MY472 - Week 11
Cloud Computing

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Outline

- Cloud computing basics
- Service models
- Trends: Going serverless
- Advantages and disadvantages of cloud computing
- Guided coding session
  1. Running an RStudio server via RStudio cloud
  2. Running an RStudio server via AWS
  3. Customising an EC2 instance and running it via the command line and an ftp client

Cloud computing basics

A definition

“Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models.” (From *NIST Definition of Cloud Computing*)

You are already using cloud application services

These are the examples of Software as a Service (more on this later)

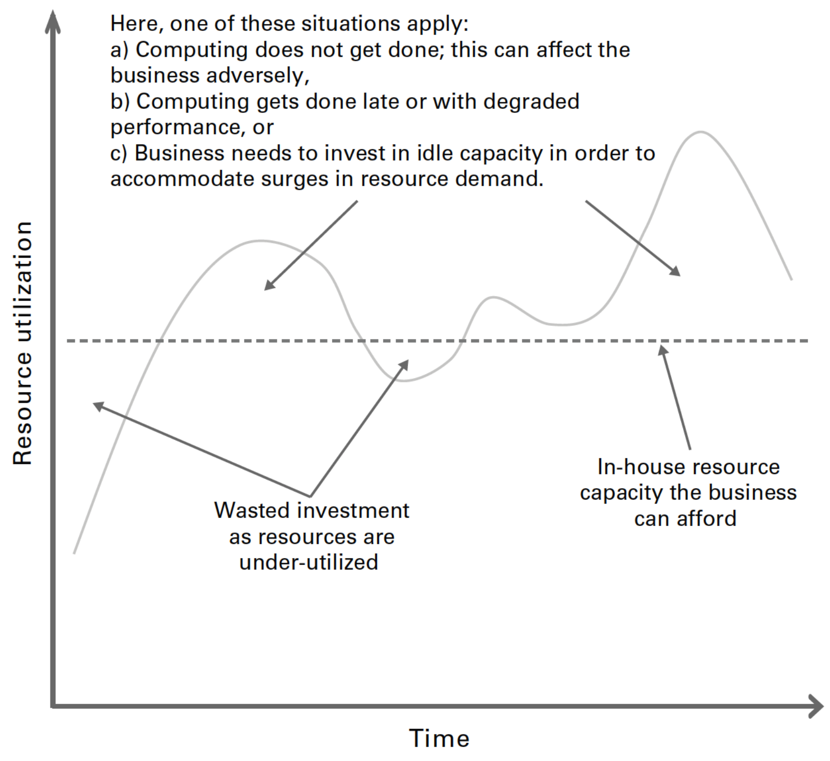
- Email
  - Gmail
  - Exchange mail
- Storage
  - Google drive
  - Dropbox
- Software
  - Google docs
  - Adobe

Possible use cases in data science

- Continuous scraping or API requests
- Large scale natural processing
- Hosting and querying (very large) databases
- Training machine learning models, e.g. in deep learning or reinforcement learning
- Hosting web applications
- …

Let’s buy a powerful computer?

Stylised issues with fixed environments and fluctuating demand



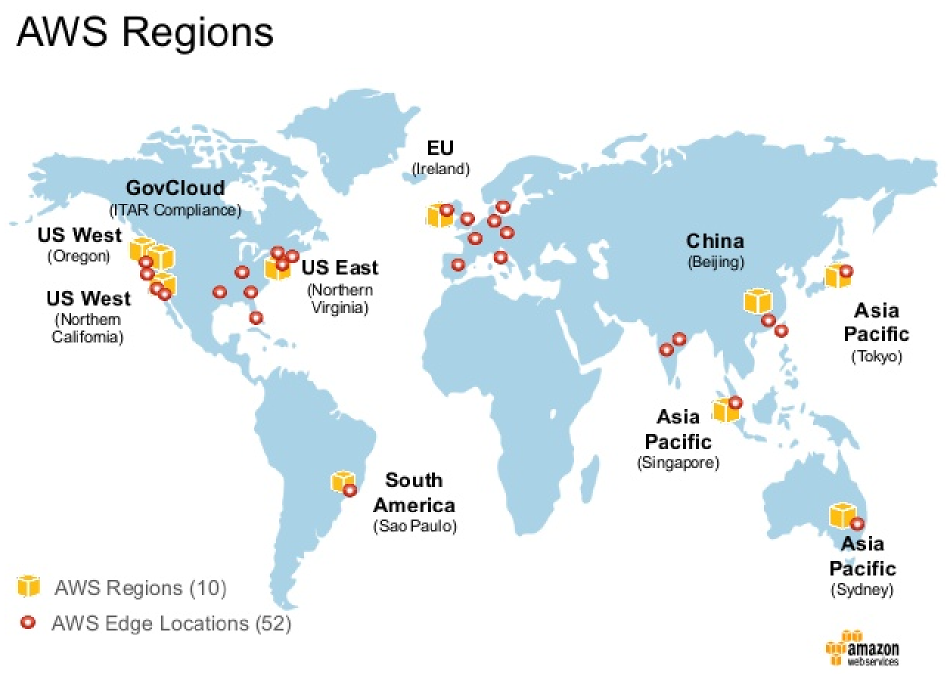
How do cloud computers look like? Virtualisation

- In cloud computing, computers are virtualised
  - Similar idea to virtual machine on your computer but readily scalable in a short time
  - In data centers connected to the internet, hardware hosts a number of virtual machines

Data centers

- For major providers of cloud service, there are data centers everywhere and you can deploy resources in any location
- Reasons for specific locations could be: Latency, data protection laws, costs
- Exact locations of data centers are usually undisclosed (for security reasons)

Example AWS



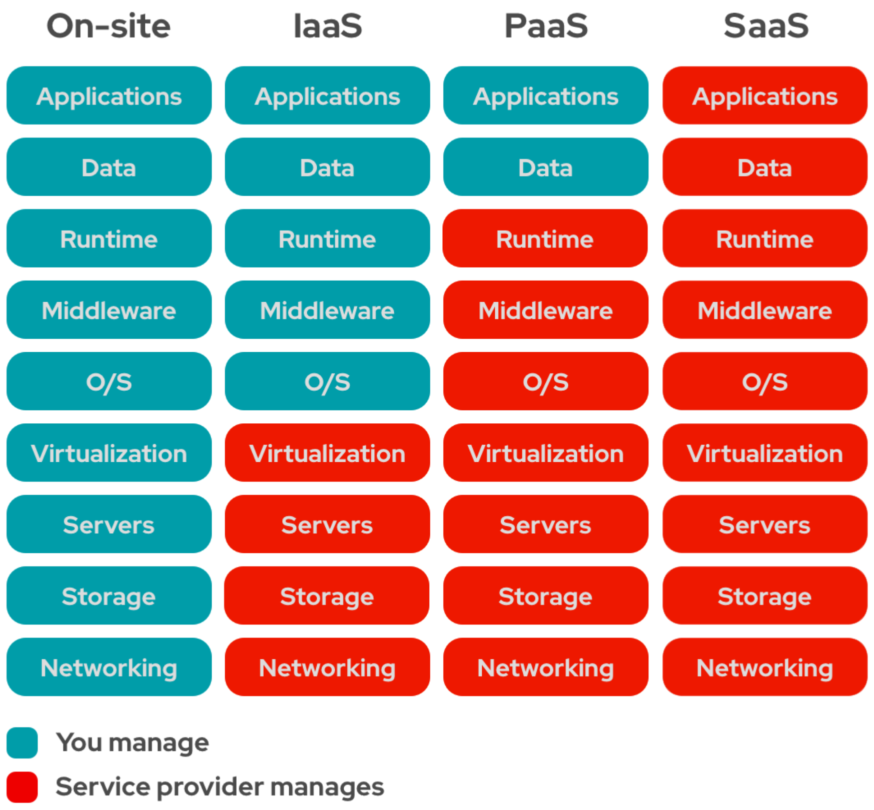
Service models

“As a service” models of cloud computing

To differentiate cloud computing services, it can be useful to think of them in the following broad categories

- Infrastructure as a service (IaaS): A cloud provider hosts the infrastructure components traditionally present in an on-premises data center, including servers, storage and networking hardware. Includes a variety of associated services such as backup, log maintenance, updates, security, etc. For example, AWS EC2, Microsoft Azure, Google Compute Engine
- Platform as a service (PaaS): Additional delivery of hardware and software tools – often those needed for application development. For example, Google App Engine, Heroku, AWS Elastic Beanstalk
- Software as a service (SaaS): Software distribution model in which applications are remotely hosted and served to users via the Internet, usually through a standard web browser. For example, Microsoft 365

Stylised figure



On-site	IaaS	PaaS	SaaS
🟦 Applications	🟦 Applications	🟦 Applications	🟥 Applications
🟦 Data	🟦 Data	🟦 Data	🟥 Data
🟦 Runtime	🟦 Runtime	🟥 Runtime	🟥 Runtime
🟦 Middleware	🟦 Middleware	🟥 Middleware	🟥 Middleware
🟦 O/S	🟦 O/S	🟥 O/S	🟥 O/S
🟦 Virtualization	🟥 Virtualization	🟥 Virtualization	🟥 Virtualization
🟦 Servers	🟥 Servers	🟥 Servers	🟥 Servers
🟦 Storage	🟥 Storage	🟥 Storage	🟥 Storage
🟦 Networking	🟥 Networking	🟥 Networking	🟥 Networking

🟦 You manage

🟥 Service provider manages

Source

Trends: Going serverless

Serverless computing

- There is a server, but cloud provider runs and manages it
- Developer can focus on code
- One area: Function as a Service (FaaS)
- Example: User enters input into website, back end runs some computation and returns it (e.g. cheapest flights on a day)
- Approach one (traditional): Rent/buy fixed sever equipment (on premise or in cloud) and run it 24/7 which might leave it mostly idle
- Approach two (serverless): Once user enters input, send function call to cloud provider who computes output and returns it
- For example AWS Lambda, Azure “Functions”, Google Cloud “Functions”

If you have a web application, such as a webapp from your personal website, it is better to use a FaaS for a simple computation (e.g., a small simulation). If the time to process is less than 15 minutes, it is manageable and you would not have to pay that much. Of course, if more people enter into your server then you would need more capacity (EC2 instance).

This might get too expensive if many people start using the lambda function.

It is really useful to use cronetab to program how many times the scraping script will be run, instead of running it continually.

Serverless cloud computing vs traditional solutions

- Advantages
  - Often cheaper - only pay when code is running
  - No/little maintenance
  - Scalable (instantly)
- Disadvantages
  - Not really suited for tasks that takes long time to process (e.g. 15min limit for AWS Lambda)
  - Not for memory intensive tasks
  - Can have higher delays for first requests
  - Costs less predictable than with fixed capacity

Advantages and disadvantages of cloud vs on site computing

Advantages

- Availability and durability
    - Services can be down, but arguably less frequently than many on-premise solution
    - Similarly, loss of data can happen but arguably less frequently than in other solutions
- Scalability
    - Inherently scalable with regard to computational power, data, etc. Deploy the same app on bigger instances or scale inherently with serverless approaches
- Costs
    - Pay computational resources depending on demand
    - Three costs of ownership: Capital expenses (hardware, software), operating expenses (service, maintenance), indirect costs (downtime, time to market)
- Security
    - For example, up to date computer systems, automated backups, physical security of infrastructure

Disadvantages

- Costs
  - Can be expensive relative to own hardware and software, e.g. for frequent computations at a stable scale
  - Lock-in: Potentially large costs in terms of developer wages to change to a different solution if the current one becomes expensive
- Security
  - Connection to the cloud and all computation/data through the internet requires careful setups and can be vulnerable
  - User responsible for connection between client and cloud, but also data encryption, application security, etc.
- Legal compliance
  - For example, GDPR requirement of encryption, data security, data physical location

Guided coding session

1. Running an RStudio server via RStudio cloud

RStudio server via RStudio cloud

- Register and log in via https://rstudio.cloud/plans/free
- Very easy to set up: Create RStudio server in the cloud by clicking on “New Project”
- Free version allows to use 1 CPU and 1 GB RAM per project
- Restricted to 25 project hours per month

It is also useful to use disk memory instead of RAM memory, that is why we use writeLines or SQLite.

2. Running an RStudio server via AWS

Using other cloud platforms to host RStudio servers

- We can also set up an RStudio server ourselves, e.g. via AWS https://aws.amazon.com/
- Registration requires a credit card, but free tier options available during first 12 months
- Because AWS is arguably the most popular cloud computing provider as of now, we use it as the example in this lecture. Yet, there are many other service e.g. Google Cloud, Microsoft Azure, Alibaba Cloud, IBM Cloud, Salesforce, …
- On AWS, EC2 (Elastic Compute Cloud) allows to create and launch virtual machines
- Many other services such as S3 (storage) or Lambda (serverless)

Setting up the RStudio server via AWS

- Rather than installing software from scratch, AMI (Amazon Machine Images) can make it more convenient to set up virtual machines
- We will use Louis Aslett's RStudio Server AMIs https://www.louisaslett.com/RStudio_AMI/
- If logged into AWS, clicking on one of the AMI links on his website leads directly to creating the associated EC2 instance
- Pick a free tier option
- One caveat: In the "security group" option, choose HTTP and port 80 to make the server accessible via the browser later
- After creating the instance, the public DNS is the URL, and the RStudio log-in details are "rstudio" (account name) and the instance id (password)
- Change this with `passwd` in terminal within RStudio after logging in

3. Creating a custom EC2 instance and using it via the command line and an ftp client

Customising and using instances via the command line

- In this example, we will use an AMI with less pre-installed software and customise our own instance by installing R etc.
- Common approach (for scientific computing): Connect to the remote machine via SSH (secure shell), run scripts via the command line and use ftp client to add/download files such as a scripts, data, outcomes, etc. to/from the instance
- Particularly helpful for large computations in the cloud such as machine learning or textual analysis, or code in production
- Does not require user input in a GUI such as selecting code, submitting to console, etc
- Could still use an AMI with pre-installed R such as the ones by Louis Aslett also for command line access to the EC2, but will create our own to study these topics

Step 1: Launching the instance

- In the EC2 dashboard click “Launch instance”
- Choose Amazon Linux 2 AMI (many other options available which would require slightly different steps and commands)
- Choose free tier option
- When launching instance, create key pair for SSH access (or choose existing one)
- Good to keep in mind: User name for Amazon Linux 2 AMI is “ec2-user” (see documentation for other AMIs)

Step 2: Connecting to the instance, setting swap memory

- Connect to EC2 instance via command line (more info)
    - Mac/linux: `chmod 400 yourkeyname.pem` and `ssh -i "path/to/key/yourkeyname.pem" ec2-user@public-instance-dns`
    - Windows: Use PuTTY - tutorial as pdf on course page
    - Linux console in browser: Right click on instance -> Connect -> EC2 Instance Connect -> Connect
- First, for small free tier instances with only 1GB of ram, create swap memory (reference) to install some larger R packages (not necessary for larger instances)

```
sudo /bin/dd if=/dev/zero of=/var/swap.1 bs=1M count=2048
sudo /sbin/mkswap /var/swap.1
sudo /sbin/swapon /var/swap.1
sudo sh -c 'echo "/var/swap.1 swap swap defaults 0 0 " >> /etc/fstab'
```

Step 3: Installing Linux libraries and R

- Before installing some of the R packages later, we need to install additional Linux libraries `sudo yum install libcurl-devel openssl-devel libxml2-devel`
- Install R with `sudo amazon-linux-extras install R4`
- Afterwards you can open R by typing `R` or run scripts with `Rscript myscript.R` (more later)

Step 4: Copying files to and from the EC2 instance

- We can copy files from and top the EC2 via the command line (`scp` command)
- Can be more convenient to use an ftp programme, for an overview of supported programmes see this link
- One option is Cyberduck, can be downloaded from cyberduck.io or Mac App Store / Windows Store
- Choose “Open connection”, enter the public DNS for server, the user name “ec2-user” and supply your .pem file for the SSH private key

Step 5: Running scripts and installing R packages

- `ls` shows all folders and files in the current directory
- `cd path/to/some/folder` goes to folder
- `Rscript myscript.R` runs R script in current folder
- `Rscript myscript.R &` runs R script in the background while the shell is open
- Install the R packages that we need with the script `install_packages.R` (this takes a while)
- Run a single iteration of the scraping script `scraping_example_to_schedule.R` to see the output it produces

Step 6: Scheduling scripts with cron (1/2)

- With this setup, we can run scripts once e.g. for large computations in textual analysis and machine learning, and then download the outcomes with our ftp client
- Yet, for repeated tasks such as scraping or API calls, it can be helpful to run scripts on a schedule
- This can e.g. be done via `crontab`
- Set schedule with `crontab -e` (in vim editor)
- vim editor basics: `i` for inserting/writing mode, `esc` to exit writing mode which allows commands such as `:w` for saving, `:q!` for quitting without saving, and `:wq` for saving and exiting

Step 6: Scheduling scripts with cron (2/2)

- Cron syntax: * * * * * (minute, hour, day, month, day of week), e.g. 15 9 * * * runs every day at 9.15am
- Important: Check time zone on machine by typing in `date` (often UTC)
- `30 8 * * * sudo reboot`: Reboots at 8.30am
- `0 9 * * * Rscript /home/ec2-user/code/scraping_example_to_schedule.R >> /home/ec2-user/code/cron_log.txt 2>&1`: Executes the scraping script every day at 9am and stores the output into a log file called cron_log.txt

The 2>&1 is writing the output of the code into the cron_log.txt, also the errors, which disappear every time you reboot the computer.

Alternative solutions

Serverless approaches such as e.g. AWS Lambda (Google Functions, Azure Functions, etc.) can also be helpful for the tasks discussed here. For example:

- Put scraping code into a small Lambda Function (unfortunately need to call R via Python in these functions as of now) which is e.g. executed on a schedule without creating an EC2 instance
- Usually creating EC2 instances is required for machine learning, scientific computing etc.
- For more cost efficiency in recurring tasks that require an EC2 instance, e.g. start and stop an EC2 instance via lambda function
- More information

The end

What we have covered today

- General introduction to cloud computing
- Setup of an RStudio server via RStudio for doing some simple computations
- Setup of RStudio sever via AWS, free tier allows longer use in first year, example of continuous scraping within R
- Launch of own instance, installing software, and accessing it via command line and ftp client. Very flexible setup for computation which also allows continuous scraping
- Connected topics from R programming, IDE vs command line, cloud computing, databases, web scraping
- Use free tier instances for the topics discussed, stop/terminate them (after the lab), and keep an eye on your costs via `Services` -> `Billing`