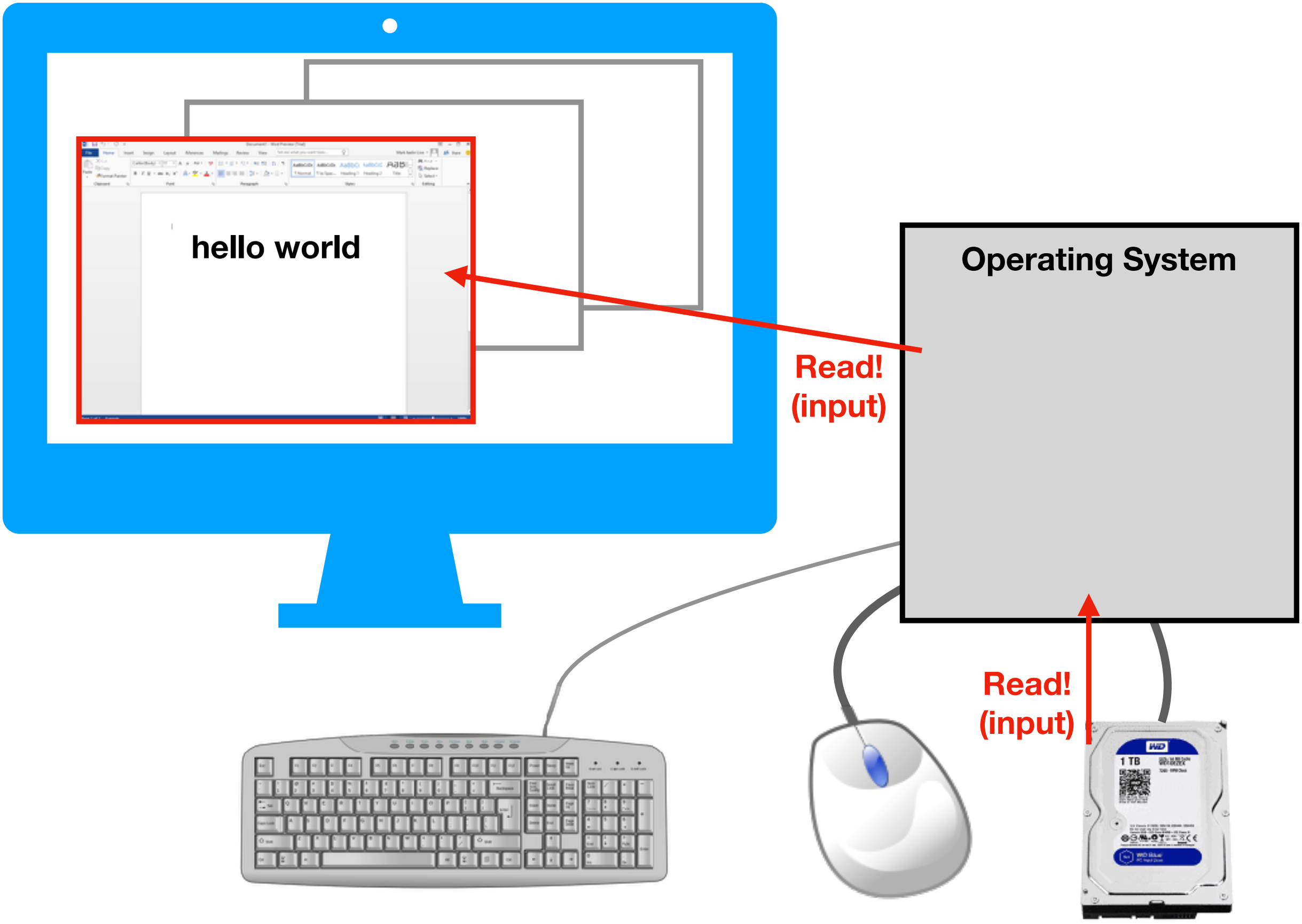
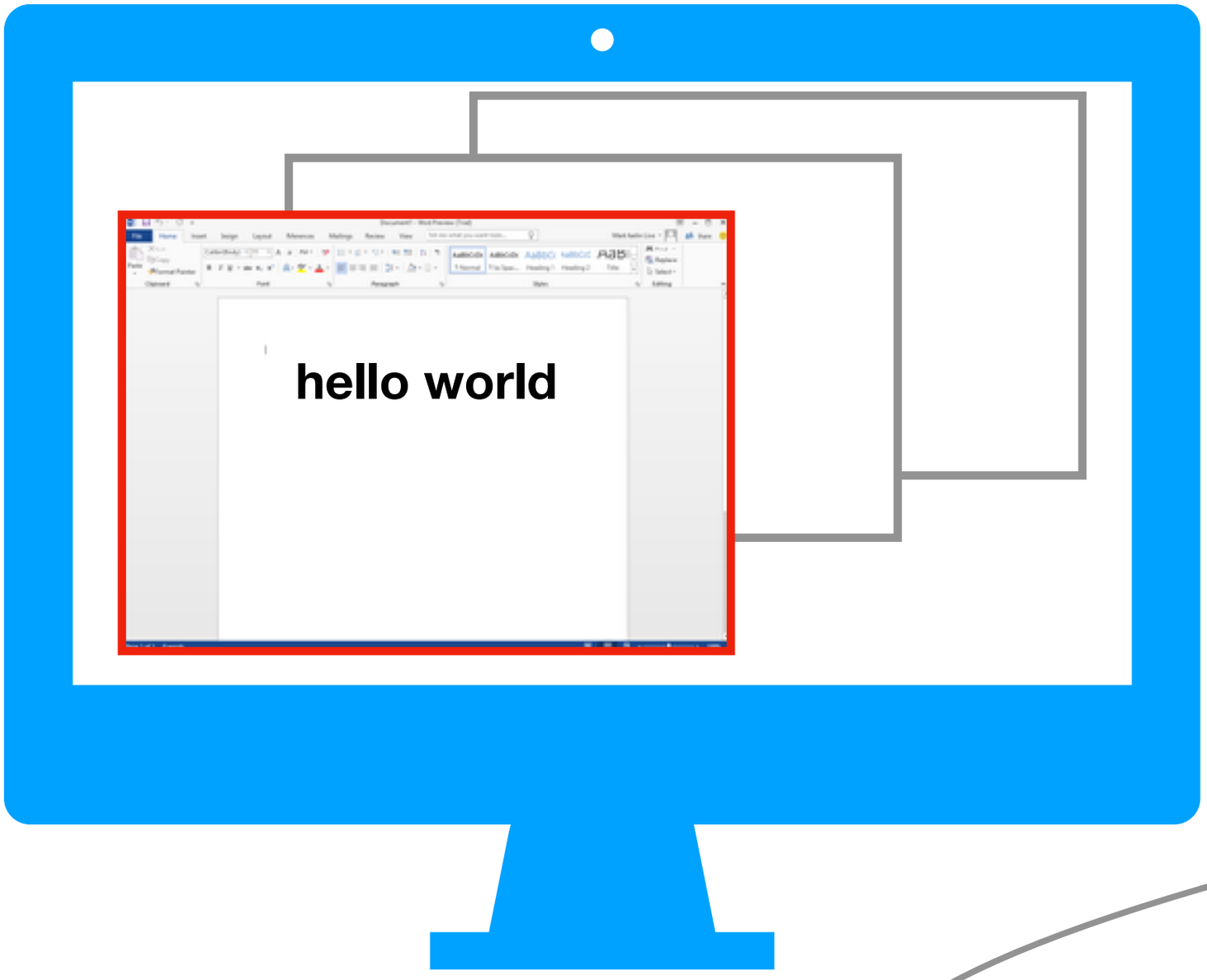


Operating System

Read!
(input)


hello world
Read!
(input)
Operating System
Read!
(input)
1 TB



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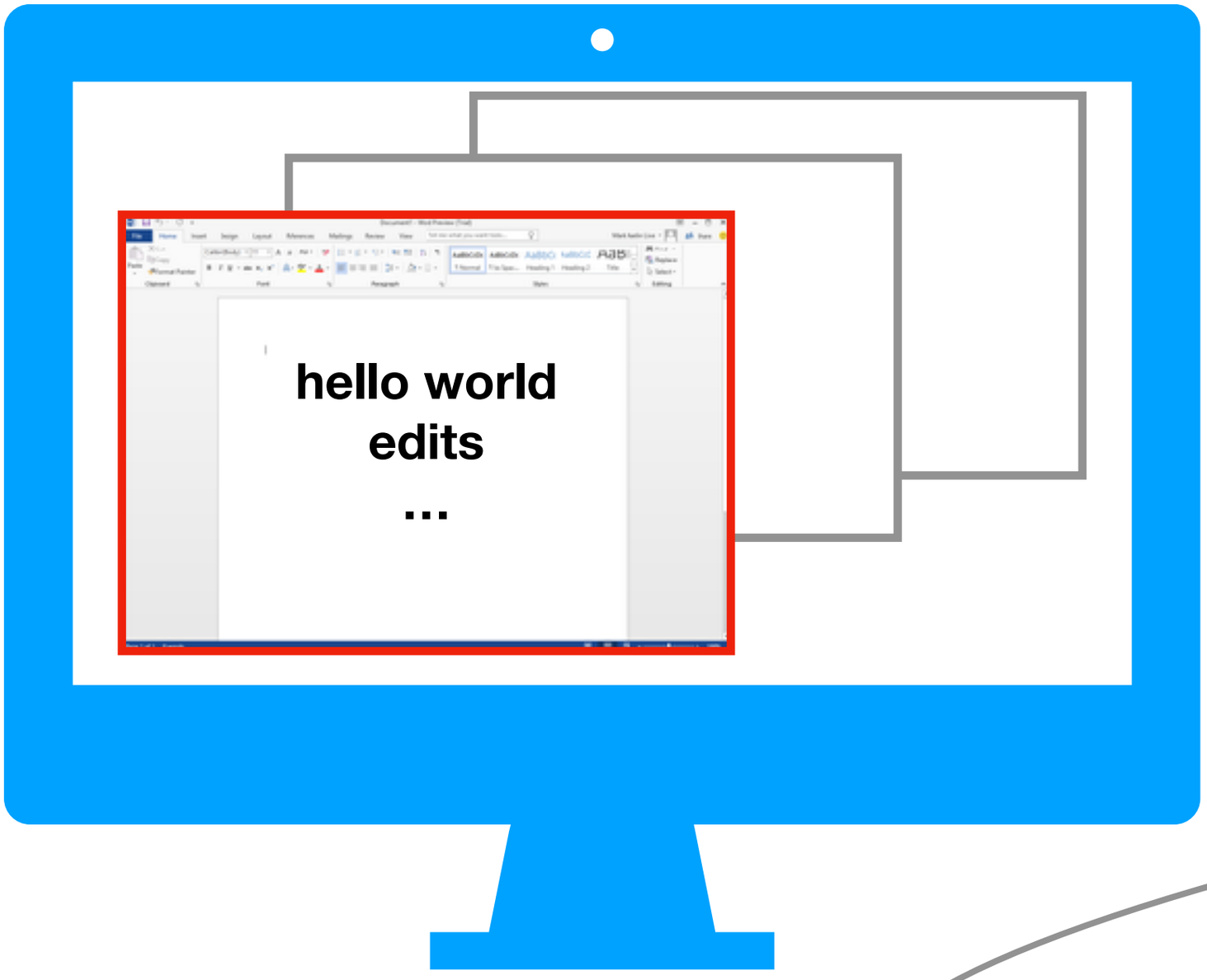

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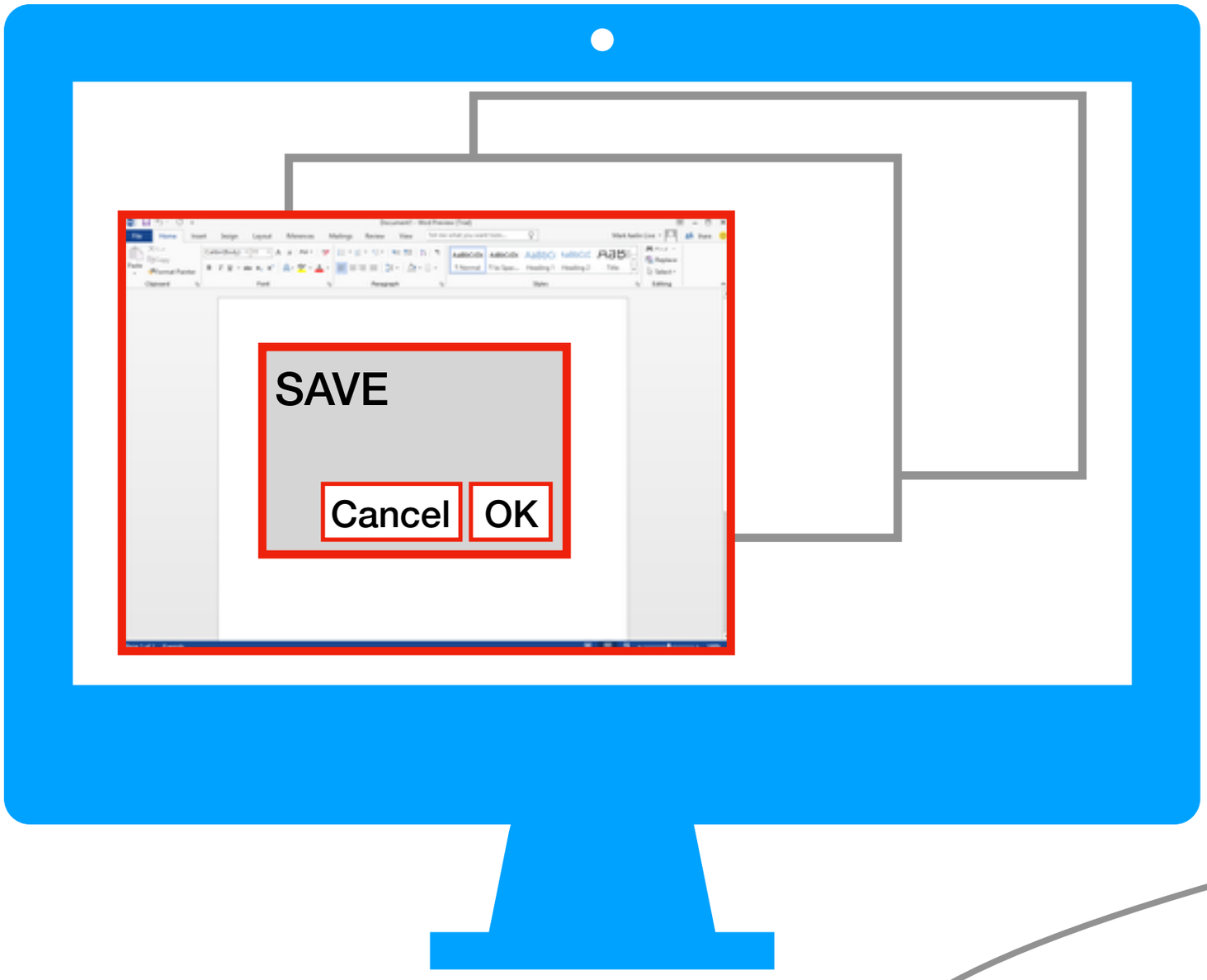


Operating System

SAVE

Cancel

OK

Write!
(output)

Operating System

1 TB

SAVE

Cancel

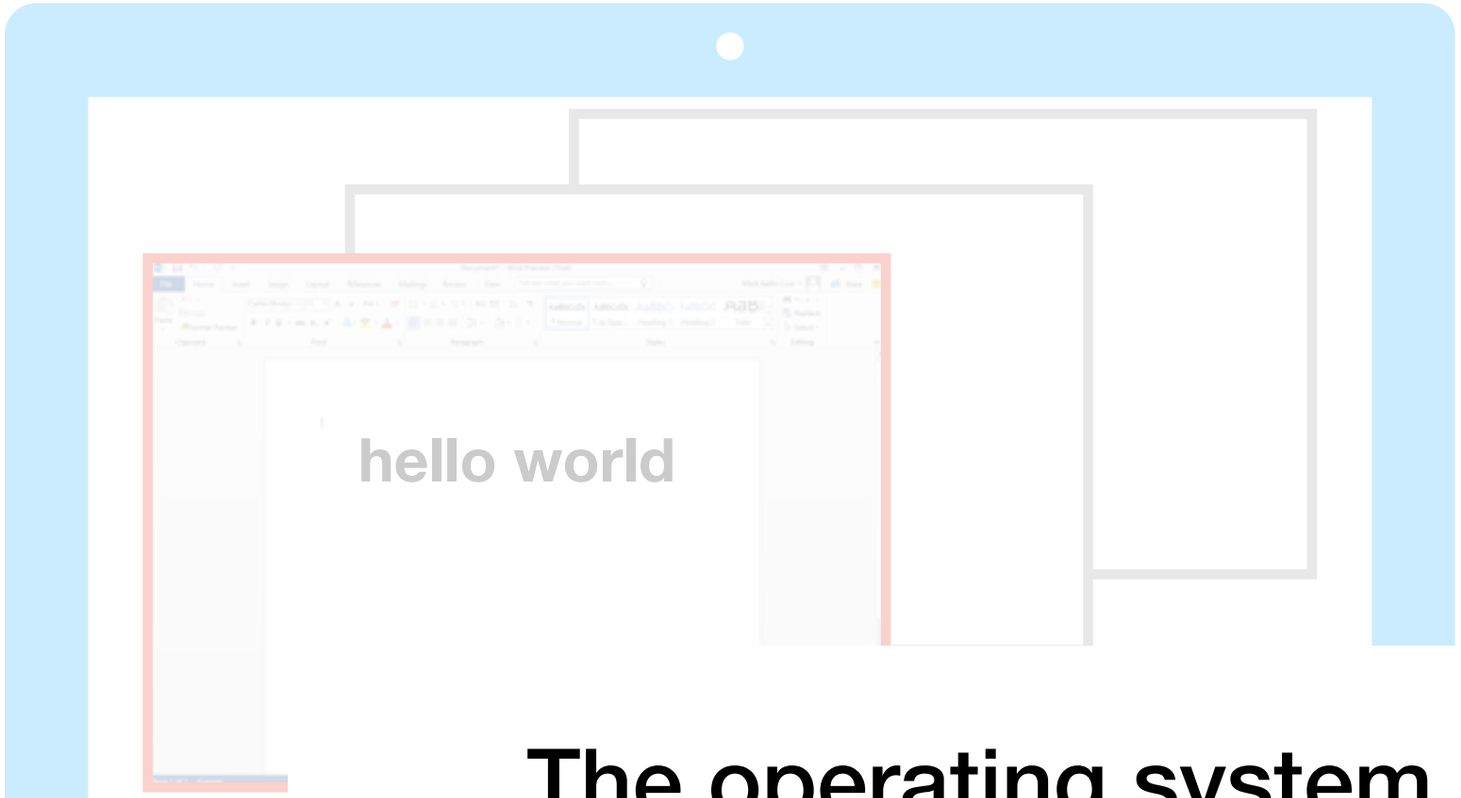
OK

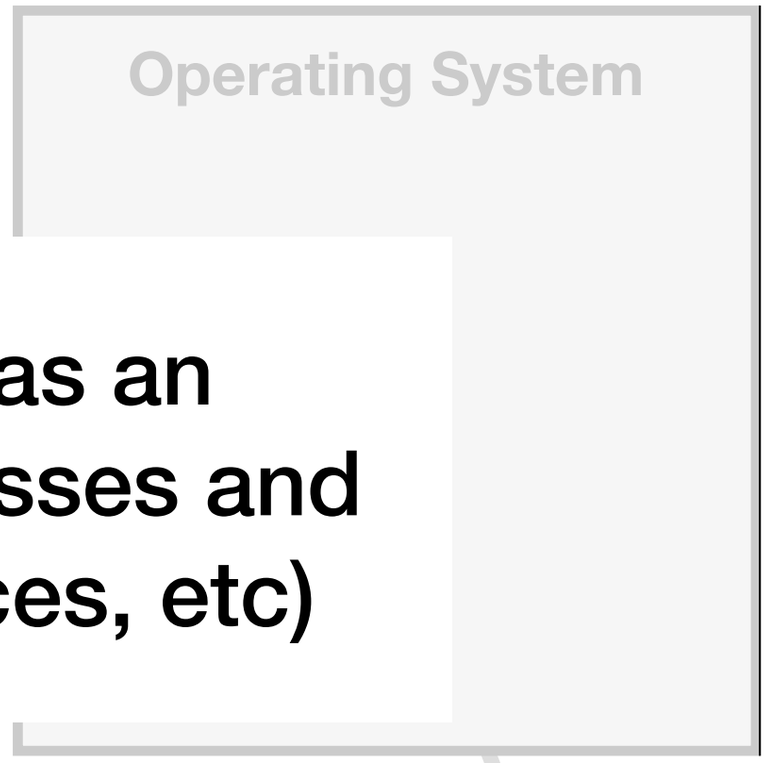
Write!
(output)

Operating System

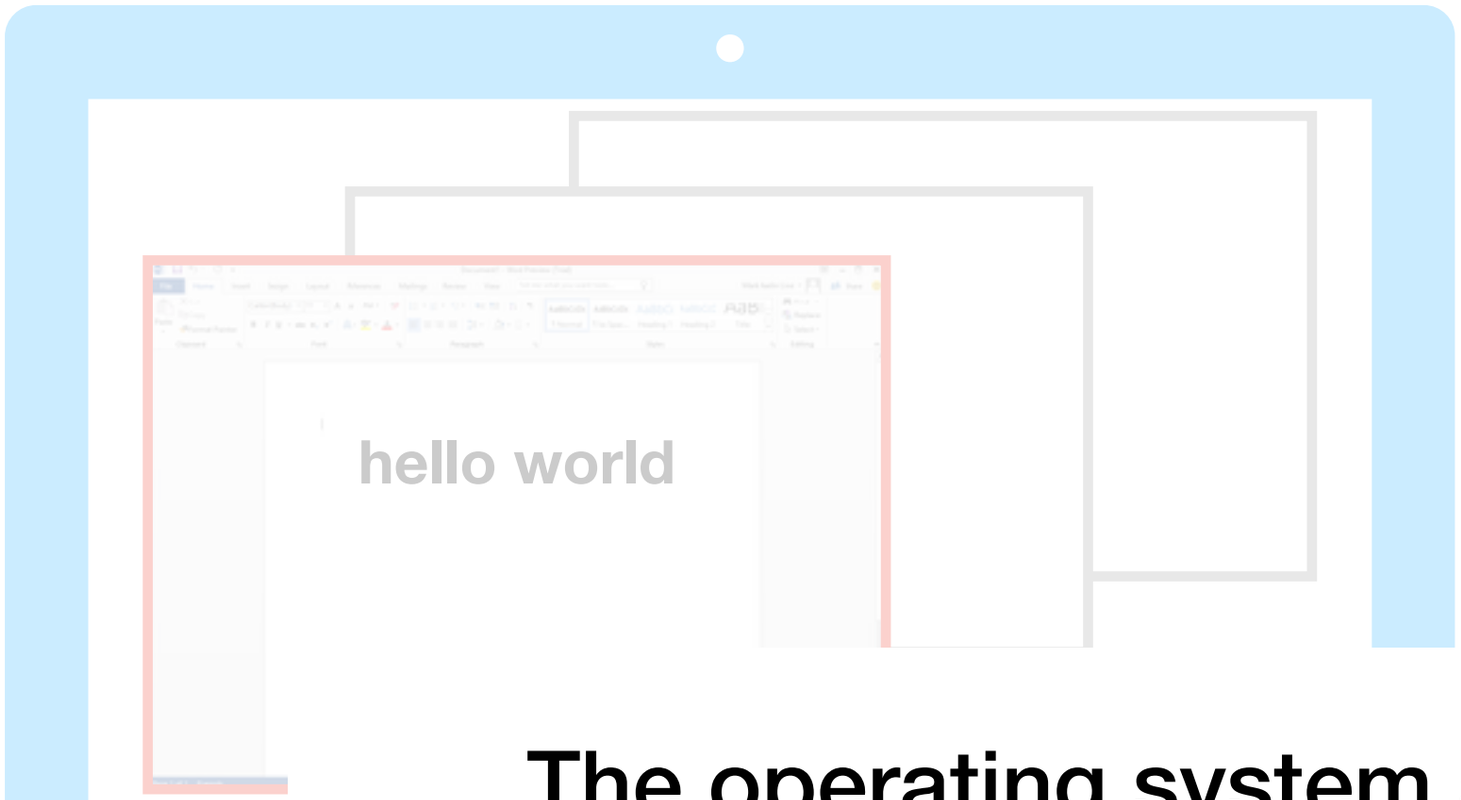
Write!
(output)

1 TB





The operating system acts as an **I/O middleman** between processes and hardware (NICs, storage devices, etc)



Operating System

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Today's Topics

Program Input/Output

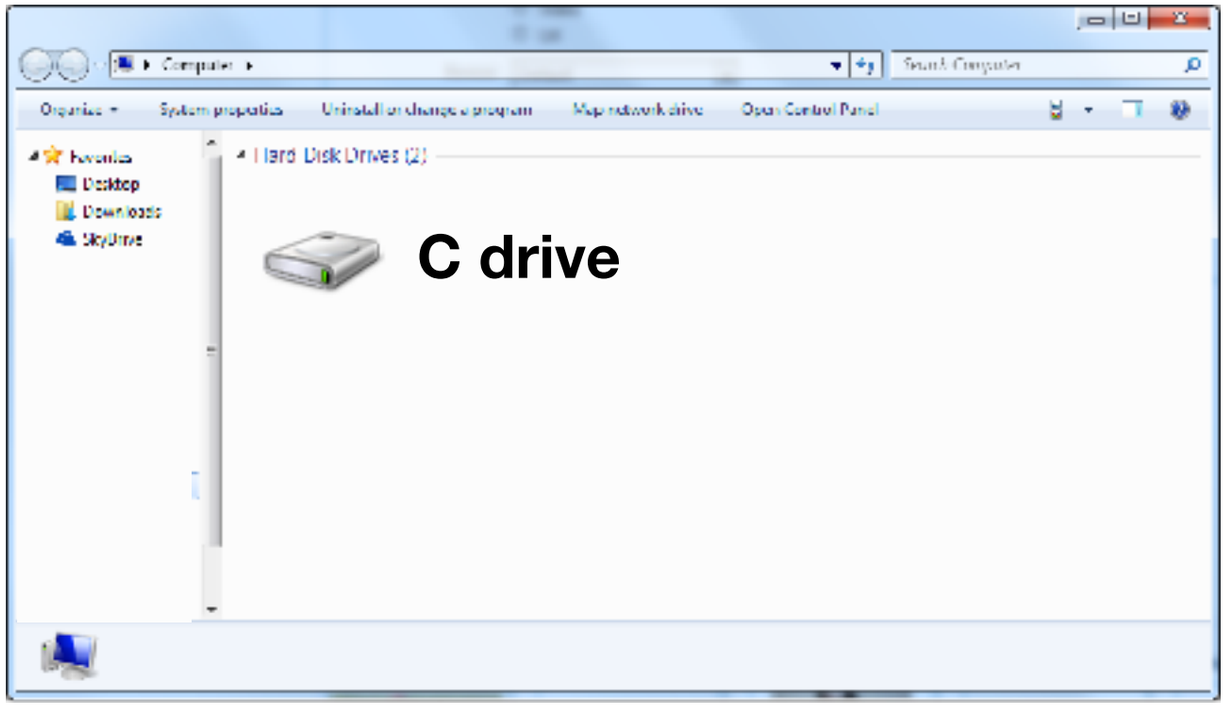
File Systems

- Storage Devices in Windows
- File I/O
- Organizing with Folders/Directories
- Storage Devices in Mac+Linux

Terminal Emulators and Shells

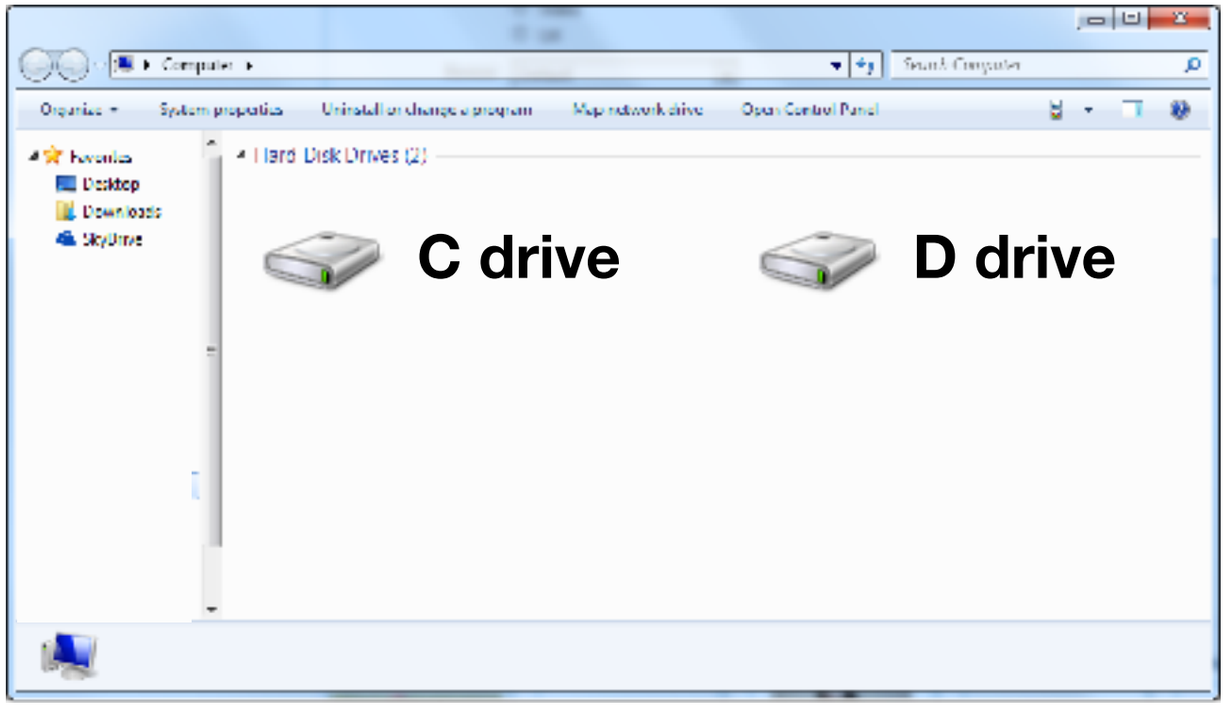
Tutorial

Windows Storage Drives



Each added drive is given its own drive letter

Windows Storage Drives



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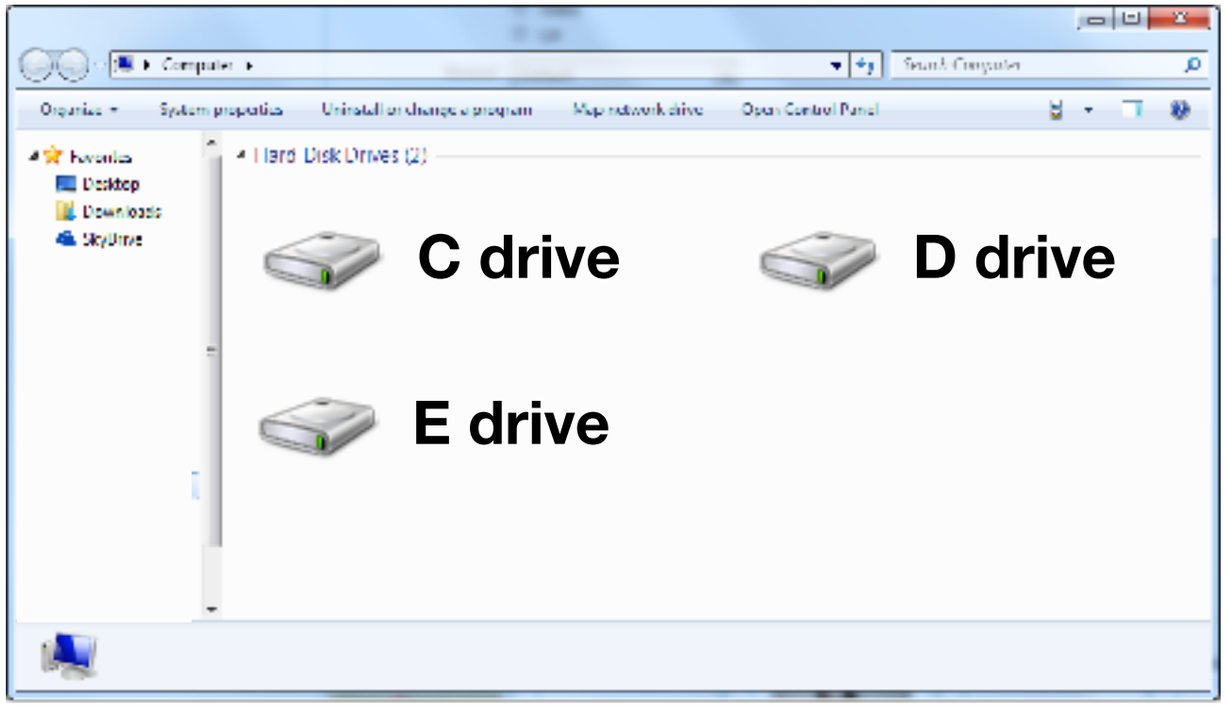

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Tutorial

File I/O

Each file has a name, called a “path name”

c:\README.txt

c:\hw.docx

d:\page.html

e:\main.py

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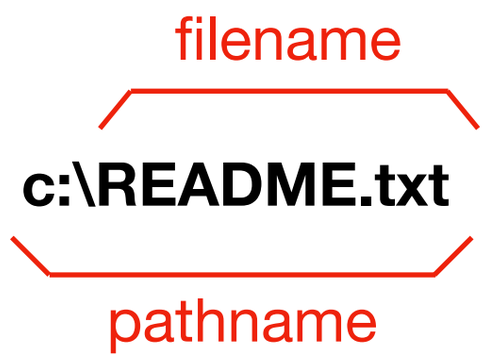

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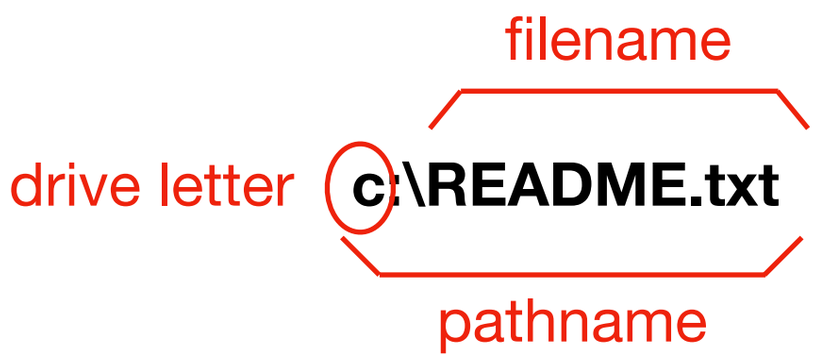

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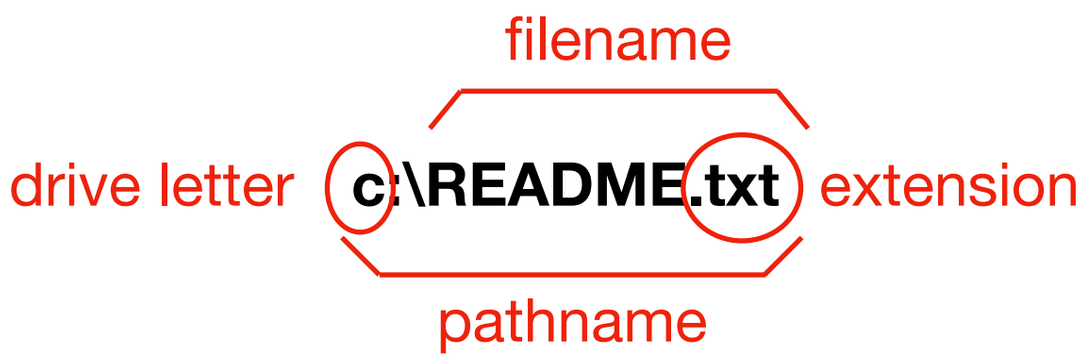

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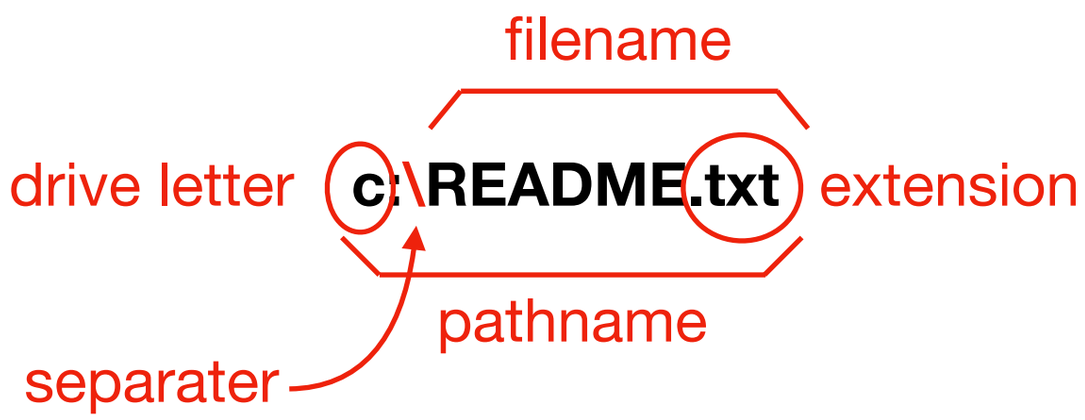

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File I/O

Files are sources of input and destinations for output for processes.

Files are managed by a part of the operating system called the “file system”

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Processes: Word | Email Program

File System: c:\template.docx

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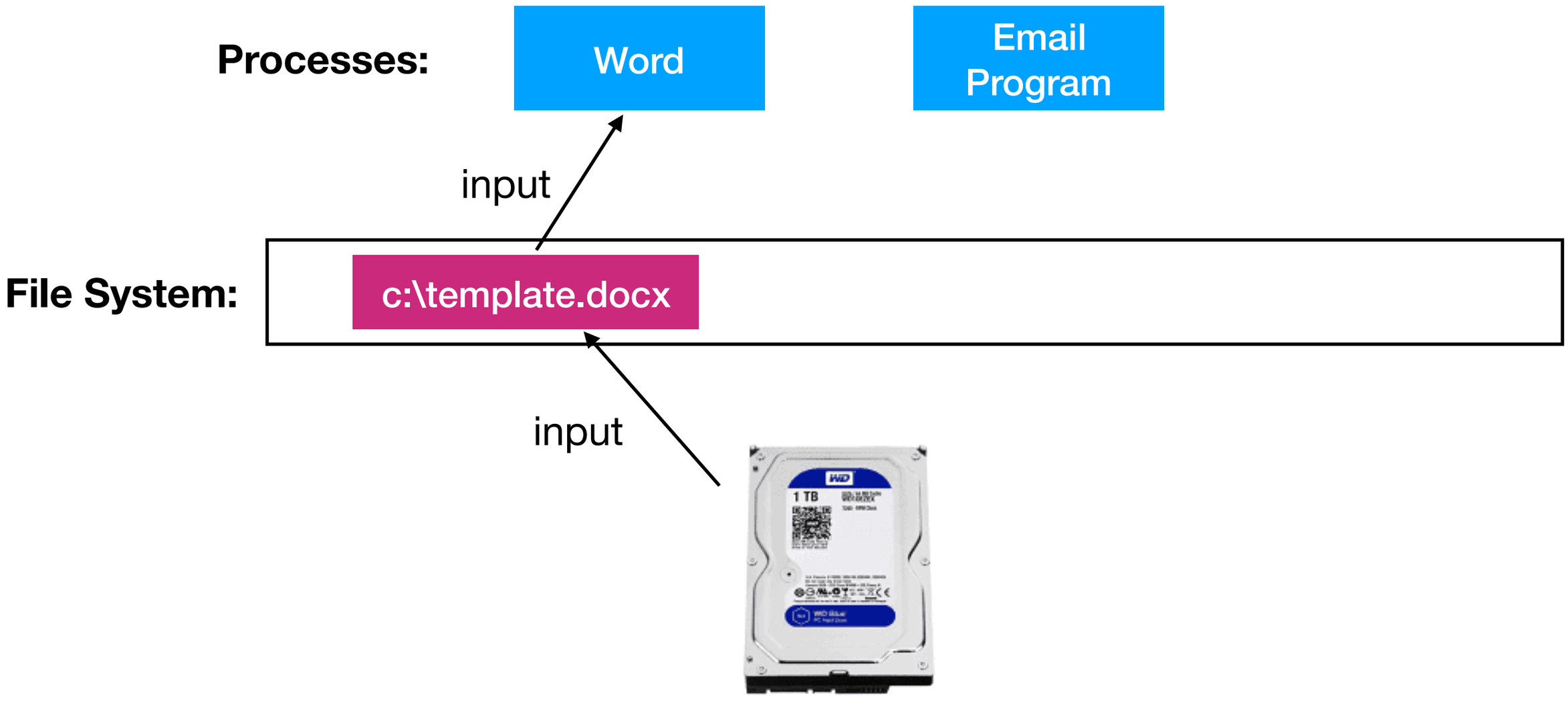

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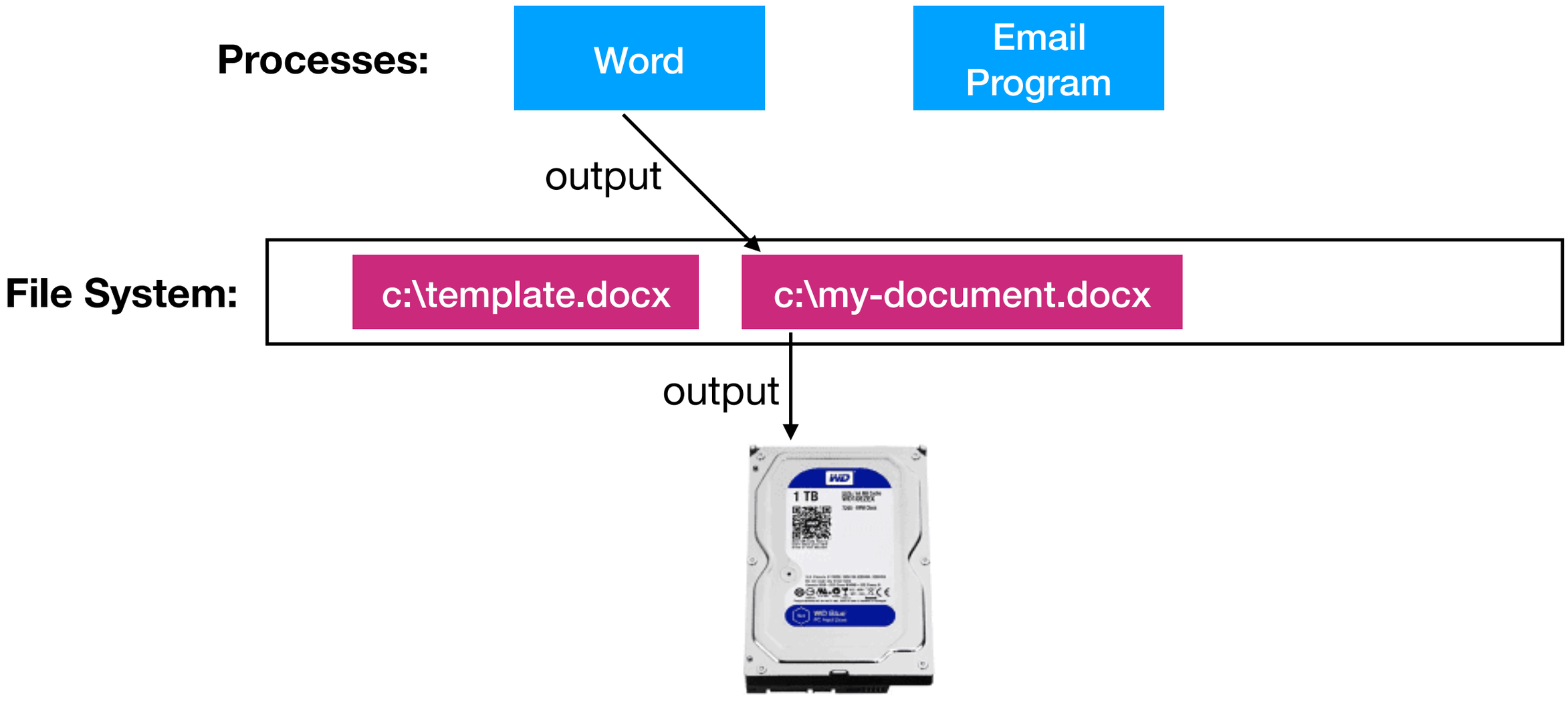

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File System: c:\template.docx, c:\my-document.docx

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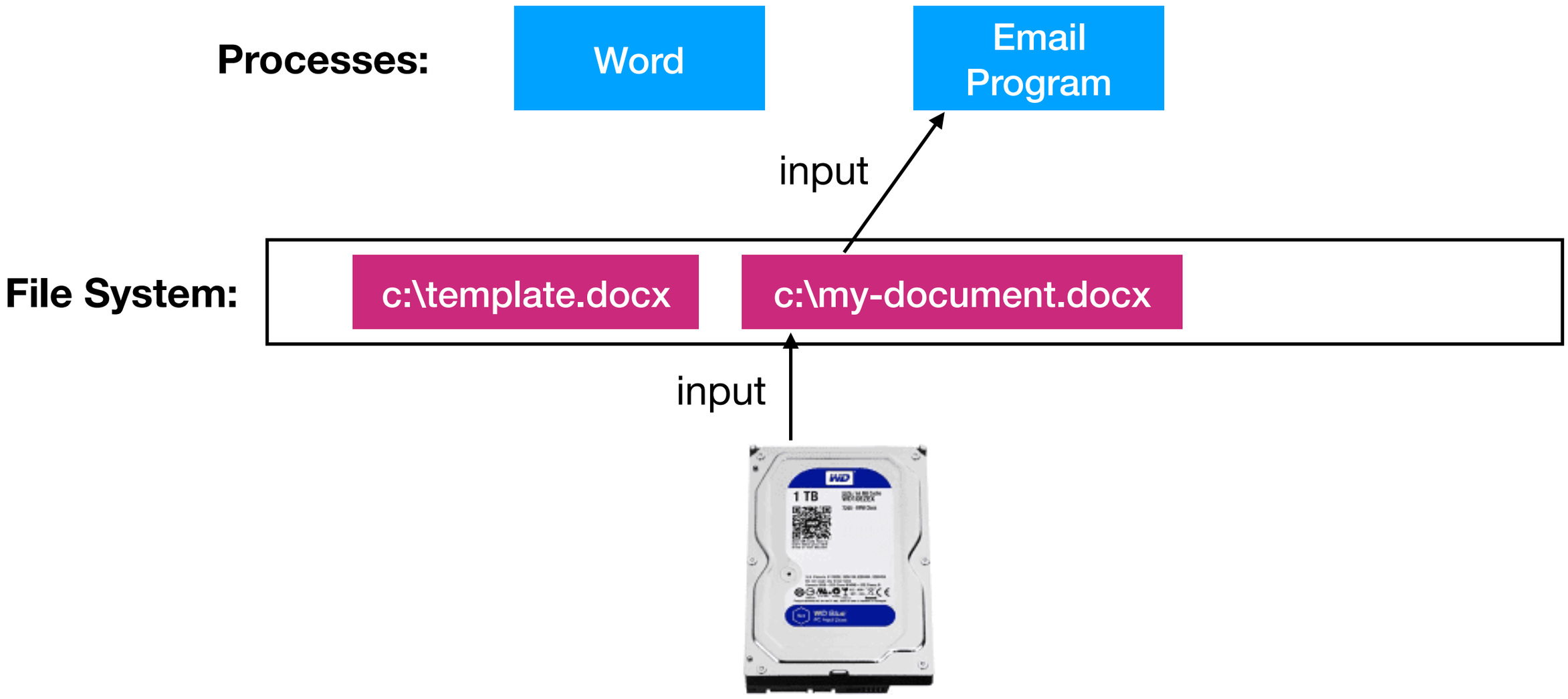

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Tutorial

Directories

Directories are used to organize files

- Also called “folders”
- A directory also has pathname
- Each directory may contain other directories and files

Example paths:

- c:\my-directory\file1.docx
- c:\my-directory\file2.docx
- c:\my-directory\file3.docx
- c:\directory1\directory2\file1.docx
- c:\same-dir\same-dir\readme.txt

Relative Paths

Where is the Computer Science building?

- Answer 1: 1210 W Dayton St, Madison, WI 53706
- Answer 2: on the other side of Johnson street

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When is Answer 2 appropriate?

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When is Answer 2 appropriate?

- When you're in the psychology building
- It may be more convenient

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Pathnames are absolute (answer 1) or relative (answer 2)

- Absolute paths: always possible
- Relative paths: if current location is known

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Pathnames are absolute (answer 1) or relative (answer 2)

- Absolute paths: always possible
- Relative paths: if current location is known
- Current location/directory is called "working directory" or "current working directory"

Absolute vs. Relative

Absolute Path	Working Directory	Relative Path
c:\test.txt	c:\	test.txt
c:\x\y\z\my.docx	c:\x\y\z	
c:\x\y\z\my.docx	c:\x\y	
c:\x\y\z	c:\x	

Absolute vs. Relative

Absolute Path	Working Directory	Relative Path
c:\test.txt	c:\	test.txt
c:\x\y\z\my.docx	c:\x\y\z	my.docx
c:\x\y\z\my.docx	c:\x\y	
c:\x\y\z	c:\x	

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c:\x\y\z	c:\x	

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c:\x\y\z\my.docx	c:\x\y	z\my.docx
c:\x\y\z	c:\x	y\z

Absolute vs. Relative

Absolute Path	Working Directory	Relative Path
c:\test.txt	c:\	test.txt
c:\x\y\z\my.docx	c:\x\y\z	my.docx
c:\x\y\z\my.docx	c:\x\y	z\my.docx
c:\x\y\z	c:\x	y\z

Two special directory names

- “..” means up a directory
- “.” means current directory

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c:\x\y\z\my.docx	c:\x\y\z	my.docx
c:\x\y\z\my.docx	c:\x\y	z\my.docx
c:\x\y\z	c:\x	y\z
c:\test.txt	c:\	.\test.txt
c:\x\y\z	c:\x	
c:\x	c:\x\y\z	

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c:\x\y\z\my.docx	c:\x\y	z\my.docx
c:\x\y\z	c:\x	y\z
c:\test.txt	c:\	.\test.txt
c:\x\y\z	c:\x	.\.\test.txt
c:\x	c:\x\y\z	

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c:\x\y\z	c:\x	y\z
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c:\x\y\z	c:\x	.\y\z
c:\x	c:\x\y\z	

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c:\x\y\z	c:\x	y\z
c:\test.txt	c:\	.\test.txt
c:\test.txt	c:\	.\.\test.txt
c:\x\y\z	c:\x	.\y\z
c:\x	c:\x\y\z	..\..

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c:\test.txt	c:\	.\.\test.txt
c:\x\y\z	c:\x	.\y\z
c:\x	c:\x\y\z	..\..
c:\B\file.txt	c:\A	

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c:\x\y\z	c:\x	y\z
c:\test.txt	c:\	.\test.txt
c:\test.txt	c:\	.\.\test.txt
c:\x\y\z	c:\x	.\y\z
c:\x	c:\x\y\z	..\..
c:\B\file.txt	c:\A	..\B\file.txt

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c:\x\y\z	c:\x	.\y\z
c:\x	c:\x\y\z	..\..
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more examples in tutorial later…

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File Systems

- Storage Devices in Windows
- File I/O
- Organizing with Folders/Directories
- Storage Devices in Mac+Linux

Terminal Emulators and Shells

Tutorials

Multiple Drives in Linux

Windows

- Generally, every absolute pathname starts with “c:\” or “d:\” or similar
- Name indicates which drive stores the file

UNIX

- Every absolute pathname starts with “/”
- For example, /home/tyler/my-file.docx (note forward slash)
- Name does not indicate on which drive a file lives

Multiple Drives in Linux

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How can we use multiple drives if every file paths starts the same, with “/” ???

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How can we use multiple drives if every file paths starts the same, with “/” ???

Answer: different drives feel like different directories in UNIX systems

Comparison

Windows	Mac	UNIX	Drives
c:\Users\tyler\file.txt	/Users/tyler	/home/tyler	
c:\Program Files	/usr/local/bin	/usr/local/bin	
c:\Windows\…\Logs	/var/log	/var/log	
d:\	/Volumes	/mnt/backup	
d:\aug	/Volumes/backup/aug	/mnt/backup/aug	
e:\movies	/Volumes/movies	/home/tyler/movies	

Comparison

Windows	Mac	Linux	Drives
c:\Users\tyler\file.txt	/Users/tyler	/home/tyler	
c:\Program Files	/usr/local/bin	/usr/local/bin	
c:\Windows\…\Logs	/var/log	/var/log	
d:\	/Volumes	/mnt/backup	
d:\aug	/Volumes/backup/aug	/mnt/backup/aug	
e:\movies	/Volumes/movies	/home/tyler/movies	

On Mac, extra drives often appear under /Volumes.
On Linux, extra drives often appear under /mnt (for mount).

Today's Topics

Program Input/Output

File Systems

Terminal Emulators and Shells

- Terminal history
- Shells
- Running programs from a shell

Tutorials

History: the Original Terminals

Mainframe
(powerful computer)

https://techcrunch.com/2015/08/16/ibm-teams-with-canonical-on-linux-mainframe/
https://en.wikipedia.org/wiki/Computer_terminal#Dumb_terminals

History: the Original Terminals

Mainframe
(powerful computer)

How to share it?

https://techcrunch.com/2015/08/16/ibm-teams-with-canonical-on-linux-mainframe/
https://en.wikipedia.org/wiki/Computer_terminal#Dumb_terminals

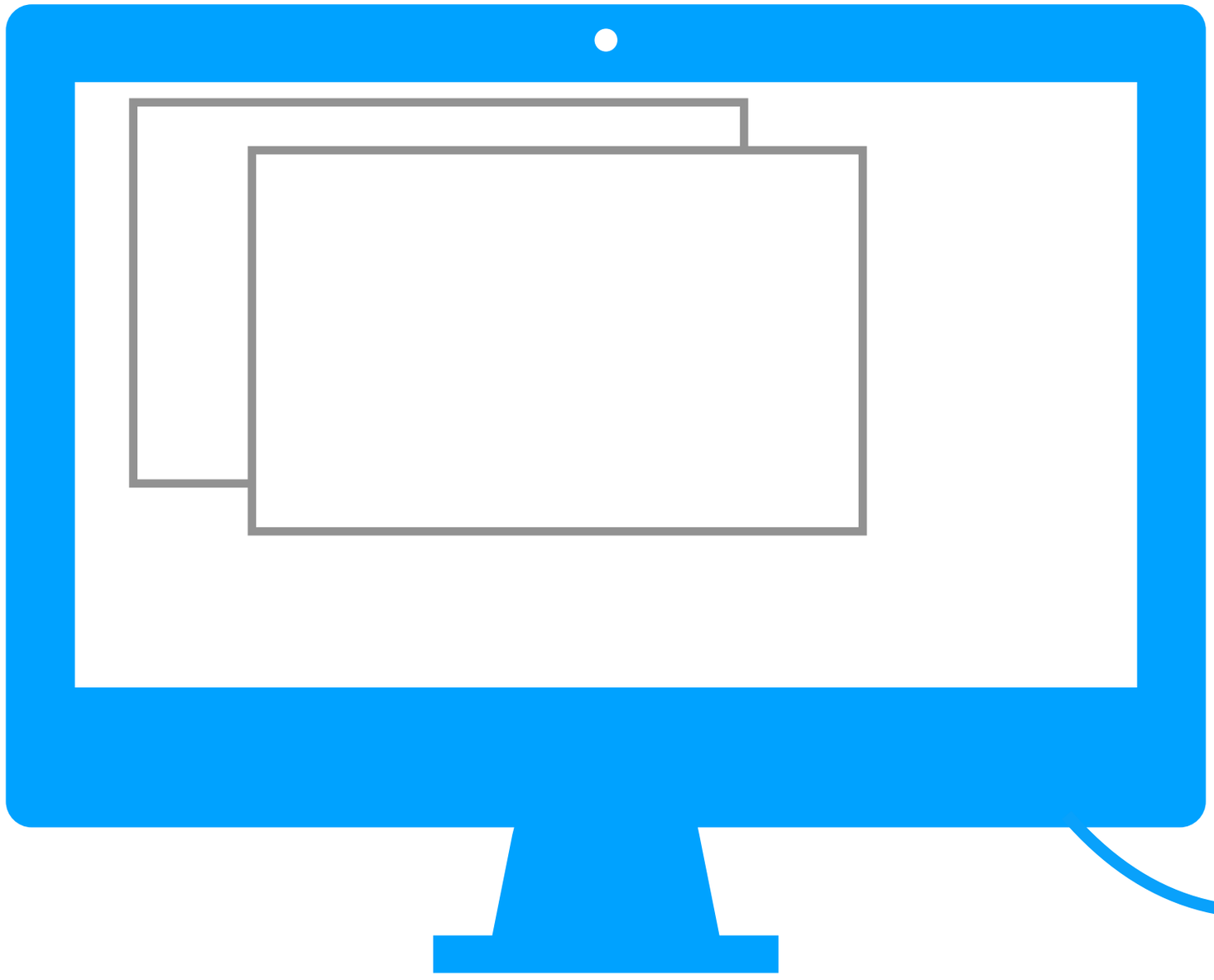
History: the Original Terminals

Mainframe
(powerful computer)

dumb terminals
(text based)

https://techcrunch.com/2015/08/16/ibm-teams-with-canonical-on-linux-mainframe/
https://en.wikipedia.org/wiki/Computer_terminal#Dumb_terminals

Terminal Emulators



https://techcrunch.com/2015/08/16/ibm-teams-with-canonical-on-linux-mainframe/
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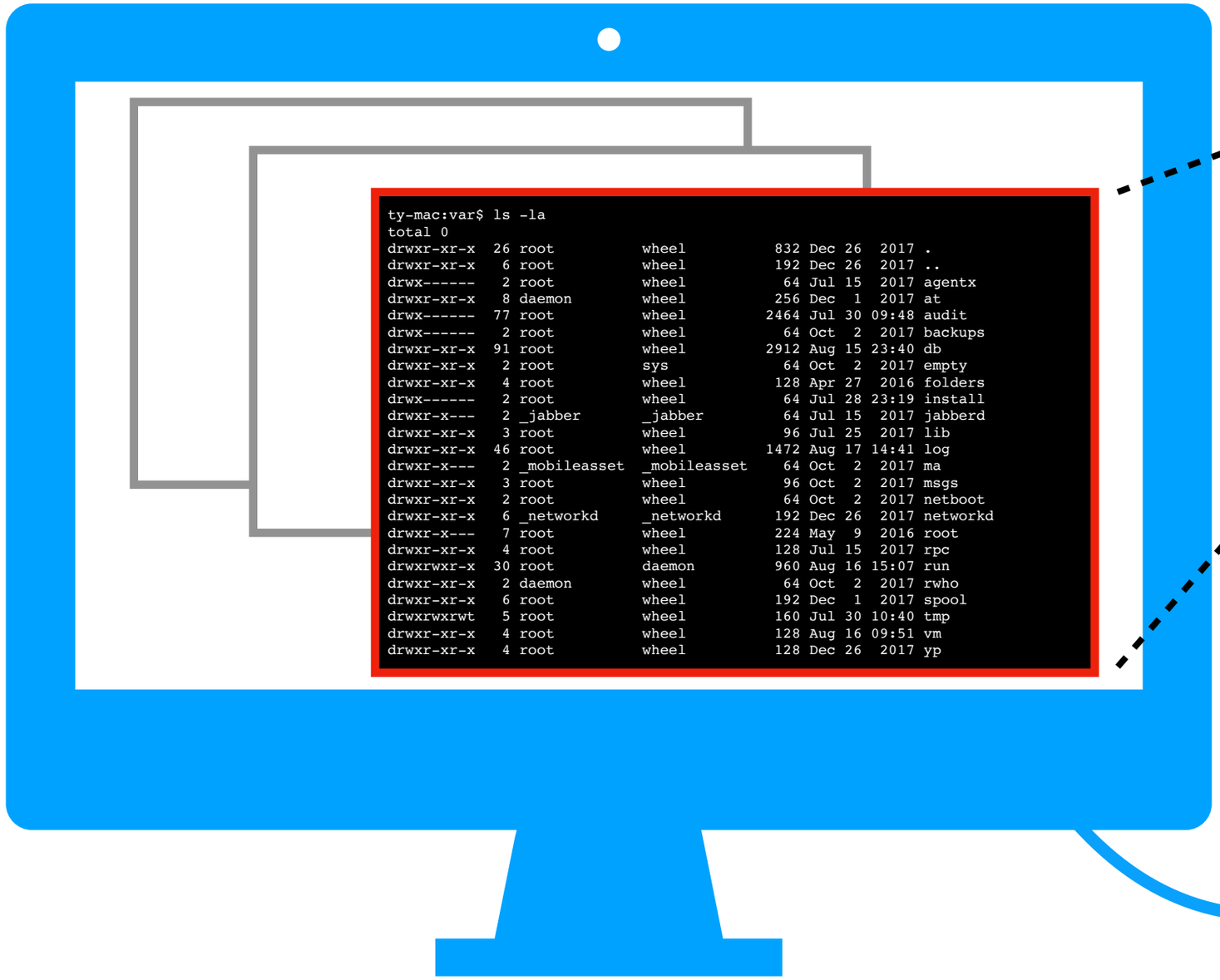
Terminal Emulators



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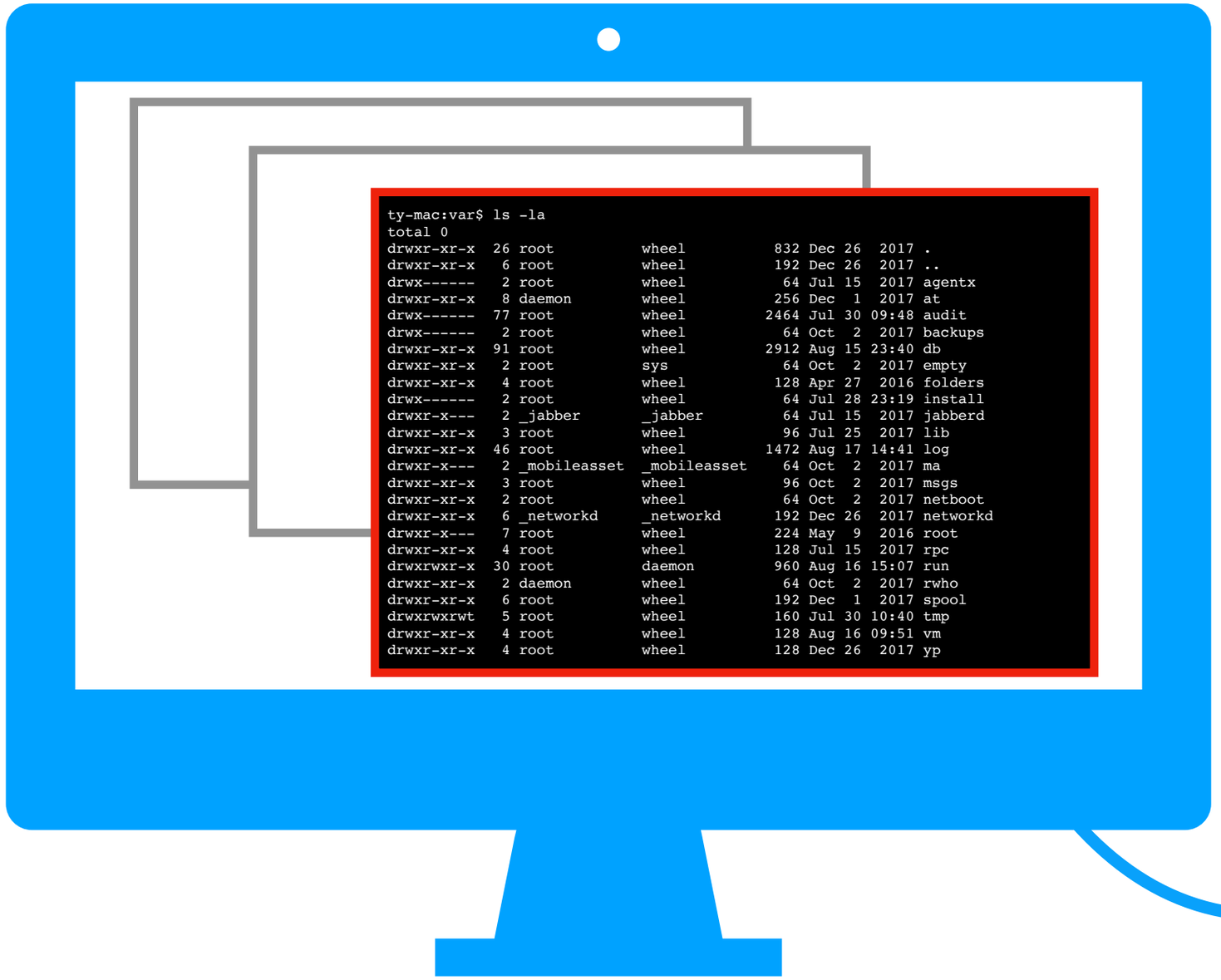
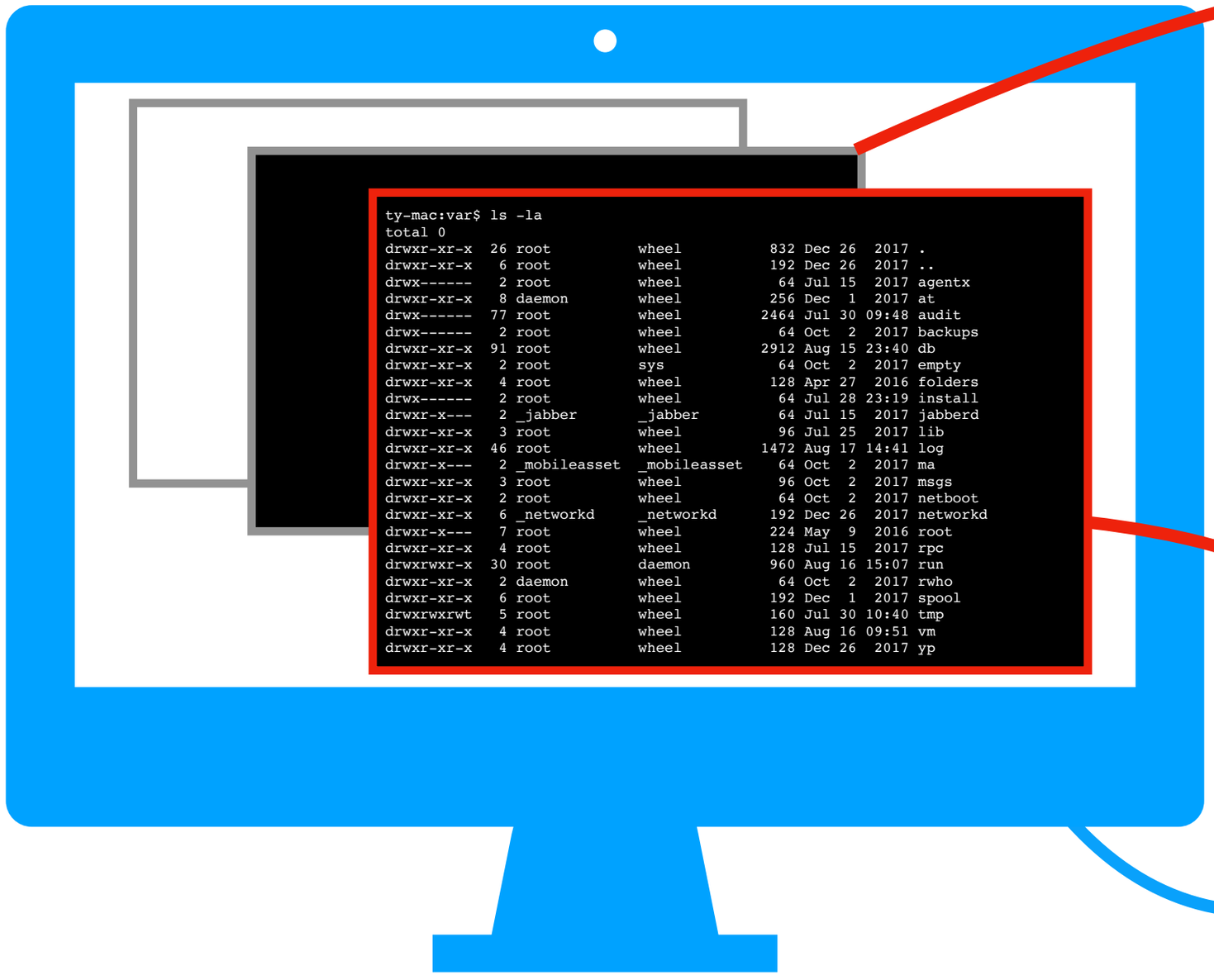
Terminal Emulators



local computer
(e.g., personal)

https://techcrunch.com/2015/08/16/ibm-teams-with-canonical-on-linux-mainframe/
https://en.wikipedia.org/wiki/Computer_terminal#Dumb_terminals

Terminal Emulators



remote computer
(e.g., CS lab)

OR

local computer
(e.g., personal)

https://techcrunch.com/2015/08/16/ibm-teams-with-canonical-on-linux-mainframe/
https://en.wikipedia.org/wiki/Computer_terminal#Dumb_terminals

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Tutorials

Shells

Inside a terminal, a program called a “shell” runs

- The shell lets users type commands, then carries out the appropriate actions
- Exploring files and running programs are common activities
- You will be running Python programs from a shell in a terminal!
- Different shells have minor (or major) variations

Shells

Inside a terminal, a program called a “shell” runs

- The shell lets users type commands, then carries out the appropriate actions
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- You will be running Python programs from a shell in a terminal!
- Different shells have minor (or major) variations

Windows Shells

- cmd
- PowerShell

UNIX Shells

- bash
- csh
- zsh
- many more

Today's Topics

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Tutorials

Running Programs

Running programs is easy, just type name of the program and hit enter:

```
ty-mac:var$
```

Running Programs

Running programs is easy, just type name of the program and hit enter:

```
ty-mac:var$ ls
```

Running Programs

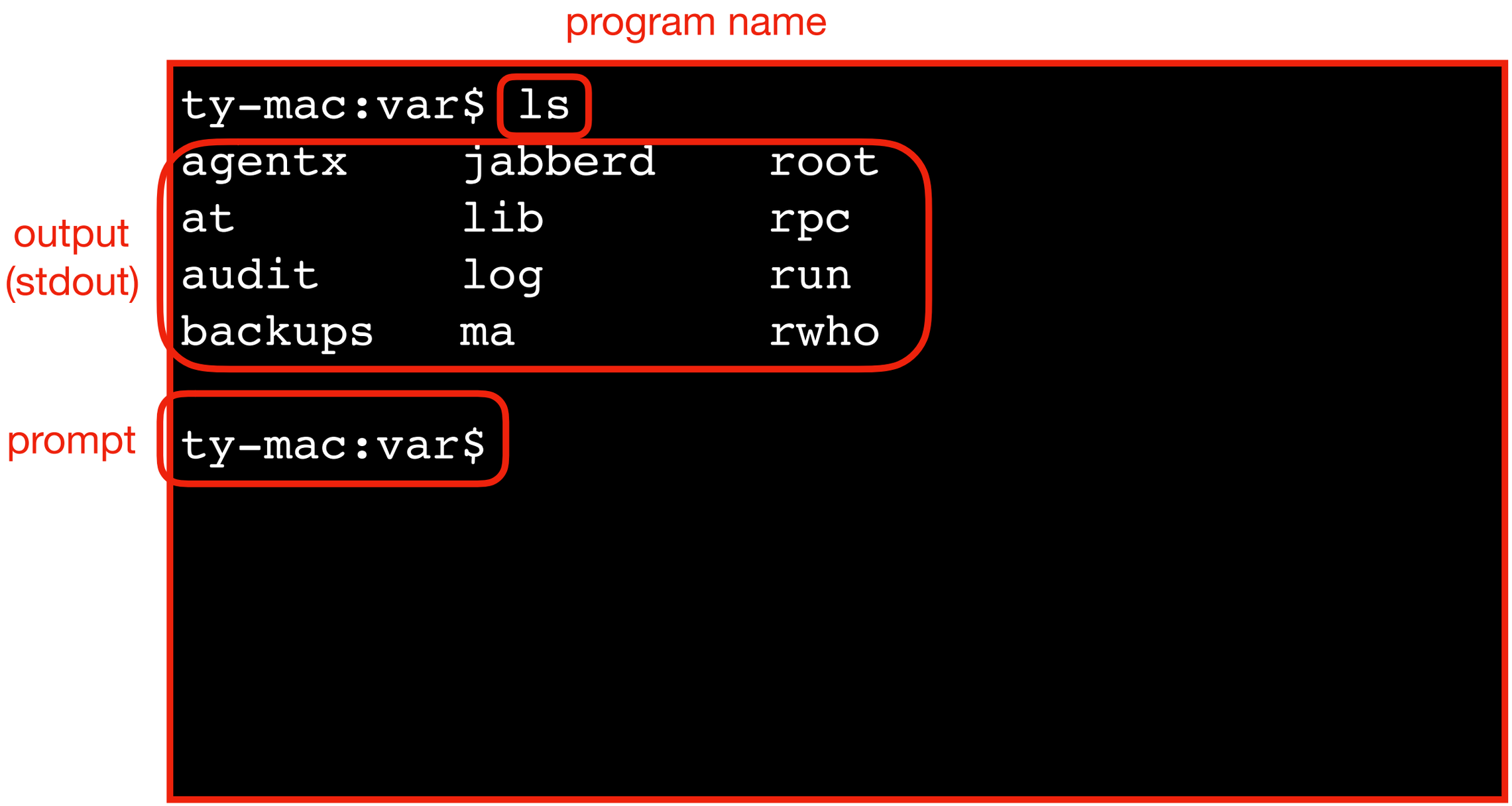
Running programs is easy, just type name of the program and hit enter:

```
ty-mac:var$ ls
agentx      jabberd     root
at          lib         rpc
audit       log         run
backups     ma          rwho

ty-mac:var$
```

Running Programs

Running programs is easy, just type name of the program and hit enter:



Today's Topics

Program Input/Output

File Systems

Terminal Emulators and Shells

Tutorials

- PowerShell
- bash
- Cover navigation, arguments, redirects, pipes, and scripts

Conclusion

Today we covered

- File systems
- Terminals
- Shells
- Navigating in PowerShell and bash
- Redirection and piping