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A Comprehensive Study on Multi-Tenancy Techniques in Cloud Computing Models

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ABSTRACT: *Cloud Computing is the most trending Information Technology computational model. This environment is enabled with an Internet to provide computing resources comprised of software, servers, Storages and applications that can be accessed by any type of client. Cloud computing is the fundamental model to provide the services like Infrastructure as a Service, Platform as a Service and Software as a Service. Majority of these services are offered based on pay per use lease style investment with very low or no startup costs to purchase all hardware or software components. The feature provides economic benefits to both users and service providers since it reduces the management cost and thus lowers the subscription price. Many users are, however, reluctant to subscribe to cloud computing services due to security concerns. To enable deployment of cloud computing, we need to advance new techniques like secure multi-tenancy, resource isolation need to be advanced further.*

Keywords: *Cloud Computing, Multi-tenancy, Security, Virtualization, Resource Isolation.*

I. INTRODUCTION

Cloud Computing is defined as "It is a model, where the software and hardware resources of a data centre is shared using virtualization technology, which also provides on demand, instant and elastic services to its users and resources offered on lease style. Cloud computing is a ubiquitous model to implement acceptable, available network access to a shared pool of self-configurable computing resources that can be fast provided and released with very low administrative support or service provider interaction. In addition, the platform provides on demand services that are always on anywhere, anytime and at any place. The development of cyber societies and online transactions imposes continuously expanding IT budgets on organizations. To handle this, organizations are redesigning their procurement and management strategies for IT infrastructure.

Cloud computing services become their candidate solutions since they provide economic benefits; they reduce hardware and software expenses while cancelling out related maintenance and upgrade costs. They offer on-demand, flexible access to appropriate amounts of computation, memory, and storage resources. The advantage is brought by their multitenant feature, which enables an IT asset to host multiple tenants. It also provides elasticity in upgrading or degrading the resources. Cloud computing is mostly adopted because of elasticity and platform independency. With the benefits of Cloud Computing come along challenges to the model; one of the most challenging of these aspects is security.

Information Security provides security for the information and information systems from insecure access, use, disclosure, disruption, modification, inspection, recording or destruction. Based on a study for the Cloud Security Alliance (CSA), there are seven top threats that organizations will face in adopting Cloud Computing. These are Abuse and Nefarious Use of Cloud Computing, Insecure Application Programming Interfaces (API), Malicious Insiders, Shared Technology Vulnerabilities, Data Loss/Leakage, Account, Service and Traffic Hijacking and Unknown Risk Profile. Multi-Tenancy is recognized as one of the unique implications of security and privacy in Cloud computing.

Multi-Tenancy is a major characteristic of Cloud Computing and a major dimension in the Cloud security problem that needs a vertical solution from the Software-as-a-Service (SaaS) down to Infrastructure-as-a-Service (IaaS). Multi-Tenancy is the characteristic feature of cloud computing. The multi-tenancy characteristic of cloud computing allows multiple users to access the same hardware and software resources simultaneously which are present in a remote location but with customized needs using virtualization concept. After highlighting Multi-Tenancy as a security concern in Cloud Computing, the need for a deep understanding of Multi-Tenancy is required in order to deal with it effectively.

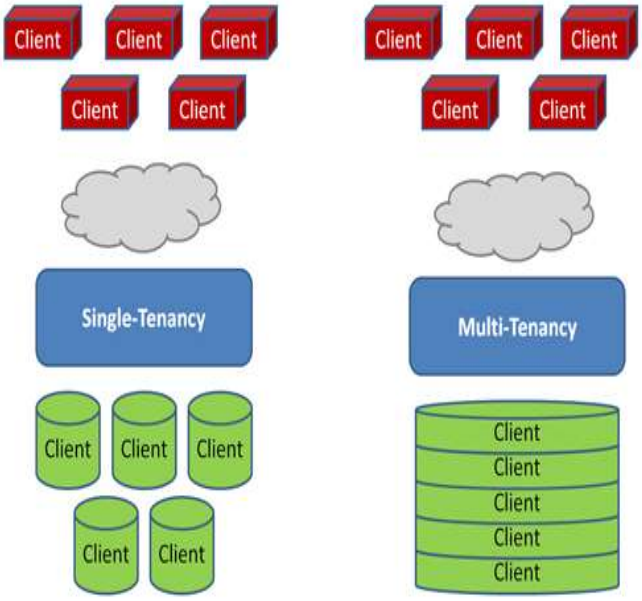

Fig1 : Single and Multi-tenancy Techniques

II. RELATED WORK

Multi-Tenancy has been identified as a security issue in Cloud Computing by several researchers such as who conducted a study conducted on security challenges in service delivery models in Clouds and stated that Multi-Tenancy is a major Cloud Computing characteristic that may lead to confidentiality violation. Also identifies Multi-Tenancy as a major threat to both confidentiality and privacy when talking about Cloud Computing security. Intel IT Centre generated a document of best practices on building secure Clouds; yet clearly highlights Multi-Tenancy and shared technology issues as security challenges for a Cloud environment.

In several areas were identified as danger in Clouds; under data governance the writer highlighted that Multi-Tenancy arrangements in Clouds are raising questions about data segregation. While NIST developed a report titled "Guidelines on Security and Privacy in Public Cloud Computing"; they identify Multi-Tenancy as of the security and privacy downsides in the Cloud. In a totally different approach interviewed five leading scientists from the cloud community, Raghu Rama krishnan the Chief Scientist for Search and Cloud Platforms at Yahoo! was one of them, where his response to the question of "On a related note, for a graduate student starting a PhD, what would you say are the key fundamental challenges of cloud computing that should be addressed by new research in the field?" included Multi-Tenancy as a fundamental challenge of Cloud Computing. Again raised questions in how Cloud Computing affecting security, privacy and trust; where he identifies Multi-Tenancy as one of the security issues.

Cloud Security Alliance (CSA) released a document titled "Security as a Service" where they tries to define categories for services; they raised the question "How does one assure data isolation in a multi-tenant environment?". Also, CSA in the same document stated that Multi-Tenancy is creating new targets for intrusion. In a study done by to identify the challenges of security and privacy in Cloud Computing; Multi-Tenancy is recognized as one of the unique implications of security and privacy in Cloud computing.

III. MULTI-TENANCY

The Main requirement of multitenancy is that the software provider gets many requests from customers with the customized needs. If a software product is implemented according to each customer needs separately and delivered, then the implementation takes more time to complete. The software cannot be maintained easily if there are different implementations of the product. The provider needs to spend more money to satisfy different customers. Here multi-tenancy comes into existence to provide solution for all the problems faced by provider to satisfy different customer with different needs. Multi-Tenancy allows single software to be served between the multiple customers by using customized settings option. The needs of each customer are stored in custom settings. The software provider serves the same product by implementing it seeing the customized requirements of each customer and makes it available only to the specific customer respectively. The tenants who share the software product cannot see each other's implementation of product. There is no contact between each customer's sharing the same software. The software provider must be in contact with multiple customers to satisfy them.

Multi-Tenancy means sharing the application software between multiple users who have different needs. Allocating single instance of an application software i.e., cloud to multiple users is called as multi-tenancy. Each user is called as tenant. The users who need similar type of resources are allocated a single instance of cloud, so that the cost is shared between the users to make the access of instance of cloud computing cost effective. Multi-Tenancy allows users to easily access, maintain, configure and manipulate the data stored in single database running on the same operating system. The data storage mechanism remains same for all users who share the similar hardware and software resources. In multitenant architecture, user cannot share or see each other's data, here the security and privacy is provided.

To perform any type of services like IaaS, SaaS and PaaS in public cloud and private clouds the key technique is Multi-tenancy. If the people discuss about the clouds they many speak about the IaaS Services. Both cloud architectures like private and public clouds go beyond the special features like Virtualization and the concept of IT-as-a-Service through payments or billing back in the event of private clouds based on metered usage. An IaaS service has an advanced features such as Service Level Agreements (SLAs), Identity and Access Management for Security Access)(IDAM), fault tolerance, disaster recovery, dynamic resource allocation and many other important properties. By Injecting all these key services at the level of infrastructure, the clouds become multitenant to a degree. In the case of IaaS multi-tenancy go beyond the layer to merge the PaaS layer and at the end SaaS layer or application layer. IaaS layer contains Servers, Storages and networking components, PaaS layer Consists of Platform for Applications like Java Virtual Machines like Java Compilers, Application Servers and SaaS Layer Consists of applications like business logic, work flow, data bases and user interfaces.

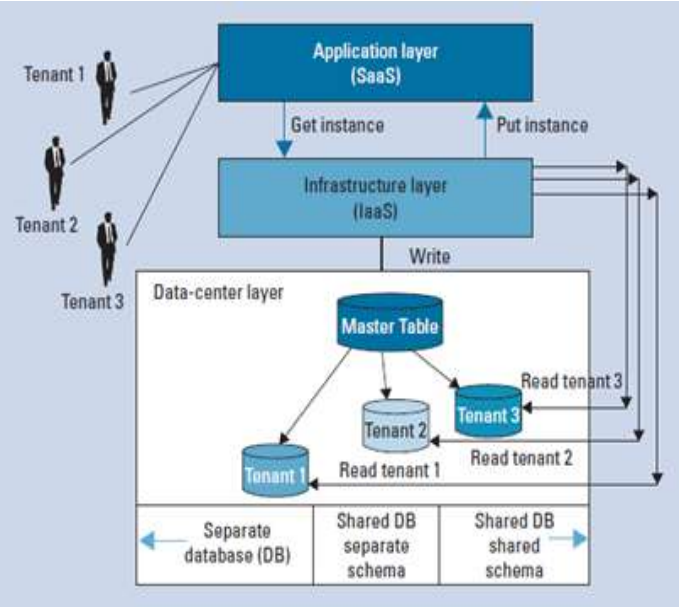

Fig2 : Architecture of Multitenancy

The tenants can like the full stream of services that are commonly used from the cloud services from the hardware infrastructure and going all the way up to the user interface based on the degree of multitenancy offered by the cloud. Cloud computing multi-tenancy is used for most if not all Software as a Service (SaaS) applications, because compute resources are scalable and allocation of these resources is defined by actual usage. There are different types of SaaS services that the clients can access by using internet, from low internet bases applications to a very big software applications that contains a very high security requirements depends on the type of information stored on the software vendors infrastructure outside the corporate network.

There are basically two type of Multitenancy Techniques like:

1. Virtual Multi-Tenancy: In this Computing and storage resources are shared among multiple users. Multiple tenants are served from virtual machines that execute concurrently on top of the same computing and storage resources.

2. Organic Multi-Tenancy: In organic multi-tenancy every component i.e., hardware and software resources in the system architecture is shared among multiple tenants.

In the cloud multitenancy concepts are implemented in three different levels of customer integration.

They are:

- Data centre layer
- Infrastructure layer
- Application layer

The infrastructure layer and application layer consumer integration levels are latest additions to the cloud computing model. This integration is used to reduce the cost and developing highly scalable SaaS applications, which they do by compromising on security and customer segregation requirements.

1. Data centre layer: This configuration provides the highest level of security requirements if implemented correctly, with firewalls and access controls to meet business requirements as well as defined security access to the physical location of the infrastructure providing the SaaS. Mostly data centre layer multi-tenancy acts as a service provider that that rents cages to companies that host their hardware, network, and software in the same building.

2. Infrastructure layer: In infrastructure layer multi-tenancy the software stacks are provided. Each customer or tenant is provided with a dedicated software stack. T his configuration saves costs compared to data centre-layer multi-tenancy, because stacks are deployed based on actual customer accounts.

The high availability of hardware and software resources can be seen in this layer. In this case, you can grow hardware requirements based on actual service use.

3. Application layer: Application-layer multi-tenancy requires architectural implementations at both the software layer and the infrastructure layer. Modifications are required for the existing software architecture, including multi-tenant patterns in the application layer. For example, multi-tenant applications require application methods and database tables to access and store data from different user accounts, which compromises on security. If done accurately, however, the benefit is cost savings.

Software as a Service provides a software model to deliver software based applications to provide remote access to the customers. In the cloud multitenancy is an important feature to provide SaaS services with different tenants simultaneously with a single application instance on the top of the shared infrastructure. Now a day's SaaS applications are build with centralization through a single instance with multitenant architecture to provide a advance rich experience with compared to on-premise models. Advantage of multi-tenancy are operational costs are reduced by dividing hardware, software resources among the different tenants are shared, simplifying the maintenance and management effort. All of these advantages of multi-tenancy effect in reducing the application costs to provide maximum benefits to small and medium organizations. Multi-tenancy Service Requirements for Cloud Services Providers are tenant data isolation, tenant workspace isolation, Isolation of tenant execution, Tenant-aware security, monitoring, management, reporting and self service administration, Isolation of tenant customizations and extensions to business logic, tenant-aware version control, Tenant-aware error tracking and recovery. The degree of multitenancy of an application is defined as the amount of base application or a SaaS layer is developed to be shared amount tenants. The highest degree of multi-tenancy allows the database schema to be shared and supports customization of the business logic, workflow and user-interface layers. private clouds are available at the lowest degree of multi-tenancy and are more suited for specific large enterprise customers.

IV. MULTITENANCY VS VIRTUALIZATION

Most of the people are assumes that the both multi-tenancy and virtualization concepts are same and each can be replaced in the place of the other. Multi-tenancy is sometimes mistaken for virtualization because the concept of multiple tenants is similar to the concept of virtualized instances. The differences lie in what is multiplied within a physical server acting as a host.

Multi-tenancy: In a multi-tenancy environment, multiple customers share the same application, running on the same operating system, on the same hardware, with the same data-storage mechanism. The distinction between the customers is achieved during application design, thus customers do not share or see each other's data. It enables each customer application to appear to run on a separate virtual machine. A physical or virtual server hosting an application is designed to allow usage by multiple different users. Each user feels as though they have exclusive usage of the application.

Virtualization: Multiple virtual copies of the server environment can be hosted by a single physical server. Each copy can be provided to different users, can be configured independently, and can contain its own operating systems and applications. It enables each customer application to appear to run on a separate virtual machine.

V APPLICATIONS OF MULTITENANCY

SaaS applications that are designed for the cloud with roots as partner database applications typically are multitenant applications. In multitenant applications, data and workload can be easily partitioned. You can partition data and workload along tenant boundaries because most requests occur within the confines of a tenant. These SaaS applications deliver a specialized software application as a service to their tenants. Tenants can access the application service and have full ownership of associated data stored as part of the application. But to take advantage of the benefits of SaaS, tenants must surrender some control over their own data. They trust the SaaS service provider to keep their data safe and isolated from other tenants' data. Examples of this kind of multitenant SaaS application are MYOB, SnelStart and Salesforce.com. Each of these applications can be partitioned along tenant boundaries. Applications that provide a direct service to customers or to employees within an organization (often referred to as users, rather than tenants) are another category on the multitenant application spectrum. Customers subscribe to the service and do not own the data that the service provider collects and stores. Service providers have less stringent requirements to keep their customers' data isolated from each other beyond government-mandated privacy regulations. Examples of this kind of customer-facing multitenant application are media content providers like Netflix, Spotify, and Xbox LIVE. Other examples of easily partition able applications are customer-facing, Internet-scale applications, or Internet of Things (IoT) applications in which each customer or device can serve as a partition. Partition boundaries can separate users and devices. All applications cannot be partitioned along a single property such as tenant, customer, user or device. A complex enterprise resource planning (ERP) application, for example, has products, orders, and customers. It usually has a complex schema with thousands of highly interconnected tables. No single partition strategy can apply to all tables and work across an application's w

VI. BENEFITS OF MULTI-TENANCY:

- **Lower cost of ownership**
  Because all users access their services from the same technology platform it is much easier to access automatic and frequent updates. No longer need to pay for report customizations or to add new functionalities.
- **Worry free capacity**
  Multi-tenancy provides companies of all sizes the ability to reside in the same infrastructure and data centre.
- **API Integration scalability**
  The integration of Web API is available in single-instances, but in the multi-tenancy environment, specific requests for integrations will now go into our product roadmap, and as they become available, they'll be rolled out to all customers.
- **Access to the latest releases**
  Before, when we wanted to roll-out a new update, it was a lengthy process because we had to code the change separately for each client instance to ensure that it was compatible with their customizations, perform QA, and then put the change into production. With more than 100 customers, it was a time-consuming task for our support team. Now with our multi-tenant environment, because every customer's instance has the same base code, the roll-out of new releases will be very seamless and provide faster access to innovative features to manage IT and communication expenses.

- **Configurable to your own needs**

This capability provides our customers with the ability to meet their requirements and communication styles to manage all IT and communication expenses.

VIII. MULTI-TENANCY PROBLEMS

- **Security:**

There is also the threat of hackers – no matter how secure an encryption is with the right knowledge. A hacker who breaks the encryption of multitenant database will be able to steal the data of hundreds of businesses who have data stored on it.

- **Capacity optimization:**

Database administrators need the tools and the knowledge to understand which tenant should be deployed on which network in order to maximise capacity and reduce costs.

- **Service delivery and high availability:**
  When failures occur or when certain services generate abnormal loads the service delivery can be interrupted – yet business clients will often request high-availability. Therefore, monitoring the service delivery and its availability is critical to ensure that the service is properly delivered.

- **Inflexible:**
  Using multi-tenancy characteristics of cloud computing, customers can store the data must be stored in servers located inside France, German customer data inside Germany etc.

IX. CONCLUSION

In present days all applications are implemented with Multi-tenancy techniques and these applications are used in most of the business applications. In this paper we have discussed about different type of multitenancy, applications, benefits,sdvantages and disadvantages of multitenancy in different cloud based service models like SaaS, PaaS and IaaS.

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