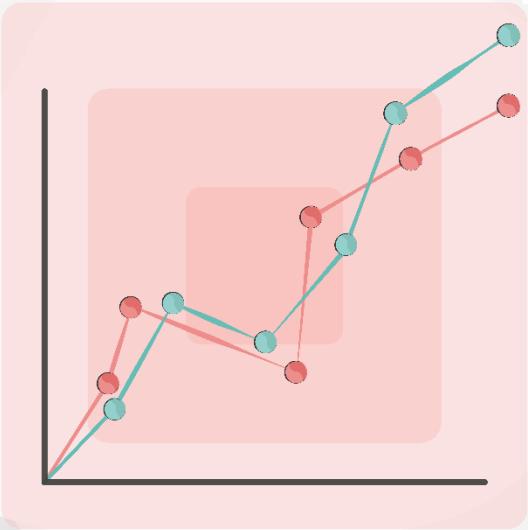
Level 5 Data Engineer
Module 4 Topic 1

Introduction to Networks for Data Engineers

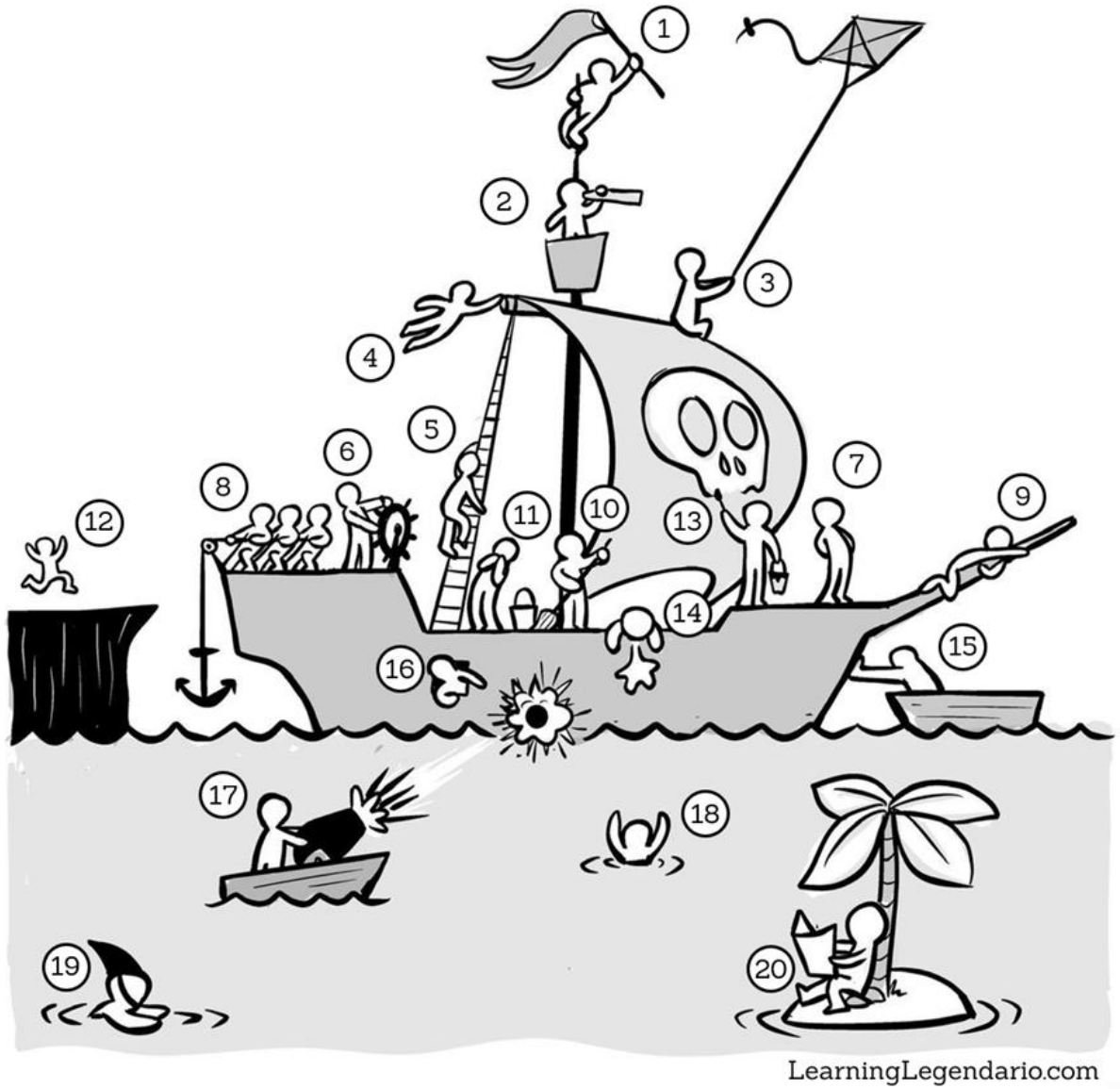
Welcome to today's webinar.



Ice breaker: Discussion

A bit of fun to start…

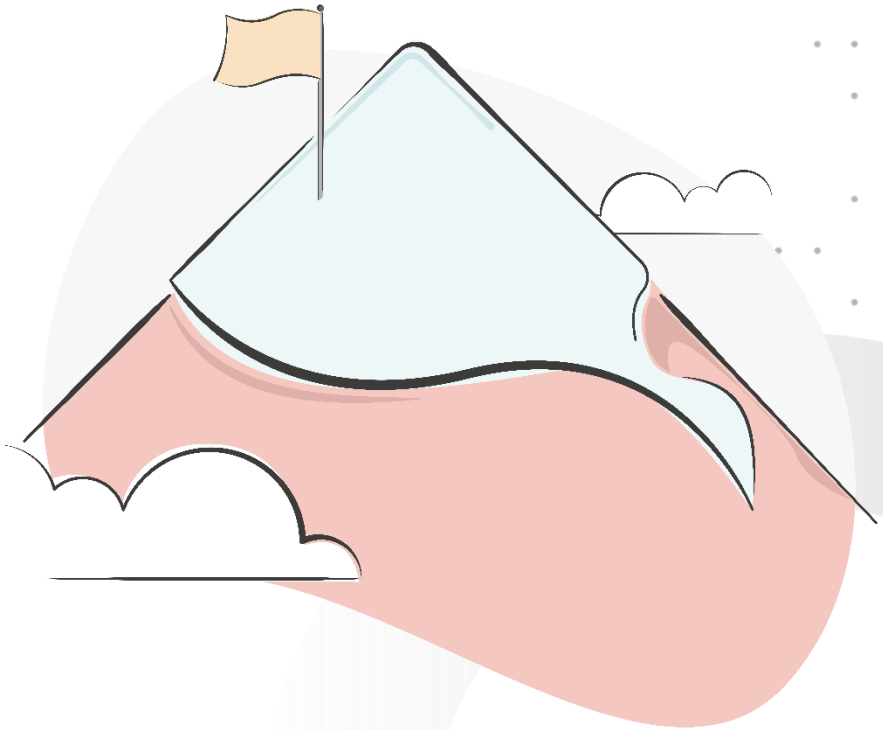
Which character are you when it comes to networks and cyber security?



Session aim and objectives

This webinar supports the following learning outcomes:

- Explain the principles of computer networks, including IP addressing, TCP/IP and the OSI model.
- Demonstrate awareness of modern networking practices.
- Learn about network infrastructure costs and sustainability.
- Explain the role of different types of network devices.



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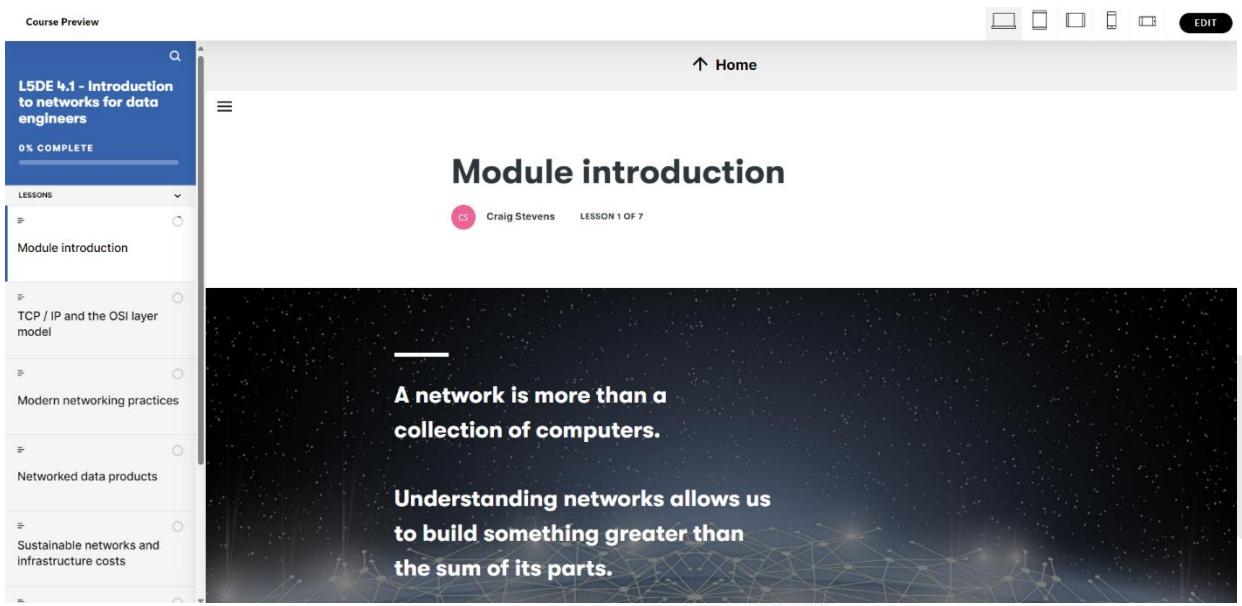
Recap of e-learning

Are you happy with your learning?

- What was the most interesting thing you learned?
- What is TCP/IP?
- How is the OSI model useful?
- Which network infrastructure elements do you remember?



A screenshot of topic 1 e-learning

Webinar Agenda

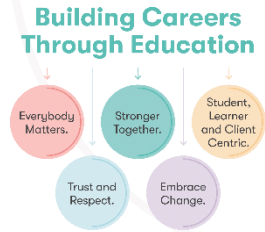
What we will cover in the webinar:

1. Basic principles of Networks
2. IP Addresses
3. Binary and hexadecimal numbers – a Data Engineer has to be able to read those!
4. Modern networking practices

Collaborate activities:

- Practical lab (tutor-led)

Basic principles of networks



The ‘What’ = Network Services…

- Routing & Switching
- Security Appliances & Firewalls
- VoIP & Unified Communications
- Wireless
- IPSec & SSL VPN
- Quality of Service (QoS)

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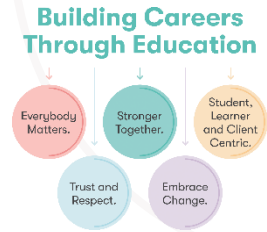
Basic principles of networks



The ‘How’ = Common network services…

- **Hub**
  - Multiport repeater
- **Switch**
  - Collision domains
  - MAC address learning
- **Router**
  - Broadcast domains
  - ‘Gateway’
- **Firewall**
  - Stateful packet inspection
- **VPN concentrator**
  - VPN termination point

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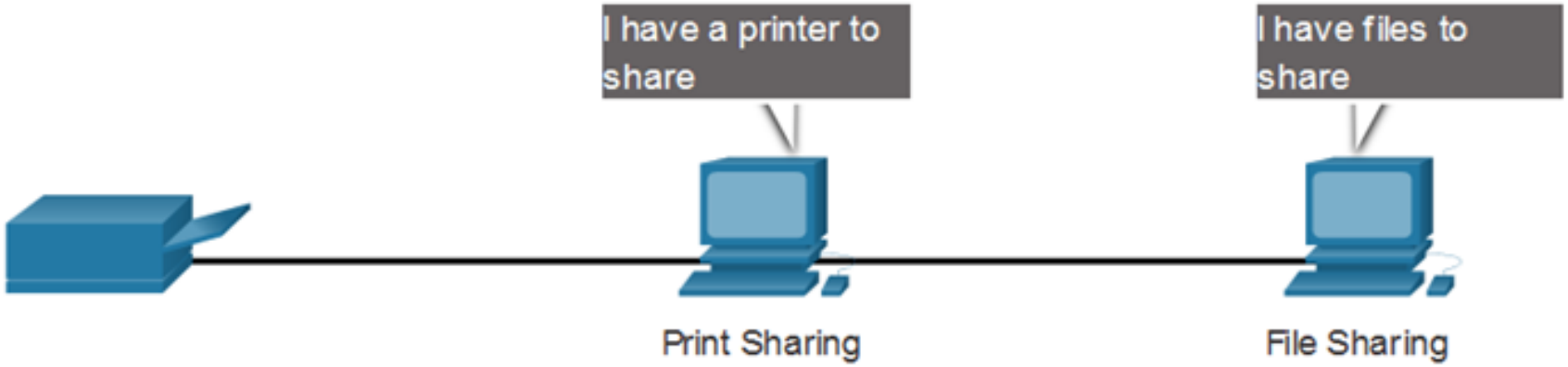
Networking models

Peer to peer…



Advantages	Disadvantages
Easy to set up	No centralised administration
Scalable	Not as secure
Lower cost	Limited reliability
Used for simple tasks: transferring files and sharing printers	Slower performance

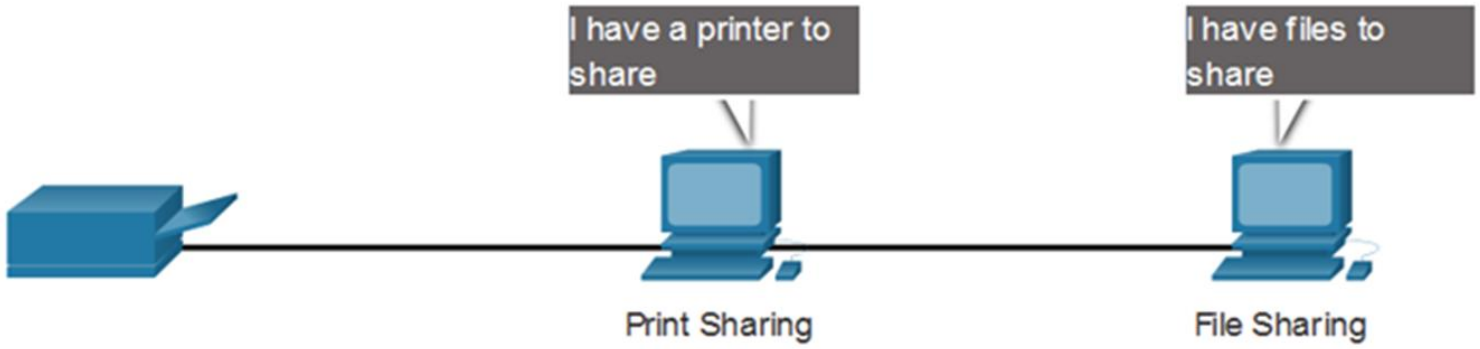
Networking models

Client/Server…

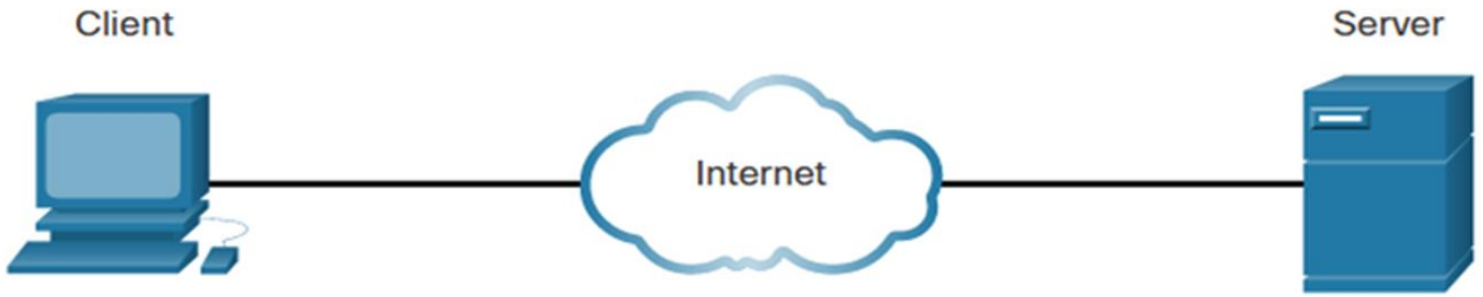
Server Type	Description
Email	Email server runs email server software. Clients use client software to access email.
Web	Web server runs web server software. Clients use browser software to access web pages.
File	File server stores corporate and user files. The client devices access these files.

Discussion

- **What computing solutions are more suited to peer-to-peer networking systems rather than client/server systems?**
- **Why?**



Peer-to-peer

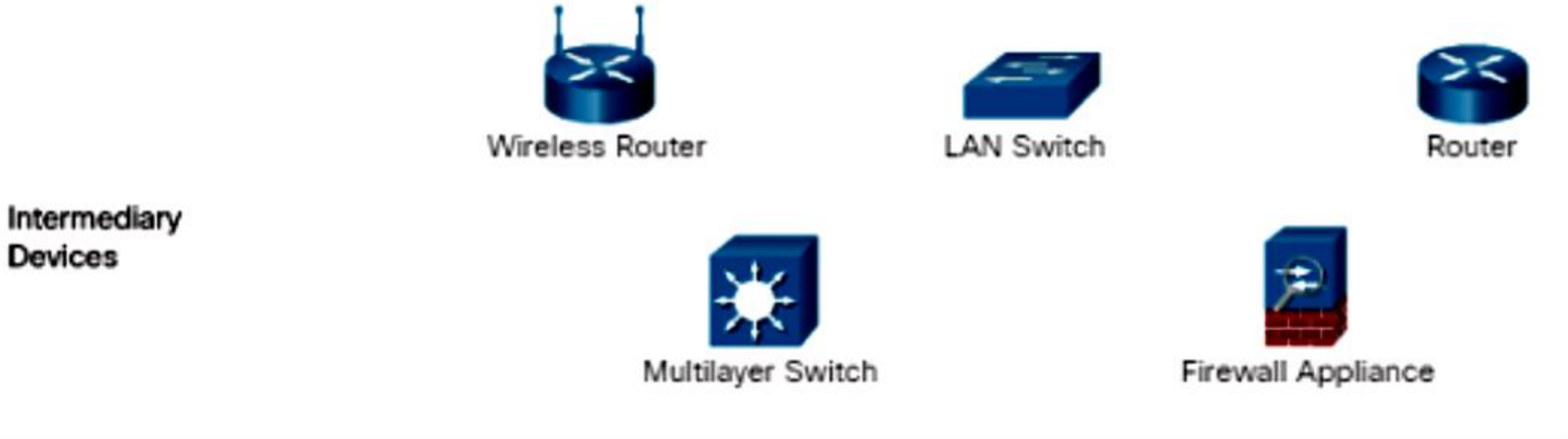


Client server

Submit your responses to the chat!

Network components

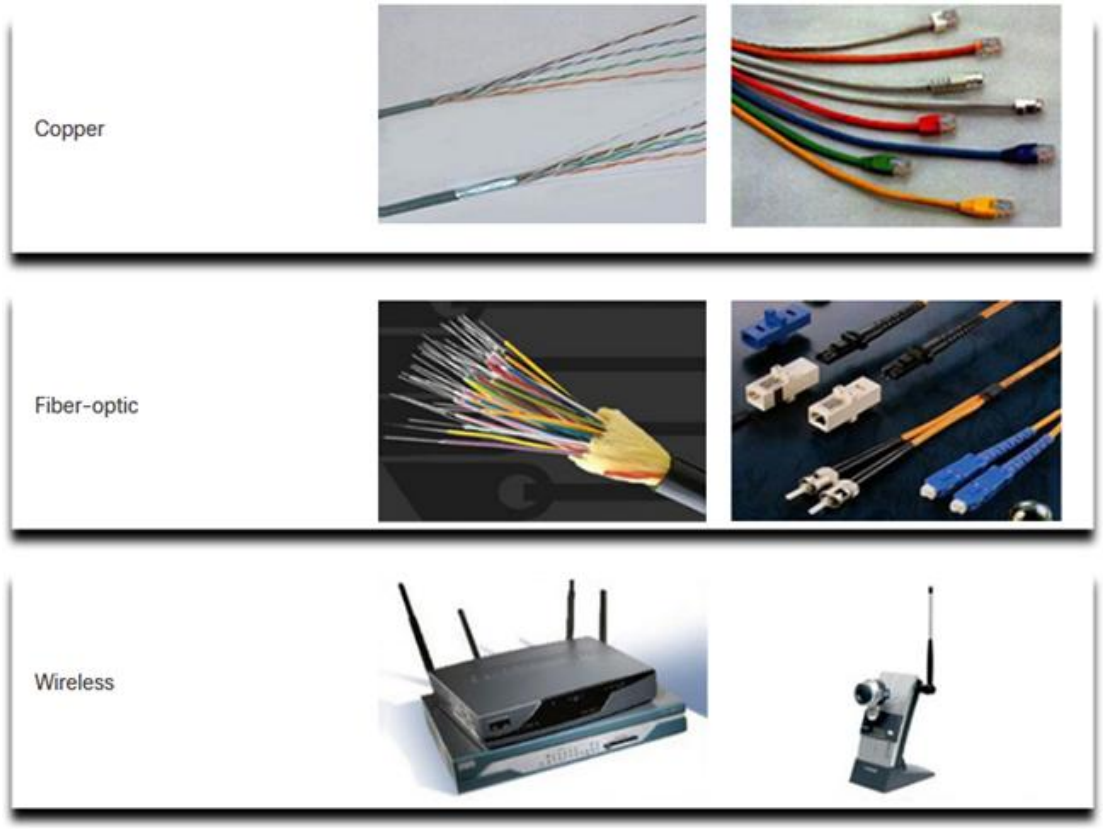
Intermediary network devices…



Network components

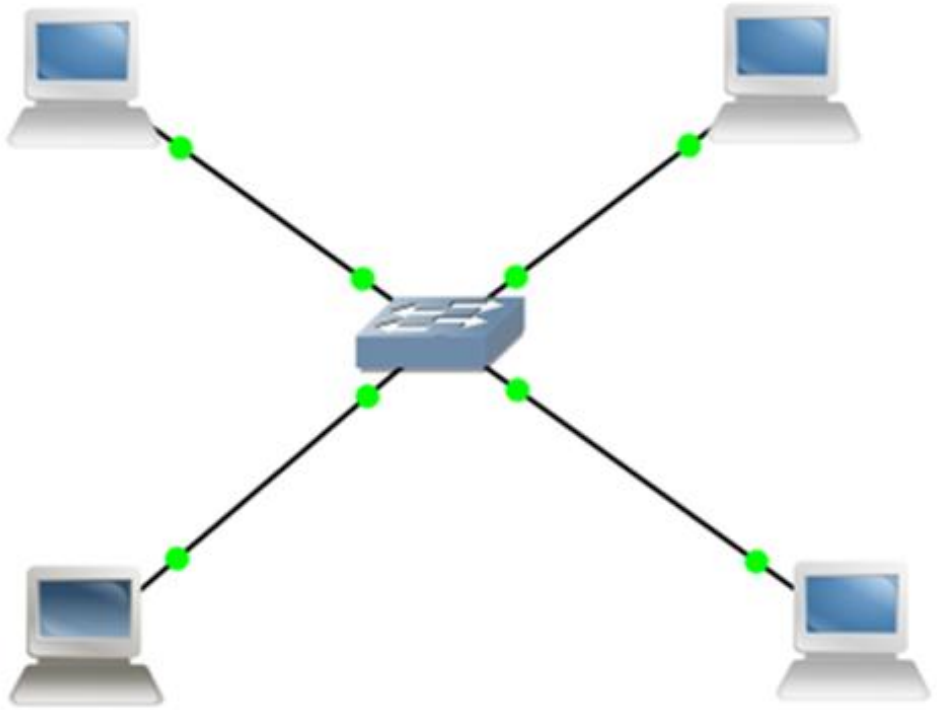
Network media…

Media Types	Description
Metal wires within cables	Uses electrical impulses
Glass or plastic fibers within cables (fiber-optic cable)	Uses pulses of light.
Wireless transmission	Uses modulation of specific frequencies of electromagnetic waves.

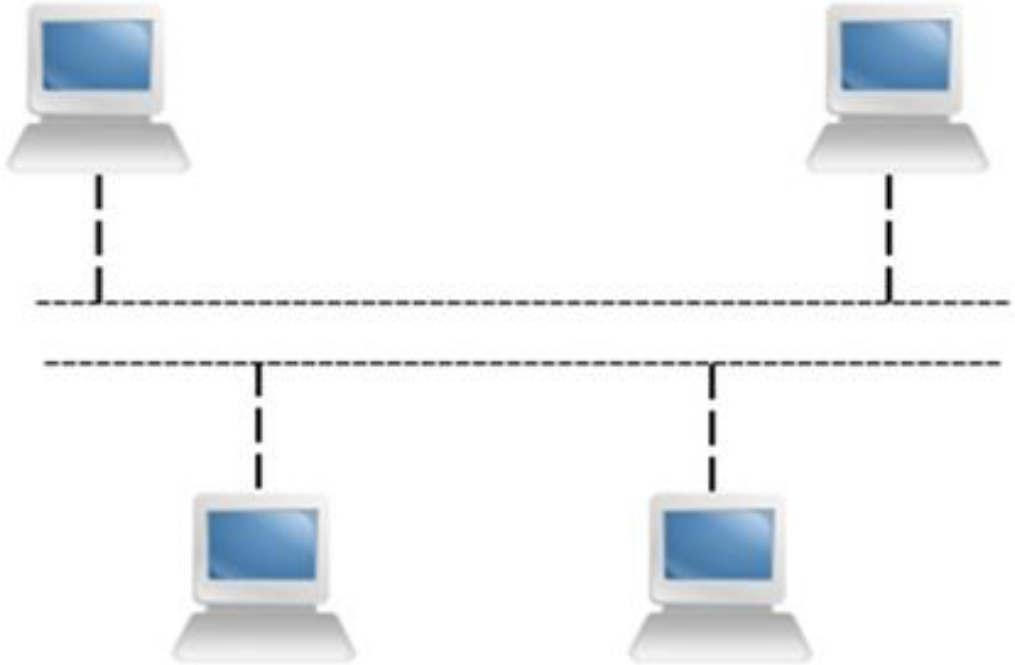


Network LAN Topologies

Most LANs are Ethernet based which have a physical star topology but logical bus topology…

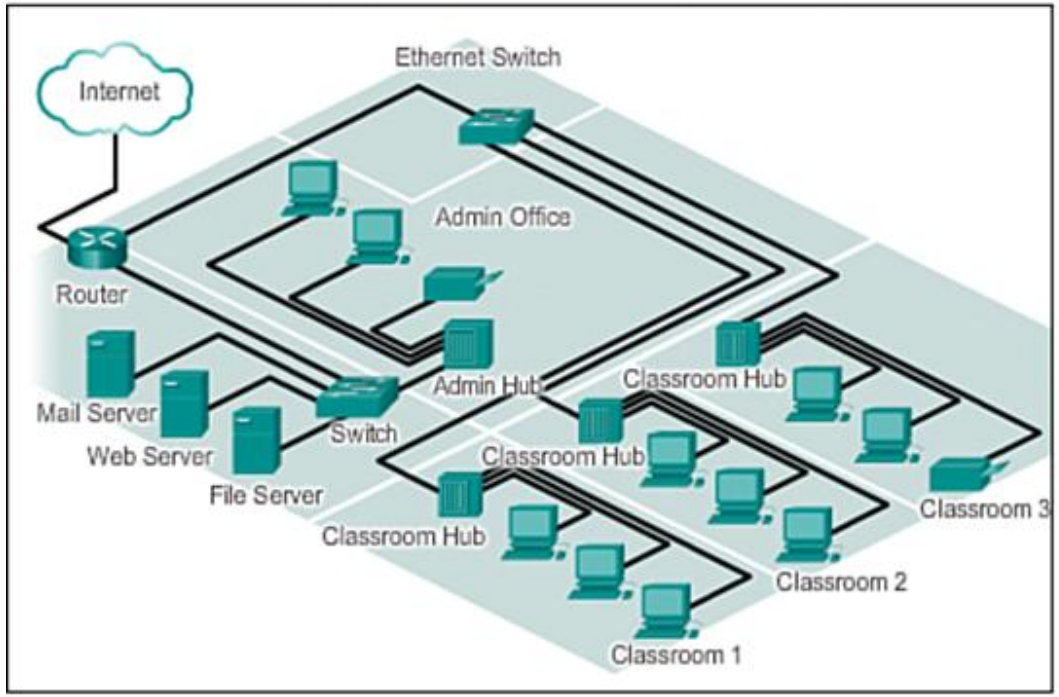


Ethernet Network Physical topology

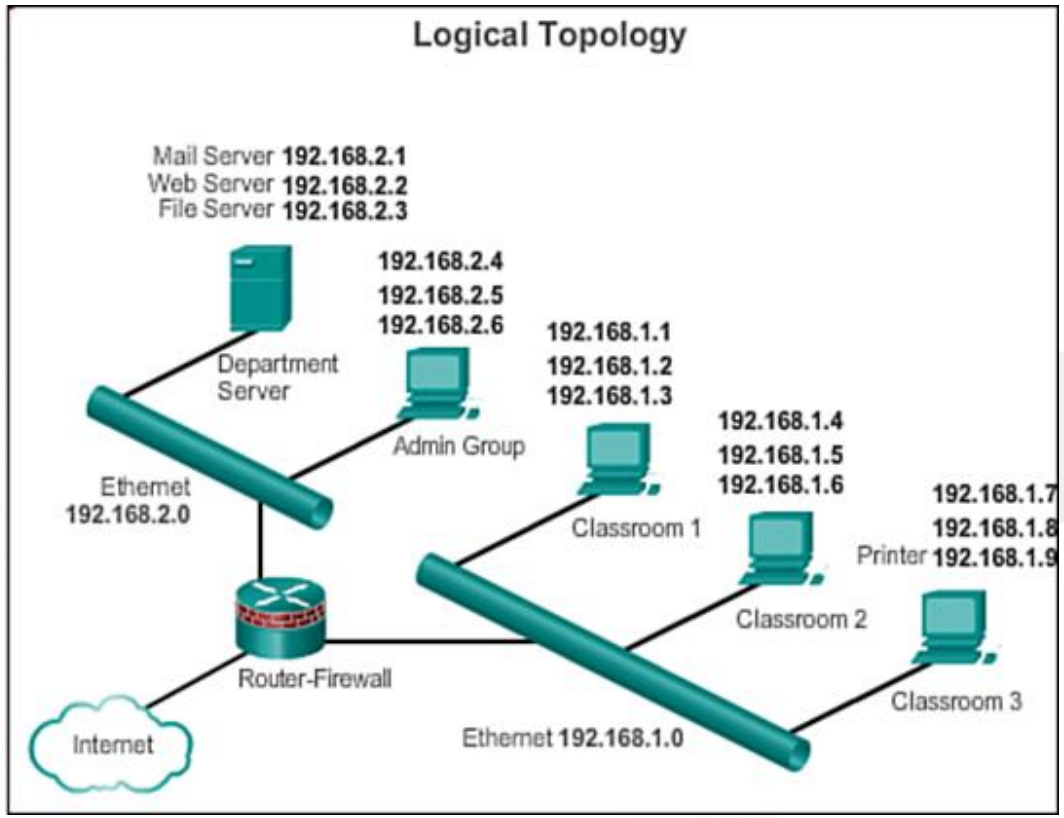


Ethernet Network Logical topology

Physical vs logical topologies



Physical topology diagram



Logical topology diagram

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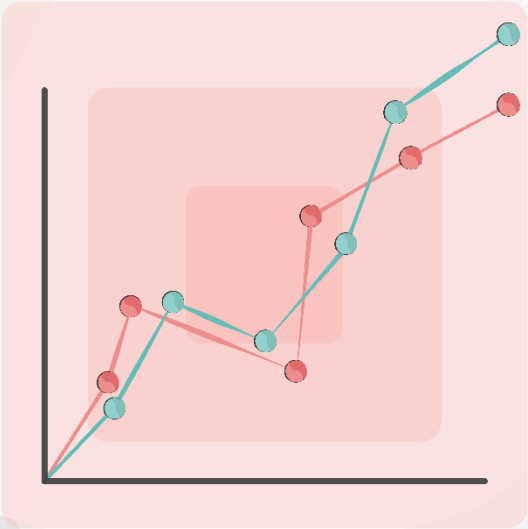
IP Addresses



IP Addresses

What you need to know…

- An identifier for a computer or device on a TCP/IP network.
- 99% of the world still use IP version 4 (IPv4) e.g. 192.168.0.1
- Addresses are 32 bits and not assigned by geographic region.
- IP version 6 is newer, uses 128-bit addresses, but adopted slowly due to compatibility issues.
- E.g. 1080:0000:0000:0000:0800:0000:417A

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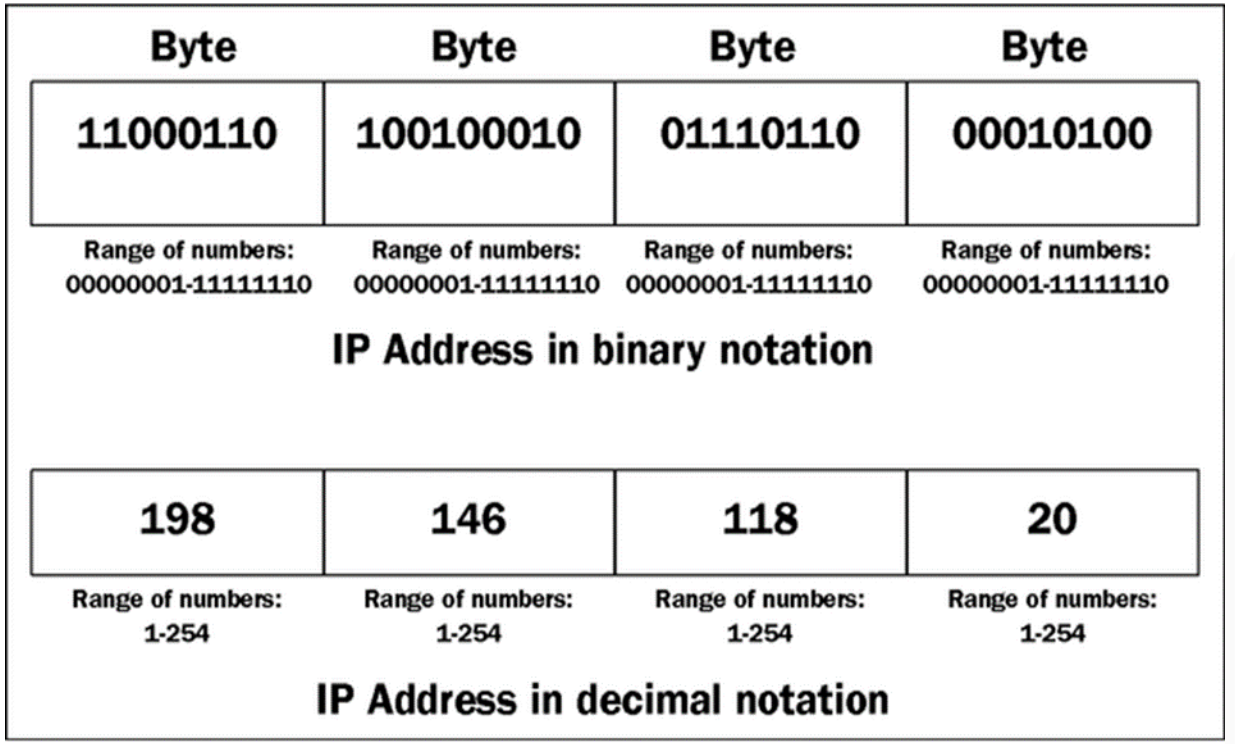
IP Addressing (IPv4)

What you need to know…

- An IPv4 address is four bytes (octets). Total 32 bits.
- Each byte is a number from 1 to 254 (0 and 255 are special)
- Stored in Big Endian order
- Written in dotted notation, e.g. 192.168.21.76



Maths Revision: Converting decimal to binary

Example convert the decimal number 198 to binary number?

Decimal: 198
Binary: 11000110

The binary number is the reminder written from the bottom to the top

Reminder	Divisor	Decimal Number
		198
0	2	99
1	2	49
1	2	24
0	2	12
0	2	6
0	2	3
1	2	1
1	2	0

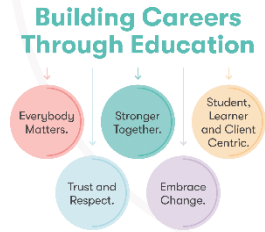
Maths Revision: Converting decimal to binary

Converting the binary number 11000110 to decimal number…

1	1	0	0	0	1	1	0
1×2^7	$+ 1 \times 2^6$	$+ 0 \times 2^5$	$+ 0 \times 2^4$	$+ 0 \times 2^3$	$+ 1 \times 2^2$	$+ 1 \times 2^1$	$+ 0 \times 2^0$
128 +	64 +	0 +	0 +	0 +	4 +	2 +	0

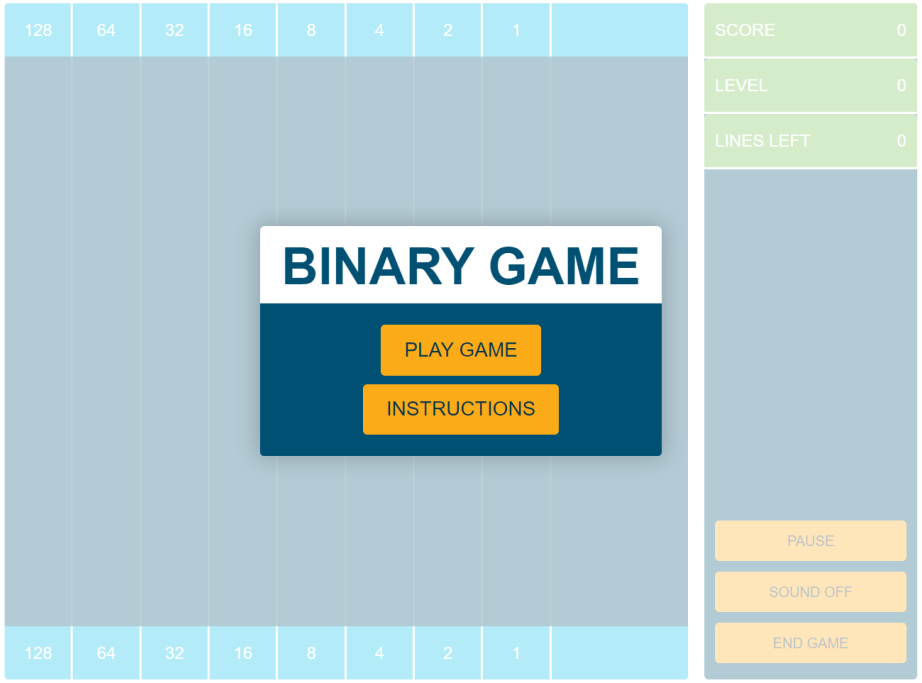
Decimal Number = 198

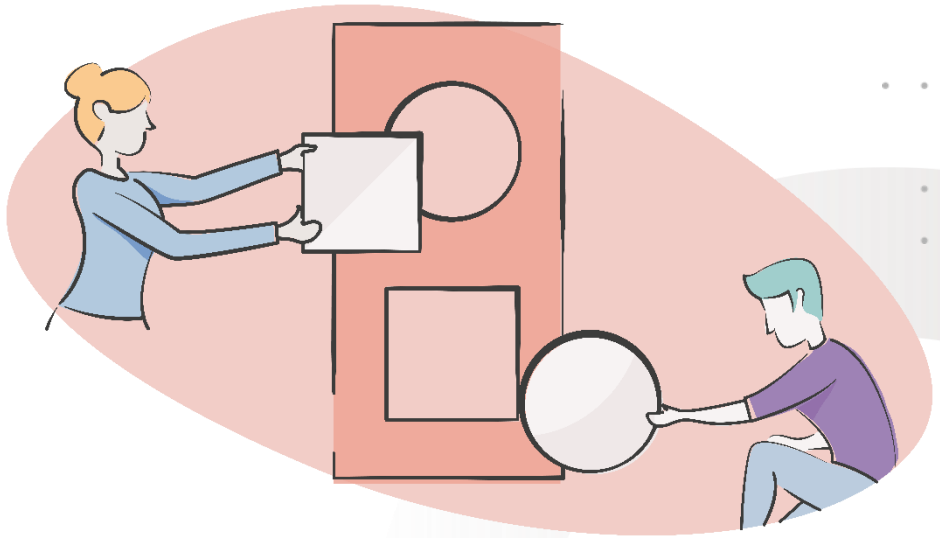
Activity



- Play the binary game
- Data Engineers have to be proficient in reading the binary system of numbering

https://learningcontent.cisco.com/games/binary/index.html





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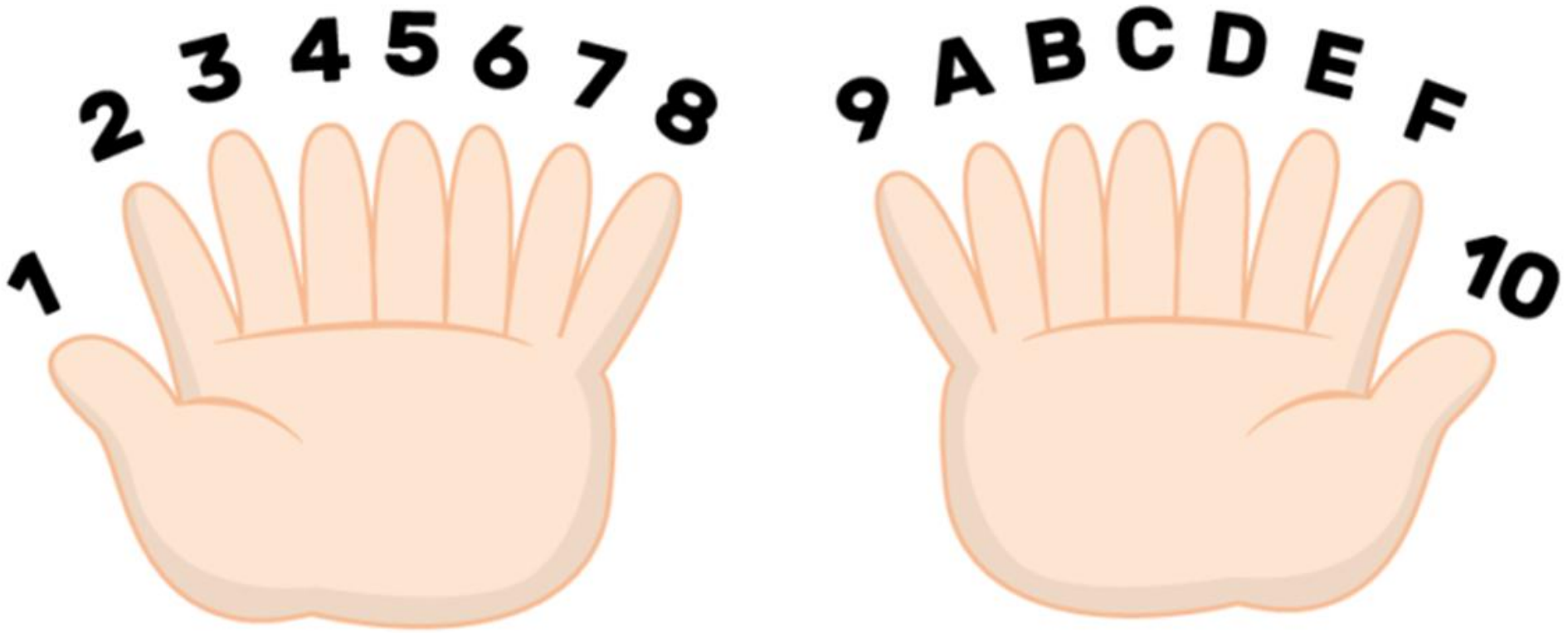
Hexadecimal



Maths!

Converting to Hex…

- Let’s convert 200 to hex.
- How many times does 16 fit into 200?
- 200 / 16 = 12, remainder 8.
- So, we have 12 lots of 16, with 8 units left
- Denary 12 is hexadecimal C, and denary 8 is hexadecimal 8
- So, denary 200 = (12 × 16) + (8 × 1) = C8 in hexadecimal.

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Maths!

Converting to Hex…

- What about 300?
- How many times does 16^2 fit into 300?
- 300 / 256 = 1, remainder 44.
- How many times 16 fit into 44?
- 44 / 16 = 2, remainder 12
- So, we have 1 lot of 162, 2 lots of 16, with 12 units left
- Denary 12 is hexadecimal C
- So, denary 300 = $(16^2 \times 1) + (16^1 \times 2) + (16^0 \times 12)$ = 12C in hexadecimal.

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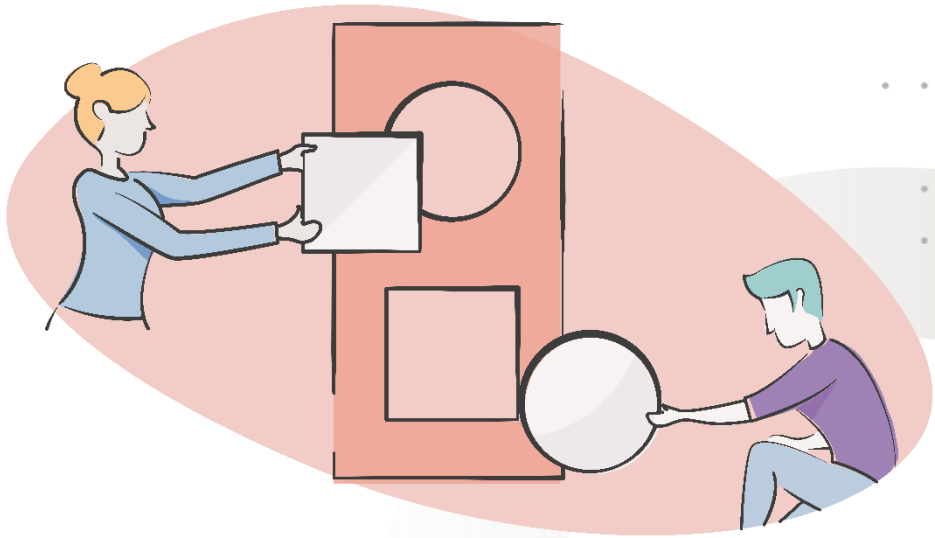
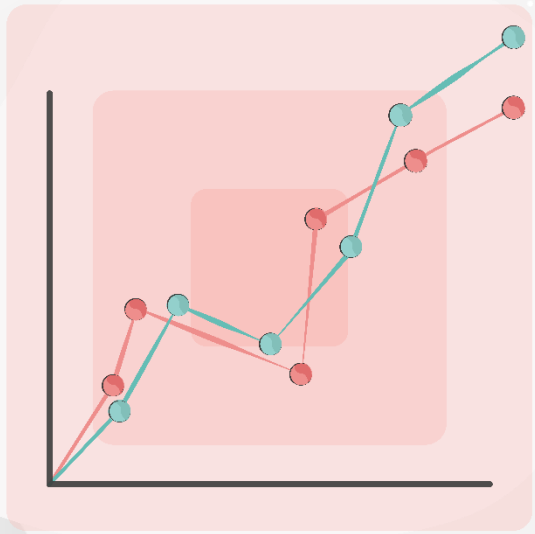
Activity

To practice, try converting the following hexadecimal numbers into denary:

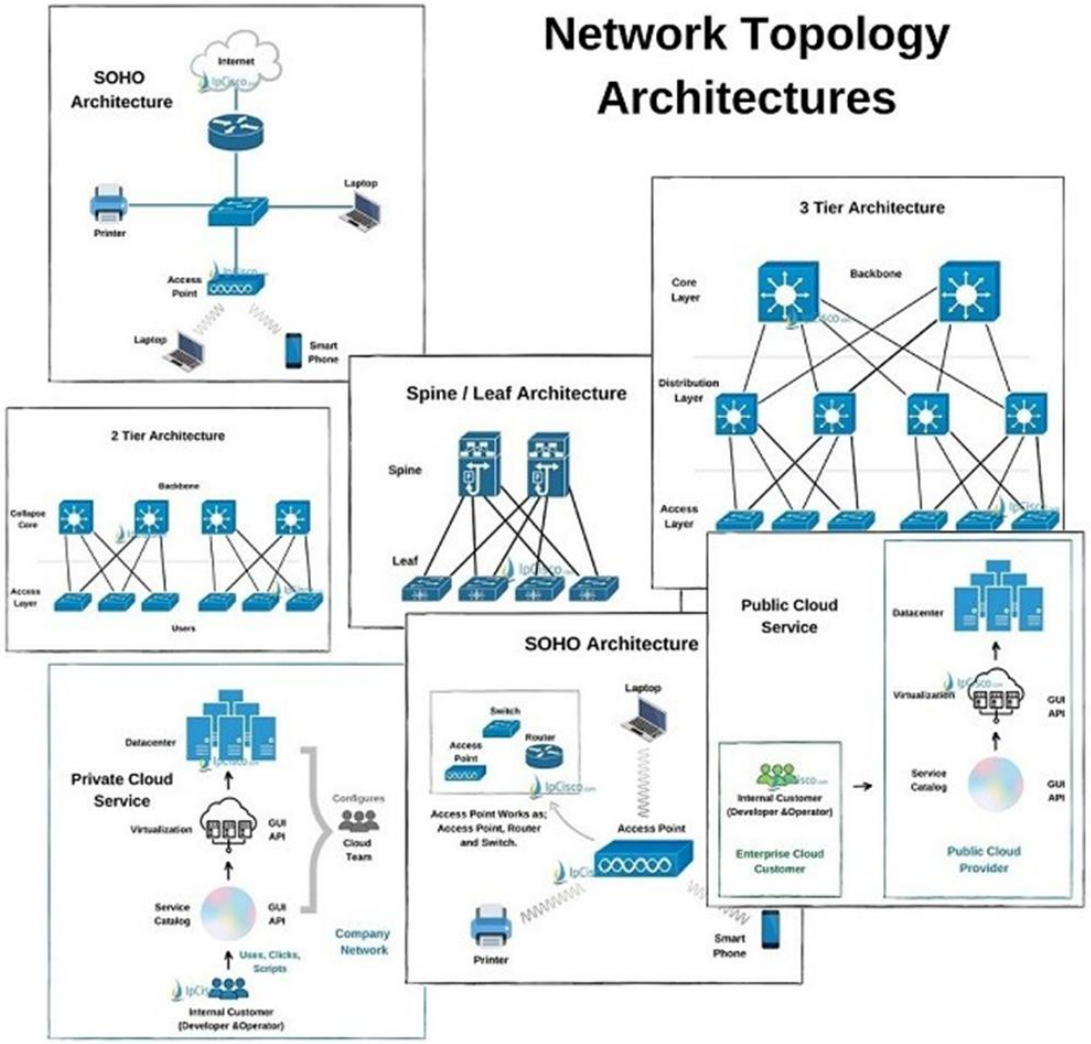
- 45
- 2D
- E9



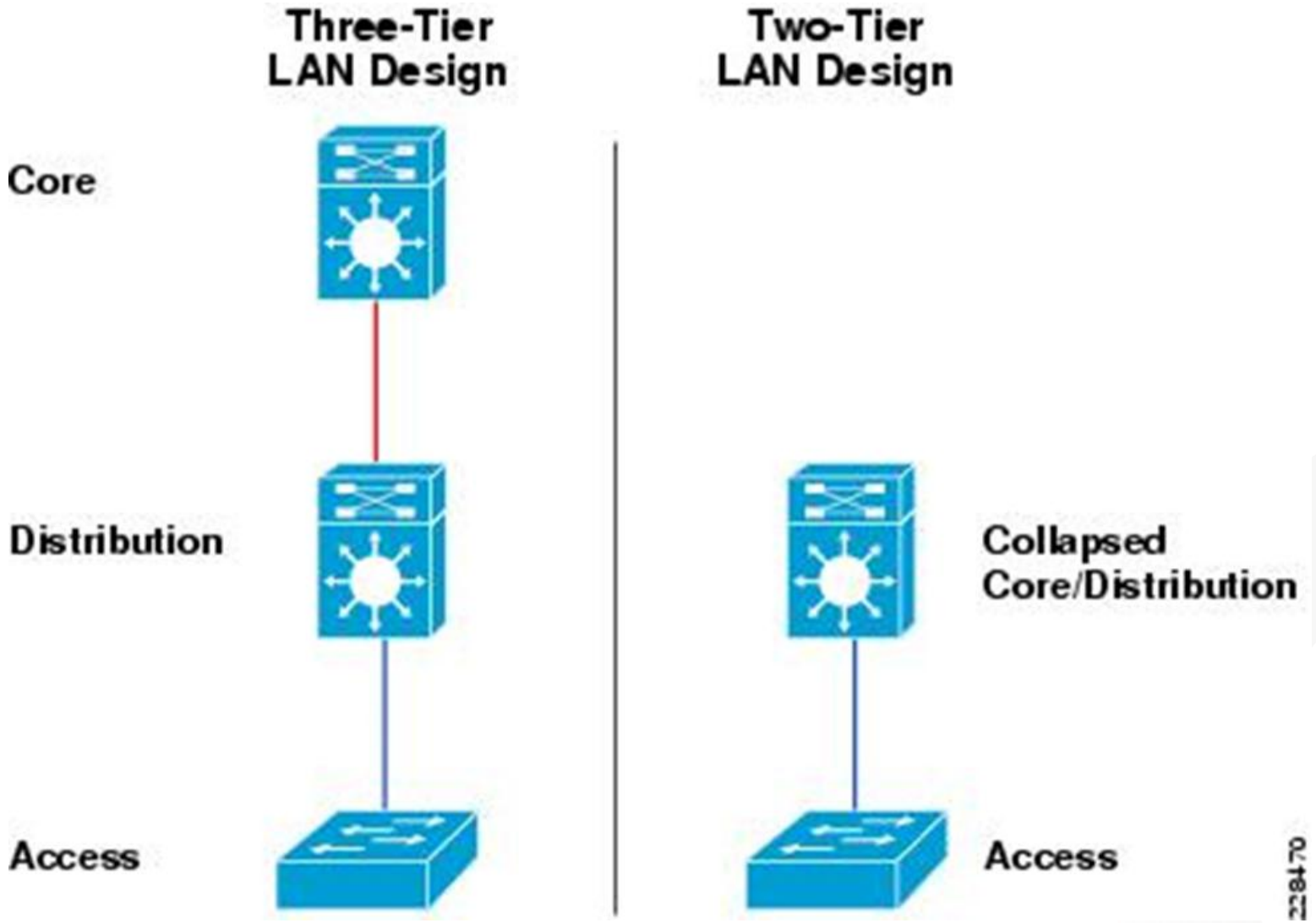
From networked infrastructures to networked data products



Network topology architectures



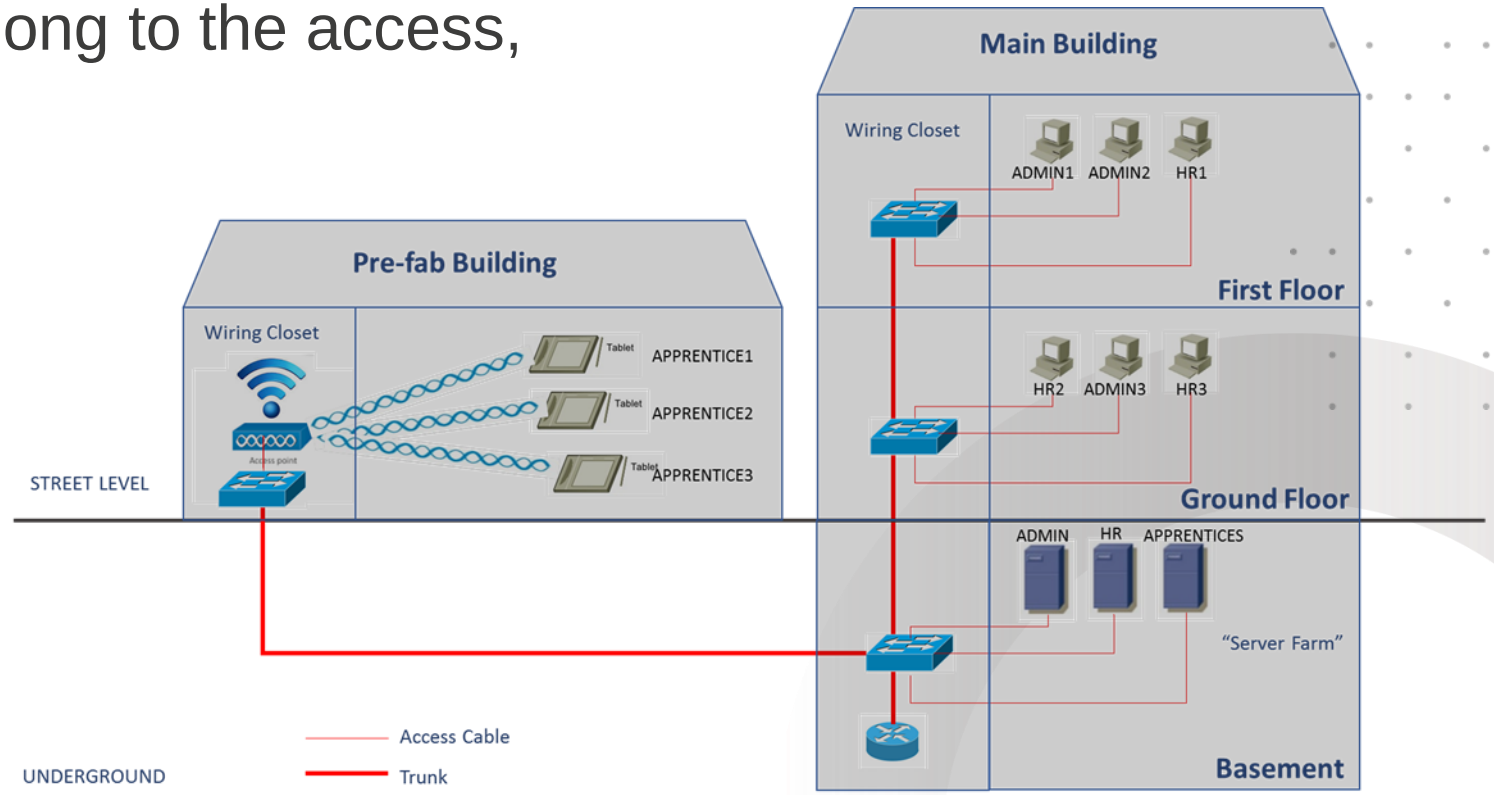
LAN Infrastructure Architecture



Activity walk-through

Campus LAN Architecture

- In this set-up, which devices belong to the access, distribution and core layers?
- Is this a 3-tier or 2-tier model?
- What is missing?

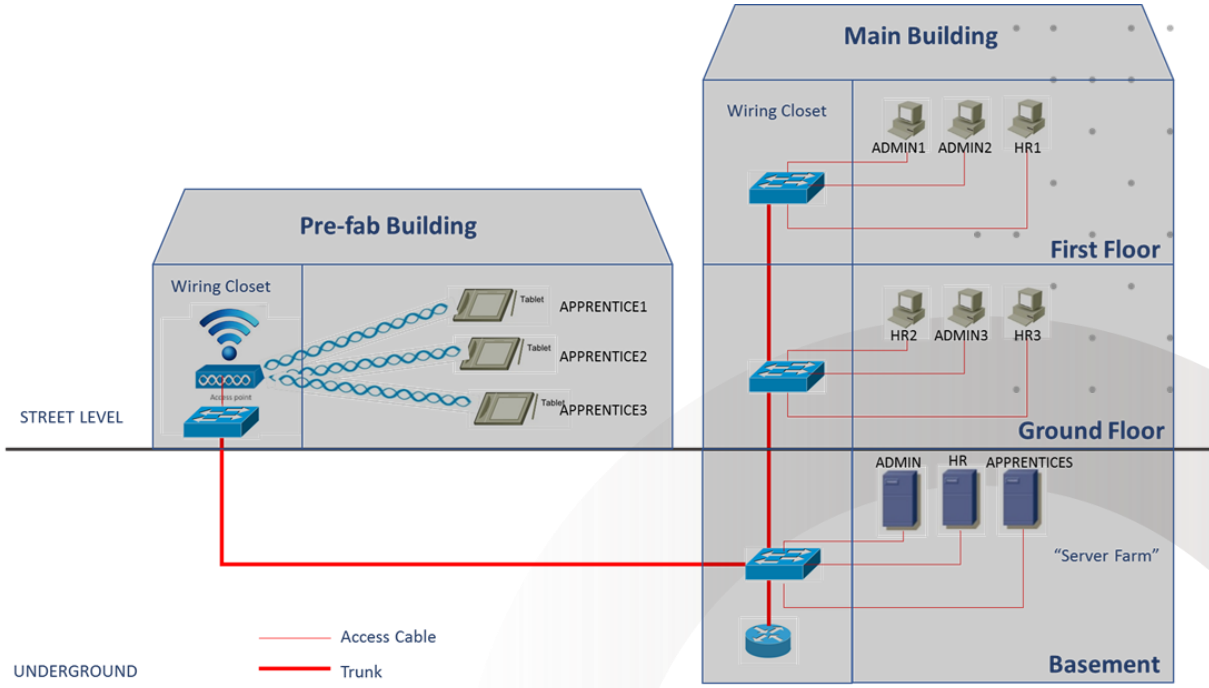


Analysis

- **Access Layer:** The devices labeled "APPRENTICE1", "APPRENTICE2", "APPRENTICE3", "HR1", "ADMIN", "HR2", "HR3", "APPRENTICES", "ADMINS", "JOB1", and "JOB2" are likely part of the access layer. These devices are at the edge of the network where end devices connect.

- **Distribution Layer:** The presence of "Wiring Closet" in both the Main Building and the Pre-fab Building suggests that these are distribution layer devices, likely aggregating connections from access layer devices and providing connectivity to the core layer if present.

- **Core Layer:** There are no clearly marked core layer devices or network segments that explicitly indicate core layer functions, such as high-speed backbone connectivity or centralized routing services.



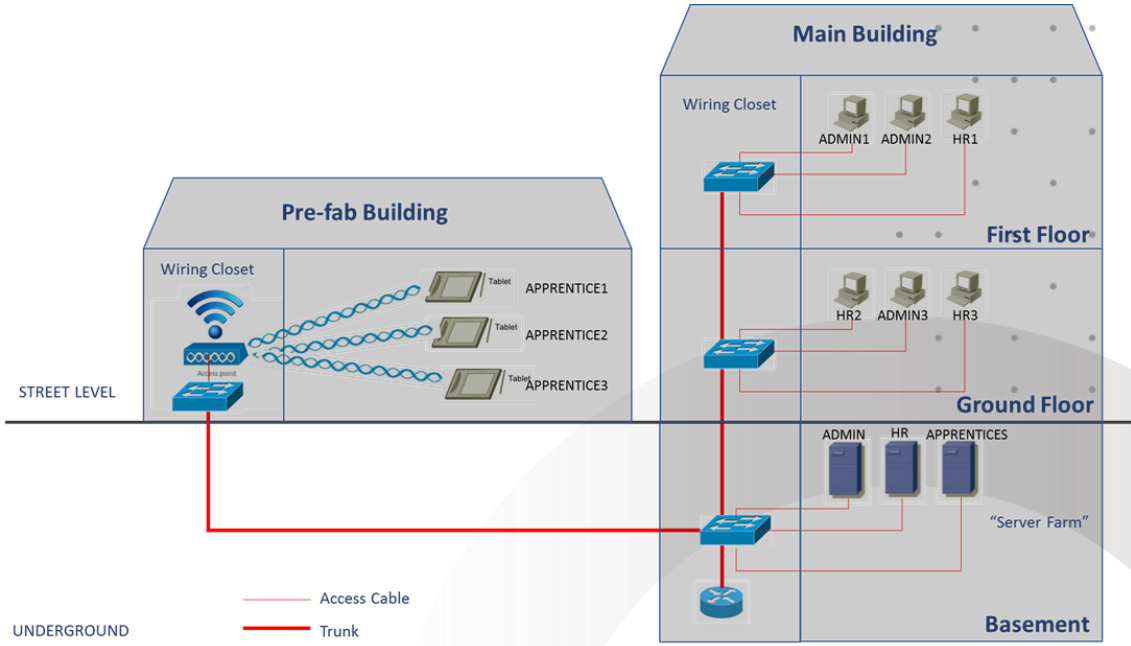
Missing Items

- **Core Layer Devices:** If this were a 3-tier architecture, we might expect to see dedicated high-speed backbone switches or routers forming a core layer distinct from the distribution layers.

- **Redundancy:** There is no explicit indication of redundancy in critical components like routers, switches, or connectivity paths, which is crucial for maintaining network availability and reliability.

- **Security Devices:** Firewalls, intrusion detection/prevention systems (IDS/IPS), and other security measures are not marked but are critical in protecting against external and internal threats.

- **Labeling for Uplinks and Connectivity Types:** More detailed labeling on the nature of connections (fiber, Ethernet) and speeds or roles (uplinks, interconnects) could help in understanding the network architecture more clearly



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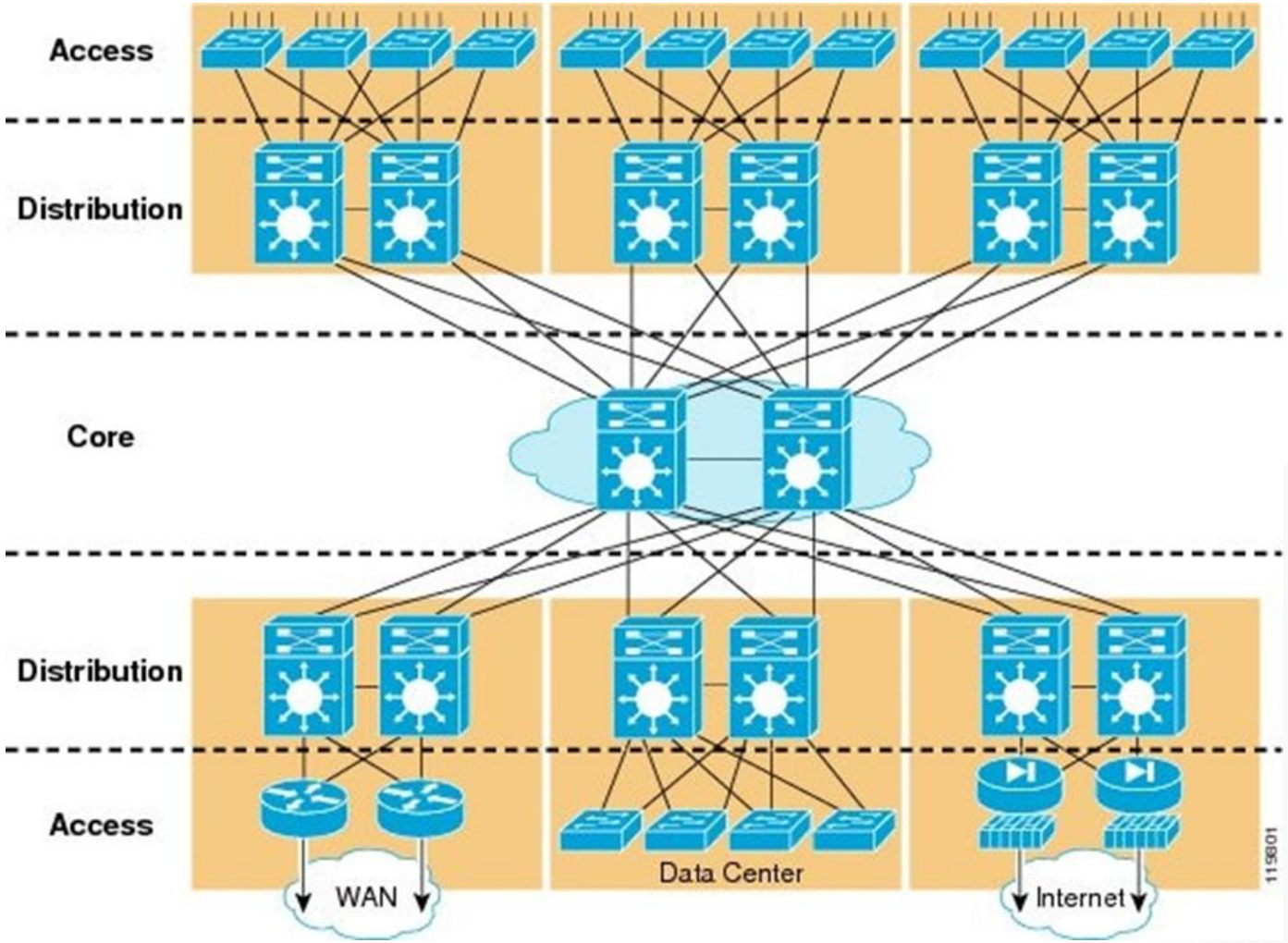
Redundancy and high availability

Redundant links for High Availability



Data Centres

Data Centre Equipment

- Data centres contain aisles, with each aisle containing rows of cabinets.
- Each cabinet contains multiple rack servers.

Aisle

Cabinet containing individual rack servers

Data Centre Equipment

Data Centre Infrastructure

- Switches, racks, servers
- Leaf and spine datacenter topology

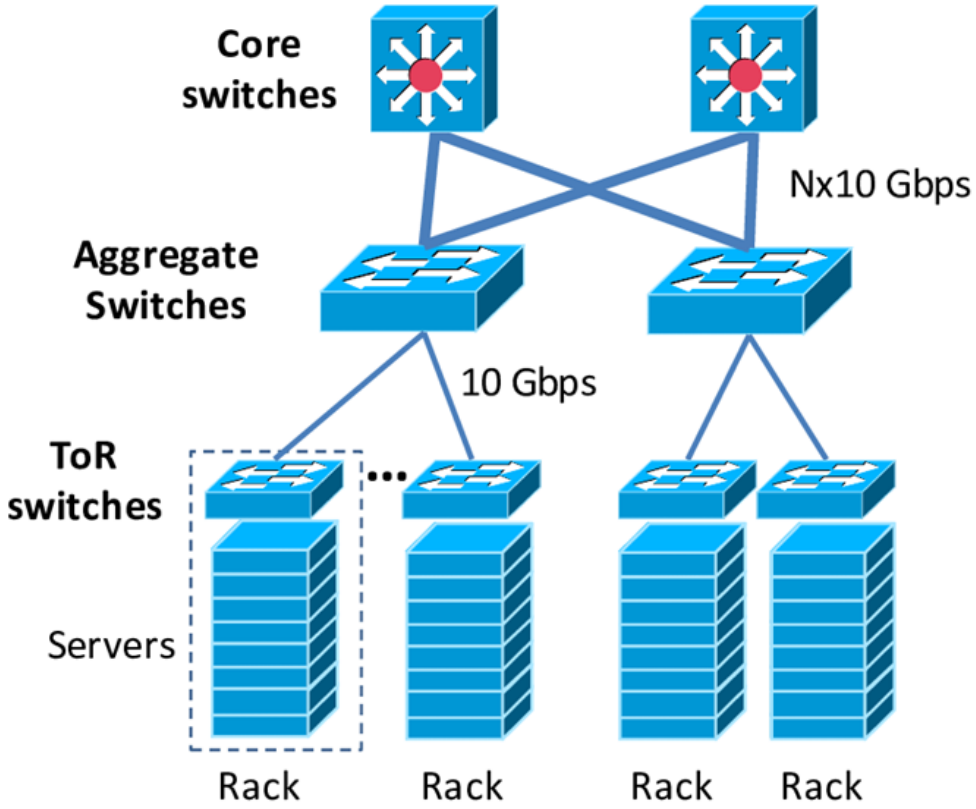
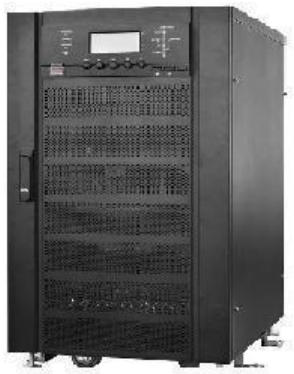


Image Source: opennebula.org

Data Centre Equipment

- To ensure a reliable uninterrupted supply of power, typically a data centre would use backup generators in case of a power outage…

- However, these can take a few minutes to come online, so in the meantime..

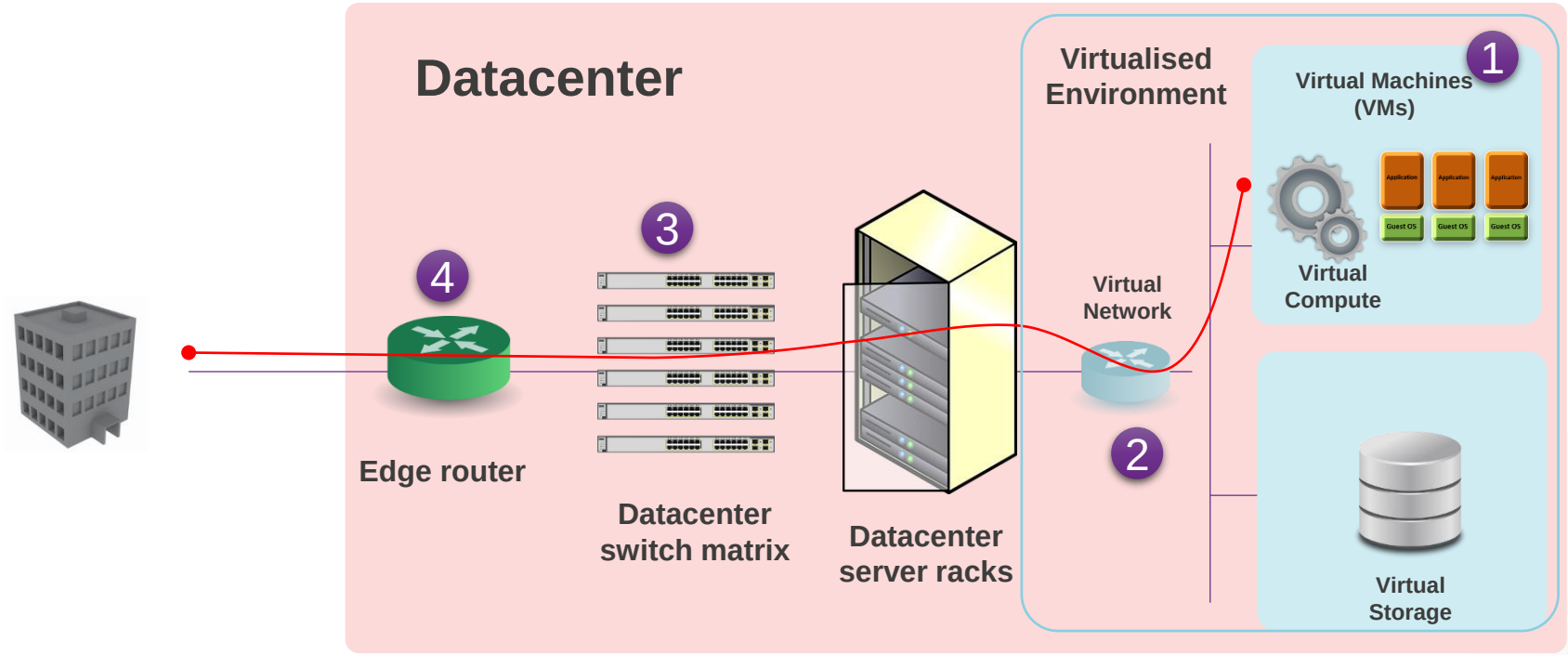


… a large set of batteries keep critical systems running for long enough to either shutdown properly, or transition to the power supplied by the generator.

This is a UPS – Uninterruptable Power Supply

Data centre infrastructure

Data Centre Components



https://www.cisco.com/c/en/us/solutions/collateral/data-center-virtualization/application-centric-infrastructure/solution-overview-c22-741487.html

Discussion

Building Careers Through Education

Everybody Matters. Stronger Together. Student, Learner and Client Centric. Trust and Respect. Embrace Change.

List and describe some of the challenges an in-house IT team would encounter in setting up an on-premise datacenter.

Submit your responses to the chat!

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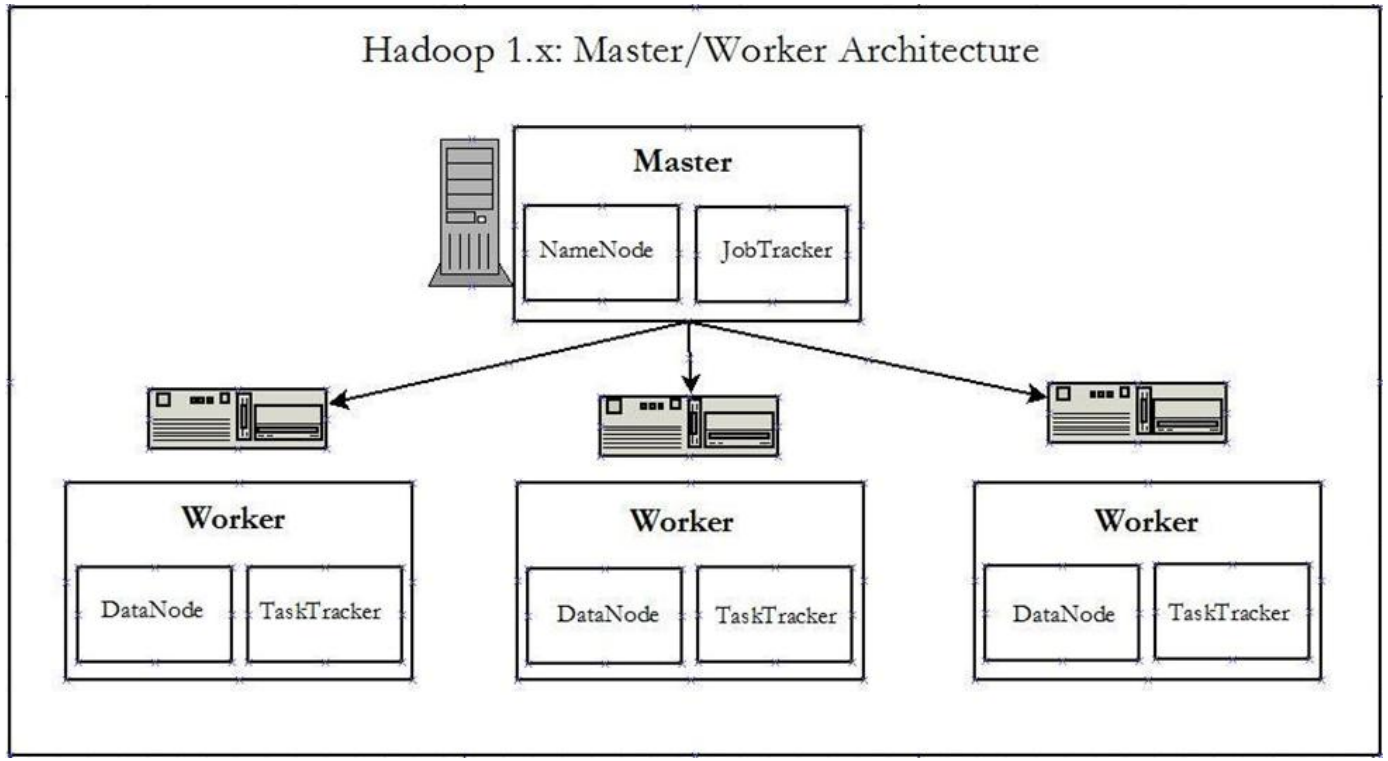
Discussion – Logical data products

Logical cluster architecture



Submit your responses to the chat!

Question: What problems can you anticipate with this sort of architecture?

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Distributed data products

- **Clients send heartbeats to the server** every three seconds
- After a period with no heartbeats, a client is marked as lost
  - **Data recovery will kick in**
- A client can rejoin the cluster at any time
  - Alternatively, **whitelists** can be created by administrators to control which worker hosts are allowed
  - Similarly, blacklists can be created

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High availability (HA)

- You may have realised that if the server becomes **unresponsive**, you cannot use the data product

- **High availability** is a mode for mitigating this **single point of failure:**
  - Two servers – standby and active

- New components keep tracking who is standby and manage **failover control**

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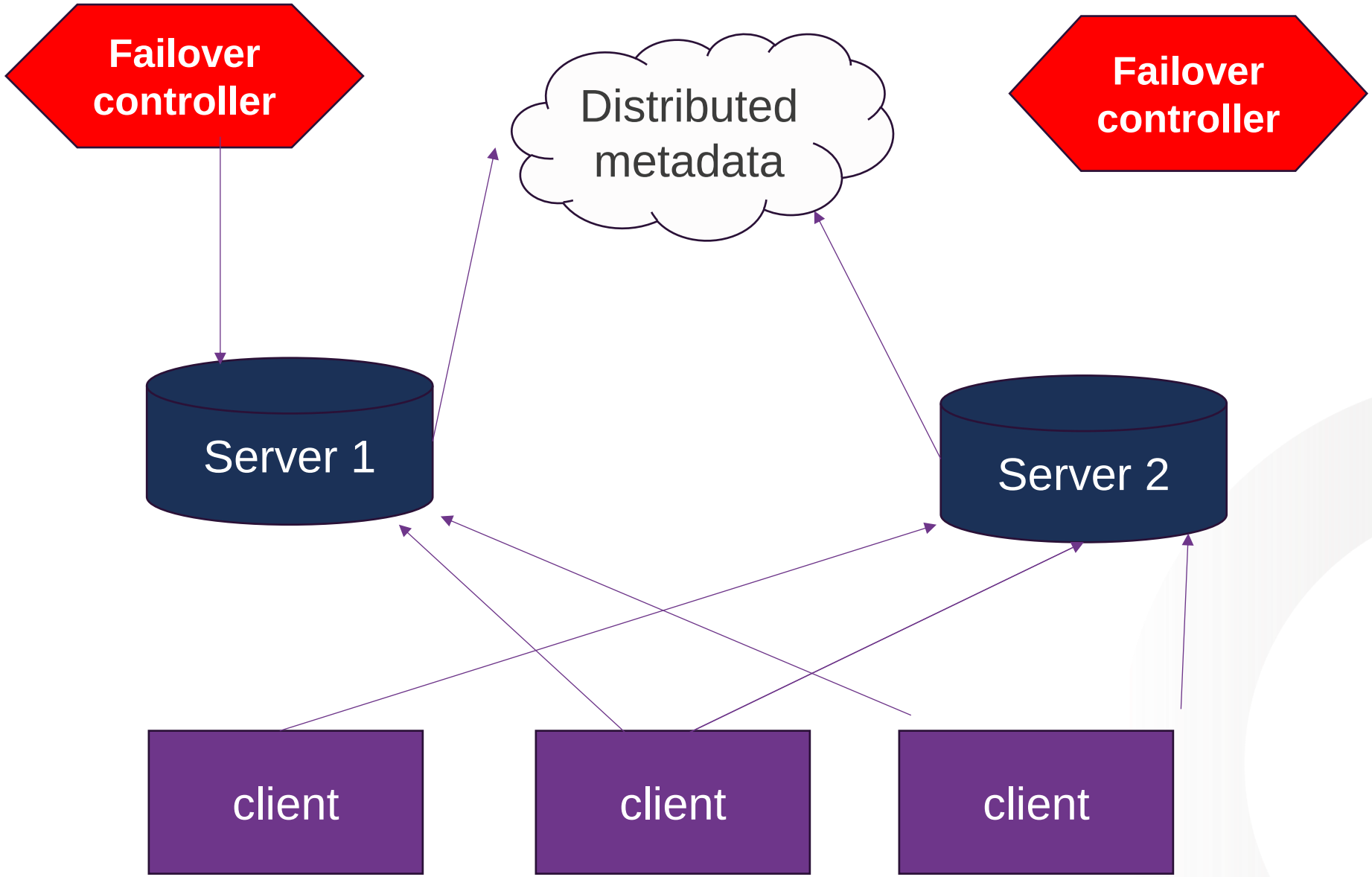
Advanced distributed networked architectures



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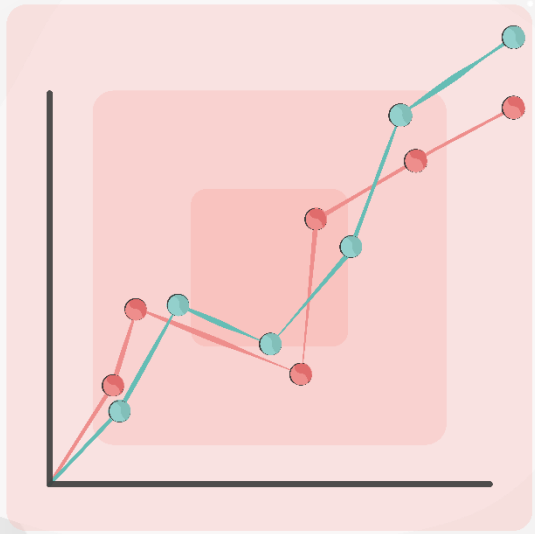
Modern networking practices



Virtual network components

- Virtual network
    - Can be created to consist solely of virtual machines on a physical server
- Most networks combine physical and virtual elements

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Virtual Local Area Networks

- Reasons for using VLANs:
  - Separating groups of users who need special security or network functions
  - Isolating connections with heavy or unpredictable traffic patterns
  - Identifying groups of devices whose data should be given priority handling
  - Containing groups of devices that rely on legacy protocols incompatible with the majority of the network's traffic
  - Separating a large network into smaller subnets

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VLANs and trunking

- Trunk
  - ➢A single physical connection between switches through which many logical VLANs can transmit and receive data
- A port on a switch is configured as either an access port or a trunk port
  - ➢Access port - used for connecting a single node
  - ➢Trunk port - capable of managing traffic among multiple VLANs

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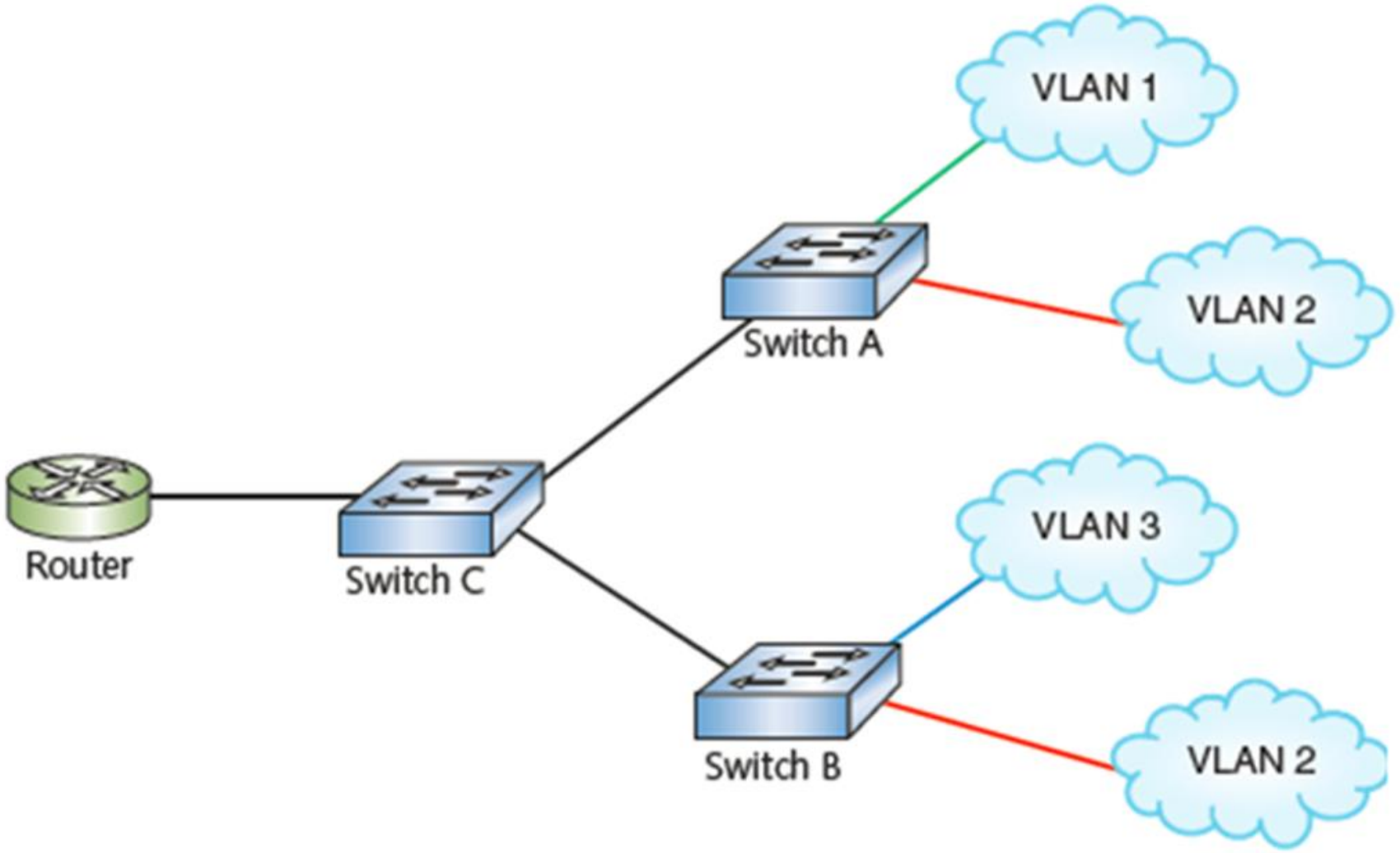
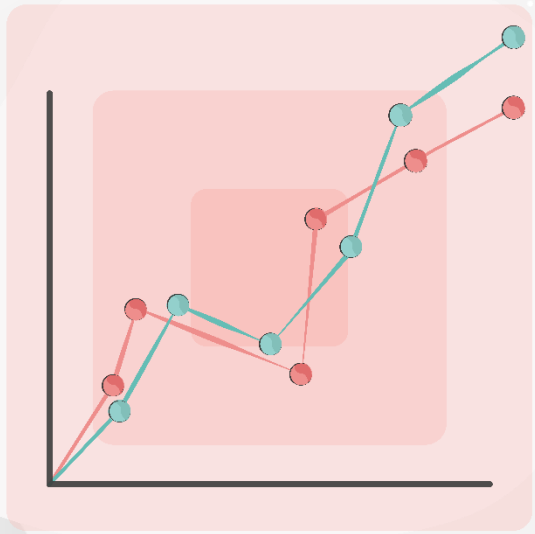
Virtual Local Area Networks



A single VLAN can be managed by multiple programmable switches

Network costs and sustainability

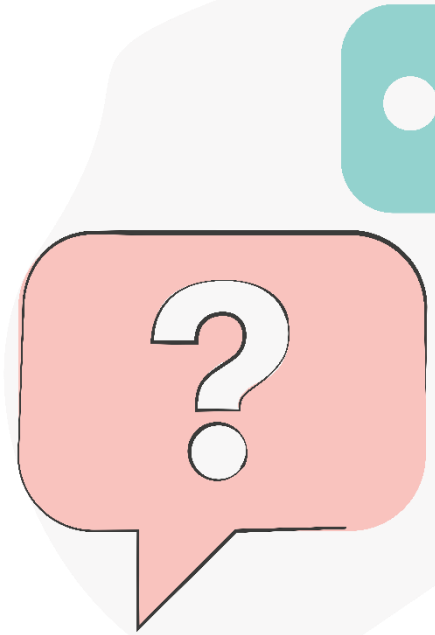


Understanding network costs

Capital Expenditure (CapEx): Initial costs for network hardware like routers, switches, servers, and cabling.

Operational Expenditure (OpEx): Ongoing costs including power consumption, maintenance, and network management.

Question: How do these costs impact budget planning and overall financial strategy for businesses?



Submit your responses to the chat!

TCO

Total Cost of Ownership encompasses all the direct and indirect costs associated with the acquisition, deployment, operation, and maintenance of network resources over their lifecycle.

- **Hardware and Software Acquisition:** Costs of purchasing network equipment and software licenses.
- **Installation and Configuration:** Expenses involved in setting up and configuring network hardware and software.
- **Maintenance and Upgrades:** Ongoing costs for maintaining, updating, and upgrading network systems to ensure efficiency and security.
- **Training and Support:** Costs related to training staff to operate and manage network systems and ongoing technical support.
- **Energy Consumption:** Operational costs for electricity which can be significant in data centres and network operations.

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Other cost factors

- **Software Licenses**: Expenses related to network management and security software.

- **Manpower:** Costs of hiring qualified IT staff for network setup, management, and troubleshooting.

- **Downtime and Risk Costs:** Financial impact associated with network downtimes, including loss of productivity and potential breach risks.

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Strategies to reduce cost

- **Energy Efficiency:** Investing in energy-efficient hardware to reduce power consumption.
- **Virtualisation:** Using virtual machines and software-defined networking to optimise resource usage.
- **Cloud Services:** Outsourcing certain network functions to cloud providers to reduce on-premises hardware needs.
- **Preventative Maintenance:** Regular maintenance to prevent costly downtime and repairs.
- **Data compression:** Reducing the size of data to save storage space and decrease transmission times.

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Transfer optimisation

- **Caching:** Storing copies of frequently accessed data closer to the user to reduce data retrieval times and bandwidth usage.
- **Load Balancing:** Distributing network traffic across multiple servers to optimize resource use and minimise response times.
- **Traffic Shaping:** Prioritising certain types of data to ensure critical applications have the bandwidth they need.
- **Benefits:** Enhanced user experience, reduced server load, and minimized energy consumption due to efficient data handling.

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Network sustainability - terms

- **Sustainability Concerns**: Environmental impact of network operations, particularly energy usage and electronic waste.

- **Green Networking:** practices and technologies that reduce the environmental footprint of network infrastructure.

- **Net-zero emissions:** the balance between the amount of greenhouse gas emissions produced and the amount removed from the atmosphere.

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Case Studies for Net Zero

Google

- Data Centre Efficiency
- Renewable Energy
- Material Use

NETFLIX

- Video Compression
- Dynamic Optimisation
- Content Delivery Network (CDN)

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Practical application

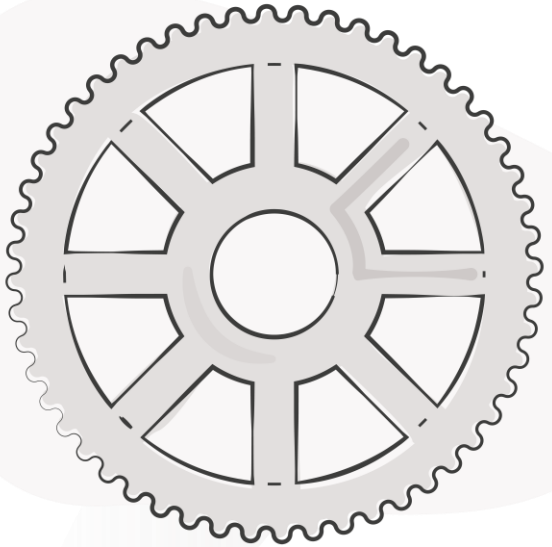
Tutorial walkthrough

For this walkthrough we complete the following steps:

1. Log in to Microsoft Azure (Github Student Pack)
2. Select Azure Databricks
3. Create a new deployment (Select free trial tier)
4. Create a new cluster
5. Create a new notebook
6. Follow the exercises in the worksheet

The link for the associated task briefing:

Briefing link



Practical application

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Key Learning Summary

The key takeaways from this session are as follows:

- Understanding the concepts of logical networking, virtualisation, SDN, and NFV is essential for managing modern network infrastructures effectively.
- By mastering distributed data products and modern cluster management solutions you will be well-equipped to handle large datasets efficiently and reliably, ensuring optimal performance and reliability in real-world applications.
- Sustainable network practices are crucial in our collective effort to combat environmental challenges
- Understanding infrastructure costs is crucial for efficient budgeting, strategic planning, and making informed network investment decisions

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