



Computing

Clouds

Cloud Computing

AMIs

Workshop AMI

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Workshop on Genomics
2026



AMIs, the Cloud, and Computing

Fundamentals

The Human Interface to the Digital World

- ⇒ You!
- ⇒ Experience computing through:
 - GUIs
 - Touch and Voice
 - CLIs
- ⇒ Technology exists to extend human capabilities?
- ⇒ User Experience (UX), Human-Computer Interface (HCI) and Accessibility

Users



Fundamentals

The Human Interface to the Digital World

- ⇒ How many computers are in this room?
 - ~70 laptops?
 - ~70 phones?
 - Tablets?
 - Smart Watches?
 - Routers
 - Other 'smart' devices?
 - Other microcontrollers/chips?
- ⇒ Ubiquitous!
 - But do you know how they work?



Fundamentals

Bridging User Needs and System Capabilities

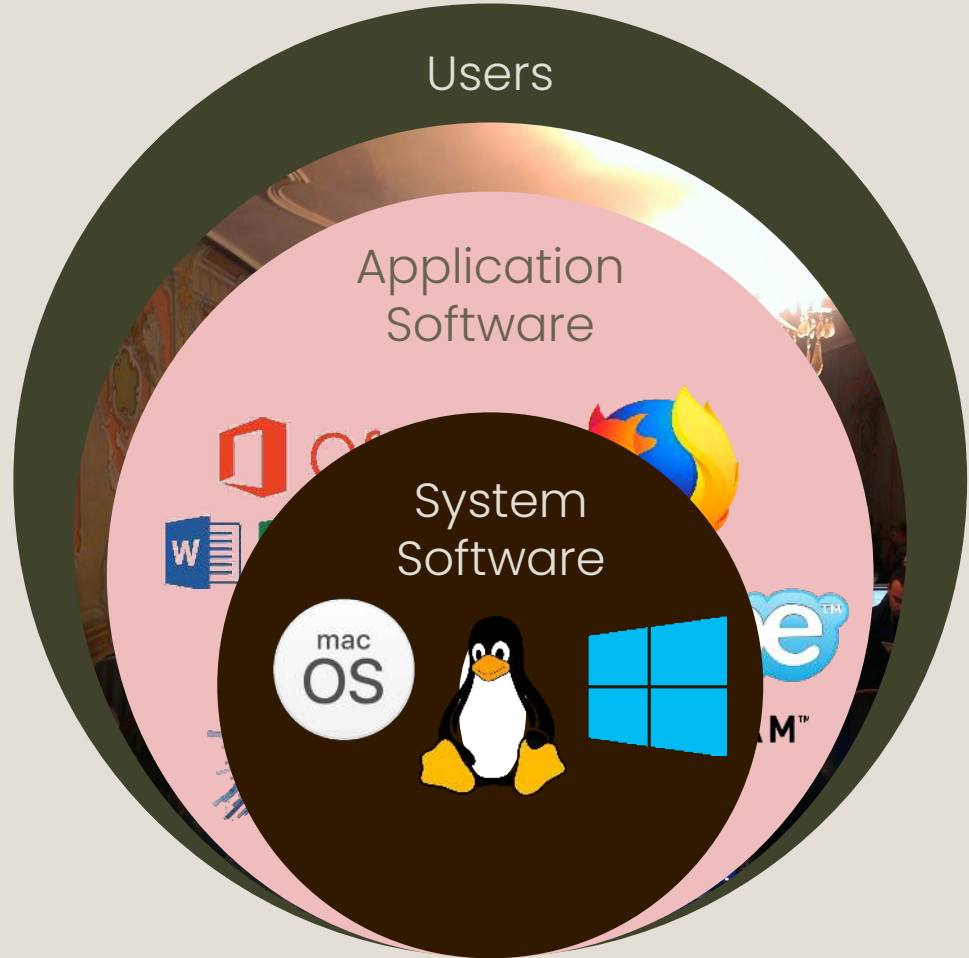
- ↪ Directly serves user requirements
 - ↪ Productivity Tools
 - MS Office
 - ↪ Creative Applications
 - Photoshop
 - ↪ Scientific and Research Software
 - The next two weeks...
 - ↪ Entertainment and Gaming
-
- ↪ Translates user intentions into computational actions



Fundamentals

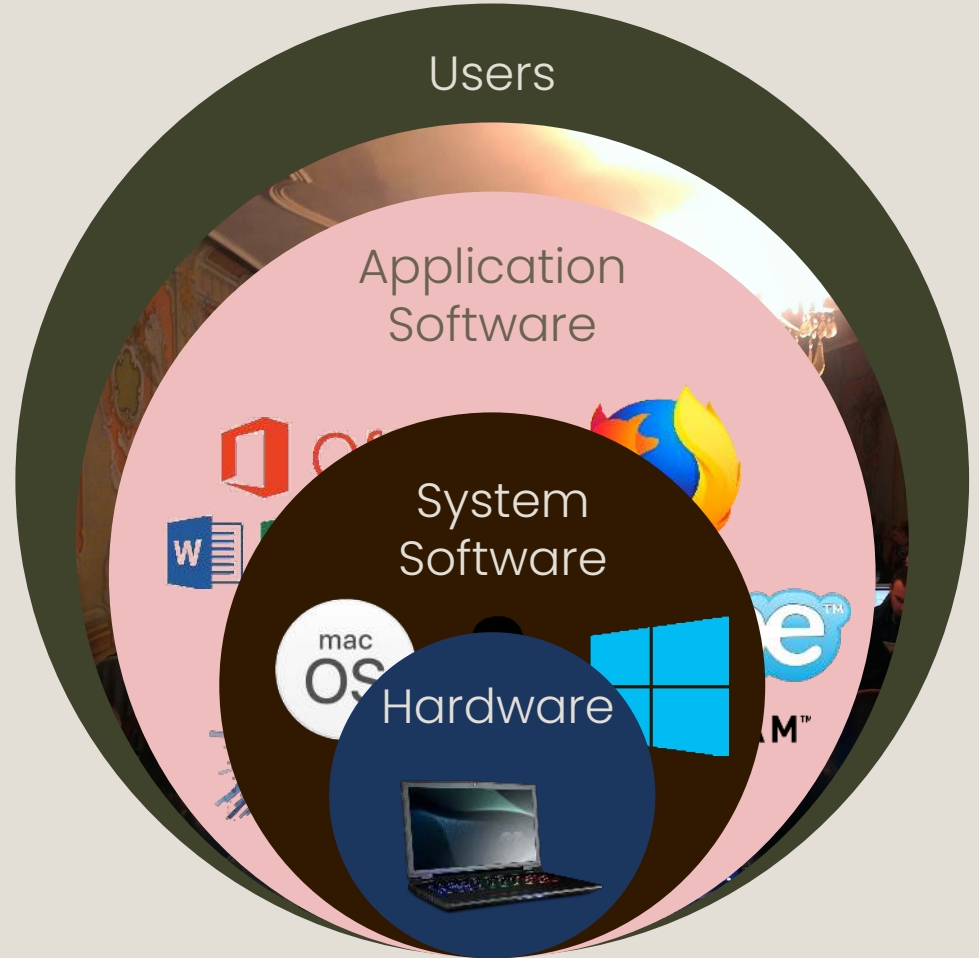
The Computational Translator

- Acts as an intermediary between hardware and application software
- Key Components:
 - Operating Systems
 - Device Drivers
 - Utility Programs
 - Runtime Environments
- Primary Functions:
 - Resource Management
 - Process Scheduling
 - Memory Allocation
 - Security and Access Control
- Compilers, Linkers and Assemblers



Fundamentals

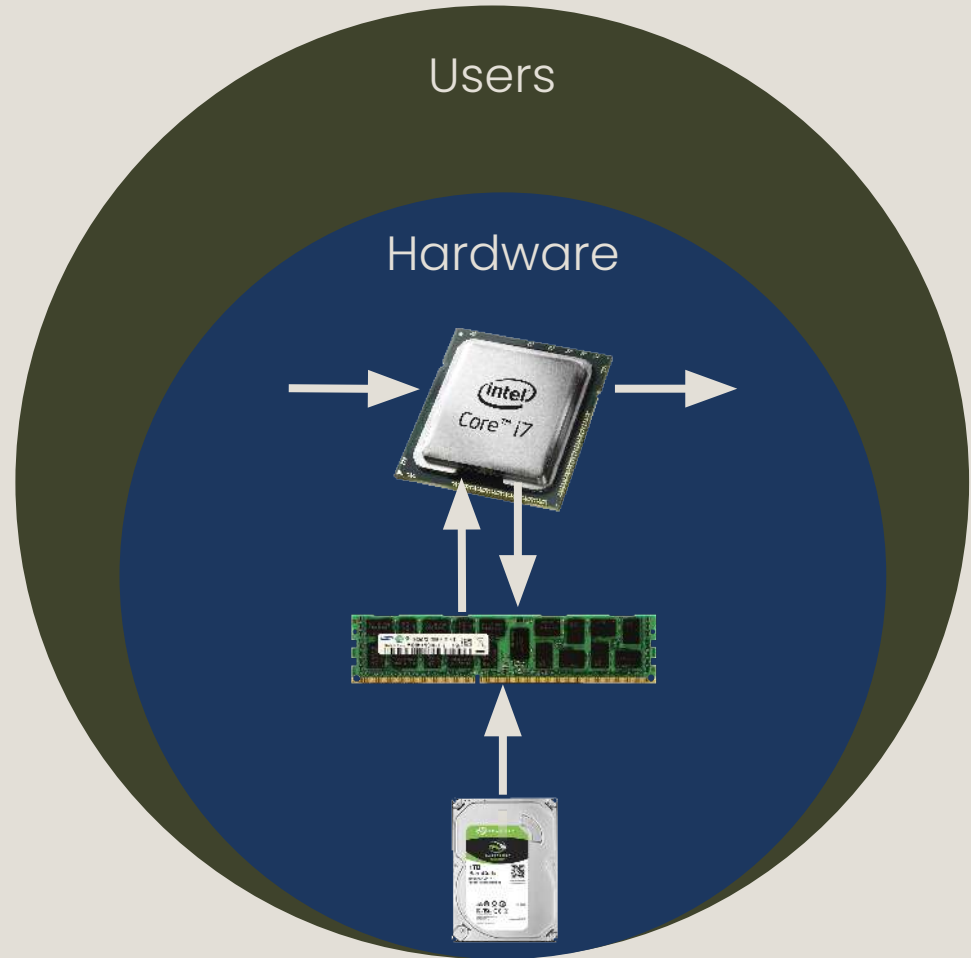
The Physical Foundation



Fundamentals

The Physical Foundation

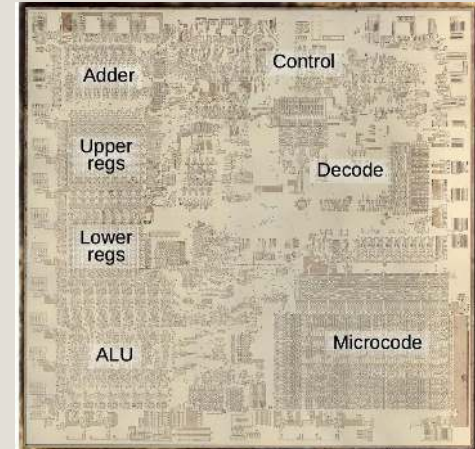
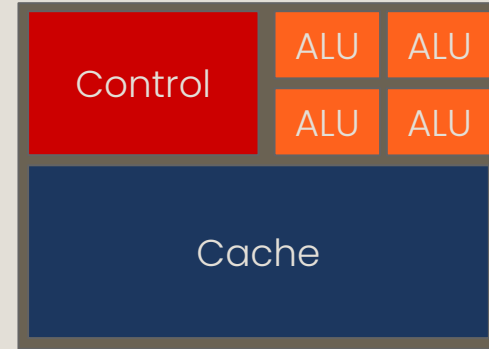
- Key Components:
 - Central Processing Unit (CPU)
 - Random Access Memory (RAM)
 - Storage Devices
 - Input/Output Devices
 - Network Interfaces
- “fetch-decode-execute” cycle to process program instructions
- Computer performance depends on cache size, clock speed and the number of cores



Fundamentals

→ CPU

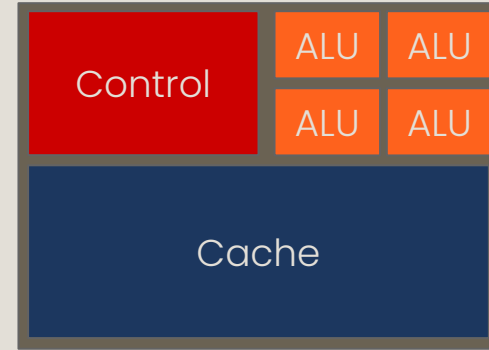
- **Control Unit**
 - “fetch-decode-execute”
 - Transfers data and instructions around the system
- **Arithmetic Logic Unit (ALU)**
 - arithmetic and logical operations
- **Cache**
 - small amount of high-speed random access memory (RAM)
- **Clock**
 - Coordinates all the components, measured in Hertz (Hz)



CPU vs GPU

→ Central Processing Unit

- Core computational operations
- Low compute density
- Complex Control Logic
- Large Cache
- Optimised for serial operations



→ Graphical Processing Unit

- Specialised computational operations
- High compute density
- High computation per memory access
- Built for parallel operations



CPU: Cores vs. Threads

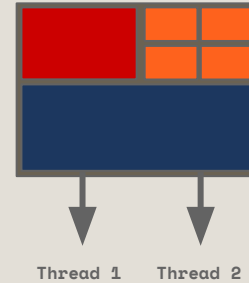
→ What is a CPU Core?

- A core is an independent processing unit within a CPU.
- Each core can execute its own instructions simultaneously.
- Early CPUs had only one core, but modern CPUs have multiple cores for parallel execution.
- More cores = better performance for multi-threaded applications.

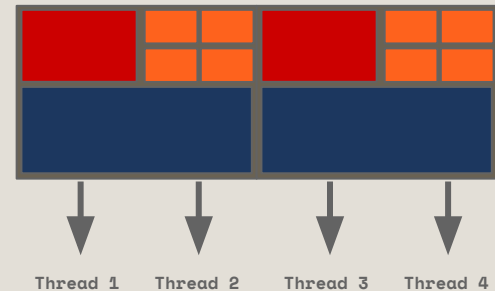
→ What is a Thread?

- A thread is a sequence of instructions executed by a CPU.
- Each physical core can run one or more threads.
- Single-threaded applications: Run on one core at a time.
- Multi-threaded applications: Can run across multiple cores for improved performance.

Single Core CPU



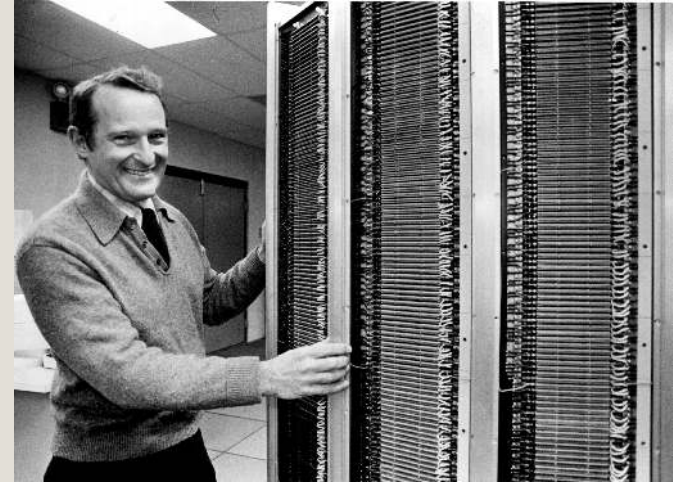
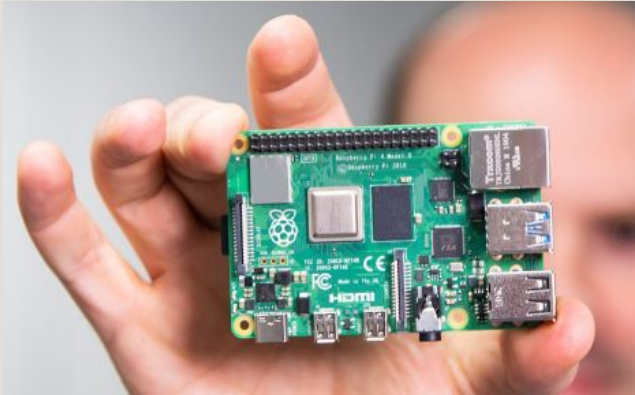
Dual Core CPU



Mainframes & Supercomputers

11

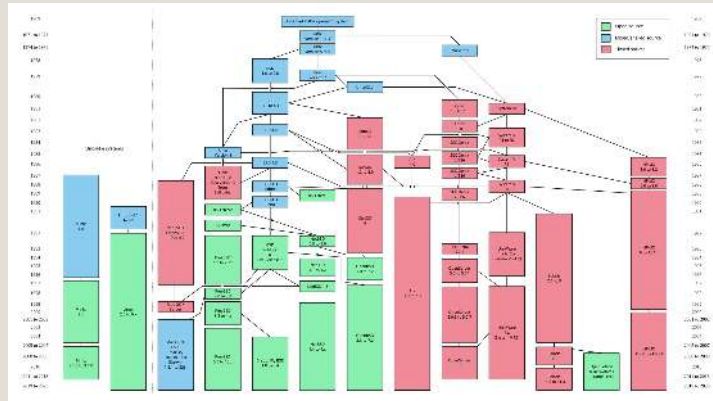
- In 1978, the Cray-1 supercomputer cost \$7 million, weighed 4762 kg and had a 115 kilowatt power supply. 1 CPU.
- The Raspberry Pi costs around \$70 (CPU board, case, power supply, SD Card), weighs 50g uses a five watt power supply and is more than 4.5 times faster than the Cray-1. 1 CPU = 4 Cores



Virtual Computing and Terminals

- ⇒ How did users access the mainframe computers?
 - Terminals!
 - Originally, a physical device (teletypewriters "TTYs") that connected to a remote computer.
 - The term "terminal" comes from it being the endpoint of a session on a mainframe.
 - Allowed users to interact with powerful shared systems (early UNICS(X) mainframes, minicomputers).
 - Eventually replaced by terminal emulators running inside modern operating systems.





Virtual Terminals

- With the advent of personal computers and 'super-computers', terminals were no longer *useful*.
 - Telnet (1970s-1990s) – Early network-based remote access (unencrypted, insecure).
 - SSH (1995-present) – Secure, encrypted alternative for remote terminal access.
- What is the Shell?
 - The shell is a command-line interpreter that sits between the user and the operating system.

User Space

Remote Space



BASH
THE BOURNE-AGAIN SHELL



What is The Cloud?

Is this it?

- ⇒ A shift from local to remote computing
- ⇒ Key characteristics:
 - On-demand resource allocation
 - Pay-as-you-go models
 - Scalability and flexibility
- ⇒ How old is it?
 - 1960s!
 - Data centres at DARPA
 - 1970s: IBM Time sharing
 - 1990s: VPNs
 - 2000s: Amazon etc



* The only generative AI content in these slides...



The Cloud

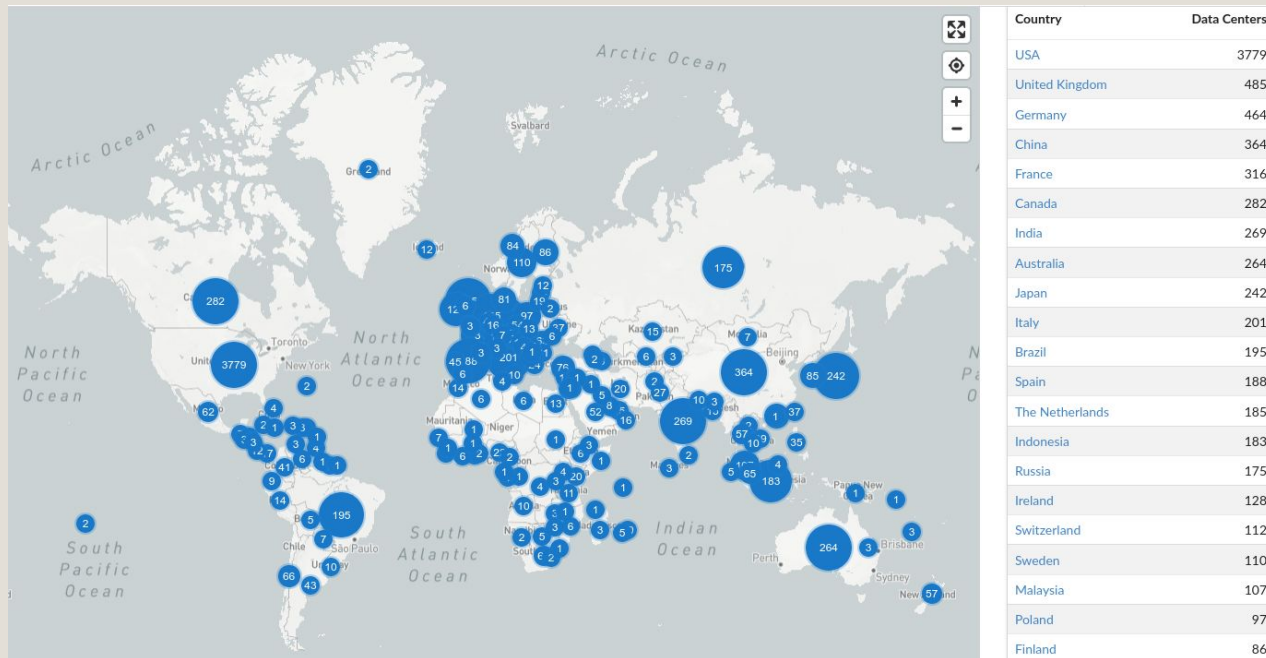
- **You have all been using it for most of your lives...**
 - Social Media
 - Email & Storage
 - Large Language Models (AI)
 - Computing
- **Amazon Web Services**
 - Early 2000s – Scalability issues running e-commerce
 - Decouple components – sped up development & reduced bottlenecks
 - Infrastructure as a service: 2006+ = EC2, S3 = Cloud!

It's these things...



Data Centres

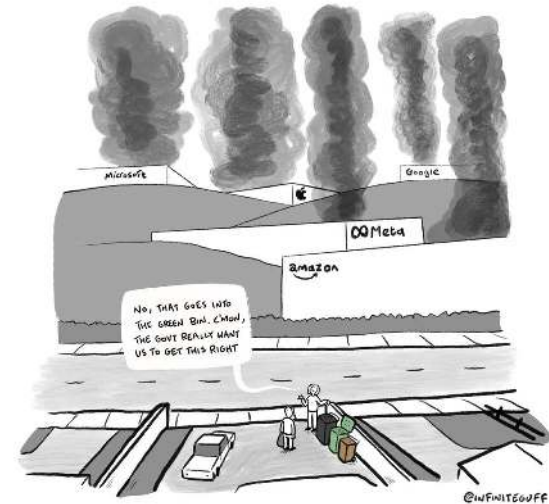
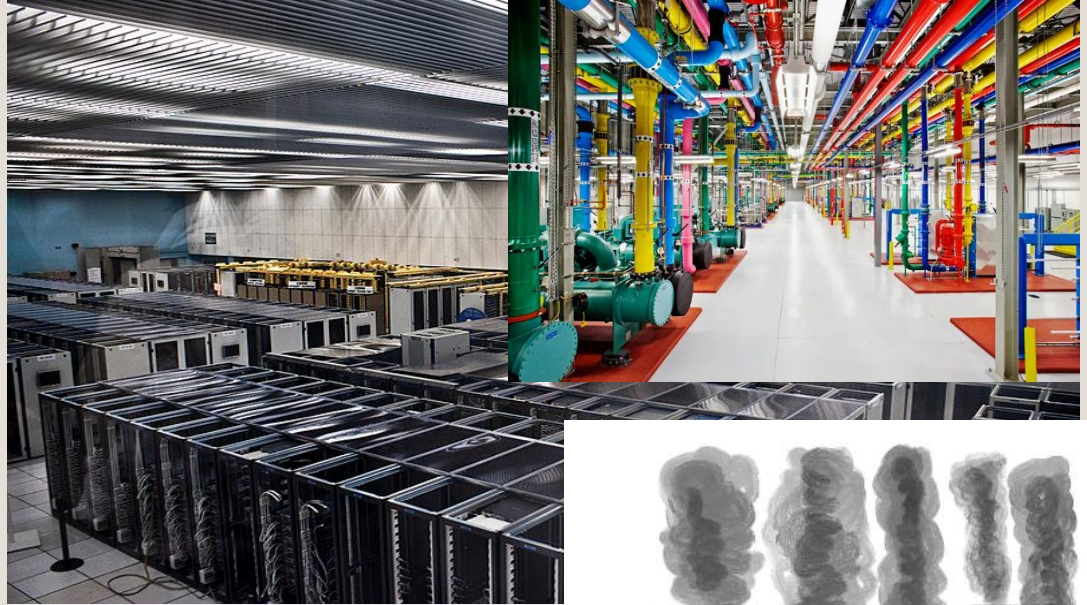
- ⇒ Cloud servers are located in data centers all over the world
- ⇒ Amazon Web Services
- ⇒ Microsoft Azure
- ⇒ Google Compute
- ⇒ Other regions have their own solutions...



Source: <https://www.datacentermap.com/>

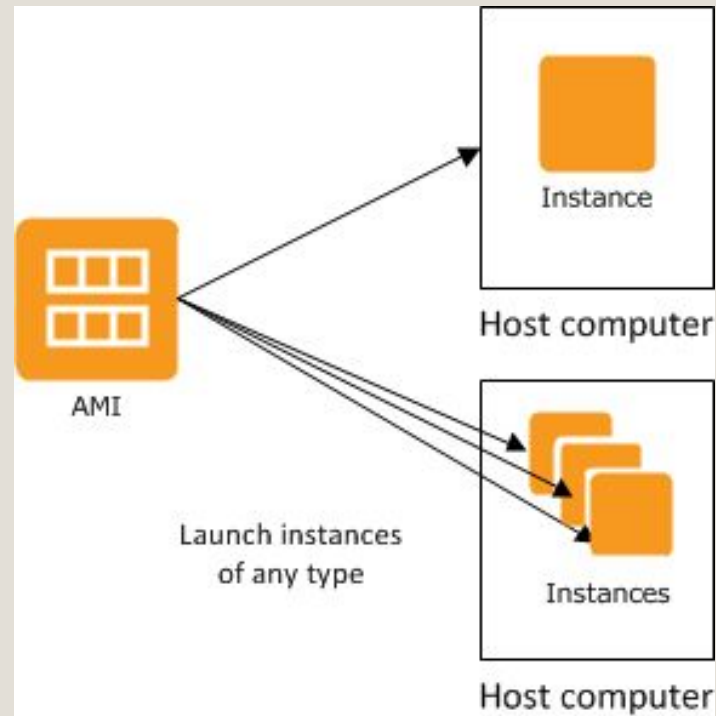
Data Centres

- Cloud servers are located in data centers all over the world
- A data center is a facility housing many networked computers that work together to process, store, and share data
- By using cloud computing, users and companies do not have to manage physical servers themselves or run software applications on their own machines



AWS, AMI and EC2

- ↪ **Amazon Web Services (AWS)**
 - comprehensive cloud platform offering 100s of on-demand services
- ↪ **Amazon Elastic Compute Cloud (EC2)**
 - core compute service within AWS, providing resizable virtual servers on demand
- ↪ **Amazon Machine Image (AMI) ~~Artificial Machine Intelligence — I am bob!~~**
 - a preconfigured virtual template used to launch EC2 instances, containing an operating system



AMI, Instance, Virtual Machines?!

↪ **Virtual Machine (VM)**

- A software-based computer that runs an entire operating system (OS) in an isolated environment.
- The VM shares the physical server's resources (CPU, memory, storage), but appears to the user like a standalone machine.

↪ **Amazon Machine Image (AMI)**

- A template provided by Amazon Web Services (AWS) used to create EC2 instances.
- Contains the operating system, software, and initial configuration.
- Acts as the base "blueprint"; you launch instances from AMIs.

↪ **Instance (in AWS context)**

- A running virtual server in AWS, launched from an AMI.
- Receives compute resources (e.g., CPU, RAM, storage) allocated by AWS.
- You can start, stop, reboot, or terminate an instance as needed.

Connecting to the Cloud



Remote Desktop
(Guacamole)



Secure
Shell (ssh)

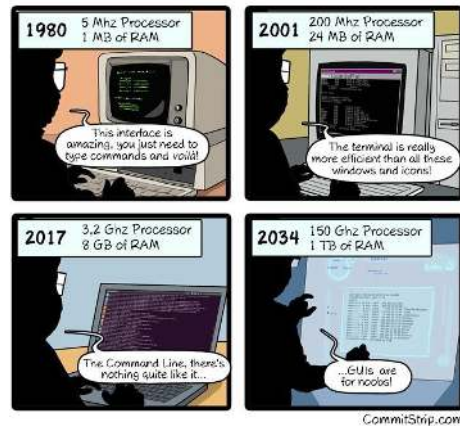
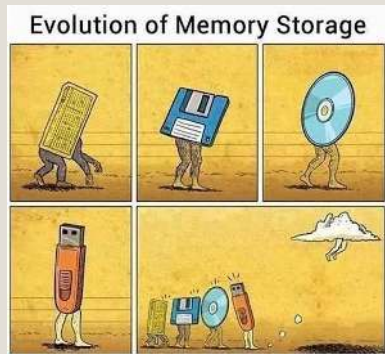


R Studio
Server

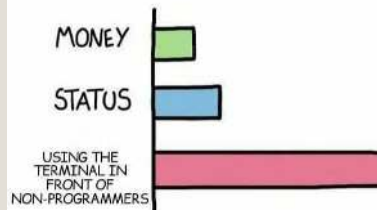


Jupyter
Notebook

Takeaways



WHAT GIVES PEOPLE FEELINGS OF POWER



Connecting to your Instance

↪ <https://evomics.org/2026-workshop-on-genomics/>

EVOLUTION AND GENOMICS

Intensive and immersive training opportunities

[WORKSHOPS](#)[LEARNING](#)[PEOPLE](#)[APPLY](#)[INFORMATION](#)

Get ready for May 2023!

Many important details can be read on our [FAQ](#) page and our [Housing and Transportation](#) page

[Instance addresses](#) (check every day for your new one!)

Check [here](#) to view Faculty / Organiser / Instructor arrival and departure dates. Check out our Faculty for 2023 [here](#) and our Instructors for 2023 [here](#)

As is tradition, we will be having a [T-shirt competition](#)! Best T-shirt design will feature on the Workshop on Genomics 2023 T-shirts – get designing!

Workshop on Genomics 2023 [BINGO!](#)

Faculty lunches sign-up sheet

Our [Code of Conduct](#) contact points are Josie Paris & Joan Ferrer Obiol

Connecting to your Instance

→ <https://...>

**Just watch for
now, you will get a
chance to do it
shortly! :)**

EVOLUTION AND

Intensive and immersive training

Get ready for

Many important

Instance addresses (

Check [here](#) to view

As is tradition, we w

Workshop on Genomics 2023 [BINGO](#)

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INFORMATION

[here](#)

signing!

Connecting to your Instance (AMI)

- Find your name and check your instance address
- Determine how to connect to your instance: using guacamole, ssh or the RStudio server

	A	B	C	D	E	F	G
1	Instance number	First Name	Last Name	Instance address	Guacamole connection	ssh connection	RStudio server connection
2	1	Joan	Ferrer Obiol	3.238.107.169	3.238.107.169:8080/guacamole	ssh genomics@3.238.107.169	3.238.107.169:8787

- Make sure you select YOUR NAME!
- Do not follow along

Connecting to your Instance (AMI)

http://18.210.10.167



Welcome to the Workshop on Genomics 2026

Web Browser Connection Options

- **Guacamole - ssh and Desktop**
- **R Studio**

If you prefer using SSH, you can connect with the following command:

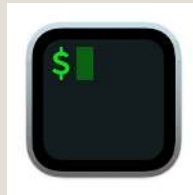
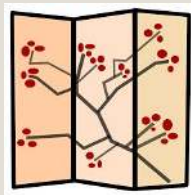
```
$ ssh genomics@18.210.10.167
```

Popular terminal/SSH programs for each OS:

Connecting through SSH

- Open your preferred terminal on your laptop
- Type `ssh genomics@[instance address]`
- Enter the password

```
[apples-MacBook-Pro.local@apple[~]$ ssh genomics@3.238.107.169  
genomics@3.238.107.169's password: [REDACTED]
```



Connecting through SSH

```
#####  
##          Workshop on Genomics 2023          ##  
##      🌴🍹 Spring Edition 🍹🌴                ##  
##          Cesky Krumlov                        ##  
##          @evomics #evomics2023              ##  
#####
```

Welcome to Ubuntu 22.04.2 LTS (5.19.0-1024-aws).

System information as of Sun May 14 15:33:29 CEST 2023

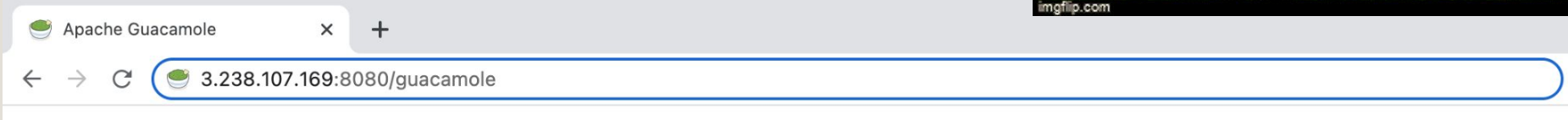
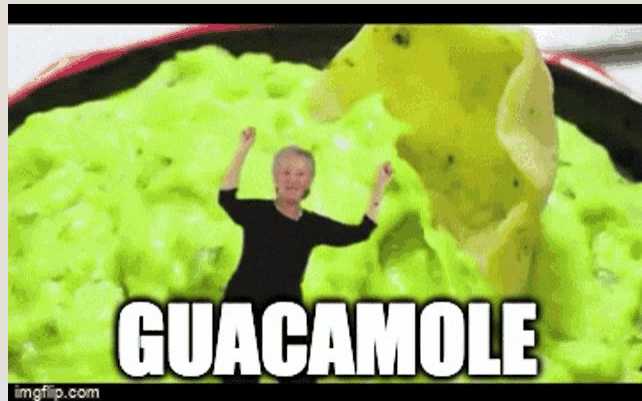
System load:	0.85107421875	Processes:	220
Usage of /:	58.1% of 484.63GB	Users logged in:	0
Memory usage:	29%	IPv4 address for docker0:	172.17.0.1
Swap usage:	0%	IPv4 address for ens5:	172.31.10.159

Last login: Sun May 14 11:08:55 2023 from 194.228.207.170

genomics@ip-172-31-10-159:~]\$

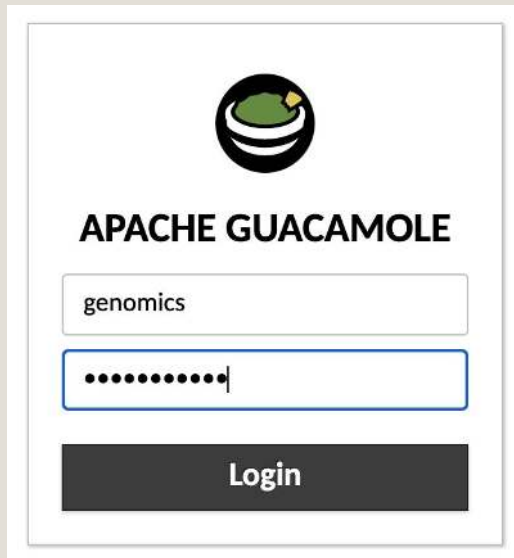
Connecting to Guacamole

- Open your preferred internet browser (i.e. chrome, firefox)
- Paste your instance address followed by :8080/guacamole



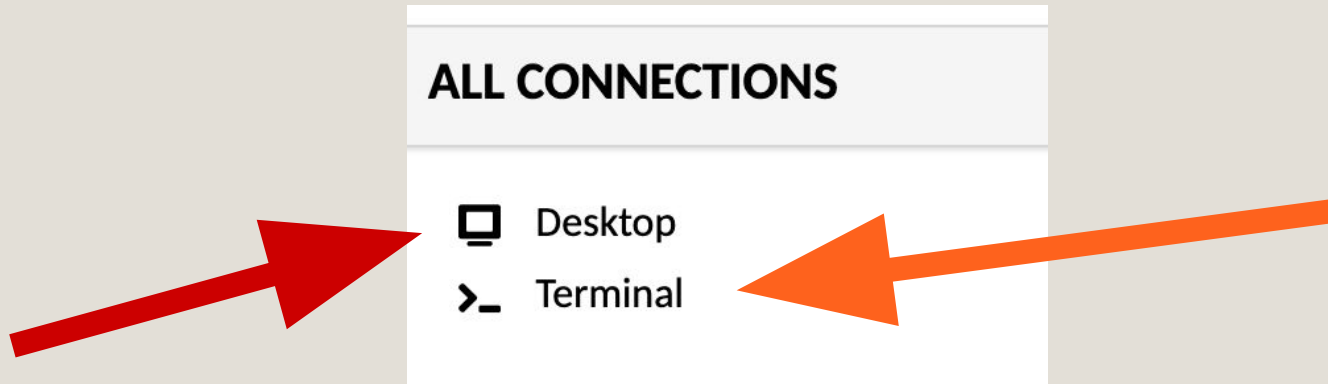
Connecting to Guacamole

- Enter the username “genomics” and the password (on the flip-chart/whiteboard)

The image shows the Apache Guacamole login interface. At the top is the Guacamole logo, which consists of a black circle containing a green bowl with a yellow spoon. Below the logo, the text "APACHE GUACAMOLE" is displayed in a bold, black, sans-serif font. Underneath this text are two input fields. The first field contains the username "genomics". The second field contains a series of dots representing a masked password, followed by a vertical cursor. Below the password field is a dark grey rectangular button with the word "Login" in white text.

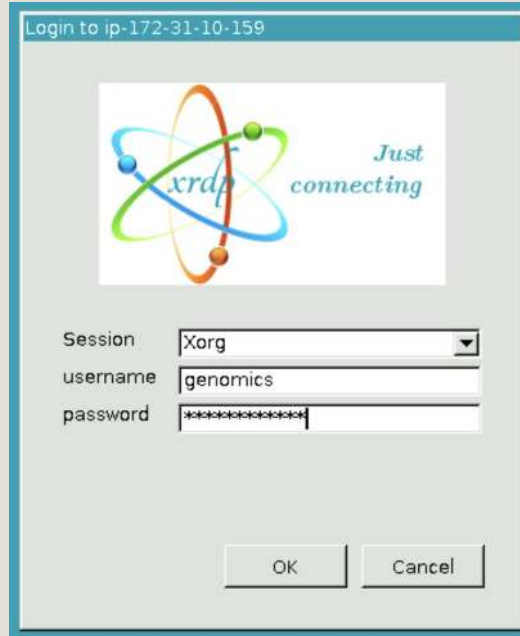
Connecting to Guacamole Desktop

- Open your preferred internet browser (i.e. chrome, firefox)



Connecting to Guacamole Desktop

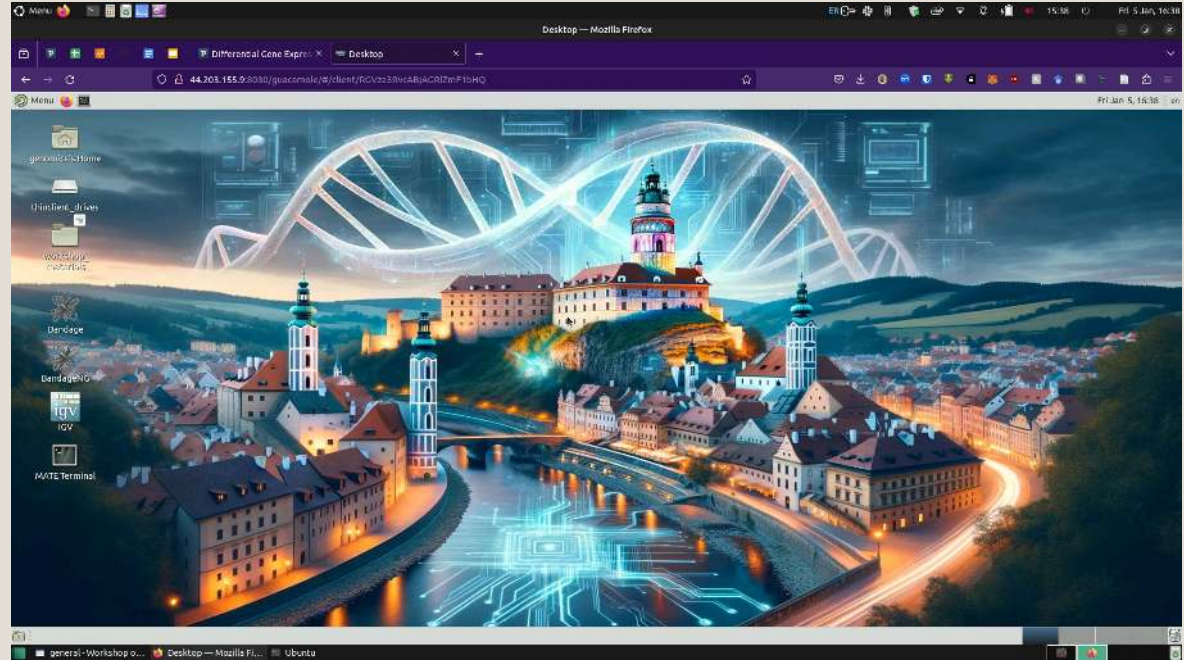
- Enter the username “genomics” and password again



Connecting to Guacamole Desktop

33

→ Open a terminal window using the terminal icon



Copying and Pasting



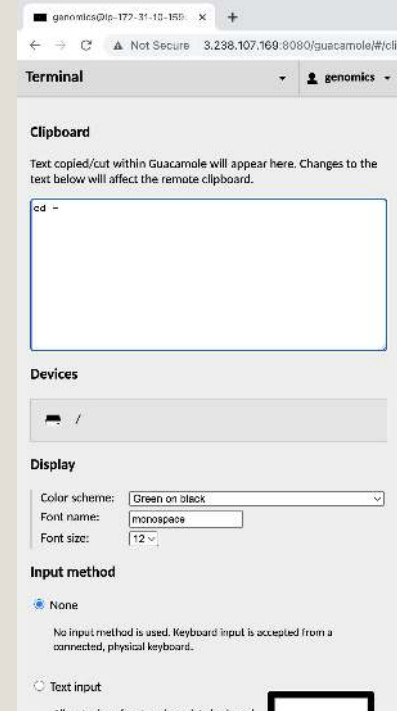
Copying and Pasting



35

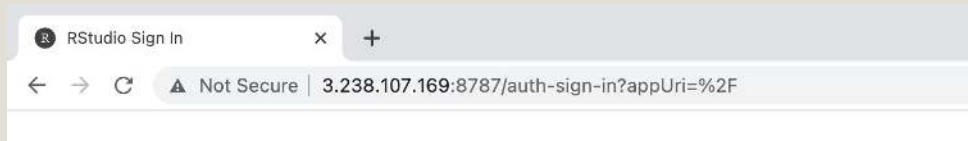
But if you need it:

- ➞ Press Ctrl+Alt+Shift (Mac: Ctrl+Opt+Shift)
- ➞ Paste the text in the pop-up box
- ➞ Press Ctrl+Alt+Shift (Mac: Ctrl+Opt+Shift) again
- ➞ Paste into the instance using right click



Connecting to R-Studio Server

- Open your preferred internet browser (e.g. Chrome, Firefox)
- Paste your instance address followed by :8787
- Username: genomics
- Password: On the whiteboard in the Prelate

A screenshot of the RStudio sign-in form. The title is 'Sign in to RStudio'. It has two input fields: 'Username:' and 'Password:'. Below the password field is a checkbox labeled 'Stay signed in when browser closes'. A note states 'You will automatically be signed out after 60 minutes of inactivity.' At the bottom is a blue 'Sign in' button.

Sign in to RStudio

Username:

Password:

☐ Stay signed in when browser closes

You will automatically be signed out after 60 minutes of inactivity.

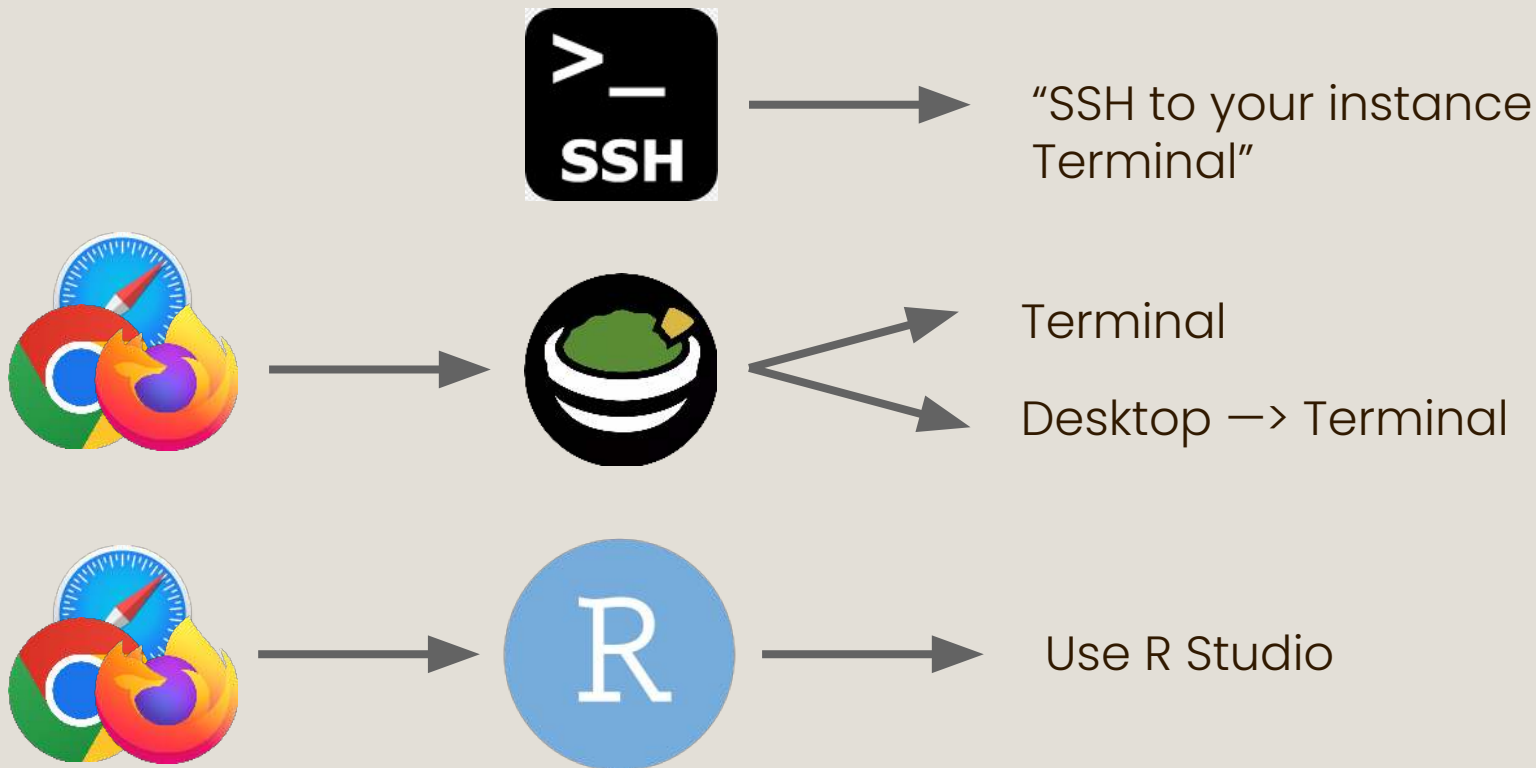
Sign in

Your Daily AMI



- ↪ The instance IP address will **change** every day after we stop and restart the instances.
- ↪ Each morning, you will need to return to the “Instance address spreadsheet” on the webpage, retrieve your new address and login again using the type of connection you need

I forgot, how do I connect?



Keyboard Troubles!

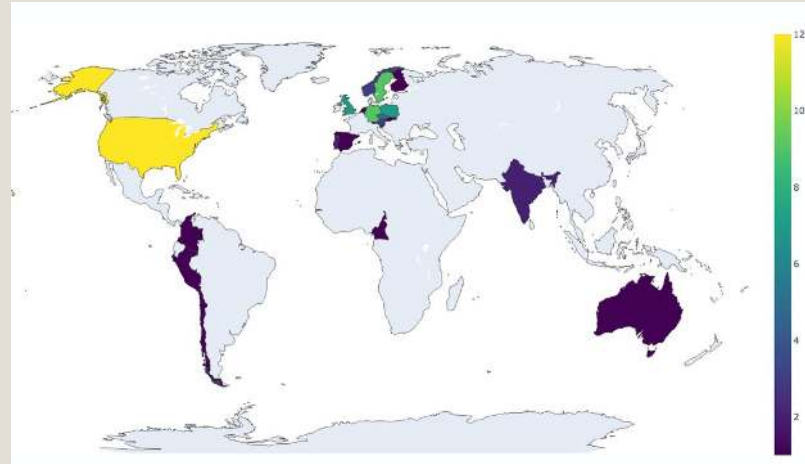
↪ **Make sure that you can type the following characters:**

↪ tilde (~)

↪ backslash (\)

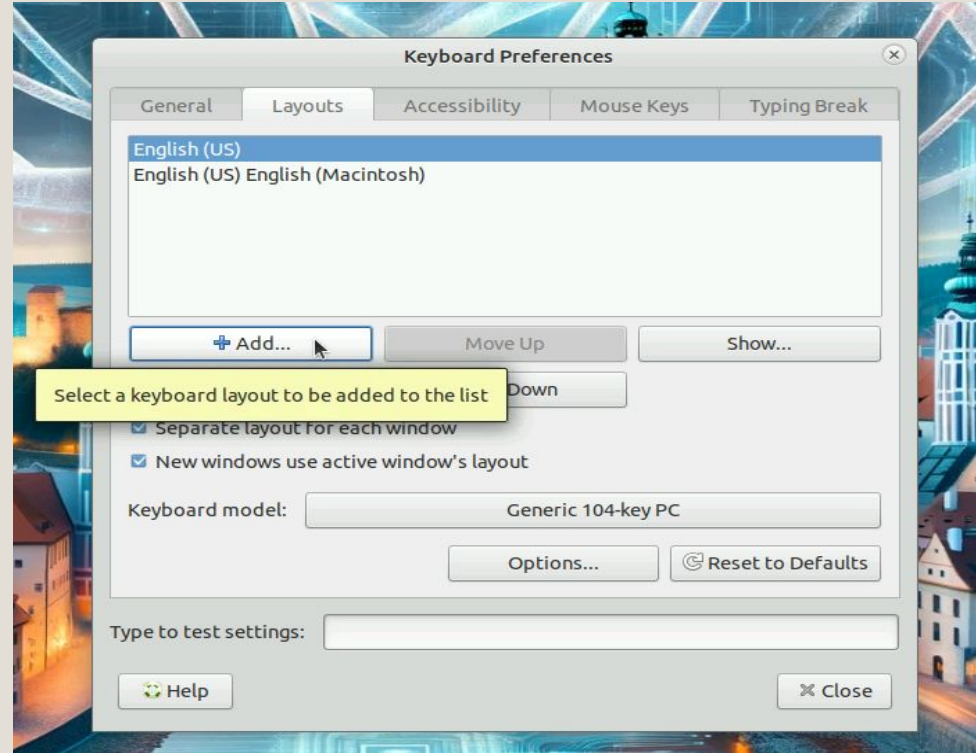
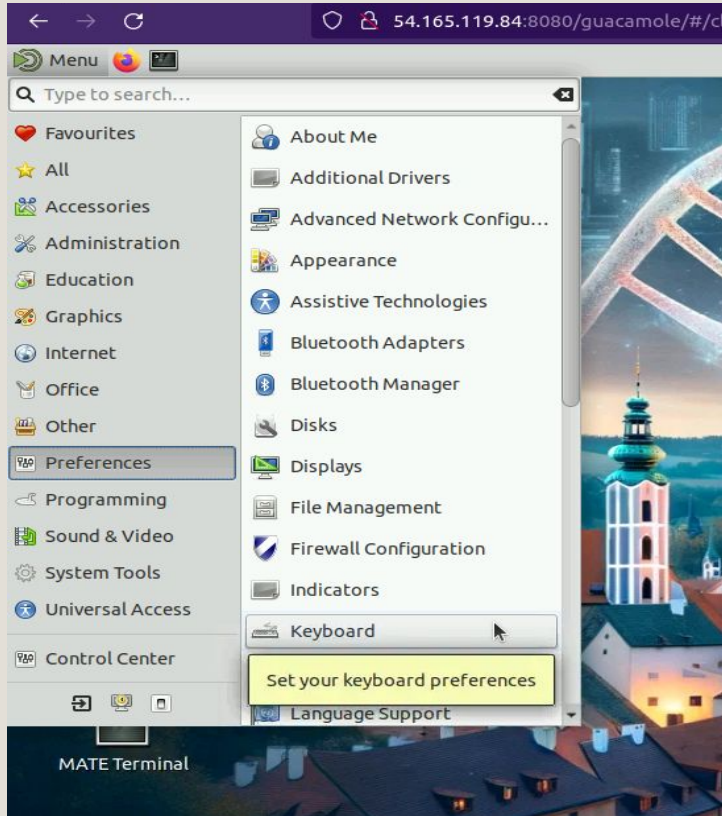
↪ pipe (|)

↪ carat (^)

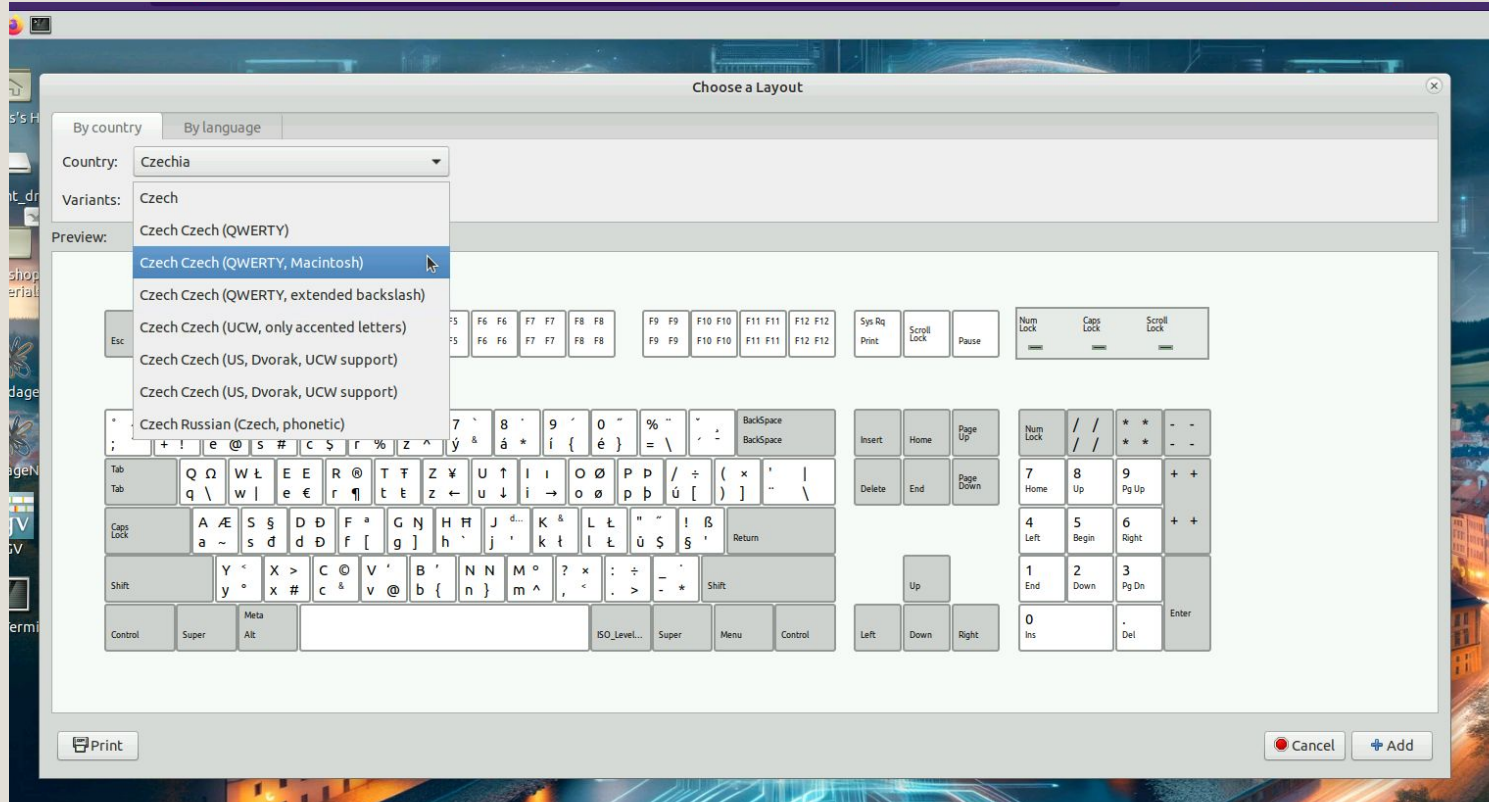


↪ If you can't type these characters, please get our attention!

Keyboard Troubles!



Keyboard Troubles!



Tilde ~



tilde

/ˈtɪldə, ˈtɪldi/



Backslash



backslash
"bakslaf/



Pipe |

vertical bar
pipe



Caret ^



Caret
/kɛɹət/

