CLOUD COMPUTING PYRAMID

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Outlined

- Roots of Cloud Computing
- Essential Characteristics of Cloud Computing
- Role of Virtualization
- Cloud Players and Their Concern
- Considerations for Cloud Data Centers

Roots of Cloud Computing

- "Cloud Computing" term became popular about two decades ago. However, its roots extend at least half a century back when users sat in front of blinking terminals far away from mainframe computers connected via cables.
  - Telecommunication engineers about a century ago used Cloud concepts.
- The following list briefly explains the evolution of Cloud Computing:
  - Grid computing: Solving large problems using parallelized solutions, e.g., in a server farm
  - Utility computing: Computing resources offered as a metered service
  - SaaS: Network-based subscriptions to applications
  - Cloud Computing: "Anytime, anywhere" access to IT resources delivered dynamically as a service

Roots of Cloud Computing

◦ The NIST (National Institute of Standards and Technology) in the USA has defined Cloud Computing as "Cloud Computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

◦ This Cloud model is composed of five essential characteristics, three service models, and five deployment models.
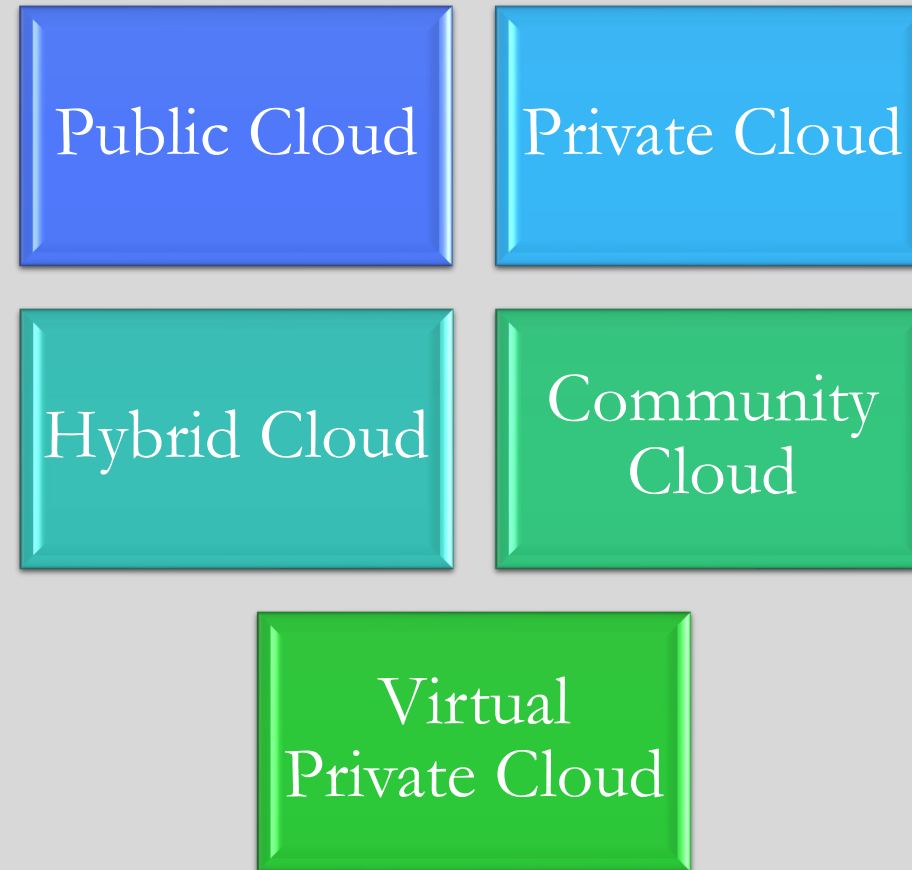
Roots of Cloud Computing

◦ The three service models of NIST:
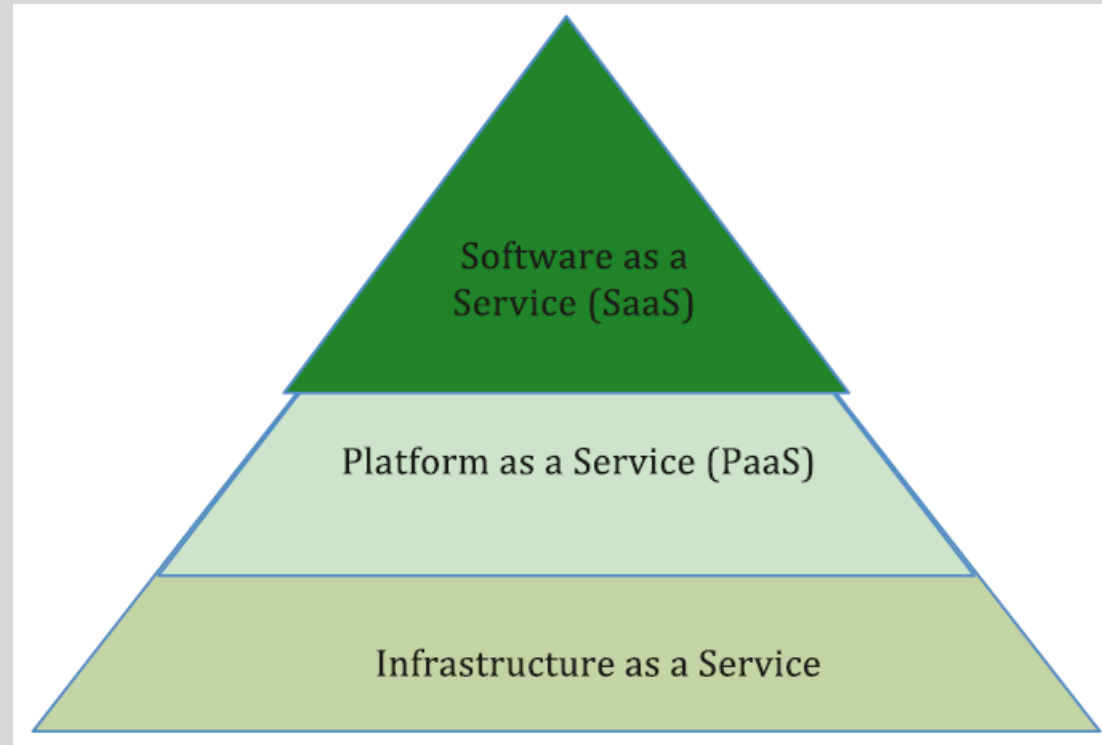
Roots of Cloud Computing

◦ Five deployment model of NIST:

Public Cloud	Private Cloud
Hybrid Cloud	Community Cloud

Virtual Private Cloud

Essential Characteristics of Cloud Computing

◦ According to NIST, five characteristics of Cloud are

Essential Characteristics of Cloud Computing

1. *Rapid Elasticity*: Elasticity is defined as the ability to scale resources both up and down as needed. To the consumers, the Cloud appears to be infinite, and they can purchase as much or as little computing power as they need. This is one of the essential characteristics of Cloud Computing in the NIST definition.

2. *Measured Service*: In a measured service, aspects of the Cloud service are controlled and monitored by the Cloud provider. This is crucial for billing, access control, resource optimization, capacity planning, and other tasks.

Essential Characteristics of Cloud Computing

3. *On-Demand Self-Service*: The on-demand and self-service aspects of Cloud Computing mean that a consumer can use Cloud services as needed without any human interaction with the Cloud provider.

4. *Ubiquitous Network Access*: Ubiquitous network access means that the Cloud provider's capabilities are available over the network and can be accessed through standard mechanisms by both thick and thin clients.

# Essential Characteristics of Cloud Computing

5. *Resource Pooling:* Resource pooling allows a Cloud provider to serve its consumers via a multi-tenant model. Physical and virtual resources are assigned and reassigned according to consumers' demand. There is a sense of location independence in that the customers generally have no control or knowledge over the exact location of the provided resources but may be able to specify a geographical location (e.g., country, state, or data center).

Role of Virtualization

◦ Virtualization is the technology enabler of sharing data center's resource among many different users.

◦ Virtualization refers to the act of creating a virtual image of the computer hardware, including CPU, memory, storage, and network elements.

  ◦ It is done to isolate the software stack from the underlying hardware.

◦ Virtualization makes each user feel that he or she has full access and control of the machine.
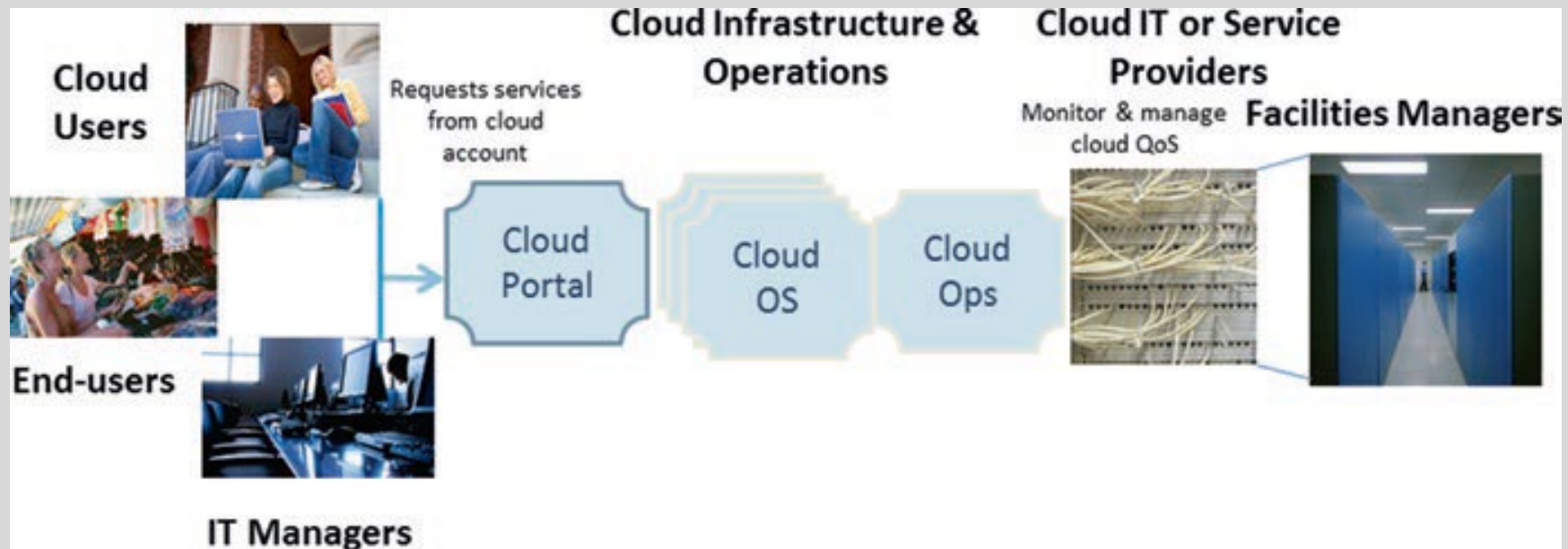
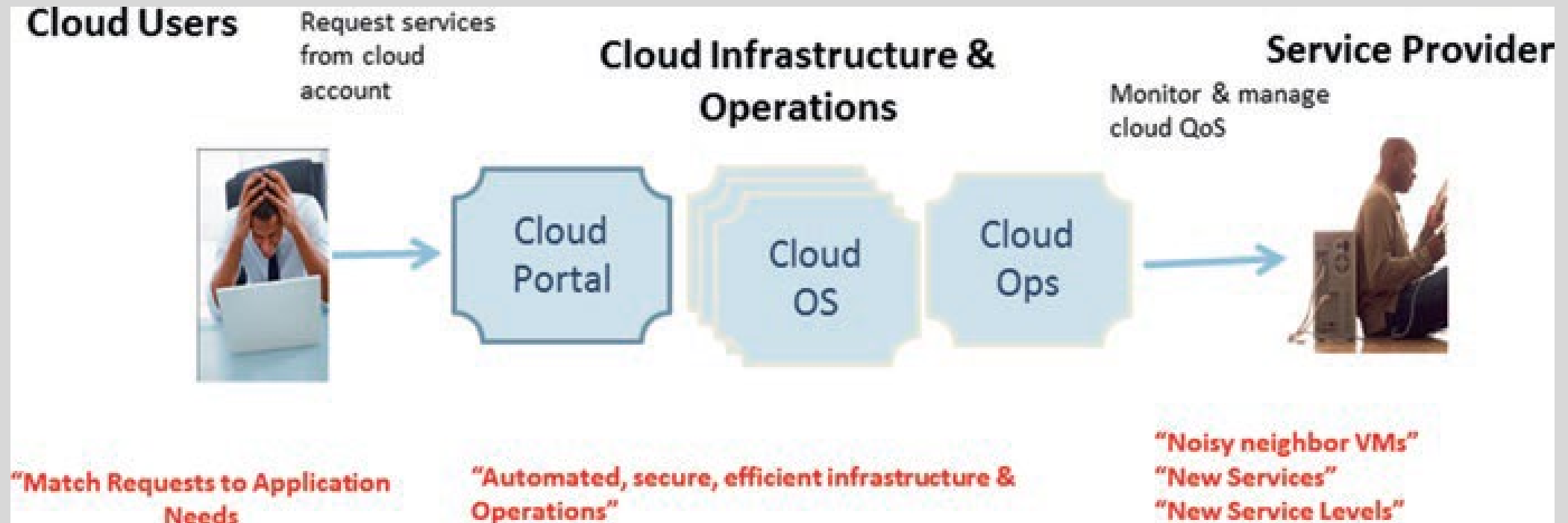# Role of Virtualization

◦ An OS vs a Virtualization Stack
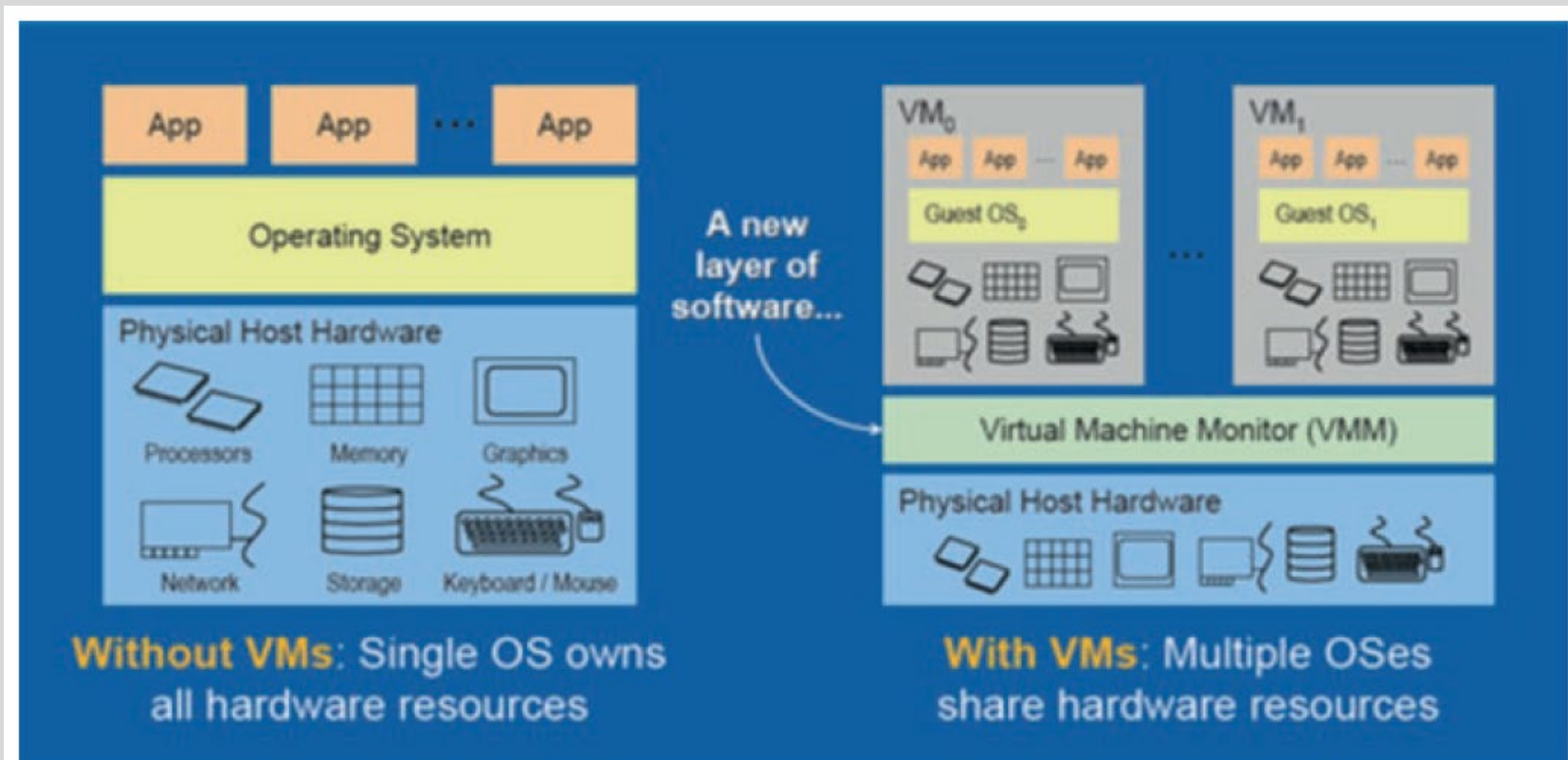
Cloud Players and Their Concern

○ In a typical Public Cloud, the following actors are involved

Cloud Players and Their Concern

◦ Pain points in the Cloud

Cloud Users Request services from cloud account

Cloud Infrastructure & Operations

Service Provider Monitor & manage cloud QoS

Cloud Portal → Cloud OS → Cloud Ops

"Match Requests to Application Needs

"Automated, secure, efficient infrastructure & Operations"

"Noisy neighbor VMs"
"New Services"
"New Service Levels"

Considerations for Cloud Data Centers

◦ A major consideration in selecting a Cloud service provider is the service-level agreements (SLA).

◦ SLAs define measurable considerations, such as listed below:

1. Response time
2. Output bandwidth
3. Number of active servers to monitor for SLA violations
4. Changes in the environment and
5. Responding appropriately to guarantee quality of service

Considerations for Cloud Data Centers

- Migration
  - Another challenge is migrating traditional workloads that require computer clusters such as HPC (high-performance computing) workloads from captive data centers to a Cloud.

- Performance

- Security

Considerations for Cloud Data Centers

○ NIST Cyber Security Framework
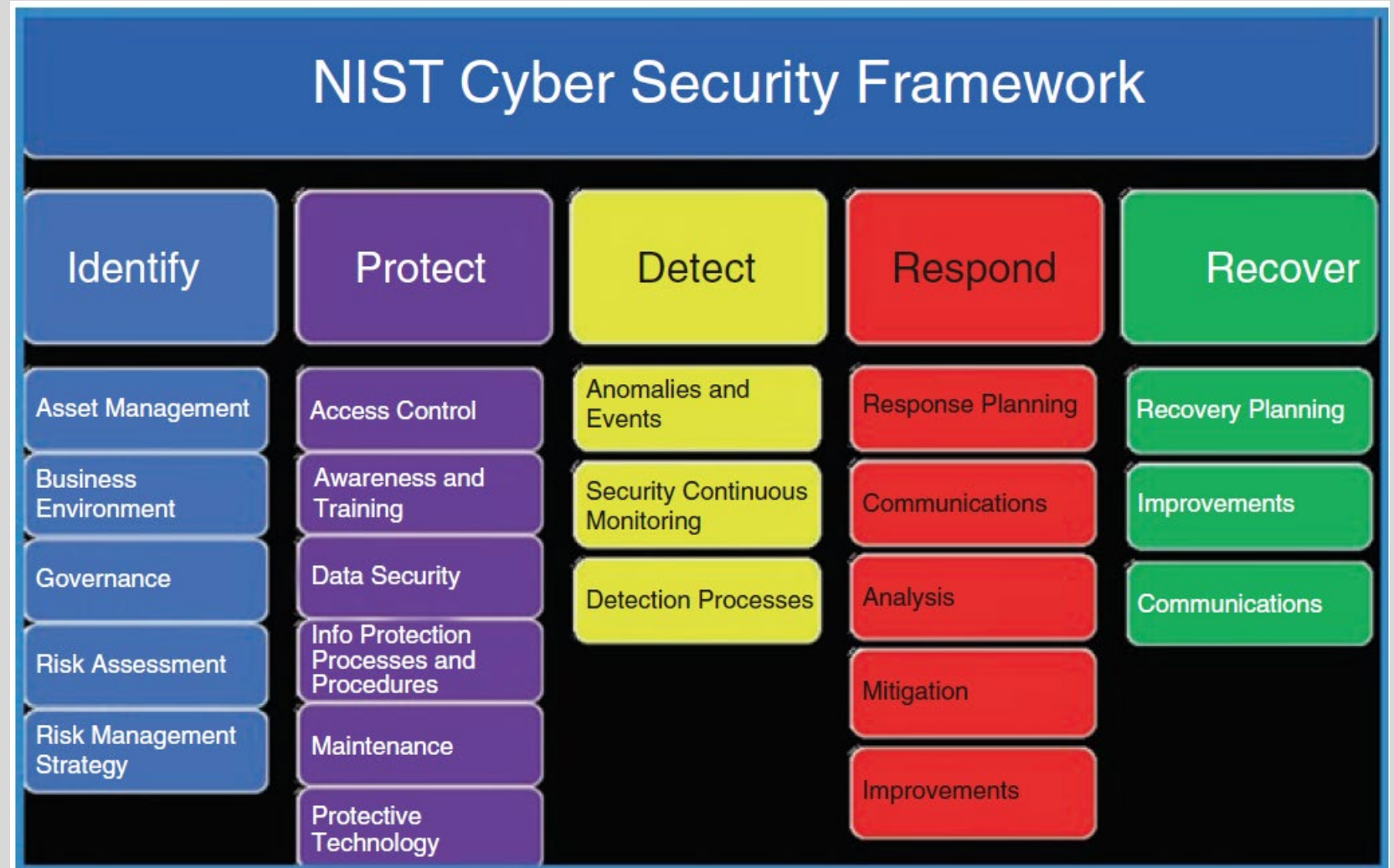
Considerations for Cloud Computing Data Centers

◦ Five functions of NIST cyber security framework include:

1. *Identify*: Develop an organizational understanding to manage cyber security risk to systems, people, assets, data, and capabilities.
2. *Protect*: Develop and implement appropriate safeguards to ensure delivery of critical services.
3. *Detect*: Develop and implement appropriate activities to identify the occurrence of a cyber security event.
4. *Respond*: Develop and implement appropriate activities to take action regarding a detected cyber security incident.
5. *Recover*: Develop and implement appropriate activities to maintain plans for resilience and to restore any capabilities or services that were impaired due to a cyber security incident.

Questions?