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Architecture Design & Network Application of Cloud Computing

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ABSTRACT: *"Cloud" computing a comparatively term, stands on decades of research & analysis in virtualization, analytical distributed computing, utility computing, and more recently computer networking, web technology and software services. Cloud computing represents a shift away from computing as a product that is purchased, to computing as a service that is delivered to consumers over the internet from large-scale data centers – or "clouds". Whilst cloud computing is obtaining growing popularity in the IT industry, academic appeared to be lagging behind the developments in this field. It also implies a service oriented designed architecture, reduced information technology overhead for the end-user, good flexibility, reduced total cost of private ownership, on-demand services and many other things. This paper discusses the concept of "cloud" computing, some of the issues it tries to address, related research topics, and a "cloud" implementation available today.*

Keywords –*Network Cloud, CAPEX, OPEX, IBM, DEC.*

I. INTRODUCTION

Cloud computing is a model for enabling ubiquitous network access to a shared pool of configurable computing resources. Cloud computing and storage solutions provide users and enterprises with various capabilities to store and process their data in third-party data centers. It relies on sharing of resources to achieve coherence and economies of scale, similar to a utility over a network. At the foundation of cloud computing is the broader concept of converged infrastructure and shared services. Cloud computing, or in simpler shorthand just "the cloud", also focuses on maximizing the effectiveness of the shared resources. Cloud resources are usually not only shared by multiple users but are also dynamically reallocated per demand [1]. This can work for allocating resources to users. For example, a cloud computer facility that serves European users during European business hours with a specific application may reallocate the same resources to serve North American users during North America's business hours with a different application. This approach should maximize the use of computing power thus reducing environmental damage as well since less power, air conditioning, rack space, etc. are required for a variety of functions. With cloud computing, multiple users can access a single server to retrieve and update their data without purchasing licenses for different applications. The term "moving to cloud" also refers to an organization moving away from a traditional CAPEX model to the OPEX model.

Proponents claim that cloud computing allows companies to avoid upfront infrastructure costs, and focus on projects that differentiate their businesses instead of on infrastructure [2]. Proponents also claim that cloud computing allows enterprises to get their applications up and running faster, with improved manageability and less maintenance, and enables IT to more rapidly adjust resources to meet fluctuating and unpredictable business demand. Cloud providers typically use a "pay as you go" model.This can lead to unexpectedly high charges if administrators do not adapt to the cloud pricing model. The present availability of high-capacity networks, low-cost computers and storage devices as well as the widespread adoption of hardware virtualization, service-oriented architecture, and autonomic and utility computing have led to a growth in cloud computing. Companies can scale up as computing needs increase and then scale down again as demands decrease. Cloud vendors are experiencing growth rates of 50% per annum.

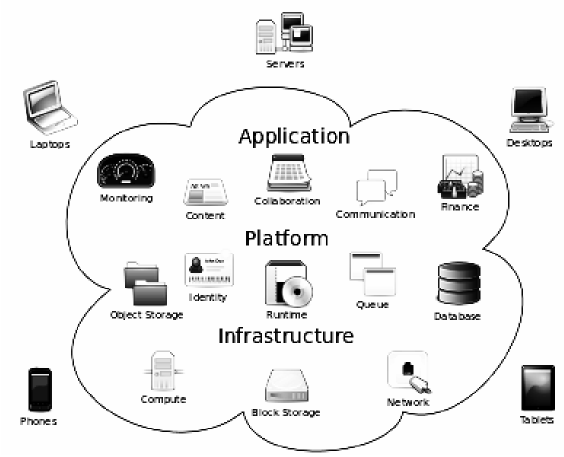

Figure 1: Cloud computing metaphor.

Figure 1 presents Cloud computing metaphor. For a user, the network elements representing the provider-rendered services are invisible, as if obscured by a cloud.

II. ORIGIN OF THE TERM "CLOUD COMPUTING"

The origin of the term cloud computing is unclear. The expression cloud is commonly used in science to describe a large agglomeration of objects that visually appear from a distance as a cloud and describes any set of things whose details are not inspected further in a given context. Another explanation is that the old programs to draw network schematics surrounded the icons for servers with a circle, and a cluster of servers in a network diagram had several overlapping circles, which resembled a cloud. In analogy to above usage the word cloud was used as a metaphor for the Internet and a standardized cloud-like shape was used to denote a network on telephony schematics and later to depict the Internet in [3]. With this simplification, the implication is that the specifics of how the end points of a network are connected are not relevant for the purposes of understanding the diagram. The cloud symbol was used to represent the Internet as early as 1994 in which servers were then shown connected to, but external to, the cloud.

The 1970s

During the mid-1970s, time-sharing was popularly known as RJE; this terminology was mostly associated with large vendors such as IBM and DEC. IBM developed the VM OperatingSystem to provide time-sharingservicesvia virtual machines.

The 1990s

In the 1990s, telecommunications companies, who previously offered primarily dedicated point-to-point data circuits, began offering virtual private network (VPN) services with comparable quality of service, but at a lower cost. By switching traffic as they saw fit to balance server use, they could use overall network bandwidth more effectively. They began to use the cloud symbol to denote the demarcation point between what the providers was responsible for and what users were responsible for. Cloud computing extends this boundary to cover all servers as well as the network infrastructure.

The New Millennium: 2000s

Since 2000 cloud computing has come into existence. In early 2008, NASA's Open Nebula, enhanced in the Reservoir European Commission-funded project, became the first open-source software for deploying private and hybrid clouds, and for the federation of clouds. In the same year, efforts were focused on providing quality of service guarantees to cloud-based infrastructures, in the framework of the IRMOS European Commission-funded project, resulting in a real-time cloud environment [4]. By mid-2008, Gartner saw an opportunity for cloud computing "to shape the relationship among consumers of IT services, those who use IT services and those who sell them" and observed that "organizations are switching from company-owned hardware and software assets to per-use service-based models" so that the "projected shift to computing .

III. TYPES OF COMPUTING

There are three different kinds of cloud computing, where different services are being provided for you. Note that there's a certain amount of vagueness about how these things are defined and some overlap between them.

- Infrastructure as a Service (IaaS) means you're buying access to raw computing hardware over the Net, such as servers or storage. Since you buy what you need and pay-as-you-go, this is often referred to as utility computing. Ordinary web hosting is a simple example of IaaS: you pay a monthly subscription or a per-megabyte/gigabyte fee to have a hosting company serve up files for your website from their servers.
- Software as a Service (SaaS) means you use a complete application running on someone else's system. Web-based email and Google Documents are perhaps the best-known examples. Zoho is another well-known SaaS provider offering a variety of office applications online [5].
- Platform as a Service (PaaS) means you develop applications using Web-based tools so they run on systems software and hardware provided by another company. So, for example, you might develop your own ecommerce website but have the whole thing, including the shopping cart, checkout, and payment mechanism running on a merchant's server. Force.com (from salesforce.com) and the Google App Engine are examples of PaaS.

IV. CHARACTERISTICS

Cloud computing exhibits the following key characteristics:

- **Agility** improves with users' ability to re-provision technological infrastructure resources.
- **Cost** reductions claimed by cloud providers. A public-cloud delivery model converts capital expenditure to operational expenditure. This purportedly lowers barriers to entry, as infrastructure is typically provided by a third party and does not need to be purchased for one-time or infrequent intensive computing tasks. Pricing on a utility computing basis is fine-grained, with usage-based options and fewer IT skills are required for implementation [6]. The e-FISCAL project's state-of-the-art repositorycontains several articles looking into cost aspects in more detail, most of them concluding that costs savings depend on the type of activities supported and the type of infrastructure available in-house.
- **Device and location independence**enable users to access systems using a web browser regardless of their location or what device they use. As infrastructure is off-site and accessed via the Internet, users can connect from anywhere.
- **Maintenance** of cloud computing applications is easier, because they do not need to be installed on each user's computer and can be accessed from different places.
- **Multitenancy** enables sharing of resources and costs across a large pool of users thus allowing for:
    - **Centralization** of infrastructure in locations with lower costs
    - **peak-load capacity** increases (users need not engineer for highest possible load-levels)
    - **Utilization and efficiency** improvements for systems that are often only 10–20% utilized.
- **Performance** is monitored, and consistent and loosely coupled architectures are constructed using web services as the system interface.
- **Productivity** may be increased when multiple users can work on the same data simultaneously, rather than waiting for it to be saved and emailed. Time may be saved as information does not need to be re-entered when fields are matched, nor do users need to install application software upgrades to their computer.
- **Reliability** improves with the use of multiple redundant sites, which makes well-designed cloud computing suitable for business continuity and disaster recovery.
- **Scalability and elasticity** via dynamic provisioning of resources on a fine-grained, self-service basis in near real-time, without users having to engineer for peak loads.
- **Security** can improve due to centralization of data, increased security-focused resources, etc., but concerns can persist about loss of control over certain sensitive data, and the lack of security for stored kernels. Security is often as good as or better than other traditional systems, in part because providers are able to devote resources to solving security issues that many customers cannot afford to tackle. However, the complexity of security is greatly increased when data is distributed over a wider area or over a greater number of devices, as well as in multi-tenant systems shared by unrelated users.

V. SERVICE MODELS

Infrastructure as a service (IaaS)

In the most basic cloud-service model & according to the IETF, providers of IaaS offer computers – physical or virtual machines and other resources IaaS clouds often offer additional resources such as a virtual-machine disk image library, raw block storage, and file or object storage, firewalls, load balancers, IP addresses, virtual local area networks (VLANs), and software bundles. IaaS-cloud providers supply these resources on-demand from their large pools installed in data centers. For wide-area connectivity, customers can use either the Internet or carrier clouds to deploy their applications, cloud users install operating-system images and their application software on the cloud infrastructure [7]. In this model, the cloud user patches and maintains the operating systems and the application software. Cloud providers typically bill IaaS services on a utility computing basis: cost reflects the amount of resources allocated and consumed.

Platform as a service (PaaS)

In the PaaS models, cloud providers deliver a computing platform, typically including operating system, programming language execution environment, database, and web server. Application developers can develop and run their software solutions on a cloud platform without the cost and complexity of buying and managing the underlying hardware and software layers. With some PaaS offers like Microsoft Azure and Google App Engine, the underlying computer and storage resources scale automatically to match application demand so that the cloud user does not have to allocate resources manually. The latter has also been proposed by an architecture aiming to facilitate real-time in cloud environments. Even more specific application types can be provided via PaaS, e.g., such as media encoding as provided by services as barcoding transcoding cloudor media.io.

Software as a service (SaaS)

In the business model using software as a service (SaaS), users are provided access to application software and databases. Cloud providers manage the infrastructure and platforms that run the applications. SaaS is sometimes referred to as "on-demand software" and is usually priced on a pay-per-use basis or using a subscription fee.In the SaaS model, cloud providers install and operate application software in the cloud and cloud users access the software from cloud clients. Cloud users do not manage the cloud infrastructure and platform where the application runs [8]. This eliminates the need to install and run the application on the cloud user's own computers, which simplifies maintenance and support. Cloud applications are different from other applications in their scalability—which can be achieved by cloning tasks onto multiple virtual machines at run-time to meet changing work demand. Load balancers distribute the work over the set of virtual machines. This process is transparent to the cloud user, who sees only a single access point. To accommodate a large number of cloud users, cloud applications can be multitenant, that is, any machine serves more than one cloud user organization.

The pricing model for SaaS applications is typically a monthly or yearly flat fee per user,so price is scalable and adjustable if users are added or removed at any point.

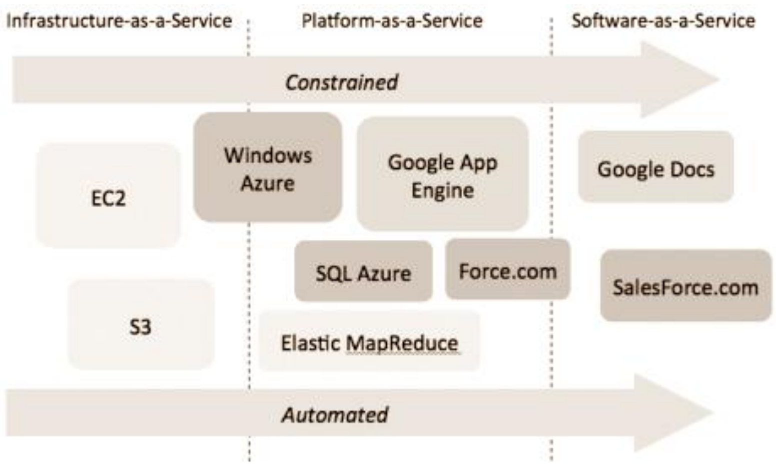

Figure 2: Service models of cloud computing

VI. DEPLOYMENT MODELS

Private cloud

Private cloud is cloud infrastructure operated solely for a single organization, whether managed internally or by a third-party, and hosted either internally or externally. Undertaking a private cloud project requires a significant level and degree of engagement to virtualize the business environment, and requires the organization to reevaluate decisions about existing resources. When done right, it can improve business, but every step in the project raises security issues that must be addressed to prevent serious vulnerabilities. Self-run data centers are generally capital intensive. They have a significant physical footprint, requiring allocations of space, hardware, and environmental controls. These assets have to be refreshed periodically, resulting in additional capital expenditures.

Public cloud

A cloud is called a "public cloud" when the services are rendered over a network that is open for public use. Public cloud services may be free. Technically there may be little or no difference between public and private cloud architecture, however, security consideration may be substantially different for services that are made available by a service provider for a public audience and when communication is effected over a non-trusted network. Generally, public cloud service providers like Amazon AWS, Microsoft and Google own and operate the infrastructure at their data center and access is generally via the Internet. AWS and Microsoft also offer direct connect services called "AWS Direct Connect" and "Azure Express Route" respectively, such connections require customers to purchase or lease a private connection to a peering point offered by the cloud provider.

Hybrid cloud

Hybrid cloud is a composition of two or more clouds (private, community or public) that remain distinct entities but are bound together, offering the benefits of multiple deployment models. Hybrid cloud can also mean the ability to connect collocation, managed and/or dedicated services with cloud resources.
Gartner, Inc. defines a hybrid cloud service as a cloud computing service that is composed of some combination of private, public and community cloud services, from different service providers. A hybrid cloud service crosses isolation and provider boundaries so that it can't be simply put in one category of private, public, or community cloud service. It allows one to extend either the capacity or the capability of a cloud service, by aggregation, integration or customization with another cloud service.

Varied use cases for hybrid cloud composition exist. For example, an organization may store sensitive client data in house on a private cloud application, but interconnect that application to a business intelligence application provided on a public cloud as a software service. This example of hybrid cloud extends the capabilities of the enterprise to deliver a specific business service through the addition of externally available public cloud services. Hybrid cloud adoption depends on a number of factors such as data security and compliance requirements, level of control needed over data, and the applications an organization uses [9].

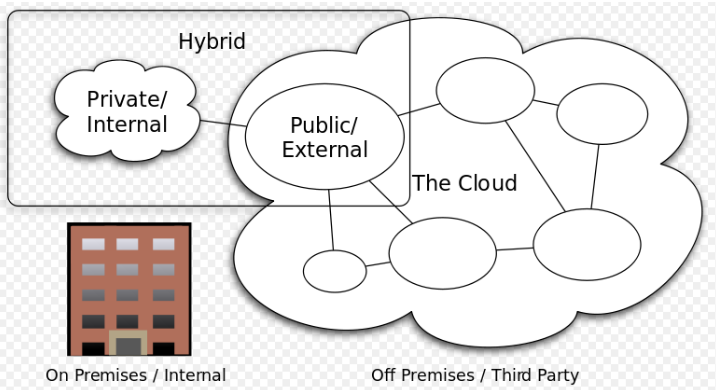

Figure 3: Deployment models

VII. ARCHITECTURE DESIGN

Enterprises and vendors follow some guidelines regarding where to use Layer 2 (switching) and Layer 3 (routing) in the network. Layer 2 is the simpler mode, where the Ethernet MAC address and VirtualLAN(VLAN) information are used for forwarding. The disadvantage of Layer 2 networks is scalability [10]. When we use Layer 2 addressing and connectivity in the manner specified previously for IaaS clouds, we end up with a flat topology, which is not ideal when there are a large number of nodes. The option is to use routing and subnets to provide segmentation for the appropriate functions at the cost of forwarding performance and network complexity.

VM migration introduces its own set of problems. The most common scenario is when a VM is migrated to a different host on the same Layer 2 topology. Consider the case where a VM with open Transmission Control Protocol (TCP) connections is migrated. If live migration is used, TCP connections will not see any downtime except for a short "hiccup." However, after the migration, IP and TCP packets destined for the VM will need to be resolved to a different MAC address or the same MAC address but now connected to a different physical switch in the network so that the connections can be continued without disruption. With VPLS and similar Layer 2 approaches, VM migration can proceed as before across the same Layer 2 network. Alternatively, it may be less complex to freeze the VM and move it across either a Layer 2 or Layer 3 network with the TCP connections having to be torn down by the counterpart communicating with the VM. This scenario is not a desired one from an application availability consideration, but it can lower complexity.

Another example of hybrid cloud is one where IT organizations use public cloud computing resources to meet temporary capacity needs that cannot be met by the private cloud.This capability enables hybrid clouds to employ cloud bursting for scaling across clouds. Cloud bursting is an application deployment model in which an application runs in a private cloud or data center and bursts to a public cloud when the demand for computing capacity increases. A primary advantage of cloud bursting and a hybrid cloud model is that an organization only pays for extra compute resources when they are needed. Cloud bursting enables data centers to create an in-house IT infrastructure that supports average workloads, and use cloud resources from public or private clouds, during spikes in processing demands.

The specialized model of hybrid cloud, which is built atop heterogeneous hardware, is called Cross-platform Hybrid Cloud. A cross-platform hybrid cloud is usually powered by different CPU architectures, for example, x86-64 and ARM, underneath. Users can transparently deploy applications without knowledge of the cloud's hardware diversity.This kind of cloud emerges from the raise of ARM-based system-on-chip for server-class computing.

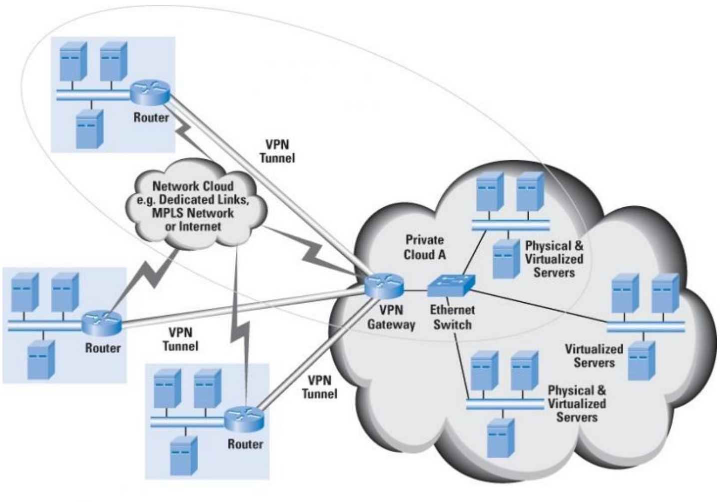

Figure 4: Architecture design of Computer cloud

VIII. SECURITY & PRIVACY

Cloud computing poses privacy concerns because the service provider can access the data that is on the cloud at any time. It could accidentally or deliberately alter or even delete information. Many cloud providers can share information with third parties if necessary for purposes of law and order even without a warrant. That is permitted in their privacy policies which users have to agree to before they start using cloud services [11]. Solutions to privacy include policy and legislation as well as end users' choices for how data is stored. Users can encrypt data that is processed or stored within the cloud to prevent unauthorized access.

According to the Cloud Security Alliance, the top three threats in the cloud are Insecure Interfaces and API's, Data Loss & Leakage, and Hardware Failure which accounted for 29%, 25% and 10% of all cloud security outages respectively together these form shared technology vulnerabilities. In a cloud provider platform being shared by different users there may be a possibility that information belonging to different customers resides on same data server. Therefore, Information leakage may arise by mistake when information for one customer is given to other. Additionally, Eugene Schultz, chief technology officer at Imagined Security, said that hackers are spending substantial time and effort looking for ways to penetrate the cloud. "There are some real Achilles' heels in the cloud infrastructure that are making big holes for the bad guys to get into". Because data from hundreds or thousands of companies can be stored on large cloud servers, hackers can theoretically gain control of huge stores of information through a single attack a process he called "hyper jacking".

Physical control of the computer equipment is more secure than having the equipment off site and under someone else's control. This delivers great incentive to public cloud computing service providers to prioritize building and maintaining strong management of secure services [12]. Some small businesses that don't have expertise in IT security could find that it's more secure for them to use a public cloud.

There is the risk that end users don't understand the issues involved when signing on to a cloud service. This is important now that cloud computing is becoming popular and required for some services to work, for example for an intelligent personal assistant Fundamentally private cloud is seen as more secure with higher levels of control for the owner, however public cloud is seen to be more flexible and requires less time and money investment from the user.

IX. FUTURE SCOPE

According to Gartner's Hype cycle, cloud computing has reached a maturity that leads it into a productive phase. This means that most of the main issues with cloud computing have been addressed to a degree that clouds have become interesting for full commercial exploitation. This however does not mean that all the problems listed above have actually been solved, only that the according risks can be tolerated to a certain degree. Cloud computing is therefore still as much a research topic, as it is a market offering. What is clear through the evolution of Cloud Computing services is that the CTO is a major driving force behind Cloud adoption. The major Cloud technology developers continue to invest billions a year in Cloud R&D; for example, in 2011 Microsoft committed 90% of its $9.6bn R&D budget to Cloud. Additionally, more industries are turning to cloud technology as an efficient way to improve quality services due to its capabilities to reduce overhead costs, downtime, and automate infrastructure deployment.

X. CONCLUSION

This article has served as a vendor-neutral primer to the area of cloud computing. We provided an introduction to the still-evolving area of cloud computing, including the technologies and some deployment concerns & also we provided a more detailed look at the networking factors in the cloud, security aspects, and cloud federation. We also highlighted some areas that are seeing increased attention with cloud-computing proponents and vendors. In theory, cloud computing is environmentally friendly because it uses fewer resources and less energy if 10 people share an efficiently run, centralized, cloud-based system than if each of them run their own inefficient local system. The area of cloud computing is very dynamic and offers scope for innovative technologies and business models. Ongoing work with respect to solutions is substantial, in the vendor research labs and product development organizations as well as in academia. It is clear that cloud computing will see significant advances and innovation in the next few years.

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