



Module 7 Lecture 02 Architectures for the Cloud -2

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Architectures for the Cloud - 2

Session Outline



- Base Mechanisms
- Sample Technologies
- Architecting in a Cloud Environment
- Summary







load

Basic Mechanisms

- Hypervisor
- Virtual Machine
- File system
- Network

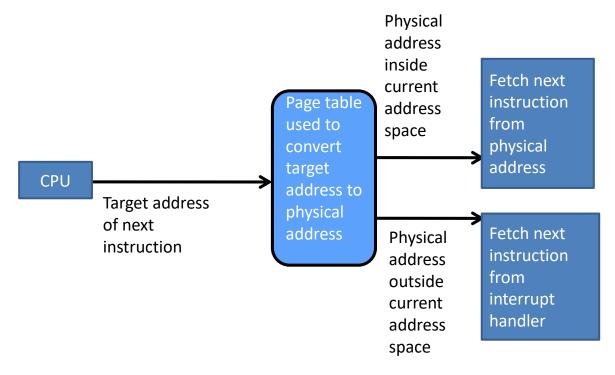
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Virtual Memory Page Table



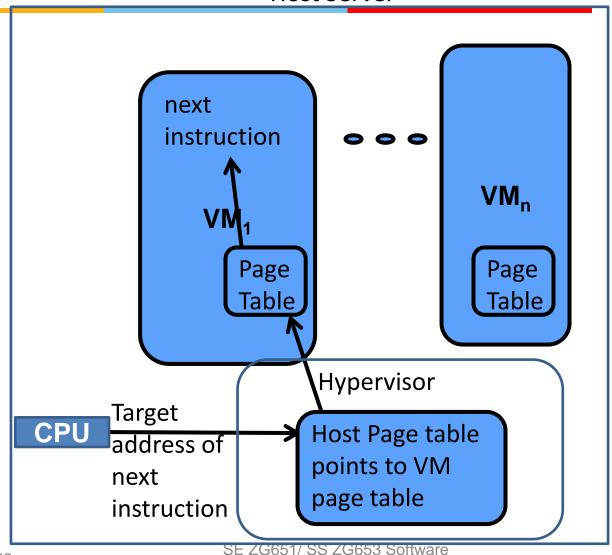
Virtual Memory Page Table

Virtual memory for non-virtualized application



Hypervisor Manages Virtualization Host Server





Virtual Machine



- A virtual machine has an address space isolated from any other virtual machine.
- Looks like a bare metal machine from the application perspective.
- Assigned an IP address and has network capability.
- Can be loaded with any operating system or applications that can execute on the processor of the host machine.

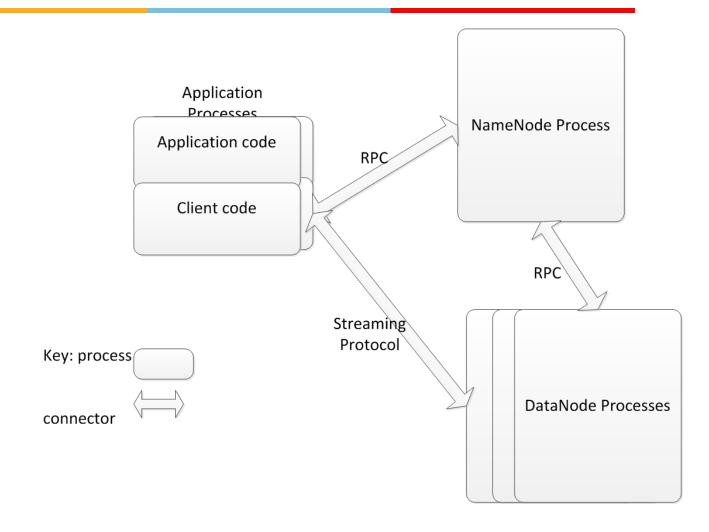




- Each virtual machine has access to a file system.
- We will present HDFS (Hadoop Distributed File System)
 - a widely used open source cloud file system.
- We describe how HDFS uses redundancy to ensure availability.







HDFS Write – Sunny Day Scenario



- Application writes as to any file system
- Client buffers until it gets 64K block
- Client informs NameNode it wishes to write a new block
- NameNode returns list of three DataNodes to hold block
- Client sends block to first DataNode and informs DataNode of other two replicas.
- First DataNode writes block and sends it to second DataNode. Second DataNode writes block and sends it to last DataNode.
- Each DataNode reports to client when it has completed its write
- Client commits write to NameNode when it has heard from all three DataNodes.



HDFS Write – Failure Cases

Client fails

- Application detects and retries
- Write is not complete until committed by Client

NameNode fails

- Backup NameNode takes over
- Log file maintained to avoid losing information
- DataNodes maintain true list of which blocks they each have
- Client detects and retries

DataNode fails

- Client (or earlier DataNode in pipeline) detects and asks NameNode for different DataNode.
- Since each block is replicated three times, a failure in a DataNode does not lose any data.

Network



- Every Virtual Machine is assigned an IP address.
- Every message using TCP/IP includes IP address in header.
- Gateway for cloud can adjust IP address for various purposes.



Sample Technologies

- laaS
- PaaS
- DataBases

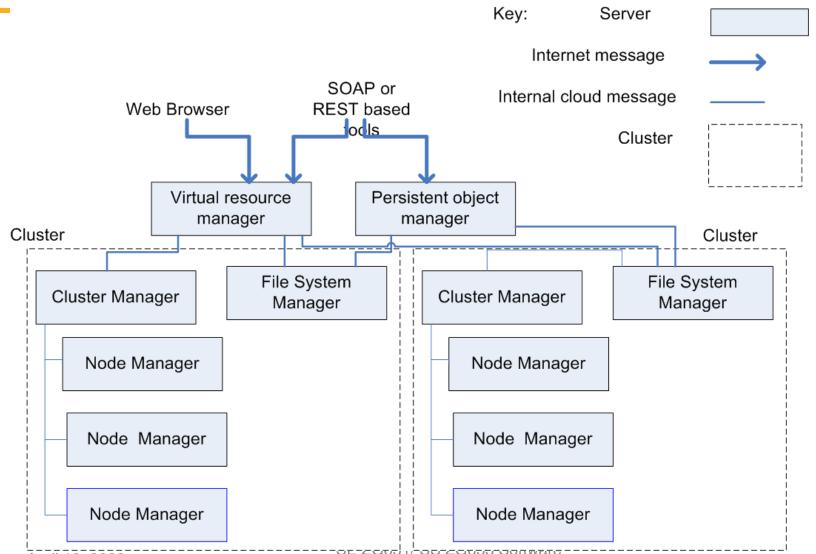
laaS



- An arrangement of servers that manages the base technologies.
 - Servers are arranged in clusters
 - May be thousands of servers in a cluster
 - Some servers are used as the infrastructure of the laaS
 - Every server has a hypervisor as its base.

laaS Architecture





15



laaS Architecture Components

- Cluster Manager responsible for managing each cluster
- Persistent Object Manager manages persistence
- Virtual Resource Manager manages other resources. It acts as a gateway for messages.
- The File System Manager is similar to HDFS. It manages the network wide file system.



Services Provided by laaS

- Automatic reallocation of IP addresses in the case of a failure of the underlying virtual machine instance.
- Automatic Scaling. Create or delete new virtual machines depending on load.

PaaS



- Provides an integrated stack for developer.
- E.g. LAMP stack
 - Linux, Apache, MySQL, Python
- The developer writes code in Python and the PaaS manages assignment to underlying layers of the stack.

Databases



- Why relational databases came into question
 - Massive amounts of data are collected from web systems. Much of this data is processed sequentially and so RDBMSs introduce overhead, especially during creation and maintenance.
 - The CAP Theorem shows that it is not possible to simultaneously achieve consistency, availability, and partitioning.
 - The relational model is not the best model for some applications.
- Caused the introduction of new data models
 - Key-value
 - Document centric

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Key Value – HBase

- One column designated as a key. The others are all values
- No schema so data can have key + any other values.
 The values are identified by their variable name.
- Data values are also time stamped
 - Hbase does not support transactions. Time stamps are used to detect collisions after the fact.



Document Centric – MongoDB

Stores objects rather than data
Access data through containing object
Objects can also contain links to other objects
No concept of primary or secondary index. A field is indexed or it is not.

What is Omitted From These DBs



- Transactions. No locking is performed. The application must detect interference with other users.
- Schemas. No predefined schemas. The application must use correct name.
- Consistency. The CAP theorem says something must give. Usually consistency is replaced by "eventual consistency"
- Normalization and Joins. Performing a join requires that the join field is indexed. Because there is not a guaranteed index field, joins cannot be performed. This means normalization of tables is not supported.

Architecting in a Cloud Environment



- Quality attributes that are different in a cloud
 - Security
 - Performance
 - Availability

Security



- Multi-tenancy introduces additional concerns over non-cloud environments.
 - Inadvertent information sharing. Possible that information may be shared because of shared use of resources. E.g. information on a disk may remain if the disk is reallocated.
 - A virtual machine "escape". One user can break the hypervisor. So far, purely academic.
 - Side channel attacks. One user can detect information through monitoring cache, for example. Again, so far, purely academic.
 - Denial of Service attacks. One users can consume resources and deny them to other users.
- Organizations need to consider risks when deciding what applications to host in the cloud.

Performance



- Auto-scaling provides additional performance when load grows.
 - Response time for new resources may not be adequate
 - Architects need to be aware of resource requirements for applications
 - Build that knowledge into the applications
 - May applications self aware so that they can be proactive with respect to resource needs.

Availability



- Failure is a common occurrence in the cloud
 - With 1000s of servers, failure is to be expected
- Cloud providers ensure that the cloud itself will remain available with some notable exceptions.
- Application developers must assume instances will fail and build in detection and correction mechanisms in case of failure.

Summary



- The cloud provides a new platform for applications with some different characteristics.
- Architect needs to know how a cloud cluster works and pay special attention to
 - Security
 - Performance
 - Availability