Cloud Computing & its Applications

Course Code: SWE4004

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Cloud Enabling Technology

Outline

- Data center technology
- Virtualization technology
- Web technology
- Multitenant technology
- Service technology.

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Data center technology

- A data center is a specialized IT infrastructure that houses centralized IT resources, such as servers, databases, and software systems.

- A data center is a physical facility that organizations use to house their critical applications and data. A data center's design is based on a network of computing and storage resources that enable the delivery of shared applications and data. The key components of a data center design include routers, switches, firewalls, storage systems, servers, and application-delivery controllers.

Data Center

Concerned Issues

- Virtualization
- Standardization and Modularity
- Automation
- Remote Operation and Management
- High Availability
- Security-Aware, operation and Management
- Facilities
- Computing Hardware
- Storage Hardware
- Network Hardware
- Other Considerations

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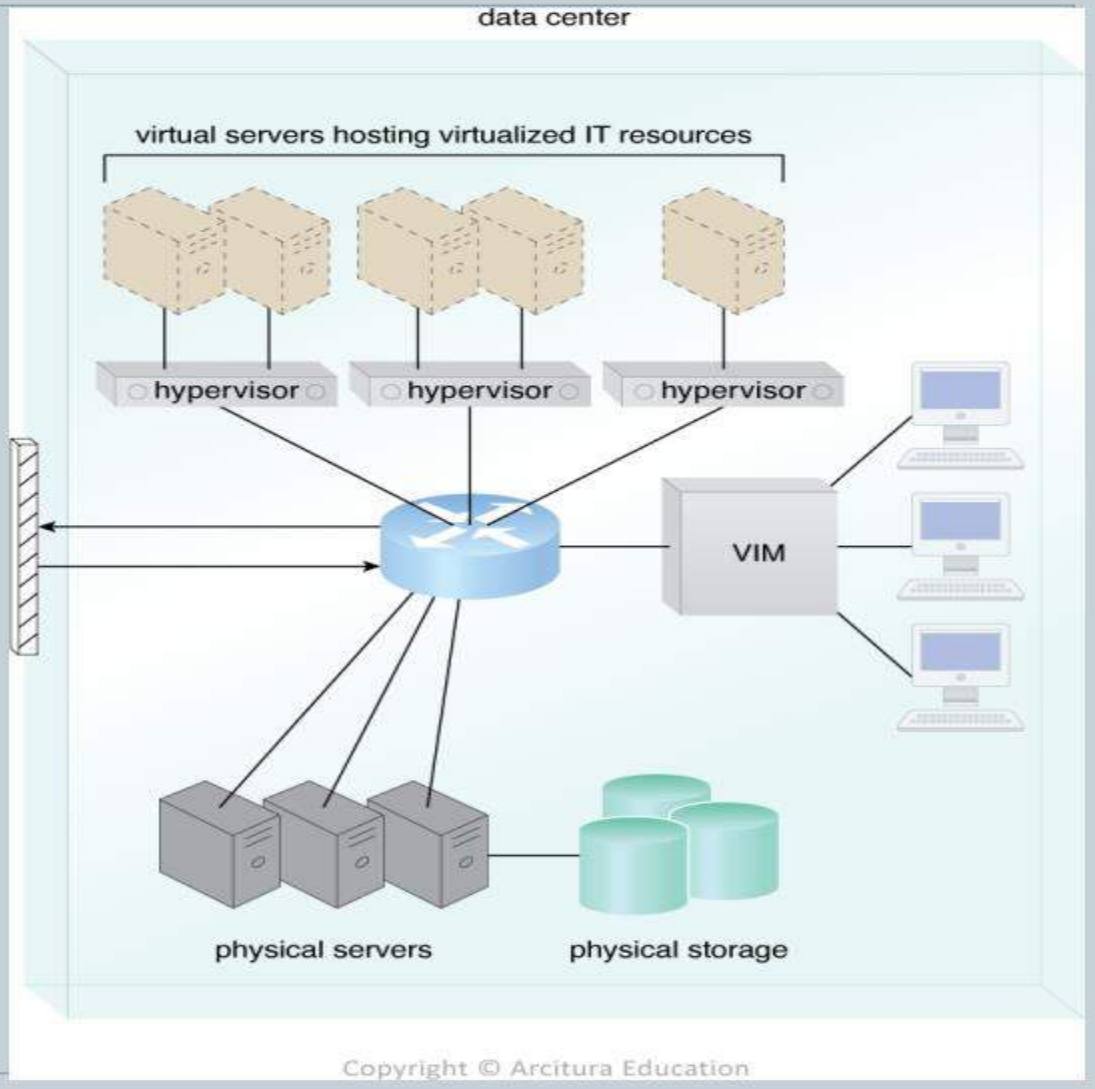
Virtualization

- Data center consist of both physical and virtualized IT resources.
- All the physical components are grouped into single network
- The resource abstraction and control on virtualization layer

Virtualization in Data center

The common components of a data center working together to provide virtualized IT resources supported by physical IT resources



Standardization and Modularity

- Commodity Hardware with modular architecture, aggregating multiple identical building blocks of infrastructure
- Key requirements for reducing investment and operational cost

Automation

- Specialized platforms and tools are needed
- Resource Provisioning, configuration, patching and monitoring
- Self-configuration and self-recovery

Remote Operation and Management

- Used for most of operational and administrative tasks of IT resources
- Equipment handling and cabling or hardware-level installation and maintenance not controlled from remotely.

High Availability

- Data center Outage significantly impacts IT Services availability
- Higher levels of redundancy to sustain availability

Security-Aware, operation and Management

- Ubiquitous access, on-demand provisioning rapid elasticity and pay-per-use.
- Physical and logical access controls and data recovery strategies.

Facilities

- Computing, Storage and network equipment
- power, cabling, cooling, fire protection

Computing Hardware

- Supports Different processing architectures like x86-32,x86-64 and RISC
- Power efficient multi-core CPU
- Redundant and hot-swappable components

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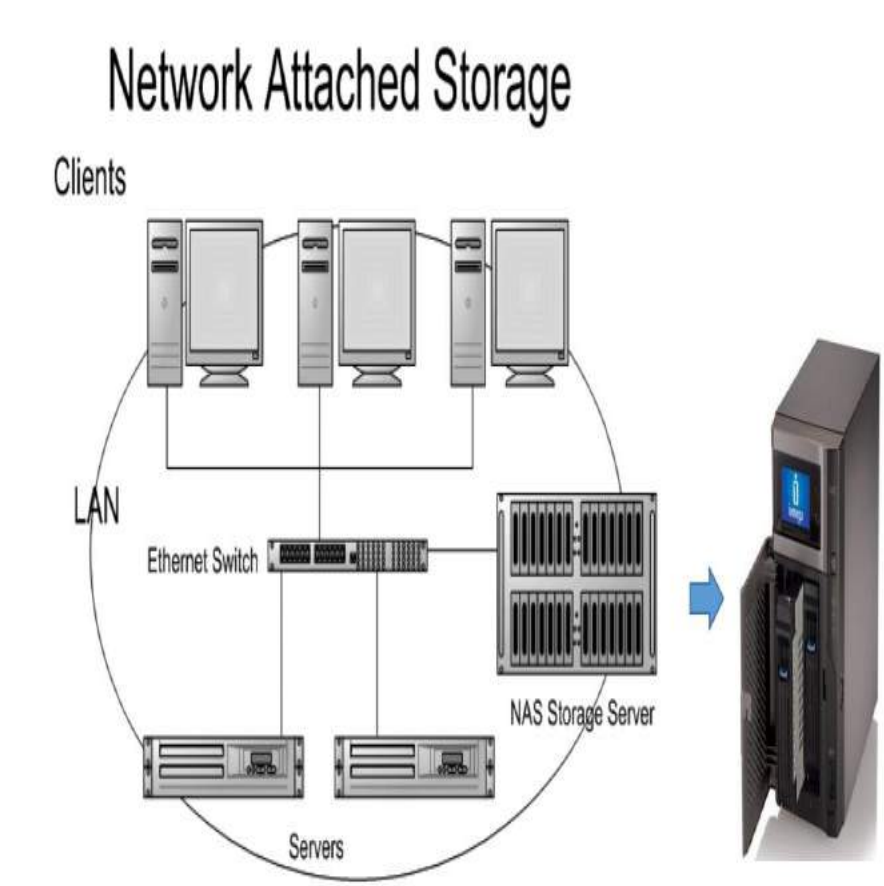
Storage Hardware

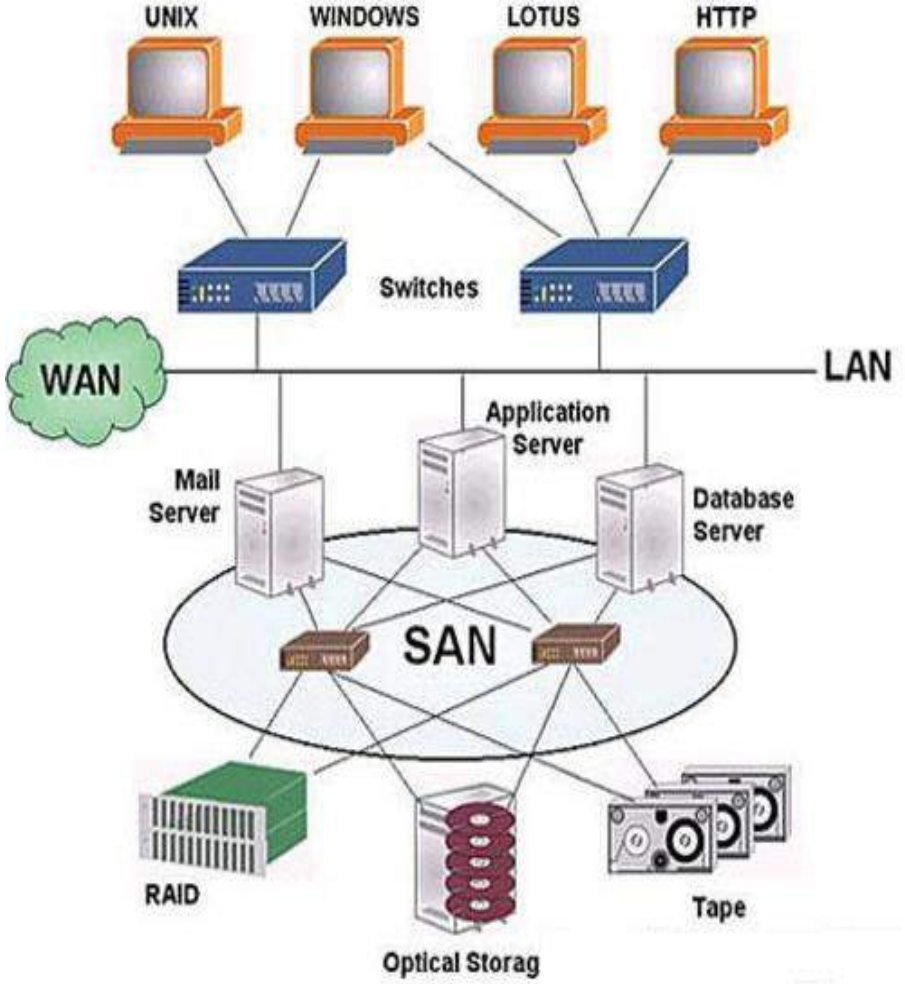
- Hard Disk Array: RAID
- I/O caching
- Storage Virtualization
- Fast Data Replication Mechanisms

Network Storage device

- storage area network(SAN)
- network attached storage(NAS)

Storage Hardware

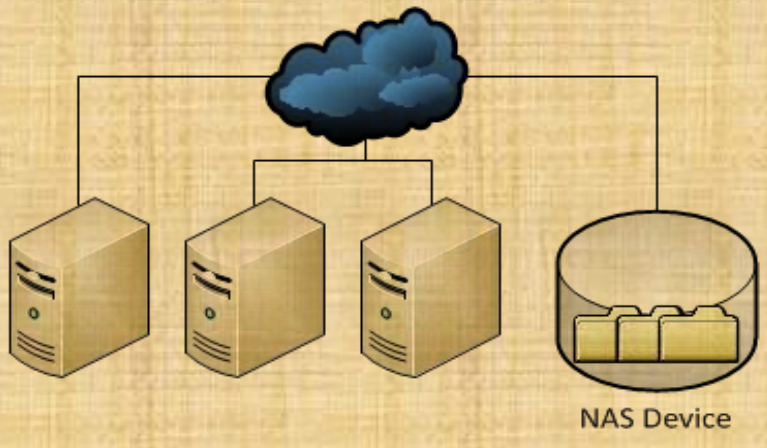




NAS vs SAN

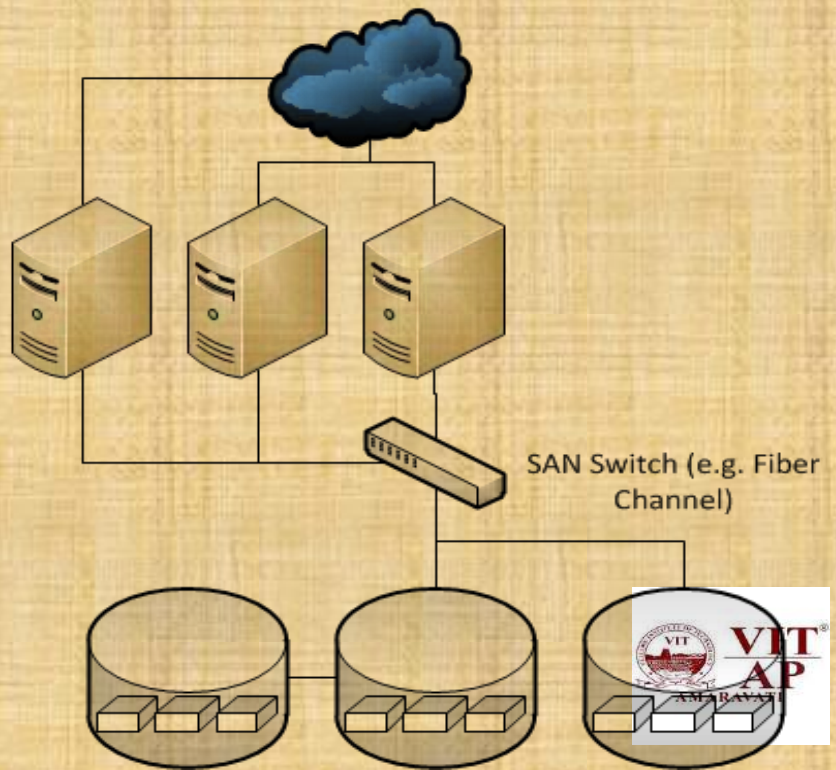
Network Attached Storage

- Shared storage over shared network
- File system
- Easier management



Storage Area Network

- Shared storage over dedicated network
- Raw storage
- Fast, but costly



Network Attached Storage

NAS Benefits

- Relatively inexpensive
- 24/7 and remote data availability
- Salability
- Redundant storage architecture
- Automatic backups to other devices and cloud
- Flexibility

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Storage Area Network

SAN Benefits

- Extremely fast data access
- Dedicated network for storage relieves stress on LAN
- Highly expandable
- OS level (block level) access to files
- High quality-of-service for demanding applications such as video editing

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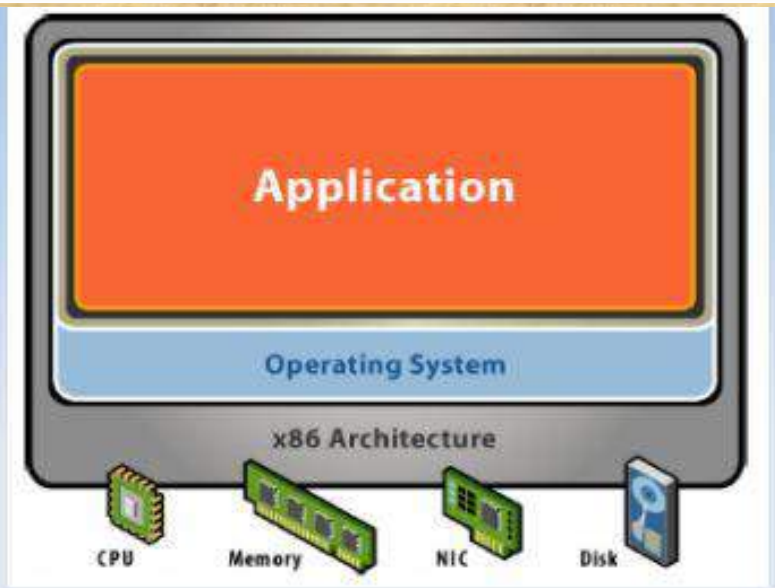
Network Hardware

- Carrier and External Networks Interconnection
- Web-Tier Load Balancing and Acceleration
- LAN Fabric
- SAN fabric
- NAS Gateways

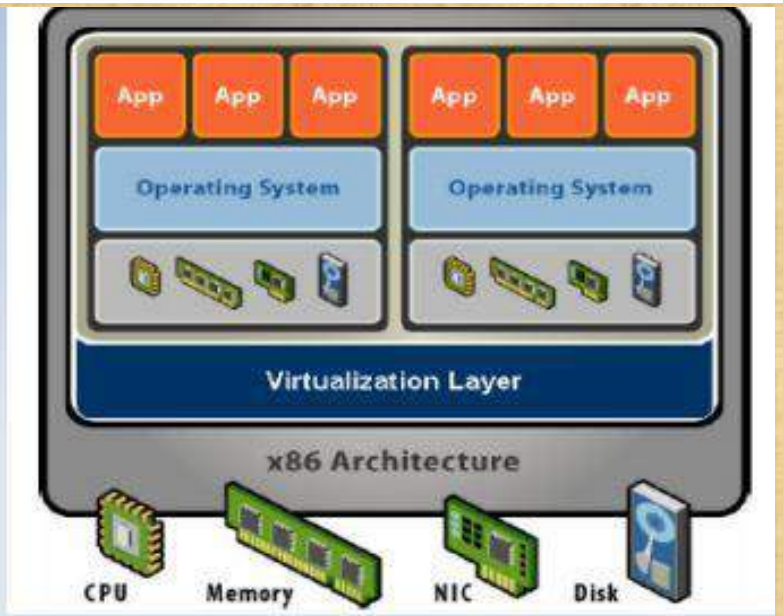
Virtualization Technology

- Virtualization is the process of converting a physical IT resources into virtual IT resources.
- Most types of IT resources can be virtualized:
- Servers : A physical server can be abstracted into a virtual server.
- Storage: A physical storage device can be abstracted into a virtual storage device or a virtual disk.
- Network : Physical routers and switches can be abstracted into logical network fabrics, such as VLANs.
- Power: A physical UPS and power distribution units can be abstracted into what are commonly referred to as virtual UPSs

Physical v/s Virtual Machine



- Single OS
- h/w + s/w tightly coupled
- Application crashes affect all
- Resource under-utilization



- Machine view to OS is independent of hardware
- Multiple OS (isolated apps)
- Safely multiplex resources across VMs

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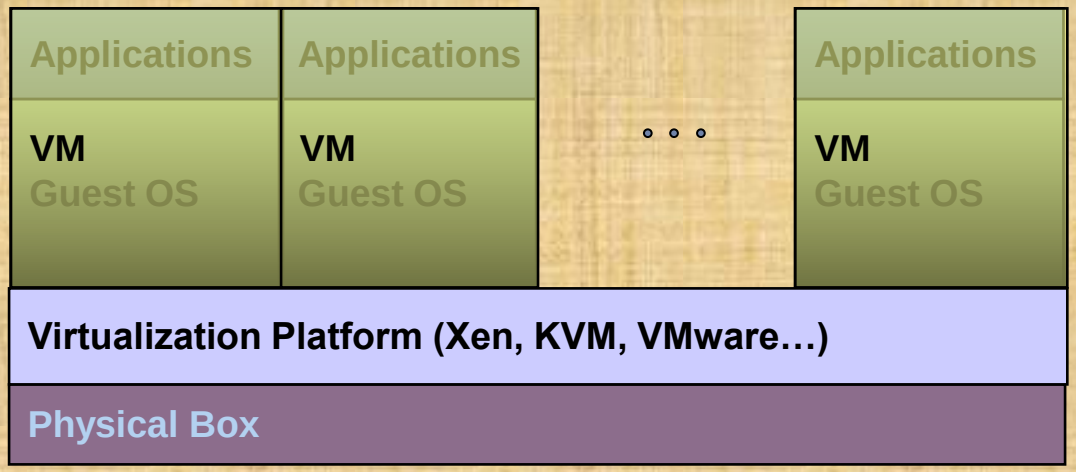
Virtualization Platform

- **A VM is an isolated runtime environment** (guest OS and applications)
- **Multiple virtual systems (VMs)** to run on a single physical system



Benefits of Virtualization Platforms

- Natural way to deal with the **heterogeneity** of the infrastructure
- Allow **partitioning and isolating** of physical resources
- Execution of **legacy applications**

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Benefits of using Virtual Machines

- Instant provisioning - fast scalability
- Live Migration is possible
- Load balancing and consolidation in a Data Center is possible.
- Low downtime for maintenance
- Virtual hardware supports legacy operating systems efficiently
- Security and fault isolation

Virtualization Technology

- Hardware Independence
- Server Consolidation
- Resource Replication
- Operating System-Based Virtualization
- Hardwar-Based Virtualization
- Virtualization Management
- Other Considerations

Hardware Independence

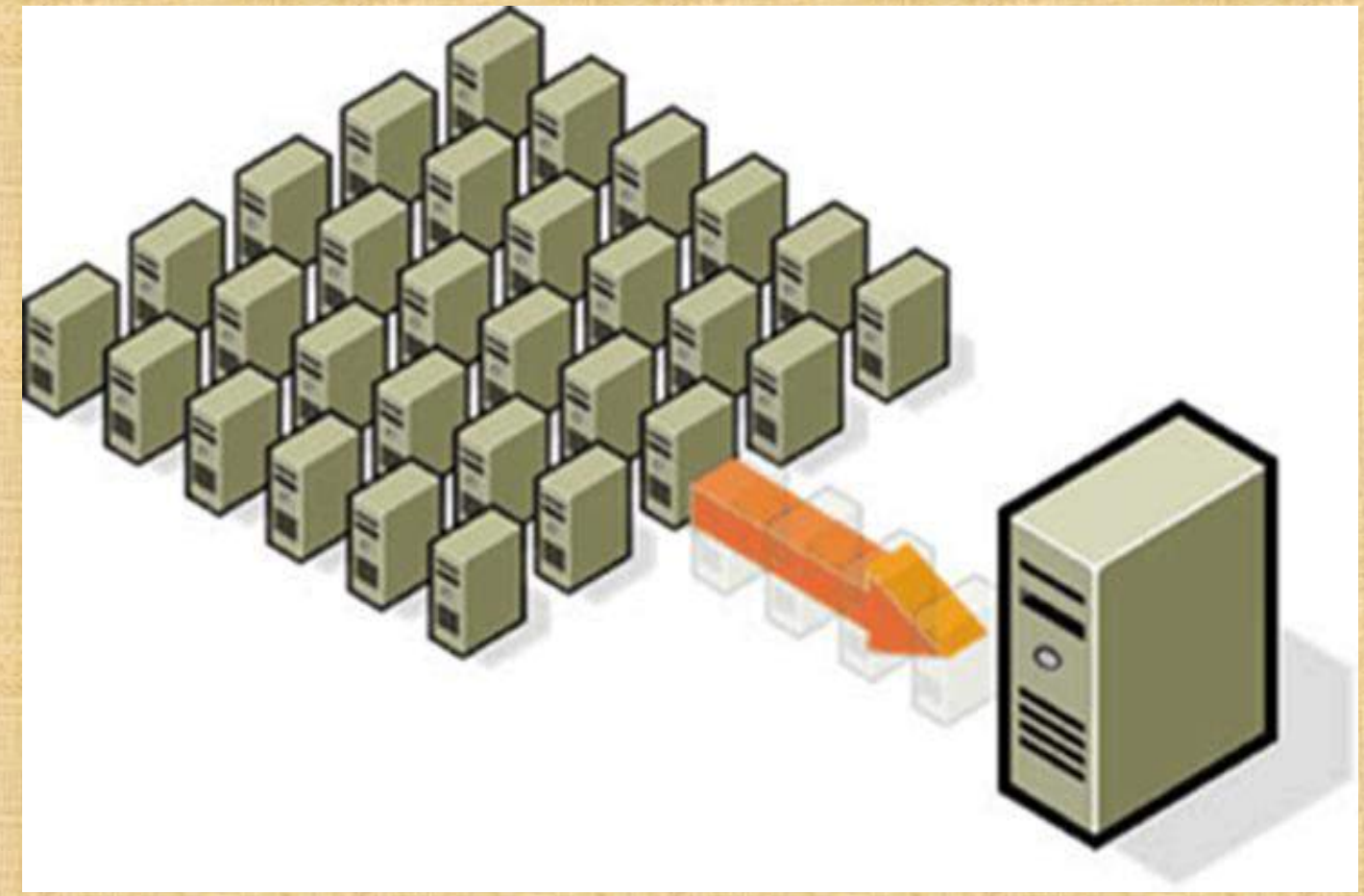
- **Virtualization** is a conversion process that translates unique IT **hardware** into emulated and standardized software-based copies.

- Through **hardware independence**, virtual servers can easily be moved to another **virtualization** host, automatically resolving multiple **hardware**-software incompatibility issues.

Server Consolidation

- Server consolidation is the practice of reducing the number of servers or server locations in order to use compute resources more efficiently and reduce costs.
- This involves moving multiple, heterogeneous workloads to a single server or combining workloads under a single operating system.

Server Consolidation



Resource Replication

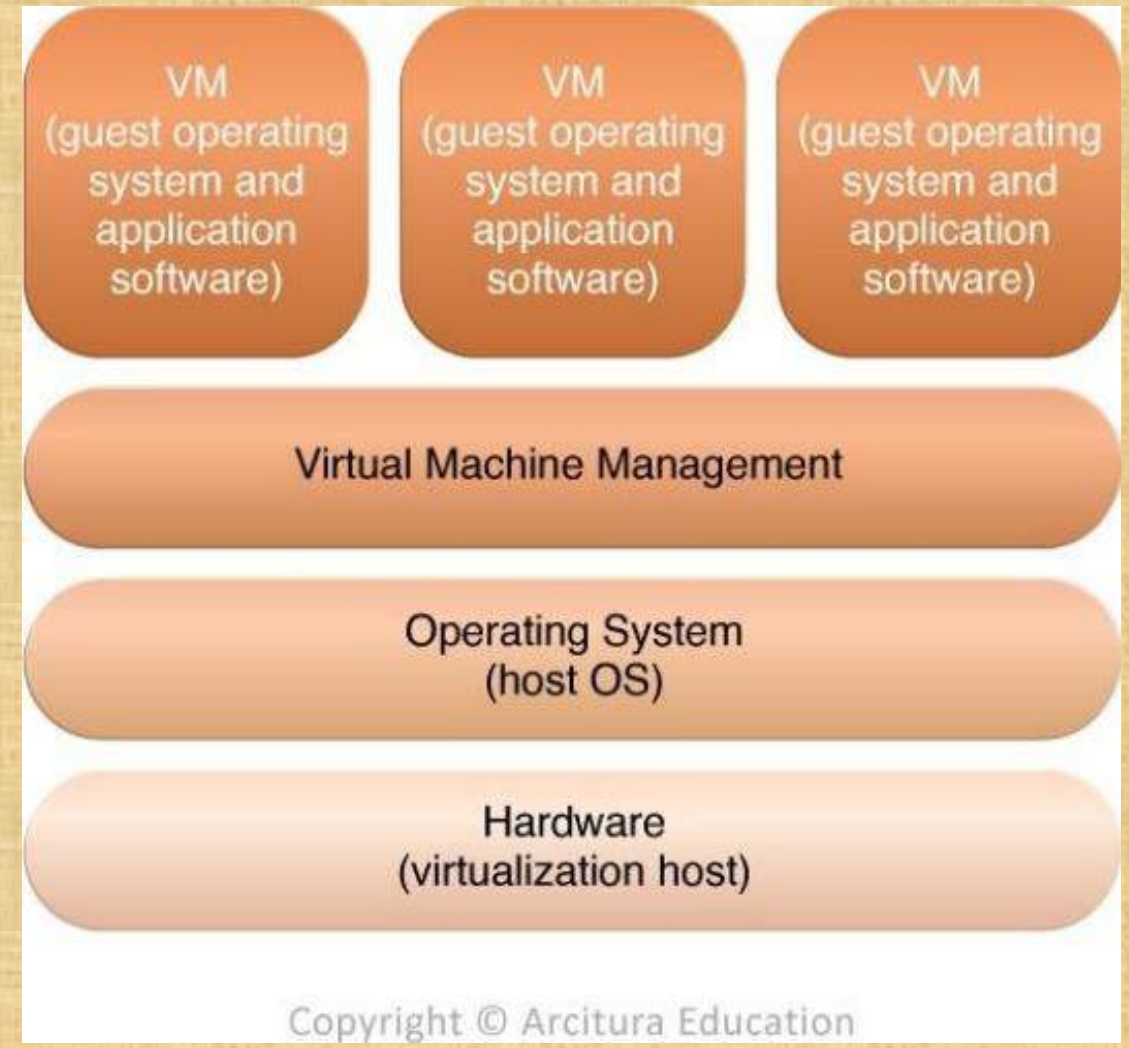
- **Resource replication** is defined as the creation of multiple instances of the same IT **resource**, and is typically performed when an IT resource's availability and performance need to be enhanced.

- Virtual disk images can be accessible using simple file operations, such as copy, move, and paste by the host's OS for replication purpose

Operating System-Based Virtualization

- Installation of virtualization software in pre-existing operating system(Host)
- Host operating system responsible to provide hardware device access
- Create more Virtual Servers
- Hardware independence is enabled

Operating System-Based Virtualization



The different logical layer of operating-system based virtualization, in which the VM is first installed into a full host operating system and subsequently used to generate virtual machines

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Operating System-Based Virtualization

Host operating system provide the following services

- Backup and Recovery
- Integration to Directory Services
- Security Management

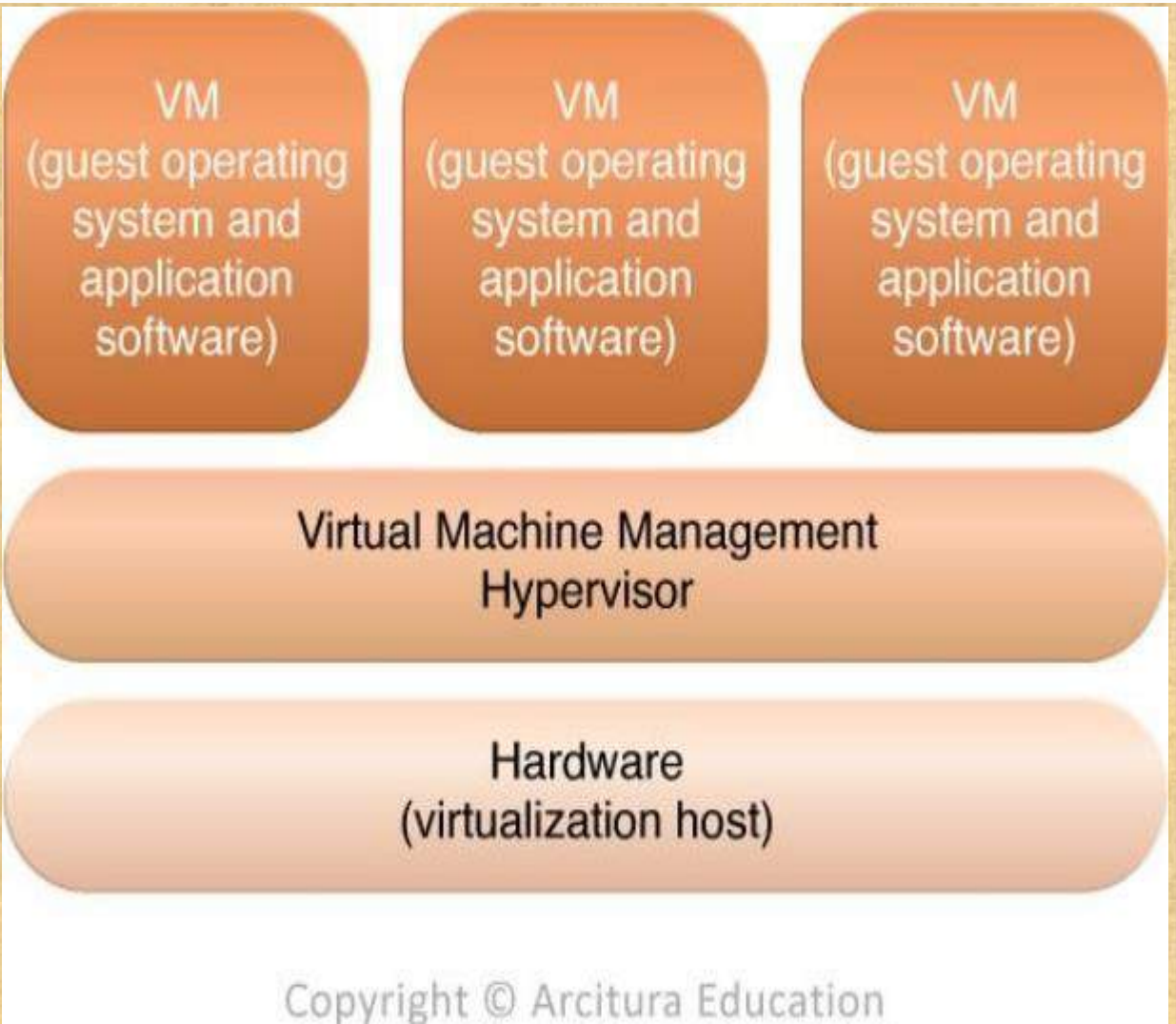
Demands and issues

- Host operating system consumes CPU, Memory and other hardware resources
- Virtual operating system instructions have to process several layers
- Host operating requires individual licence

Hardware-Based Virtualization

- Bypass the host operating system
- With out host operating interaction, it allows virtual servers to interact with hardware
- VMM require a negligible amount of storage
- VMM is a thin layer software
- Device drivers and system services are optimized

Hardware-Based Virtualization



The different logical layers of hardware-based virtualization, which does not require another host operating system.

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Hardware-Based Virtualization

Issues of Hardware-based Virtualization

- Compatibility with hardware devices
- Device drivers may not be available

Virtualization Management

- Many administrative task can be performed more easily
- Modern virtualization software several advanced management functions that can automate administration tasks
- Virtualization infrastructure Management (VIM) tools that collectively manage virtual resources

Other considerations

- Performance overhead
- Special hardware compatibility
- Portability

Best virtualization software

- VMware Workstation Player
- VirtualBox
- Parallels Desktop
- QEMU
- Citrix Hypervisor
- Xen Project
- Microsoft Hyper-V

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Web Technology

- Web technologies create interfaces between web servers and clients, and insure safe usage of internet based applications and permanent access to information.
- Cloud computing refers to internet-based computing systems used to deliver applications between computers through the internet.
- Cloud system users access computing services using web browsers, which represents a computing model that shifts the computing workload to a remote location.

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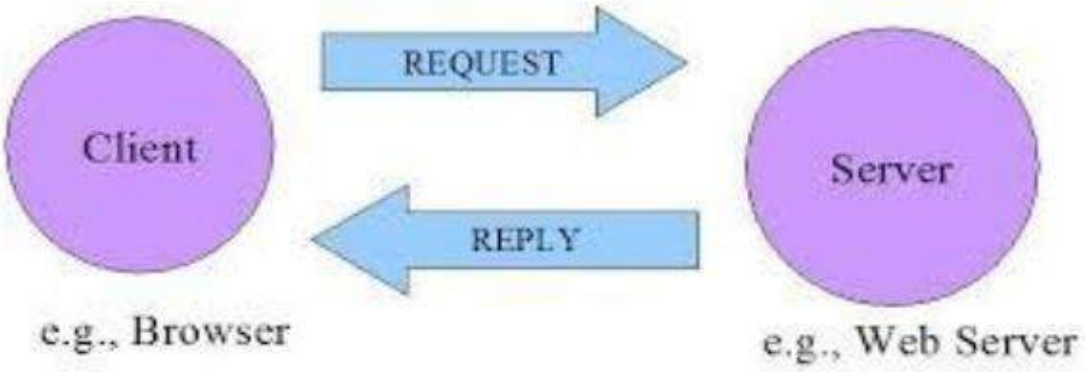
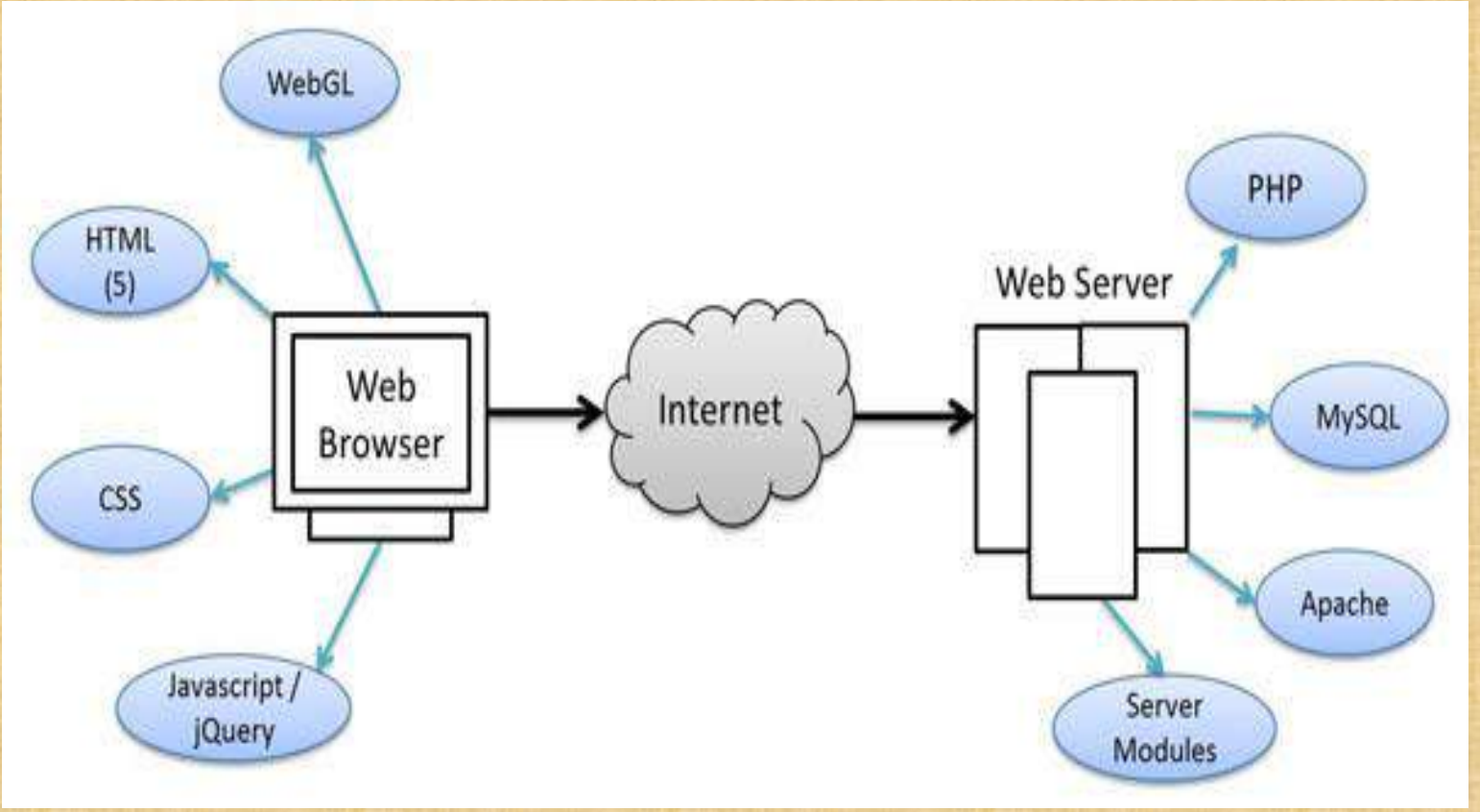
Web Technology

Communication on web



A very simplified view of web technology

Web Technology



Web Technology

Communication on web

In order to communicate on the web, **computers/devices need to understand each other**. This is made possible **by making all devices follow the same protocol**, namely TCP/IP.

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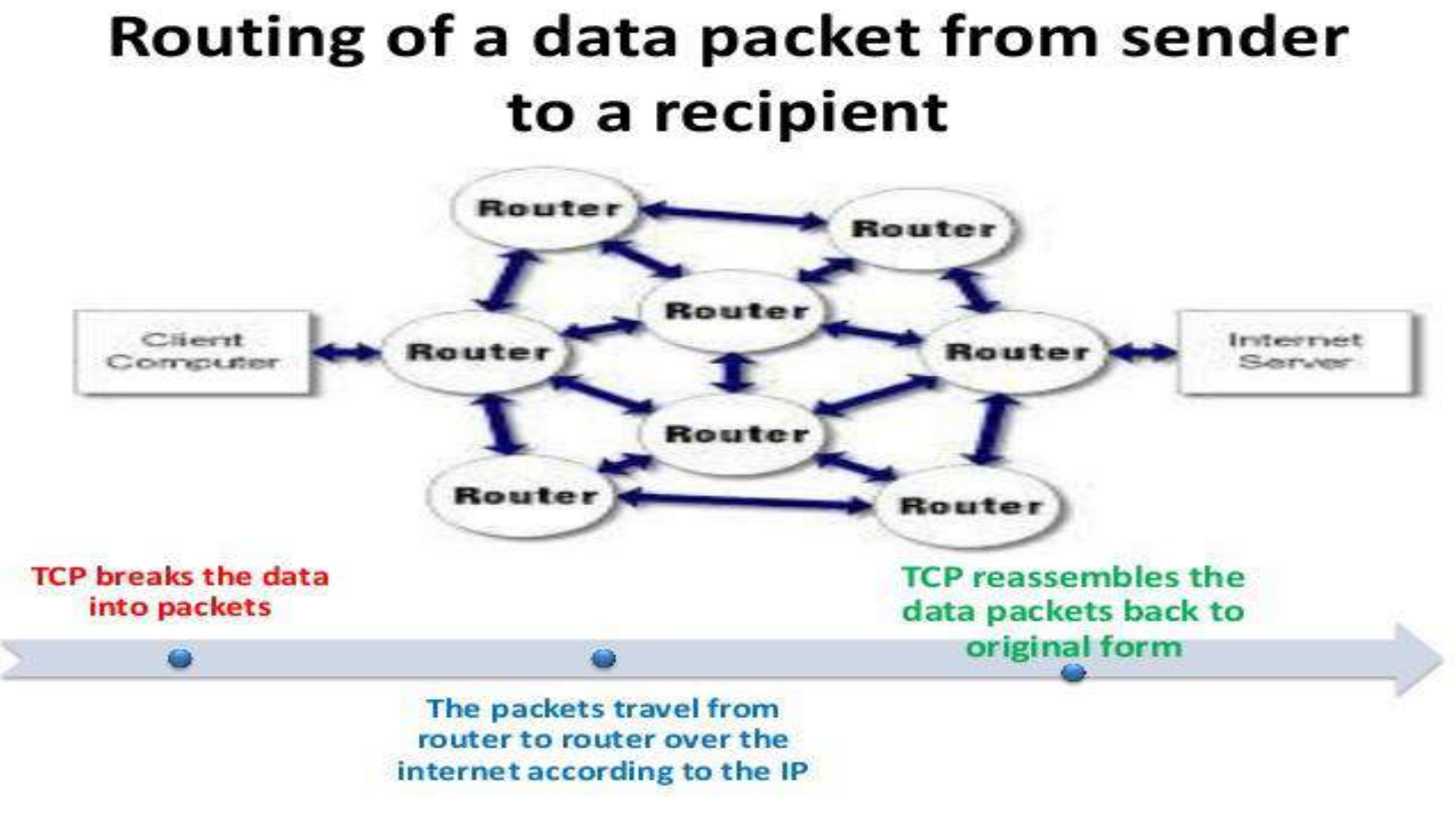
Web Technology



Web Technology

Communication protocols

- HTTP
- SMTP
- IP

Communication on the web can be categorised as

1. Client (browser) to webserver

2. Web server to Web server communication

Essential for Communication over the Internet

1. **Authentication :** is the process of determining whether a computer / server is the computer that it claims to be.

2. **Security :** it should be provided to communication over Internet so that the messages are not intercepted and modified by hackers.

Web server

- It is a **server computer that hosts websites**
- It **enables us to deliver web pages or services like e-mail, blog etc., to users on the Internet**
- It consists of **a server computer** that runs **a server OS** and **a web software** installed on it for providing services over the Internet

Popular Server OS

- Linux distributions
  - Redhat, openSUSE, Debian, Ubuntu, etc)
- Microsoft Windows Server
- FreeBSD
- Oracle Solaris etc.,

Some of the preferred web server packages are

- Apache Server
- Microsoft Internet Information Server (IIS)
- Google Web Server (GWS)
- nginex (engine-x)

Other Software packages : FTP, e-mail, DNS, databases etc

Scripting Languages

- Some of the popular scripting languages are given below:

1. **JavaScript**
2. **VB Script**
3. **PHP (Hypertext PreProcessor)**
4. **ASP (Active Server Pages)**
5. **JSP (Java Server Pages)**

Popular web designing softwares

Bluefish

Bootstrap

Adobe Dreamweaver

Microsoft Expression web

Web Technology

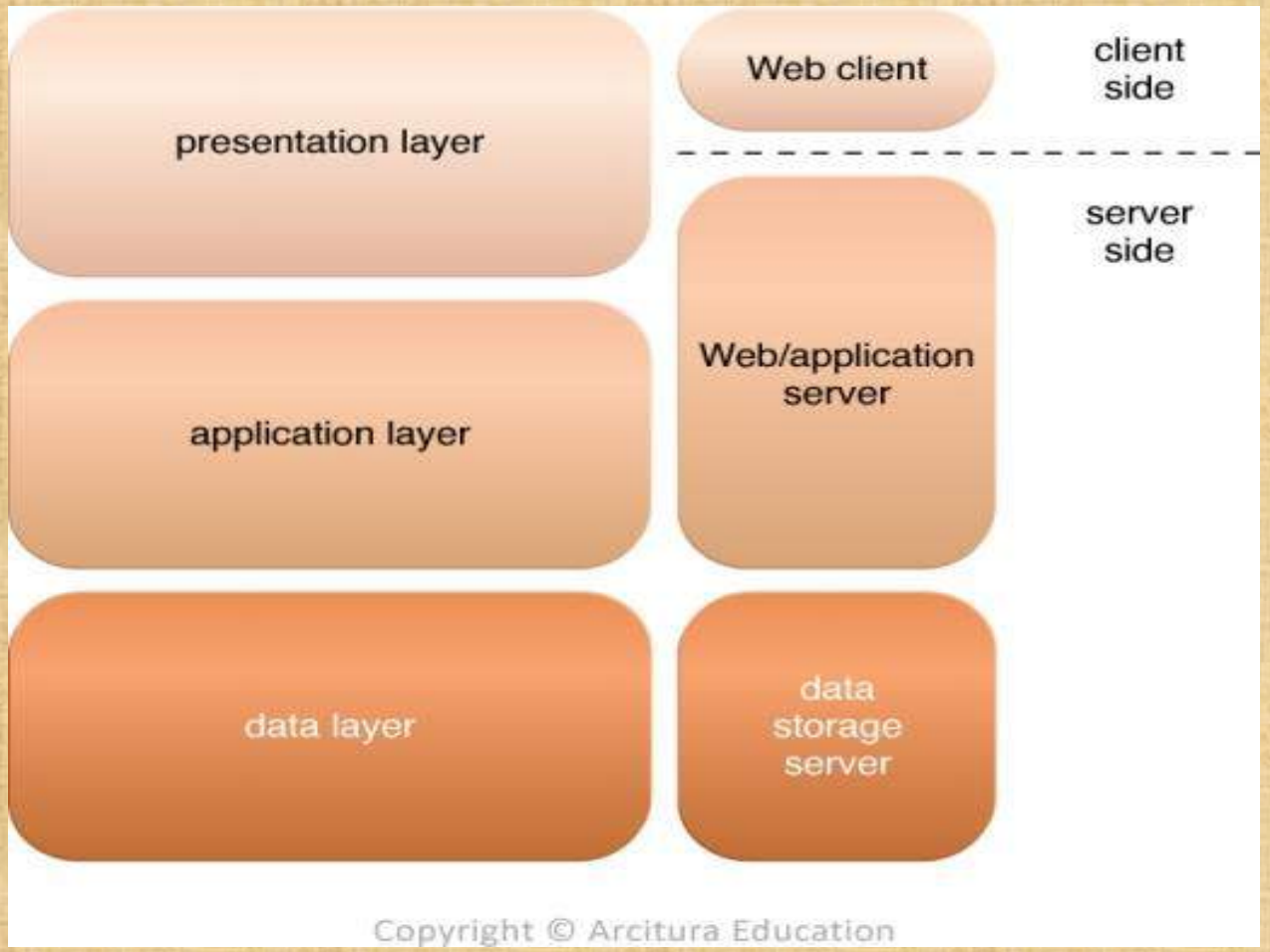
Basic Web Technology

- Uniform Resource Locator (URL)
- Hypertext Transfer Protocol (HTTP)
- Markup Language (HTML, XML)

Web Applications

- Presentation layer (user interface)
- Application layer (application logic in application server)
- Data layer (data store in data server)

Web Applications



- *Figure 5.10 - The three basic architectural tiers of Web applications.*

Summery of Web Technology

- Web technology is very commonly for cloud service implementations and for front-ends used to remotely manage cloud-based IT resources.
- For instance, typical PaaS offerings have separate instances of the Web server, application server, and data server.
- Fundamental technologies of Web architecture include the URL, HTTP, HTML, and XML.

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Multitenant Technology

- Multitenant – a single instance of an IT resource serves multiple consumers (tenants).
- Multitenant application architecture is often significantly more complex than that of single-tenant applications.
- Multi-tenant applications need to support the sharing of various artifacts by multiple users (including portals, data schemas, middleware, and databases), while maintaining security levels that segregate individual tenant operational environments.

Customize features

Tenants can individually customize features of the application, such as:

- User Interface
- Business Process
- Data Model
- Access Control

Characteristics of Multitenant

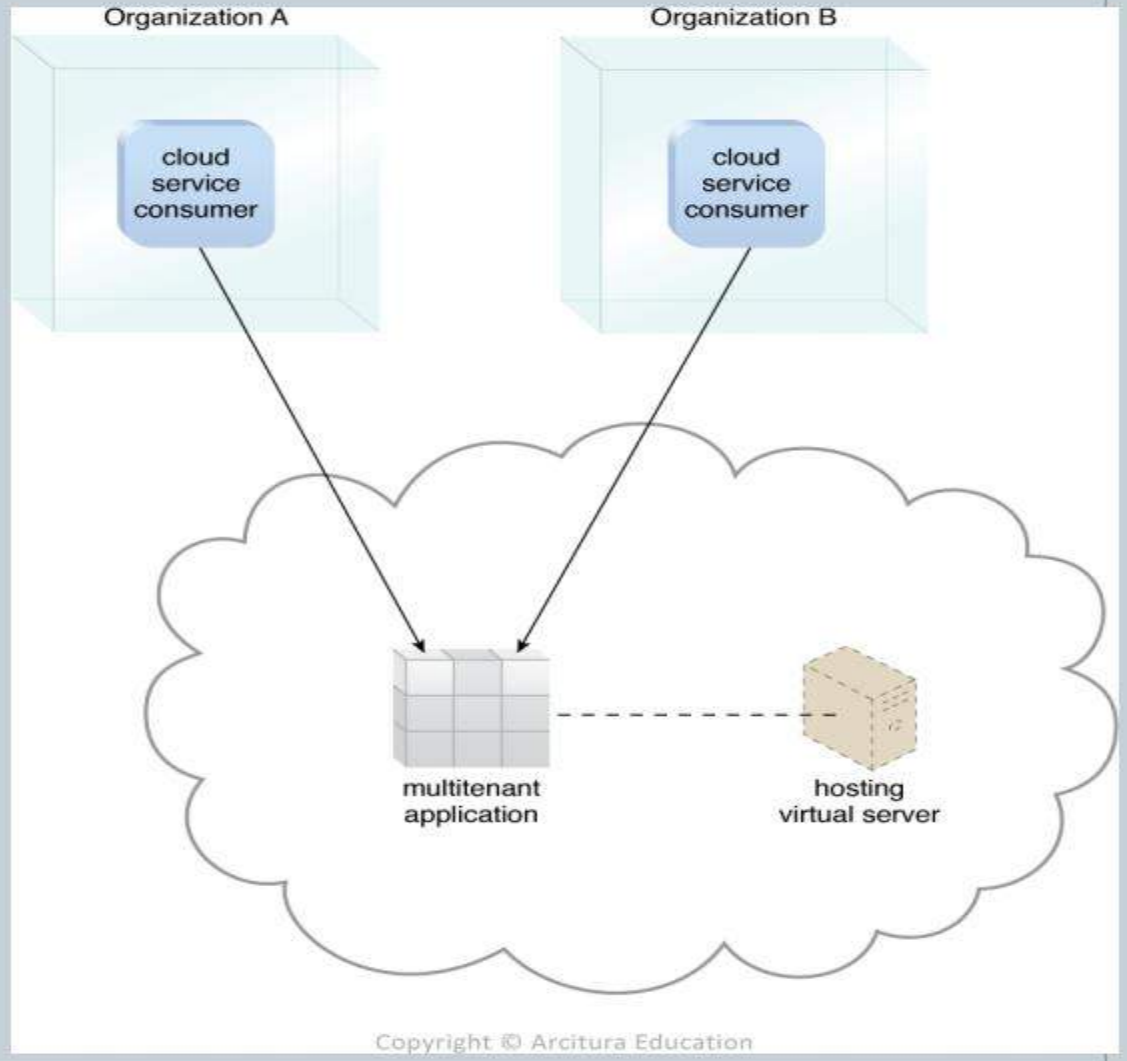
- Usage isolation
- Data security
- Recovery
- Application upgrades
- Scalability
- Metered usage
- Data tier isolation

Multitenancy

- Multitenancy is sometimes mistaken for virtualization because the concept of multiple tenants is similar to the concept of virtualized instances.

Multitenant

A multitenant application that is serving, multiple cloud service, consumers simultaneously



Multitenancy VS. Virtualization

The differences lie in what is multiplied within a physical server acting as a host:

- With virtualization:

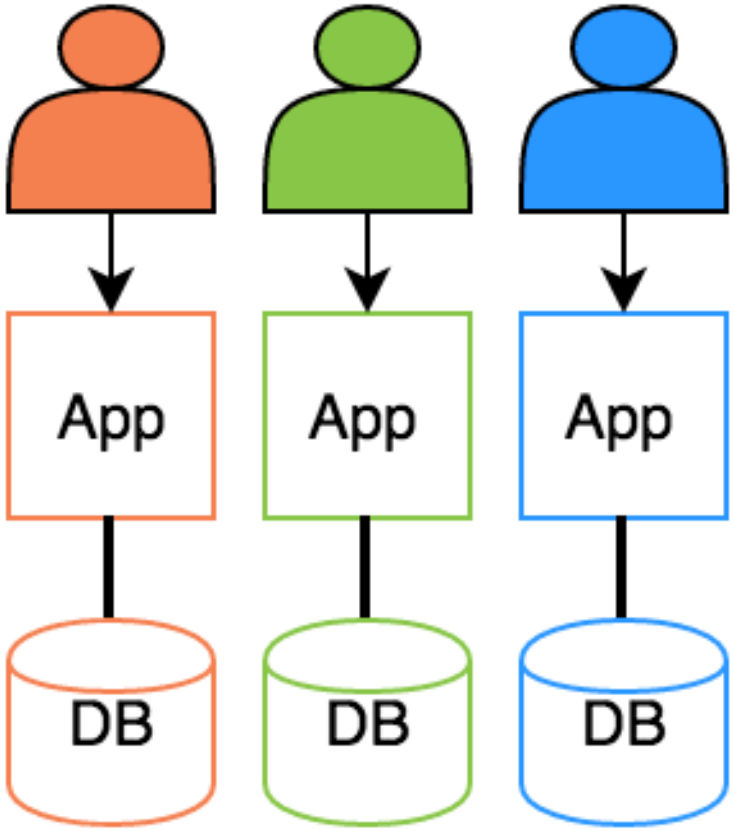
Multiple virtual copies of the server environment can be hosted by a single physical server. Each copy can be provided to different users, can be configured independently, and can contain its own operating system and applications.

- With multitenancy:

A physical or virtual server hosting an application is designed to allow usage by multiple different users. Each user feels as though they have exclusive usage of the application.

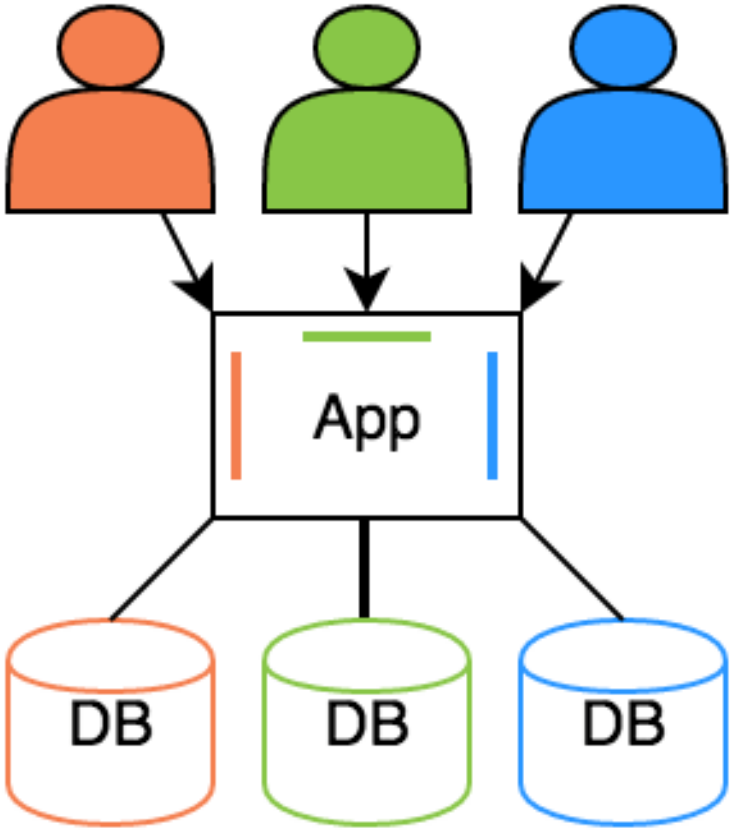
SINGLE TENANT

Seperate Application,
Seperate Database



MULTI TENANT

Same Application,
Seperate Database



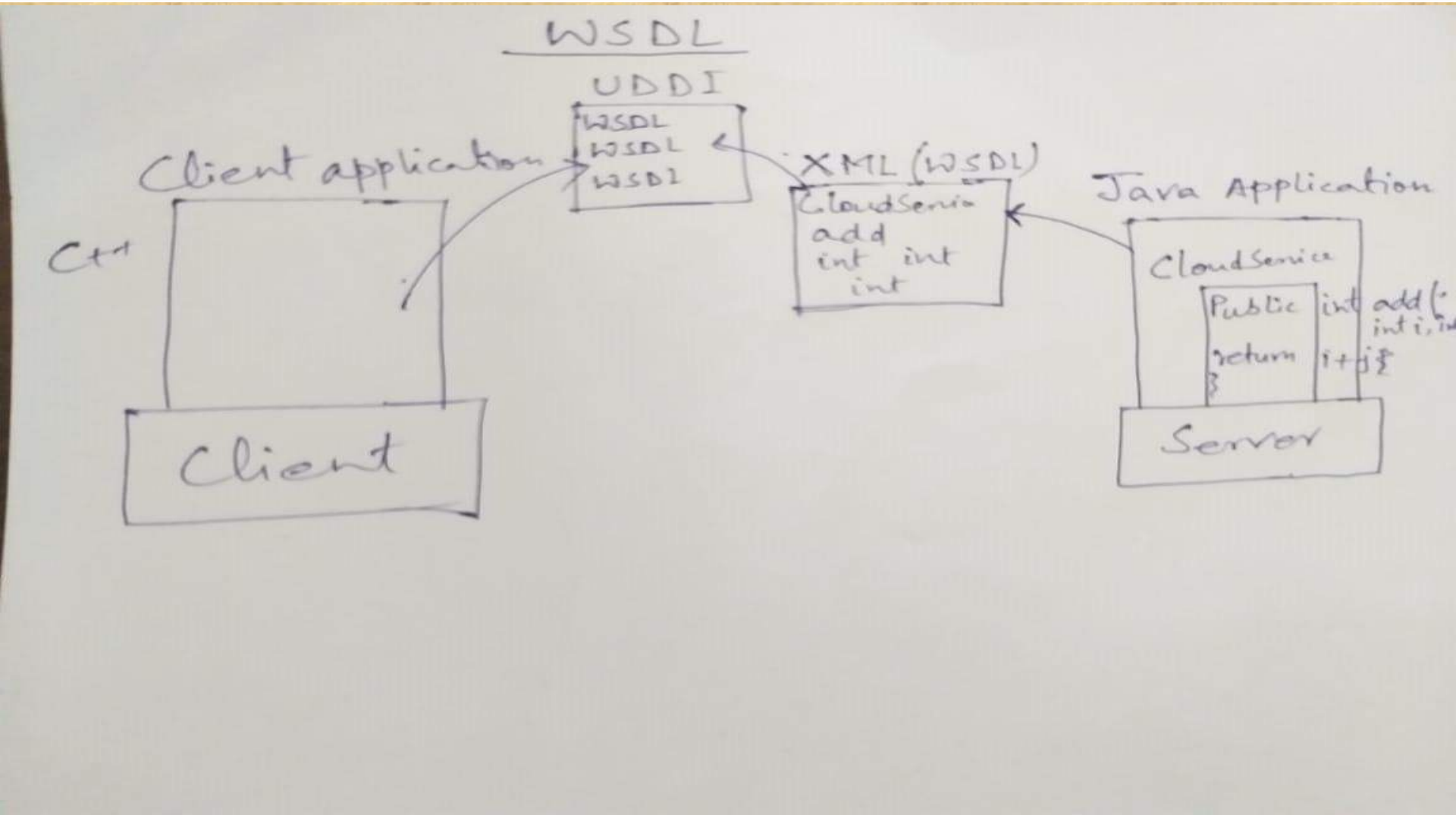
Service Technology

Along with XML, the core technologies behind Web services are represented by the following industry standards:

- Web Service Description Language (WSDL)
- XML Schema Definition Language (XML Schema)
- Simple Object Access Protocol (SOAP)
- Universal Description, Discovery, and Integration (UDDI)

Note that: These 4 technologies collectively form the first generation of Web service technology. The 2 generation (WS-*) addresses additional features, such as security, reliability, transactions, routing, and business process automation.

WSDL


WSDL
UDDI
WSDL
WSDL
WSDL
Client application
XML (WSDL)
CloudServic
add
int int
int
Java Application
CloudServic
Public
return
Client
Server

WSDL Document

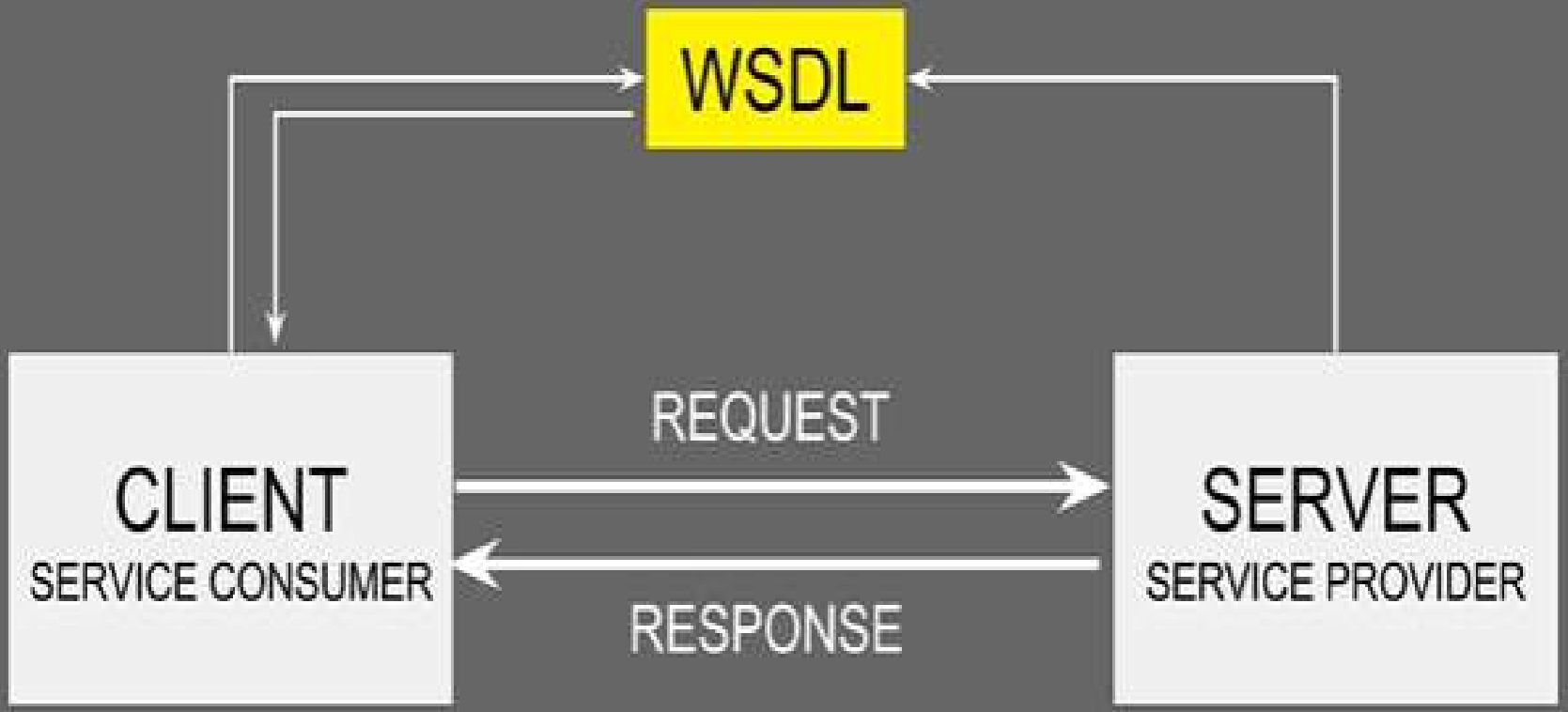
Element	Description
<types>	Defines the (XML Schema) data types used by the web service
<message>	Defines the data elements for each operation
<portType>	Describes the operations that can be performed and the messages involved.
<binding>	Defines the protocol and data format for each port type

WEB SERVICES

Services available over the web

WSDL

UDDI



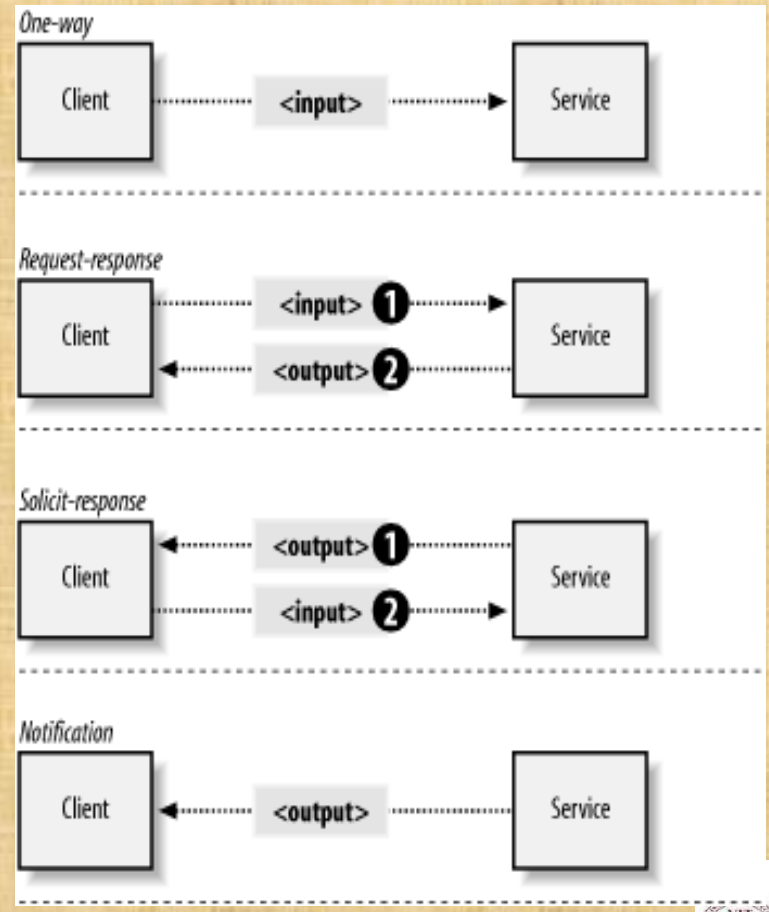
WSDL Operations

One-way: The operation can receive a message but will not return a response

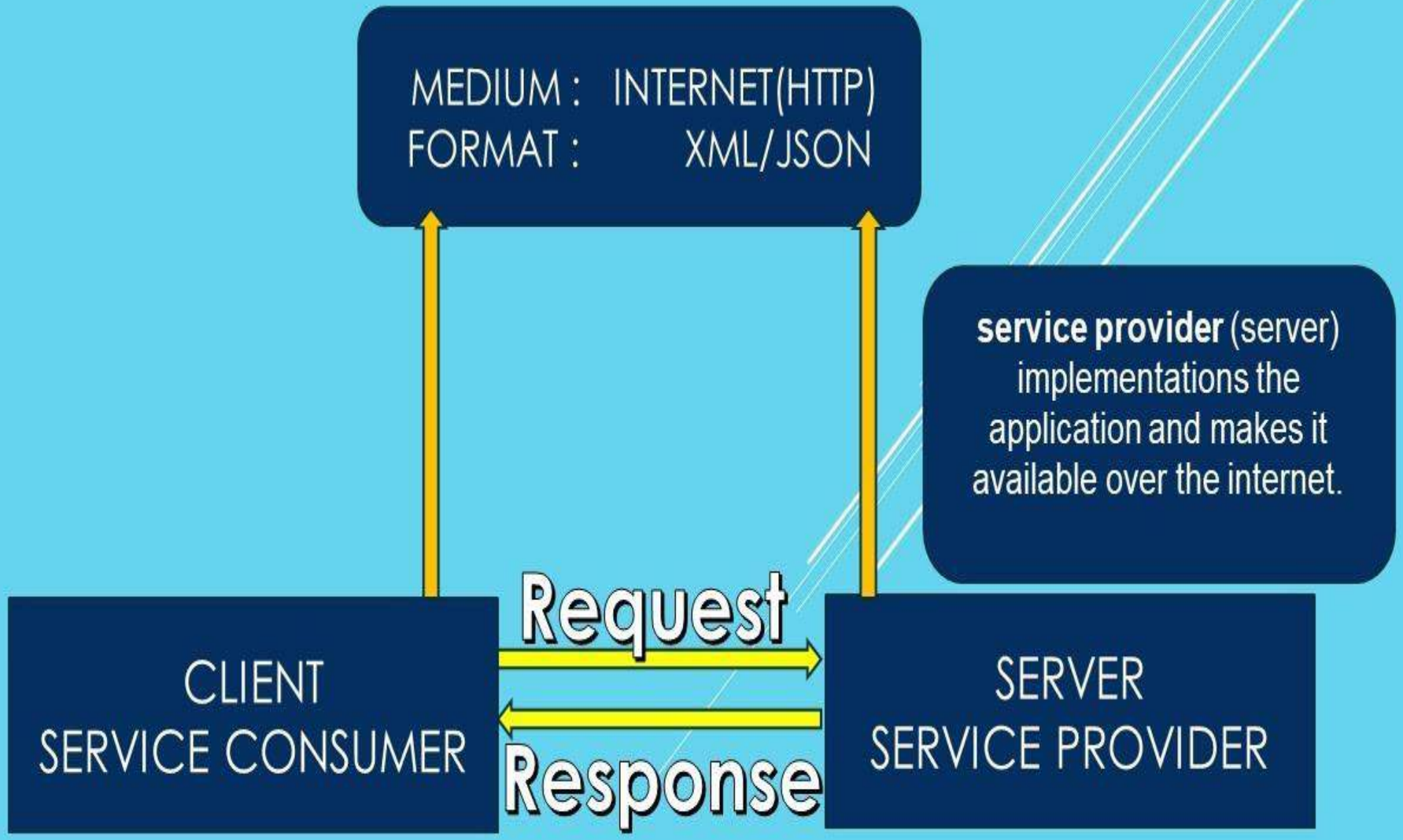
Request-response:The operation can receive a request and will return a response

Solicit-response:The operation can send a request and will wait for a response

Notification: The operation can send a message but will not wait for a response



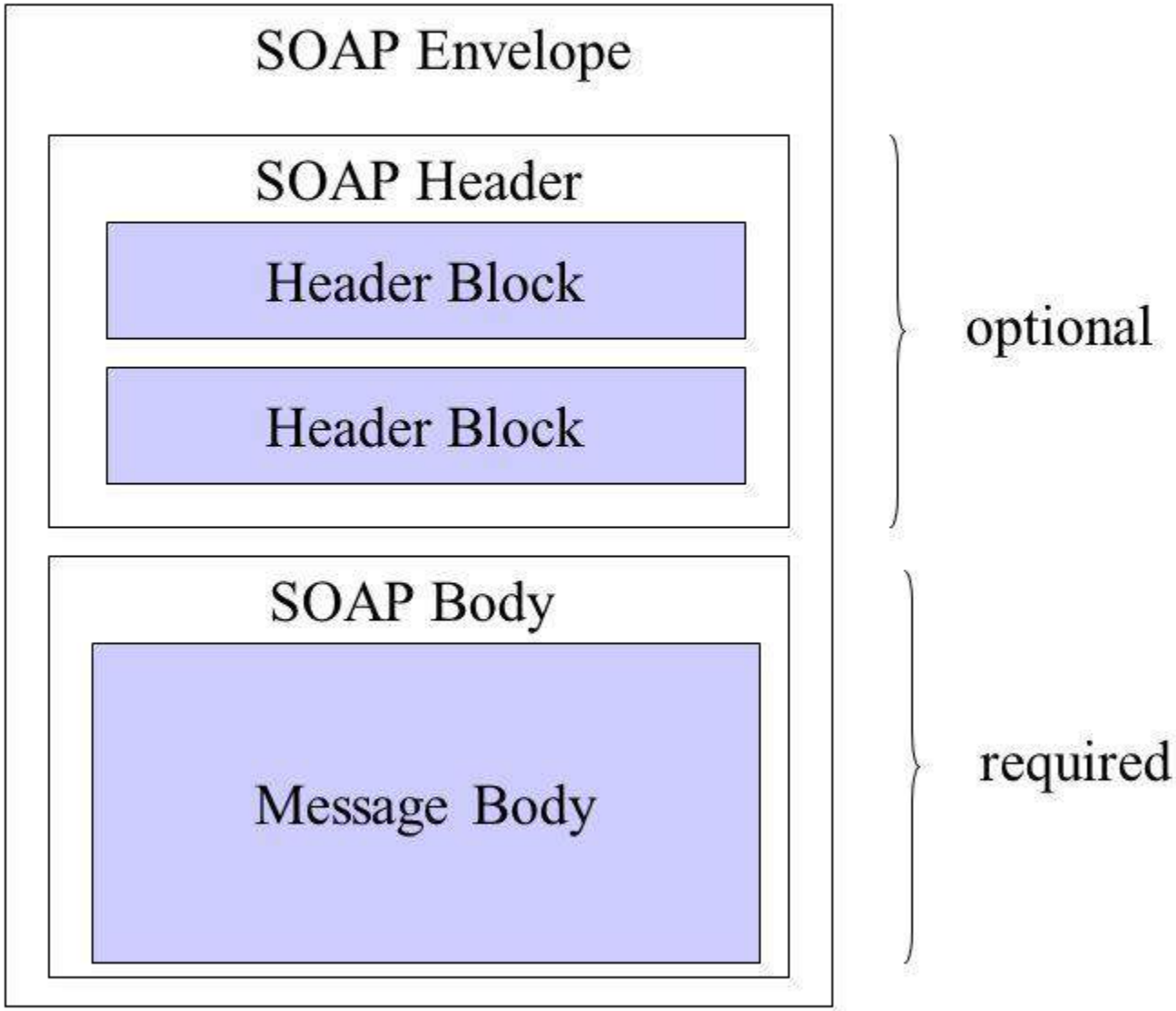
HOW WEB SERVICES WORKS?



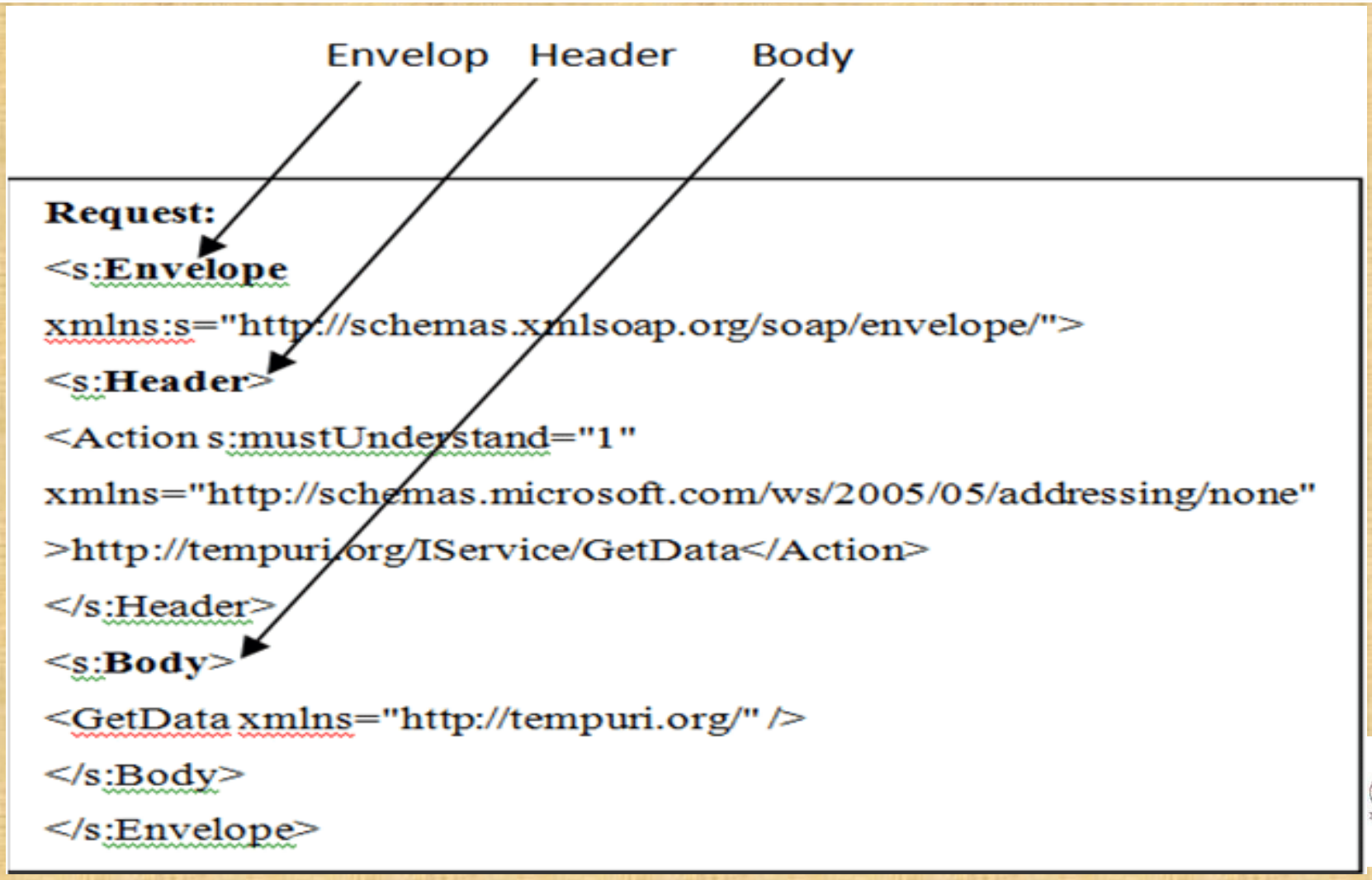
SOAP

- SOAP – Simple Object Access Protocol.
- SOAP relies heavily on XML, and together with schemas, defines a very strongly typed messaging framework.
- Every operation the service provides is explicitly defined, along with the XML structure of the request and response for that operation.
- Each input parameter is similarly defined and bound to a type: for example an integer, a string, or some other complex object.
- All of this is codified in the WSDL – Web Service Description (or Definition, in later versions) Language.

SOAP Message

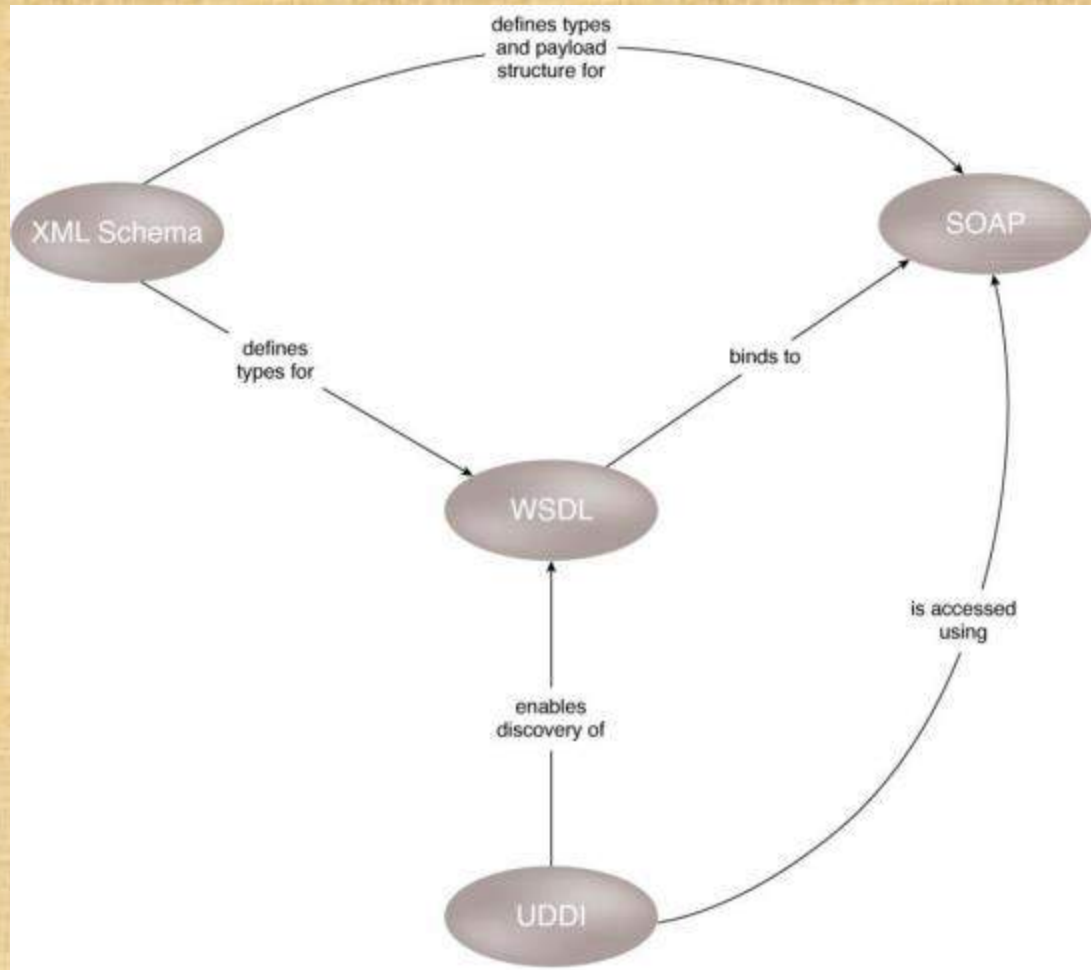


SOAP Request Mesage



WSDL Binding to SOAP

An overview of how first-generation *Web service technologies commonly relate to each other*

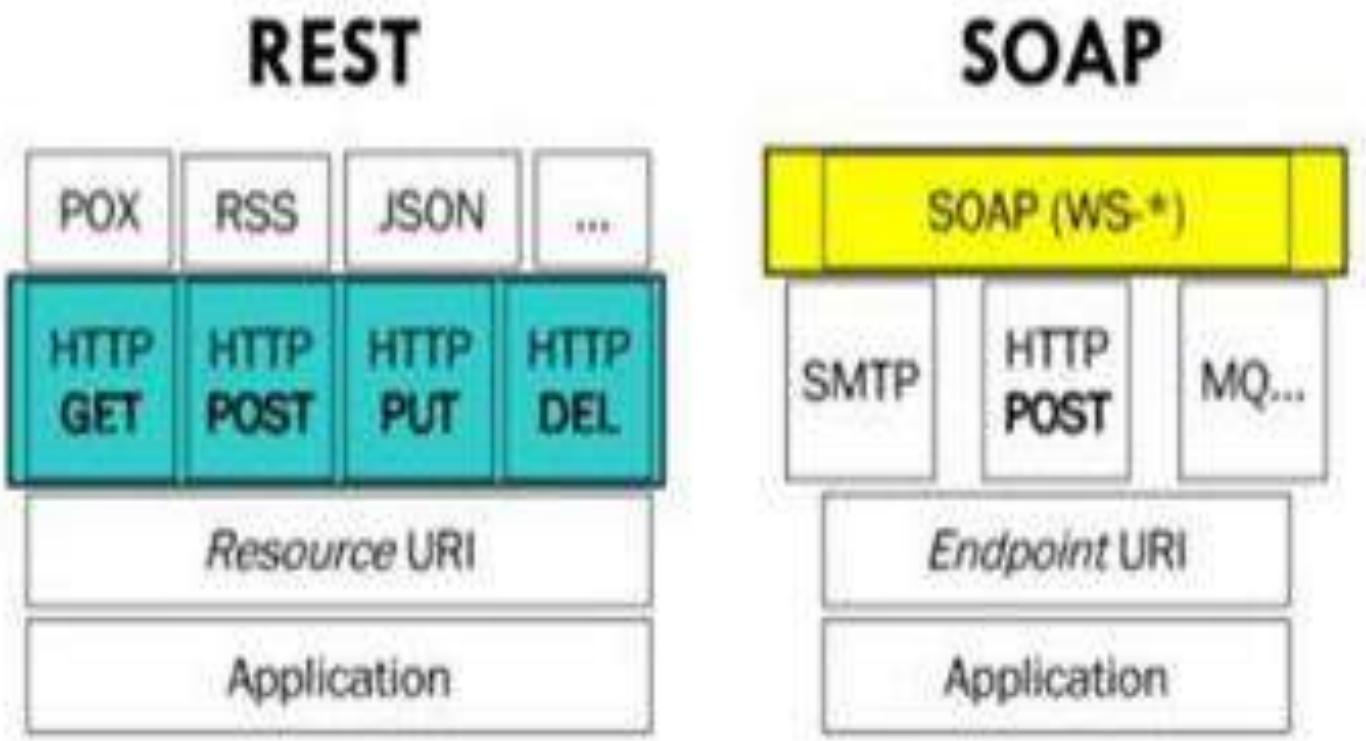


REST Service and Service Agents

- REST services are designed according to a set of constraints that shape the service architecture to emulate the properties of the WWW.
- Service agents are event-driven programs designed to intercept messages at runtime, either active agent or passive agent.
- Falling under the umbrella of service technology is the large of middle platform. Two main categories are the enterprise service bus (ESB) and the orchestration platform.

REST v/s SOAP

- Protocol Layering



Differences in SOAP and REST

#	SOAP	REST
1	A XML-based message protocol	An architectural style protocol
2	Uses WSDL for communication between consumer and provider	Uses XML or JSON to send and receive data
3	Invokes services by calling RPC method	Simply calls services via URL path
4	Does not return human readable result	Result is readable which is just plain XML or JSON
5	Transfer is over HTTP. Also uses other protocols such as SMTP, FTP, etc.	Transfer is over HTTP only
6	JavaScript can call SOAP, but it is difficult to implement	Easy to call from JavaScript
7	Performance is not great compared to REST	Performance is much better compared to SOAP - less CPU intensive, leaner code etc.

Summary of Service Technology

- Web-based services such as Web services and REST services rely on non-proprietary communications and technical interface definitions to establish standardized communications frameworks based on Web technology.
- Service agents provide event-driven runtime processing that can be applied to numerous functional areas within clouds.
- Service middleware, such as ESBs and orchestration platforms, can be deployed on clouds.

DTGOV Case Study

DTGOV has assembled cloud-aware infrastructures in each of its data centers, which are comprised of the following components:

- Tier-3 facility infrastructure, which provides redundant configurations for all of the central subsystems in the data center facility layer.

- Redundant connections with utility service providers that have installed local capacity for power generation and water supply that activates in the event of general failure.

Cont..

- An internetwork that supplies an ultra-high bandwidth interconnection between the three data centers through dedicated links.

- Redundant Internet connections in each data center to multiple ISPs and the .GOV extranet, which interconnects DTGOV with its main government clients.

- Standardized hardware of higher aggregated capacity that is abstracted by a cloud-aware virtualization platform.

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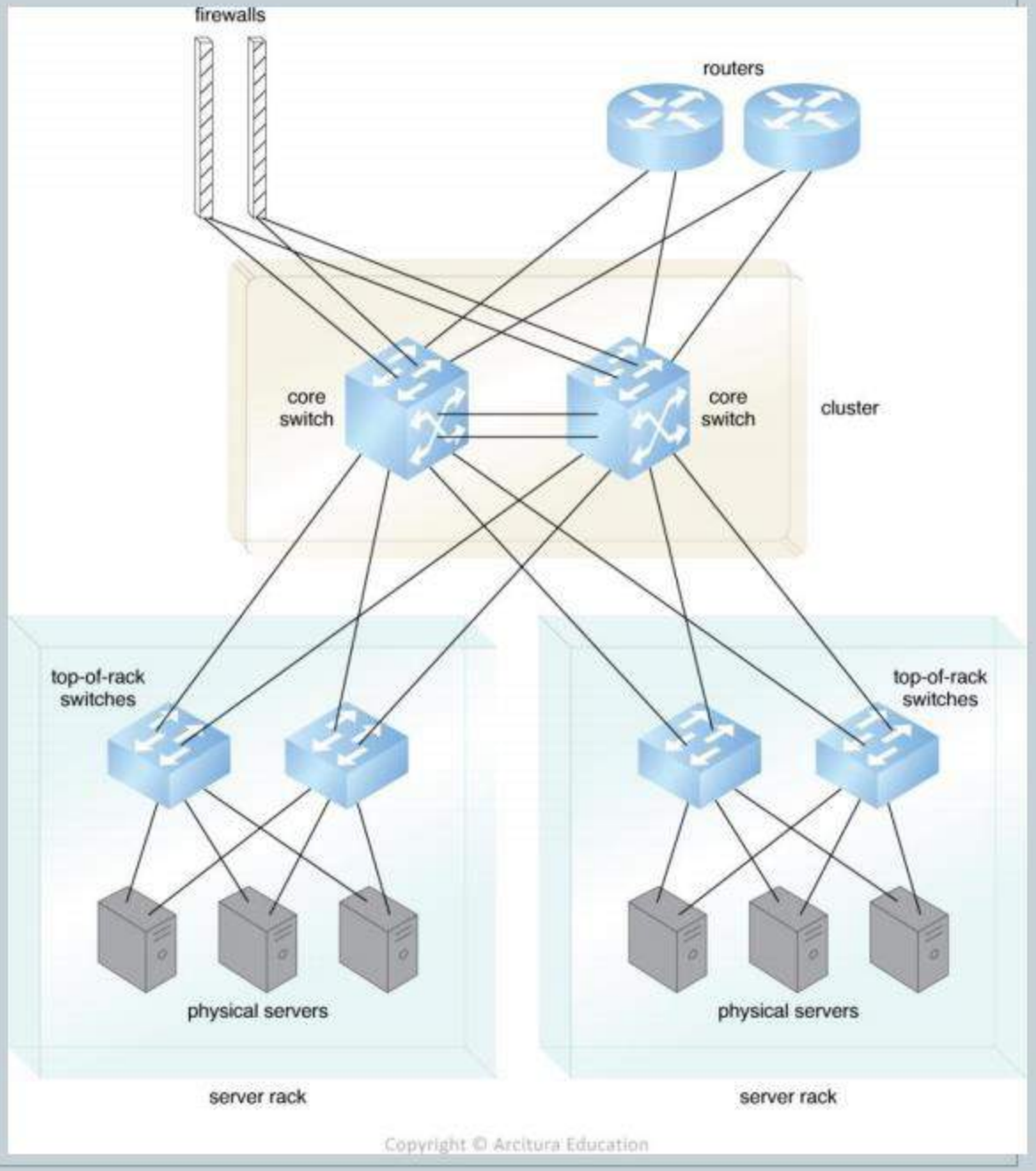
Cont..

- Physical servers are organized on server racks, each of which has two redundant top-of-rack router switches (layer 3) that are connected to each physical server.
- These router switches are interconnected to LAN core-switches that have been configured as a cluster.
- The core-switches connect to routers that supply internetworking capabilities and firewalls that provide network access control capabilities.

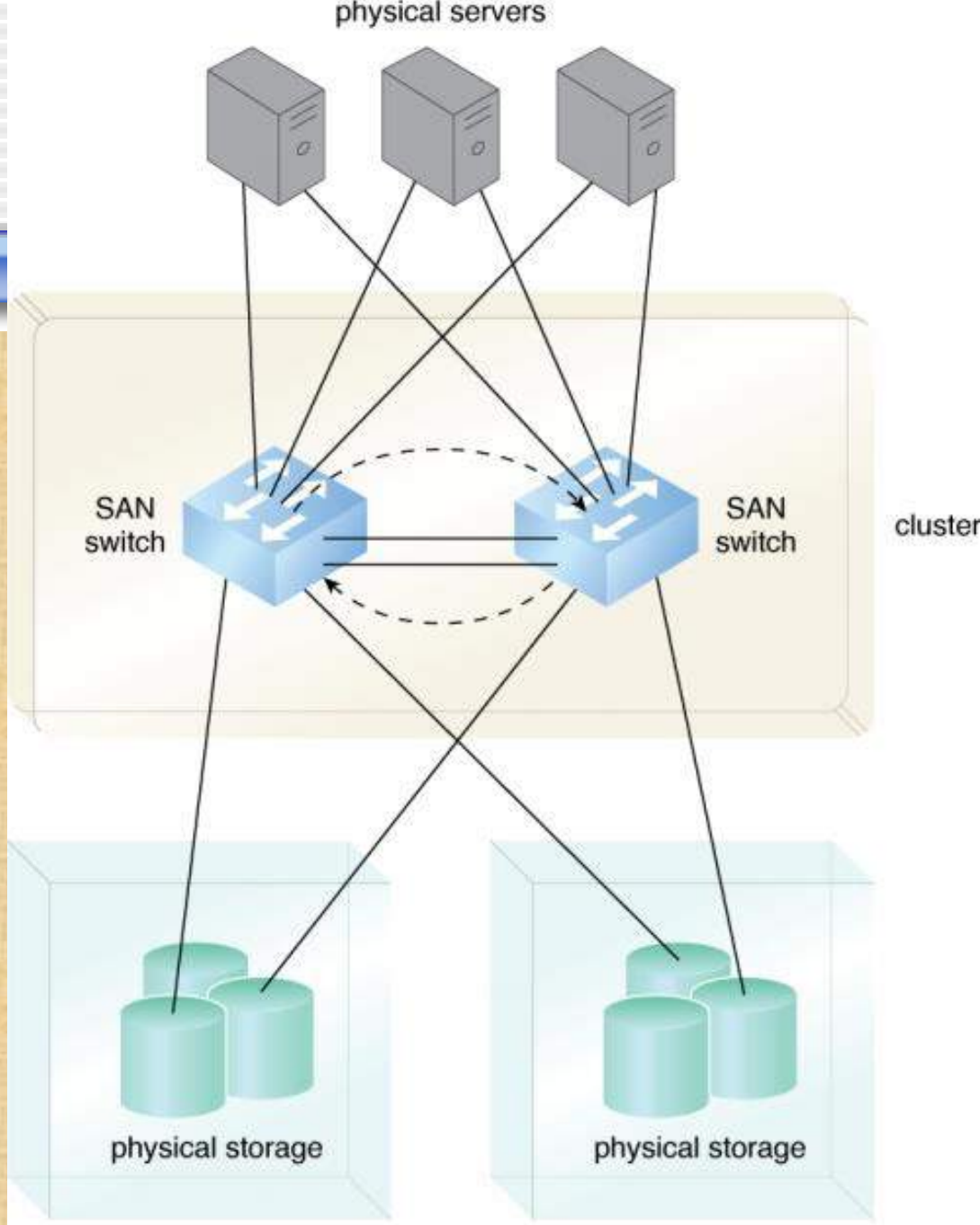
Cont..

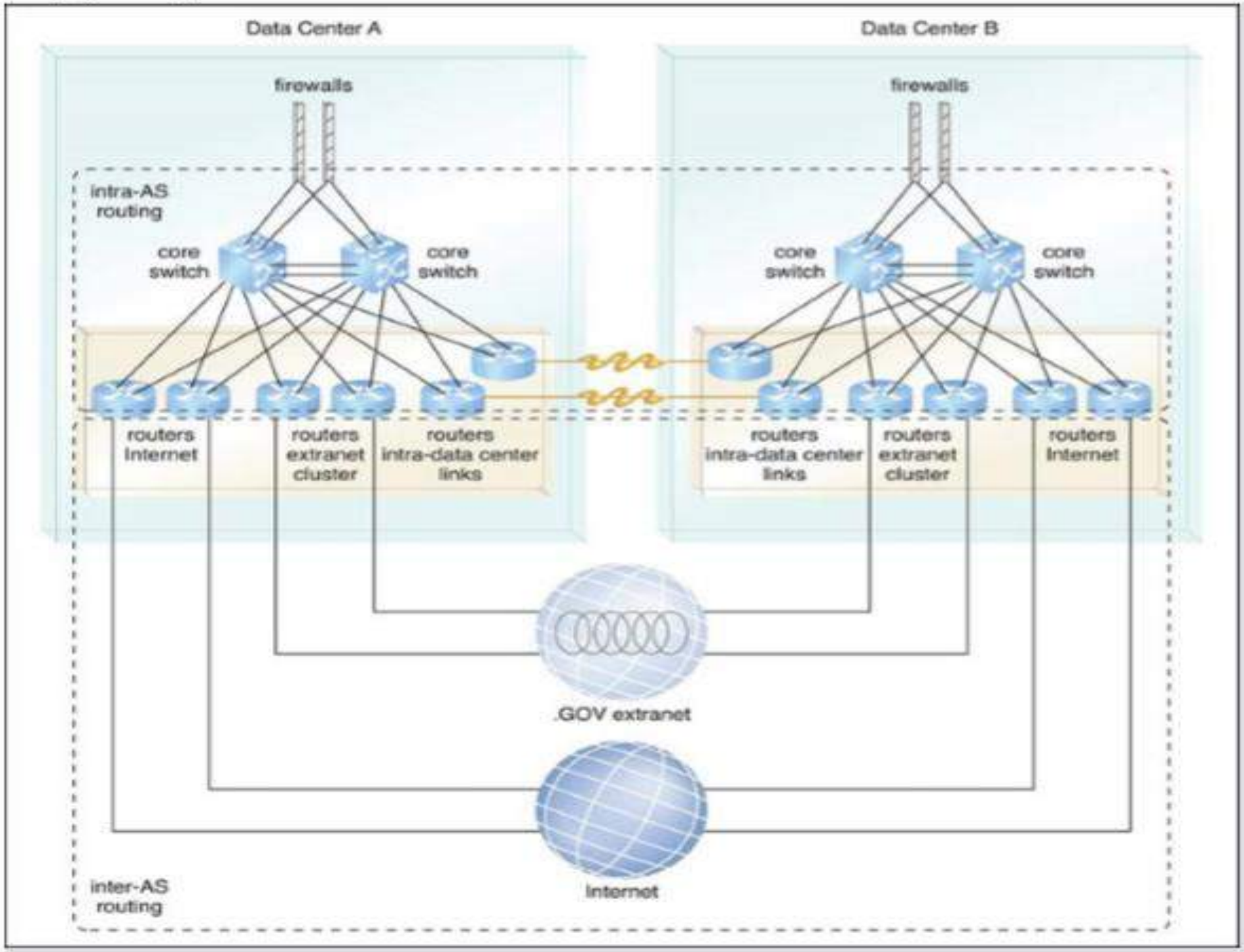
- A view of the server network connections inside the DTGOV data center.
- A view of the storage system network connections inside the DTGOV data center.
- A view of how two data center are connected each other in DTGOV

A view of the server network connections inside the DTGOV data center.



A view of the storage system network connections inside the DTGOV data center.




Data Center A
Data Center B
firewalls
firewalls
intra-AS routing
core switch
core switch
core switch
core switch
routers Internet
routers extranet cluster
routers intra-data center links
routers intra-data center links
routers extranet cluster
routers Internet
GOV extranet
Internet
inter-AS routing

Greenlight Technology Simplified

Server Consolidation

Server consolidation is a strategy to reduce the total number of physical servers or server locations that an organisation requires. The practice has been developed in response to the problem of server sprawl, a situation in which multiple, underutilized servers take up more space and consume more resources than can be justified by their workload. Reducing the number of servers brings down the associated costs with servers and compute resources for an organisation. The more dense the consolidation, the higher the ROI is for the migration and the sooner the cost benefit of consolidation is realised.

VIT AP AMARAVATI

Case Study

- Our client is a software development company in the application of handheld devices and industrial inventory management systems for large freight companies, specialist firms, and warehouses. Their existing IT systems had some virtualisation in place, along with single purpose server blades and standalone servers for other organisation needs.
- The systems had been over provisioned and the resources were underutilised. Although virtualisation was already in place, they were using SAN storage with limited extensibility and all the existing hardware was out of warranty and in excess of 4 years in age. The only cost effective solution was to migrate the environment to new hardware with much greater performance, as well as increased data density.

Initial Requirement

- Our client had previously made a large investment in hardware to run their operation; this hardware was aging and becoming unreliable. With current generation hardware, it was straightforward to have a similar level of resources on new infrastructure.

Existing hardware

- The existing hardware was a complex mix of physical machines, server blades, and virtual machines that were VMware based.
- In line with the customers objectives for the virtualization project the decision was made to take the entire environment and convert it to VMware virtual machines running on ESXi 5.
- The existing environment consisted of two racks of equipment's containing a fully populated HP Blade Centre, a selection of older generation HP servers and older generation SAN.

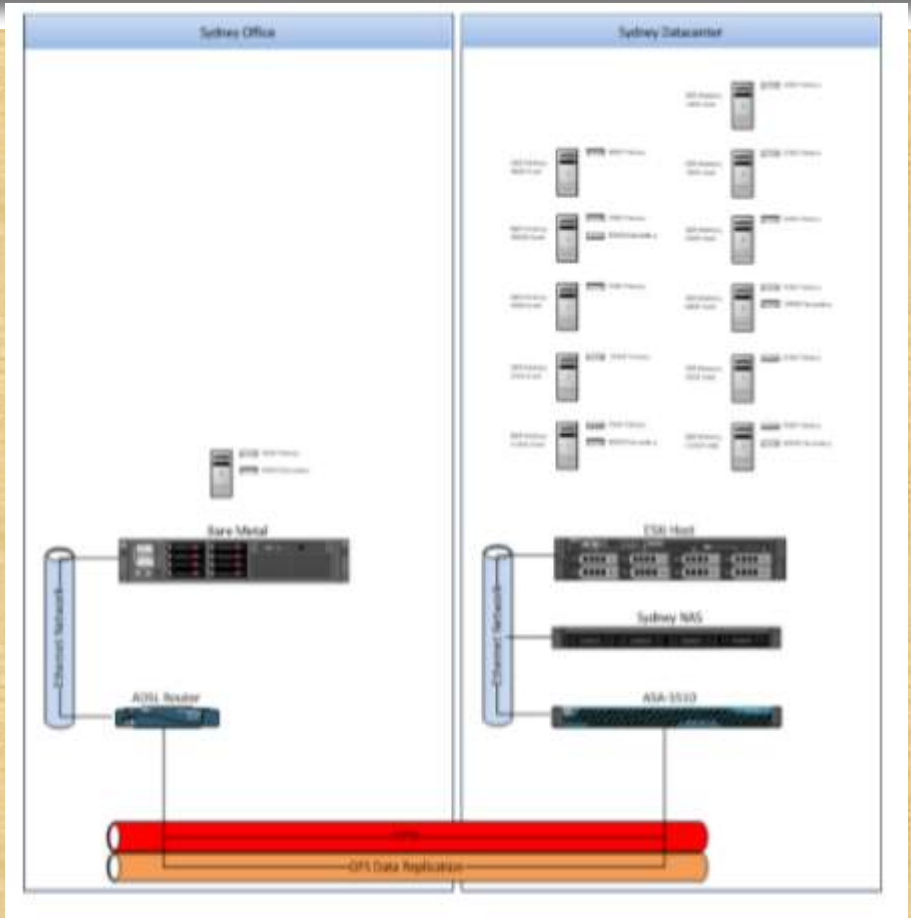
REST v/s SOAP

New layout and hardware

By leveraging the performance and memory density of the latest generation of Dell rack mount servers we are able to condense the entire environment on to a single two rack unit virtualisation host, which was relocated into Global Switch and a single two rack unit storage server for local file access located in the office.

The new Dell server has redundant power supplies, fault tolerant RAID arrays and accelerated cache for optimal speed and redundancy.

We also redeployed one of the existing HP servers to provide local replication of the file storage via DFS. The previously slow and unstable VPN connections that were coming into the office for remote workers are now being terminated on the Data Centre side on a Cisco ASA with SSL VPN's with significantly increased bandwidth and stability.



The Conversion Process

- We leveraged the features in VMware converter to convert the existing virtual machines and physical machines to VMware virtual machines.
- The conversion was done in a staggered fashion outside of office hours to avoid interrupting business operations.
- The VMware converter allows for machines to be processed in batches, with a technician working on Virtual Machine configuration settings such as networking, then reconfiguring each machines after the move. The migrations are still ongoing in the background minimising the time wastage of technicians sitting around waiting for the conversions.

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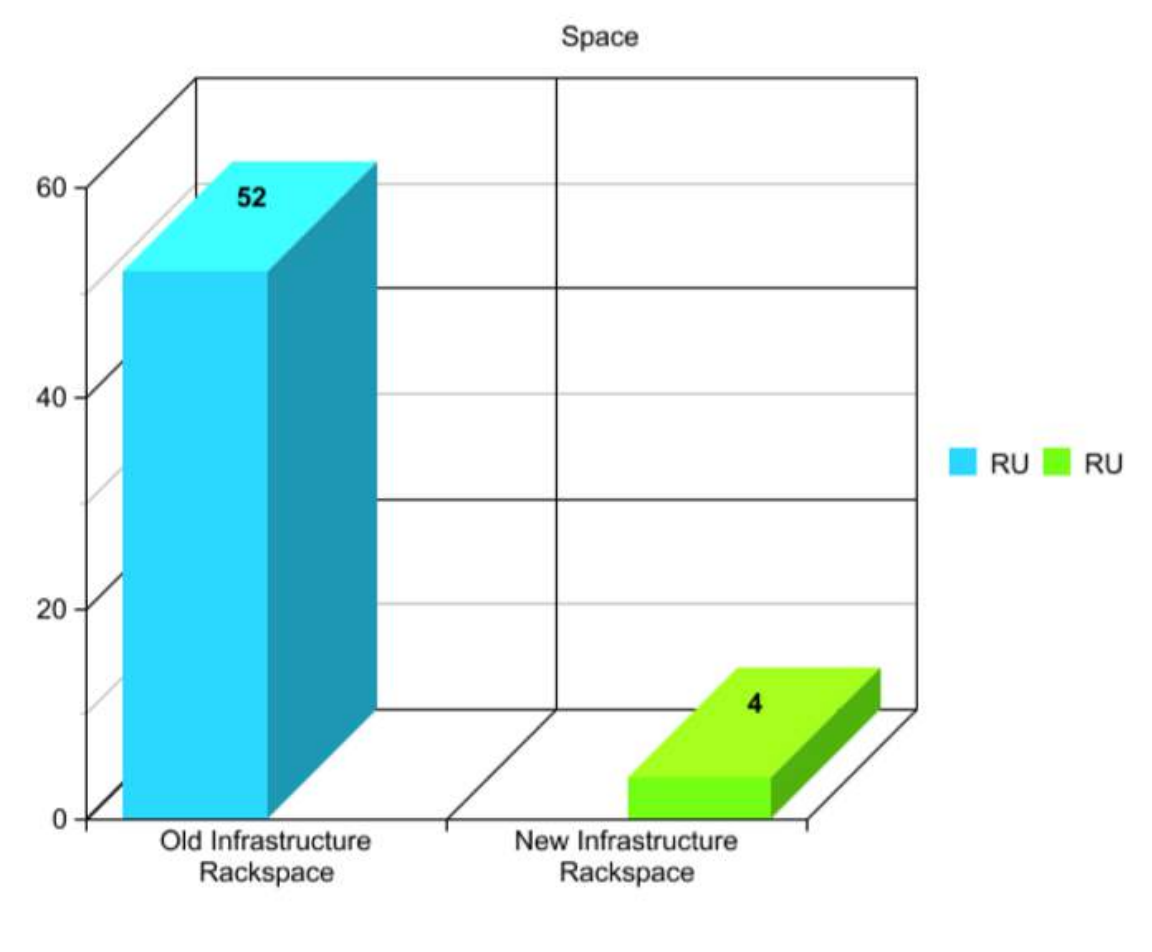
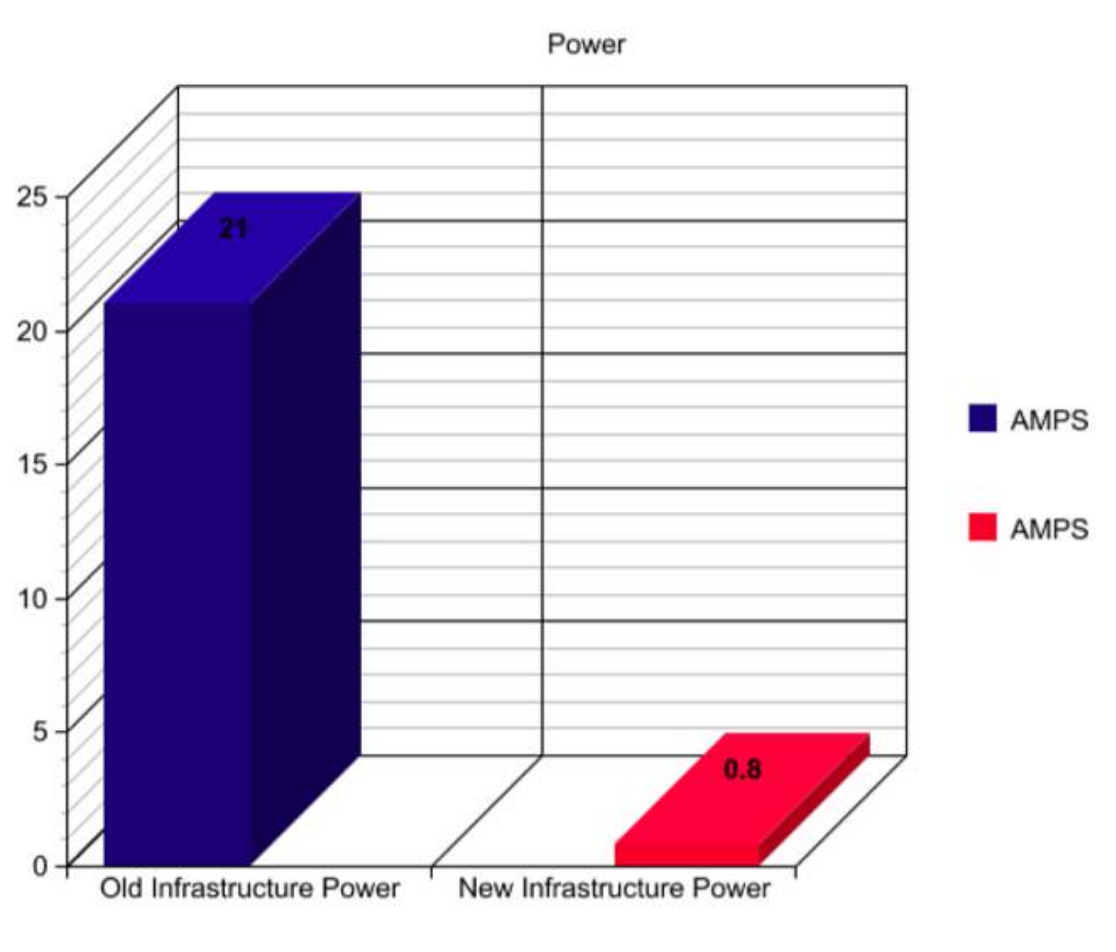
RESULT


Space
60
40
20
0
52
4
Old Infrastructure Rackspace
New Infrastructure Rackspace
RU
RU

Cont..


Power
25
20
15
10
5
0
21
0.8
Old Infrastructure Power
New Infrastructure Power
AMPS
AMPS

Conclusion

- With the virtualization project now complete, our client is now reaping the benefits of the consolidated infrastructure. Remote workers now no longer suffer from bandwidth issues and, applications hosted on the new infrastructure now run much faster.