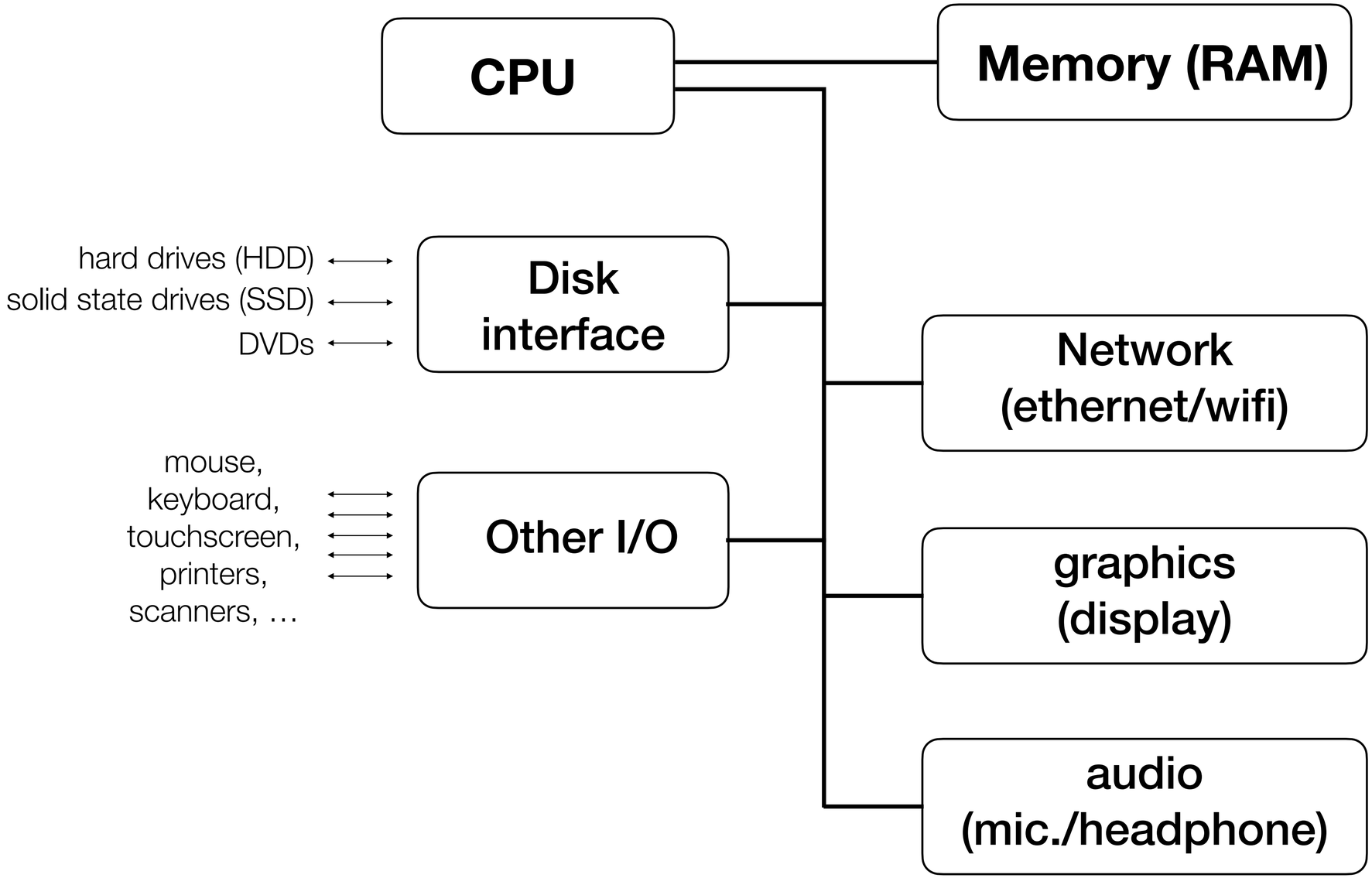
Introduction to computers and computing environments

Mark Stenglein, MIP 280A4

Basic computer architecture



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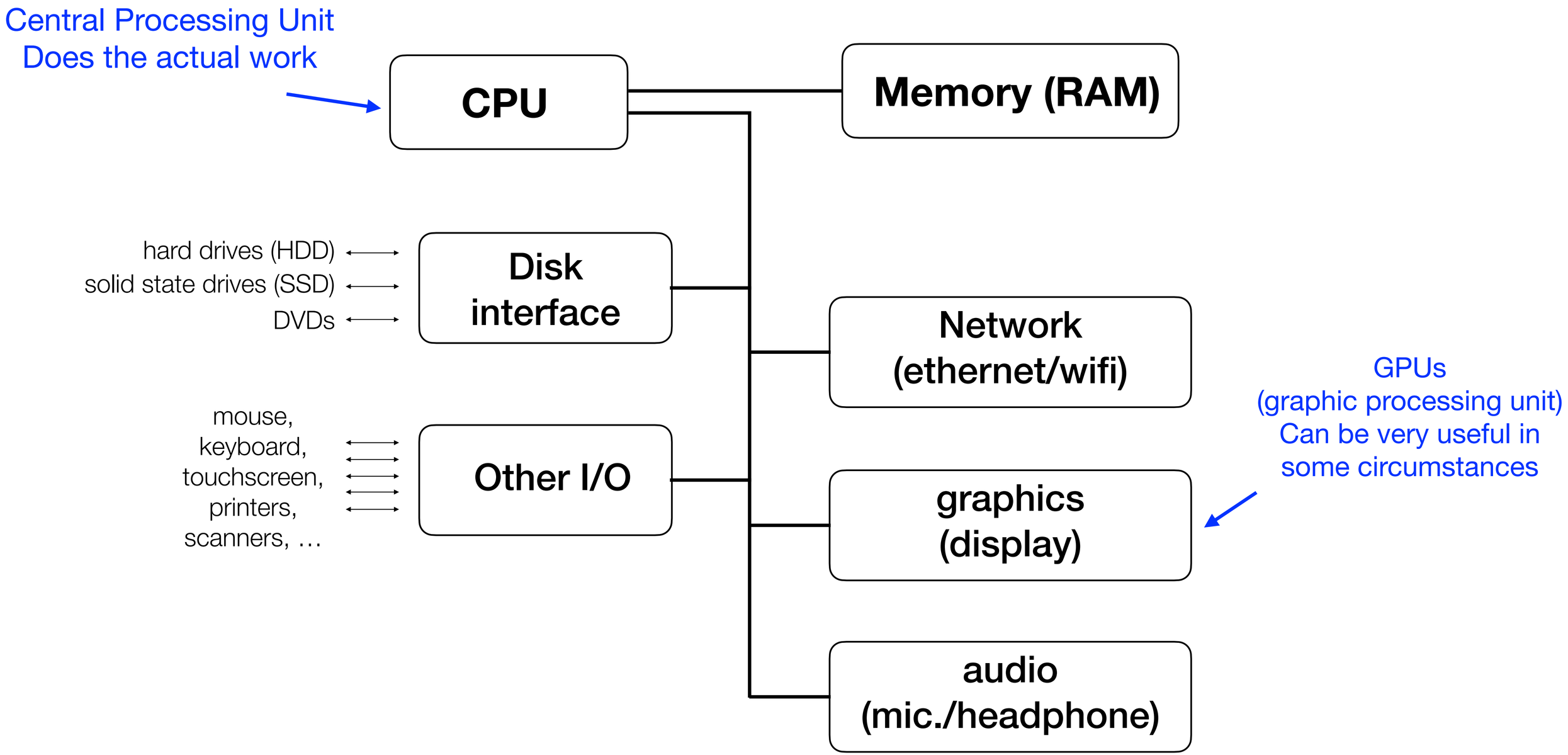

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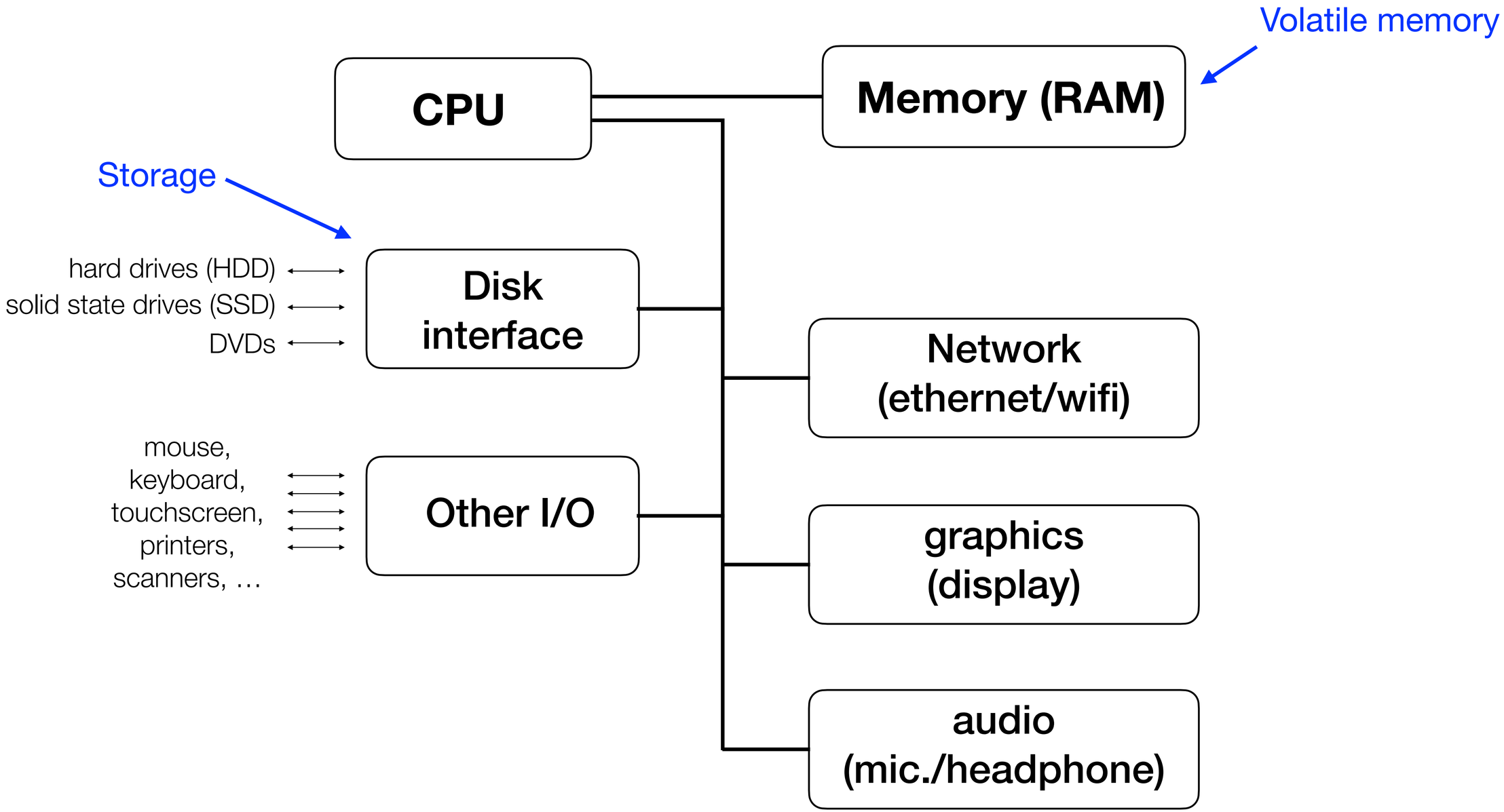

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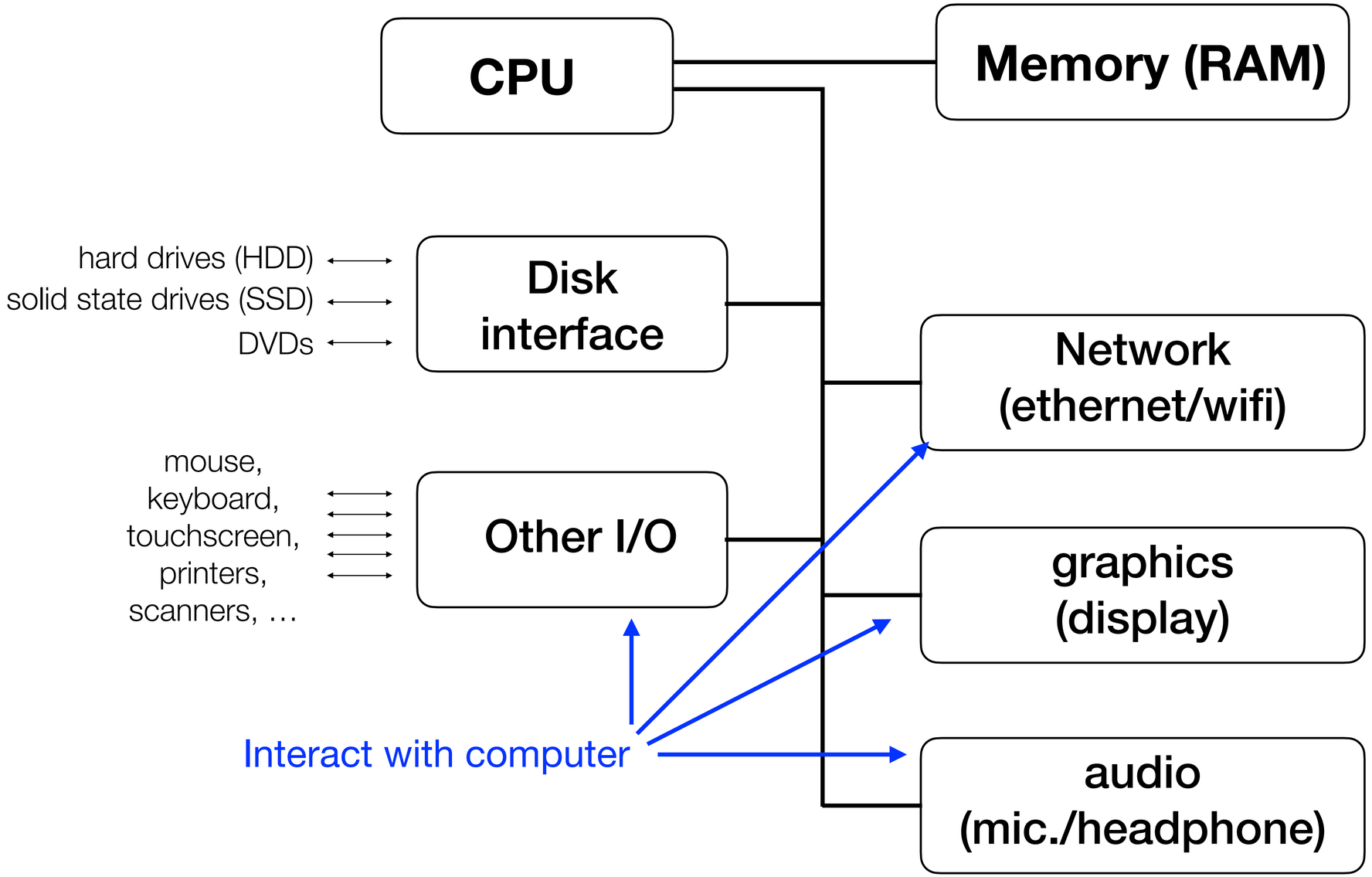
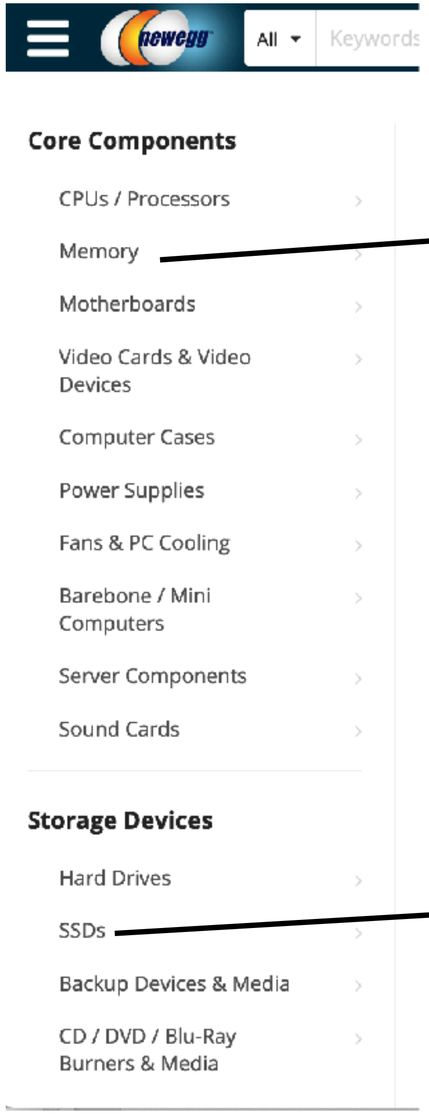


Sometimes people conflate memory (RAM) and storage (hard drives)
But they are different things with different purposes.



Memory (RAM) vs. storage (SSD & HDD)

	Hard drives (HDD)	Solid state drives (SSD)	Main memory (RAM)
Speed	Slow	Much faster	Fastest
Cost per Gb	$0.025	$0.20	$4
Volatile*	No	No	Yes
Uses	Long term storage of large datasets	Laptops, long term storage, OS boot drives	
Other comments	Has moving parts	Replacing HDDs	Some bioinformatic tasks, like genome assembly, require lots of RAM (>128 Gb)

* volatile storage means that the contents of the storage will be lost when the computer is turned off

Storage and memory capacity and computer file sizes are measured in bytes and use the same SI prefixes as genome size

SI prefixes used to quantify storage capacity and file sizes

Name	Symbol	Base 10*	Decimal	English Name
tera	T	10^{12}	1,000,000,000,000	trillion
giga	G	10^{9}	1,000,000,000	billion
mega	M	10^{6}	1,000,000	million
Kilo	k	10^{3}	1,000	thousand

1 byte = 8 bits (binary digit: 1 or 0)

byte 1	byte 2	byte 3
10110100	01110001	11110000

* There is some disagreement about how these value are defined:
(1 kilobyte also sometimes defined as 1024 bytes not 1000 bytes).
Both definitions are used.

Memory (RAM) is like a “mise en place” station in a kitchen. Storage is like a pantry.

Limited capacity but quick to access

Larger capacity, slower to access

How much RAM do you need?

Laptops usually have somewhere between **2Gb** - **16 Gb** of RAM. That much RAM is plenty for some tasks.

Some bioinformatics tasks are processor (CPU) intensive, but use little RAM. For instance, making phylogenetic trees.

Other tasks, like assembly of large eukaryotic genomes or searching large databases with tools like BLAST, require lots of RAM (128 Gb or more). These types of analyses are better done on a dedicated server, a ‘super-computer’, or in the cloud.

How much processing power do you need?

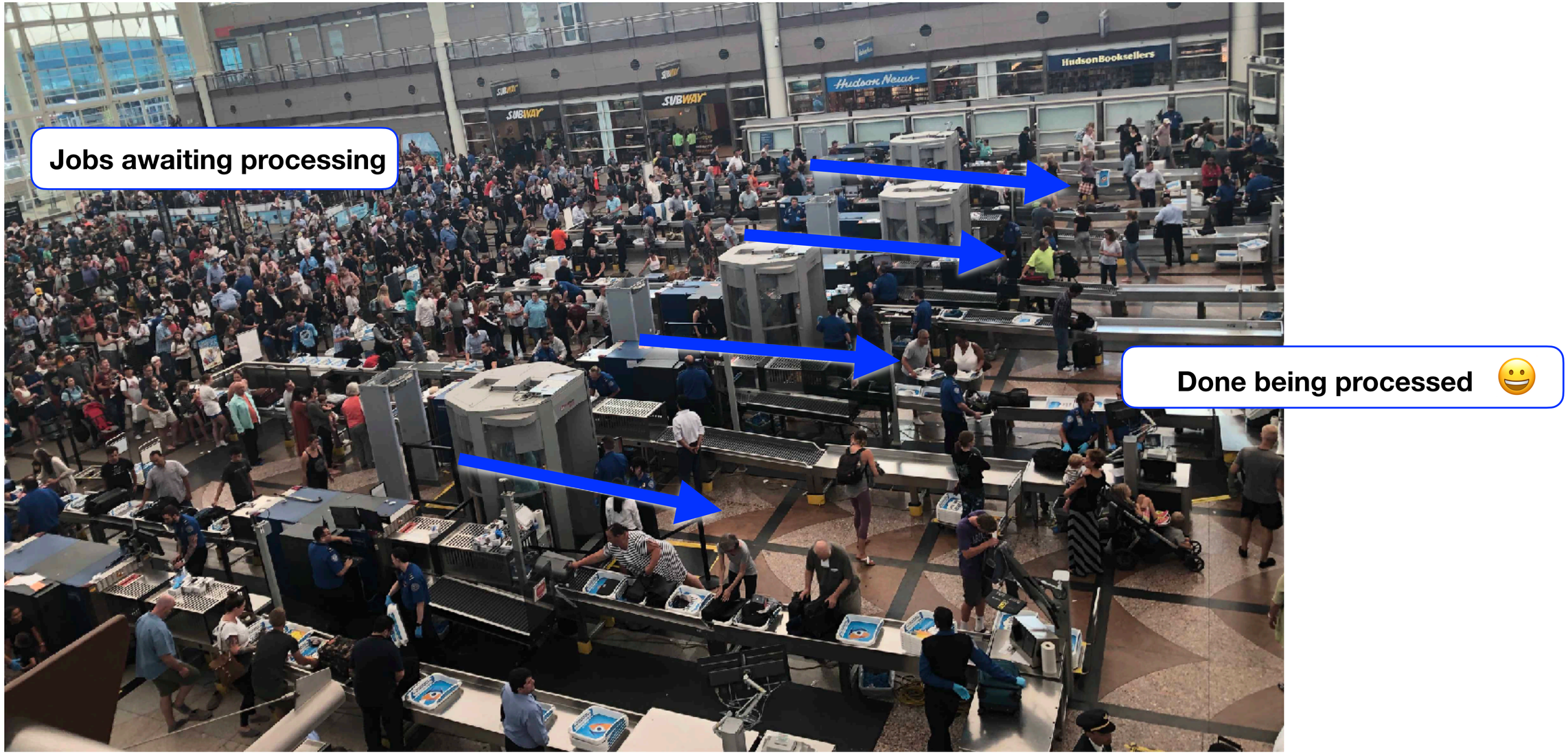
The CPUs in typical laptops (and cell phones even) are very fast compared to past computers.

Nevertheless, some computing tasks would take a long time to run on your laptops. These types of analyses are better done on a dedicated server, a ‘super-computer’, or in the cloud.

One way to know is to just try running a task: if it takes a long time, try moving to a faster computer (server or super-computer).

Parallelization makes life better by shortening the time it takes to accomplish tasks

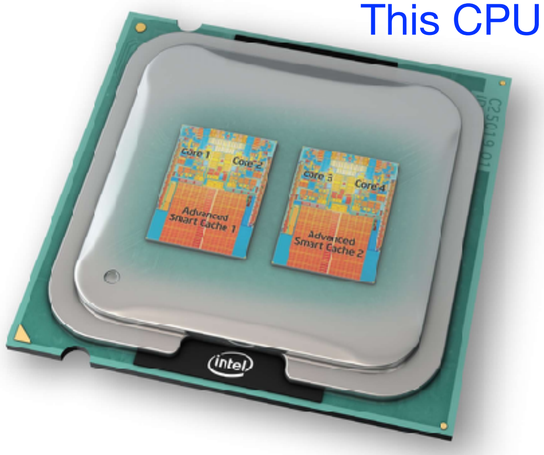
Like airport security, computers can run in parallel



Modern computers have more than one processor

Typically, these are referred to as “cores”.

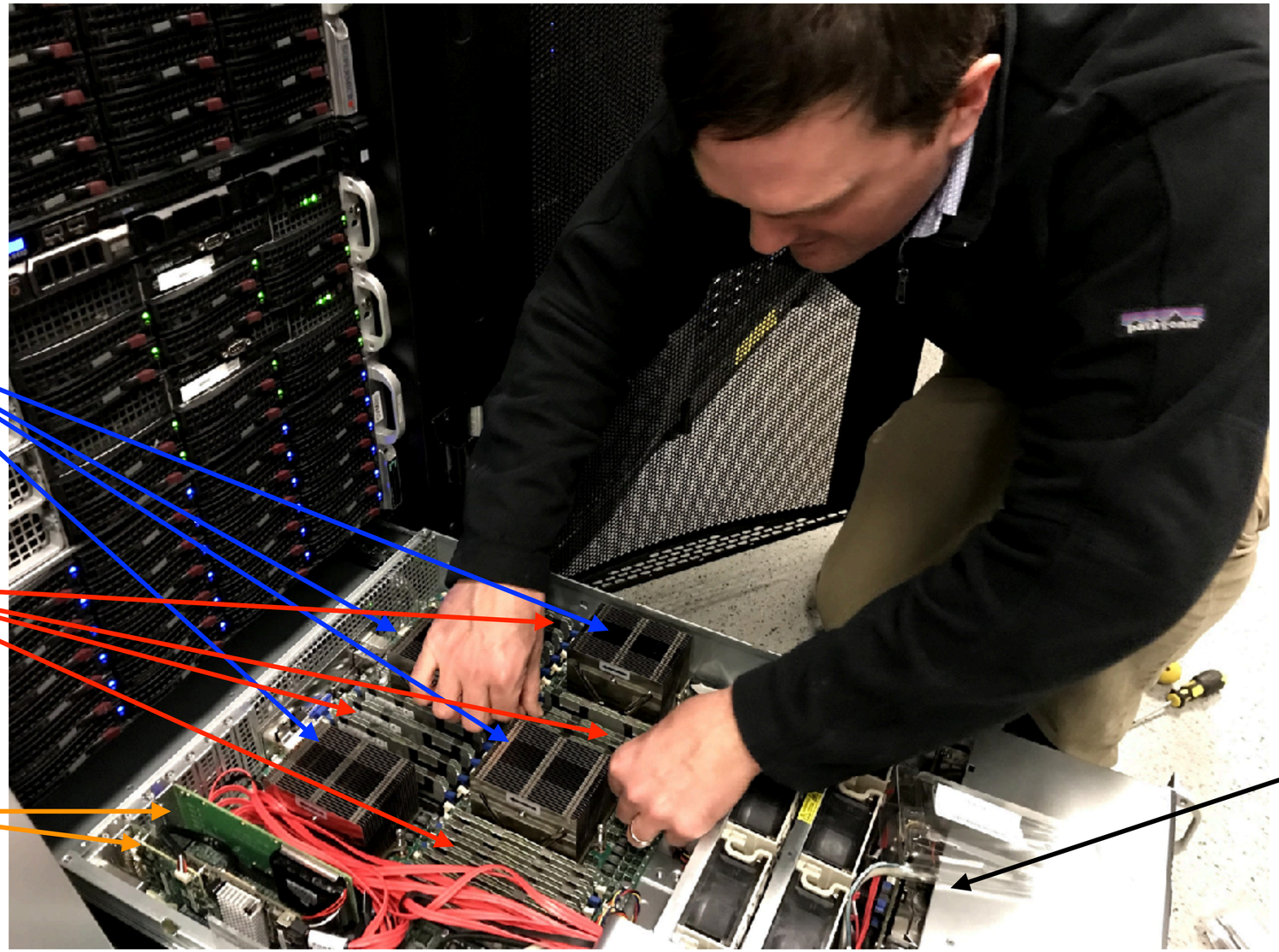
This CPU has 4 cores (4 CPUs)



To add to the confusion: cores can have multiple “threads”, which are effectively additional cores. Intel cores are “hyper-threaded” with 2 threads, which means that the operating systems sees these 4 cores as 8 CPUs.

```
MDSTENGL-M01:Desktop _mdstengl$ sysctl hw.physicalcpu hw.logicalcpu
hw.physicalcpu: 4
hw.logicalcpu: 8
```

A typical bioinformatics server



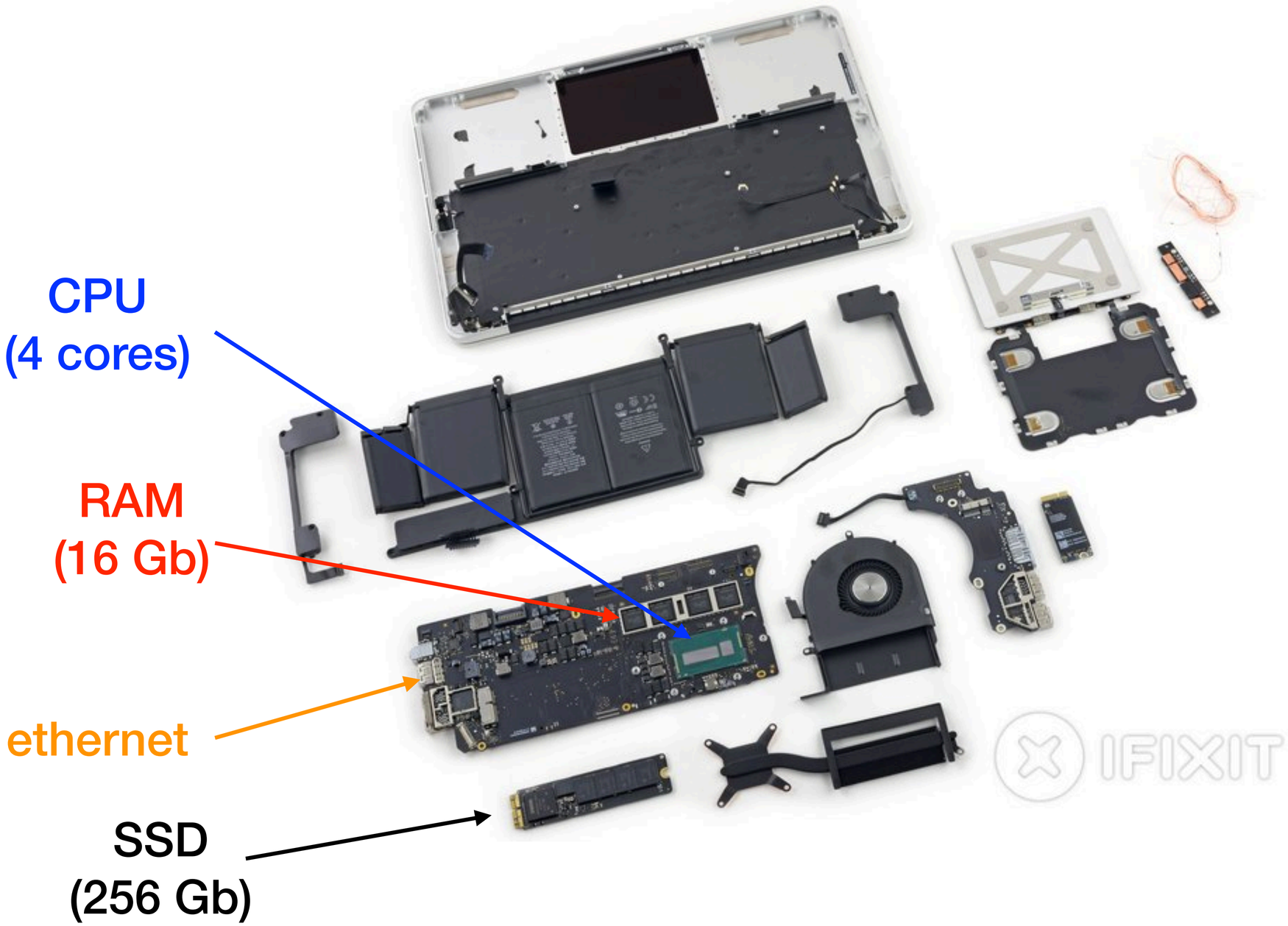
CPUs
(4 x 16 cores =
64)

RAM
(16 x 32Gb =
512 Gb)

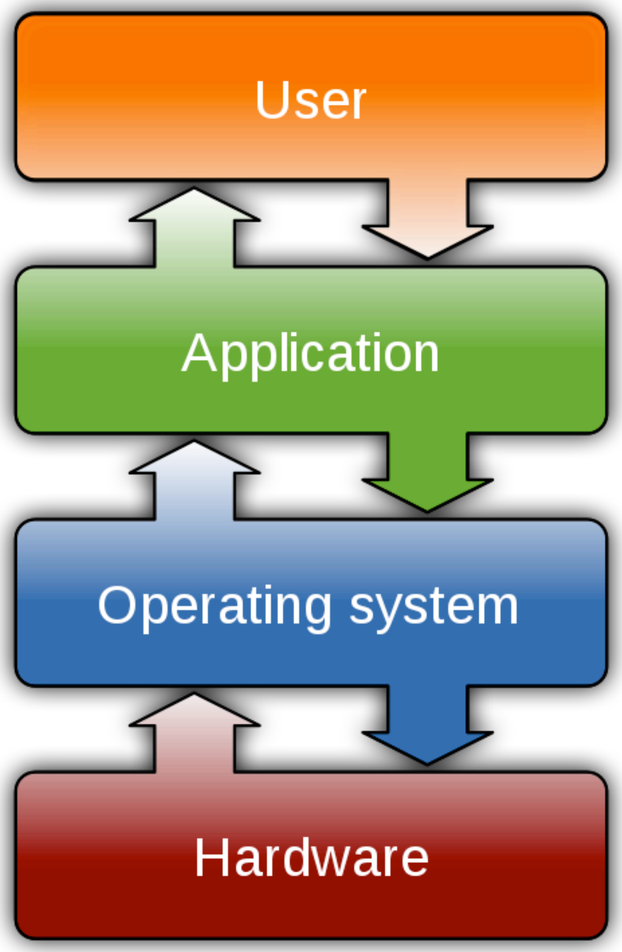
ethernet
(main user
interface)

HDDs (6 x 8 Tb)
& SSDs (2 x 128Gb)
RAID configured

The components of a Macbook



A computer's operating system (OS) is the software that provides an interface between the hardware and the applications and user



Common Operating systems:

- Windows
- Mac OS
- Linux
- Chrome OS
- iOS
- Android

How do you check resource usage and availability?

On your own laptop:

- How much memory is available? How much is used?
- How much storage is available? What type is it? How much is used?
- How many cores and threads are there? What fraction of these are being used?

Exercise: How do you check resource usage and availability?

On your own laptop:

- How much memory is available? How much is used?
- How much storage is available? What type is it? How much is used?
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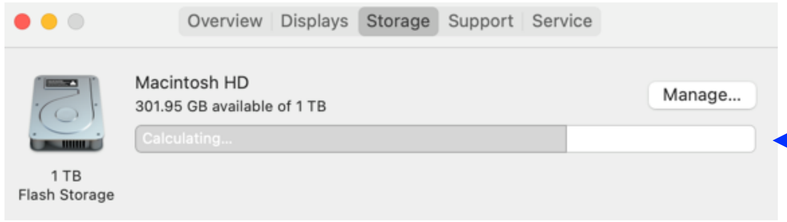
Check resources available on Mac:

Apple menu -> About This Mac

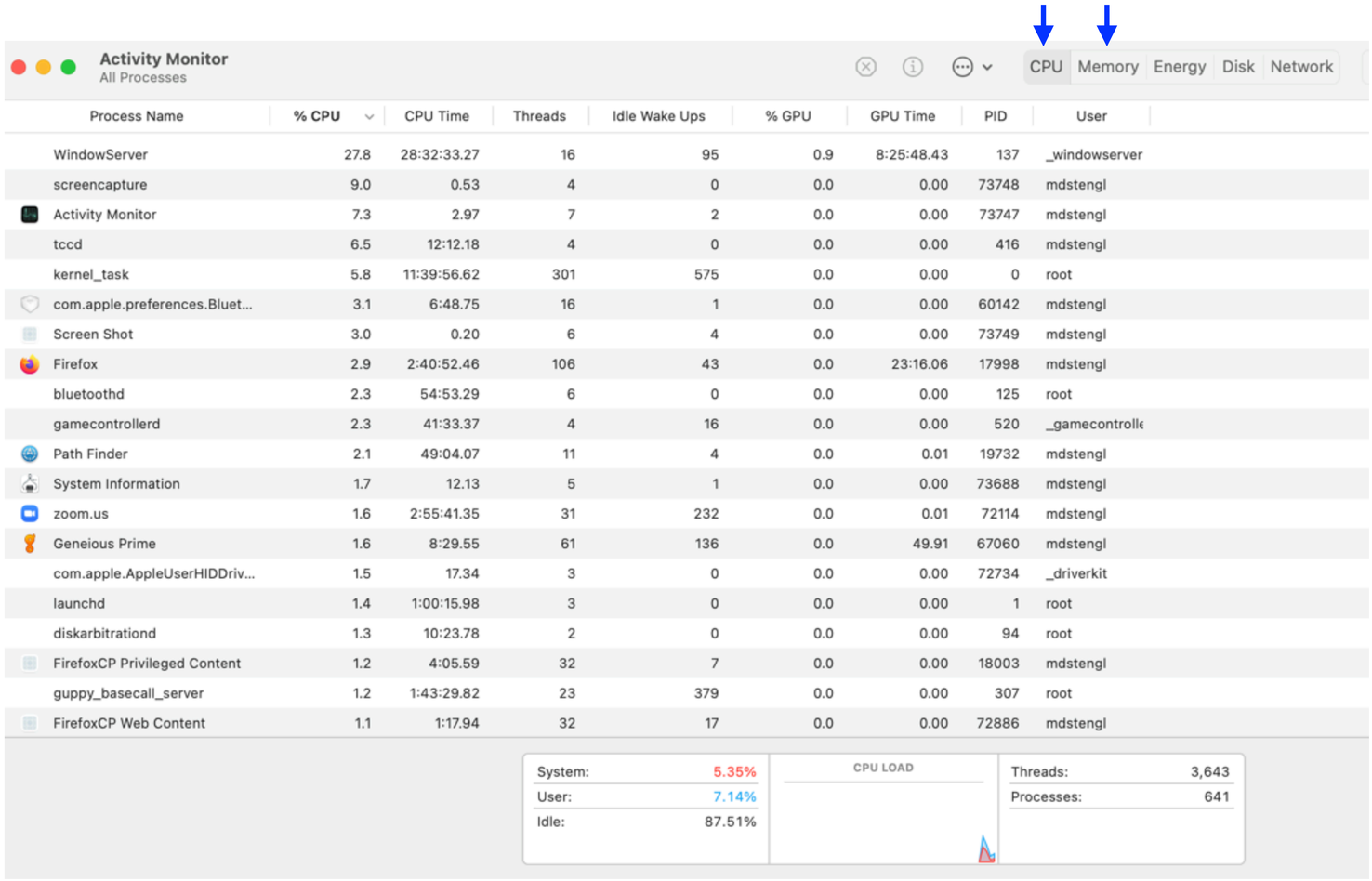
CPU: quad Intel core = 4 cores x 2 threads = effectively 8 CPUs

16 Gb of RAM



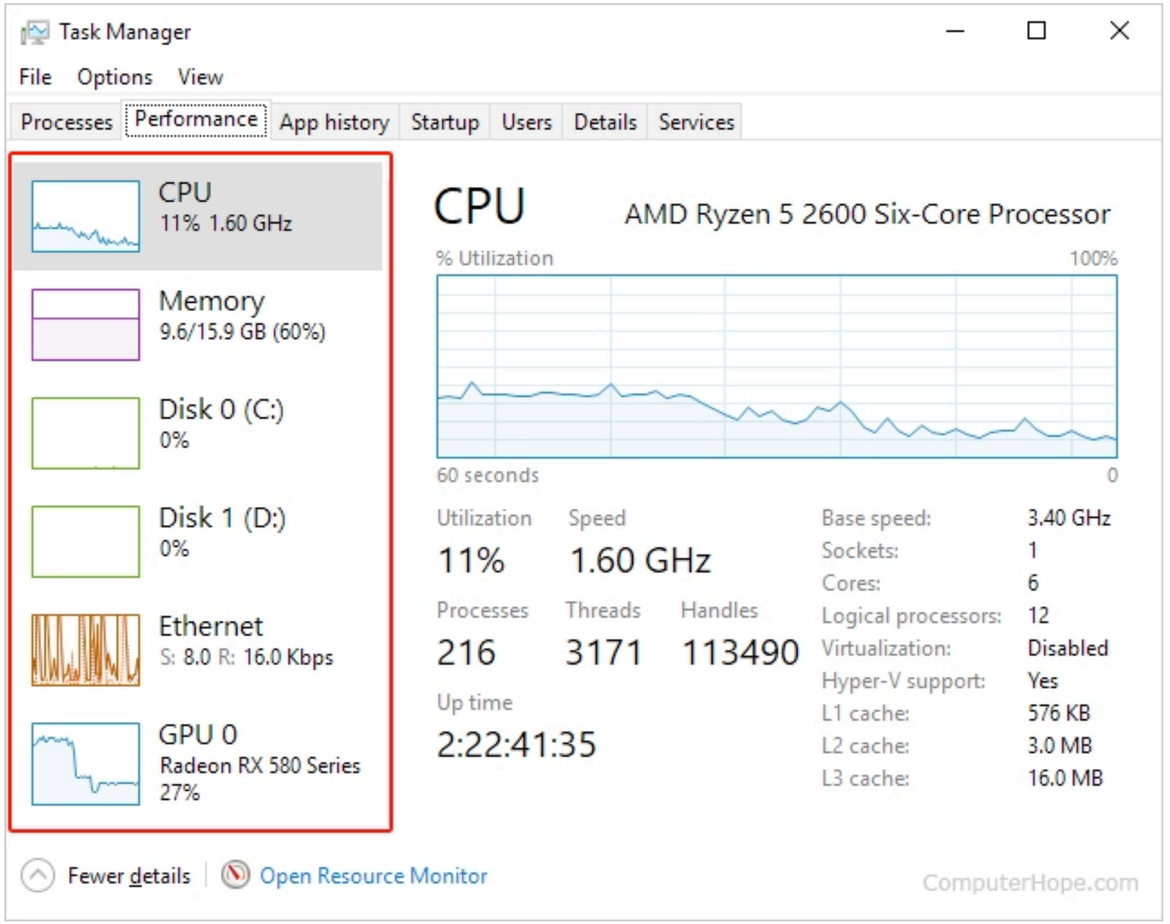
1 Tb SSD for storage
(Flash storage = SSD)

Activity Monitor: checks resource usage on a Mac



Use Task Manager to check resource usage in Windows

- Windows tab (bottom left-hand corner)
- Type ‘task manager’
- Performance tab



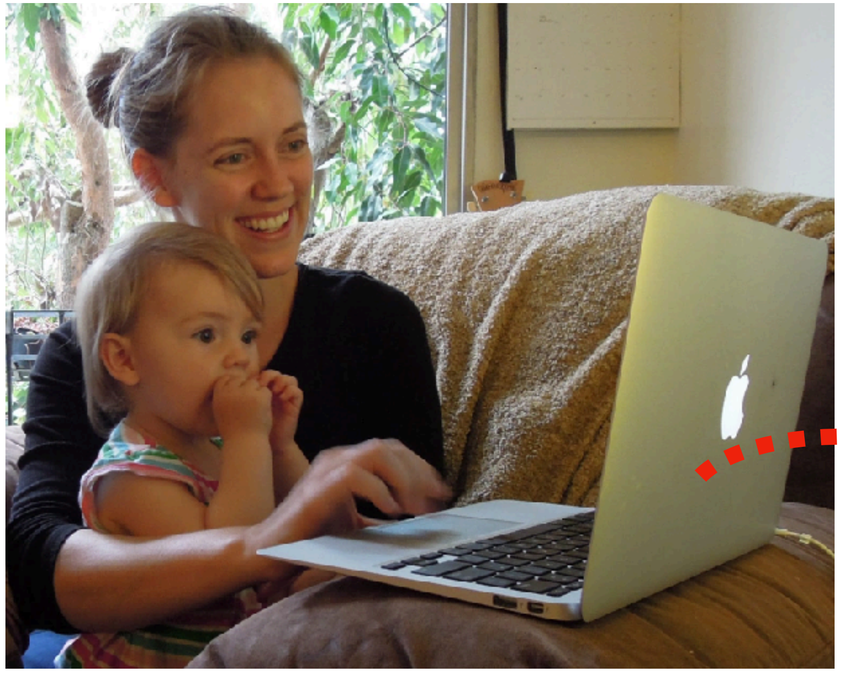
For chromebooks

https://www.lifewire.com/how-to-check-chromebook-specs-hardware-4782658

Local vs. remote computing

Local: you are using the resources on your computer

Remote: you are using the resources of a distant computer, but probably still connected through your own computer



the internet

a server somewhere

Connecting to remote computers on the command line

Typically you connect to a remote server via the command line using a “secure shell” (ssh). For instance, to connect to the thoth01 server, I would open the Mac OS Terminal and run:

```
ssh mdstengl@thoth01.cvmbs.colostate.edu
```

Replace mdstengl with your CSU eid

- Mac OS: use the built-in Terminal app
- Windows: use MobaXterm: https://mobaxterm.mobatek.net/
- Chrome OS: use the ssh chrome extension: https://chrome.google.com/webstore/detail/secure-shell/iodihamcpbpeioajjeobimgagajmlibd

Connecting to remote computers on the command line

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ssh mdstengl@thoth01.cvmbs.colostate.edu
```

Note that this server is inside the CSU firewall, so to connect to it you have to either:

1. Be on the CSU ethernet (ethernet cable plugged in to your computer)
2. Be on the csu-eid wifi network
3. Be connected through a virtual private network (VPN). See: https://www.acns.colostate.edu/security/#1478123291089-f3918698-6eec

Thoth is the Egyptian god of
“moon, wisdom, writing, hieroglyphs, science, magic, art, and judgment”

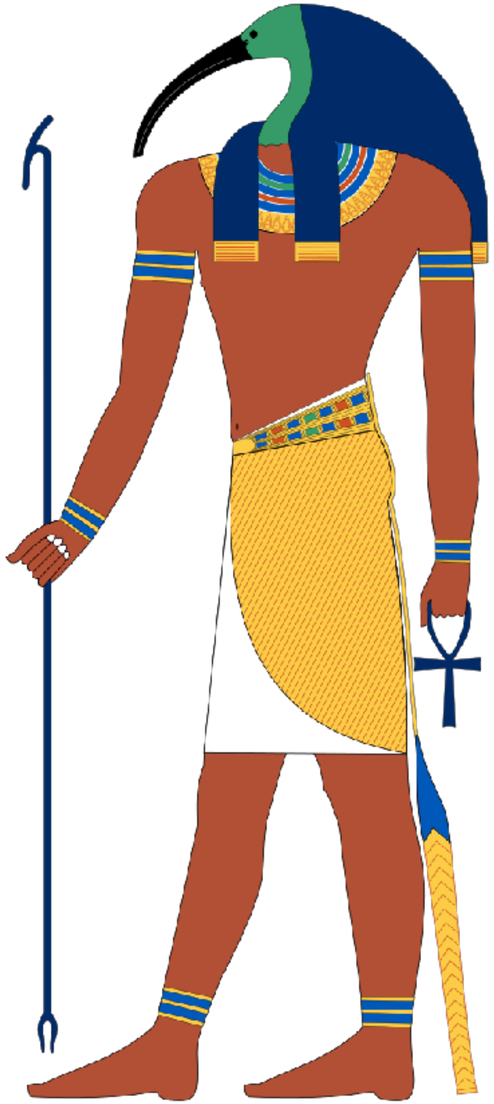

Image: Jeff Dahl, CC-BY-SA-4.0. Link

Source: https://en.wikipedia.org/wiki/Thoth

Checking resource usage and availability on a remote server through the command line

command		better way to run it
`df`	reports disk usage and storage	`df -h`
`top`	reports CPU & memory usage	`htop`

Use these commands to answer the same questions:

- How much storage is available? How much is used?
- How much memory is available? How much is used?
- How many cores and threads are there? What fraction of these are being used?

Cloud computing is an increasingly popular form of remote computing

Advantages:

- Scalable and flexible
- Don’t have to buy, host, or maintain servers
- Can take advantage of pre-existing images and containers

Disadvantages:

- Can be expensive
- Have to pay to store and transfer data
- Can be slow to transfer data

Real physical computing resources are available as virtual computers through the internet

image: gigabitmagazine.com

Cost of cloud computing depends on how many resources you need

	vCPU	ECU	Memory (GiB)	Instance Storage (GB)	Linux/UNIX Usage
t2.large	2	Variable	8 GiB	EBS Only	$0.1104 per Hour
t2.xlarge	4	Variable	16 GiB	EBS Only	$0.2208 per Hour
r5.12xlarge	48	173	384 GiB	EBS Only	$3.36 per Hour
r5.24xlarge	96	347	768 GiB	EBS Only	$6.72 per Hour

Similar to typical laptops

Similar to the servers my lab uses

Plus ~$0.05-$0.15 per Gb-month for (short term) storage: $50-$150 per month per Tb

Plus ~$0.09 per Gb to transfer from Amazon to anywhere else: $90 per Tb

An Amazon Web Services (AWS) linux environment