Cloud Computing

Cloud Computing

- “A model for enabling 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”

- Cloud computing represents a new way to deploy computing technology to give users the ability to access, work on, share, and store information using the Internet.
- The cloud itself is a network of data centers, each composed of many thousands of computers working together that can perform the functions of software on a personal or business computer by providing users access to powerful applications, platforms, and services delivered over the Internet. It is in essence a set of network enabled services that is capable of providing scalable, customized and inexpensive computing infrastructures on demand, which could be accessed in a simple and pervasive way by a wide range of geographically dispersed users.
- The Cloud also assures application based Quality-of-Service (QoS) guarantees to its users. Thus, Cloud Computing provides the users with large pools of resources in a transparent way along with a mechanism for managing the resources so that a user can access it ubiquitously and without incurring unnecessary performance overhead. The ideal way to describe Cloud Computing then would be to term it as “Everything as a Service” abbreviated as XaaS

Key Features of Cloud Computing

- Agility – helps in rapid and inexpensive re-provisioning of resources.
- Location Independence – resources can be accessed from anywhere and everywhere.
- Multi-Tenancy – resources are shared amongst a large pool of users.
- Reliability – dependable accessibility of resources and computation.
- Scalability – dynamic provisioning of data helps in avoiding various bottleneck scenarios.
- Maintenance – users (companies/organizations) have less work in terms of resource upgrades and management, which in the new paradigm will be handled by service providers of Cloud Computing.

Cloud Computing Methdologies

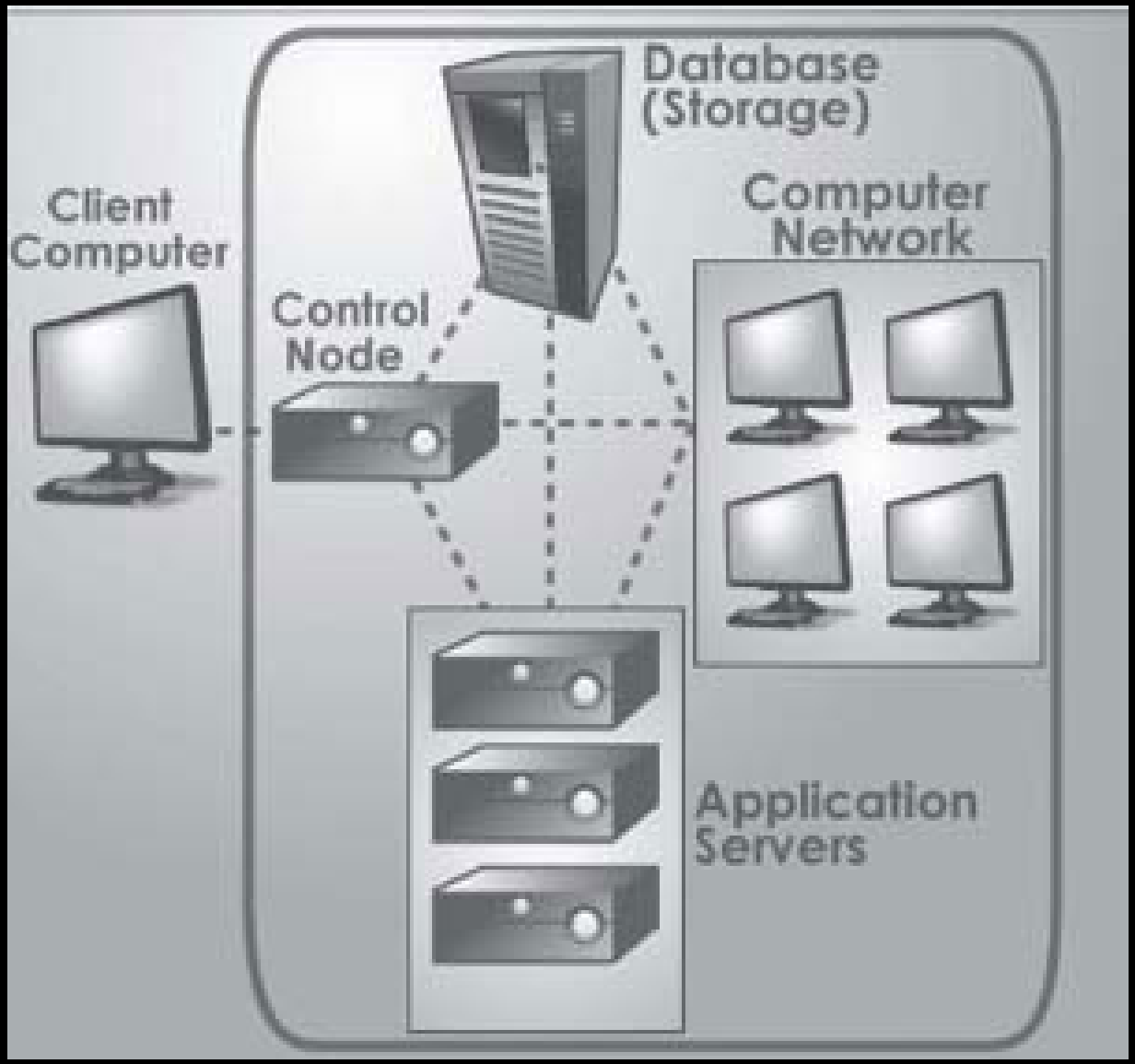
- Cloud Computing is based on two main techniques:
  - Service Oriented Architecture
  - Virtualization.
- **Service Oriented Architecture (SOA)**: Since the paradigm of Cloud computing perceives of all tasks accomplished as a “Service” rendered to users, it is said to follow the **Service Oriented Architecture**.
- This architecture comprises a flexible set of design principles used during the phases of system development and integration.
- The deployment of a SOA-based architecture will provide a loosely-integrated suite of services that can be used within multiple business domains.
- The enabling technologies in SOA allow services to be discovered, composed, and executed.
- For instance, when an end-user wishes to accomplish a certain task, a service can be employed to discover the required resources for the task.
- This will be followed by a composition service which will plan the road-map to provide the desired functionality and quality of service to the end-user

Cloud Computing Methdologies (2)

- **Virtualization**: The concept of virtualization is to relieve the user from the burden of resource purchases and installations.
- The Cloud brings the resources to the users.
- Virtualization may refer to:
  - **Hardware** (execution of software in an environment separated from the underlying hardware resources),
  - **Memory** (giving an application program the impression that it has contiguous working memory, isolating it from the underlying physical memory implementation),
  - **Storage** (the process of completely abstracting logical storage from physical storage),
  - **Software** (hosting of multiple virtualized environments within a single Operating System (OS) instance),
  - **Data** (the presentation of data as an abstract layer, independent of underlying database systems, structures and storage) and
  - **Network** (creation of a virtualized network addressing space within or across network subnets).

Virtualization

- Virtualization has become an indispensable ingredient for almost every Cloud; the most obvious reasons being the ease of abstraction and encapsulation.
- Amongst the other important reasons for which the Clouds tend to adopt virtualization are:
  - **Server and application consolidation** – as multiple applications can be run on the same server resources can be utilized more efficiently.
  - **Configurability** – as the resource requirements for various applications could differ significantly, (some require large storage, some require higher computation capability) virtualization is the only solution for customized configuration and aggregation of resources which are not achievable at the hardware level.
  - **Increased application availability** – virtualization allows quick recovery from unplanned outages as virtual environments can be backed up and migrated with no interruption in services.
  - **Improved responsiveness** – resource provisioning, monitoring and maintenance can be automated, and common resources can be cached and reused.

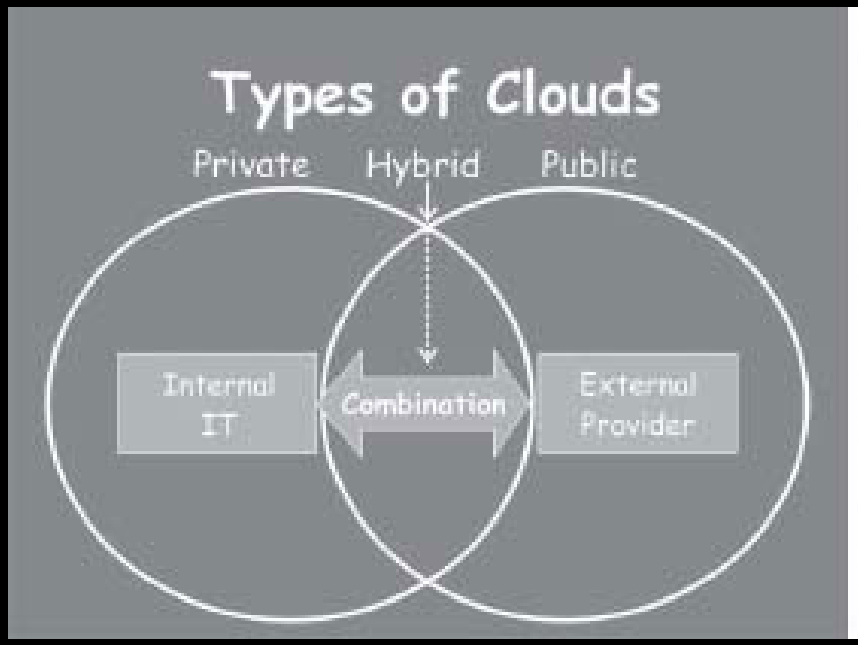

Database
(Storage)
Client
Computer
Computer
Network
Control
Node
Application
Servers

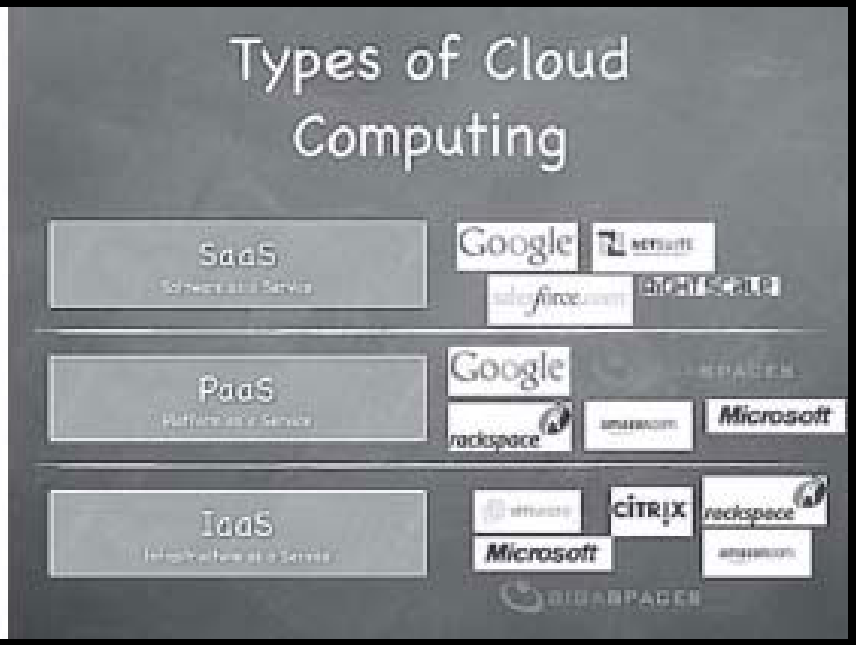
- **Clients**: the Clients of a Cloud comprise computer hardware and/or computer software that relies on the computational capability of the Cloud for application or service delivery. Examples include computers, mobile devices, operating systems, and browsers.
- **Services**: this refers to the different service models made available by the Cloud like **SaaS** (Software-as-a-Service), **IaaS** (Infrastructure-as-a-Service) and **PaaS** (Platform-as-a-Service). This layer acts as a middleman between the user and the vast amount of resources accessible to the user. A resource includes “products, services and solutions that are delivered and consumed in real time over the Internet”. Examples include location services and Search Engines among others. See https://www.gartner.com/newsroom/id/3616417
- **Application**: the Cloud enables resource management and user activity tracking from central locations rather than at each customer’s site, enabling customers to access applications remotely via the Internet. Cloud application services deliver software as a service over the Internet, eliminating the need to install and run the application on the customer’s own computer, thereby simplifying (almost eliminating) maintenance and support at the customer’s end. Examples include Web Application and Peer-to-Peer computing.
- **Platform**: it facilitates deployment of applications without the cost and complexity of buying and managing the underlying hardware and software layers. This layer delivers a computing platform and/or solution stack as a service, often consuming Cloud infrastructure and sustaining Cloud applications. Examples include Web Application Frameworks like Ruby on Rails and Web Hosting.

- **Storage**: the storage layer consists of computer hardware and/or computer software products that are specifically designed for the storage of Cloud services. Computer hardware comprises huge data centers that are used for resource sharing. Examples include Amazon SImpleDB, and Nirvanix SDN (Storage Delivery Network).
- **Infrastructure**: this layer delivers computer infrastructure, typically a platform virtualization environment as a service. It includes management of virtual resources too. Rather than purchasing servers, software, data center space or network equipment, clients instead buy those resources as a fully outsourced service. Examples include Network Attached Storage and Database services.
- The main advantage of such a layered architecture is the ease with which they can be modified to suit a particular service. The way in which these components interact leads to various architectural styles. There are two basic architectural styles on which most of the services are based. They are:
  - **Outside-In**: This architectural style is inherently a top-down design emphasizing the functionality of the components. Implementing this style leads to a better architectural layering with various functionalities. It infuses more feasibility enabling better integration and interoperation of components.
  - **Inside-Out**: This architectural style, on the other hand, is inherently a bottom-up design which takes an infrastructural point of view of the components. This style is more application oriented than service oriented.

Types of clouds

- Cloud deployment techniques which predominantly comprise (i) the Public deployment, (ii) the Private deployment or (iii) the Hybrid deployment





Public Cloud

- **Public Cloud**: it is the traditional mainstream Cloud deployment technique whereby resources are dynamically provisioned by third party providers who share them with the users and bill the users on a fine grained utility computing basis. It offers easy resource management, scalability and flexibility with an economical pay-as-you-go model which is extremely viable especially for small businesses. On the negative side, the user lacks visibility and control over the computing infrastructure. Since computing infrastructures are shared between various organizations, these Clouds face various security and compliance issues. Amazon’s Web Services and Google’s AppEngine are few examples of Public Clouds, also known as external Clouds.

Private Cloud

- **Private Cloud**: in this Cloud deployment technique, the computing infrastructure is solely dedicated to a particular organization or business. These Clouds are more secure because they belong exclusively to a particular organization. These Clouds are more expensive because one needs in-house expertise for their maintenance. Private Clouds are further classified based on their location as:
  - **On-Premise Clouds** – these refer to Clouds that are for a particular organization hosted by the organization itself. Examples of such Clouds would include Clouds related to military services which have a considerable amount of confidential data.
  - **Externally hosted Clouds** – these refer to Clouds that are also dedicated for a particular organization but are hosted by a third party specializing in Cloud infrastructure. These are cheaper than On-premise Clouds. Examples of such Clouds would be small businesses using services from VMware, Amazon etc. Such Clouds are also known as Internal Clouds.

Hybrid Cloud

- **Hybrid Cloud**: this deployment technique integrates the positive attributes of both the Public Cloud and Private Cloud paradigm. For instance, in a Hybrid Cloud deployment, critical services with stringent security requirements may be hosted on Private Clouds while less critical services can be hosted on the Public Clouds. The criticality, flexibility and scalability requirement of a service governs its classification into either the Public or Private Cloud domain. Each Cloud in the Hybrid domain retains its unique entity. However, they function synchronously to gracefully accommodate any sudden rise in computing requirements. Hybrid Cloud deployment is definitely the current trend amongst the major leading Cloud providers currently

Cloud Services

- The Cloud can provide us with a myriad service models and services. They include SaaS (Software as a Service), PaaS (Platform as a Service), HaaS (Hardware as a Service), DaaS ([Development, Database, Desktop] as a Service), IaaS(Infrastructure as a Service), BaaS (Business as a Service), FaaS (Framework as a Service), OaaS (Organization as a Service) amongst others.
- However, Cloud Computing products can be broadly classified into three main Services (SaaS, PaaS and IaaS).

Infrastructure-as-a-Service (IaaS)

- This service provisions for hardware related services like storage, and virtual servers on a pay-as-you-go basis.
- The main advantage of IaaS is the usage of latest technology at all times with regard to computer infrastructure which allows users to achieve faster service.
- Organizations can use IaaS to quickly build new versions of applications or environments without incurring unnecessary purchase and configuration delay. On-demand scaling via resource virtualization and use-based billing makes IaaS competent enough for any kind of businesses. The major companies already providing IaaS are Amazon, Rackspace, GoGrid, AT&T and IBM.

Platform-as-a-Service (PaaS)

- PaaS offerings may include facilities for application design, application development, testing, deployment and hosting as well as application services such as team collaboration, web service integration and marshalling, database integration, security, scalability, storage, persistence, state management, application versioning, application instrumentation and developer community facilitation.
- These services may be provisioned as an integrated solution over the web, providing an existent managed higher-level software infrastructure for building particular classes of applications and services. The platform includes the use of underlying computing resources, typically billed similar to IaaS products, although the infrastructure is abstracted away below the platform. Major companies providing PaaS are Google’s AppEngine, Microsoft Azure, and www.Force.com etc.

Software-as-a-Service (SaaS)

- Provides specific already created applications as fully or partially remote services. Sometimes it is in the form of web-based applications and other times it consists of standard non-remote applications with Internet-based storage or other network interactions. It allows a user to use the provider’s application using a thin client interface. Users can access a software application hosted by the Cloud vendor on pay-per-use basis.
- It is a multi-tenant platform. The pioneer in this field has been www.Salesforce.com offering online Customer Relationship Management (CRM) space. Other examples are online email providers like Google’s Gmail and Microsoft’s hotmail, Google docs and Microsoft’s online version of office called BPOS (Business Productivity Online Standard Suite)

Storage-as-a-Service (SaaS)

- Storage as a Service is a business model that helps a smaller company or individual in renting storage spaces from a large company. Storage as a Service is generally seen as a good alternative for a small or mid-sized business that lacks the capital budget and/or technical personnel to implement and maintain their own storage infrastructure. SaaS is also being promoted as a way for all businesses to mitigate risks in disaster recovery, provide long-term retention for records and enhance both business continuity and availability. Examples include Nirvanix, Cleversafe’s dsNET etc.

Database-as-a-Service (DbaaS)

- It constitutes delivery of database software and related physical database storage as a service. A managed service, offered on a pay-per-usage basis that provides on-demand access to a database for the storage of application data is what constitutes DbaaS. Examples include Amazon, www.Force.com etc.

Information-as-a-Service (IfaaS)

- Information as a service accepts the idea that data resides within many systems and repositories. Its main function is to standardize the access of data by applying a standard set of transformations to the various sources of data thus enabling service requestors to access the data regardless of vendor or system. Examples include IBM, Microsoft etc.

Process-as-a-Service (PraaS)

- Refers to a remote resource that’s able to bind many resources together, either hosted within the same Cloud computing resource or remote, to create business processes. These processes are typically easier to change than applications, and thus provide agility to those who leverage these process engines that are delivered on-demand. Process-as-a-service providers include Appian Anywhere, Akemma, and Intensil.

Integration-as-a-Service (InaaS)

- Integration-as-a-Service includes most of the features and functions found within traditional Enterprise Application Integration technology, but delivered as a service. Integration-as-a-Service takes the functionality of system integration and puts it into the Cloud, providing for data transport between the enterprise and SaaS applications or third parties. Examples include Amazon SQS, OpSource Connect, Boomi, and Mule OnDemand.

•Security-as-a-Service (SeaaS)

- Delivers core security services remotely over the Internet like anti-virus, log management etc. While typically the security services provided are rudimentary, more sophisticated services are becoming available such as identity management. Security-as-a-Service providers include Cisco, McAfee, Panda Software, Symantec, Trend Micro and VeriSign

Management/Governance-as-a-Service (MaaS)

- Provides the ability to manage one or more Cloud services, typically simple things such as topology, resource utilization, virtualization, and uptime management. Governance systems are becoming available as well, such the ability to enforce defined policies on data and services. Management/governance-as-a-service providers include RightScale, rPath, Xen, and Elastra.

Testing-as-a-Service (TaaS)

- These systems have the ability to test other Cloud applications, Web sites, and internal enterprise systems, and do not require a hardware or software footprint within the enterprise. They also have the ability to test services that are remotely hosted. SOASTA is one of the many Testing-as-a-Service providers

Issues with Cloud Computing

- **Security Issues**: Security is as much of a concern in Cloud computing as it would be in any other computing paradigms.
- Cloud Computing can be vaguely defined as outsourcing of services, which in turn causes users to lose significant control over their data. There is always a risk of seizure associated with the public Clouds. For instance, an organization sharing data in an environment where other organizations are doing the same is always under the threat of compromising the security and privacy of its data if any other organization in the shared scheme happens to violate the security protocols.
- Moreover, in a virtualized environment one needs to consider the security of not just the physical host but also the virtual machine. This is because if the security of a physical host is compromised, then automatically all virtual machines face security threat and vice versa. Since the majority of services in Cloud computing are provided using web browsers, there are many security issues related with it as well.
- Flooding is also a major issue where an attacker sends huge amounts of illegitimate service requests which cause the system to run slow thereby hampering the performance of the overall system. Cloud networks stand the potential threat of both Indirect Denial of Service attacks and Distributed Denial of Service attacks.

- **Legal and Compliance Issues:** Clouds are sometimes bounded by geographical boundaries. Provision of various services is not location dependent but because of this flexibility Clouds face Legal & Compliance issues.
- These issues are related mainly to the vendors though they still affect the end users. These issues are broadly classified as functional (services in the Clouds that have legal implications for both service providers and end users), jurisdictional (where governments administer laws to follow) and contractual (terms and conditions).
- Issues include
  - Physical Location of the data referring to where the data is physically located and if a dispute occurs, which jurisdiction will help in resolving it.
  - Responsibilities of the data where if a vendor is hit by a disaster will the businesses using its services be covered under insurance.
  - Intellectual Property Rights which deals with the way trade secrets are maintained

- **Performance and QoS Related Issues**: For any computing paradigm performance is of utmost importance. Quality of Service (QoS) varies as the user requirements vary. One of the critical QoS related issues is the optimized way in which commercial success can be achieved using Cloud computing. If a provider is not able to deliver the promised QoS it may tarnish its reputation.
- Since Software-as-a-Service (SaaS) deals with provision of softwares on virtualized resources, one faces the issue of Memory and Licensing constraints which directly hamper the performance of a system.

- **Data Management Issues**: The main purpose of Cloud Computing is to put the entire data on the Cloud with minimum infrastructure requirements for the end users. The main issues related to data management are scalability of data, storage of data, data migration from one Cloud to another and also different architectures for resource access.
- Since data in Cloud computing even includes high confidential information it is of utmost importance to manage these data effectively. There has been an instance where an online storage service called The Linkup got shut down after losing access to as much as 45% of its customers. While transferring data, i.e., data migration, in a Cloud has to be done very carefully as it could lead to bottlenecks at each and every layer of the network model, as huge chunks of data are associated with the Cloud

- **Interoperability Issues**: The Cloud computing interoperability idea was conceived by Reuven Cohen. Reuven Cohen is founder and Chief Technologist for Toronto based Enomaly Inc. Vint Cerf, who is a co-designer of the Internet's TCP/IP standards and widely considered a father of the Internet, spoke about the need for data portability standards for Cloud computing. Companies such as Microsoft, Amazon, IBM, and Google all own their independent Clouds but they lack interoperability amongst them.
- Each service provider has its own architecture, which caters to a specific application. To make such uniquely distinct Clouds interoperate is a non-trivial problem. The lack of standardized protocols in the domain of Cloud computing further makes interoperability a challenge. The key issues hampering implementation of interoperable Clouds are the large scale access and computational capabilities of the Clouds, resource contention and the dynamic nature of the Cloud. However, interoperability amongst the various Clouds would only add to the value of this technology, making it more widely accessible, fault tolerant, and thereby robust

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