Cloud computing reference architecture

Upon completion of this module, you should be able to:

- Explain the essential cloud characteristics

- Explain the cloud deployment and service models

- Explain the key benefits of the cloud computing

- Explain the cloud reference architecture

Cloud drives digital transformation

- Cloud computing is the key enabler for the digital transformation.
    - Reduction of IT infrastructure investment and management complexity
    - Provides unlimited and dynamic IT resources

> Cloud computing has become an integral element of any successful digital transformation strategy.
>
> - IDC

Cloud drives digital transformation

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Cloud concepts

This lesson covers the following topics:

- Cloud computing forecast

- Essential characteristics of the cloud computing

- Cloud service offering examples
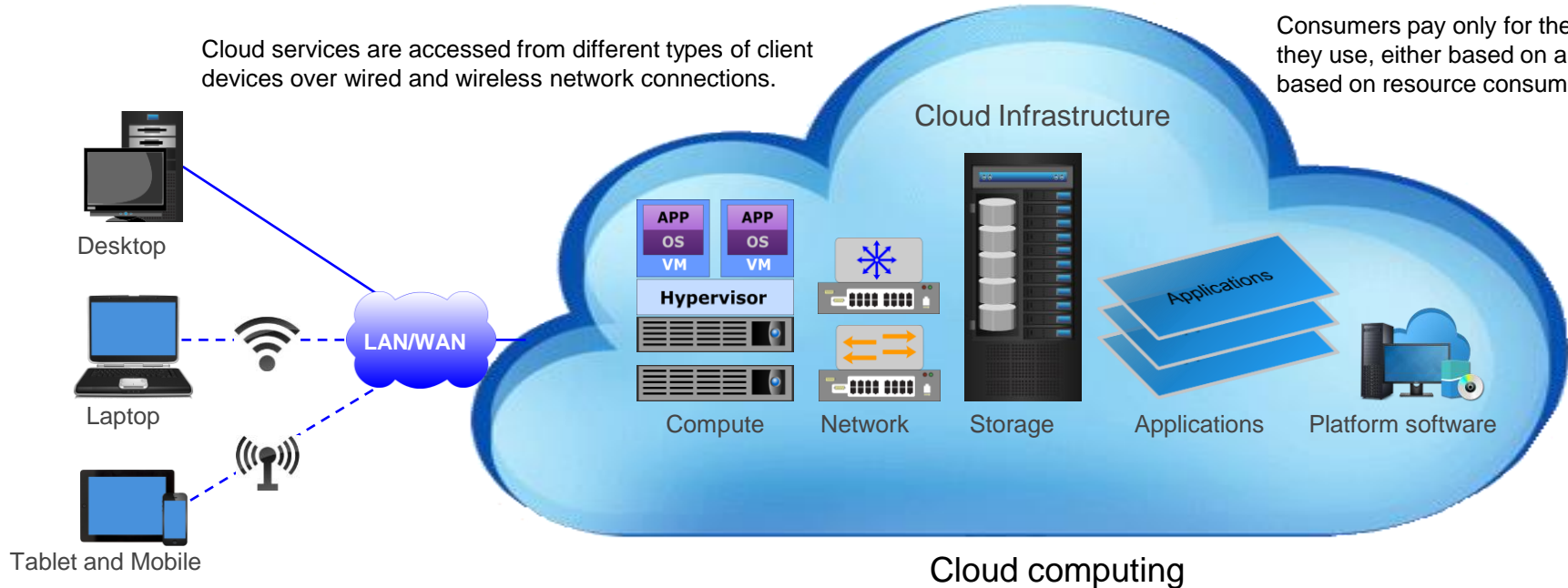
- Cloud computing benefits

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What is Cloud computing?

A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources, (e.g., servers, storage, networks, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.
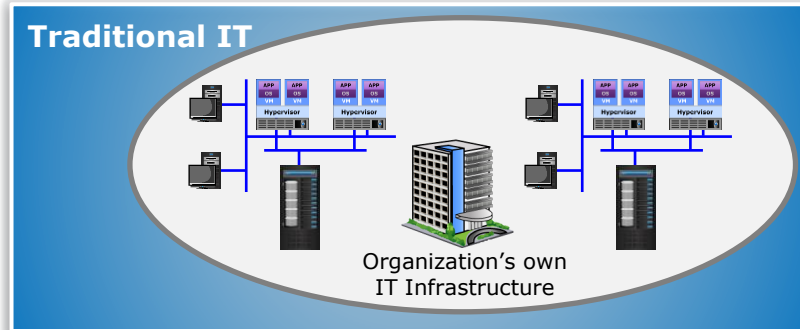
- NIST

Cloud services are accessed from different types of client devices over wired and wireless network connections.

Consumers pay only for the services that they use, either based on a subscription or based on resource consumption.

Cloud Infrastructure

Desktop

Laptop

Tablet and Mobile

LAN/WAN

APP
OS
VM

APP
OS
VM

Hypervisor

Compute

Network

Storage

Applications

Applications

Platform software

Cloud computing

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Traditional IT vs. cloud computing

Traditional IT

Organization's own
IT Infrastructure

Cloud Computing

Cloud Infrastructure

Organization rents IT resources

- IT resources are owned and managed
- Needs considerable time to acquire and provision resources
- Lacks ability to support needed business agility
- IT resources are planned for peak usage
- Underutilized resources
- High capital expenditure
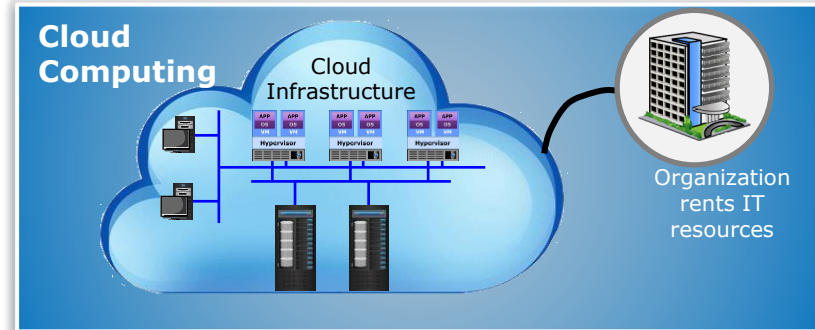
- IT resources are rented as services
- On-demand resource provisioning and scalability
- Self-service provisioning of resources
- Resource consumption is metered
- Provides business agility and high utilization
- Offers reduced capital expenditure

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Essential cloud characteristics

5 Essential Characteristics of Cloud Computing
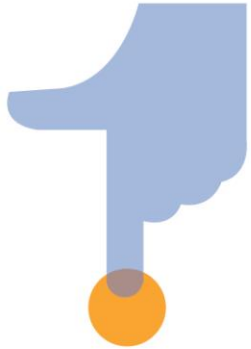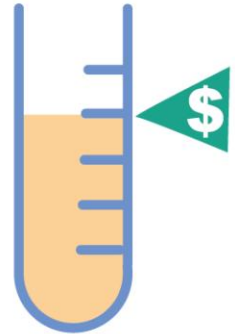
On-demand Self-service
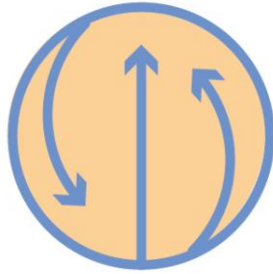
Ubiquitous Network Access

Location Transparent Resource Pooling

Rapid Elasticity

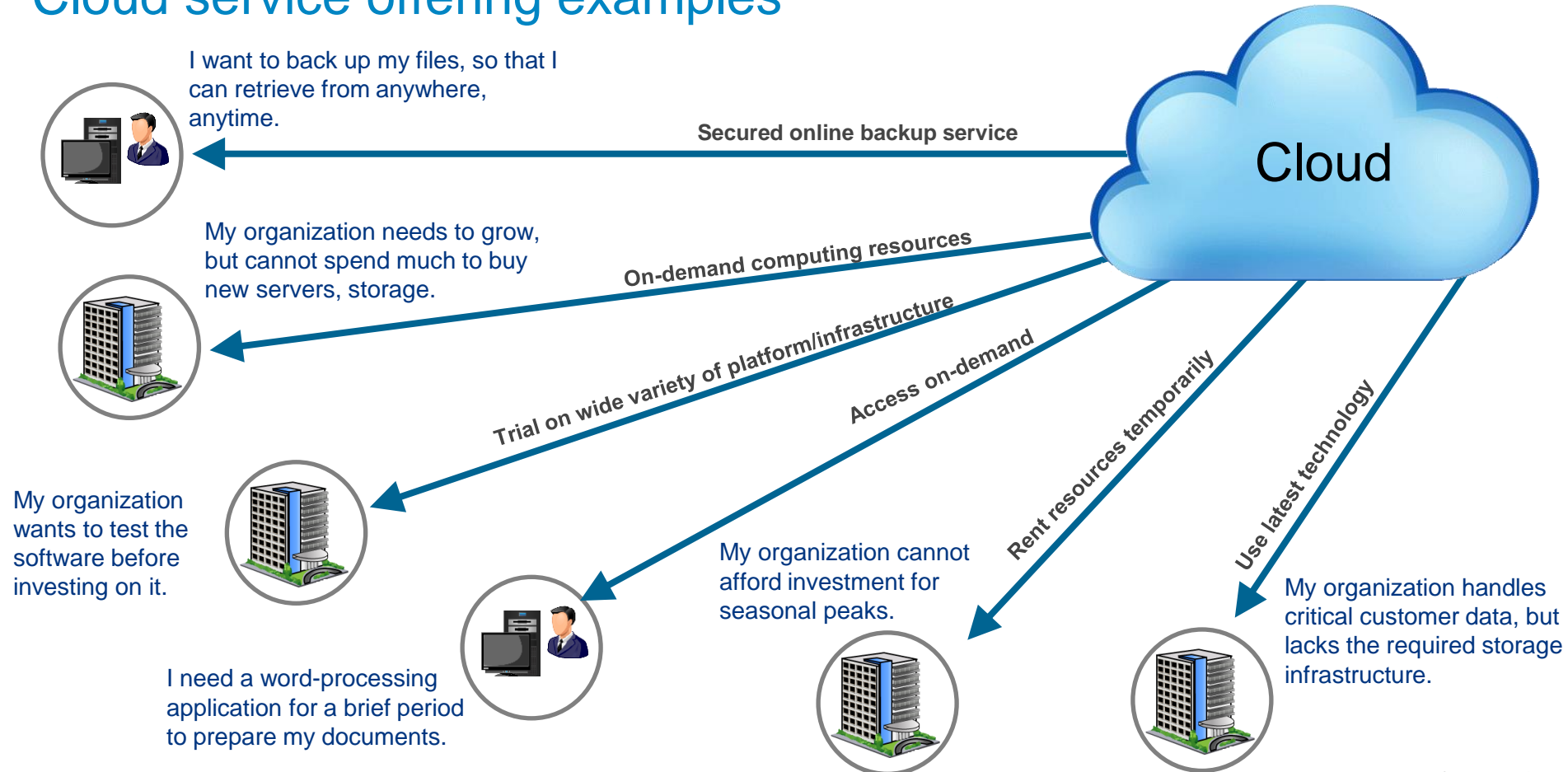**Measured Service with Pay-per-Use**

Jackson, Kevin L., and Scott Goessling. *Architecting Cloud Computing Solutions: Build cloud strategies that align technology and economics while effectively managing risk*. Packt Publishing Ltd, 2018.

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Essential cloud characteristics

To access the video, please click the below link

https://edutube.emc.com/Player.aspx?vno=fMMKCMNedySfw9/y33eHMw==&autoplay=true&t=0h0m0s

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Cloud service offering examples

I want to back up my files, so that I can retrieve from anywhere, anytime.

Secured online backup service

My organization needs to grow, but cannot spend much to buy new servers, storage.

On-demand computing resources

Cloud

Trial on wide variety of platform/infrastructure

Access on-demand

Rent resources temporarily

Use latest technology

My organization wants to test the software before investing on it.

I need a word-processing application for a brief period to prepare my documents.

My organization cannot afford investment for seasonal peaks.

My organization handles critical customer data, but lacks the required storage infrastructure.

Cloud service offering examples
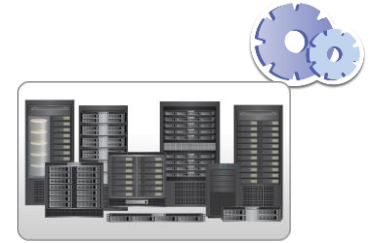
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Cloud computing benefits

Business agility

Flexibility of access

Simplified infrastructure management

Reduced IT costs

High availability

Flexible scaling

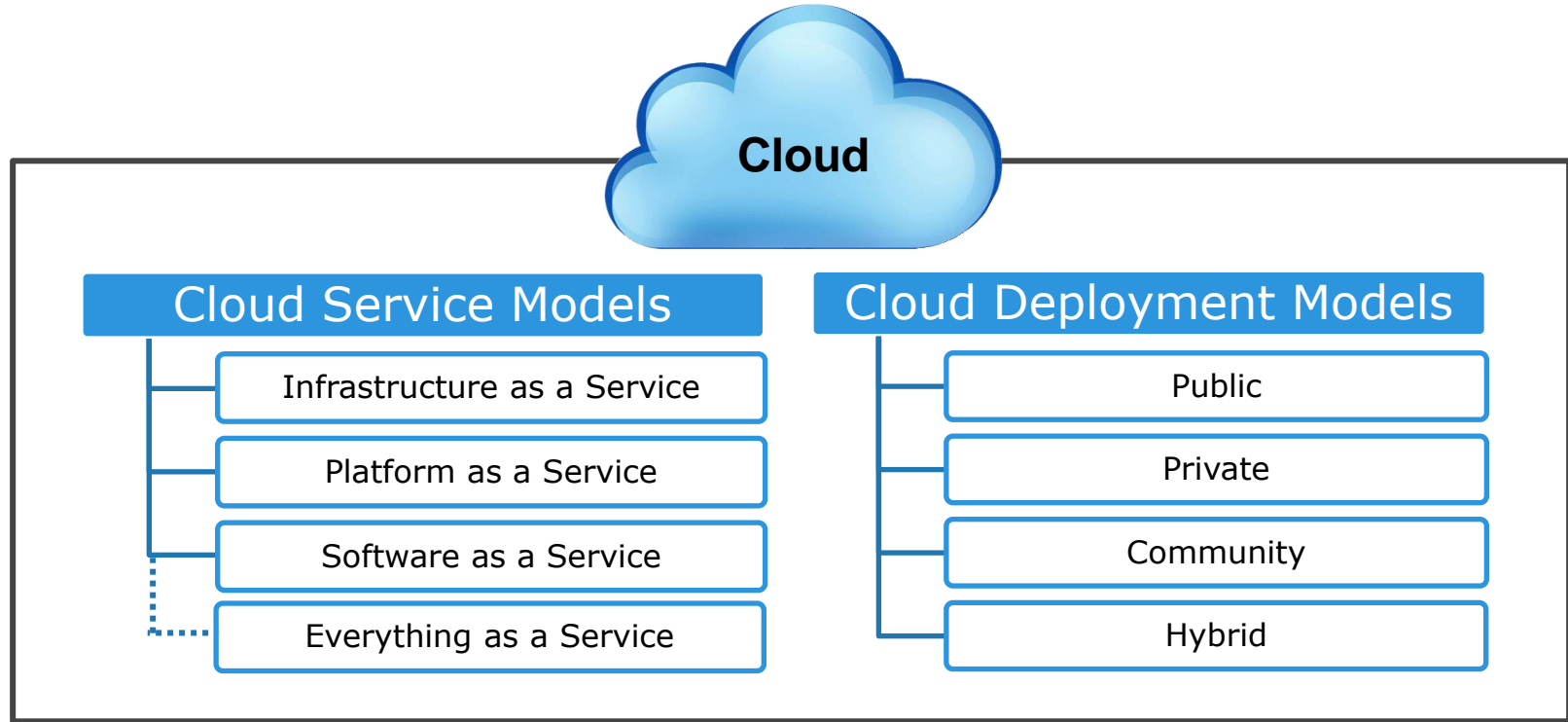Business continuity

Increased collaboration

Cloud computing benefits

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Cloud deployment and service models

This lesson covers the following topics:

- Cloud computing deployment models

- Cloud computing service models

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Cloud service and deployment models

Cloud

Cloud Service Models	Cloud Deployment Models
Infrastructure as a Service	Public
Platform as a Service	Private
Software as a Service	Community
Everything as a Service	Hybrid

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Infrastructure as a Service (IaaS)

- Provides capability to the consumer to hire infrastructure components such as servers, storage, and network

- Enables consumers to deploy and run software, including OS and applications

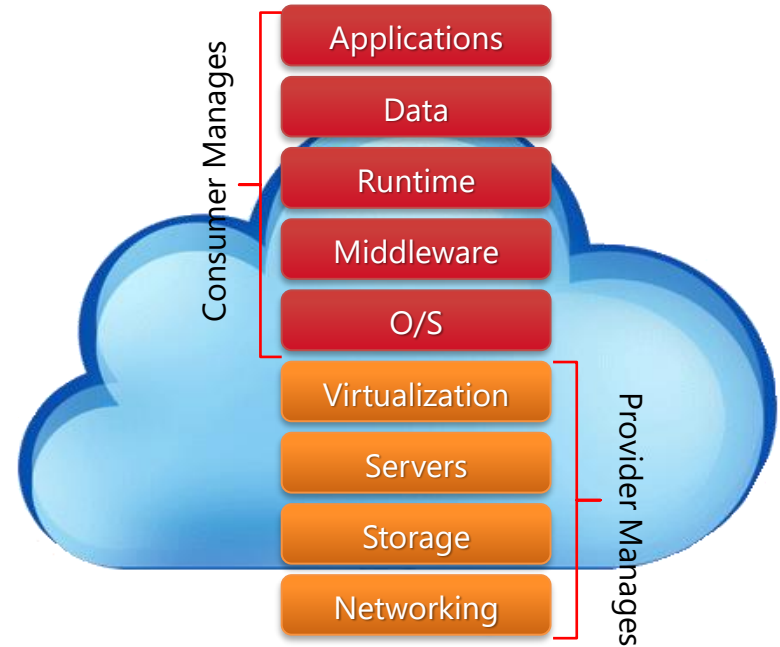**IaaS Examples:**

Amazon EC2, VPC, S3

VMware Cloud Foundation

Virtustream

Google Compute Engine
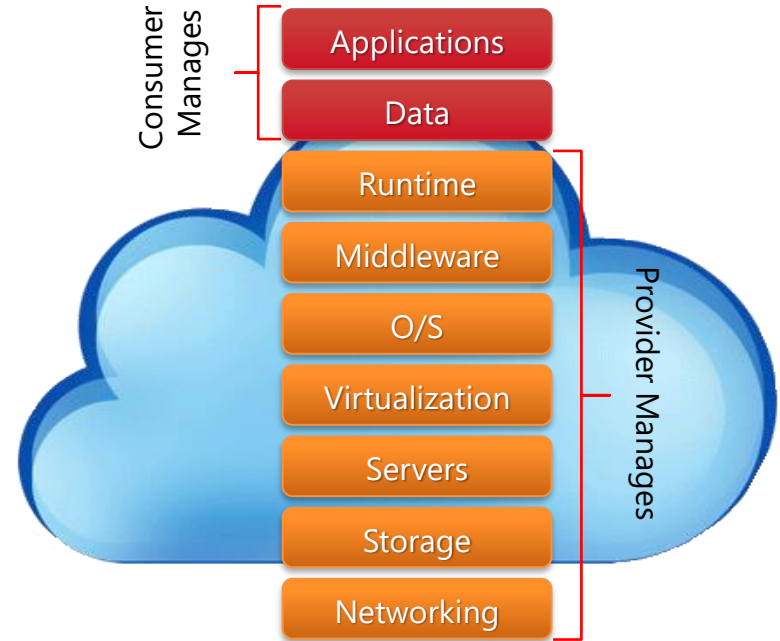
Azure Virtual Machine

Azure Stack HCI solutions

Consumer Manages

Applications

Data

Runtime

Middleware

O/S

Provider Manages

Virtualization

Servers

Storage

Networking

Infrastructure as a Service (IaaS)

DELLEMC

Platform as a Service (PaaS)

- Capability provided to the consumer to deploy consumer-created or acquired applications on the provider's infrastructure

- Consumer has control over
  - Deployed applications
  - Possible application hosting environment configurations

PaaS Examples:

Cloud Foundry,
OpenShift,
Heroku,
Deis,
Google App Engine,
AWS Elastic Beanstalk,
Amazon Elastic
Container Service,
Microsoft Azure Pack
for Windows Server

Consumer Manages

| Applications |
| Data |

Provider Manages

| Runtime |
| Middleware |
| O/S |
| Virtualization |
| Servers |
| Storage |
| Networking |

Platform as a Service (PaaS)

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Software as a Service (SaaS)

- Capability provided to the consumer to use provider's applications running in a cloud infrastructure

- Complete stack including application is provided as a service

- Application is accessible from various client devices, for example, via a thin-client interface such as a Web browser
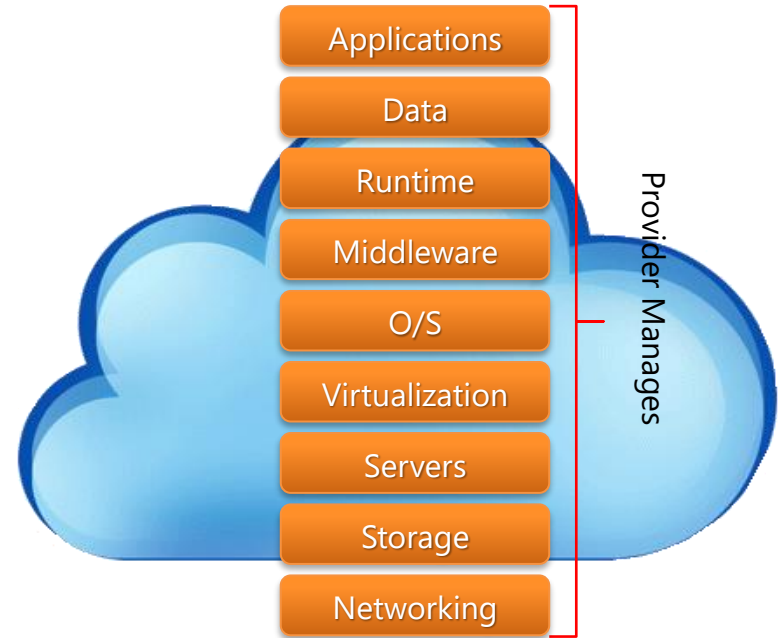
SaaS Examples:

AWS SaaS Factory Program

Microsoft 365

Google Workspace

Salesforce.com

Dell EMC Syncplicity

Google Apps

Applications

Data

Runtime

Middleware

O/S

Virtualization

Servers

Storage

Networking

Provider Manages

Software as a Service (SaaS)

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Everything as a Service (XaaS)

- Often been used as an umbrella term to encompass SaaS, PaaS, and IaaS

- It includes services such as IaaS, PaaS, storage as a service, desktop as a service, DRaaS

- It also includes other services such as Transportation as a Service and Accommodation as a Service
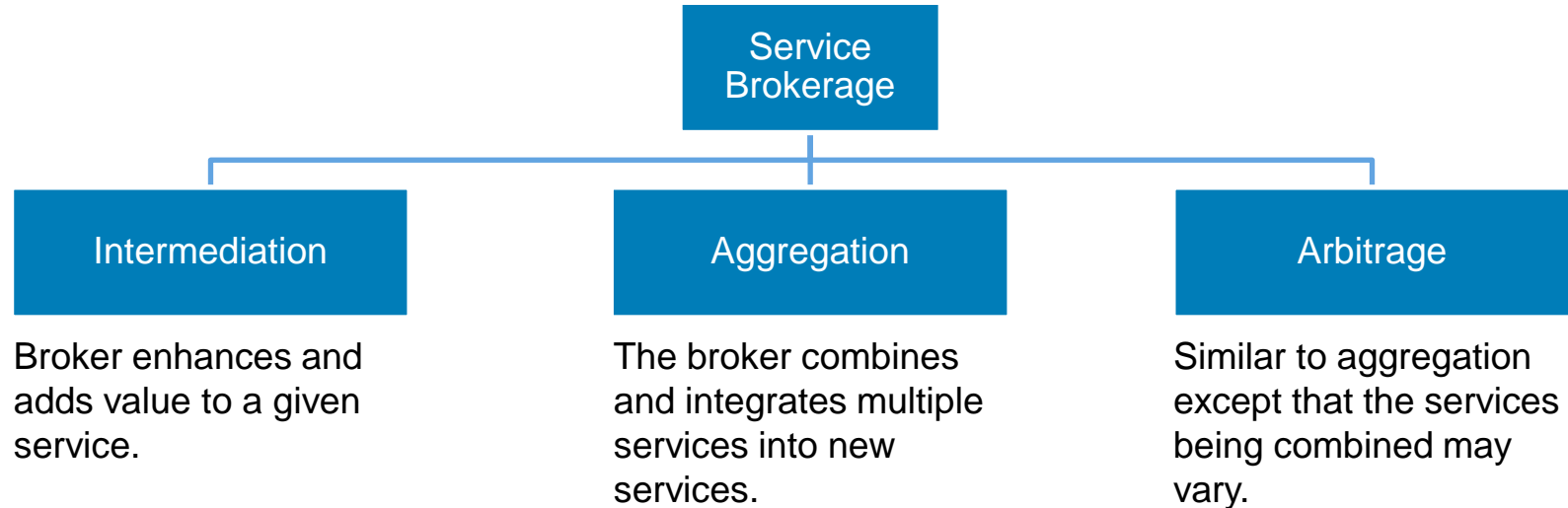

Everything as a Service- XaaS

Cloud Computing Explained
https://www.youtube.com/watch?v=M988_fsOSWo

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Cloud service brokerage (CSB)

An entity that manages the use, performance and delivery of cloud services, and negotiates relationships between cloud providers and cloud consumers.

- NIST

```
                    ┌──────────────────┐
                    │     Service      │
                    │    Brokerage     │
                    └──────────────────┘
        ┌───────────────────┼───────────────────┐
┌───────────────┐  ┌───────────────┐  ┌───────────────┐
│ Intermediation │  │  Aggregation  │  │   Arbitrage   │
└───────────────┘  └───────────────┘  └───────────────┘
```

Intermediation

Broker enhances and adds value to a given service.

Aggregation

The broker combines and integrates multiple services into new services.

Arbitrage

Similar to aggregation except that the services being combined may vary.
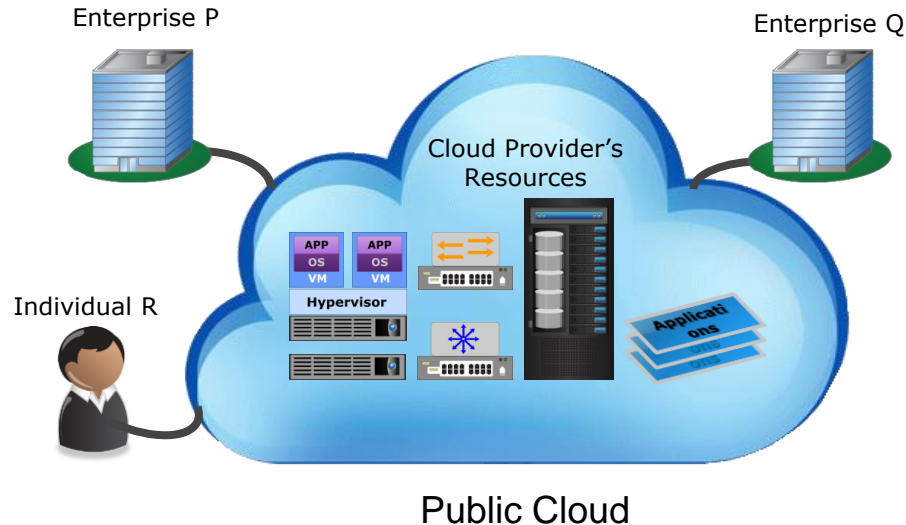
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Public cloud

The cloud infrastructure is provisioned for open use by the general public. A business, academic, or government organization, or some combination of them owns, manages, and operates cloud infrastructure. It exists on the premises of the cloud provider.
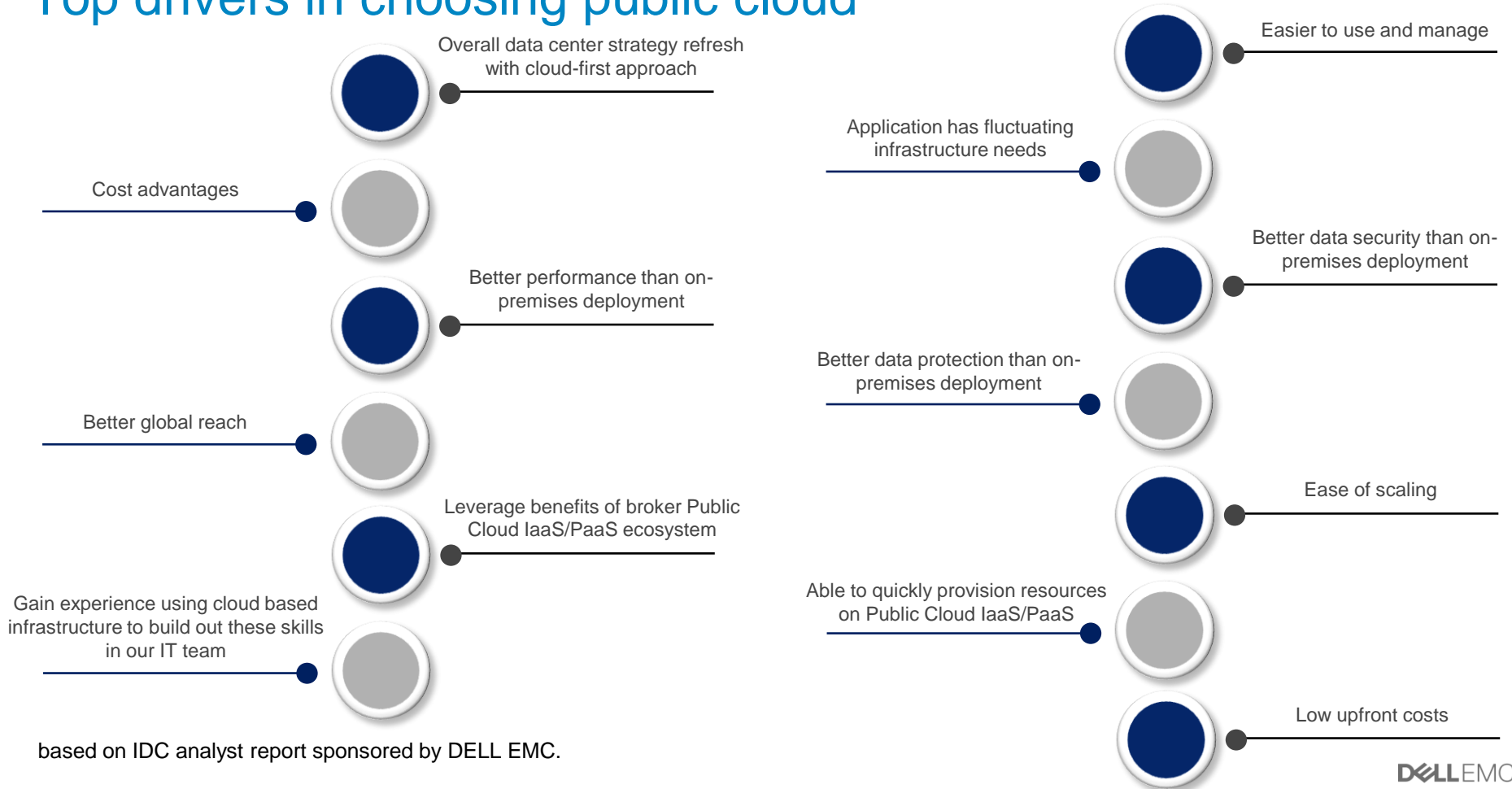
- NIST

Enterprise P

Enterprise Q

Cloud Provider's Resources

Individual R

APP **OS** **VM** **APP** **OS** **VM**

Hypervisor

Applications

Public Cloud

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Public cloud forecast

The public cloud services market is expected to maintain its pattern of growth, fueled by the demand for Desktop-as-a-Service (DaaS) and Software-as-a-Service (SaaS) solutions.
This is according to a new report from market analyst Gartner, which predicts the market will grow to $257.9 billion this year - a 6.3 percent increase year-on-year.
The most significant growth is expected from the DaaS segment, with Gartner predicting a rise of 95.4 percent to $1.2 billion. (By Sead Fadilpašić July 23, 2020)

- Gartner https://www.itproportal.com/news/gartner-forecasts-major-growth-in-global-public-cloud/

"By the end of 2021, based on lessons learned in the pandemic, most enterprises will put a mechanism in place to accelerate their shift to cloud-centric digital infrastructure and application services **twice as fast** as before the pandemic. Spending on cloud services, the hardware and software components underpinning cloud services, and the professional and managed services opportunities around cloud services will surpass $1 trillion in 2024."
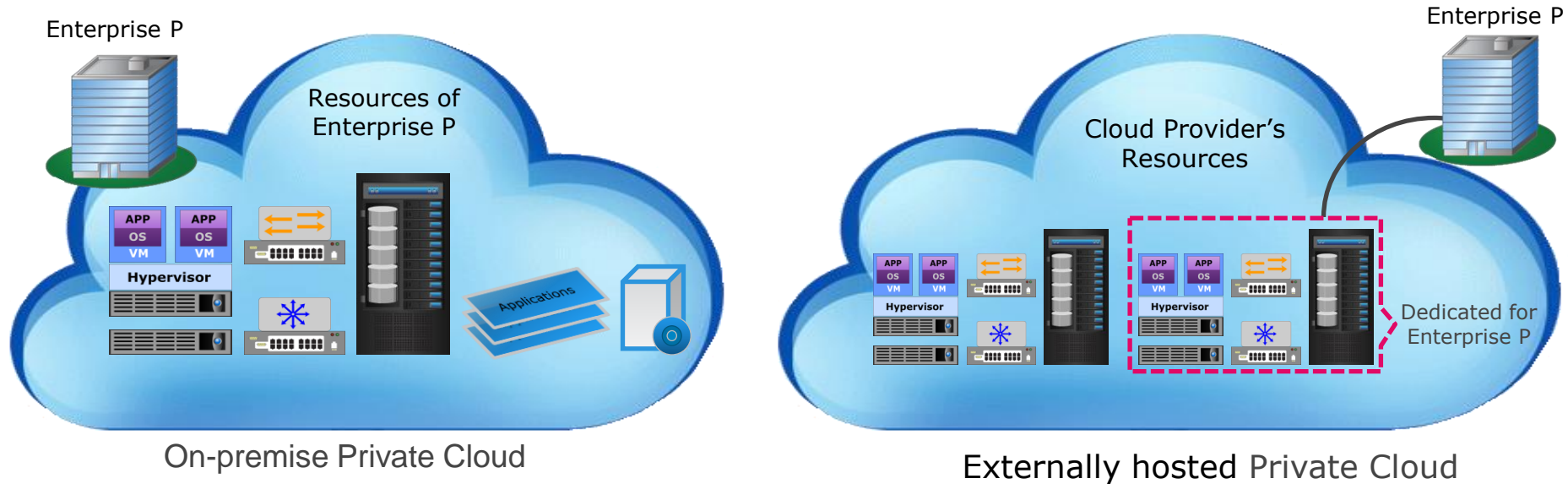
- IDC https://www.idc.com/getdoc.jsp?containerId=US46020420

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Top drivers in choosing public cloud

Overall data center strategy refresh with cloud-first approach

Easier to use and manage

Cost advantages

Application has fluctuating infrastructure needs

Better performance than on-premises deployment

Better data security than on-premises deployment

Better global reach

Better data protection than on-premises deployment

Leverage benefits of broker Public Cloud IaaS/PaaS ecosystem

Ease of scaling

Gain experience using cloud based infrastructure to build out these skills in our IT team

Able to quickly provision resources on Public Cloud IaaS/PaaS

Low upfront costs

based on IDC analyst report sponsored by DELL EMC.

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Private cloud

The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers - for example, business units. It may exist on or off premises and an organization, a third party, or some combination of them may own, manage, and operate it.

– NIST

Enterprise P

Resources of Enterprise P

On-premise Private Cloud

Enterprise P

Cloud Provider's Resources

Dedicated for Enterprise P

Externally hosted Private Cloud

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Forecast and top drivers for choosing private cloud

- On-premises private clouds will account for 62.3% of spending on private cloud IT infrastructure and will grow 13.1% year over year in 2017
  - IDC

Top Drivers

Cost effective for our workloads compared to other options

Meets compliance and regulatory requirements

More security than Public Cloud IaaS/PaaS

Ease of scaling and provisioning for applications

Flexibility to configure the platform and resources as needed

Less risk than using Public Cloud IaaS/PaaS

Ease of allocating costs and resources for multiple applications

Control and service level considerations

Top down decision in the organization

Source: IDC Hybrid Cloud Market Survey, by DELL EMC, January 2017

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Top private cloud computing platforms

BMC Software
7.8 2.6 🔥 95
☰+ Compare

VMware
7.6 8.1 🔥 76
☰+ Compare

Microsoft Cloud
7.7 7.0 🔥 75
☰+ Compare

IBM Bluemix Cloud
7.7 6.1 🔥 74
☰+ Compare

SAP HANA Cloud Platform
7.7 8.4 🔥 73
☰+ Compare

Red Hat Cloud
7.6 6.3 🔥 67
☰+ Compare

Cisco Systems
7.6 7.8 🔥 65
☰+ Compare

Dell Cloud
7.7 7.8 🔥 65
☰+ Compare

Platform.sh
7.6 9.5 🔥 62
☰+ Compare

Citrix Cloud
7.6 8.8 🔥 51
☰+ Compare

HP Helion
7.6 8.3 🔥 50
☰+ Compare

Source: https://www.predictiveanalyticstoday.com/top-private-cloud-computing-solutions/
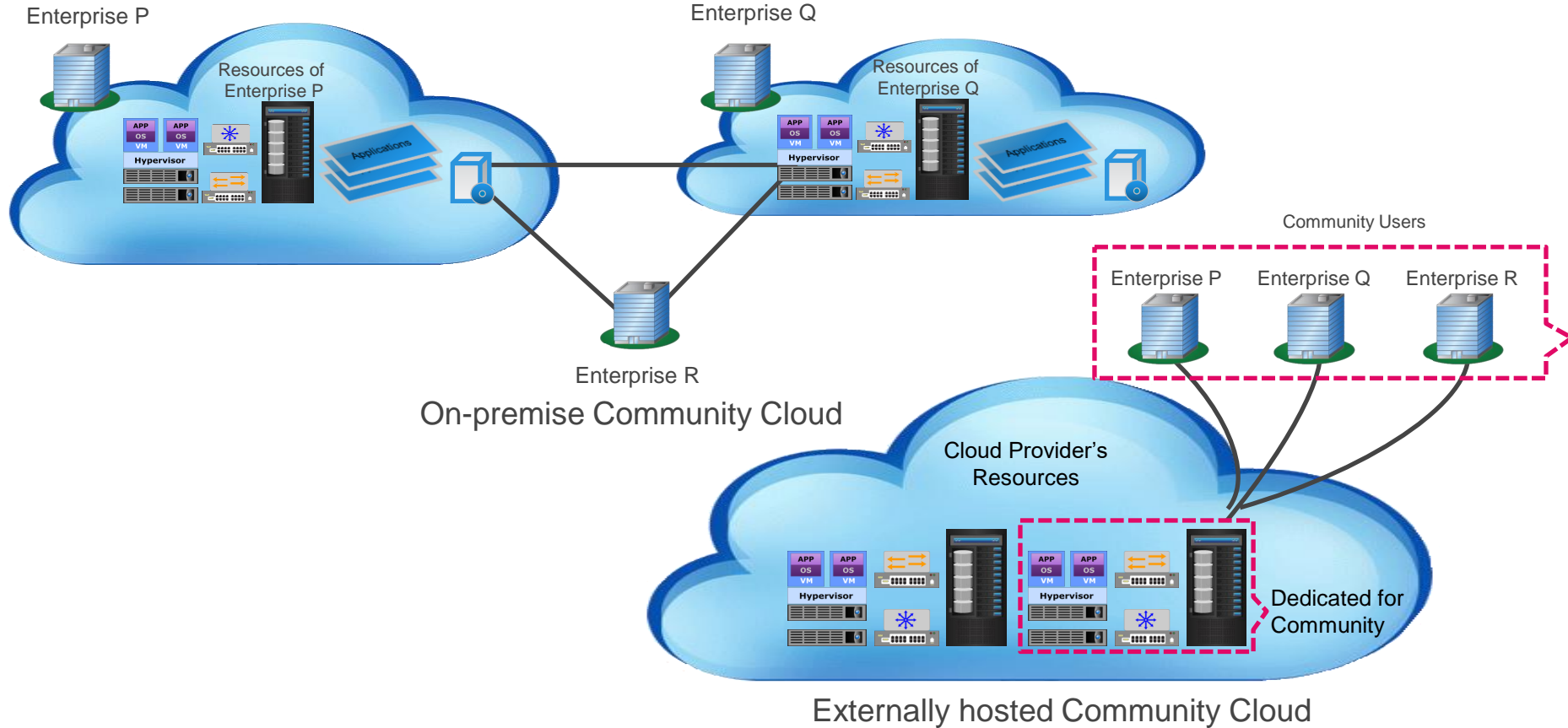
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Community cloud

The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns like security, compliance and so on. One or more of the organizations in the community, a third party, or some combination of them own, manage, and operate it, on or off premises.

– NIST

- Organizations participating in the community cloud typically share the cost of deploying the cloud and offering cloud services.

- Two variants of a community cloud
  - On-premise
  - Externally hosted

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Community cloud Contd.

Enterprise P

Resources of Enterprise P

Enterprise Q

Resources of Enterprise Q

Enterprise R

On-premise Community Cloud

Community Users

Enterprise P   Enterprise Q   Enterprise R

Cloud Provider's Resources

Dedicated for Community
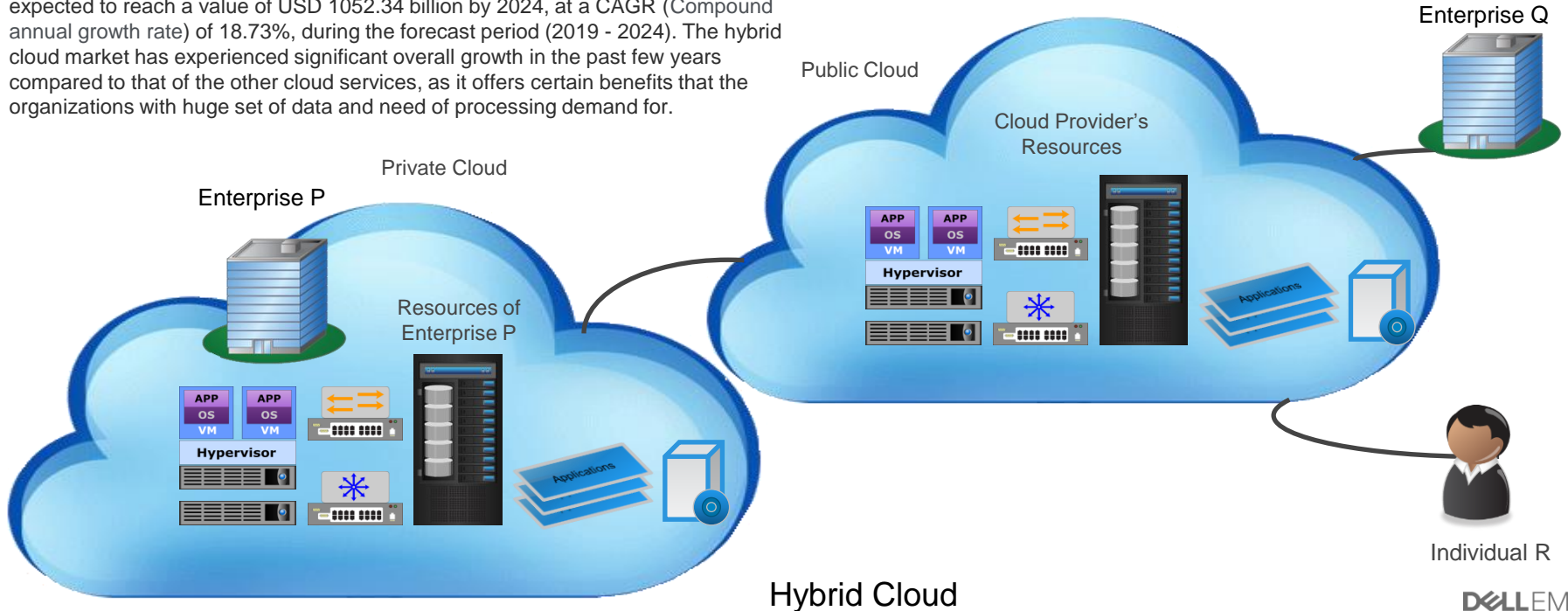
Externally hosted Community Cloud

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Hybrid cloud

The cloud infrastructure is a composition of two or more distinct cloud infrastructures such as private, community, or public that remain unique entities, but are bound by standardized or proprietary technology that enables data and application.

– NIST

The global hybrid cloud market was valued at USD 38.49 billion in 2018, and is expected to reach a value of USD 1052.34 billion by 2024, at a CAGR (Compound annual growth rate) of 18.73%, during the forecast period (2019 - 2024). The hybrid cloud market has experienced significant overall growth in the past few years compared to that of the other cloud services, as it offers certain benefits that the organizations with huge set of data and need of processing demand for.
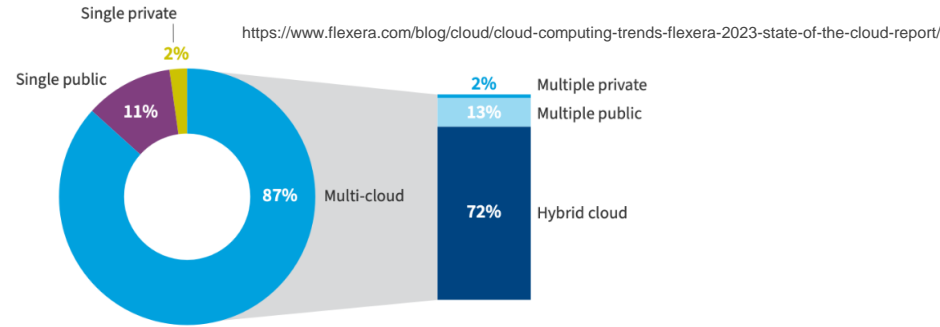
Enterprise Q

Public Cloud

Cloud Provider's Resources

Private Cloud

Enterprise P

APP
OS
VM

APP
OS
VM

Hypervisor

Resources of Enterprise P

Applications

APP
OS
VM

APP
OS
VM

Hypervisor

Applications

Individual R

Hybrid Cloud

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Hybrid cloud model use cases

Use case	Description
Cloud bursting	Provisioning resources for a limited time from a public cloud to handle peak workloads
Web application hosting	Hosting less critical applications such as e-commerce applications on the public cloud
Migrating packaged applications	Migrating standard packaged applications such as email to the public cloud
Application development and testing	Developing and testing applications in the public cloud before launching them

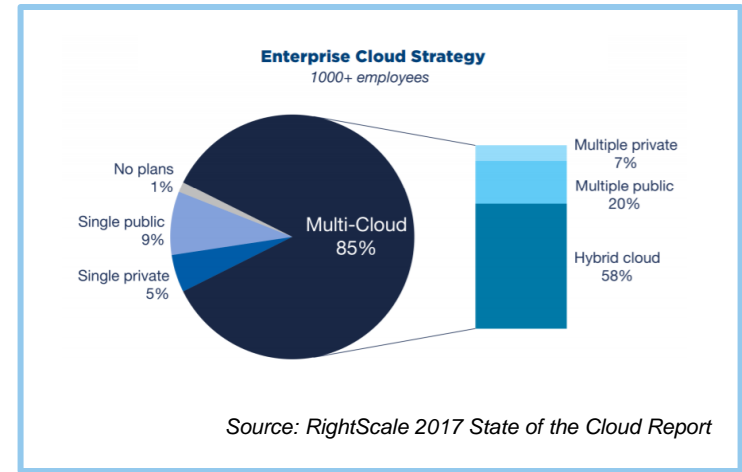**DELL**EMC

Multi-Cloud

Multi-Cloud Strategy

- Organization have started adopting a multi-cloud approach to meet the business demands
  - Since no single cloud model can suit the varied requirements and workloads across the organizations

- Organizations are able to choose services from different providers to create the best possible solution for their business

- Multi-cloud adoption may reduce the risk of vendor lock-in

- Multi-cloud adoption helps organizations to meet compliance and regulatory requirements
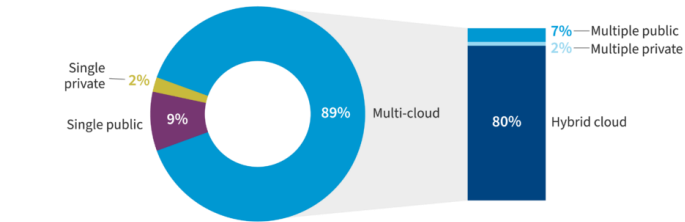

Source: RightScale 2017 State of the Cloud Report

https://www.flexera.com/blog/cloud/cloud-computing-trends-flexera-2023-state-of-the-cloud-report/

N=750
Source: Flexera 2023 State of the Cloud Report

http://sib.com.ua/sib-03-118-2021/runok-oblakov.html

https://sib.com.ua/sib-6-129-2023/hmaru-ta-cod.html

N=753
Source: Flexera 2022 State of the Cloud Report

https://www.flexera.com/blog/cloud/cloud-computing-trends-2022-state-of-the-cloud-report/

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Customer success story of hybrid cloud

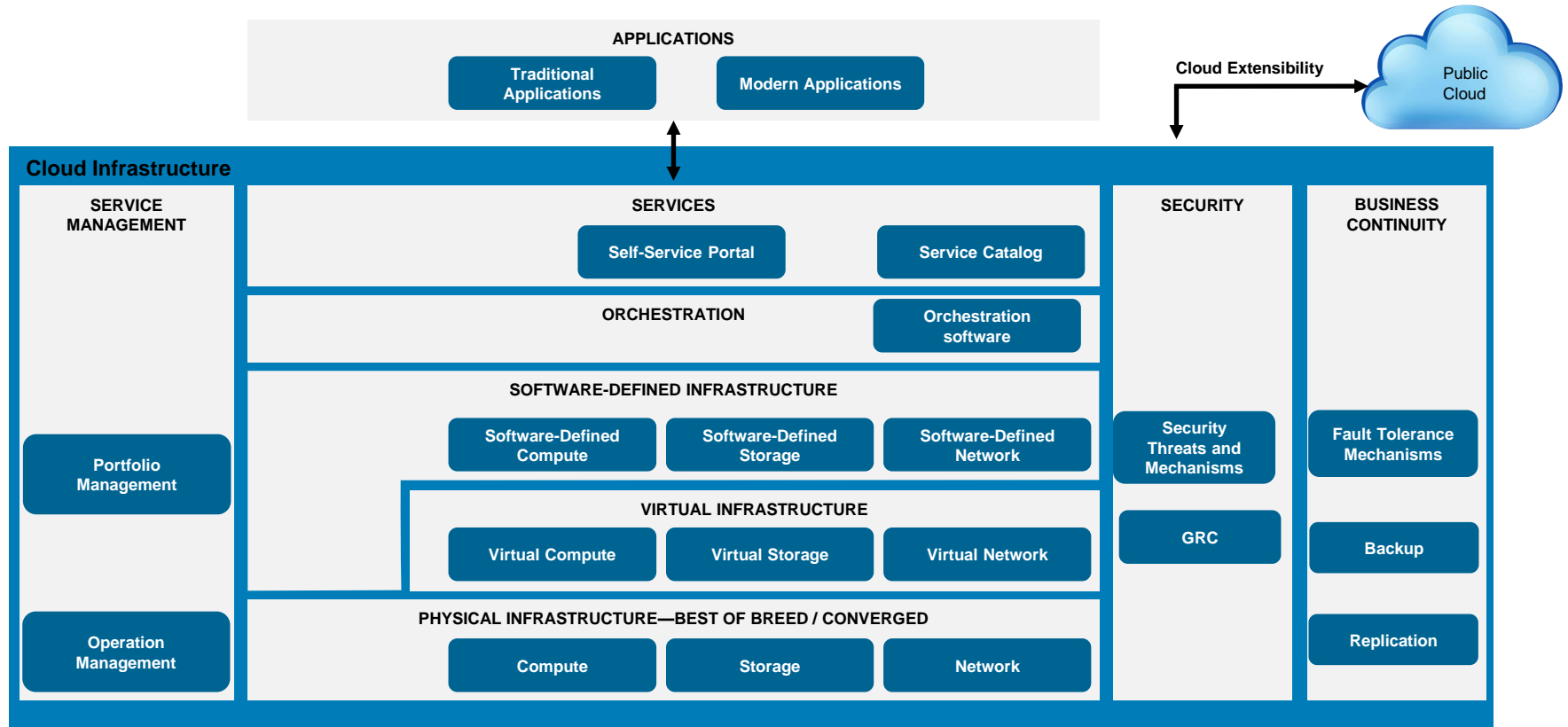**To access the video, please click the below link**

https://edutube.emc.com/Player.aspx?vno=bj7KAc6b1mLYYRXWCvkkag==&autoplay=true&t=0h0m0s

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Cloud computing reference architecture

This lesson covers the following topics:

- Explain the cloud reference architecture

- Explain the building blocks of the cloud computing infrastructure

Cloud reference architecture

APPLICATIONS

| Traditional Applications | Modern Applications |

Cloud Extensibility → Public Cloud

Cloud Infrastructure

SERVICE MANAGEMENT
- Portfolio Management
- Operation Management

SERVICES
- Self-Service Portal
- Service Catalog

ORCHESTRATION
- Orchestration software

SOFTWARE-DEFINED INFRASTRUCTURE
- Software-Defined Compute
- Software-Defined Storage
- Software-Defined Network

VIRTUAL INFRASTRUCTURE
- Virtual Compute
- Virtual Storage
- Virtual Network

PHYSICAL INFRASTRUCTURE—BEST OF BREED / CONVERGED
- Compute
- Storage
- Network

SECURITY
- Security Threats and Mechanisms
- GRC

BUSINESS CONTINUITY
- Fault Tolerance Mechanisms
- Backup
- Replication

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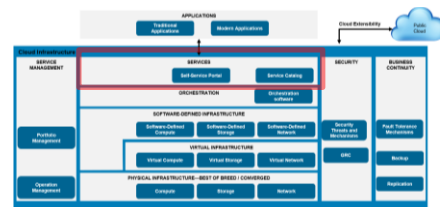# Cloud reference architecture

Application

- Application is designed to perform a group of coordinated tasks or functions for the benefit of the user.

- Applications can be broadly classified as
    - Traditional Applications
    - Modern Applications

- For organization to be successful in digital transformation, it is important for them to transform their application itself

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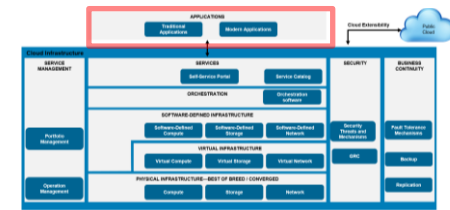
Cloud reference architecture

Cloud service

- Delivers IT resources as services to the consumers
  - Enables users to achieve desired business results
  - Users have no liabilities associated with owning the resources

- Service components include:
  - Service catalog
    - Presents the information about all the IT resources being offered as services
  - Self-service portal
   - Displays the service catalog to the consumers

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Cloud reference architecture

Orchestration

- Provides workflows for executing automated tasks to accomplish a desired outcome
  - Workflow refers to a series of interrelated tasks that perform a business operation

- Associated with each service listed in the service catalog, there is an orchestration workflow defined.

- Interacts with various entities to invoke provisioning tasks

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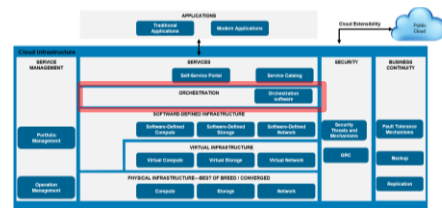
Cloud reference architecture

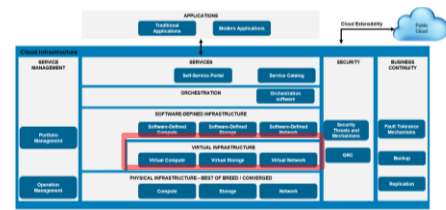
Software-defined infrastructure

- Deployed either on virtual or on physical components

- All infrastructure components are virtualized and aggregated into pools
  - Underlying resources are abstracted from applications

- Centralized, automated, and policy-driven management and delivery of heterogeneous resources

- Key architectural components in the software-defined approach:
  - Software-defined compute
  - Software-defined storage
  - Software-defined network

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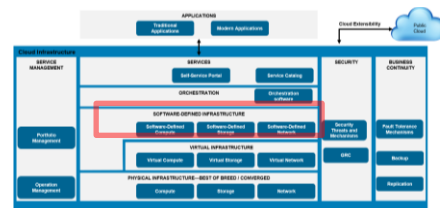
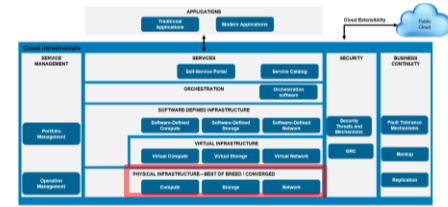# Cloud reference architecture

Virtual infrastructure

- Virtualization abstracts physical resources and creates virtual resources

- Virtual components:
  - Virtual compute, virtual storage, and virtual network
    - Created from physical resource pools using virtualization software

- Benefits of virtualization:
  - Resource consolidation and multitenant environment
  - Improved resource utilization and increased ROI
  - Flexible resource provisioning and rapid elasticity

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Cloud reference architecture

## Physical infrastructure

- Foundation layer of the data center infrastructure

- Physical components:
  - Compute systems, storage, and network devices
  - Require operating systems, system software, and protocols for their functions

- Executes the requests originating form the virtual and software-defined layers

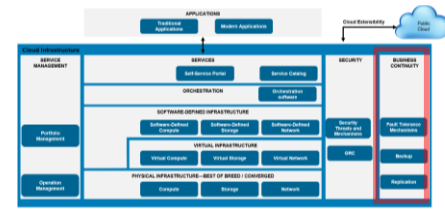**D∕∕LL**EMC

Cloud reference architecture

Security

- Cloud is transforming in the business and at the same time it has created security challenges and requirements

- Cloud security protects the applications, data, and the infrastructure associated with cloud

- Unique features of the cloud leads to various security threats and one of the issues that arises among the customers is trust
  - Trust depends on the degree of control and visibility available to the customers for their data stored in the cloud

- Power of cloud security can be harnessed with Governance, Risk, and Compliance- GRC framework

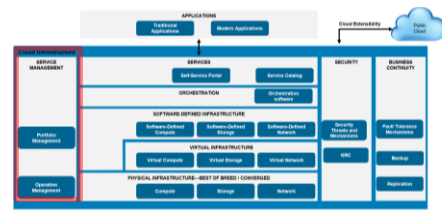**DELL**EMC
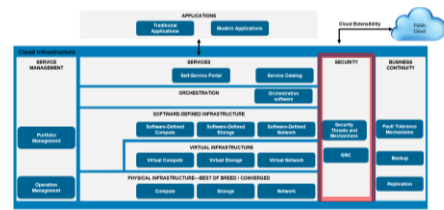
Cloud reference architecture

Business continuity

- Business continuity is a set of processes that includes all activities that a business must perform to mitigate the impact of service outage
  - Continuous availability of services is required for the smooth functioning of business operations for any organization

- BC includes adoption of measures to mitigate the impact of downtime

- BC function supports all the components of cloud reference architecture to provide uninterrupted services to the consumers

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Cloud reference architecture

Service management

Activities	Description
Service portfolio management	• Defines service roadmap, service features, and service levels • Establishes budgeting and pricing • Deals with consumers in supporting activities • Performs market research • Collects information about competitors
Service operation management	• Enables infrastructure configuration and resource provisioning • Enables problem resolution • Enables capacity and availability management • Enables compliance conformance • Enables monitoring cloud services and their constituent elements

What is the difference between a traditional data center, and an on-premise private cloud?

Concepts in practice

- Microsoft Azure Stack (January 2016) https://azure.microsoft.com/en-us/products/azure-stack/#overview

- AWS Outposts (December 2019) https://aws.amazon.com/outposts/

- Google Anthos (April 2019) https://cloud.google.com/anthos/docs/concepts/overview

- OpenStack is a set of software components that provide common services for cloud infrastructurehttps://www.openstack.org/

- 15 Hybrid Cloud Computing Examples https://builtin.com/cloud-computing/hybrid-cloud-data-management

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Concepts in practice (Cont'd)

Dell EMC Cloud for Microsoft Azure Stack
• Hybrid cloud platform for delivering Infrastructure and Platform as a service with a consistent Microsoft Azure experience on-premises and in the public cloud
• Dell EMC Cloud for Microsoft Azure Stack provides a fast and simple path to digital and IT transformation
• It is engineered with best in class hyperconverged infrastructure, networking, backup and encryption from Dell EMC, along with application development tools from Microsoft

Pivotal Cloud Foundry
• Open-source PaaS project
• Supports multiple cloud deployment models, programming languages, and database systems
• Includes a self-service application execution engine, an automation engine for application deployment and lifecycle management

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Cloud Computing Trends: Flexera 2023 State of the Cloud Report

>> FINOPS AND CLOUD OPTIMIZATION

Cloud computing trends and statistics: Flexera 2023 State of the Cloud Report

Tanner Luxner
April 5, 2023

https://www.flexera.com/blog/cloud/cloud-computing-trends-flexera-2023-state-of-the-cloud-report/

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Summary

Key points covered in this module:

- Cloud deployment and service models

- Hybrid cloud and its adoption

- Key benefits of the cloud computing

- Cloud reference architecture

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