

# Assignment I – Computer Architecture

1.a) Research on the characteristics of CPUs, GPUs, and TPUs. What purpose have they been designed for? Which data science problems benefit most?

## **CPUs (Central Processing Unit)**

### Characteristics:

- Optimized for general-purpose computing.
- Fewer Cores (typically up to 64 cores in high-end server CPUs).
- High single threaded performance.

### Designed Purpose:

They are designed for handling general computing tasks like running, operating system, applications and background processes.

### Data Science Benefits:

Basic data science problems like data parsing, data preprocessing, and small scale machine learning tasks.

## **GPUs (Graphic Processing Unit)**

### Characteristics

- Optimized for parallel processing.
- Initially designed for rendering graphics but evolved into general-purpose parallel processors.
- Thousands of smaller cores.

### Designed Purpose:

They are designed for graphics rendering, video editing and increasingly for general-purpose parallel computing tasks.

### Data Science Benefits:

Highly beneficial for tasks that can be parallelized, such as training deep learning models, image and video processing.

# TPUs (Tensor Processing Unit)

## Characteristics:

- Optimized for tensor operations.
- Matrix multiplication is the core operation.

## Designed Purpose:

Accelerating machine learning workloads, especially deep learning models.

## Data Science Benefits:

Extremely beneficial for training large scale deep learning models and other tensor intensive computations.

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1.b) Choose a current model each (one CPU, one GPU, and one TPU) and compare

- Performance
- Power consumption
- Cost

Current Model Comparison

### **CPU: Intel core i9-12900k**

Performance:

- Multi-core: 16 Cores
- Single Threaded performance is excellent.

Power Consumption:

- TDP: 125W

Cost:

- Around \$500 – \$600

### **GPU: NVIDIA GeForce RTX 3090**

Performance:

- CUDA Cores: 10496
- Memory: 24 GB GDDR6X

Power Consumption:

- TDP: 350W

Cost:

- Around \$1500 - \$2000

## **TPU: Google Cloud TPU v4**

Performance:

- Matrix Multiply Units: 2048

Power Consumption:

- Not directly comparable due to it's cloud nature

Cost:

- Around \$32 per TPU per hour

References:

1. Chat gpt – 3
2. Inter core i9 -12900K: <https://www.intel.com/content/www/us/en/homepage.html>
3. NVIDIA GeForce RTX 3090: <https://www.nvidia.com>
4. Google Cloud TPU v4: <https://cloud.google.com/tpu>

## Assignment III - Cost of Cloud Computing

For a data science project you need the following IaaS resources

- Virtual machine with at least 4 vCPUs & 8 GB RAM (no special instance needed)
- Object storage for up to 100TB of data (standard)
- Hosted in Europe

1.a) How much will this setting cost you per year? Choose one of the providers presented in the lecture.

## Cost per year on AWS:

Virtual Machine:

For a VM with atleast **4 vCPUs** and **8 GB RAM**

Amazon EC2 Pricing:

- Instance type: t3.xlarge
- Price: \$0.3328 per hour

We assume VM runs 24/7 for a year:

Cost per Day:  $0.3328 * 24 = \$7,9872$

Cost per Month:  $7,9872 * 30 = \$239,616$

Cost per Year =  $12 * 239,616 = \$2875.392$

### On-Demand Plans for Amazon EC2

#### Select a location type and region

Location Type

AWS Local Zone ▼

Local Zone

Germany (Hamburg) ▼

#### Select an operating system, instance type, and vCPU to view rates

Operating system

Windows ▼

Instance type

General Purpose ▼

vCPU

4 ▼

#### Viewing 1 of 8 available instances

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Instance name ▲	On-Demand hourly rate ▼	vCPU ▼	Memory ▼	Storage ▼	Network performance ▼
t3.xlarge	\$0.3328	4	16 GiB	EBS Only	Up to 5 Gigabit

## Object Storage:

For **100TB** of standard object storage on AWS, let's use Amazon S3.

## Amazon S3 Pricing:

- Standard Storage Price:
  - First 50 TB/Month = \$0.0245 per GB
  - Next 450 TB/Month = 0.0235 per GB

Cost per Month(100TB) =  $50 * 1000 * 0.0245 + 50 * 1000 * 0.0235 = \$2,400$

Cost Per Year =  $2,400 * 12 = \$28,800$

Amazon S3		Overview	Features ▾	Storage classes ▾	Pricing	Security	Resources ▾	FAQs
		Storage pricing						
		S3 Standard - General purpose storage for any type of data, typically used for frequently accessed data						
		First 50 TB / Month			\$0.0245 per GB			
		Next 450 TB / Month			\$0.0235 per GB			
		Over 500 TB / Month			\$0.0225 per GB			

**Total Cost per Year on AWS:  $2875.392 + 28,800 = \$31,675.39$**

1.b) You put your project in operation and monitor a mean value of 50TB/month data transfer (outgoing). How much will that cost you per month?

For outgoing transfer of **50TB/Month** on AWS:

Amazon EC2 Data Transfer Pricing:

- First 10 TB/Month: \$0.09 per GB
- Next 40 TB/Month: \$0.085 per GB

Cost per Month(50TB) =  $10 * 1000 * 0.09 + 40 * 1000 * 0.085 = 900 + 3400 = \text{\$4,300}$

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#### Data Transfer OUT From Amazon S3 To Internet

AWS customers receive 100GB of data transfer out to the internet free each month, aggregated across all AWS Services and Regions (except China and GovCloud). The 100 GB free tier for data transfer out to the internet is global and does not apply separately or individually to AWS Regions.

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First 10 TB / Month	\$0.09 per GB
Next 40 TB / Month	\$0.085 per GB
Next 100 TB / Month	\$0.07 per GB
Greater than 150 TB / Month	\$0.05 per GB