Technologies used in Cloud - Computing :-

The various technologies that are used in Cloud - Computing are given as follows —

* Virtualization
* SOA (Service Oriented Architecture).
* Grid Computing
* Utility Computing

If we talk about the latest technologies, there are various trends in 2020. The various latest technologies are as follows.

* Serverless Computing.
* Omni - Cloud.
* Quantum - Computing.
* Kubernetes
* Digital Natives

Virtualization :-

* It is the creation of virtual version of something, such as server, a desktop, a storage device, an operating system or network resources. i.e resources are made available to the users but virtually not physically.

* It is a technique which allows sharing a single physical instance of resources to multiple users.

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Need of Virtualization :-

Needs of Virtualization →
- Enhanced Performance. (by providing additional resources to user)
- Limited use of Resources. (for better utilization of resources)
- Shortage of Space. (lack of resources from user side)
- Eco-friendly Initiatives. (reduces power consumption.)
- Administrative Costs. (reduces mgmt cost from client side)

Advantages of Virtualization :-

* Economical :- (Dont need to buy high capacity hardware and other resources.).
* Flexible Operations :- (You can access it from anywhere and customization can be done)
* Security :- Provided by cloud-service Provider.
* Eliminates the risk of system failure.
* Flexible transfer of data
* Faster provisioning of applications and resources.
* Greater business continuity and disaster recovery.
* Simplified data centre management.

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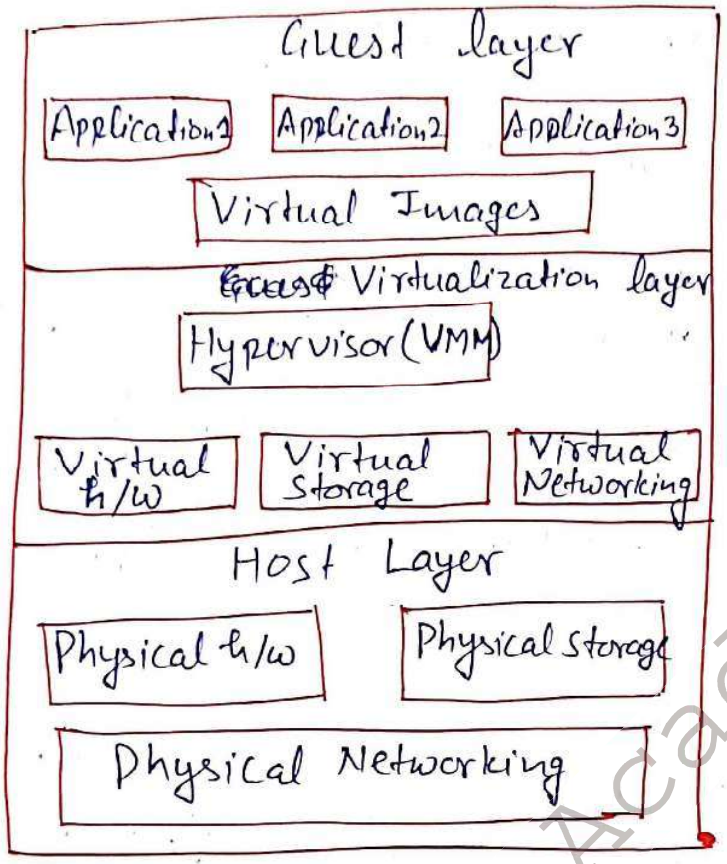
Virtualization Reference Model:



Four major components of Virtualization reference Model is available here.

i) Host Layer:

⇒ The host layer represents the original environment where the guest is supposed to be managed.

⇒ All the physical resources and physical networking is present in this layer.

⇒ Each guest runs on the host machine using shared resources donated to it by the host.

⇒ The OS works as the host and manages the physical resources management and the device support.

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Guest Layer:

⇒ The guest represents the system components that interacts with the virtualization layer rather than with the host.

⇒ Guest usually consists of one or more virtual disk files, and a VM definition file.

⇒ Virtually machines are centrally managed by a host application that sees and manages each virtual machine as a different application.

Virtualization Layer:

⇒ The virtualization layer is responsible for recreating the same or a different environment where the guest will operate.

⇒ It is an additional abstraction ~~layer~~ layer between a network and a storage hardware, computing and the application running on it.

Hypervisor:

⇒ A hypervisor, also known as Virtual Machine Monitor (VMM), is a software that creates and runs virtual machines (VMs)

⇒ A hypervisor allows one host computer to support multiple guest VMs by virtually sharing its resources, such as memory and processing.

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Implementation Levels of Virtualization:

(2-5)

Application Level
Library (user-API) level
Operating System Level
Hardware Abstraction layer (HAL) level
Instruction Set architecture (ISA) level.

Instruction Set Architecture (ISA) Level: Applications

⇒ In ISA level implementation, every machine has an instruction set which is an interface b/w software and hardware.

⇒ An emulator is created which receives all the instructions from the virtual machines.

⇒ The emulator interprets what type of instruction it is and then map that instruction to the host machine's instruction and then that instruction will be carried out on host machine and the results will be passed to the emulator and emulator will return it to the virtual machine.

Problems in ISA level implementations:

Since every instruction has to be interpreted before mapping it, too much time is consumed and performance becomes poor.

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Virtualization at HAL level:

⇒ To overcome the problems of ISA level implementation of virtualization, we have virtualization at HAL level.

⇒ In HAL level we map the virtual resources with physical resources.

⇒ we dont interpret every instruction (as of in ISA level), but we just check whether it is priviledged or non-priviledged.
(ex:- memory mgmt, scheduling etc)

⇒ If the instruction is not priviledged we simply allow normal execution because already virtual and physical resources are mapped.

⇒ If the instruction is priviledged, we pass the control to VMM and it deals with it accordingly.

~~Virtual~~ Problems in HAL implementation:

⇒ even after many advancements still there are certain exceptions which cannot be caugh by this method.

⇒ Since, in this method each VM is build from scratch i.e by installing OS, application suites, networking systems etc., so if it is required to initialize more virtual machine at a single time, then it will take too much of time.

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Virtualization at OS level:

⇒ To overcome the problems of HAL level implementation we can use OS level virtualization.

⇒ In this method each VM is not built from scratch rather we share operating system b/w virtual machine along with the h/w.

⇒ we keep the base OS same and install only the differences in each single virtual machine.

Problem with OS level implementation:

The major problem with this is that we can install only those OS in VMs whose base OS family is same like for example we can't install ubuntu on a VM whose base OS is windows.

Virtualization at library level or Programming language level:

⇒ In this type, we use library level interfaces to provide a different virtual environment (VE) for that application.

⇒ In short we provide user with an emulator with which user can run applications of different OSs.

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Virtualization at Application Layer Level: (2-8)

⇒ In this kind of virtualization virtual machine run as an application on the Host operating-system.

⇒ we create a virtualization layer which is present above the host OS and it encapsulates all the applications from the underlying OS.

⇒ While all the applications are loaded, Host OS provides them with a runtime-environment

⇒ But virtualization layer replaces a part of this runtime environment and gives a virtual environment to the virtualized applications.

Types of Virtualization:

Desktop - Virtualization.	
Types [Virtual desktop infrastructure Hosted Virtual desktop	ex:- Citrix, Xen desktop
Data - Virtualization	
Types → Databases	ex:- e-commerce websites, web-portals etc.
Software - Virtualization	
Types → [OS Level Virtualization Application " Service "	ex:- Virtual box, VMware etc.
Memory - Virtualization	
Types → [Software base Hardware Assisted.	Memory virtualization in paging and segmentation.
Storage - Virtualization	
Types → Block & File Virtualization	ex:- windows Storage spaces.
N/w Virtualization	
Types → Internal & External	ex:- Virtual LAN (VLAN)
Hardware - Virtualization	
Types → Full, Para, Partial	ex:- Microsoft hyperV, Xen etc.

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① Hardware Virtualization: (also known as Server Virtualization).

(2.9)

⇒ In h/w virtualization, multiple physical segments of hardware or physical servers are consolidated into one virtual server and provides services to the users.

⇒ The hardware resource allotment is done by the hypervisor.

Types:

Full Virtualization:

In this type, the complete simulation of the actual hardware takes place to allow the s/w to run an unmodified guest OS.

Para Virtualization:

In this type, s/w unmodified runs in modified OS as a separate system.

Partial Virtualization:

In this type of h/w virtualization, the s/w may need modification to run.

② Network Virtualization:

Network virtualization is a method of n/w, combining the available resources in a n/w, to consolidate multiple physical networks, divide the network into segments or create s/w networks b/w virtual machines (VMs).

Types: ~~Entered~~.

Internal: Provide n/w like functionality to a single system.

External: Combine many networks or parts of n/ws into virtual unit.

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3) Storage Virtualization:

In this type of virtualization, multiple physical storage devices are grouped together, which then appear as a single ~~unit~~ storage device for easier and more efficient management of these resources.

Types of Storage Virtualization:

i) Block Virtualization:

Multiple storage devices are consolidated into one.

ii) File Virtualization:

Storage system grants access to files that are stored over multiple hosts.

4) Memory Virtualization:

⇒ Physical memory across different servers is aggregated into a single virtualized memory pool.

⇒ It enhances performances by providing greater memory capacity without any addition to the main memory.

Types of Memory Virtualization:-

(i) S/w based memory Virtualization:

Guest's physical memory is virtualized by adding an extra level of address translation.

(ii) H/w Assisted Memory Virtualization: In this type Some CPUs such as AMD SVM-V and intel Xeon 5500 series, provides h/w support to memory virtualization by using ~~[illegible]~~ different types (layers) of page tables.

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5) Software Virtualization: (Application Virtualization) (2-11)

⇒ It provides the ability to the main computer to run and create one or more virtual environments.

⇒ One S/w is physical while others are virtual as it allows 2 or more OS using only one computer

Types of S/w Virtualization:

(i) Operating System Virtualization:
In OS virtualization, the h/w is used which consists of software on which different OSs work.

(ii) Application Virtualization:
It is a S/w technology that encapsulate computer programs from the underlying operating system on which they are executed.

(iii) Service Virtualization:
Service virtualization is a method that helps us to emulate the behaviours of the component in heterogenous component based applications such as API-driven applications, cloud-based applications and Service Oriented architectures.

6) Data Virtualization:-
Data Virtualization is the process of retrieving data from various resources without knowing its type and physical location where it is stored.

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⇒ It collects heterogenous data from different resources and allows data users across the organization to access this data according to their requirements. (2.12)

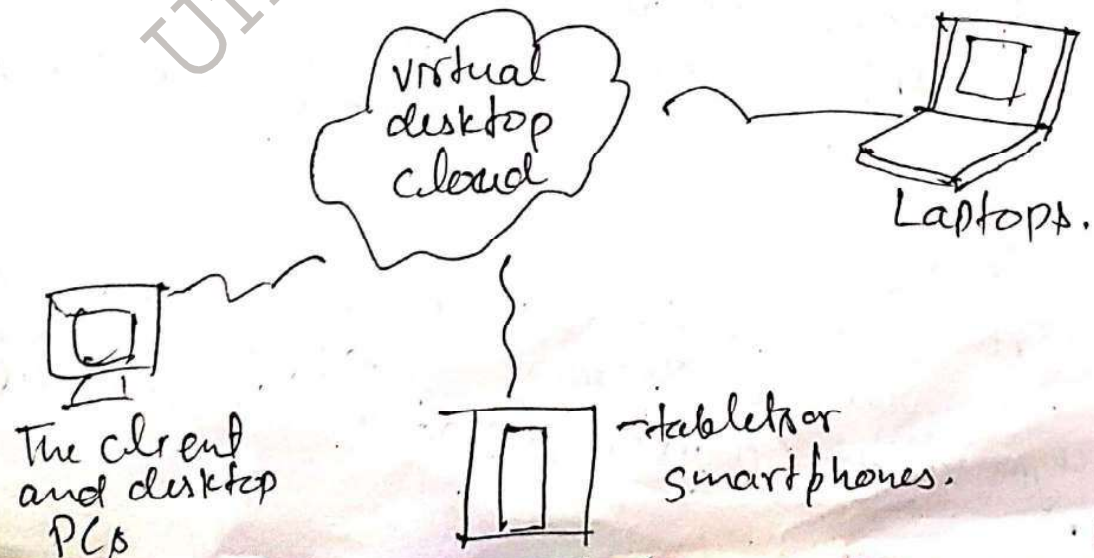
⇒ This heterogenous data can be ~~used~~ accessed using any application such as web portals, web services, E-commerce, SaaS and mobile applications.

7) Desktop Virtualization:

⇒ The user's desktop is stored on a remote server, which allows the user to access his desktop from any device or location.

⇒ It provides work convinience and security.

⇒ It also protects confidential data from being lost or stolen by keeping it safe on central servers.



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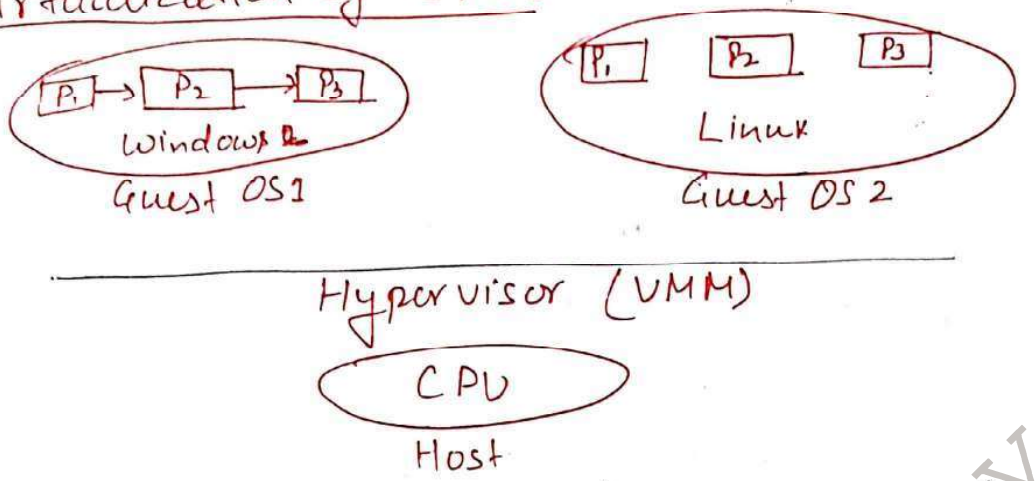
Virtualization of CPU, Memory & I/O devices

2-13

Virtualization of CPU:-



⇒ CPU virtualization involves a single CPU acting as if it were multiple separate CPUs.

⇒ This allows an OS to more effectively & efficiently utilize the CPU power in the computer so that it runs faster.

⇒ All the programs and instructions are running through virtual machines giving the feeling like physical workstations

⇒ All the operations are handled by an emulator that controls software to run according to it.

Types:-

1) Software based CPU Virtualization:-

⇒ The CPU virtualization is S/W based where with the help of it, application code gets executed on the processor and the privileged code gets translated first and that translated code gets executed directly on the processor.

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⇒ The translation process used here is k/a Binary Translation (BT).

(2.14)

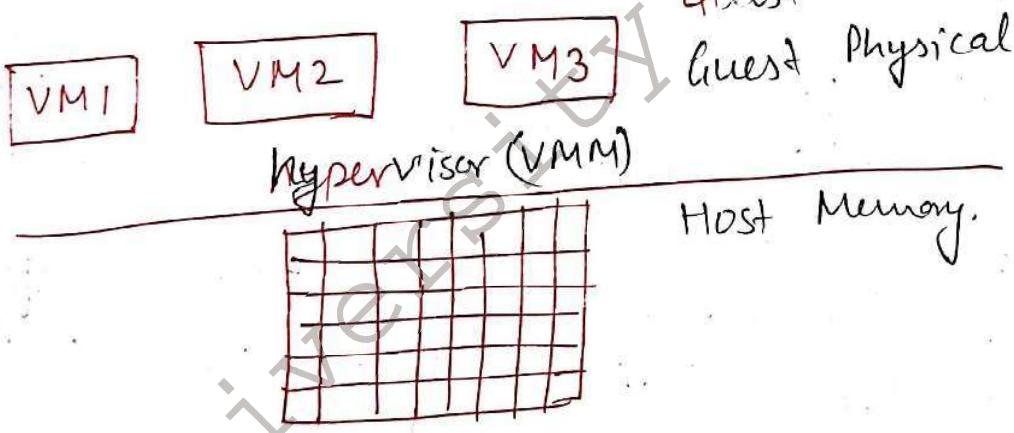
(ii) Hardware Assisted CPU Virtualization:

⇒ In h/w assisted CPU virtualization the h/w gets assistance from certain processors but it also requires hypervisor for creating virtual machine.

⇒ In this method there is no requirement of translation.

⇒ The system calls runs faster than expected.

Virtualization of Memory:



Memory virtualization is the process of consolidating random memory access resources from individual systems in the data centres, aggregates them and then provides them to the individual users with the help of virtualization using hypervisors.

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Basically three layers of memory are present

(2-18)

1) Host Machine Memory:

Provides a contiguous memory space for use by the virtual machine.

2) Guest Operating System Physical Memory:

Presented to the VM (virtual Machine) by VMkernel.

3) Guest Operating System Virtual ~~Machine~~ Memory:

Presented to applications by the guest Operating System.

Process of Memory Virtualization:

Two key concepts are used in the process of Memory Virtualization.

1) Mapping
2) Shadow Page Table

1) Mapping:

Mapping is required here for providing host's physical memory to the users with the help of virtualization. i.e. hypervisor creates different virtual copies of the same memory and provides them to the different users.

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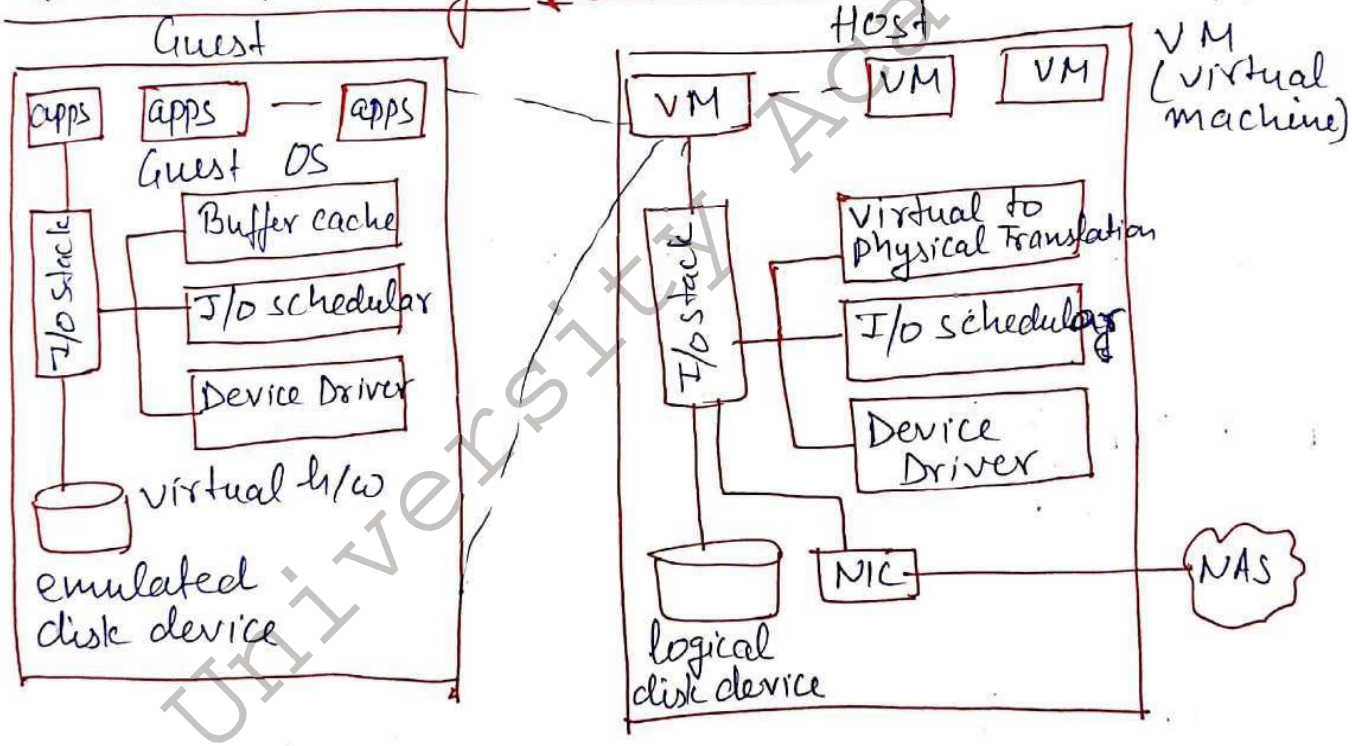
2) Shadow Page Table:

* Shadow Page Tables are used by the hypervisors to keep track of the state in which the guest defines the allocations or gives the info about the allocation of resources.

* It provides the record ~~that~~ of the resources allocated to the users i.e. how many virtual machines have been created actually.

Virtualization of I/O devices:



⇒ I/O device virtualization is the process of providing I/O devices (resources) ~~to the~~ from Host to the user virtually. i.e. virtual machine of the I/O resources are created and provided to the user.

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Process of I/O device Virtualization :-

(2-17)

1) User made a request for the I/O devices with the help of guest OS.

2) All the requests of the user are put into the I/O stack of the guest OS.

3) Guest OS provides various facilities like Buffur caching, I/O scheduling & also consists of device driver.

4) With the help of emulated disk device or emulator all the requests are sent to the Host i.e. to the virtual machine of the host.

5) All the requests are store in the I/O stack of Host and checked by the hypervisor.

6) Different virtualized copy of resources are created from the host side and stored.

7) If any request is made for any resource (i.e. for I/O device) then with the help of hypervisor different VM are created and provided to the different users.

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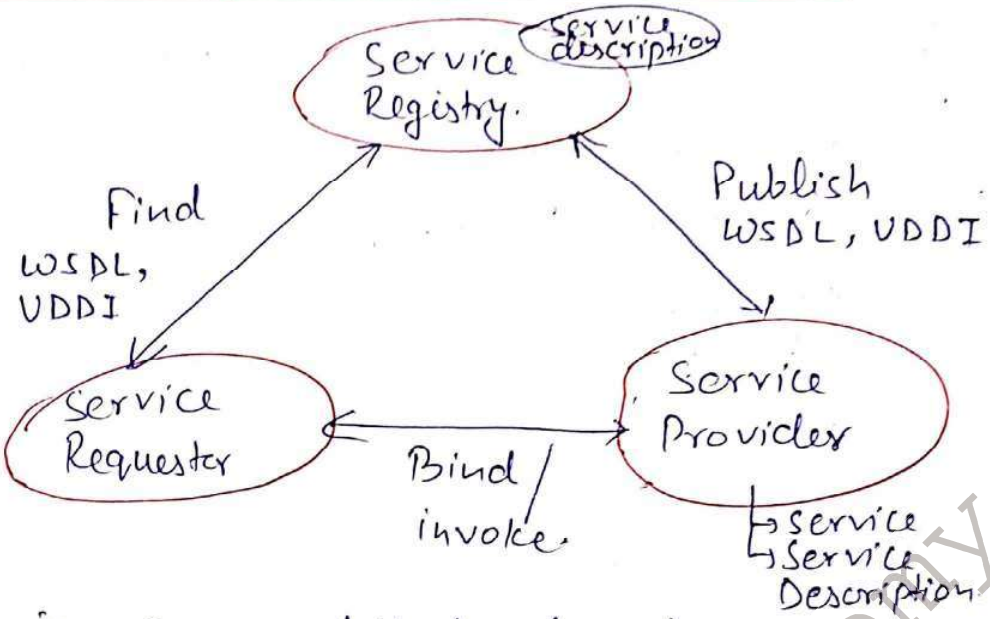
SOA (Service Oriented Architecture) :-



⇒ SOA is an architectural frame-work in which different services provided by the service provider communicates with each other.

⇒ It describes a standard method for requesting services from distributed components and after that the result or outcome is managed.

⇒ SOA provides a translation and management layer within the cloud architecture that removes the barrier for cloud clients obtaining desired services.

ex:- Suppose if we are using any service over the cloud and we want to incorporate some other service with previous one then SOA can be used for the communication b/w those services.

ex. ⇒ Online printing of credit card statements.
⇒ Putting some add-on services to google docs.
⇒ Using location services in some other applications. etc.

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Components of SOA:

Basically it consists of 3- components.

1) Service Provider
2) Services Consumer (Requester)
3) Service Registry

1) Service Provider:

* Service provider will create the services and provide them to the user.
* After creating the services provider will convert them in WSDL format and by using UDDI request for the service registry is made to the service directory.
* So basically it is the platform which will host the services.

2) Service Consumer:

* Service consumer is the entity who will actually use the services.
* Service consumer requests to the provider for invoking the services.
* The browser plays the requestors role driven by a consumer.
* services consumer searches within the service directory for finding the services of their need.

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3) Service Registry :

Service requestor finds services and obtain binding infor for services during development.

Operations used in SOA :

i) Publish : for publication of service descriptions
ii) Find : Finding of any service descriptions.
iii) Bind : Invoking of services based on service descriptions.

Benefits of SOA :

1) Greater Buisiness Agility.
2) Ability to leverage legacy functionality in new markets.
3) Improved Collaboration b/w busines & IT.
4) Platform independent.
5) Availability
6) reliability
7) Service Reusability
8) Scalability

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Guiding Principles of SOA:

(2-21)

1) Standardized Service Contract.
2) Loose - Coupling.
3) Abstraction
4) Reusability
5) Discoverability.
6) Composability.

Disadvantages:

1) High - Overhead.
2) High investment
3) Complex Service Management

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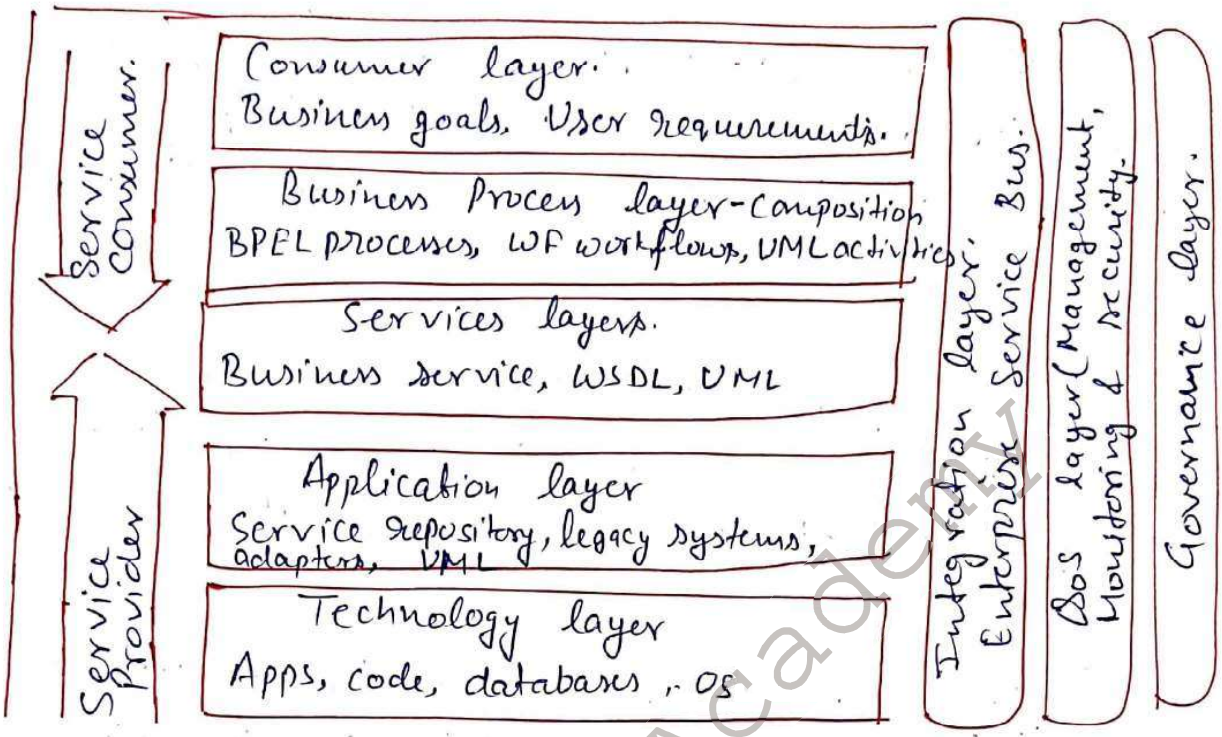
SOA Reference Model & layered Architecture of SOA

(2.22)



⇒ The goal of SOA reference model is to provide a blueprint for creating or evaluating architecture.

⇒ It provides the insights, patterns and the building blocks for integrating fundamental elements of SOA into a solution or enterprize architecture.

SOA reference model consists of following layers.

* Technology layer
* Application layer
* Services layers
* Business Process Layer
* Consumer layer
* Integration layer
* QoS layer
* Governance Layer

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Functions of Each layers :-

(2.23)

1) **Technology Layer :-** This layer consists of variety of application, databases, code and operating system with the help of which service provider can create their services.

2) **Application Layer :-**

⇒ This layer basically serves as the service repository of service provider, where variety of services can be stored at a common place.

⇒ These services are ideally reusable ~~services~~ utility services which can be used by the service consumer.

⇒ Various service adapters are used here for integrating and transfering services to the next level. The various adapters that can be used here are as follows —

* FTP and File → For file exchange.
* JMS (Java Messaging Services)
* Message Queue. → For message exchange.
* Sockets → For Modeling standards.

⇒ UML can also be used in this layer for modeling of services which provide a stand standard way to visualize the design of the system.

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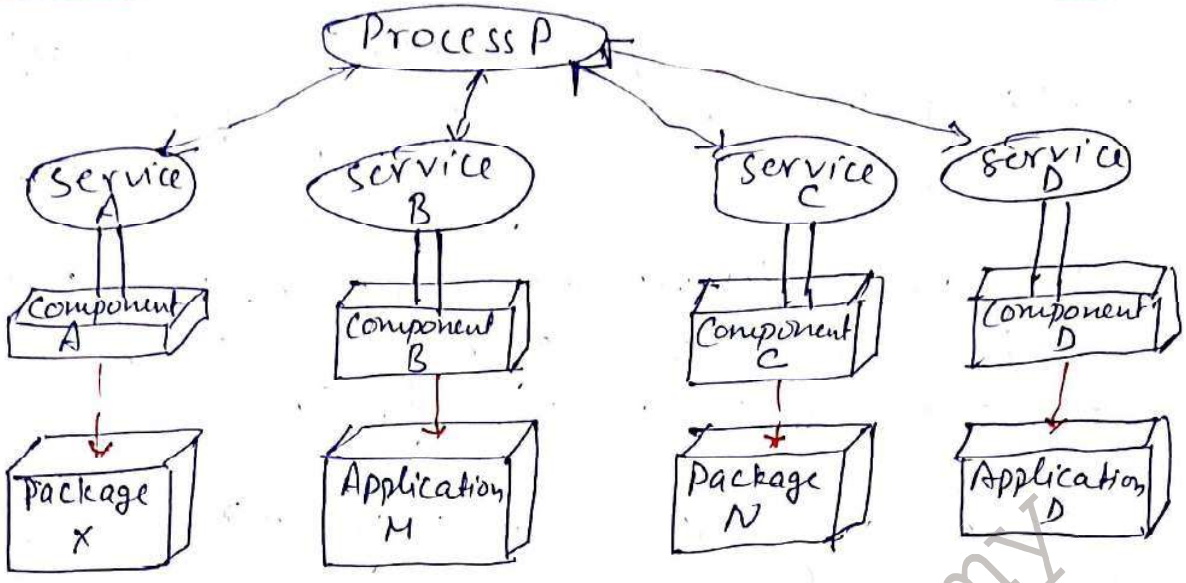
Services Orchestration :-



⇒ Service orchestration can be defined as the coordination and arrangement of multiple services exposed as a single service.

⇒ Service orchestration works through the exchange of messages in the domain layer of enterprize-applications.

Consumer-Layers

⇒ Consumer layer is the point where consumer interact with SOA.

⇒ It is the entry point for interactive consumers and services from external sources.

⇒ In this layer all the services are presented in such a form that user can view ~~are~~ it and utilize it.

⇒ Backend integration is accomplished in this layer for integrating consumer layer with backend and legacy systems using SOAs so that users can use it according to their need.

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Service Layer:

This layer consists of all the services defined within the SOA. Basically it defines the functional capabilities of all the services.

The service descriptions, contracts, and policies are given in this layer using predefined standards, and various formats.

The various responsibilities of service layer are as follows —

⇒ To identify and define services

⇒ To provide a container which houses the services.

⇒ To provide a registry that virtualizes runtime service access.

~~To provide a~~

Business Process Layer:

⇒ This layer supports and manages business processes and enables the SOA to orchestrate services to realize business processes.

⇒ This layer covers process representation and composition and provides building blocks for aggregation.

⇒ This layer includes infon exchange flow between participants (individual user or business entities), resources and processes.

⇒ BPEL and WF workflows are used for supporting business processes.

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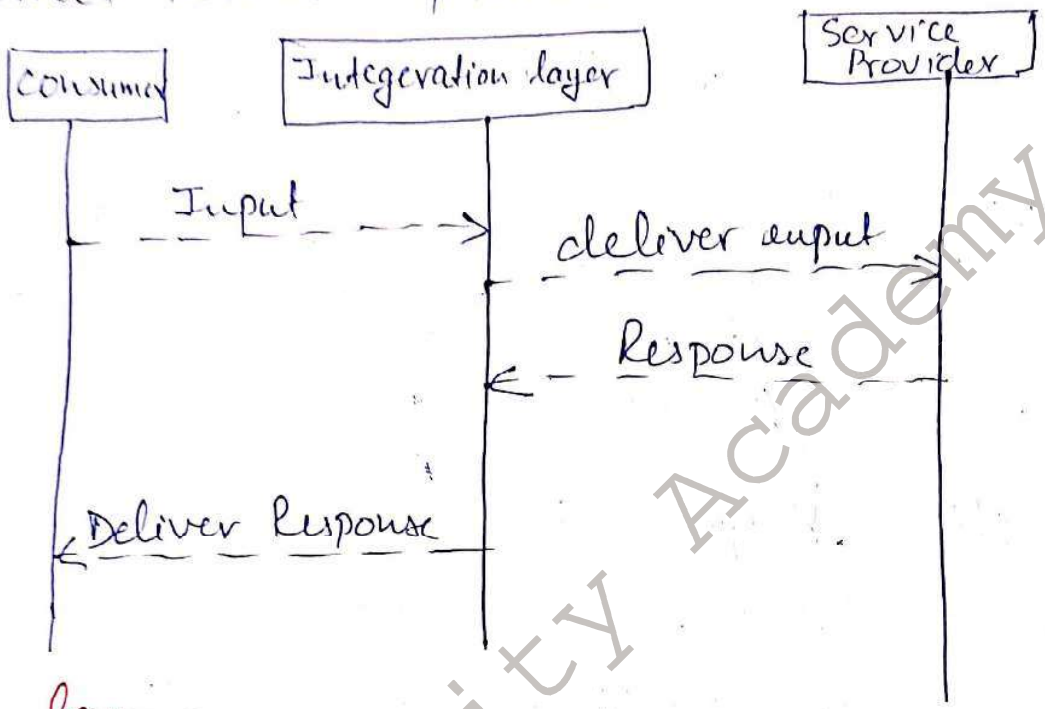
Integration - Layer :

This layer provides the capability to mediate which includes transformation, routing and protocol conversions to transport service requests from the service requester to the correct service provider.



QoS layer:

This layer provides solution QoS mgmt of various aspects such as availability, reliability, security and safety as well as mechanism to support, track, monitor and manage solution QoS control.

Activities Performed in this layer:

1) Command and Control Management.
2) Security Management
3) IT system Monitoring & Management.
4) Application monitoring & Management.

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5) Business Activity Monitoring & Management. (2-27)

6) Event Management.

7) Policy Monitoring & Enforcement.

Governence Layer:

This layer ensures that the services and SOA solutions within an organization are adhering to the defined policies, guidelines and standards that are defined as a function of objective, strategies and regulations applied in the organization.

Activities Performed:

1) Defines Policies & compliance.
2) Monitors the health of SOA services.
3) Provides a consolidation point of business rules.

This layer includes both SOA governance as well as service governance.

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Web Services:

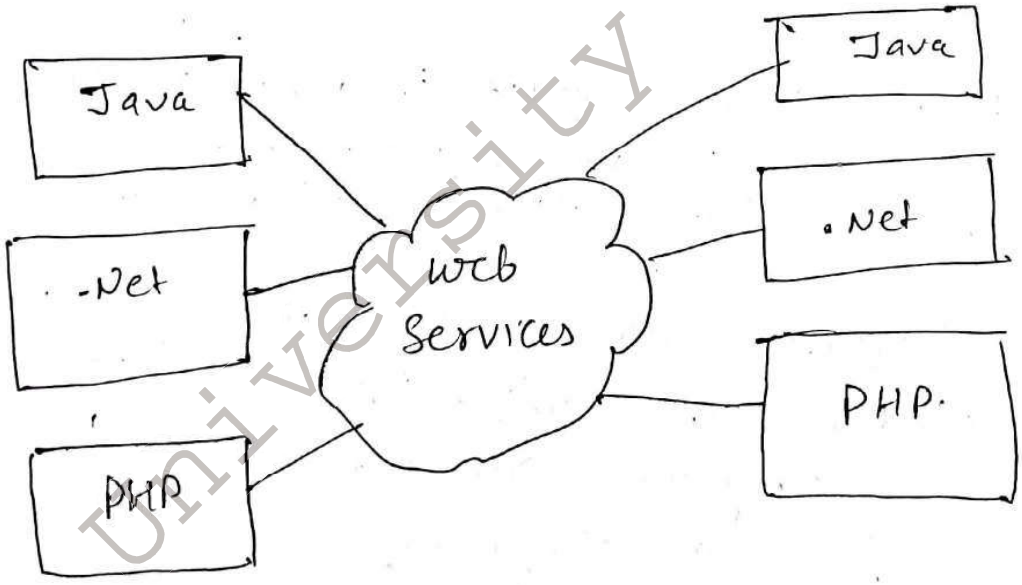
⇒ A web service is a collection of open protocols and standards used for exchanging data b/w applications or system.

⇒ It is a technology to communicate one programming language with another.

ex:- java programming language can communicate with PHP and .Net by using web services.

~~It is a s/w system for machine to machine communication.~~ interoperable

⇒ The web services can be searched for over the internet and can also be invoked accordingly.



⇒ When invoked, the web services would be able to provide the functionality to the client, which invokes that web service.

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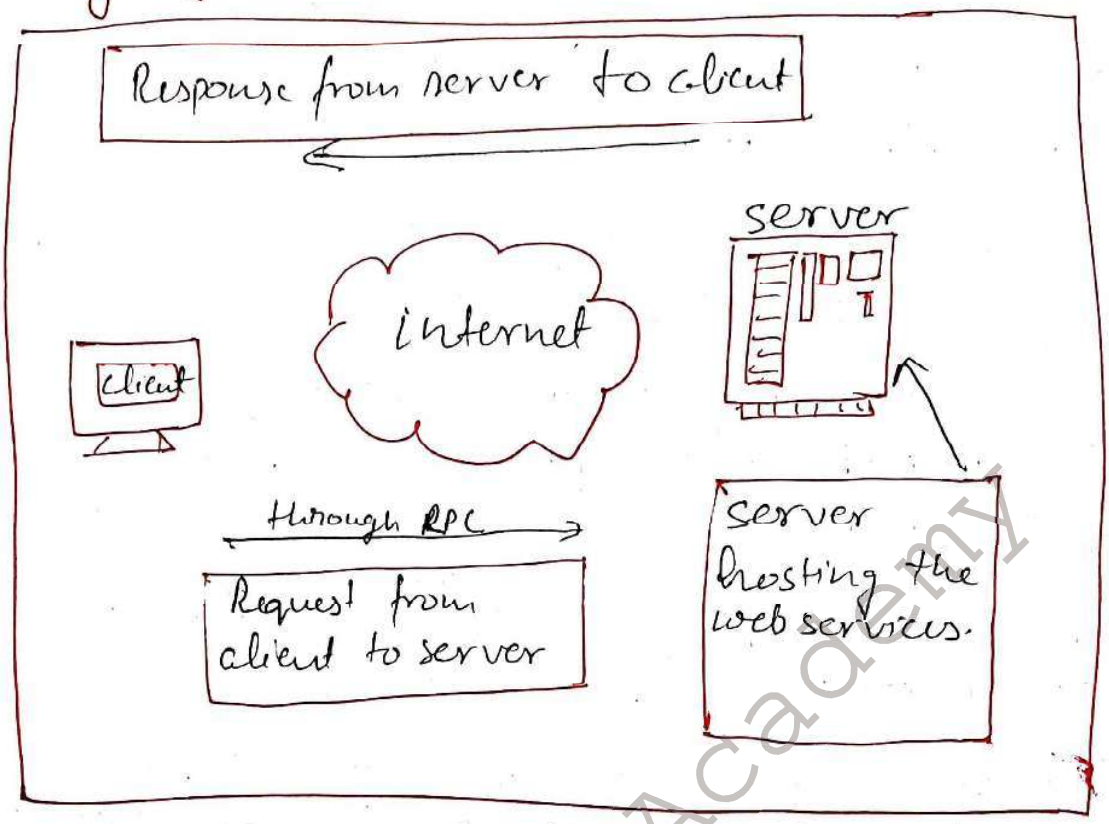
Working of web-services: ~~Architecture~~



Steps:-

) The client would request (invoke) a series of web service calls via requests to a server which would host the actual web service.

) These requests are made through RPC (Remote Procedure Calls). RPC is a protocol that one program can use to request a service from a program.

.) The data which is transferred b/w client and server is in XML, i.e the applications can talk to each other in XML.

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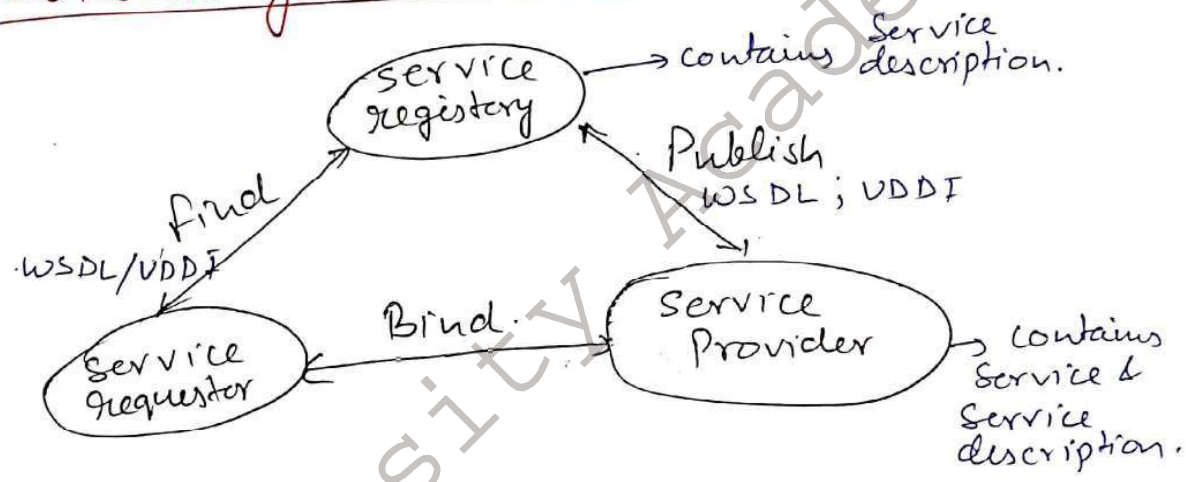
4) web services use SOAP protocol (Simple Object access Protocol) for sending the XML data b/w applications.

2.30

5) The data is sent over HTTP.

6) The data which is sent from the web service to the application is called SOAP message, which is actually an XML document.

Architecture of web services:-



Roles in web Service Architecture:-

There are basically three roles in web service architecture.

i) Service Provider :-

It is the platform that hosts the services.

(ii) Service Requestor:-

* It is the application that is looking for and involving or initiating an interaction with a service.

* The browser plays the requestor role, driven by a consumer.

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(iii) Service Registry :

(2-31)

Service requesters finds services and obtain binding infon. for services during development

Operations in web Service Architecture :

(i) Publish : for publication of service descriptions.

(ii) Find : Finding of any service descriptions

(iii) Bind : Invoking of service based on service descriptions.

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REST (Representational State Transfer)

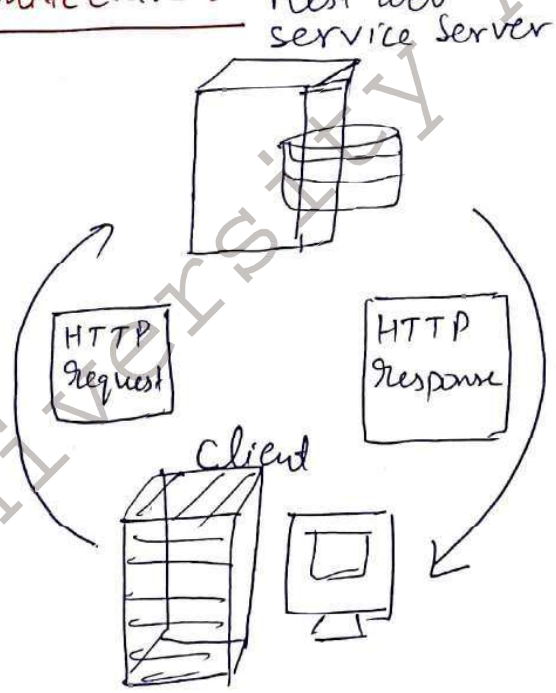
↳ a term coined by Roy Fielding in 2000.

It is an architectural style for designing loosely coupled applications over HTTP, that is often used in the development of web-services.

web services which follow the REST architectural style are known as RESTful web services.

Interaction in REST based system happen through ~~Hyper text~~ hypertext transfer Protocol (HTTP).

REST Architecture :



Basically it consists of :-

i) A client who request for the resources.

(ii) A Server who has the resources.

ex:- Facebook, twitter, Google etc. exposes their functionality in the form of Restful web services

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Architectural Constraints of RESTful API :-

(2.33)

There are six architectural constraints which can be used for implementing web services.

1) Uniform Interface:-

It suggests that there should be an uniform way of interacting with a given server irrespective of device or type of application. (website, mobile app).

There are four guidelines principles of uniform interface are:-

a) **Resource based:-**

Individual resources are identified in requests. ex:- API/users.

b) **Manipulation of resources through representations:-**

Client contain enough infor to modify or delete the resource on the server, provided it has permission to do so.

c) **Self descriptive Message:-**

Each message includes enough infor to describe how to process the message so that server can easily analyses the request.

d) **Hypermedia as the Engine of Application State (HATEOAS):-**

It needs to include links for each response so that client can discover other resources easily.

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2. Stateless:

It means that the necessary state to handle the request is contained within the request itself and server would not store anything related to the session. i.e. client must include all the information.

3. Cacheable:

Every response should include whether the response is cacheable or not and for how much time response can be cached at the client side.

4. Client - Server:

REST API should have a client-server architecture.

Client can request for resources and not concerned with data storage.

Server holds the resources and are not concerned with user interface. or user state.

5. Layered System:

An application architecture needs to be composed of multiple layers, Each layer doesn't know anything about any ~~other~~ layer other than that of immediate layer.

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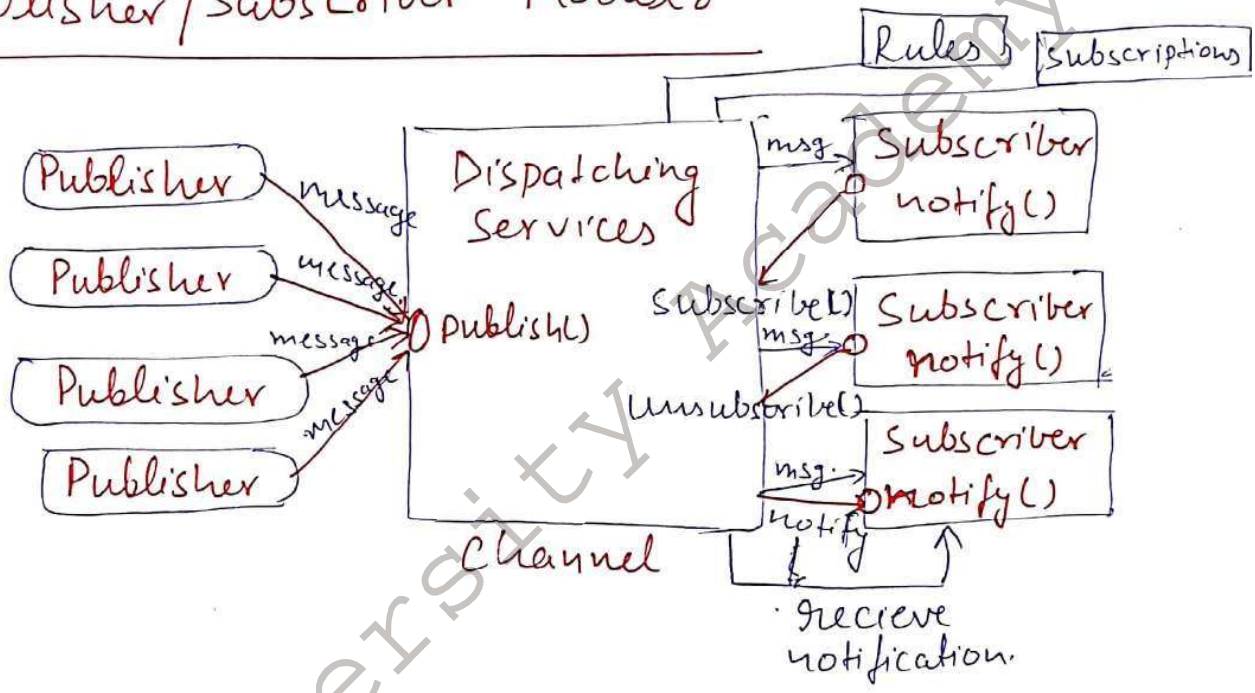
There can be lot of intermediate servers b/w client and server. 2.35

6- Code - on - demand:

It is optional feature.

Server can provide executable code to the client if demanded.

Publisher/Subscriber Model:



1- Publisher:

Publisher will publish the services i.e. post services or send messages to the channel.

2- Subscriber:

Subscribe to a category of messages.

3- Channel:

Receives messages from publisher and maintain subscriber subscription.

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Disadvantages of Publisher - Subscriber Model:

(2.36)

1) Inflexibility of data sent by the publisher.
↳ i.e. changing the format of the message is not an easy task. It ~~req~~ requires affirmation of all the publishers.

2) **Instability of Delivery:**

i.e. Publisher does not have the perfect idea of the subscriber, sometimes unwanted or false subscribers can be there.

3) **Bottleneck:**

Sometimes load surges can slow down message sending, and subscriber gets a spike in the response time.

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Process:

* If publisher wants to publish any content using the channel, he sends the message to the channel using publish command.

* As soon as the content is published to the channel, all the subscribers gets a notification regarding the same and can check the content also.

* The activities that the subscriber can perform are :-
  (i) Subscriber can subscribe to the channel
  (ii) Subscriber can unsubscribe from the channel.

* Subscriber follows the rules & subscription methods provided by the channel.

* Advantages of Publisher - Subscriber Model :

1) Low coupling on the publisher's end.
2) Reduced Cognitive load on the subscribers.
3) Separation of concerns
4) Improved testability
5) Improved Security.

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