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Overview

- 1. Data Center Physical Layout**
- 2. Data Center Network**
- 3. Data Center Network Topologies**
- 4. ToR vs. EoR**
- 5. Data Center Networking Issues**
- 6. Data Center Networking Requirements**





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Data Centre

Consists of:

- Servers (Physical machines)
- Storage
- Network devices (switch, router, cables)
- Power distribution systems
- Cooling systems



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Data Centre Network

Communications infrastructure – Could be described by:

- Topology
- Routing / switching equipment
- Protocols

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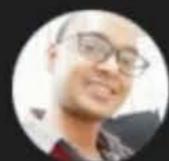
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Data Centre Network

Data Centre Network vs. ISP Networks:

- Number of nodes
- ISPs backbones (hundreds)
- 487 for AT&T Data centres (thousands)
- Google (12000)
- Topology
- Topology with specific properties are used for data centre in order to allow topology specific routing optimization

What is the difference between
Data Centre and Cloud?



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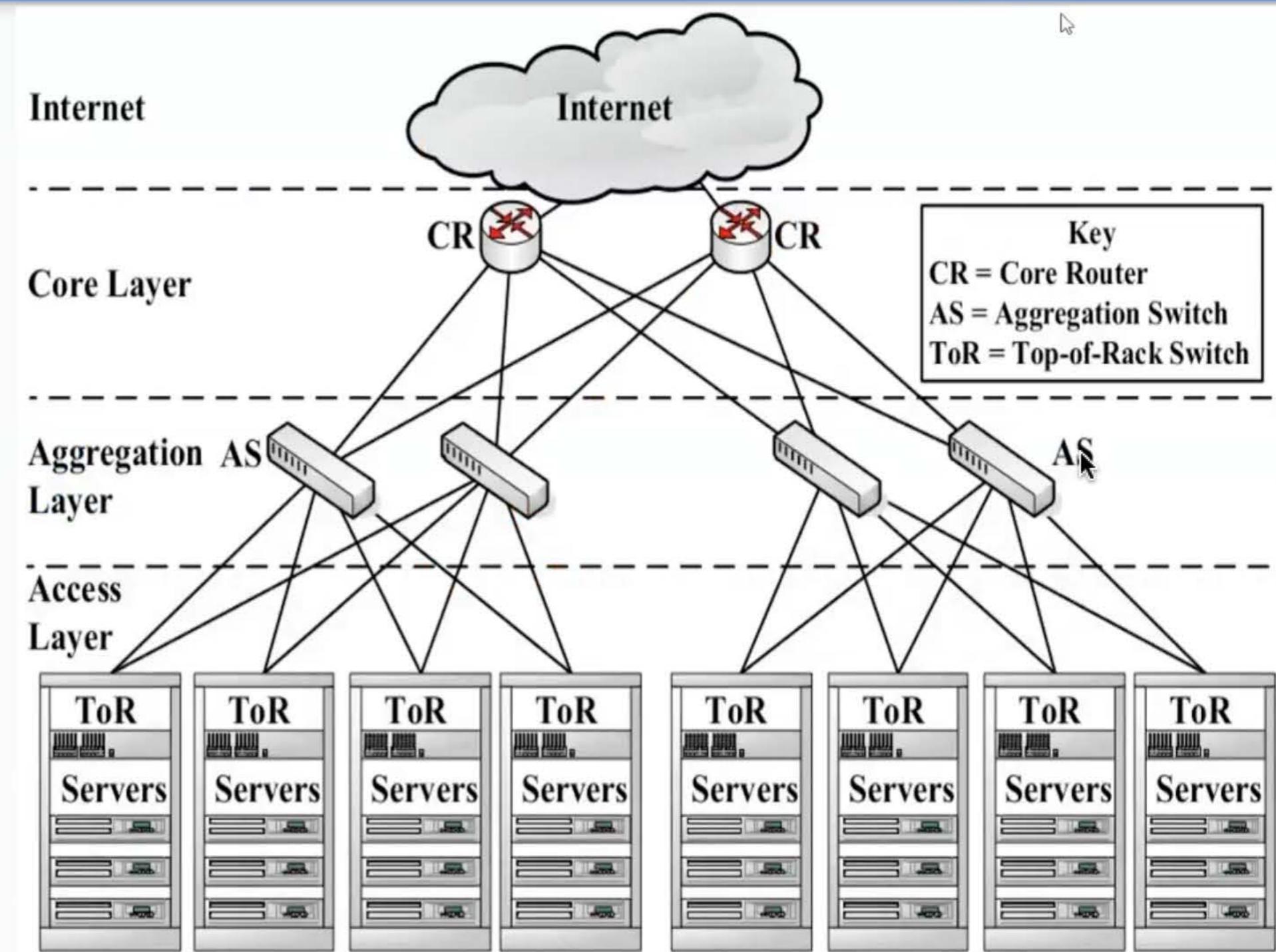


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Conventional Topology

Three layers:

- Access layer with Top of the Rack (ToR) switches
- Aggregation layer
- Core layer





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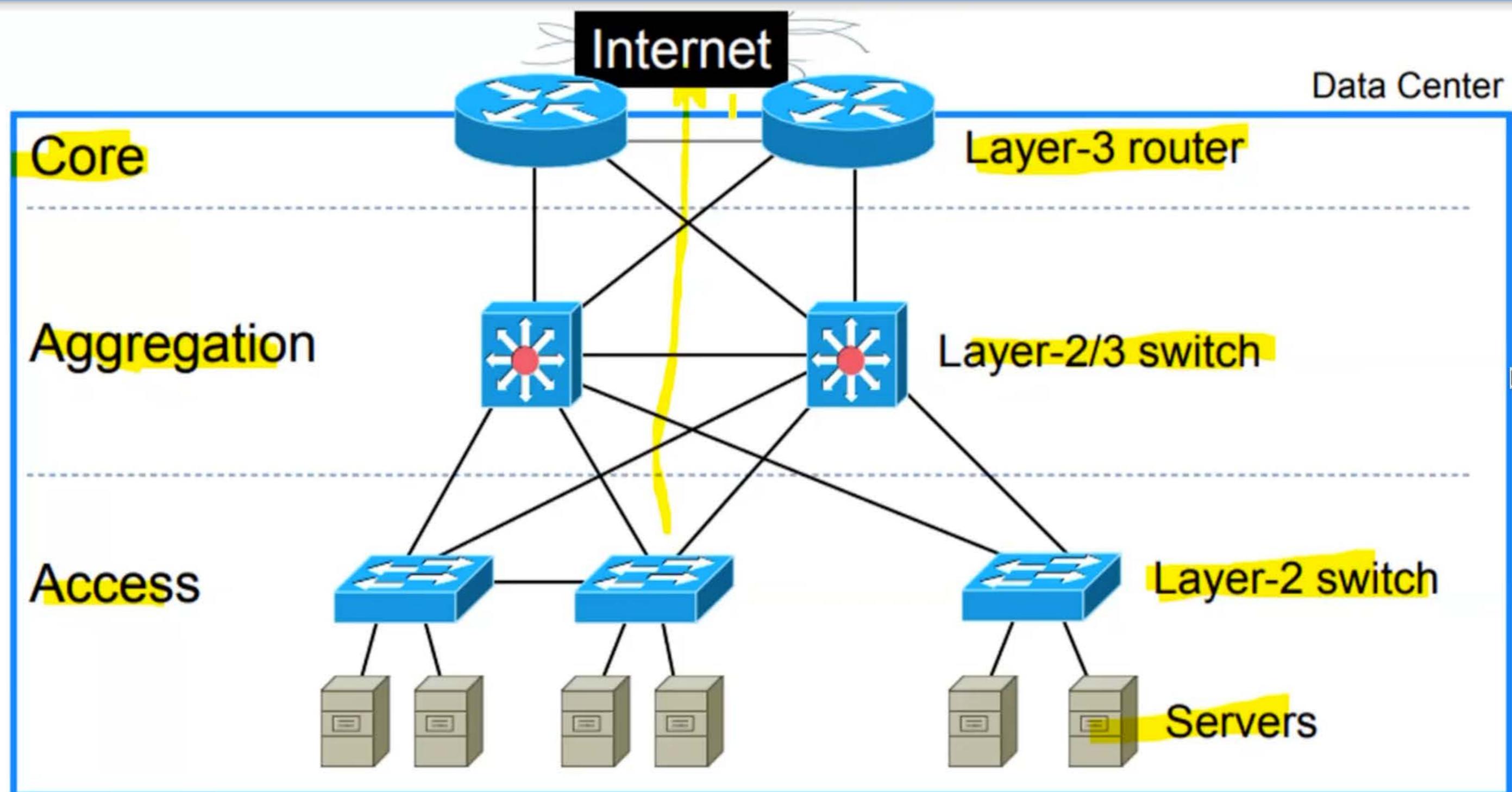
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Common Data Center Topology



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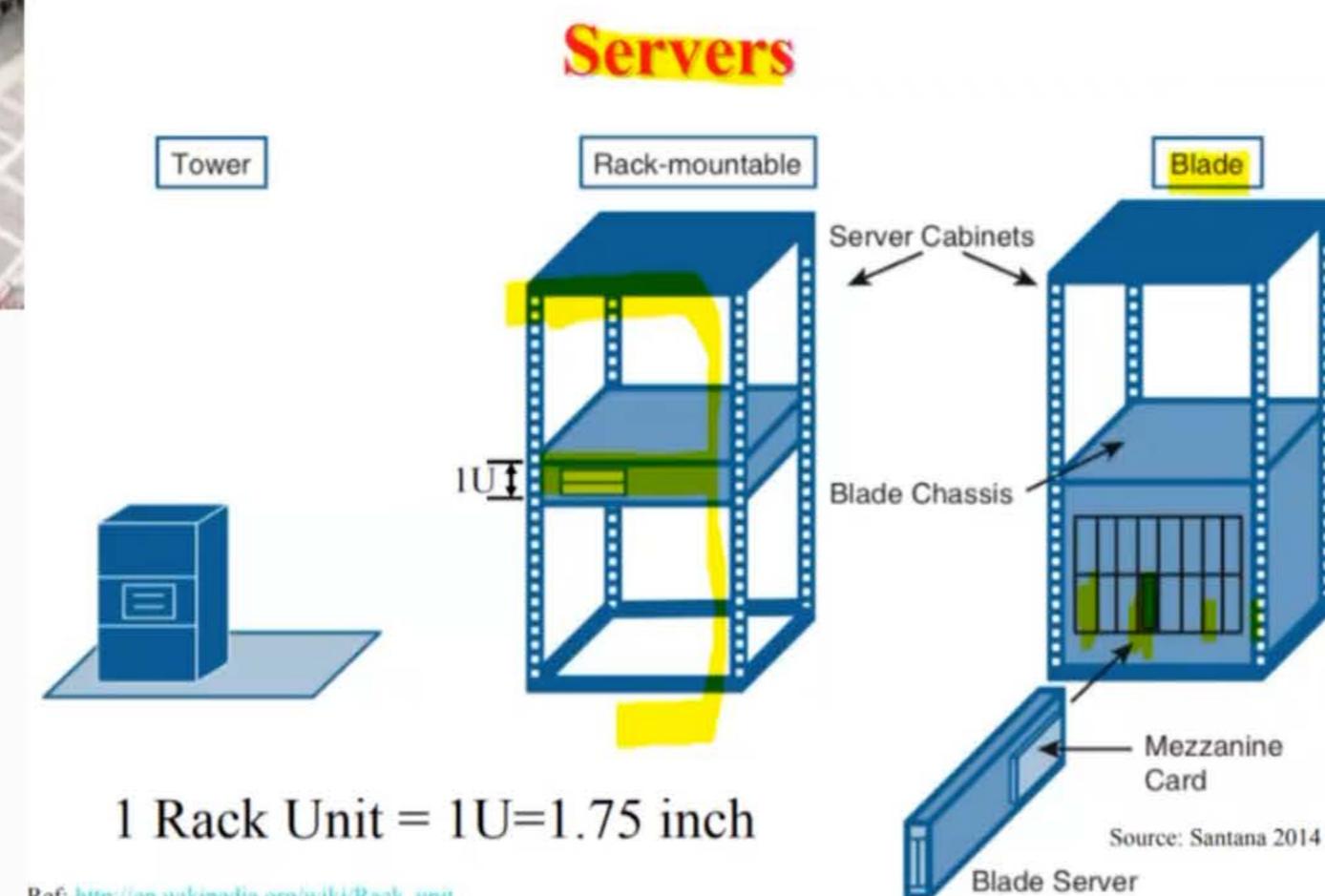
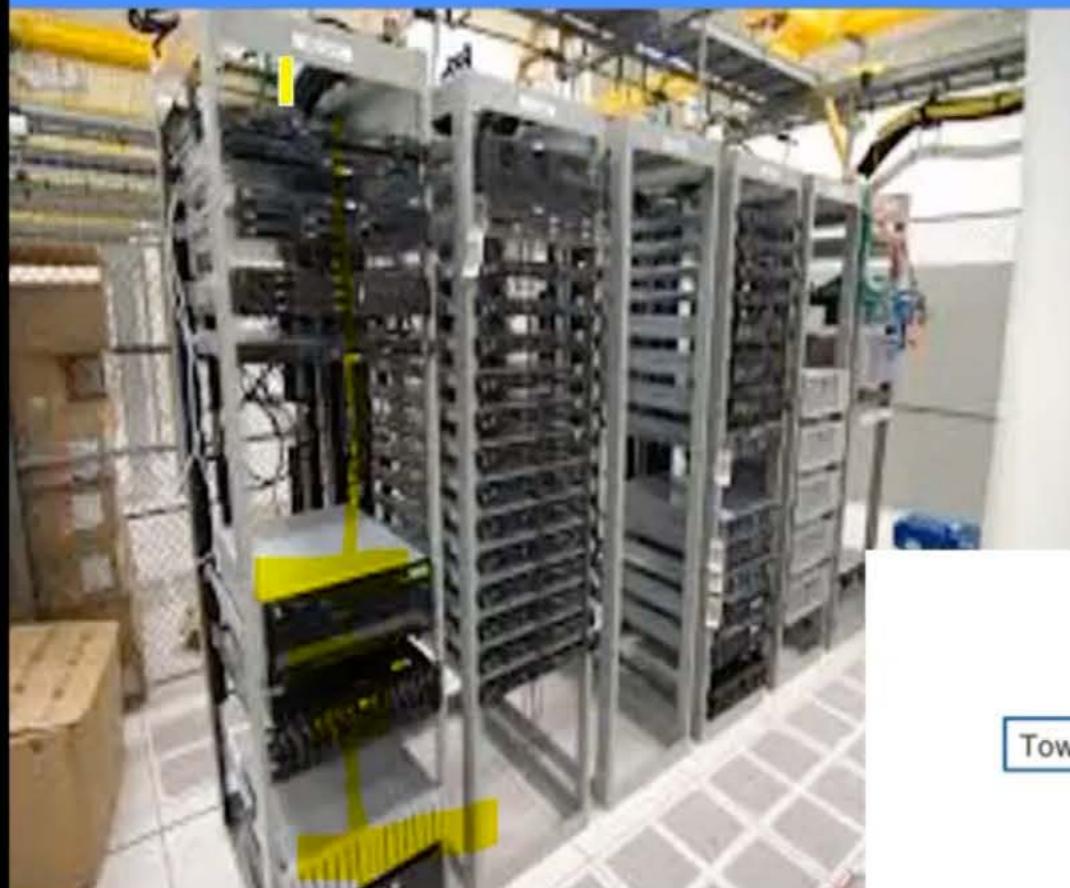
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Server and Server Rack





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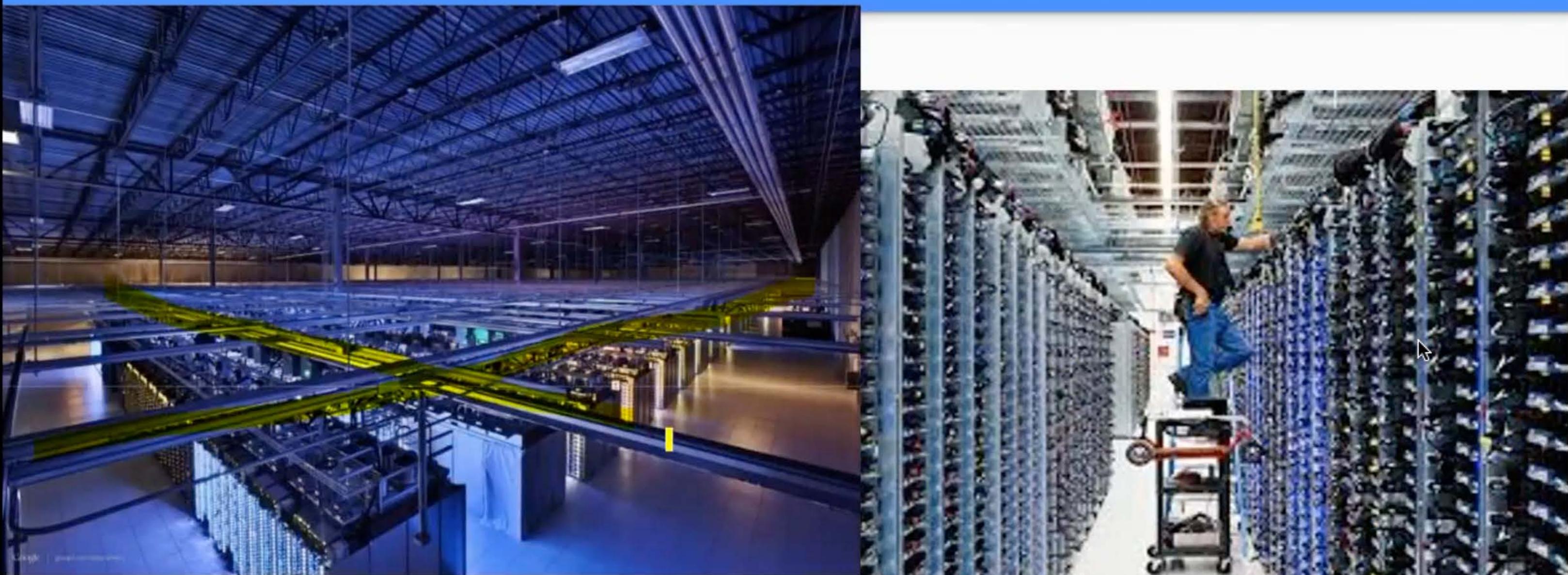
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Data Center Street View



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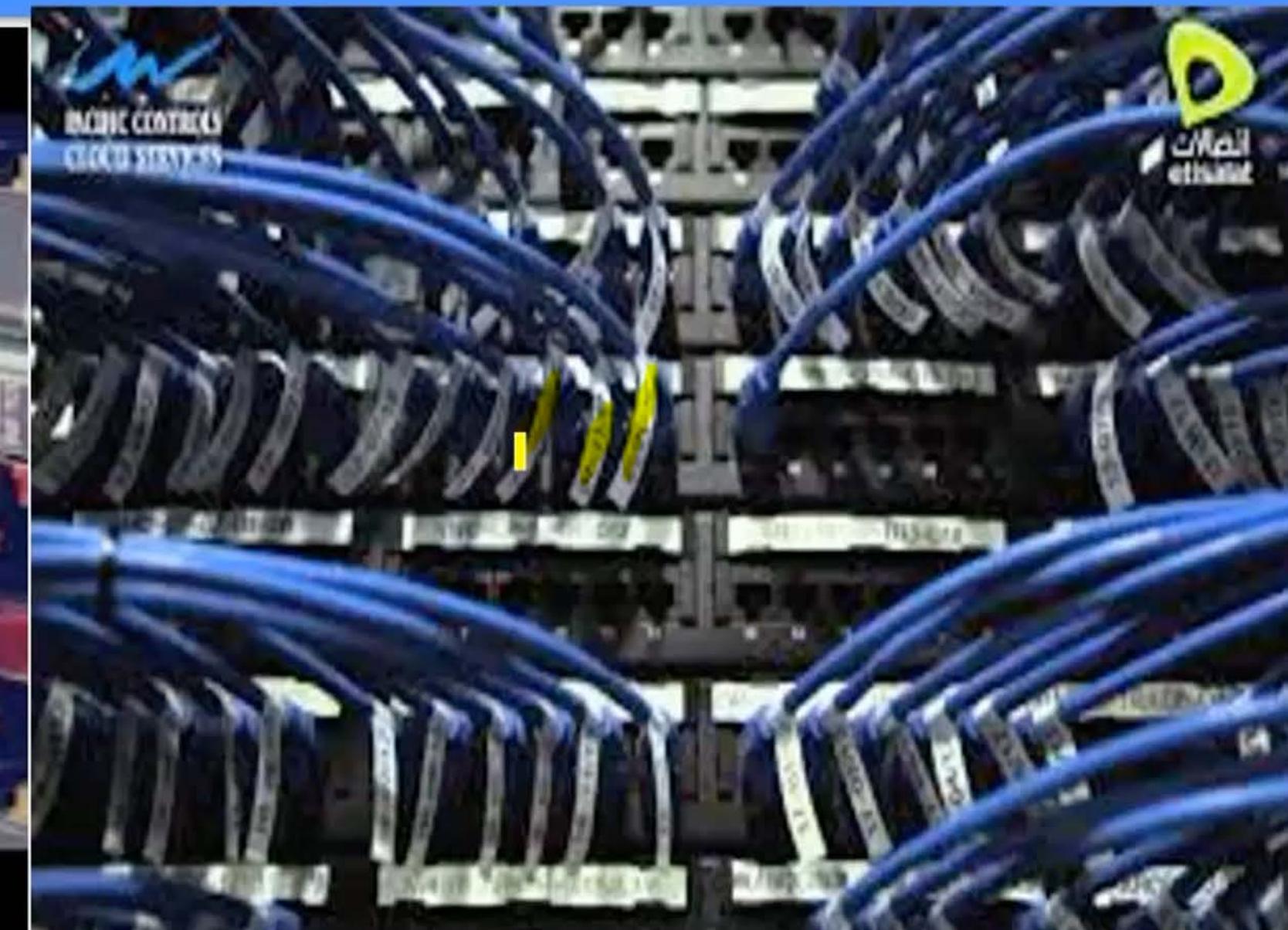
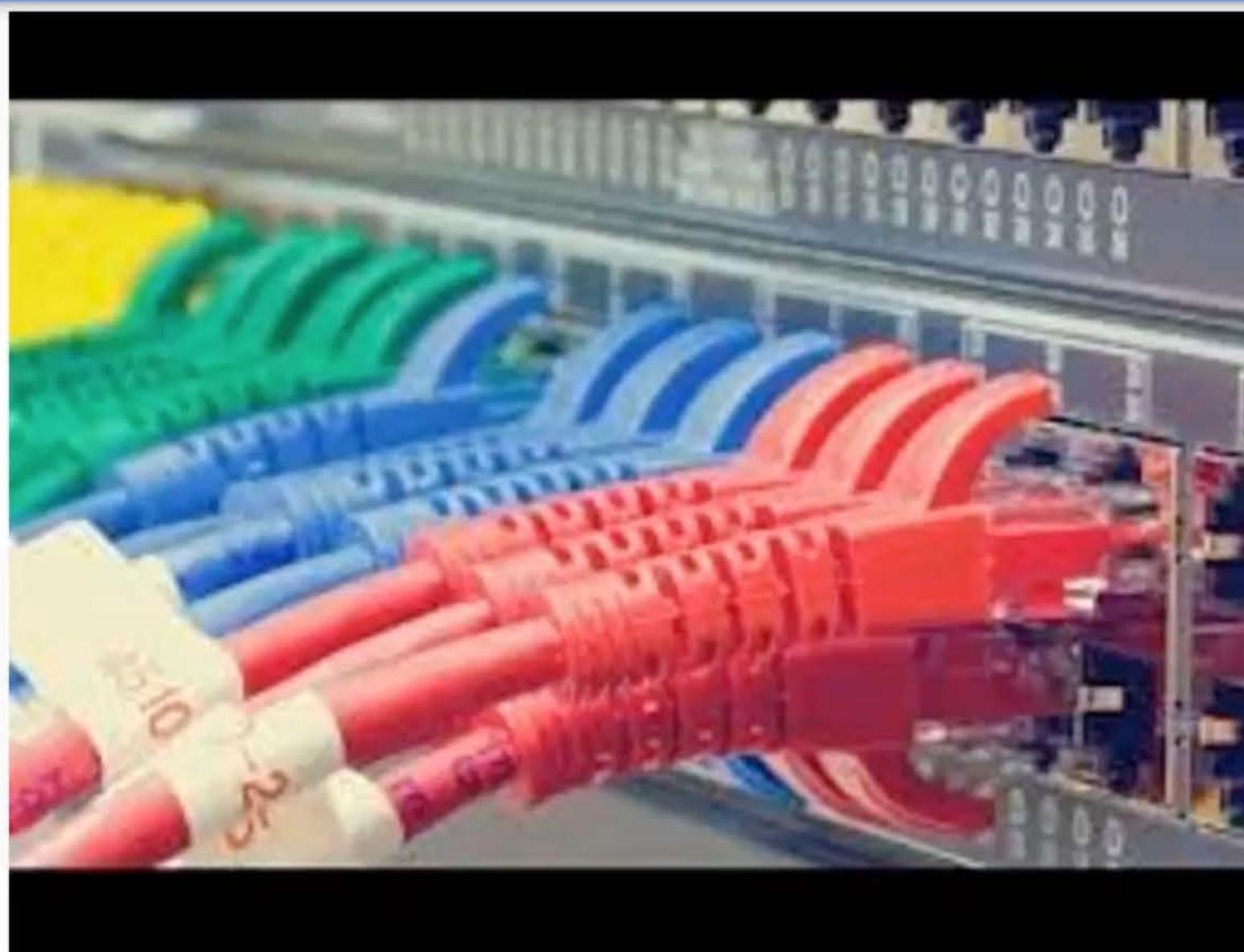
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Structured Cabling



- **Cables are pretty structured with proper tags, numbers and path identifications.**

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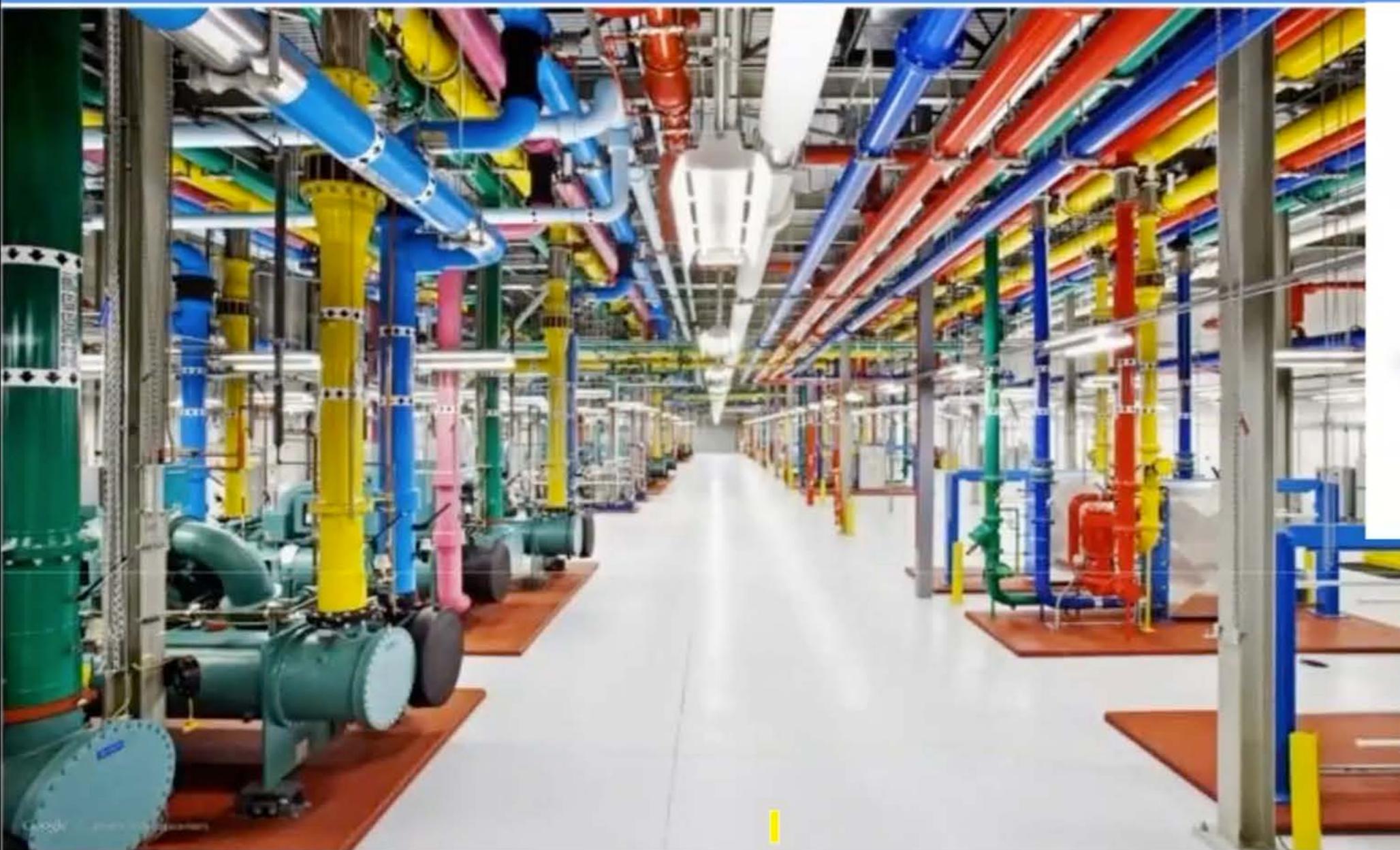
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Cooling Systems



- Cooling System Data Center



- Cooling System is built in inside the ICE Cube Air, it is known as **Modular Data Center**



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Modular Data Centers

Small: < 1 MW, 4 racks per unit

Medium: 1-4 MW, 10
racks per unit Large:
> 4 MW, 20 racks per
unit

Built-in cooling, high PUE (power usage
effectiveness) 1.02 PUE = Power In/Power
Used

Rapid deployment



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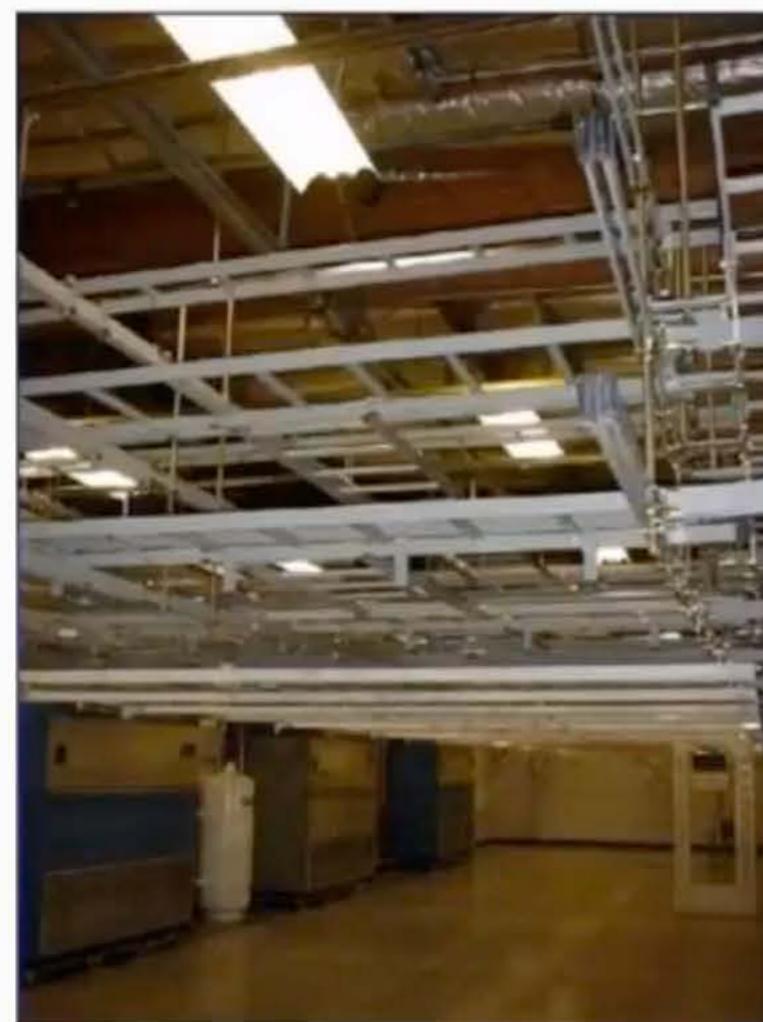
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Data Center Equipment Cabinets

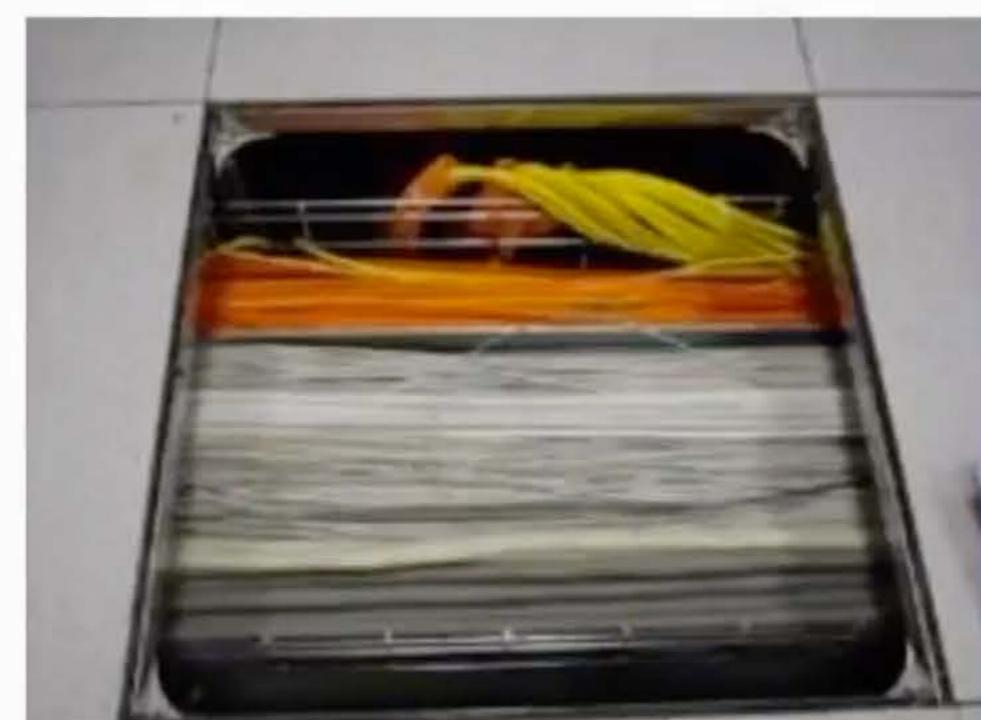
Three Layers: Bottom: Signal,
Middle: Power, Top: Fiber



Minimize patching between
cabinets and racks



Cabling under raised
floors provides better
appearance and cooling



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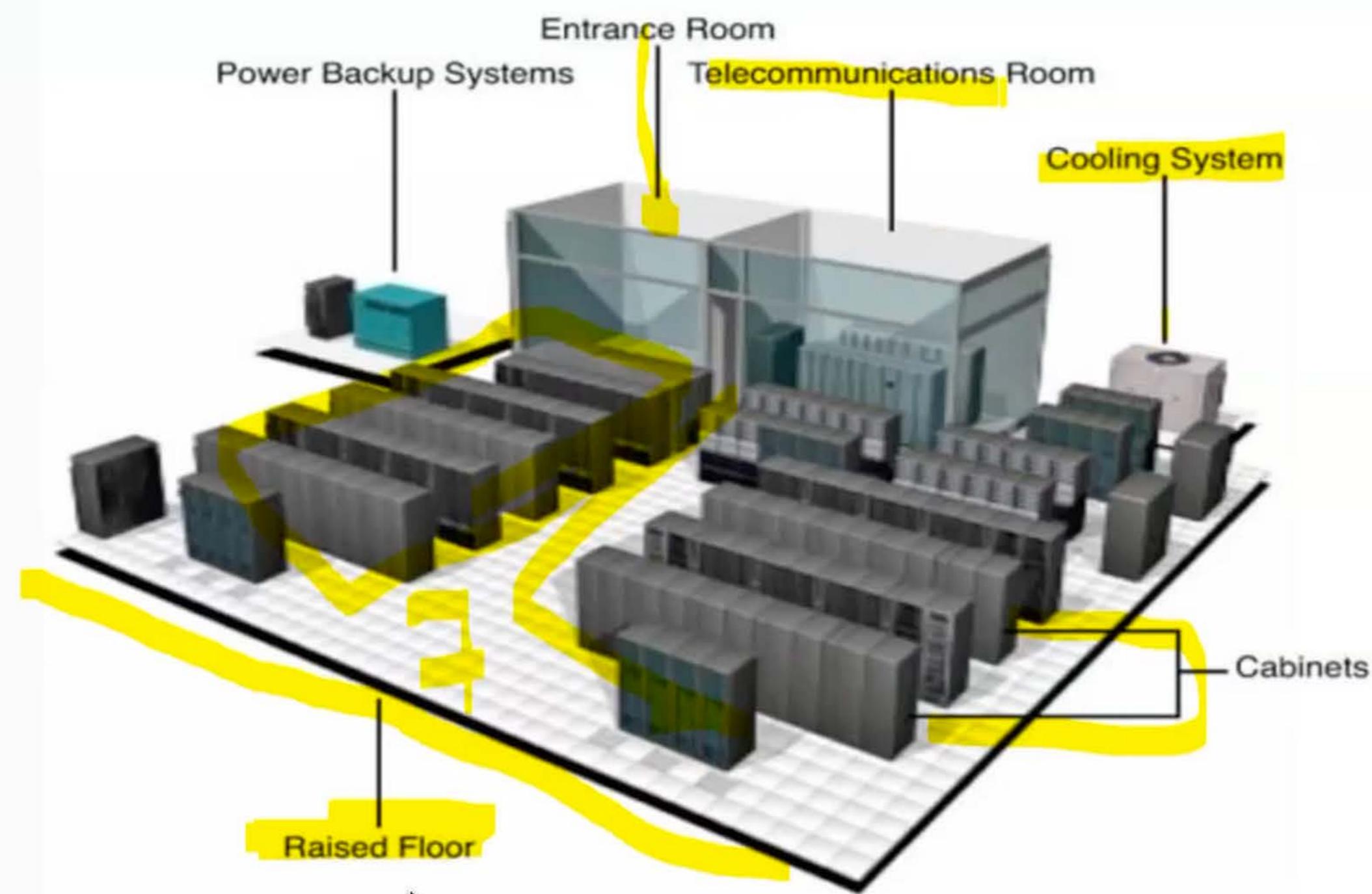
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Data Center Physical Layout



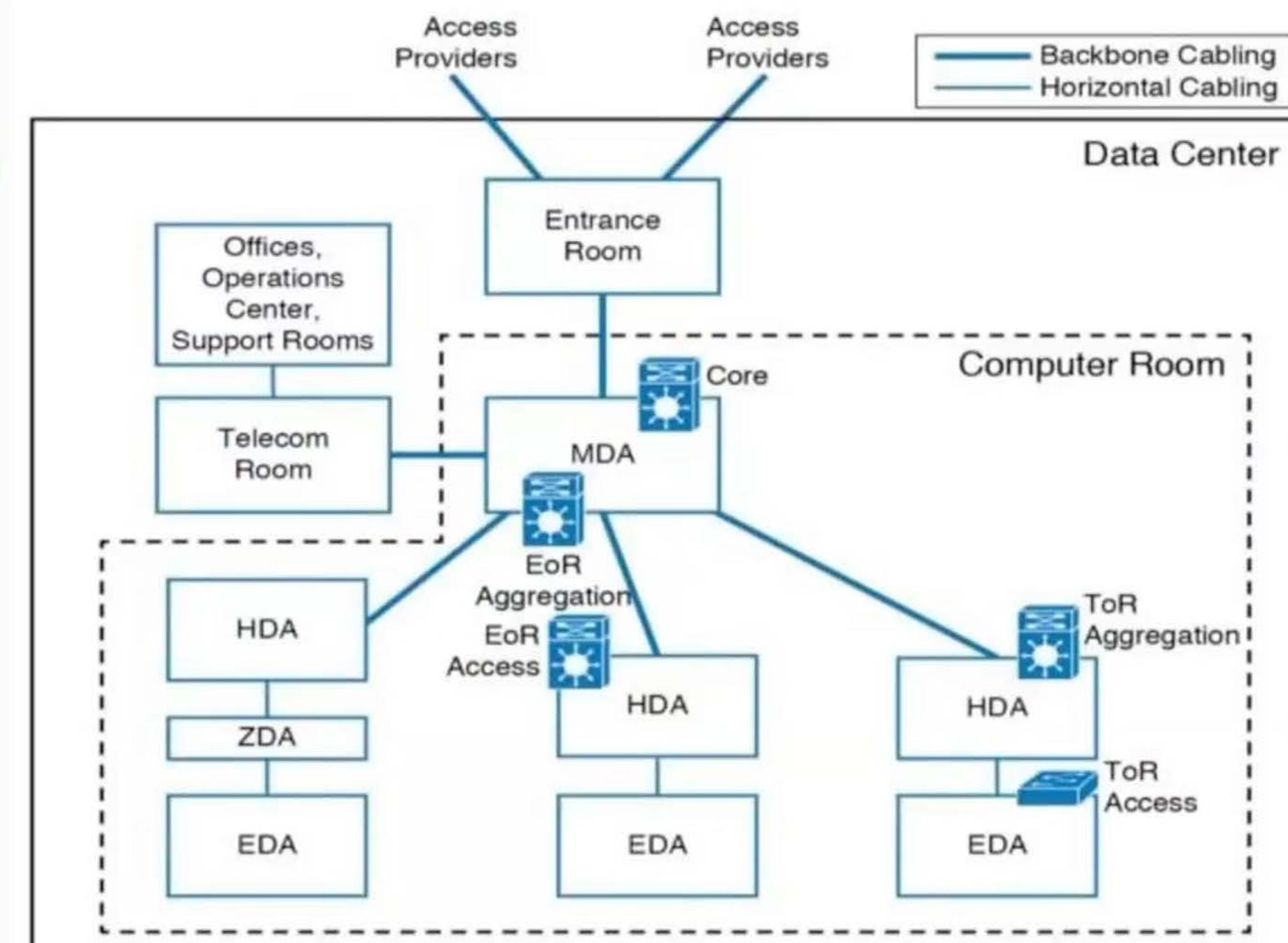
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ANSI/TIA-942-2005 Standard (American National Standard Institute/ Tel Indus Asso)

- Main Distribution Area (MDA)
 - Horizontal Distribution Area (HDA)
 - Equipment Distribution Area (EDA)
 - Zone Distribution Area (ZDA)





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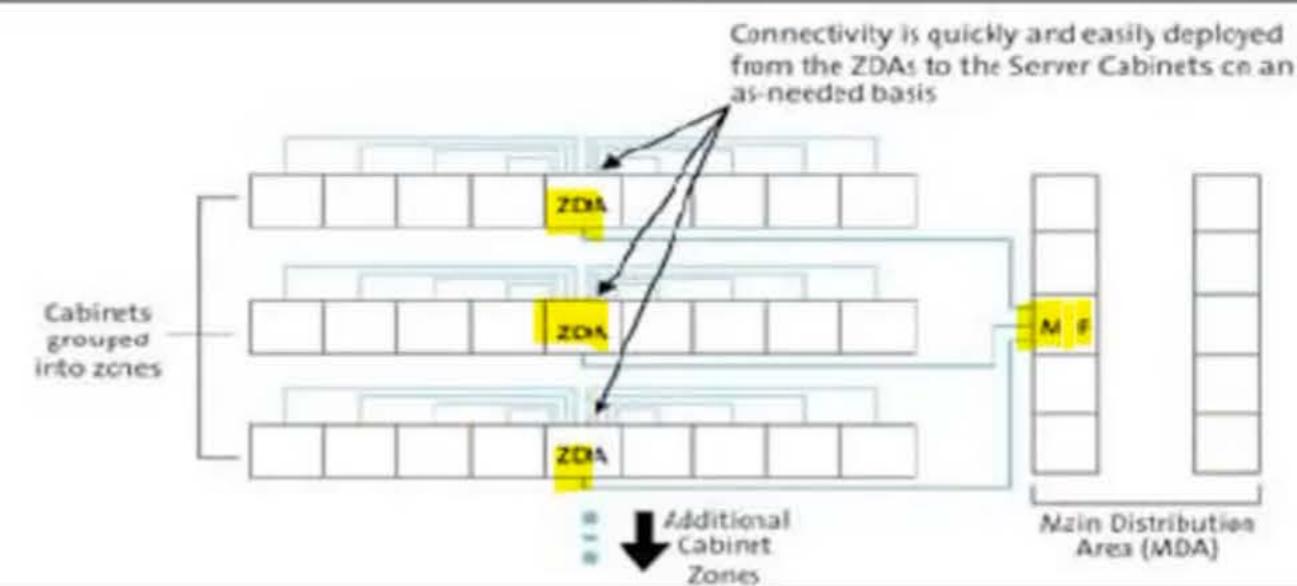
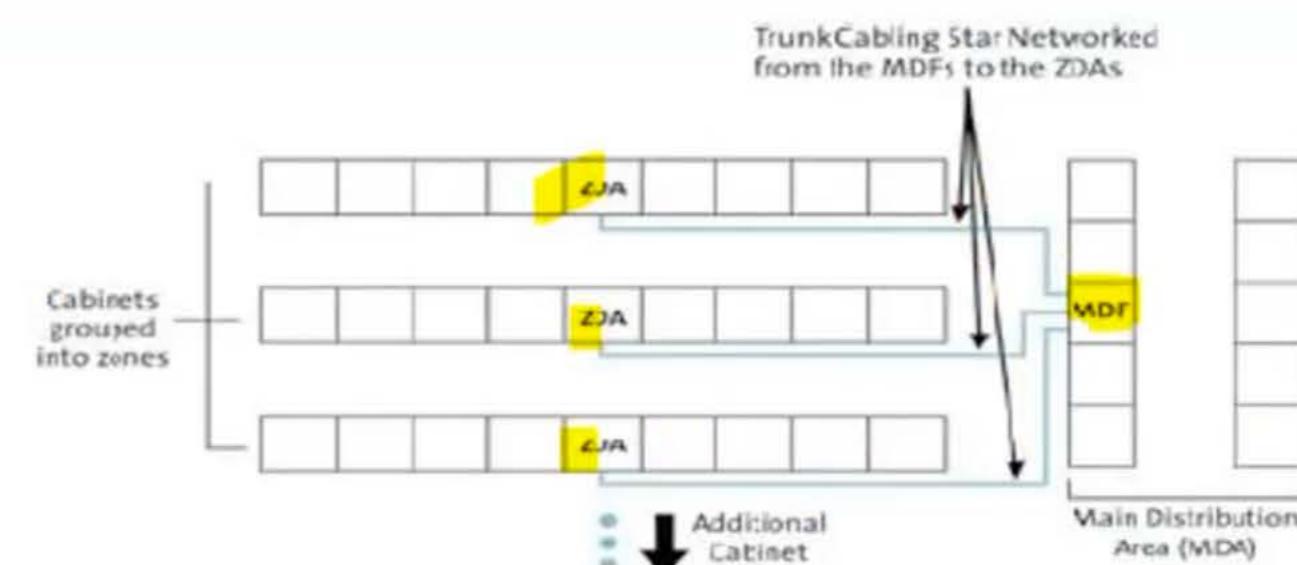


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Zone Distribution Area

High-fiber count cables connect ZDA to MDA or HDA.

Low-fiber count cables connect ZDA to EDA as needed.





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ANSI/TIA-942-2005 Standard

- **Computer Room:** Main servers
- **Entrance Room:** Data Center to external cabling
- **Cross-Connect:** Enables termination of cables
- **Main Distribution Area (MDA):** Main cross connect.
- **Central Point of Structured Cabling.** Core network devices
- **Horizontal Distribution Area (HDA):** Connections to active equipment.
- **Equipment Distribution Area (EDA):** Active Servers+Switches. Alternate hot and cold aisle.
- **Zone Distribution Area (ZDA):** Optionally between HDA and EDA. ZDA allows easy
- **Backbone Cabling:** Connections between MDA, HDA, and Entrance room

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Speaker icon



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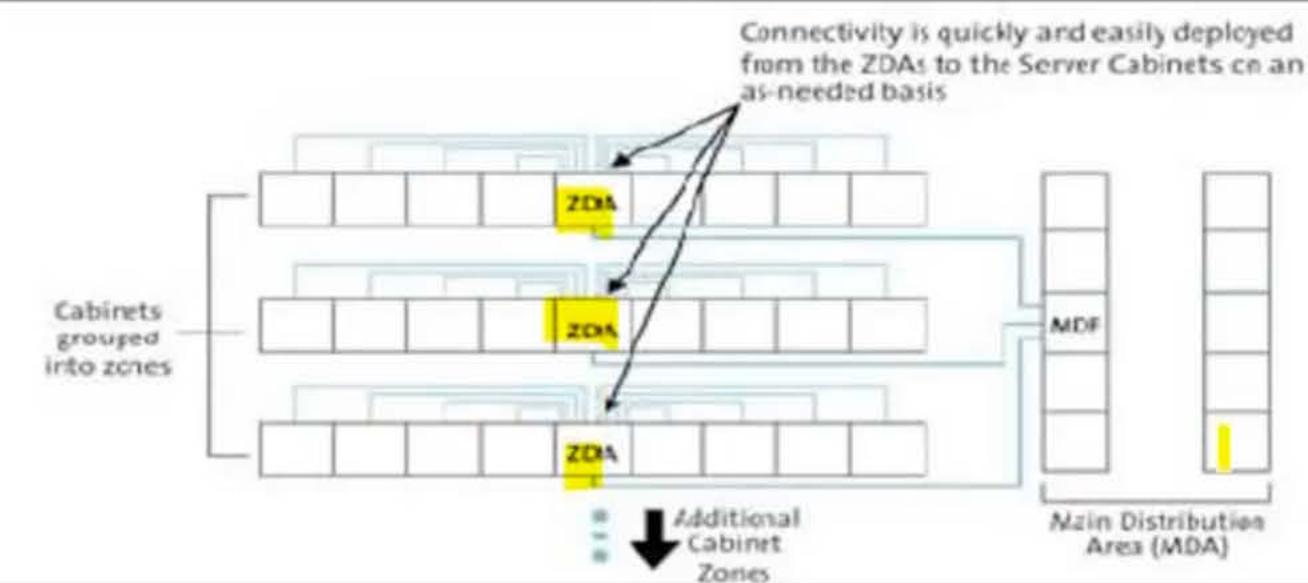
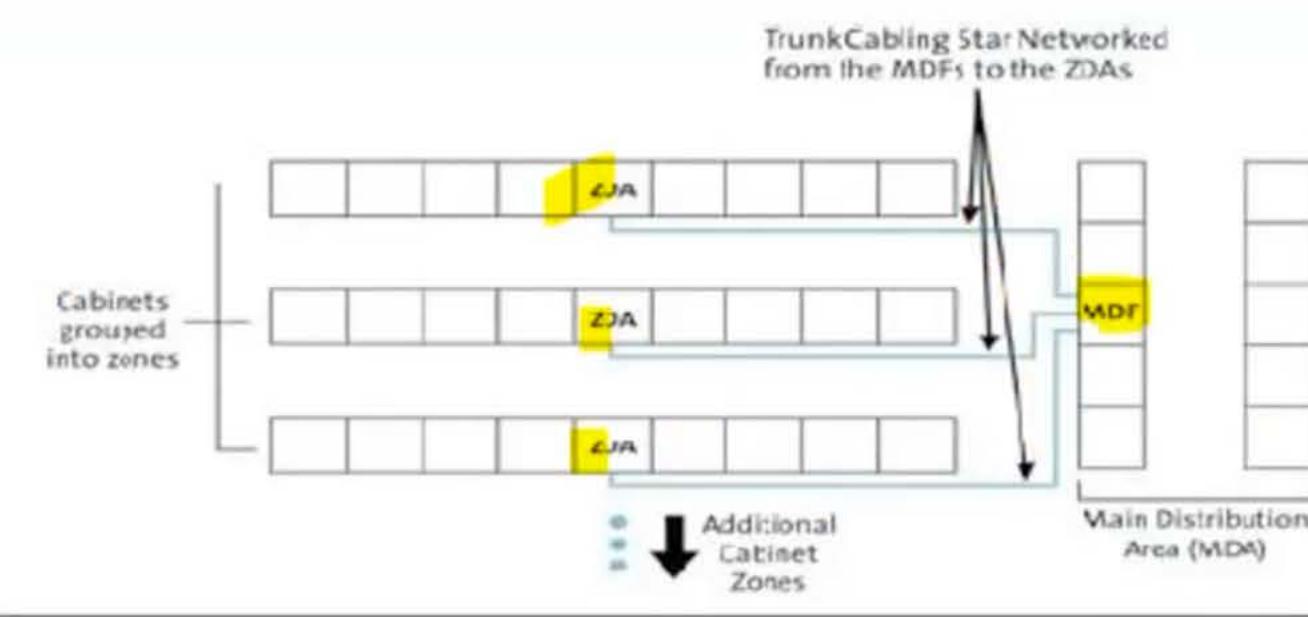


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Zone Distribution Area

High-fiber count cables connect ZDA to MDA or HDA.

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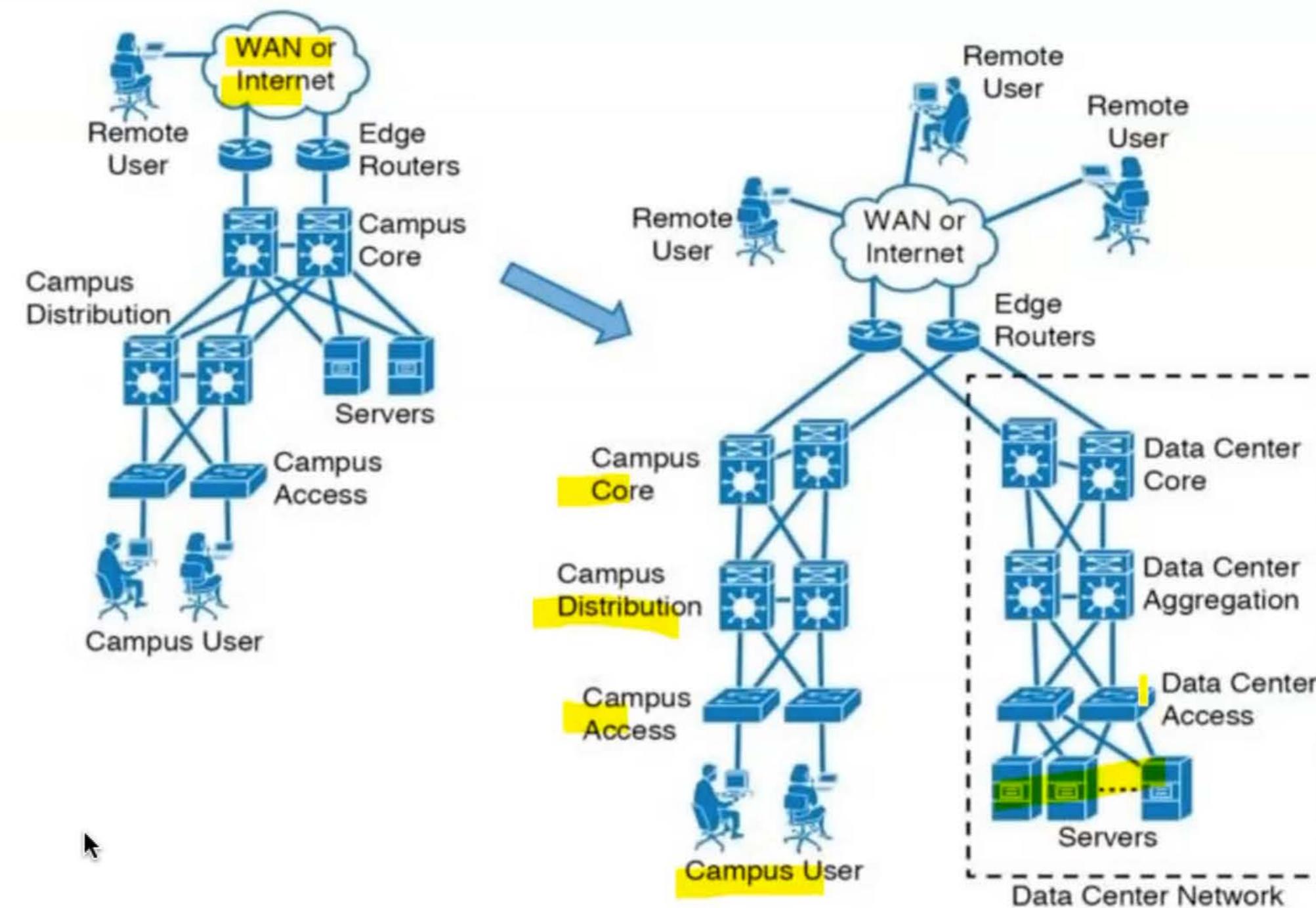
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- **Core,**
- **Aggregation,**
- **Access**

Data Center Network Topologies



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Data Center Networks

- 20-40 servers per rack
- Each server connected to 2 access switches with 1 Gbps (10 Gbps becoming common)
- Access switches connect to 2 aggregation switches
- Aggregation switches connect to 2 core routers Core routers connect to edge routers
- Aggregation layer is the transition point between L2-switched access layer and l3-routed core layer
- Low Latency: In high-frequency trading market, a few microseconds make a big difference.



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Data Center Networks (Cont)

- Core routers manage traffic between aggregation routers and in/out of data center
- All switches below each pair of aggregation switches form a single layer-2 domain
- Each Layer 2 domain typically limited to a few hundred servers to limit broadcast
- Most traffic is internal to the data center. Network is the bottleneck.
- Uplinks utilization of 80% is common.
- Most of the flows are small.
- Mode = 100 MB. DFS uses 100 MB chunks.



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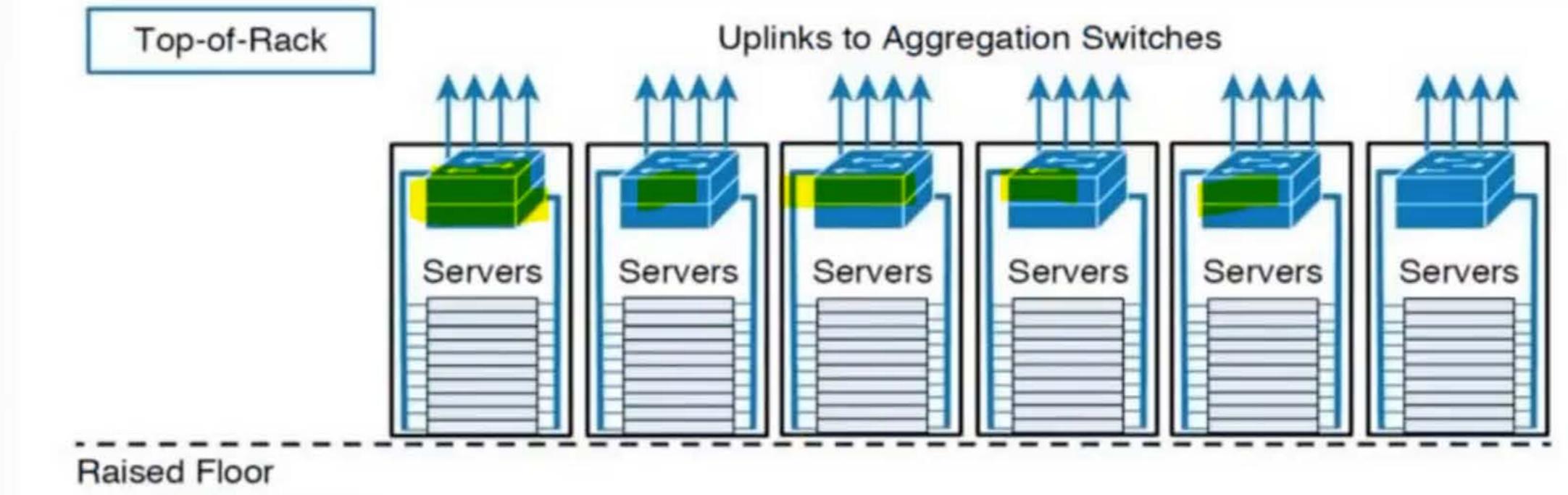
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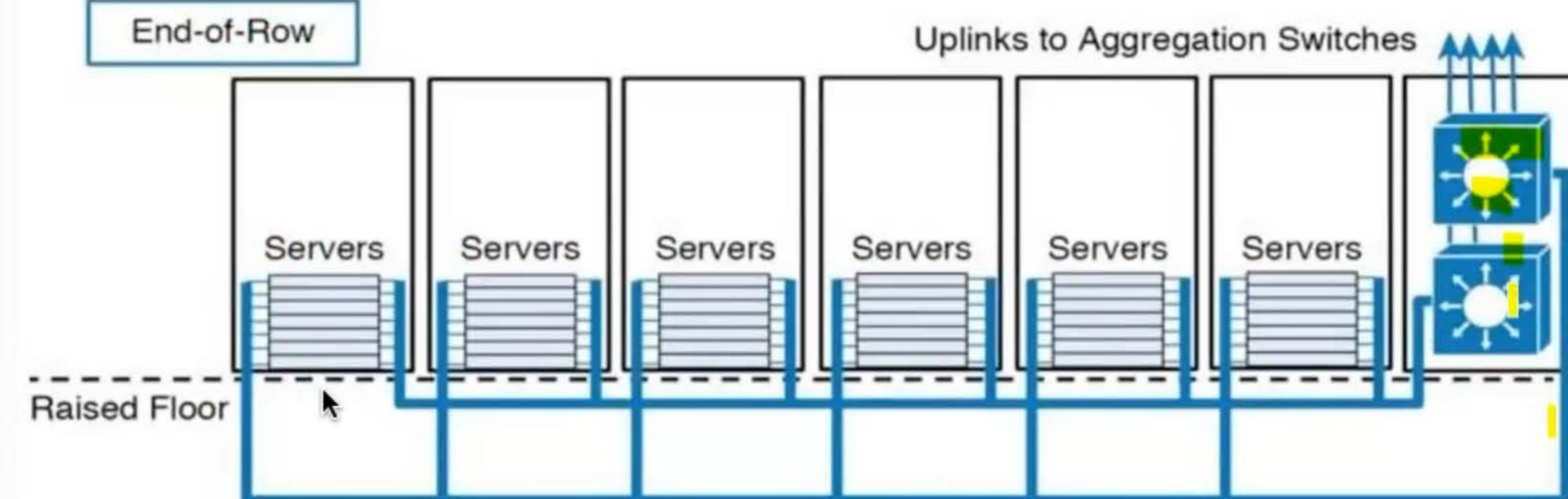
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Switch Locations

- Smaller cable between servers and switches
- Network team has to manage switches on all racks



- All network switches in one rack





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ToR vs EoR

- **ToR:**

- **Easier cabling**

- If rack is not fully populated unused ToR ports
 - If rack traffic demand is high, difficult to add more ports
 - Upgrading (1G to 10G) requires complete Rack upgrade

- **EoR:**

- **Longer cables**
 - Servers can be placed in any rack
 - Ports can easily be added, upgraded





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Hierarchical Network Design

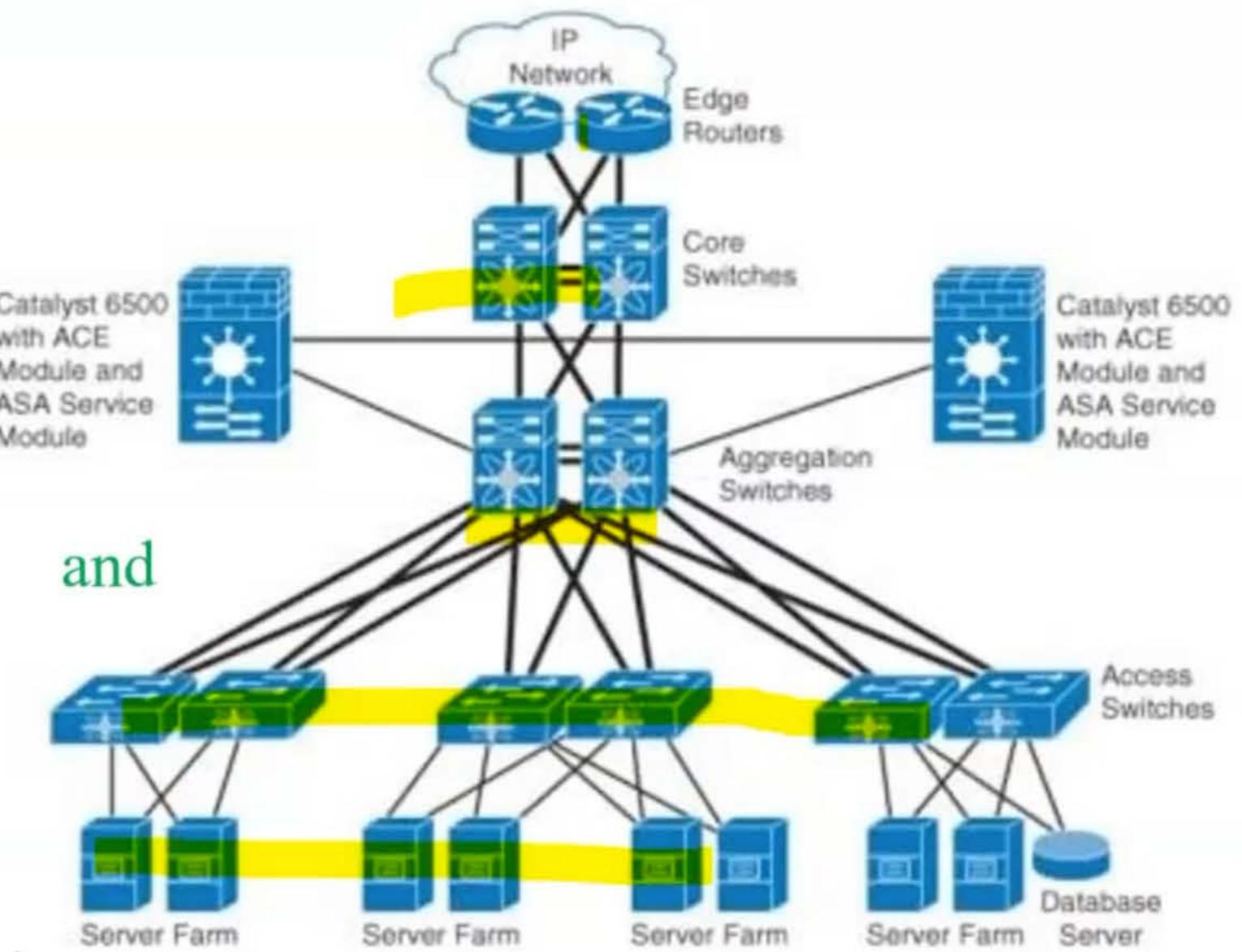
All servers require **application delivery services** for security (**VPN**, **Intrusion detection**, **firewall**), **performance** (load balancer), networking (**DNS**, **DHCP**, **NTP**, **FTP**, **RADIUS**), **Database services** (SQL)

All above shared between Access and Aggregation.

ADCs are located between the **aggregation and core routers** and are shared by all servers

Stateful devices (firewalls) on Aggregation layer

Stateful = State of TCP connection (Eg. Firewall)



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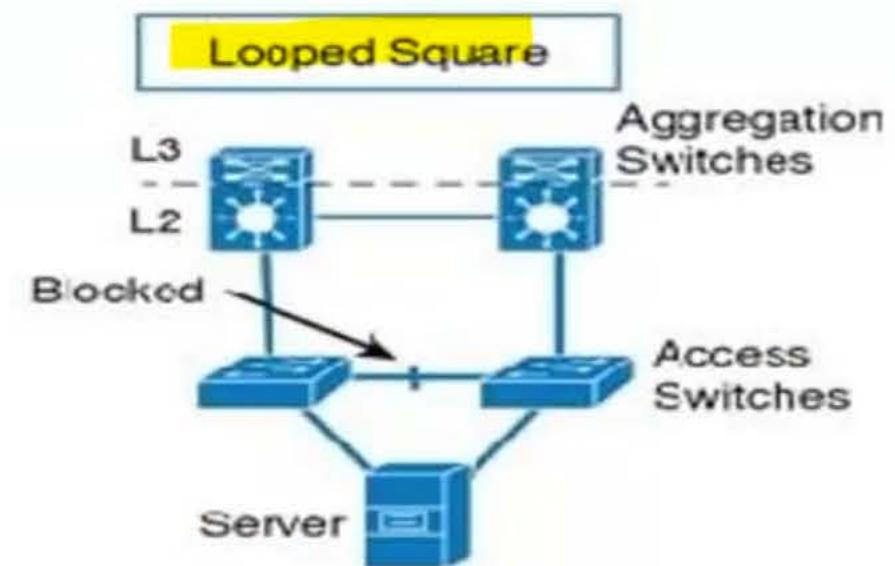
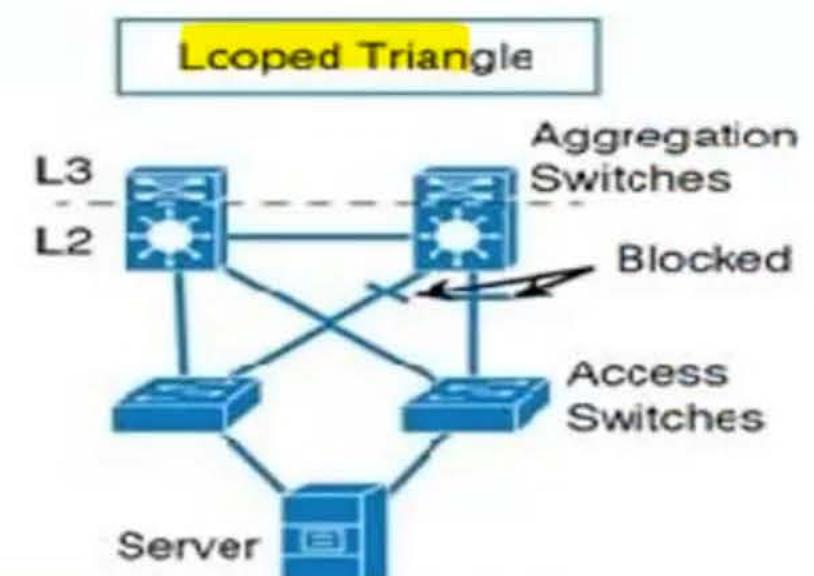
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Access Aggregation Connections

1. Looped Triangle:

Most common. Spanning Tree Protocol (STP) blocks links.

Paid but not used only 50%



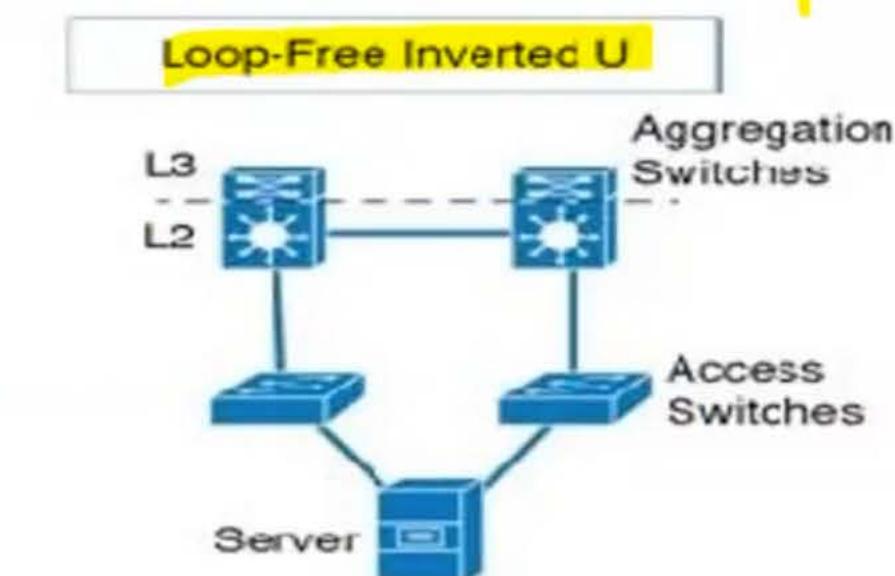
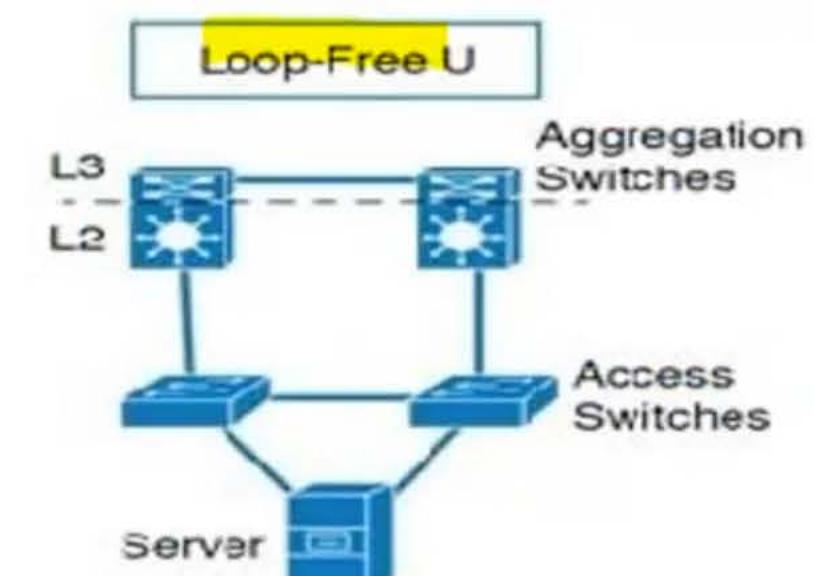
2. Looped Square:

Oversubscription doubles if failure.



3. Loop-Free U:

No L2 communication between aggregation switches if any switch links fail



4. Loop-Free Inverted U:

Black-holes on some failures



Source: Santana 2014



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DCN Requirements

- Needs to be Scalable, Secure, Shared, Standardized, and Simplified (5 S's)
 - Converged Infrastructure: Servers, storage, and network have to work together
 - Workload Mobility: Large L2 domains required for VM mobility
 - East-West Traffic: Significant server-to-server traffic as compared to server to user.
 - Storage traffic on Ethernet: Congestion management on Ethernet



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Clos Networks

Multi-stage circuit switching network proposed by Charles Clos in 1953 for telephone switching systems

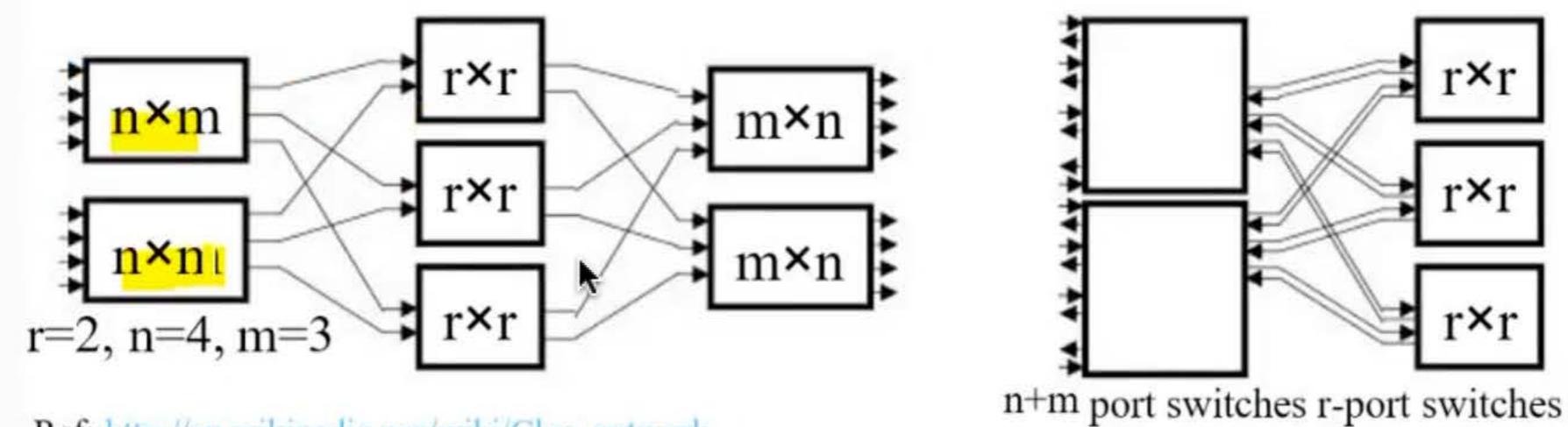
Allows forming a large switch from smaller switches

The number of cross-points is reduced

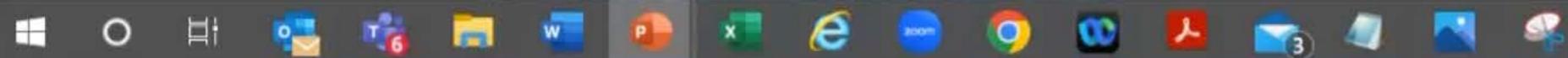
Lower cost (then) 3-Stage Clos(n, m, r): ingress ($r \times m$), middle ($m \times r$), egress ($r \times m$)

Can have any odd number of stages, e.g., 5

Folded: Merge input and output in to one switch = **Fat-tree**



Ref: http://en.wikipedia.org/wiki/Clos_network



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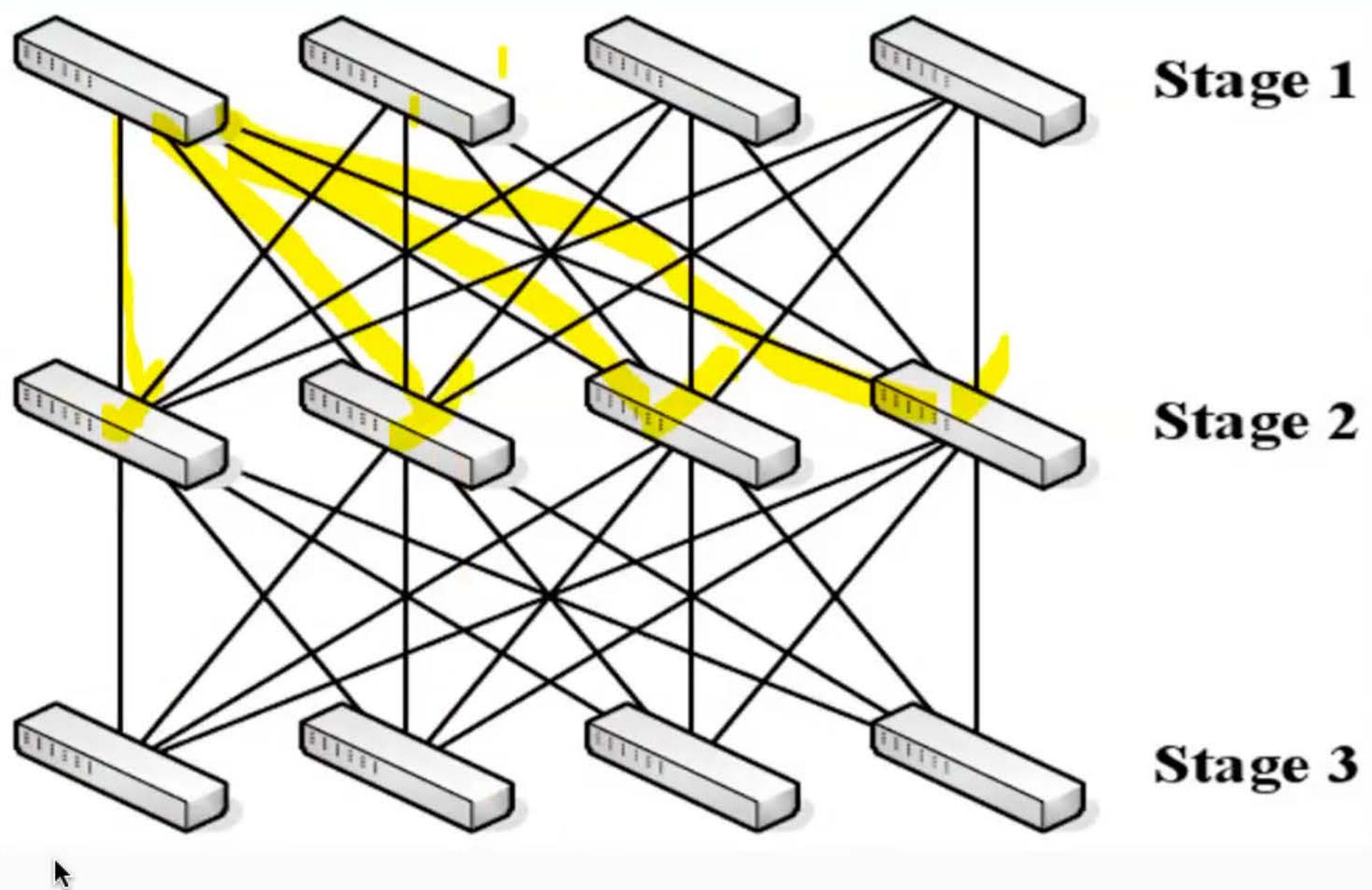


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Clos Topology

Hierarchical /
staged/layered:

- Each switch in a stage is connected to all the switches in the next stage
- Key benefit:
Extensive path diversity





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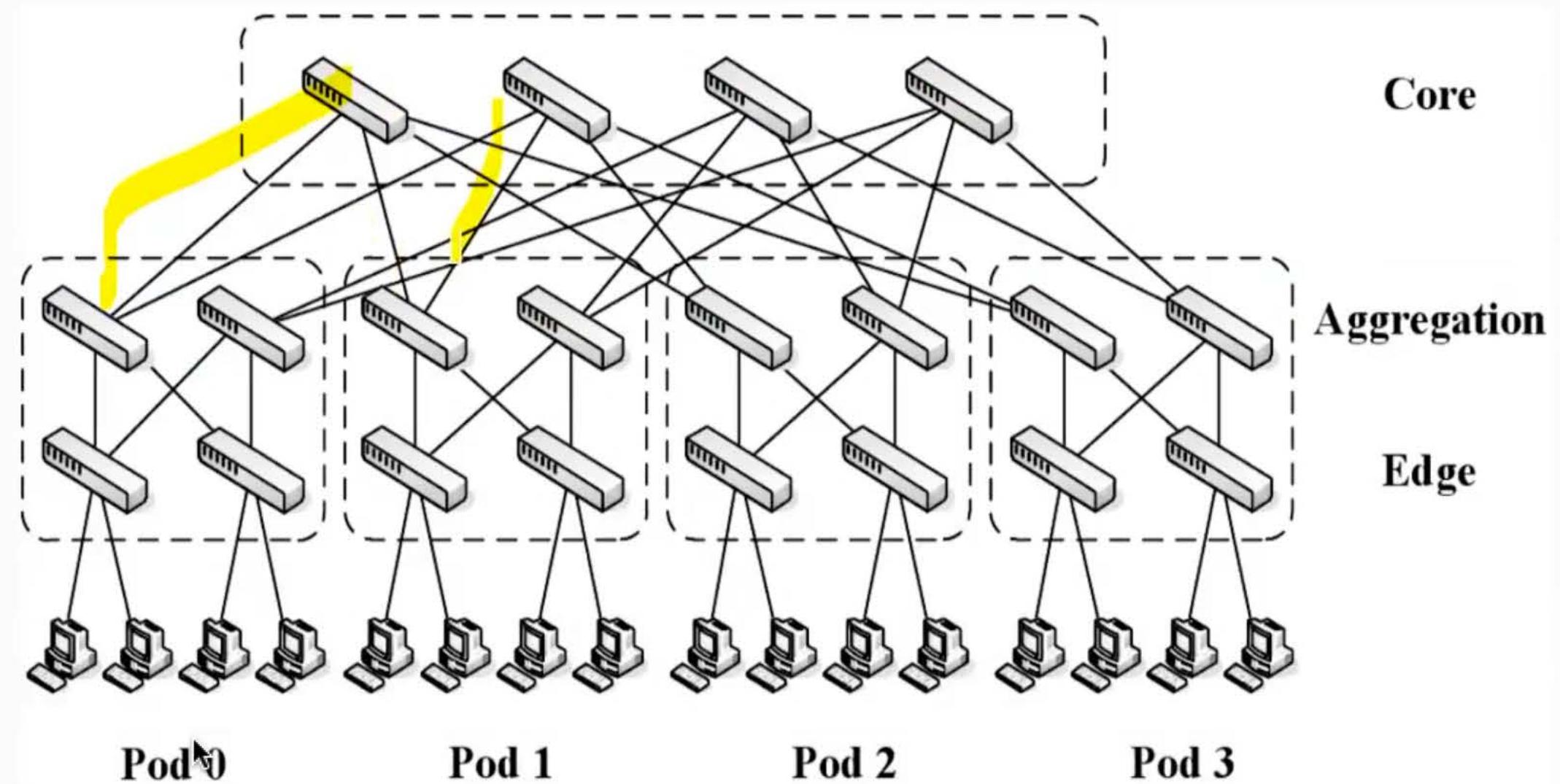


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Clos Topology- Fat tree

Specific case: Fat tree

Built in a tree like structure





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Summary

- Modular data centers can be used for easy assembly and scaling
 - Three tiers: Access, Aggregation, Core
 - Application delivery controllers between Aggregation and core
 - Need large L2 domains
 - Fat-tree topology is sometimes used to improve performance and reliability



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Cloud Metrics

Dr Noor Zaman Jhanjhi

Professor | Program Director Postgraduate Programmes | Director
– Center for Smart Society [CSS5] | Cluster Head Cybersecurity

School of Computer Science, Taylor's University, Malaysia



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Cloud Metrics

- **Cloud Performance Metrics**

By Use Case



Cost Per Customer Analysis

Understand your cloud unit economics and measure cost per customer on AWS



Kubernetes Cost Analysis

Discover and monitor your real Kubernetes and container costs



Unit Cost Analysis

Measure and monitor the unit metrics that matter most to your business



Tagging And Cost Allocation

Allocate cost and gain cost visibility even if your tagging isn't perfect



SaaS COGS Measurement

Identify and measure your software COGS



Engineering Cost Awareness

Decentralize cost decisions to your engineering teams



Cloud Cost Optimization

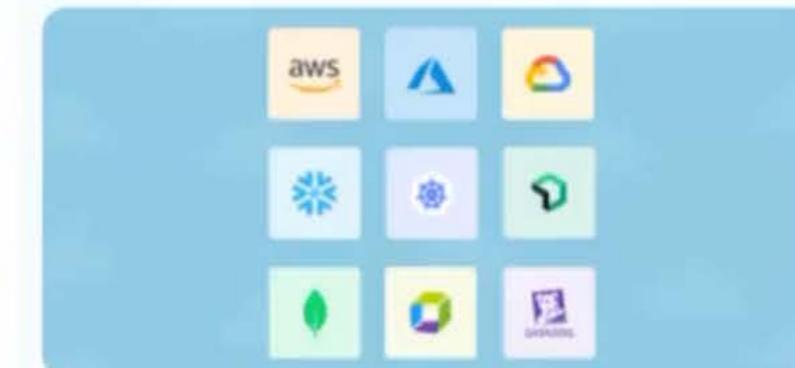
Automatically identify wasted spend, then proactively build cost-effective infrastructure



Migration Cost Monitoring

Monitor your AWS cost and track progress in real-time as you move to the cloud

All Your Cloud Spend, In One View



CloudZero ingests data from AWS, GCP, Azure, Snowflake, Kubernetes, and more

[View all cost sources →](#)



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Cloud Performance Metrics

- **Cloud-based** infrastructure, applications, and other components generate metrics companies can use to measure the reliability and operational excellence of their cloud services.
- **Uptime or availability**
- This metric measures the percentage of time a service or system is available to serve customer requests. Downtime is the opposite. Uptime increases your chances of retaining customers and generating revenue.

<https://www.cloudzero.com/solutions/kubernetes>

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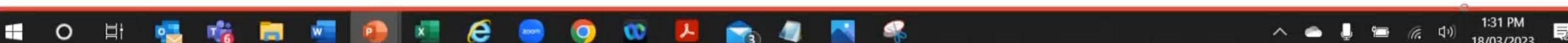
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Cloud Performance Metrics

- **Memory utilization**
- Memory utilization helps to measure memory usage in public, private, and hybrid cloud environments. A consistently high memory utilization may require you to scale up your memory capacity to ensure smooth performance.

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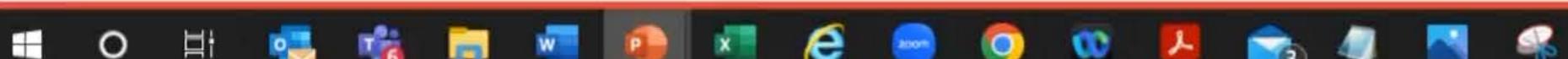


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Cloud Performance Metrics

- **Requests per minute**
- Requests per minute tell how many requests a cloud-based application receives each minute. It is crucial to monitor how and when users access the app, so you can scale your cloud resources to meet demand, ensuring optimal performance.

<https://www.cloudzero.com/solutions/kubernetes>

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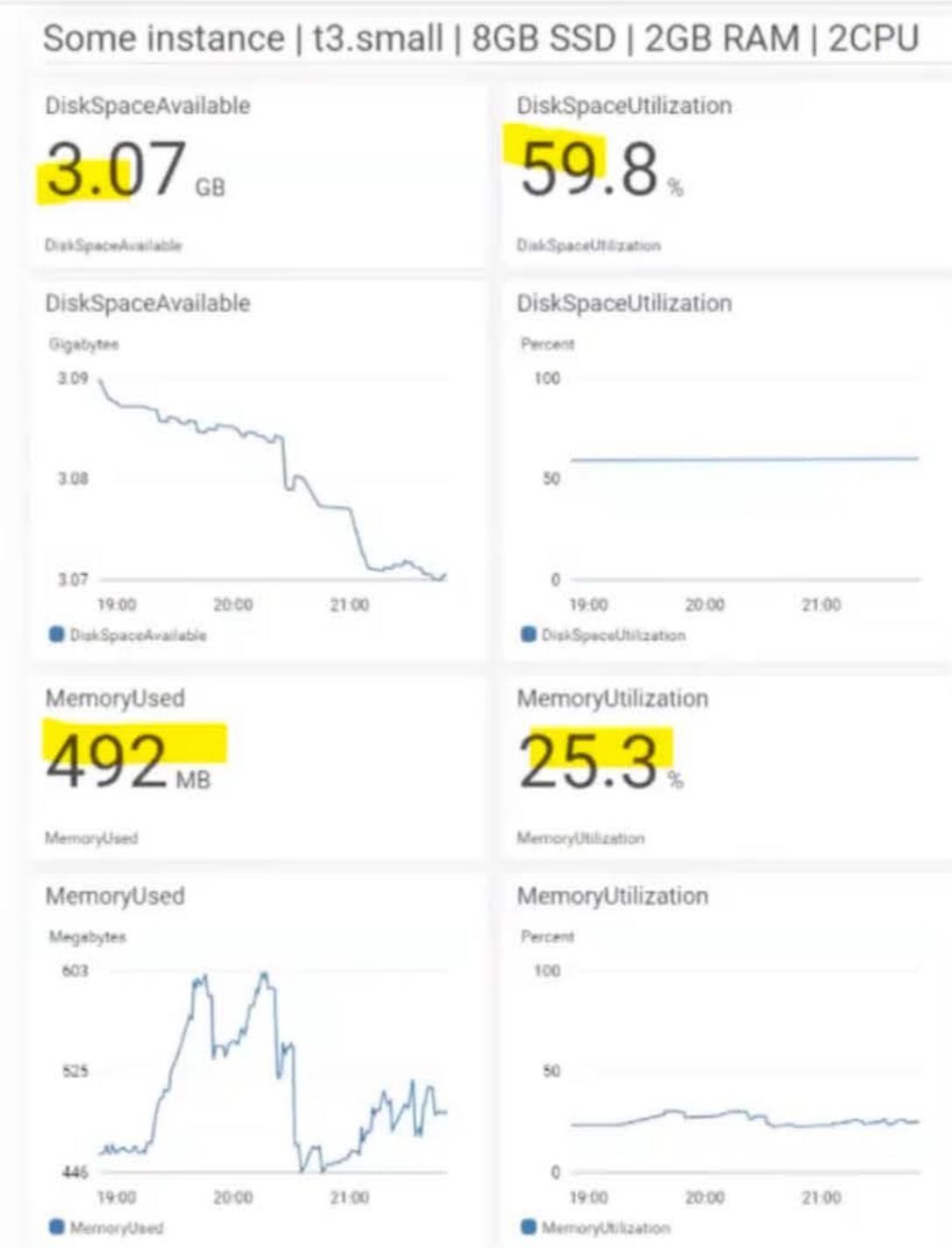
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Cloud Performance Metrics

- **Disk utilization**
- Disk utilization enables you to track the disk volume on a node's storage capacity to tell if it is sufficient for your workloads. Typical storage metrics include IOPS and throughput. The IOPS metric describes the number of reads and writes per second, whereas throughput measures the amount of data transferred from and to storage in bytes per second (bps).

Credit: [Letswp](#)

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Cloud Performance Metrics

- **Average time to acknowledge**
- Average time to acknowledge refers to the average time your application takes to begin a response to a request. If acknowledgement times are slow, then there may be a load balancer issue, or the app is struggling with underprovisioning and other latency issues.

<https://www.cloudzero.com/solutions/kubernetes>



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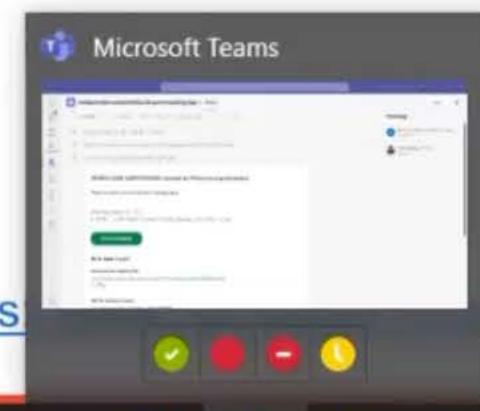
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Cloud Performance Metrics

- **Latency**
- Latency measures the time between when a customer sends a request (request time) and when the cloud provider sends back a response (response time). High latency can negatively impact productivity. Your cloud provider's backend servers, web server dependencies, and network problems could all lead to increased latency.

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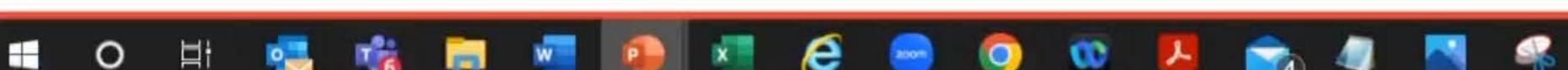


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Cloud Performance Metrics

- **The error rate**
- The error rate measures how often a request results in an error. You can troubleshoot issues like improperly configured access credentials by identifying the types of errors the system generates.

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Cloud Performance Metrics

- **Mean time between failure (MTBF)**
- Mean Time Between Failure (MTBF) refers to the average time a **repairable cloud component** works before failing. It will help you understand why systems fail, so you can identify repair methods that improve **MTBF** and be better equipped to tolerate failures.

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Cloud Cost Metrics

Cost data, enriched with context

The CloudZero platform doesn't just look at your Cost and Usage Report. It pulls in context and metadata from your environment to enrich your billing data and help you understand how your cost connects with your architecture.



<https://www.cloudzero.com/solutions/kubernetes>

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Cloud Cost Metrics

Track Changes To Your Unit Cost Baseline

Whether your total spend goes up or down is arbitrary without context — especially when you're continuously adding new features and customers. CloudZero helps you monitor your average cost per unit, like customers, so you know if you're achieving economies of scale — or not.

You are calculating the cost of
76 customers in the past
51 days

In the last week you total median
customer spend decreased by
-14%

Total Customer Spend x Total Cost



<https://www.cloudzero.com/solutions/kubernetes>

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Cloud Cost Metrics

Monitor The Cost To Build And Run Your Product Features

CloudZero aligns cost to however you measure your COGS — by product feature, business unit, dev team, environment, and more. This enables you to report relevant metrics to finance, while engineering teams each get views of the cost they're responsible for.



<https://www.cloudzero.com/solutions/kubernetes>



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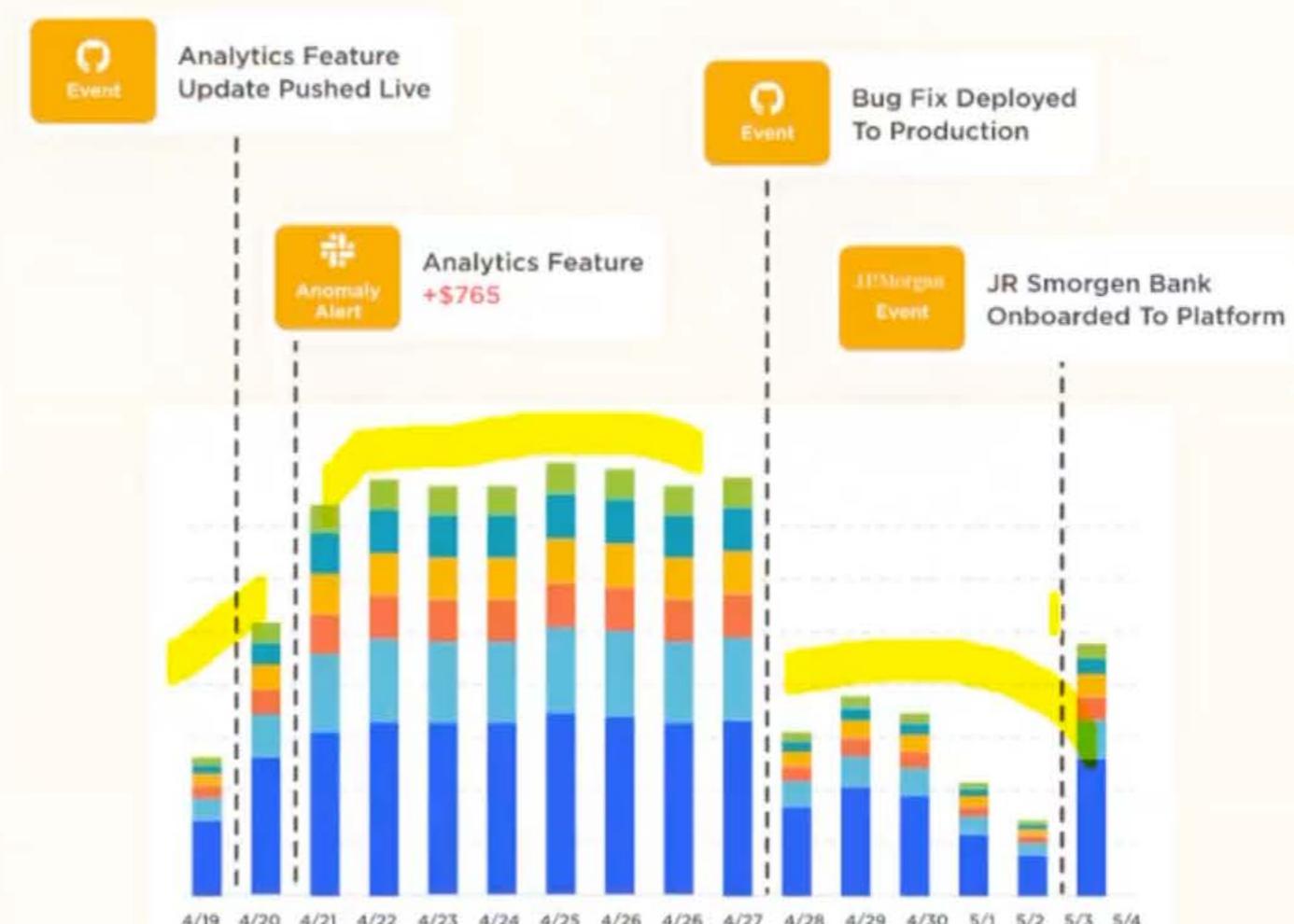


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Cloud Cost Metrics

Understand How Costs Change Over Time — And Why

The cost of your applications isn't static — it evolves once your customers start using your products. CloudZero helps you understand your cost to build software, plus how it fluctuates with new updates, customer utilization, and more.



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Cloud Cost Metrics

- **Cost-conscious** teams treat cloud costs as a first-class metric. Engineers can then build cost-effective solutions while finance optimizes cloud costs without hindering innovation.
- But it is not enough to collect high-level cost metrics that are difficult to link to actual business activity. Instead, monitor unit costs that relate to specific business activities

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Cloud Cost Metrics

- **Cost per feature**
- Cost per feature is a measure of the amount you spend to release and support a particular product feature. You can track which customers use it, when, and how often. You can also use this metric to calculate how much you need to charge for the feature to turn a profit.

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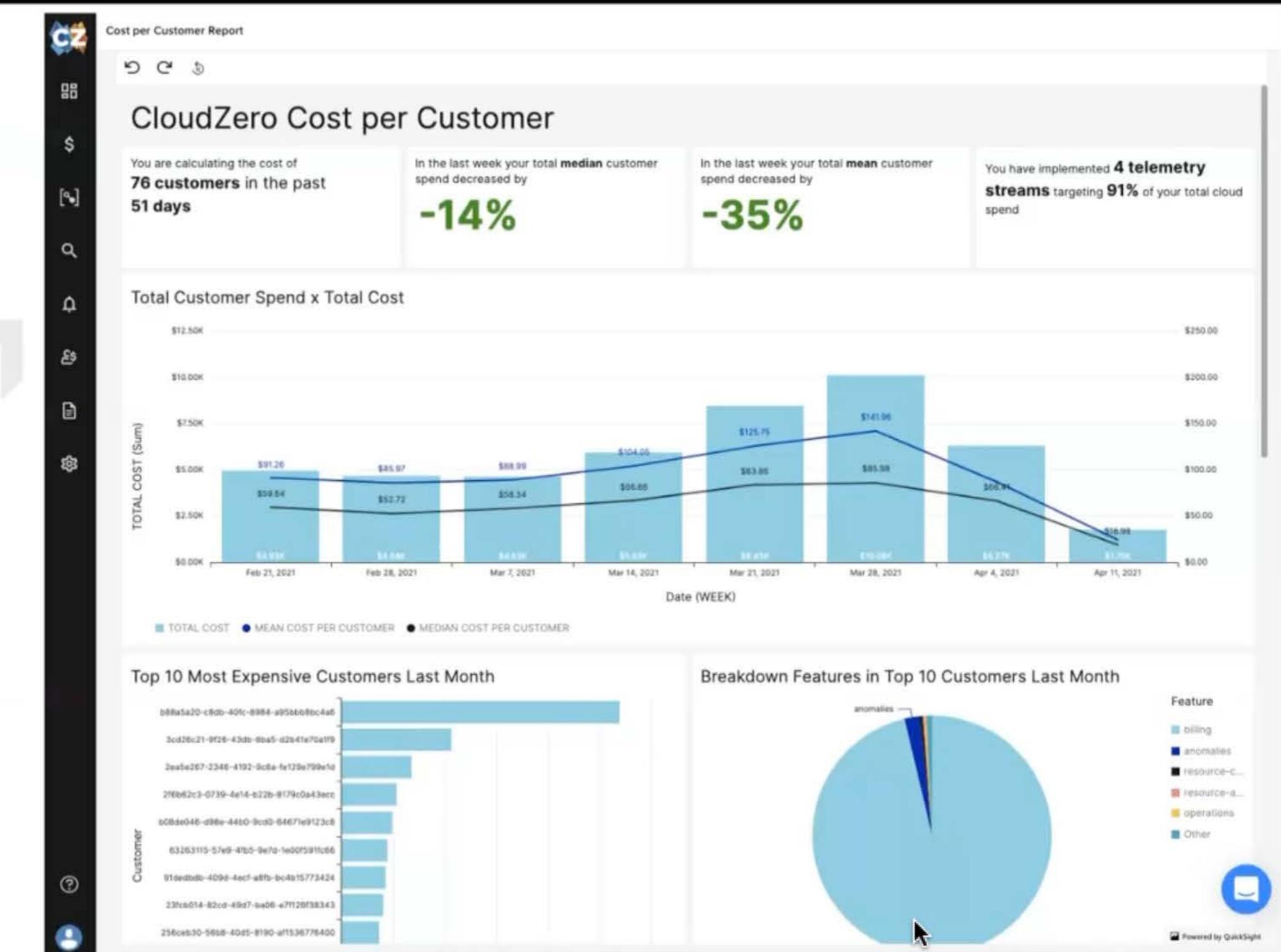
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Cloud Cost Metrics

- **CloudZero** aligns clouds costs to **key business metrics**, such as **cost per customer** or **product features**.
- **Cost per customer** report allows teams to see how individual customers drive their cloud spend and how much specific customer cost their business.
- With cloud **cost intelligence**, companies can make informed **engineering**, **business**, and **pricing** that ensure profitability.



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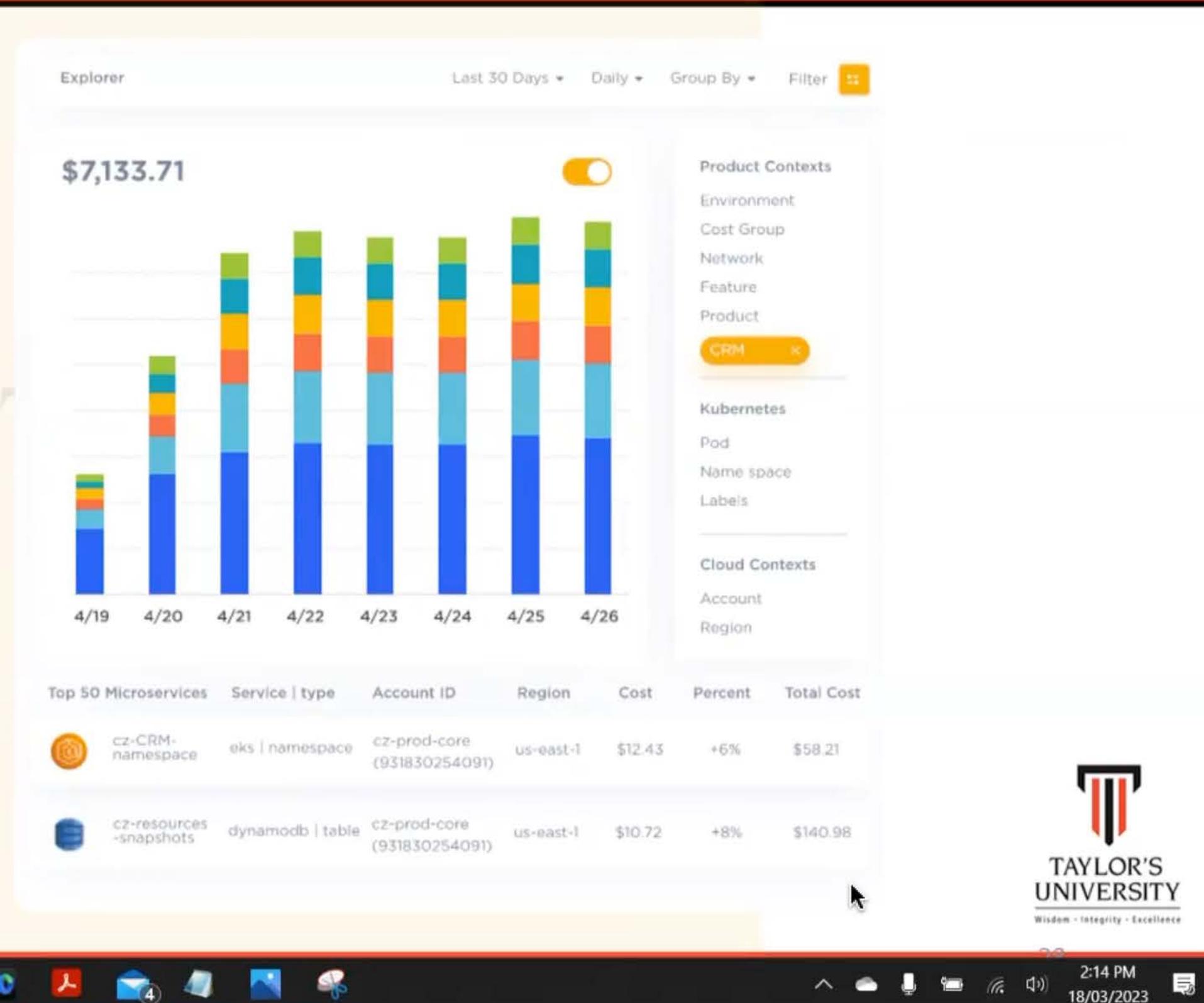
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Cloud Cost Metrics

- **Kubernetes cost metrics**
- Cost metrics in containerized applications and Kubernetes clusters are difficult to monitor using most cloud cost management tools.


<https://share.vidyard.com/watch/Qu1tpCDvt6ecikTf3ECzmP?>



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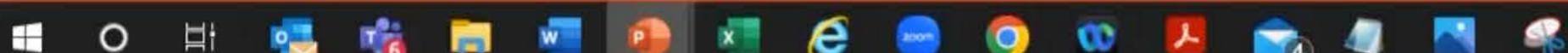


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Cloud Cost Metrics

- **Enter Cloud Cost Intelligence**
- Using CloudZero, you can easily collect, analyze, and report on multiple unit cost metrics that matter to your business. Like an observability tool, CloudZero collects cloud metrics from multiple sources, so you don't have to have perfect AWS tags to get accurate cost insights.

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Cloud Cost Metrics

- **Cloud Performance Testing Metrics**
- There are a variety of metrics to gauge the robustness of cloud infrastructure and the applications it hosts
- **1. Capacity test metrics**
- Capacity test metrics indicate the maximum load amount or traffic your cloud system can handle without throttling performance in production.



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Cloud Cost Metrics

- **Target infrastructure metrics**
- Targeted infrastructure metrics enable you to isolate and fix problem areas of a specific layer or application component.
- **Stress testing metrics**
- Stress testing metrics help gauge the stability and responsiveness of your cloud environment and its components under high loads.

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Cloud Performance Metrics

- **Load testing metrics**
- Load testing metrics enable engineering to check how cloud resources perform when multiple users try to access and use them simultaneously.
- **Failover test metrics**
- Failover test metrics measure a system's ability to call up additional cloud resources to handle heavy or peak loads.

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Cloud Performance Metrics

- **Latency test metrics**
- Latency test metrics help you determine the time it takes your cloud resources to transfer data messages between two points on the network.
- **Soak test metrics**
- Soak test metrics are indicators of your cloud system's resilience during prolonged periods of heavy traffic.

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Cloud Performance Metrics

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Cloud Security Metrics

- **Keeping track of security and compliance** KPIs is particularly challenging in the cloud's dynamic computing environment. Yet, it is possible. To mitigate threats, monitor metrics
- **Patched/unpatched known vulnerabilities**
- Patched/unpatched known vulnerabilities will indicate how timely and adequately patch cloud security risks in your system -- or if you leave them open for too long.

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Cloud Security Metrics

- **Other important security threats**

- New user accounts that delete multiple users
- A computer instance that starts and stops programmatically could be a warning sign of an ongoing or inevitable attack.
- Temporary security credentials that last a long time
- Employee access credentials that are reassessed frequently
- Cloud activity that deletes CloudTrail logs (in Amazon Web Services)
- A sudden spike in "super user" usage levels
- Data on violations, compliance score, and resolution progress are examples of compliance metrics.
- By monitoring security and compliance metrics, you can prevent your cloud system from leaking confidential business information, customer data, and damaging your reputation.

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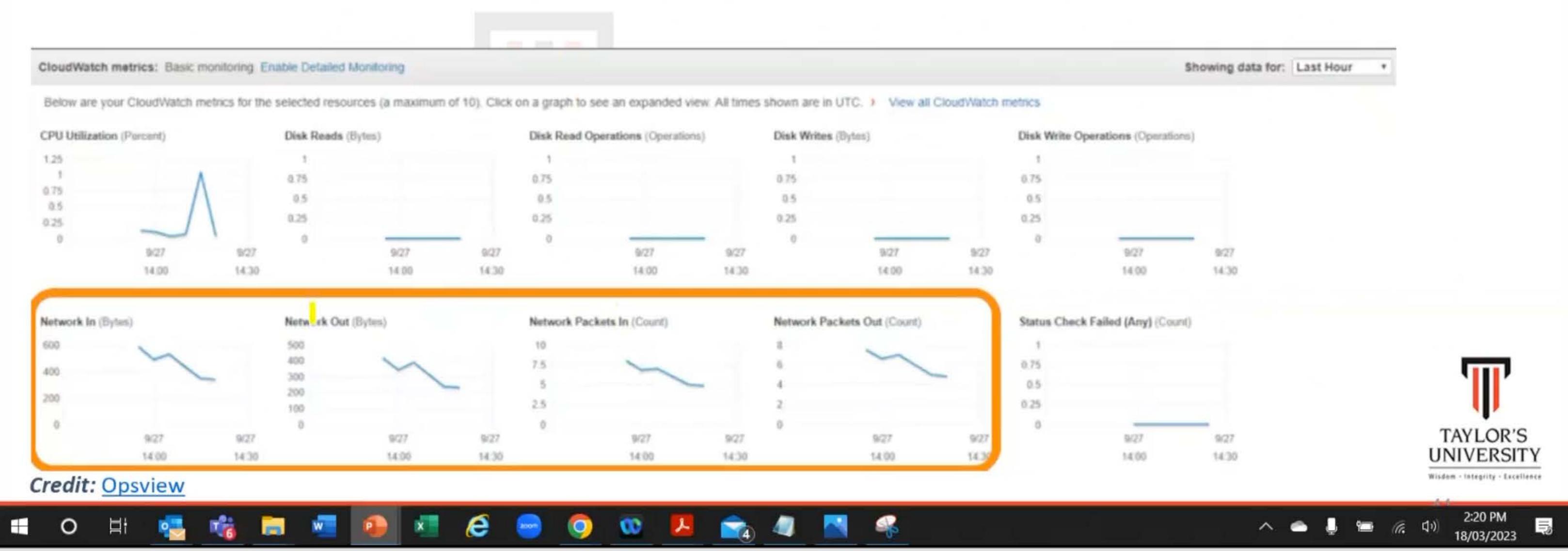
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Cloud Networking Metrics

It was fairly straightforward to fix **network issues** when apps were hosted over a Local Area Network (LAN). It takes greater attention to identify the cause of network issues in the cloud.



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Cloud Networking Metrics

- **Network capacity**
- Network capacity is the maximum data transit rate possible between a source and destination through the most congested hop in the application delivery path.
- Available capacity measures the actual amount of network resources available to applications, while Utilized capacity is a strong indicator of network performance degradation. Both metrics will help you determine the root cause of service degradation.

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Cloud Networking Metrics

- **Packet loss**

- Packet loss is a measure of the percentage loss of network packets between the source and destination. Packet loss can cause latency and network congestion when an internet protocol retransmits the data. Track this metric to make sure your system doesn't drop users' requests, resulting in customer frustration.

- **Network metrics** provide a good indication of the kind of customer experience your organization provides. While modern networking technologies can easily handle small packet losses and jitter, sustained network problems can cause customers to unsubscribe from your service.

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