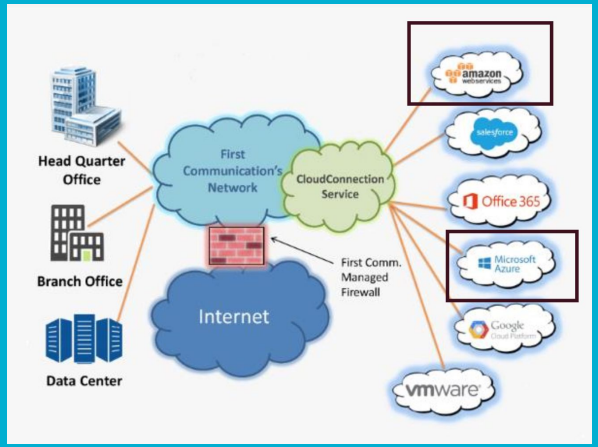
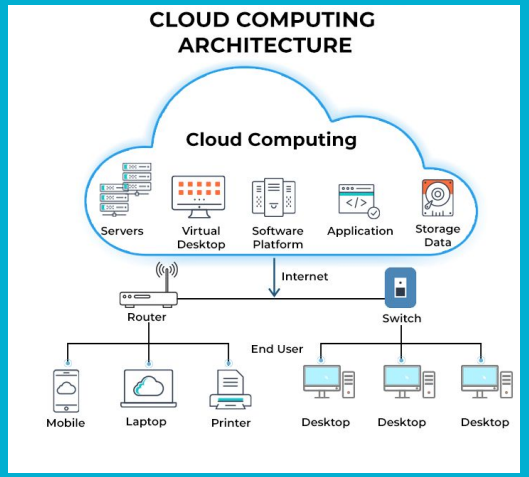
B2. Cloud Platform Offerings for Data Management

Nathan Eng, Bozhou Lu, Anh Nguyen, Shrey Shivaiah, Sanjeev Viswan

1. Key Concept

- Cloud Computing
  - Cloud computing is the on-demand delivery of computing services over the Internet with pay-as-you-go pricing. Instead of buying, owning, and maintaining physical data centers and servers, you can access technology services on an as-needed basis from a cloud provider
  - Includes servers, storage, databases, networking, software, analytics, intelligence, etc.

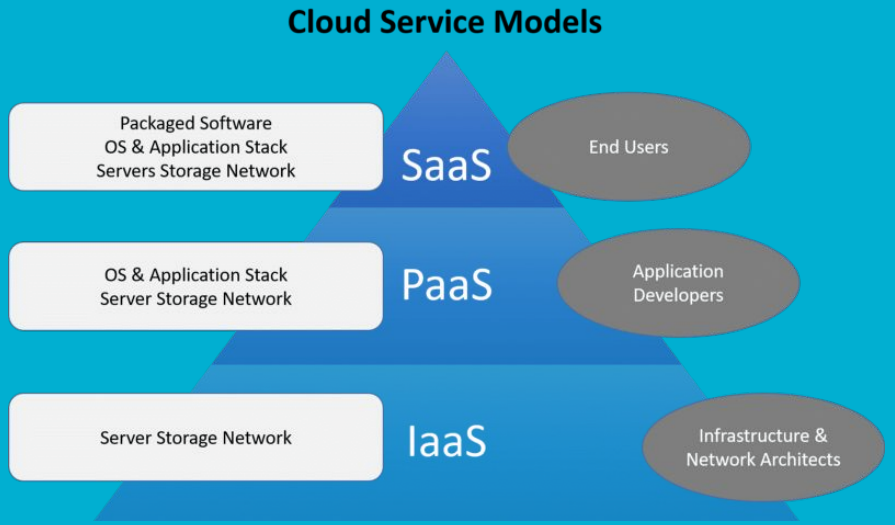




What is cloud computing? - cloud computing services, benefits, ... (n.d.). https://aws.amazon.com/what-is-cloud-computing/

- SaaS (Software as a Service)
  - Applications are hosted by a service provider and made available to customers over the internet. E.g. Dropbox.

- PaaS (Platform as a Service)
  - Cloud platform services, providing a framework for developers that they can build upon , allowing developers to concentrate on software creation without concern for storage and infrastructure. All the servers, storage, and networking can be managed by the enterprise or a third-party provider while the developers can maintain management of the applications.



- IaaS (Infrastructure as a Service)
  - A form of cloud computing that provides virtualized computing resources over the internet. It offers a complete infrastructure, from virtual servers to storage and networking.

Grant, M. (n.d.). Software as a service (SAAS): Definition and examples. Investopedia. https://www.investopedia.com/terms/s/software-as-a-service-saas.asp

2. Product Overview/Business Appeal

- Data management in the cloud
  - Storage, ingestion, processing, manipulation/analysis
- For Developers & Analysts:
  - Easier collaboration on datasets
  - Out-of-the-box APIs and tools for easier development
  - Easier deployment processes
  - Less time spent on infrastructure design

Amazon. (2024). Six advantages of cloud computing - overview of Amazon Web Services. Amazon Web Services. https://docs.aws.amazon.com/whitepapers/latest/aws-overview/six-advantages-of-cloud-computing.html

Google. (n.d.). Advantages of Cloud Computing | Google Cloud. Google Cloud. https://cloud.google.com/learn/advantages-of-cloud-computing

Dr. Ramnath Chellappa, Professor of Information Systems at Emory University

Emory University. (n.d.). Ramnath K Chellappa. Emory University Goizueta Business School. https://goizueta.emory.edu/faculty/profiles/ramnath-k-chellappa

"[A] computing paradigm where the boundaries of computing will be determined by economic rationale rather than technical limits alone."

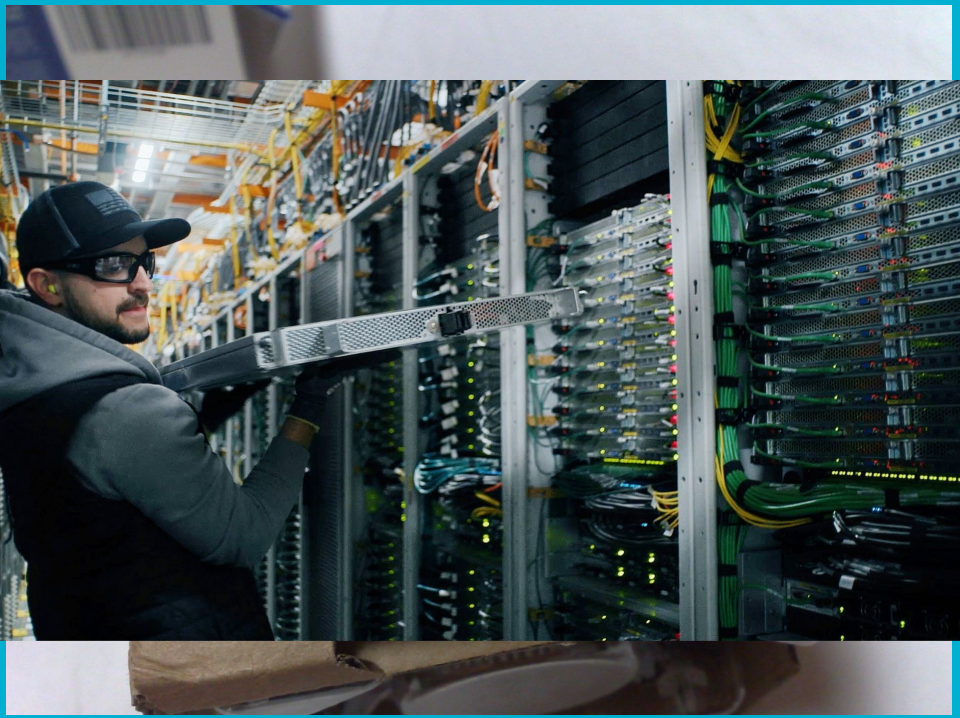
2. Product Overview/Business Appeal

- For Businesses:
  - Save costs with a “pay-as-you-go”/flexible model
  - Be ready for traffic fluctuation with easy remote scalability
  - Skip timely procurement processes
  - Built-in data loss prevention
  - Save costs by placing the burden of maintenance/security

Amazon. (2024). Six advantages of cloud computing - overview of Amazon Web Services. Amazon Web Services. https://docs.aws.amazon.com/whitepapers/latest/aws-overview/six-advantages-of-cloud-computing.html

Google. (n.d.). Advantages of Cloud Computing | Google Cloud. Google Cloud. https://cloud.google.com/learn/advantages-of-cloud-computing

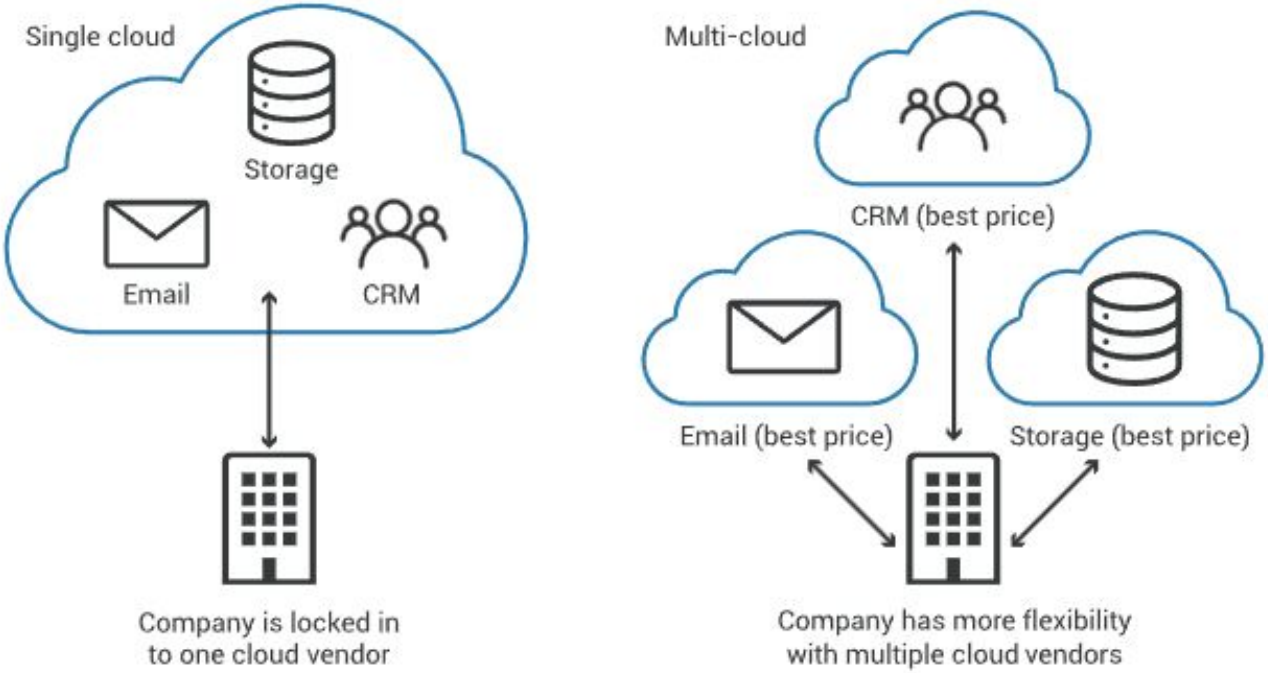
By John O'Neill, (User:Jjron) - (wikimedia), CC0, https://commons.wikimedia.org/w/index.php?curid=24925504
By Calreyn88 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=114957569



By Dsimic at English Wikipedia, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=31270305
Contreras, F. (2023, November 30). An AWS technician gives us a tour of a data center in Eastern Oregon-see what it's like inside. Amazon. https://www.aboutamazon.com/news/aws/aws-data-center-inside

VENDOR LOCK-IN

What is vendor lock-in in cloud computing?



Cloudflare. (n.d.). What is vendor lock-in? | vendor lock-in and cloud computing | ... Cloudflare. https://www.cloudflare.com/learning/cloud/what-is-vendor-lock-in/

3. Brief History

- 1969 - ARPANET (TCP/IP implementation)
- 1999 - Salesforce uses cloud computing to distribute popular software
- 2002 - Amazon Web Services (AWS)
- 2006 - AWS launches S3 for Cloud Object Storage
- 2008 - NASA's OpenNebula (Open Source)
- 2008 - Google Cloud Platform (GCP)
- 2010 - Microsoft Azure

Qian, L., Luo, Z., Du, Y., & Guo, L. (2009). Cloud computing: An overview. Lecture Notes in Computer Science, 626–631. https://doi.org/10.1007/978-3-642-10665-1_63

Microsoft. (2010, February 1). Windows Azure General Availability. Microsoft. https://web.archive.org/web/20140511230956/http://blogs.technet.com/b/microsoft_blog/archive/2010/02/01/windows-azure-general-availability.aspx

Foote, K. D. (2023, May 4). A brief history of cloud computing. DATAVERSITY. https://www.dataversity.net/brief-history-cloud-computing/

Amazon. (2006, August 24). Announcing Amazon Elastic Compute Cloud (amazon EC2) - beta. AWS. https://aws.amazon.com/about-aws/whats-new/2006/08/24/announcing-amazon-elastic-compute-cloud-amazon-ec2---beta/

4. Typical Features + Functions

- AWS - 200+ services, GCP 100+ services
  - analytics & data lakes
  - virtual machines
  - serverless computing
  - machine learning
  - databases
- full stack
- SaaS, PaaS, IaaS
- pay-as-you-go cost model
- dev support

4. Typical Features + Functions - SaaS

- deliver services/apps over the Internet
- access from browser
- pay-as-you-go
- pros
  - cost-effective
  - efficient
  - scalable
- cons
  - limited customization
  - data privacy
  - dependence on internet connectivity
- ex: Salesforce, Zoom, Dropbox, Google Drive

GfG. (2023, February 2). Cloud based services. GeeksforGeeks. https://www.geeksforgeeks.org/cloud-based-services/, 10 extraordinary examples of SAAS Applications. Quixy. (2024a, February 21). https://quixy.com/blog/examples-of-saas-applications/, Wikimedia Foundation. (n.d.). File:salesforce.com logo.svg. Wikipedia. https://en.m.wikipedia.org/wiki/File:Salesforce.com_logo.svg, Category:google logos. Wikimedia Commons. (n.d.). https://commons.wikimedia.org/wiki/Category:Google_logos

4. Typical Features + Functions - PaaS

- provides a platform and environment for devs to build apps/services
- hosted in the cloud, accessed via browser
- provider hosts hardware/software on its own infrastructure
- pros
  - simplicity and conveniency
  - cost-effective
  - some configuration
- cons
  - limited control over infrastructure
  - dependence on provider
- ex: AWS Elastic Beanstalk, Google App Engine

GfG. (2023a, February 2). Cloud based services. GeeksforGeeks. https://www.geeksforgeeks.org/cloud-based-services/, Salman Ravoof, Salman Ravoof is a self-taught web developer. (2024, January 8). What is paas? how platform as a service is different from iaas and SAAS. Kinsta®. https://kinsta.com/blog/what-is-paas/

4. Typical Features + Functions - IaaS

- computer infrastructure provided as outsourcing
- provides underlying OS, security, networking, servers
- pros
  - no maintenance
  - cost-effective
  - more customizable
- cons
  - limited control over infrastructure
  - security
- ex: AWS EC2, Google Compute Engine

GfG. (2023a, February 2). Cloud based services. GeeksforGeeks. https://www.geeksforgeeks.org/cloud-based-services/

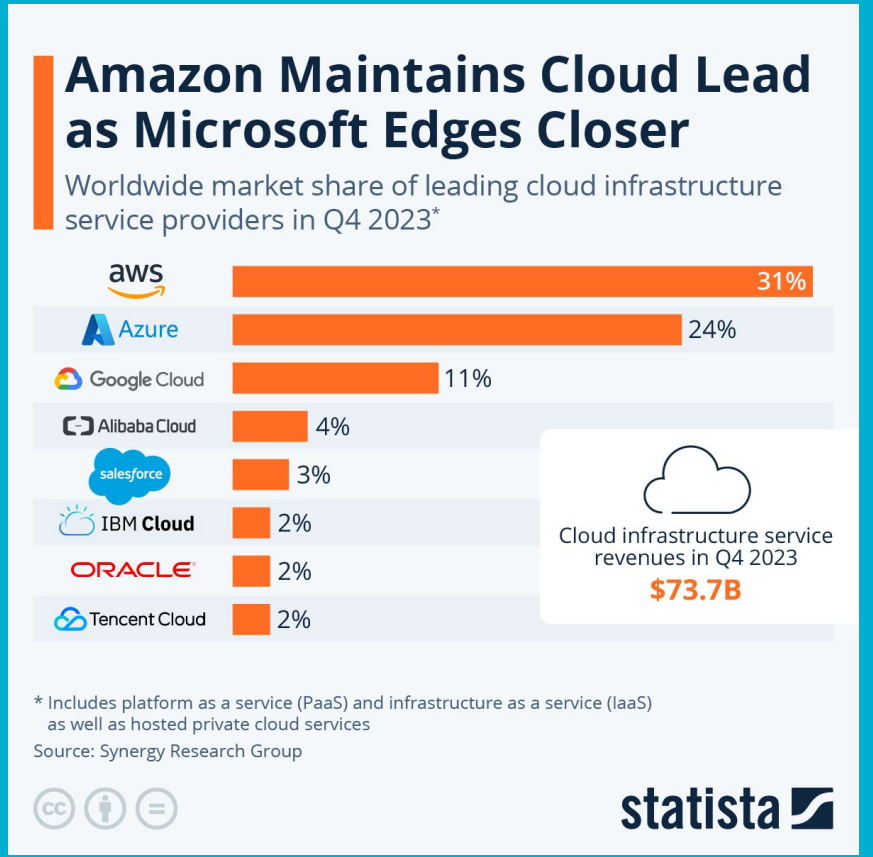
4. Typical Features + Functions

- APIs
  - integrate scripts with services - ex: AWS Boto3
  - automate workflows - AWS CloudFormation, GCP Deployment Manager
- account management
- console & CLI

AWS CloudFormation vs AWS Service catalog: What are the differences?. StackShare. (n.d.). https://stackshare.io/stackups/aws-cloudformation-vs-aws-service-catalog#:~:text=In%20summary%2C%20AWS%20CloudFormation%20is,catalogs%20of%20pre%2Dapproved%20services.

5. Leading Products in Space

- Use-Case Specific, beyond Data Management itself
  - AWS - mature ecosystem, breadth of add-on services, extensive data network
  - Azure - strong emphasis on security & compliance, direct Microsoft service integration
  - Google - Emphasis on data management & analytics, Kubernetes ease-of-use
- Still smaller startups in market like DigitalOcean



Richter, F. (2024, February 5). Infographic: Amazon maintains cloud lead as Microsoft edges closer. Statista Daily Data. https://www.statista.com/chart/18819/worldwide-market-share-of-leading-cloud-infrastructure-service-providers/

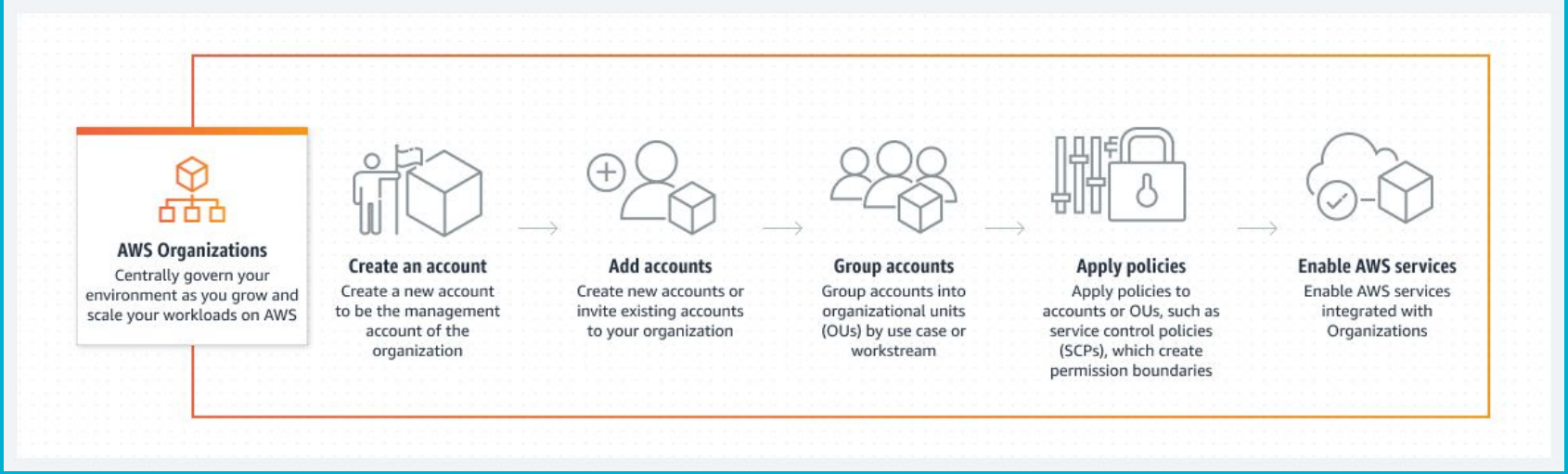
DigitalOcean. (n.d.). Comparing AWS, Azure, GCP. DigitalOcean. https://www.digitalocean.com/resources/article/comparing-aws-azure-gcp

6. Product 1: AWS Technical Details - Architecture

- organization/account hierarchy
- as of 2014…
  - 100+ data centers
    - up to 50,000 servers per
  - 1.4 million+ servers total
- AWS region (33)
  - North America, Europe, Southeast Asia
- AWS Availability Zone (105)
  - group of logically connected but geographically separated data centers
- AWS local Zone
  - extension of AWS region, run services close to end users

BB Agency, info@bb. agency, & Slingerland, C. (2023, December 5). AWS Data Centers today: 100+ locations, 1.5 million servers, and more. CloudZero. https://www.cloudzero.com/blog/aws-data-center-locations/, Global infrastructure. (n.d.). https://aws.amazon.com/about-aws/global-infrastructure/

6. Product 1: AWS Technical Details - Architecture



Policy-based management - AWS organizations - AWS. AWS Organizations. (n.d.). https://aws.amazon.com/organizations/

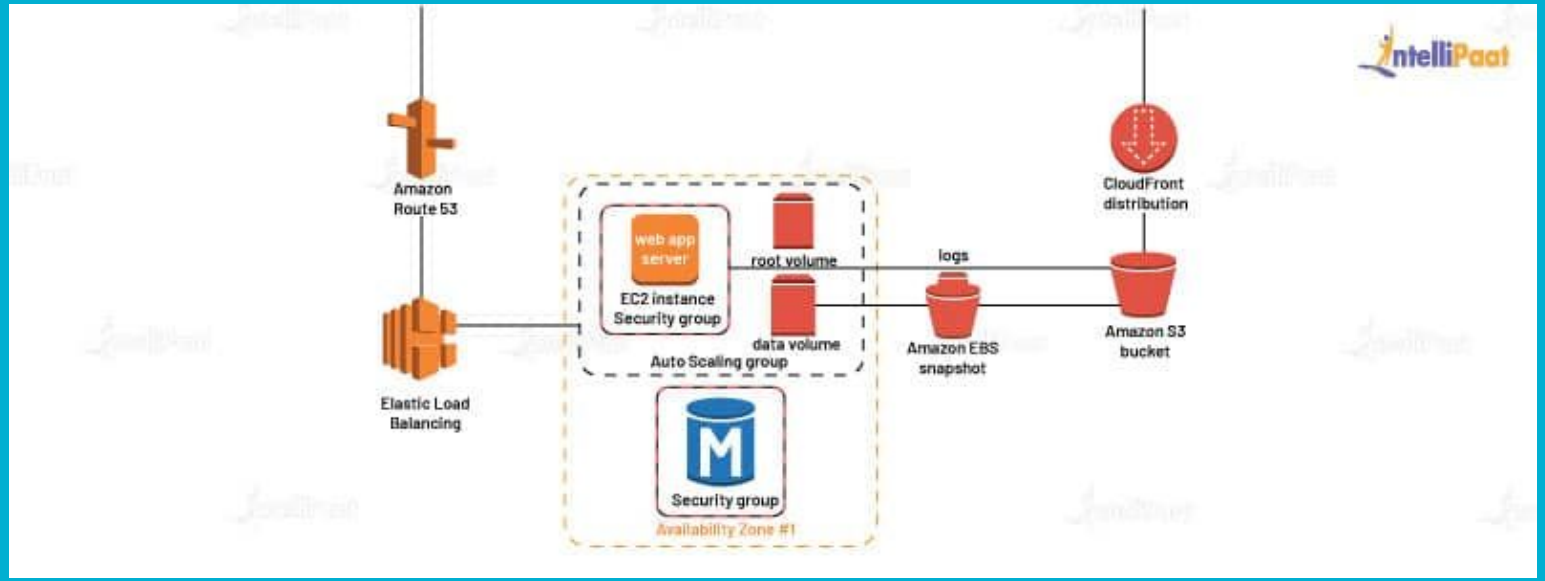
6. Product 1: AWS Technical Details - Security

- 143 security standards
  - PCI-DSS, HIPAA/HITECH
- 3rd-party validation
- security of the cloud vs. security in the cloud
- AWS global network - data automatically encrypted at physical layer
- IAM policies - define permissions for an action
  - groups and roles

Cloud compliance - amazon web services (AWS). (n.d.-a). https://aws.amazon.com/compliance/, What is the Hitech Act? 2024 update. What is the HITECH Act? (n.d.). https://www.hipaajournal.com/what-is-the-hitech-act/, PCI DSS: What it is and how to comply. IT Governance. (n.d.). https://www.itgovernance.co.uk/pci_dss#:~:text=The%20PCI%20DSS%20(Payment%20Card%20Industry%20Data%20Security%20Standard)%20is,security%20controls%20around%20cardholder%20data., Global infrastructure. (n.d.-b). https://aws.amazon.com/about-aws/global-infrastructure/, Managing access permissions for your AWS organization - AWS ... (n.d.-d). https://docs.aws.amazon.com/organizations/latest/userguide/orgs_permissions_overview.html

6. Product 1: AWS Technical Details - Ex

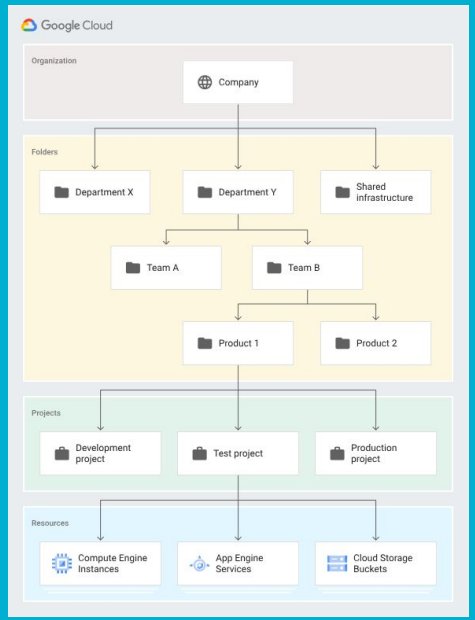
- AWS architecture - basic ex.



Intellipaat. (2023, December 20). What is AWS Architecture? Components explained using diagram. https://intellipaat.com/blog/what-is-aws-architecture/#introduction_to_aws_architecture

7. Product 2: GCP Technical Details - Architecture

- folder/project hierarchy
- 40 regions, 121 zones
- 200+ countries
- internal network & network cables
- data centers
- redundancy, load balancing, auto-scaling, disaster recovery



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7. Product 2: GCP Technical Details - Security

- multi-layered security
  - security measures at each infrastructure layer
  - data privacy and compliance defined by Google
- dedicated security team
  - penetration tests
  - scan for threats with commercial and custom tools
  - collaboration with security research community
- certifications like HIPAA, PCI-DSS, etc.
- custom hardware/software

Google. (n.d.-a). Global infrastructure. Google. https://cloud.google.com/infrastructure?hl=en, Google. (n.d.). Google security overview. Google security overview | documentation | google cloud. https://cloud.google.com/docs/security/overview/whitepaper, GfG. (2023c, March 30). Google Cloud Architecture Framework. GeeksforGeeks. https://www.geeksforgeeks.org/google-cloud-architecture-framework/

8. Case study 1: Netflix uses AWS

Companies used AWS are Netflix, Airbnb, Lyft, etc

AWS provides the follow benefits for Netflix:

- Reliable infrastructure without any single point of failure
- Highly reliable databases, storage, and redundant data centers
- Using multiple AWS cloud regions feature helps Netflix expand global infrastructure capacity access all countries

Slingerland, C. (2023, May 23). Netflix architecture: How much does Netflix's AWS cost? CloudZero. Retrieved from https://www.cloudzero.com/blog/netflix-aws/

8. Case study 1: Netflix uses AWS continue

- **Control plane:** is the part of a network that controls how data packets are forwarded — meaning how data is sent from one place to another.
- **Data plane**: is responsible for the actual forwarding of the packet

- Netflix uses AWS as their control plane. That includes online storage, a recommendation engine, video transcoding, databases, and analytics
- Netflix has their own data plane using its CDN called Open Connect to deliver videos to customer

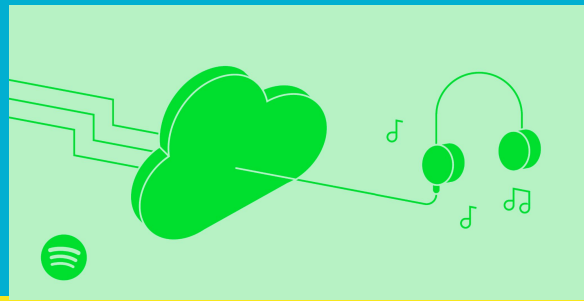
Singh, A. K. (2020, September 22). Case study: How Netflix is using AWS and its own CDN. Medium. Retrieved from https://ayushhsinghh.medium.com/case-study-how-netflix-is-using-aws-and-its-own-cdn-64ca6282eda0

9. Case study 2: Spotify uses Google Cloud Platform

Companies that use GCP are Spotify, Coca-cola, Snapchat, etc

Reasons for migration:

- It is incredibly intensive to manage physical data centers for a global company like Spotify with over 170 million users and this effort does not directly contributing to make Spotify's best music platform.
- Taking advantage of Google Cloud's innovative services



Carey, S. (2018, July 30). How Spotify migrated everything from on-premise to Google Cloud Platform. Computerworld. Retrieved from https://www.computerworld.com/article/3427799/how-spotify-migrated-everything-from-on-premise-to-google-cloud-platform.html

9. Case study 2: Spotify uses GCP continue

- **What tools are helpful to Spotify in particular:**
  - BigQuery for analysis
  - Pub/Sub for faster software application development
  - Dataflow for real-time and historical data analysis
- **Result of Cloud migration:**
  - GCP has positioned Spotify to better scale its service, innovate faster, and reduce the operational overhead associated with physical data centers
  - Eliminate the operation complexity, give the teams more time to concentrate on Spotify's primary mission

Carey, S. (2018, July 30). How Spotify migrated everything from on-premise to Google Cloud Platform. Computerworld. Retrieved from https://www.computerworld.com/article/3427799/how-spotify-migrated-everything-from-on-premise-to-google-cloud-platform.html

10. Compare and Contrast Products: GPC

Google Cloud: perfect choice for businesses that want to use Google products because of the existing ecosystem or Google's AI and machine learning capabilities.

- **Best for Big Data Analytics**
  - BigQuery is a powerful tool that allows Google to offer excellent support for data-intensive applications.
- **Exceptional Customer Support**
  - It provides 24/7 customer support with live chat and email support, while AWS only offers the latter
- **Superior Database Capabilities**
  - Most databases on Amazon's RDS lacks many capabilities offered by native cloud solutions
- **Advanced Cloud Services**
  - Beyond the databases and cloud networking, GCP also offers capabilities for machine learning and AI services, which are often vital in Big Data processing.

Timbó, R. (March 21, 2023). Google Cloud vs. AWS: Comparison and Features. Revelo. Retrieved February 27, 2024, from https://www.revelo.com/blog/google-cloud-vs-aw

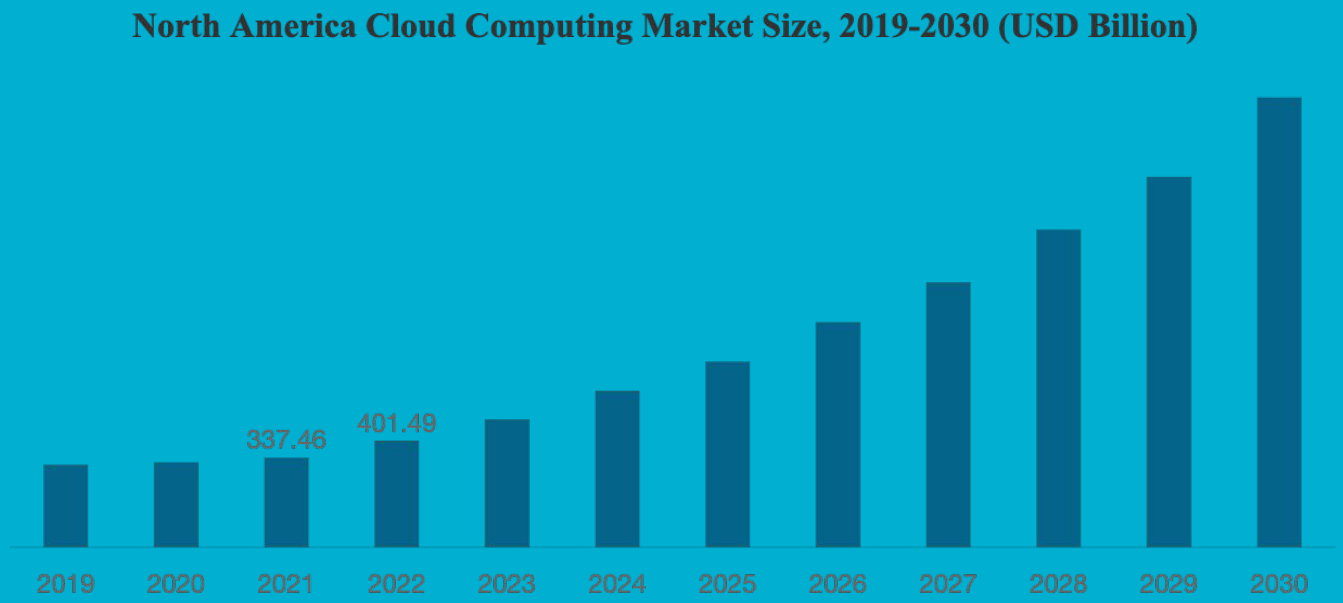
10. Compare and Contrast Products: AWS

AWS: provide flexibility, best choice for startups and small businesses

- **Easy to Deploy and Manage Web Applications with Flexible Digital Solutions**
  - Elastic Beanstalk manages all the deployment details with little work from developer. It's easy to scale on demand and gives users high control over all the offered tools
- **Product Variety and Increased Control**
  - Provides more raw compute power than GCP, so it is a better option for developers who need more control over their computing environment.
- **Lower Cost in a Bulk**
  - Offers a discount for reserved instances that you commit to using for a certain period
- **Cancelation flexibility**
  - Good choice for businesses that use many cloud services and need the flexibility to change or cancel their services at any time

Carey, S. (2018, July 30). How Spotify migrated everything from on-premise to Google Cloud Platform. Computerworld. Retrieved from https://www.computerworld.com/article/3427799/how-spotify-migrated-everything-from-on-premise-to-google-cloud-platform.html

11. Marketing Data



The global cloud computing market size was valued at $569.31 billion in 2022 & is projected to grow from $677.95 billion in 2023 to $2,432.87 billion by 2030.

Zhang, M. (2024, January 10). Top 10 cloud service providers globally in 2024. Dgtl Infra. https://dgtlinfra.com/top-cloud-service-providers/
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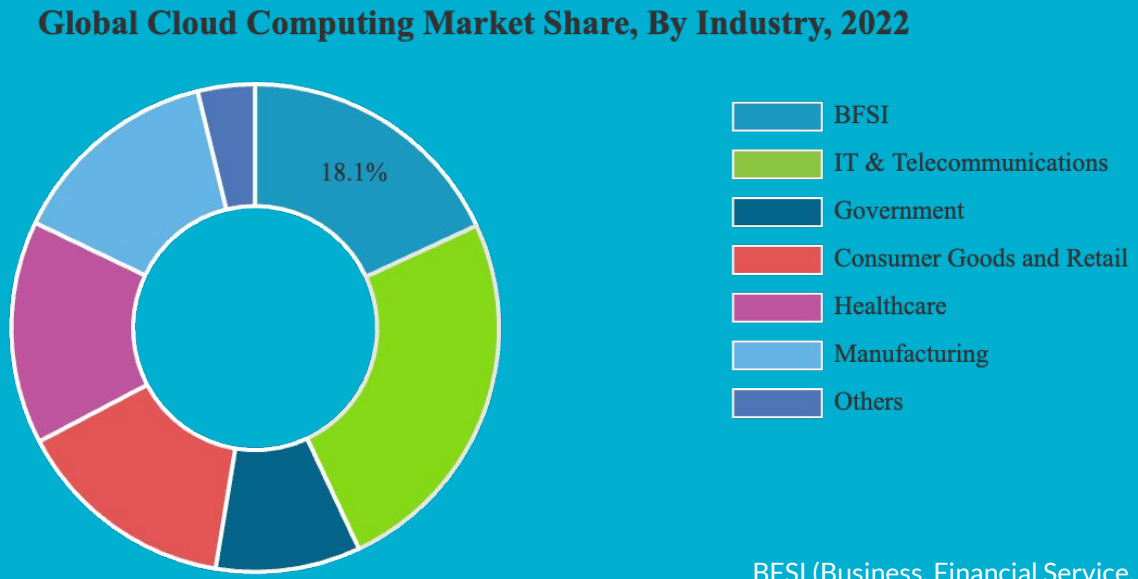

BFSI (Business, Financial Service, Insurance

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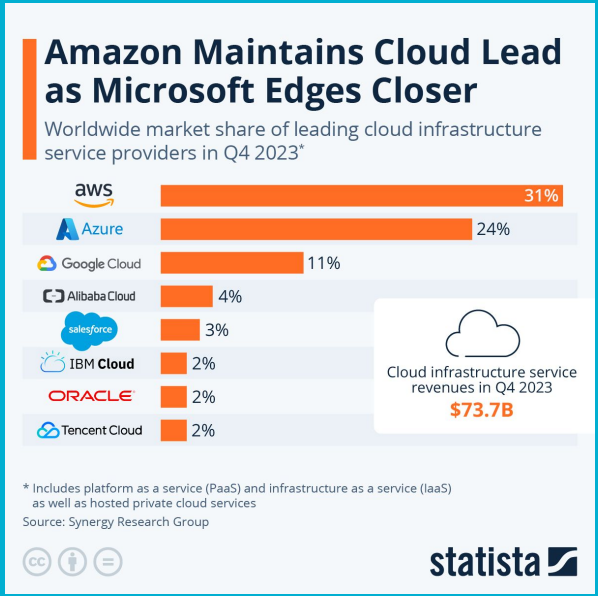


#	Cloud Service Provider	Regions	Availability Zones
1	Amazon Web Services (AWS)	32	102
2	Microsoft Azure	62	120
3	Google Cloud Platform (GCP)	39	118
4	Alibaba Cloud	30	89
5	Oracle Cloud	46	56
6	IBM Cloud (Kyndryl)	10	30
7	Tencent Cloud	21	65
8	OVHcloud	17	37
9	DigitalOcean	9	15
10	Linode (Akamai)	20	20

Zhang, M. (2024, January 10). Top 10 cloud service providers globally in 2024. Dgtl Infra. https://dgtlinfra.com/top-cloud-service-providers/
Cloud computing market size & share: Growth analysis, [2030]. Cloud Computing Market Size & Share | Growth Analysis, [2030]. (n.d.). https://www.fortunebusinessinsights.com/cloud-computing-market-102697
DigitalOcean. (n.d.). Comparing AWS, Azure, GCP. DigitalOcean. https://www.digitalocean.com/resources/article/comparing-aws-azure-gcp

11. Marketing Data

Cloud Provider	Cloud Hosting Offer	Price Per Month
Google Cloud Platform	Custom Machine 8 GB RAM / 4x CPUs	$126
Microsoft Azure	A4 v2 Virtual Machine	$159
Amazon Web Services	EC2 c5.xlarge + 1 TB SSD EBS	$225

Company	2018 Revenue	2018 Market Share (%)	2017 Revenue	2017 Market Share (%)	2018-2017 Growth (%)
Amazon	15,495	47.8	12,221	49.4	26.8
Microsoft	5,038	15.5	3,130	12.7	60.9
Alibaba	2,499	7.7	1,298	5.3	92.6
Google	1,314	4.0	820	3.3	60.2
IBM	577	1.8	463	1.9	24.7
Others	7,519	23.2	6,768	27.4	11.1
Total	**32,441**	**100.0**	**24,699**	**100.0**	**31.3**

Zhang, M. (2024, January 10). Top 10 cloud service providers globally in 2024. Dgtl Infra. https://dgtlinfra.com/top-cloud-service-providers/
Cloud computing market size & share: Growth analysis, [2030]. Cloud Computing Market Size & Share | Growth Analysis, [2030]. (n.d.). https://www.fortunebusinessinsights.com/cloud-computing-market-102697
DigitalOcean. (n.d.). Comparing AWS, Azure, GCP. DigitalOcean. https://www.digitalocean.com/resources/article/comparing-aws-azure-gcp

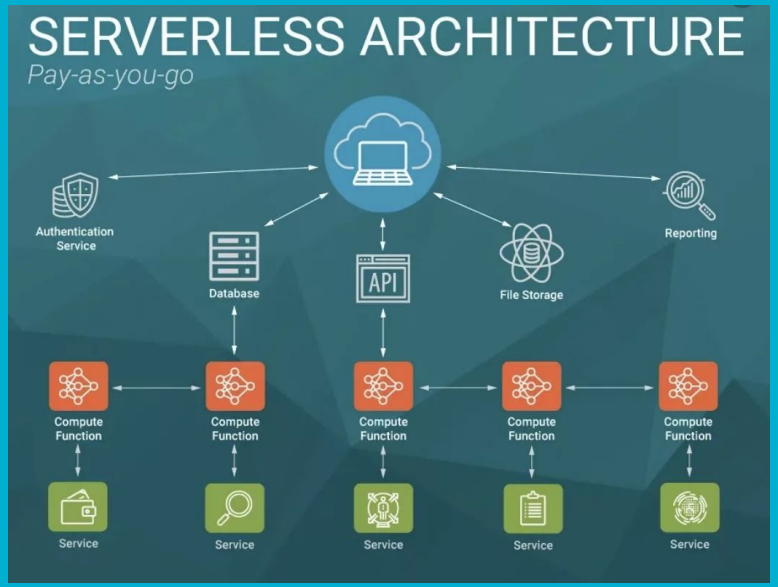
11. Marketing Data

AWS	Azure	GCP
AWS offers a pay-as-you-go model with flexibility and cost control. Offers various instance types with different pricing based on performance and capacity. Storage costs are based on capacity and access patterns for services like Amazon S3 and Amazon EBS. Ingress (data received) is typically free, while egress (data sent) costs vary based on volume and region, but is usually $0.05 to $0.09 per GB across the varying network interfaces and pricing plans. Discounts available through Reserved Instances and AWS Savings Plans with upfront payments.	Utilizes a pay-as-you-go model and offers Reserved VM Instances for cost savings. Instance families optimized for different workloads. Storage costs based on capacity and usage for Azure Blob Storage and Azure Disk Storage. Generally offers free ingress, egress costs applied based on data volume and region. Volume discounts through Azure Hybrid Benefit for customers with existing licenses.	Pay-as-you-go model with predefined and custom machine types. Storage costs based on capacity and access frequency for Google Cloud Storage and Google Persistent Disk. Data transfer costs vary based on the amount of data sent and received. Discounts available through Committed Use Contracts with upfront commitments for one or three years. Three support tiers available - Basic, Development, and Production, with varying levels of support coverage and response times.

DigitalOcean. (n.d.). Comparing AWS, Azure, GCP. DigitalOcean. https://www.digitalocean.com/resources/article/comparing-aws-azure-gcp

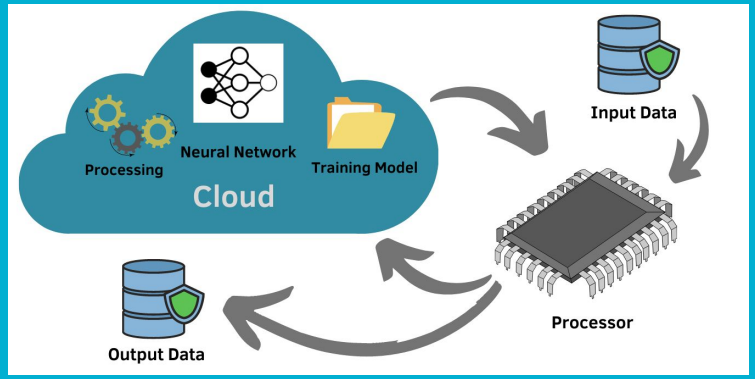
12. Future of Cloud Computing

- Serverless Computing
  - In a serverless model, there are no physical servers that need to be maintained; instead, application code is executed in response to events, and all of the infrastructure required to run the code is managed by a cloud provider.
  - simplify deployments and reduce the overall cost of running an application



Cloud computing future: 12 trends & predictions about cloud. KnowledgeHut. (2023, September 8). https://www.knowledgehut.com/blog/cloud-computing/cloud-computing-future

12. Future of Cloud Computing



- Integrate AI/ML
  - With the rapid advancements in artificial intelligence (AI), businesses and individuals are increasingly turning to the cloud to store and manage their data.
  - AI-powered data analytics can help to identify patterns and trends that would otherwise be undetectable.
  - Cloud-based AI systems can learn and evolve over time, becoming more effective at processing data.

Cloud computing future: 12 trends & predictions about cloud. KnowledgeHut. (2023, September 8). https://www.knowledgehut.com/blog/cloud-computing/cloud-computing-future

13. Problem 1 - How to increase availability?

Problem:

- DDOS attack is choreographed by a “botnet”
- DDOS attacks and congested network are sometimes unavoidable
- AWS reported 44% increase in 2020 in total DDOS attack volume from previous year
- Packet inspecting is infeasible

Catch Me If You Can: A Cloud-Enabled DDoS Defense | IEEE Conference Publication | IEEE Xplore. (n.d.). Ieeexplore.ieee.org. Retrieved February 27, 2024, from https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6903585

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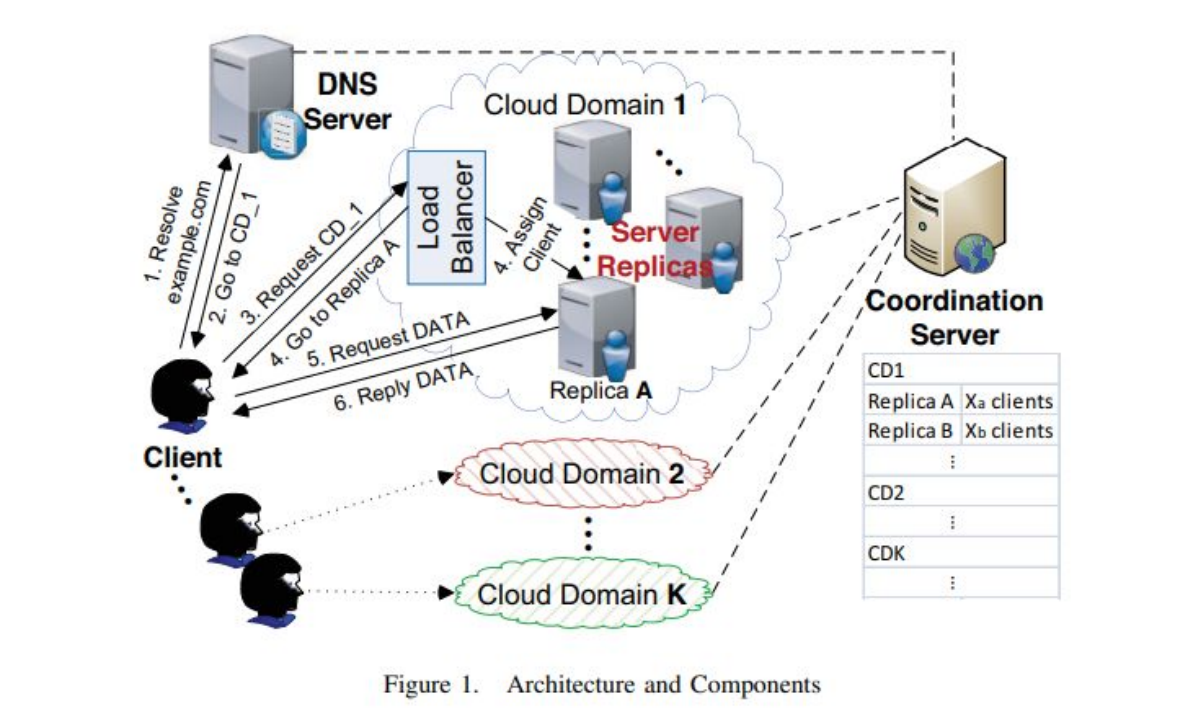

Figure 1. Architecture and Components

Catch Me If You Can: A Cloud-Enabled DDoS Defense | IEEE Conference Publication | IEEE Xplore. (n.d.). Ieeexplore.ieee.org. Retrieved February 27, 2024, from https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6903585

14. Problem 2 - Streaming Data Rate

Problem:

- How do we strike the balance between over and under utilization of data?
- Utility computing is emerging (IAAS and SAAS)
- Cloud computing already is elastic

Dynamic Resource Provisioning for Data Streaming Applications in a Cloud Environment | IEEE Conference Publication | IEEE Xplore. (n.d.). Ieeexplore.ieee.org. Retrieved February 27, 2024, from https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5708483

14. Problem 2 - Streaming Data Rate

4 Main Goals

- Converge quickly to optimal CPU allocation for data stream
- Adaptive to network fluctuations
- Different streaming apps must be supported
- Algorithm itself not computationally expensive

ALGORITHM CPUMANAGER ()

// Read the buffer statistics

$w\_time = \sum_{i=0}^{SAMPLE\_COUNT} cur\_round\_writeTime$

$p\_time = \sum_{i=0}^{SAMPLE\_COUNT} cur\_round\_processTime$

// Determine which of coarse or fine grained adjustment required

if $\|p\_time - w\_time\| > MAX\_LAG \times p\_time$

  if $(p\_time - w\_time) > 0$

    if (buffer occupancy is in high occupancy region)

    then

      // CPU allocation is low with chance of buffer-full

      $CPU_{new} = CPU_{old} \times HIGH\_OCC\_FACTOR$

    else

      // CPU allocation is low

      $CPU_{new} = CPU_{old} \times NORMAL\_OCC\_FACTOR$

  else

    if (buffer occupancy is in underflow region)

    then

      // CPU allocation is too high with chance of buffer-empty

      $CPU_{new} = CPU_{old} - LOW\_OCC\_DECREASE$

    else

      // CPU allocation is too high

      $CPU_{new} = CPU_{old} - NORMAL\_OCC\_DECREASE$

elseif $\|p\_time - w\_time\| > FINE\_LAG \times p\_time$

  if $(p\_time - w\_time) > 0$

    // CPU allocation is a little low

    $CPU_{new} = CPU_{old} + NORMAL\_INCREASE$

  else

    // CPU allocation is a little low

    $CPU_{new} = CPU_{old} - NORMAL\_DECREASE$

return (CPU_{new})

Dynamic Resource Provisioning for Data Streaming Applications in a Cloud Environment | IEEE Conference Publication | IEEE Xplore. (n.d.). Ieeexplore.ieee.org. Retrieved February 27, 2024, from https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5708483

14. More Problems

- Application can become too dependent on cloud environment and services
- Security privacy concerns over cloud provider