



INDIAN INSTITUTE OF  
INFORMATION  
TECHNOLOGY

# Cloud Computing Architecture

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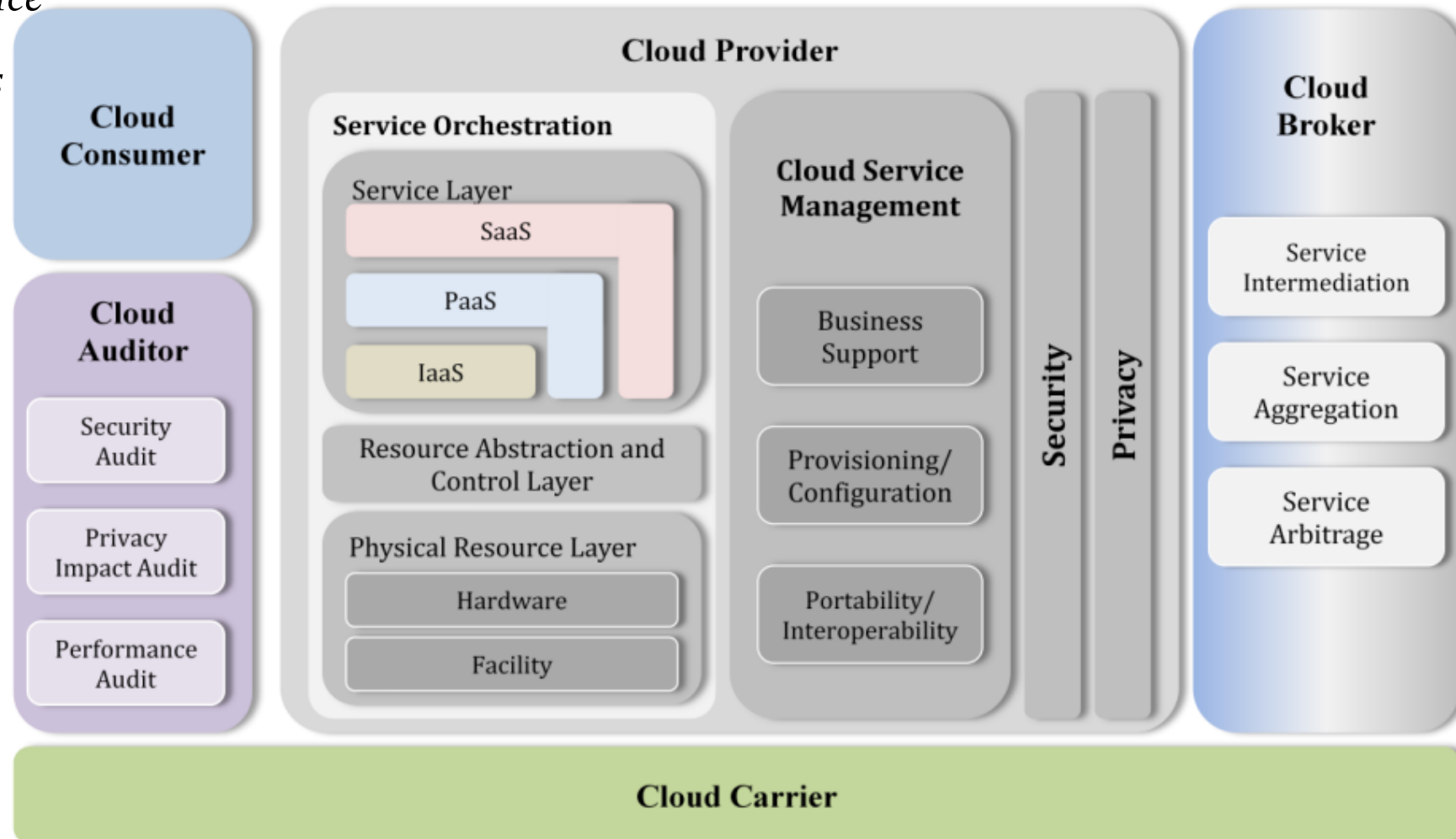
Indian Institute of Information Technology,  
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# NIST Cloud computing architecture

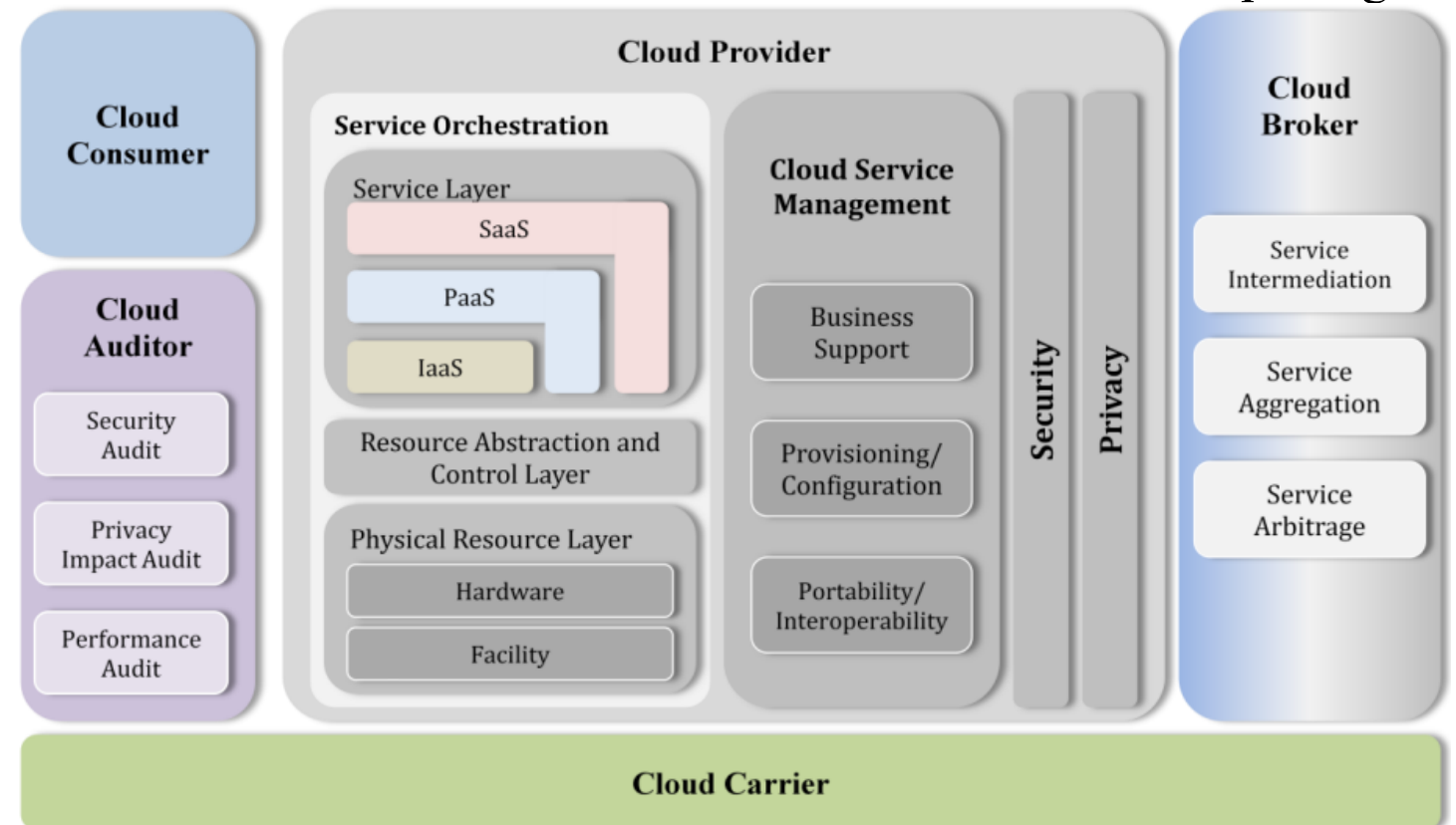
# Cloud Service Characteristics

- *On demand self-service*
- *Broad network access*
- *Resource pooling*
- *Rapid elasticity*
- *Measured service*

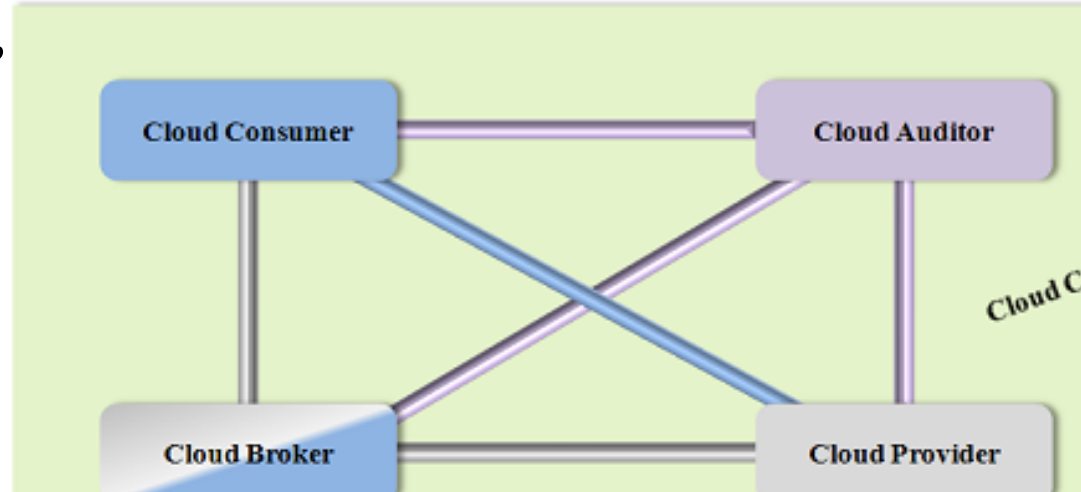


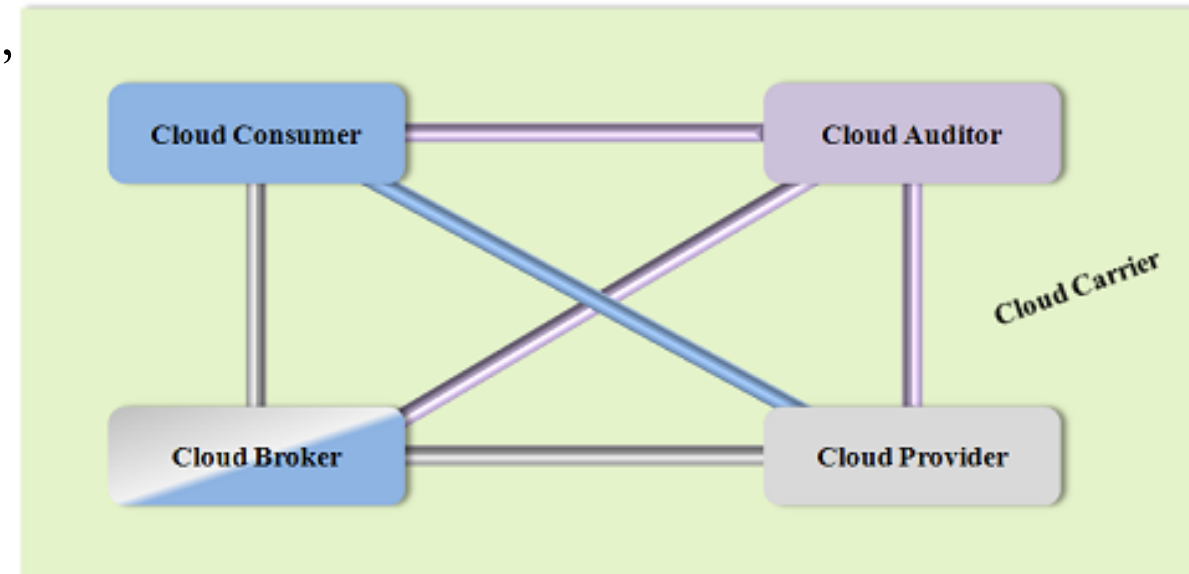
# Cloud Conceptual Reference Model

- Cloud High-level architecture
  - Five major actors with their roles, responsibilities, activities and functions in cloud computing.
  - Understanding of the requirements, uses, characteristics and standards of cloud computing.
1. *Cloud Consumer*
  2. *Cloud Provider*
  3. *Cloud Broker*
  4. *Cloud Auditor*
  5. *Cloud Carrier*



# Actors in Cloud Computing

- **Cloud Consumer** A person or organization that maintains a business relationship with, and uses service from, *Cloud Providers*.
  - **Cloud Provider** A person, organization, or entity responsible for making a service available to interested parties.
  - **Cloud Auditor** A party that can conduct independent assessment of cloud services, information system operations, performance and security of the cloud implementation.
  - **Cloud Broker** An entity that manages the use, performance and delivery of cloud services, and negotiates relationships between *Cloud Providers* and *Cloud Consumers*.
  - **Cloud Carrier** An intermediary that provides connectivity and transport of cloud services from *Cloud Providers* to *Cloud Consumers*.
- 
- The diagram illustrates the relationships between four entities in a cloud service ecosystem: Cloud Consumer, Cloud Auditor, Cloud Broker, and Cloud Provider. These entities are arranged in a square layout. The Cloud Consumer (top-left, blue box) and Cloud Auditor (top-right, purple box) are connected by a horizontal line. The Cloud Broker (bottom-left, blue box) and Cloud Provider (bottom-right, grey box) are connected by a horizontal line. Vertical lines connect the Cloud Consumer to the Cloud Broker and the Cloud Auditor to the Cloud Provider. Diagonal lines connect the Cloud Consumer to the Cloud Provider and the Cloud Auditor to the Cloud Broker. A label 'Cloud C' is partially visible on the right side of the diagram.



# Scenarios in Cloud: 1

1. Cloud consumer interacts with the cloud broker instead of contacting a cloud provider directly.
2. The cloud broker may create a new service (mash up) by combining multiple services or by enhancing an existing service.
3. Actual cloud providers are invisible to the cloud consumer.



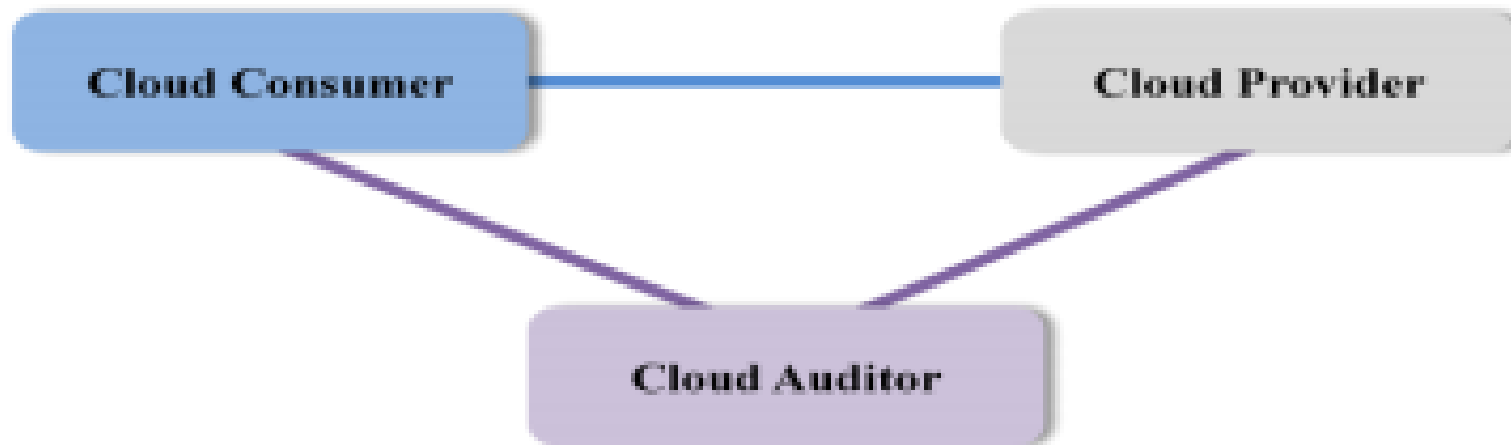
# Scenarios in Cloud: 2

1. Cloud carriers provide the connectivity and transport of cloud services from cloud providers to cloud consumers.
2. Cloud provider participates in and arranges for two unique service level agreements (SLAs), one with a cloud carrier (e.g. SLA2) and one with a cloud consumer (e.g. SLA1).
3. A cloud provider may request cloud carrier to provide dedicated and encrypted connections to ensure the cloud services (SLA's).



# Scenarios in Cloud: 3

1. Cloud auditor conducts independent assessments for the operation and security of the cloud service.
2. The audit may involve interactions with both the Cloud Consumer and the Cloud Provider.

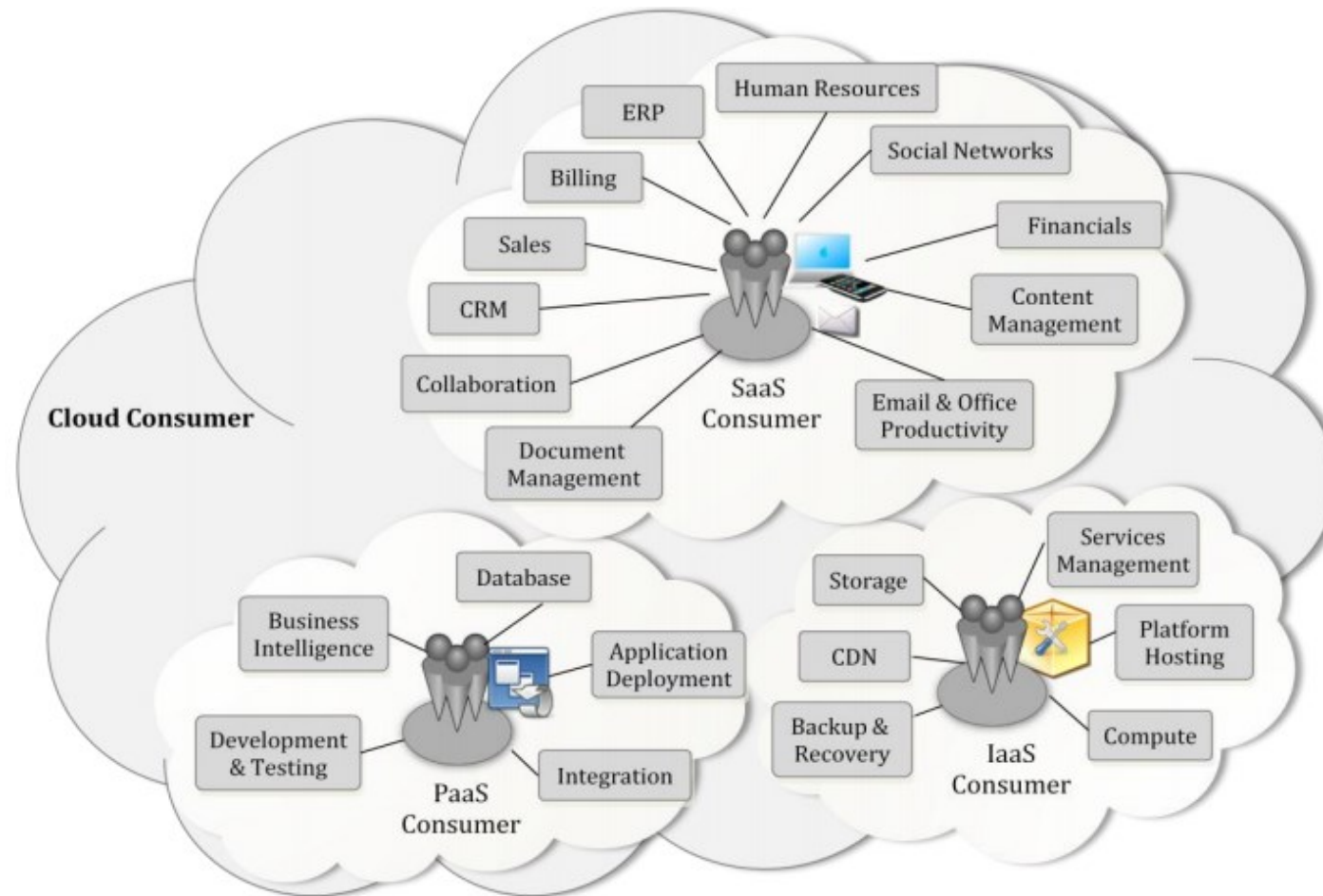




# Cloud Consumer

- Cloud consumer browses & uses the service.
- Cloud consumer sets up contracts with the cloud provider.
- Cloud consumers need SLAs to specify the technical performance requirements fulfilled by a cloud provider.
- SLAs cover the quality of service, security, remedies for performance failures.
- A cloud provider list some SLAs that limit and obligate the cloud consumers by must acceptance.
- Cloud consumer can freely choose a cloud provider with better pricing with favorable conditions.
- Pricing policy and SLAs are non-negotiable.

# Cloud Consumer



# SaaS consumers

- SaaS consumers can be organizations that provide their members with access to software applications, end users who directly use software applications, or software application administrators who configure applications for end users.
- SaaS consumers can be **billed** based on the number of end users, the time of use, the network bandwidth consumed, the amount of data stored or duration of stored data.

# PaaS consumers

- PaaS consumers can be application developers or administrators
  1. who design and implement application software
  2. application testers who run and test applications
  3. who publish applications into the cloud
  4. who configure and monitor application performance.
- PaaS consumers can be **billed** according to, processing, database storage and network resources consumed by the PaaS application, and the duration of the platform usage.

# IaaS consumer

- IaaS consumer can be system developers, system administrators and IT managers who are interested in creating, installing, managing and monitoring services for IT infrastructure operations.
- IaaS consumer can be **billed** according to the amount or duration of the resources consumed, such as CPU hours used by virtual computers, volume and duration of data stored, network bandwidth consumed, number of IP addresses used for certain intervals.

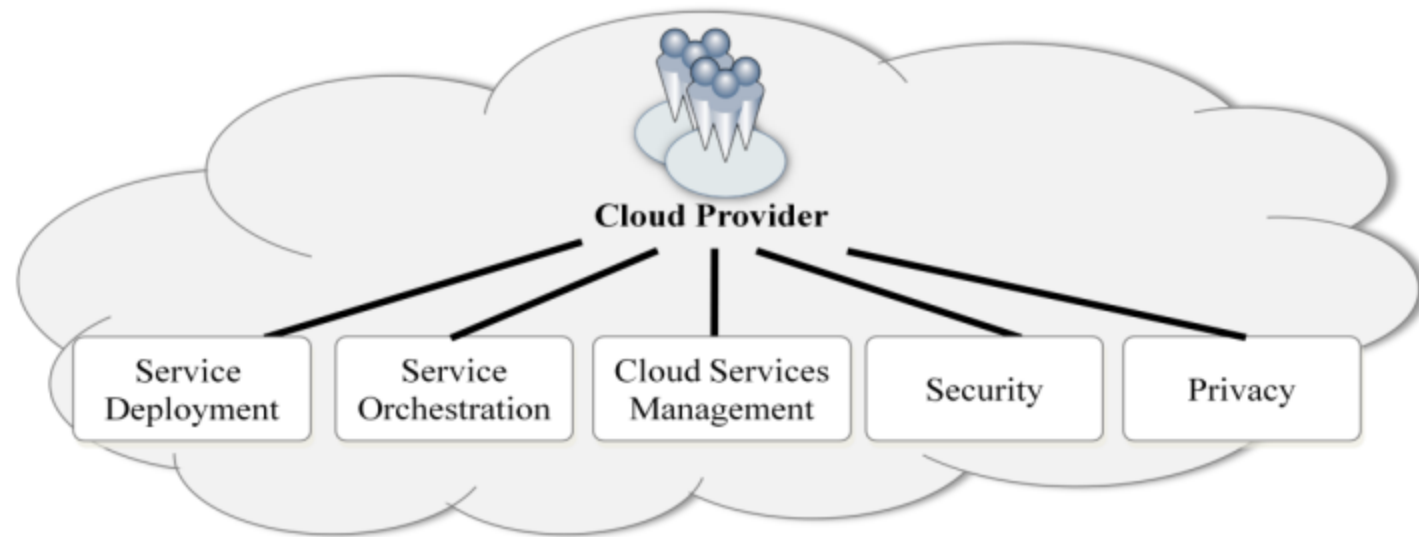
# Cloud Provider

- Cloud Provider acquires and manages the computing infrastructure required for providing the services, runs the cloud software that provides the services, and makes arrangement to deliver the cloud services to the Cloud Consumers through network access.
- SaaS provider deploys, configures, maintains and updates the operation of the software applications on a cloud infrastructure. SaaS provider maintains the expected service levels to cloud consumers.
- PaaS Provider manages the computing infrastructure for the platform and components (runtime software execution stack, databases, and other middleware).
- IaaS Cloud Provider provides physical hardware and cloud software that makes the provisioning of these infrastructure services, for example, the physical servers, network equipments, storage devices, host OS and hypervisors for virtualization.

# Cloud Provider

Five major activities of Cloud Provider's

- *Service deployment*
- *Service orchestration*
- *Cloud service management*
- *Security*
- *Privacy*



NIST Cloud Computing Reference Architecture

# Cloud Auditor

- Audits are performed to verify conformance to standards.
- Auditor evaluates the security controls, privacy impact, performance, etc.
- Auditing is especially important for federal agencies.
- Security auditing, can make an assessment of the security controls to determine the extent to which the controls are implemented correctly, operating as intended, and producing the desired outcome. This is done by verification of the compliance with regulation and security policy.
- Privacy audit helps in Federal agencies comply with applicable privacy laws and regulations governing an individual's privacy, and to ensure confidentiality, integrity, and availability of an individual's personal information at every stage of development and operation.



# Cloud Broker

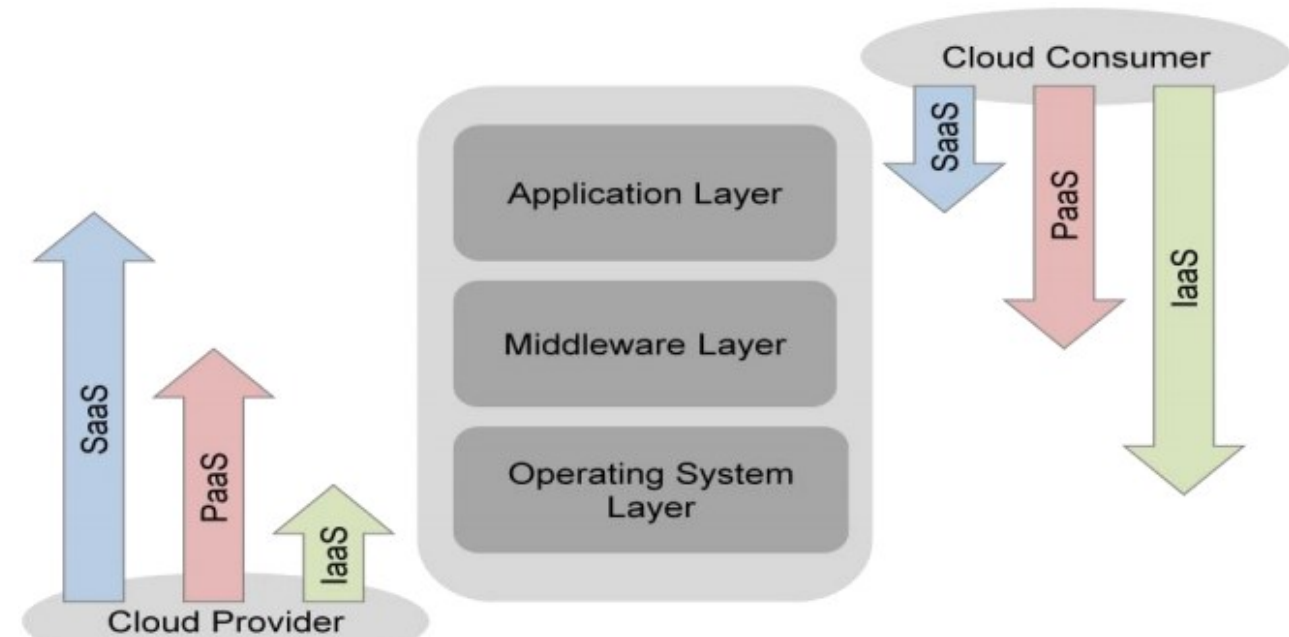
- Integration of cloud services can be complex for consumers. Hence cloud broker, is needed.
- Broker manages the use, performance and delivery of cloud services and negotiates relationships between cloud providers and cloud consumers.
- In general, a cloud broker can provide services in three categories:
  - *Service Intermediation*: Broker enhances a service by improving capability and providing value-added services to consumers. The improvement can be managing access to cloud services, identity management, performance reporting, enhanced security, etc.
  - *Service Aggregation*: Broker combines and integrates multiple services into one or more new services. The broker provides data integration and ensures the secure data movement.
  - *Service Arbitrage*: It is similar to service aggregation with the flexibility to choose services from multiple agencies. For example, broker can select service with the best response time.

# Cloud Carrier

- Cloud carriers provide access to consumers through network, telecommunication and other access devices.
- For example, cloud consumers can obtain cloud services through network access devices, such as computers, laptops, mobile phones, mobile internet devices (MIDs), etc.
- The distribution of cloud services is normally provided by network and telecommunication carriers or a *transport agent*, where a transport agent refers to a business organization that provides physical transport of storage media such as high-capacity hard drives.
- Cloud provider can set up SLAs with a cloud carrier to provide services consistent with the level of SLAs offered to cloud consumers.

# Scope of Control between Provider and Consumer

- Application layer are used by SaaS consumers, or installed/managed/ maintained by PaaS consumers, IaaS consumers, and SaaS providers.
- Middleware is used by PaaS consumers, installed/managed/maintained by IaaS consumers or PaaS providers. Middleware is hidden from SaaS consumers.
- IaaS layer is hidden from SaaS consumers and PaaS consumers. Consumers have freedom to choose OS to be hosted.



NIST Cloud Computing Reference Architecture

<https://sites.google.com/site/animeshchaturvedi07/academic-teaching/cloudcomputing>

# Cloud Services

Application (SaaS)

Platform (PaaS)

Infrastructure (IaaS)

Cloud

# Cloud Services

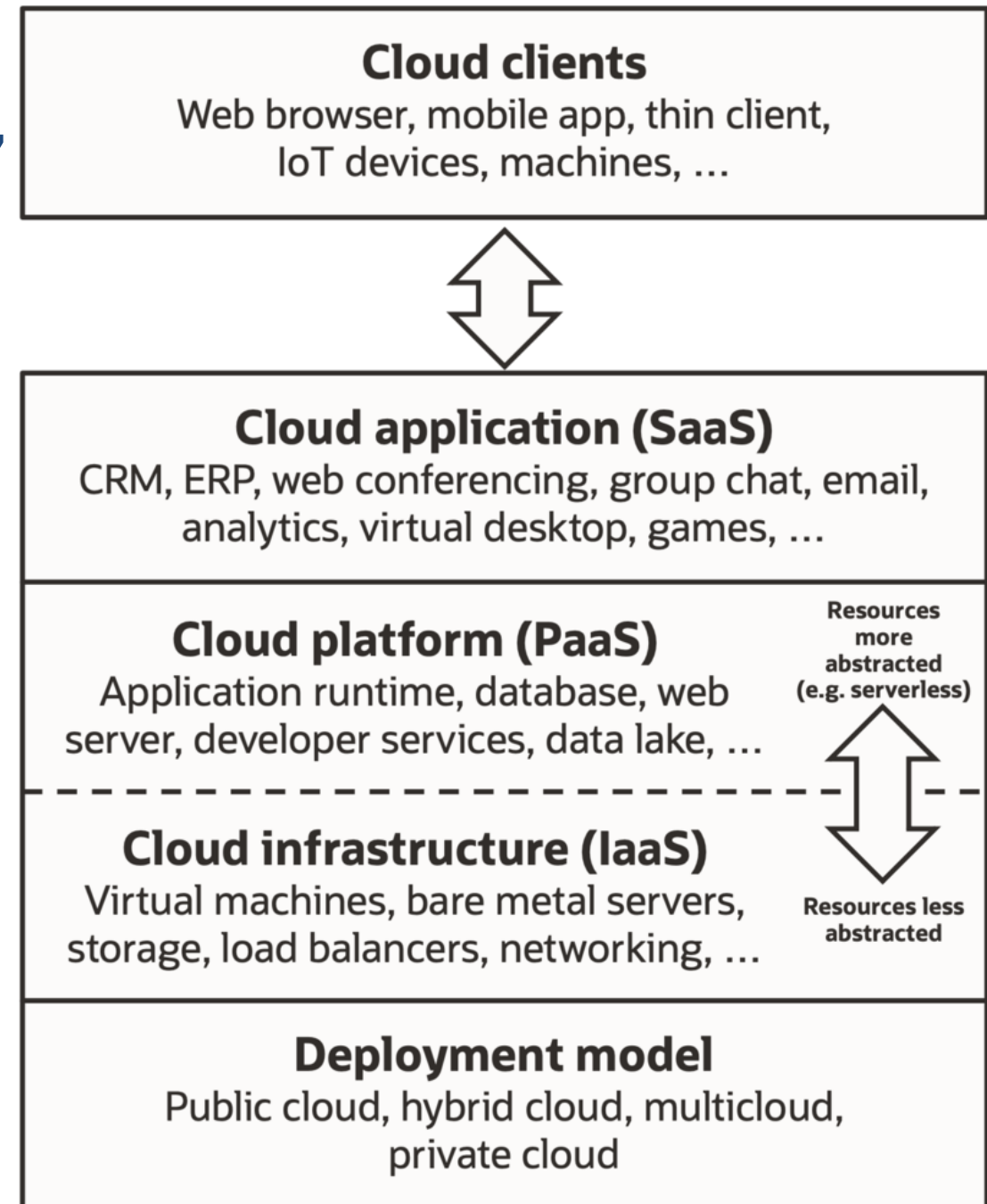
- Cloud services means on demand services available to users via the network from a vendor servers.
- Cloud services are easy to use, scalable and are fully managed by a services provider.
- Services which are dynamically scale to meet the needs of its users with the help of giant hardware and software. A user does not require to provision or deploy resources or allocate IT staff.
- Examples: Data storage and backup solutions, Web-based e-mail, and document collaboration, database processing, and many more.

# Classification and Vendors

- Infrastructure as a service (IaaS) offers hardware environment services. Kind of storage services (database or disk storage) or virtual servers. Some vendors are [Amazon EC2](#), [Amazon S3](#), [Rackspace Cloud Servers](#) and [Flexiscale](#).
- Platform as a Service (PaaS) offers development (platform) environment services. PaaS offered by different vendors are generally not compatible. Typical players in PaaS are [Google Application Engine](#), [Microsofts Azure](#), [Salesforce.com](#) .
- Software as a service (SaaS) offers software. Application are based on 'pay-as-you-go' basis. Vendors Salesforce.coms in Customer Relationship Management (CRM), [Gmail](#) and [Hotmail](#), [Google docs](#) and [BPOS](#) (Business Productivity Online Standard Suite) a MS Office online.

# Different “X as a Service”

- Application-as-a-service
- Platform-as-a-service
- Integration-as-a-service
- Storage-as-a-service
- Database-as-a-service
- Information-as-a-service
- Process-as-a-service
- Security-as-a-service
- Testing-as-a-service
- Infrastructure-as-a-service
- Management/Governance-as-a-service



# Cloud Application

- [Cloud computing applications](#), are also known as Software as a Service (SaaS).
- Similar to the software's installed on computers, additionally they are available online with or without credentials (username and password).

## Benefits

- Global accessibility → collaborative working with multiple users.
- Automatic Up gradation → all user on same version.
- Equal benefits to all → New developments to every user at same time.
- Safety → Wallet + Money          Bank + Funds

Similarly, Data + cloud application.

Here reference of Wallet is in context of better arrangement and bank for security



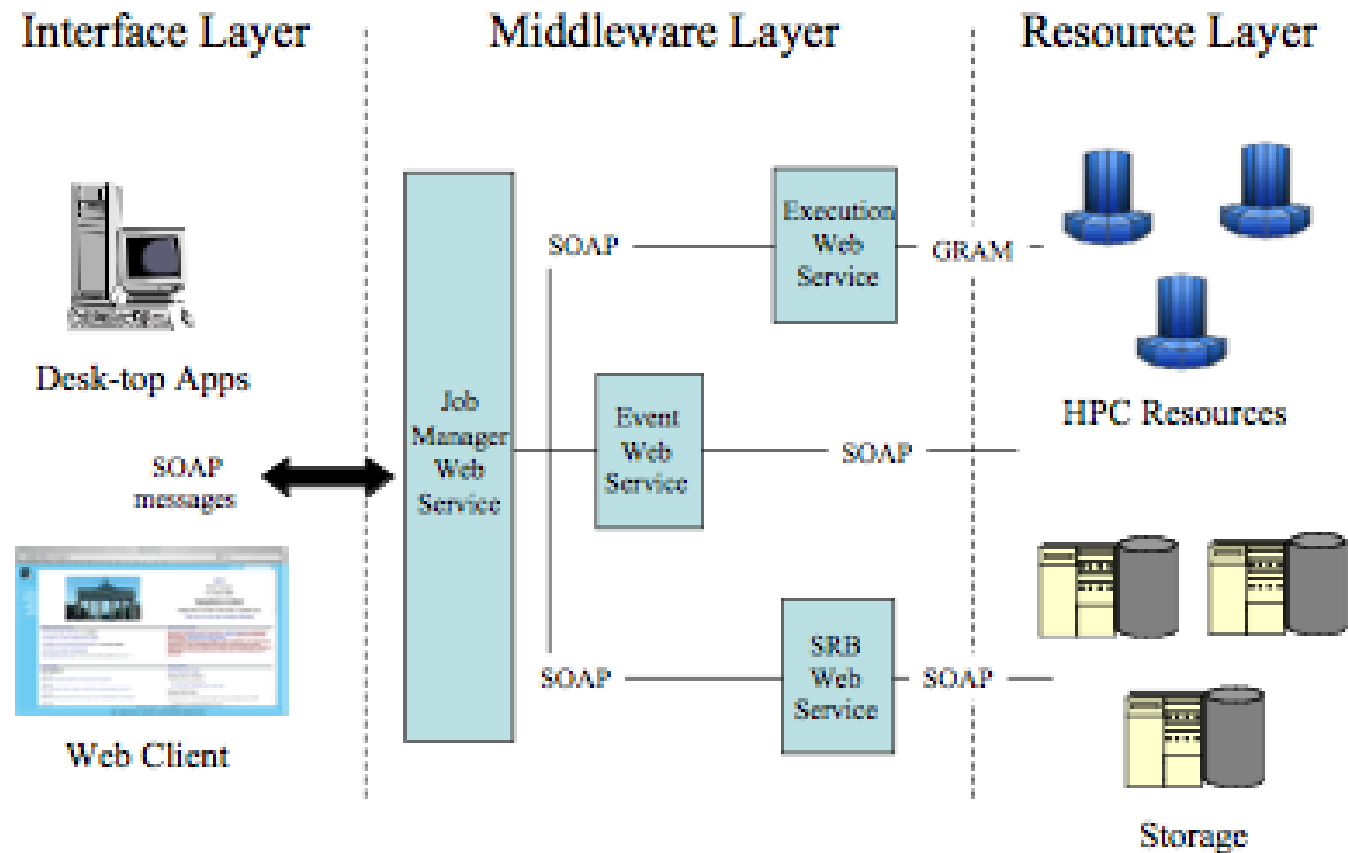
# Example of Cloud Applications

- Some of the important applications
  - Twitter - [twitter.com](https://twitter.com)
  - Facebook - [facebook.com](https://facebook.com)
  - Bonus – Chatter.com! - [chatter.com](https://chatter.com)
  - Google Apps for Business - [google.com](https://google.com) (text documents, spreadsheets, slide shows, Google Docs and many more)
  - Skype - [skype.com](https://skype.com)
- There are many cloud application please refer to [http://en.wikipedia.org/wiki/Category:Cloud\\_applications](http://en.wikipedia.org/wiki/Category:Cloud_applications)

# SOA, Grid and Cloud Computing

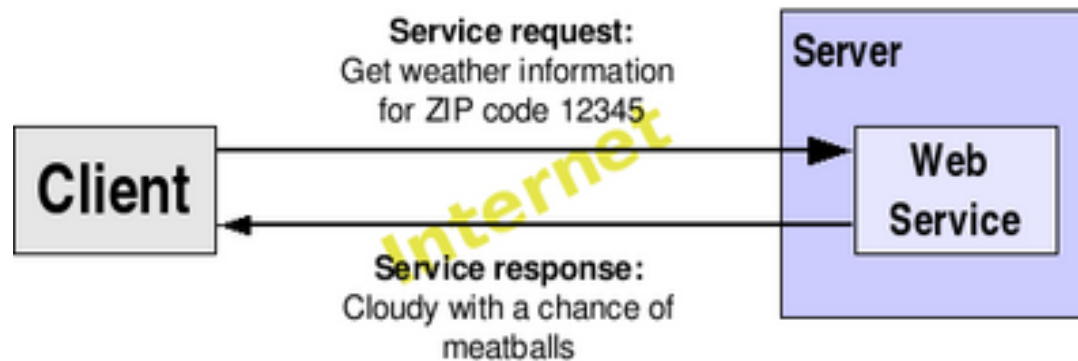
How Services are being involved in Grid and Cloud computing architecture.

# Common Architecture



# URL V/S URI

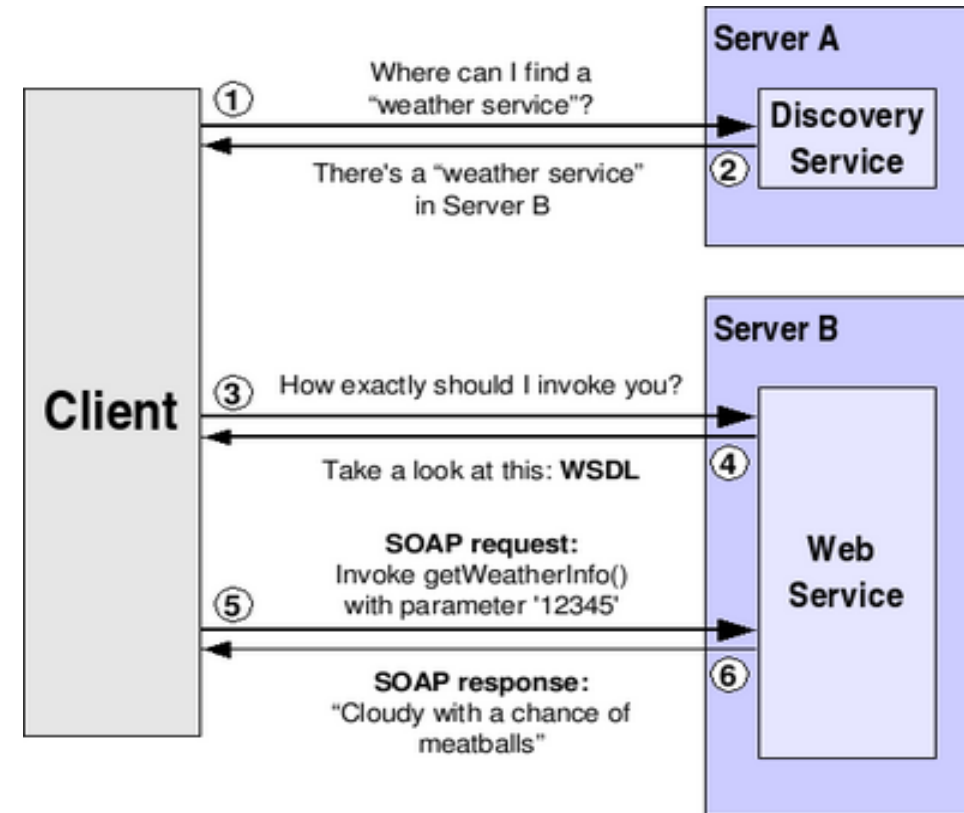
- Websites for humans, Web Services for software
- <http://webservices.mysite.com/weather/us/WeatherService>
- Web Services use HTTP as the application layer protocol to exchange SOAP messages over the network.



# Web Service Invocation

Sequence of Web service invocation process

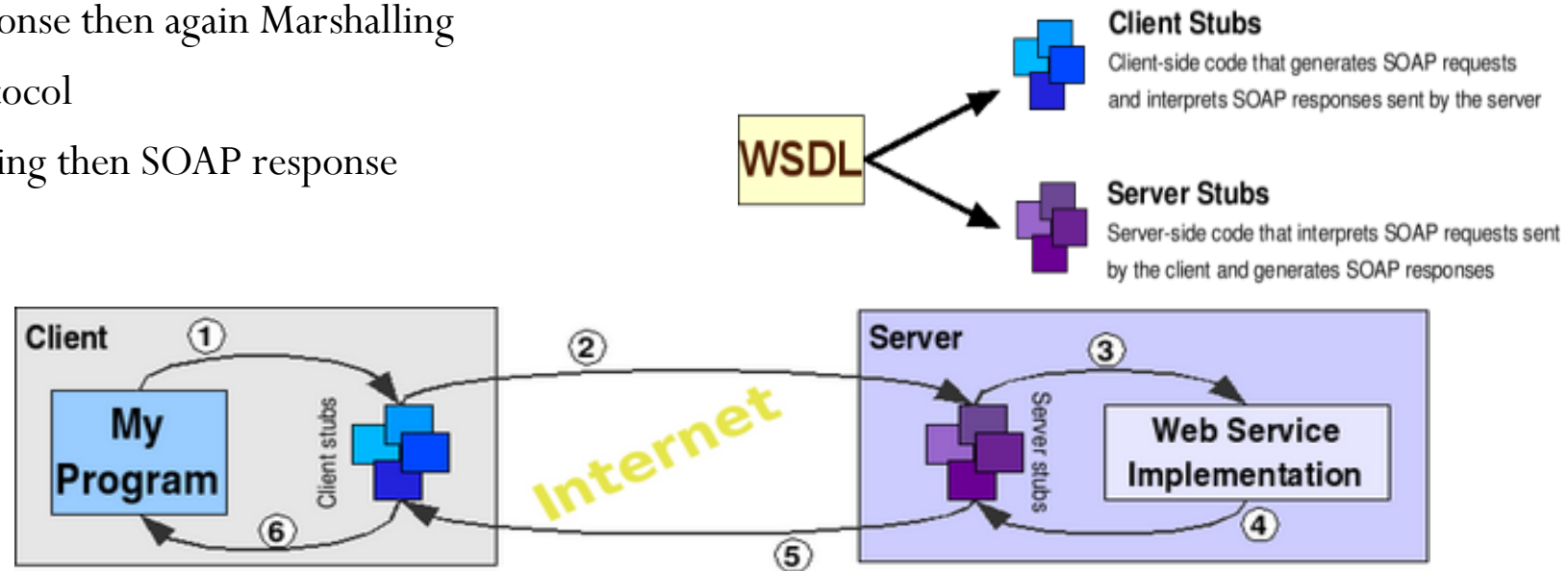
- Discovery service
- Discovery service will reply
- Web Service Descriptive Language (WSDL)
- SOAP request
- Method invocation
- SOAP response



# Web Service Invocation

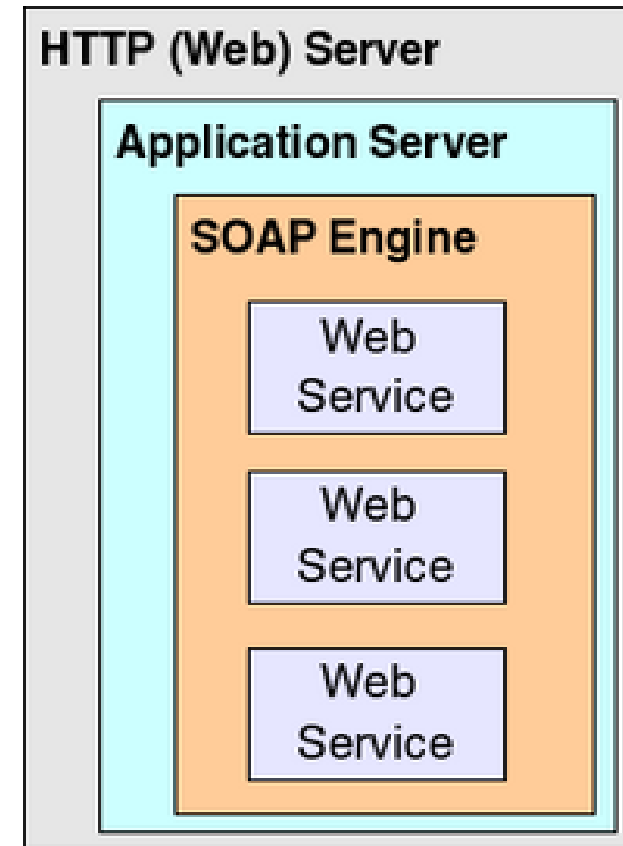
A stub is an API that handles Marshalling/Unmarshalling. Marshalling also refers to serializing and Unmarshalling also refers to deserializing.

1. SOAP request then Marshalling or serializing
2. HTTP protocol
3. Unmarshaling or deserializing then SOAP request
4. SOAP response then again Marshalling
5. HTTP protocol
6. Unmarshaling then SOAP response



# Web Service Invocation

- Web service
- SOAP engine
- Application server
- HTTP Server



# REST API



# Representational State Transfer (REST)

- *Representational State Transfer* (REST) was introduced and defined in 2000 by Roy Fielding in his doctoral dissertation.
- The REST principles: "HTTP Object Model" begin and design *Uniform Resource Identifiers* (URI) standards in 1994.
- Intended to invoke an image: it is a network of Web resources (a Virtual State Machine) where the user progresses through the application by selecting resource identifiers and resource operations such as GET or POST (application state transitions),
- Resulting in the next resource's representation (the next application state) being transferred to the end user for their use.

# Representational State Transfer (REST)

- WWW: "Web resources" are documents or files at URLs.
- Web 2.0: "Web Resources" are generic and abstract entities, or actions that can be identified, named, addressed, handled, or performed in many way on the internet as URI or URL.
- requests to a resource's URI:
  - a response with a payload formatted in many ways
  - e.g., HTML, XML, JSON, or some other format.
- The response given alternate resource state,
  - provide hypertext links to alternate related resources.

# Representational State Transfer (REST)

- REST is a software architectural style that defines a set of constraints to be used for creating Web services.
- Web services that conform to the REST architectural style, called RESTful Web services, provide interoperability between computer systems on the internet.
- RESTful Web services allow the requesting systems to access and manipulate textual representations of Web resources by using a uniform and predefined set of stateless operations.

# Representational State Transfer (REST)

- Stateless protocol and standard operations,
- Rest API: The operations HTTP methods available are GET, HEAD, POST, PUT, PATCH, DELETE, CONNECT, OPTIONS and TRACE.
- Ability to grow by reusing components that can be managed and updated without affecting the system.
- Other kinds: SOAP Web services, expose their own arbitrary sets of operations.

# Representational State Transfer (REST)

HTTP Method	Operations for resource management
GET	<i>Retrieve</i> the URIs and representation of resource in the response body.
POST	<i>Create</i> a resource using the instructions in the request body. The URI of the created resource is <i>automatically assigned</i> and returned in the response <i>Location</i> header field.
PUT	<i>Replace</i> all the representations of the resources with the representation in the request body, or <i>create</i> the resource if it does not exist.
PATCH	<i>Update</i> all the representations of the resources of the resource using the instructions in the request body, or <i>may create</i> the resource if it does not exist.
DELETE	<i>Delete</i> the representations of the resources.

# Web Oriented Architecture (WOA)

- Software architecture: extends SOA to web-based applications and sites, such as social websites and personal websites.

$WOA = SOA + WWW + REST$

- A core set of Web protocols like HTTP, HTTPS and plain XML, the only real difference between traditional SOA and the concept of WOA
- WOA advocates REST a method for HTTP as a Web service
- Enterprise WOA is a sub-style of Enterprise SOA
- Resource Oriented Architecture (ROA) use design and develop an internetworked software with resources enabled by "RESTful" interfaces.

# Web Oriented Architecture (WOA)

- WOA is substyle of SOA that integrates systems and users via a web of globally linked hypermedia based on Web architecture.
- Emphasize generality of User interfaces and APIs for global network effects through five fundamental:
  - Identification of resources
  - Manipulation of resources through representations (Web resource)
  - Self-descriptive messages
  - Hypermedia as the engine of application state
  - Application neutrality

# Web 2.0, Mash-up, RSS Feed



# Web 2.0

## Features

- Web 2 based Homepage
- Search
- RSS
- Chats, Sharing
- Personalized web sites,
- Mashups
- POD Casting, Video Casting, You Tube
- Focus on community, online collaboration, tagging

# Mashup

- A mashup, is a phenomenon to create new services on web, with the combination of presentation, data, or functionality from two or more resources.
- What are the benefits?
  - Innovation, new business insights, increase agility, speed up the development, reduce development costs, easy & fast integration, widgets are readily available, reuse software, immediate benefit, less cost, rich ecosystem, may not be original raw source data, produce enriched results of data & services
- Mashup is divided into three layers with the following technologies.
- **Presentation:** [HTML](#), [XHTML](#), [CSS](#), [Javascript](#), [Ajax](#), [API](#).
- **Web Services:** are [XMLHttpRequest](#), [XML-RPC](#), [JSON-RPC](#), [SOAP](#), [REST](#).
- **Data:** Sending, storing and receiving. The technologies used are [XML](#), [JSON](#), [KML](#).

# RSS feed

- RSS is an XML language for syndicating subscribed contents on the web.
- Registers with an organization on web, who creates an RSS feed.
- User is automatically updated with the RSS feed (notification of new items)
- Information is received quickly at a location.

תודה רבה

Hebrew

Ευχαριστώ

Greek

Спасибо

Russian

Danke

German

Merci

French

धन्यवादः

Sanskrit

நன்றி

Tamil

شكراً

Arabic

ಧನ್ಯವಾದಗಳು

Kannada

Thank You

English

നന്നി

Malayalam

Grazie

Italian

ధన్యవాదాలు

Telugu

આભાર

Gujarati

多謝

Traditional Chinese

Gracias

Spanish

ਧੰਨਵਾਦ

Punjabi

धन्यवाद

Hindi & Marathi

多谢

Simplified Chinese

<https://sites.google.com/site/animeshchaturvedi07>

Obrigado

Portuguese

ありがとうございました

Japanese

ขอบคุณ

Thai

감사합니다

Korean