Cloud Computing (CS60118)

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Service and Data Management in Cloud

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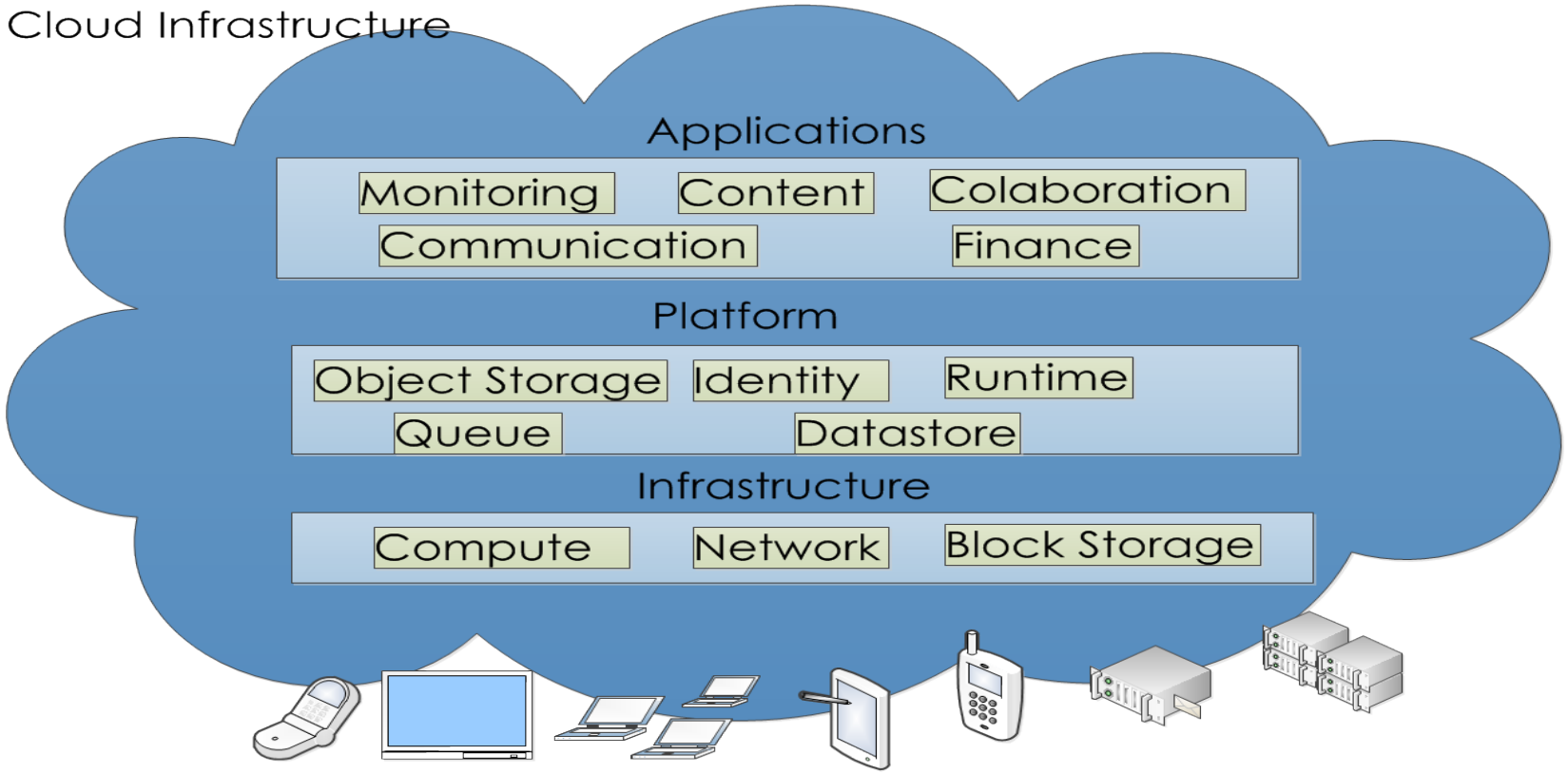
Contents

- Resource Abstraction and Workloads
- Load Management
- Storage Access Protocols
- Functions and Benefits of the Services and Storage

Resource View of Cloud

- Consumer View -
  - Metered scalable service consists of infinite resource pool, capable to provide any amount of resource .
- Cloud Service Provider View
  - Serve as many as consumers with finite amount of resource pool.
  - Optimal management of resources.
  - Provision of minimal service accessing overhead of consumers through resource abstraction

Different Types of Resource in Cloud



Source: cloud computing-wikipedia

Need of Resource Management

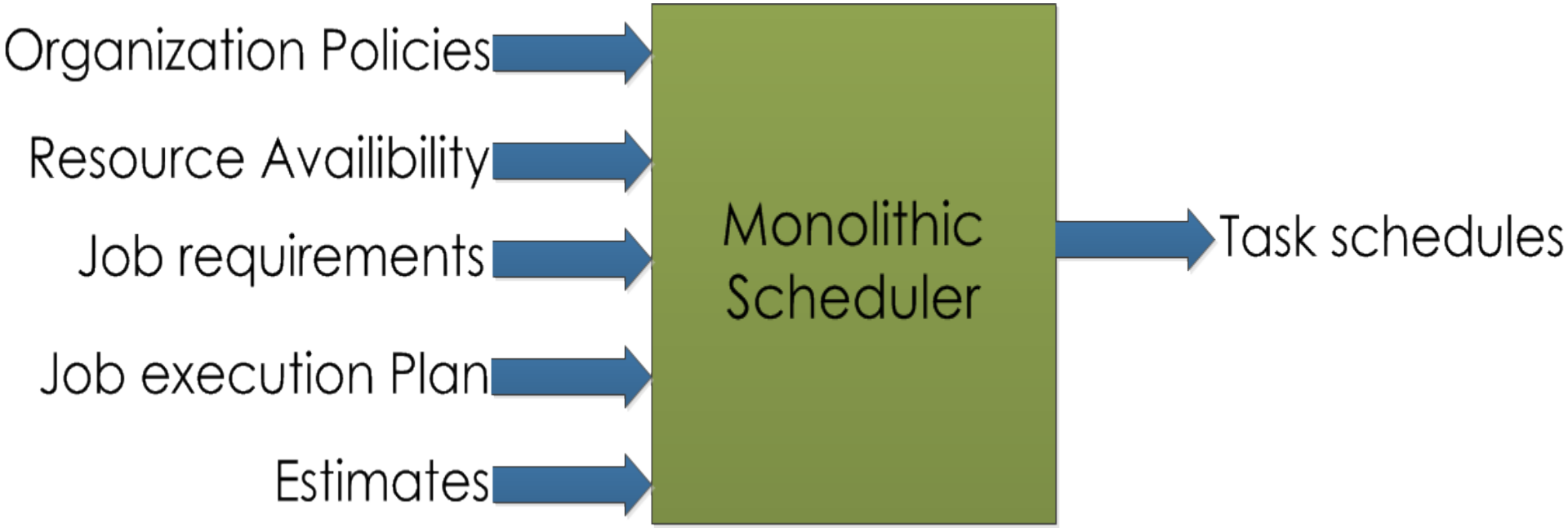
- Integration of heterogeneous resources in cloud enhances the adoption of cloud computing by service consumer. The advantages of heterogeneous resource integrations are
  - Wide range of application support.
  - Mapping between application requirements and resource features or characteristics.
  - Maximization of cloud service provider (CSP) profit
  - Maximization of Cloud Service Consumer satisfaction.

Cloud Resource Scheduler

- Cloud Resource scheduler is grouped into three types –
  - Monolithic scheduler
  - Two-Level scheduler
  - Shared State scheduler

Monolithic Scheduler

- Monolithic Scheduler -- A Monolithic Scheduler has a single instance, is sequential, and must implement all policy choices in a single code base. e.g. Google Borg scheduler.

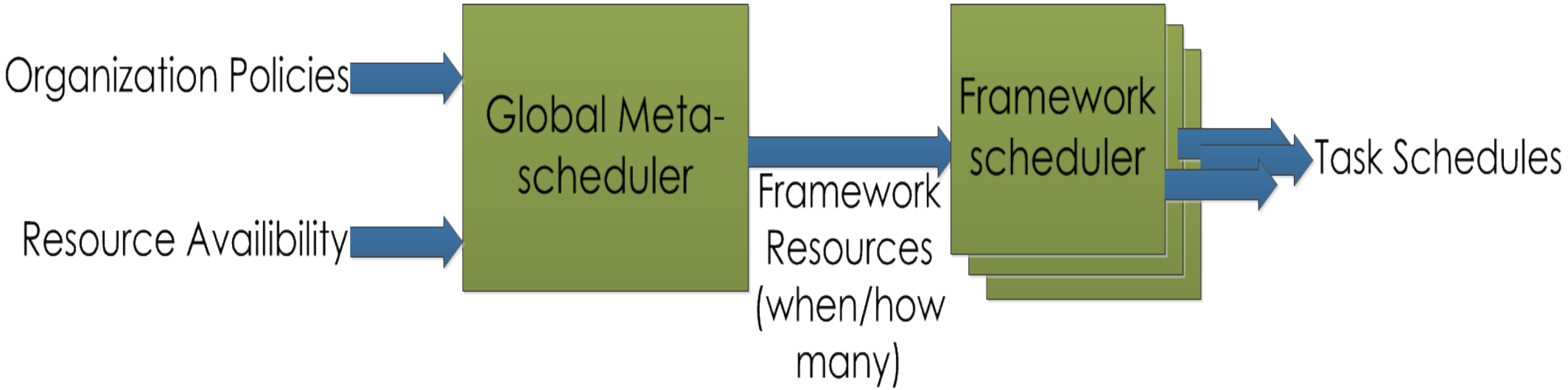


Source: https://bit.ly/3kC8agV

Two-level Scheduler

- It is an infrastructure management framework and separates application schedulers from resource schedulers.
- Master scheduler decides the number of resources from the available pool can be assigned to a framework.
- Application scheduler allocates resources to each application within a framework.
- Mesos is an example of two-level scheduler.

Two-level Scheduler

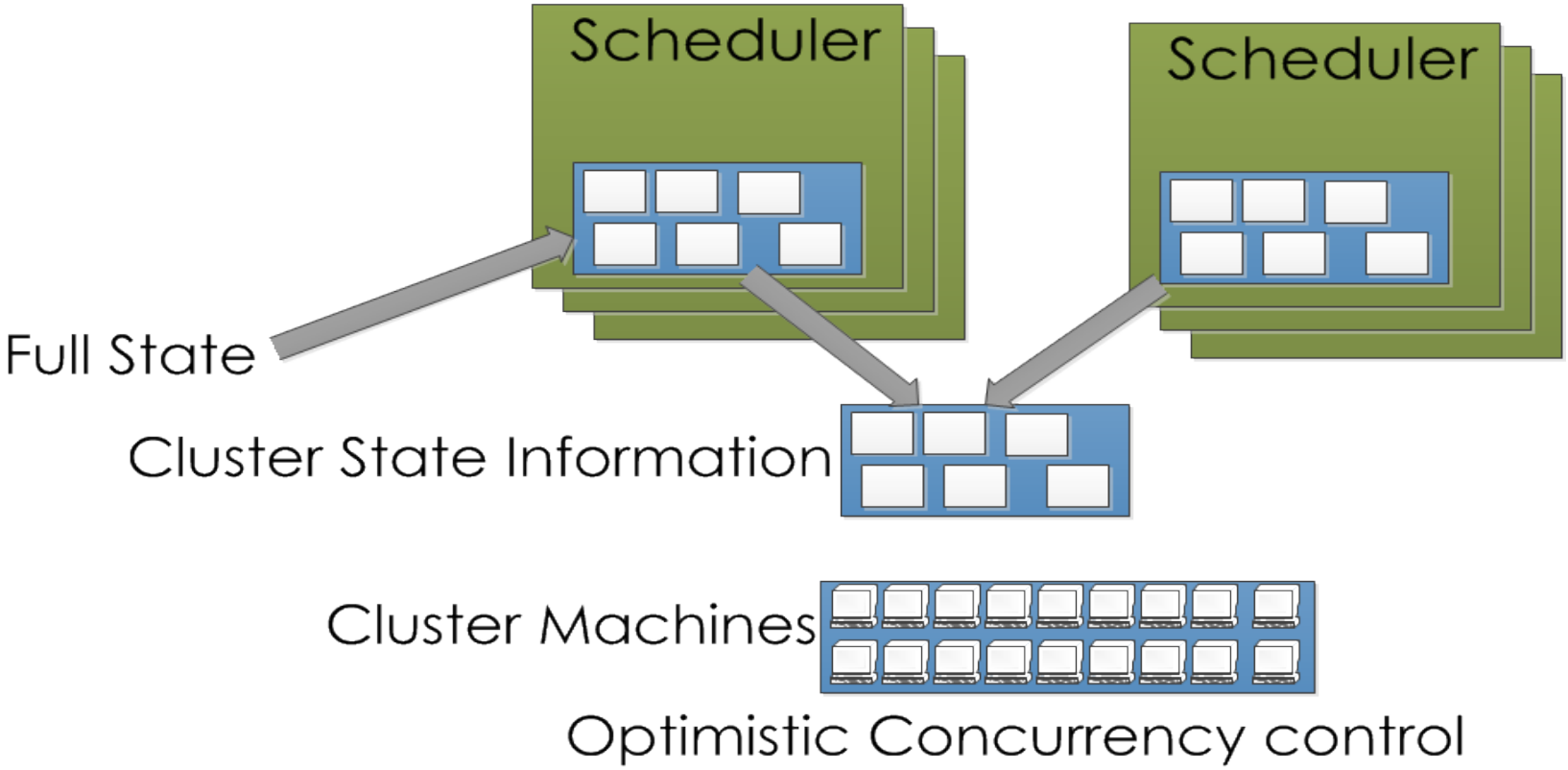


Source: https://bit.ly/3kC8agV

Shared State Scheduler

- Supports multiple parallel scheduler.
  - Each scheduler maintains a local copy of the global state for local decision making.
  - After each local decision the shared copy of the global state is also updated. The state synchronization is done through atomic commit.
  - Google omega is a shared state scheduler.

Shared State Scheduler



Source: https://bit.ly/3kC8agV

Cloud Resource Scheduling Decision Parameters

- Parameters to map the applications to cloud resources are --
  - Resource requirement of applications.
  - Number of available CPU cores.
  - Free memory space.
  - Available storage space.
  - System state Information.

Resource Abstraction

- Abstraction enables shared, ubiquitous access to cloud resources.
- Virtualization or containerization is the key to resource abstraction in cloud.
- Virtualization uses a set of technologies to create virtual machine, virtual server, virtual storage and virtual network.
- Virtualization assigns a logical name to physical resources and provides a pointer when a request is made.
- The mapping in virtualization is dynamic.

Types of Virtualization

- Access – Consumer can access cloud resources from any location.
- Application — Cloud has multiple application instances and directs request to one of instances based on predefined criteria.
- CPU — Computers are partitioned into set of virtual machines and each machine is assigned a workload.
- Storage — Data is stored in storage and virtual storage is assigned by exhibiting the redundancy via replication.

Virtual Machine

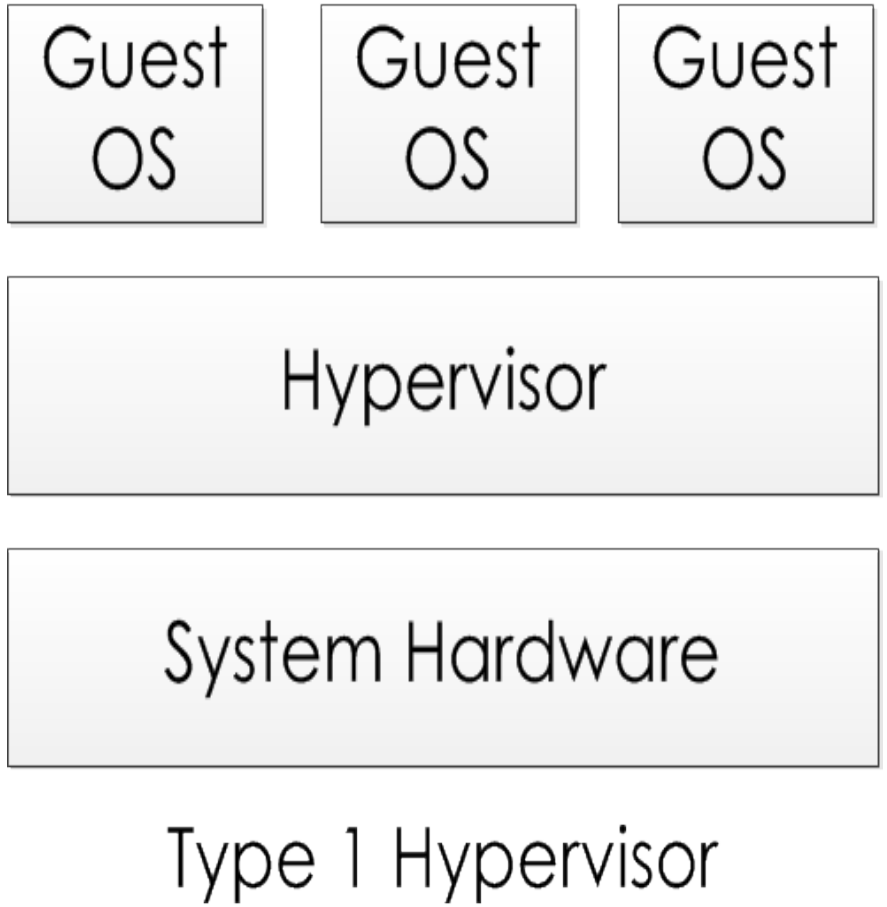
- A virtual machine has all the features of a physical machine, but is a software which emulates a physical machine.
- A system virtual machine or hardware virtual machine has own resource allocation, I/O with virtual driver and address space in memory.
- Process virtual machine runs as a single application or process.
- A virtual machine is logically separated from the host physical machine.
- Host machine can run multiple virtual machine at the same time, each with separate operating system and applications.

Hypervisor or Virtual Machine Monitor

- A low level program which helps to create and manage virtual machines.
- The operating system running on the physical machine is known as host operating system.
- The operating system installed on virtual machine is known as guest operating system.
- There are two types of virtual machine –
  - Type 1 Hypervisor
  - Type 2 Hypervisor

Type 1 Hypervisor

- A hypervisor running on a bare metal is called type 1 hypervisor or native VM.
- Type 1 hypervisor has no host operating system.
- LynxSecure, RTS Hypervisor, Oracle VM, Sun xVM Server, VirtualLogix VLX, VMware ESX and ESXi are example of type 1 hypervisor.

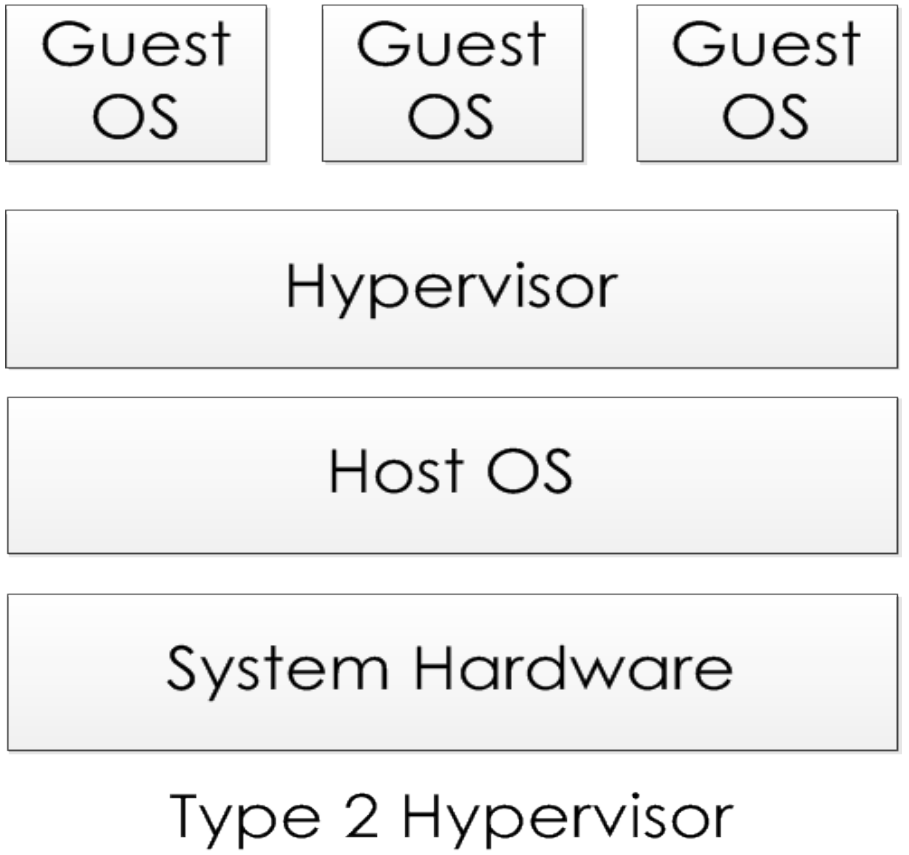


Type 1 Hypervisor

Source: Cloud Computing Bible.

Type 2 Hypervisor

- Type 2 hypervisor installed over host operating system and runs as a single application.
- KVM, Microsoft Hyper V, Parallels Desktop for Mac, Wind River Simics, VMWare Fusion, Virtual Server 2005 R2, Xen, Windows Virtual PC, and VMware Workstation 6.0 and Server are example of type 2 hypervisor.



Type 2 Hypervisor

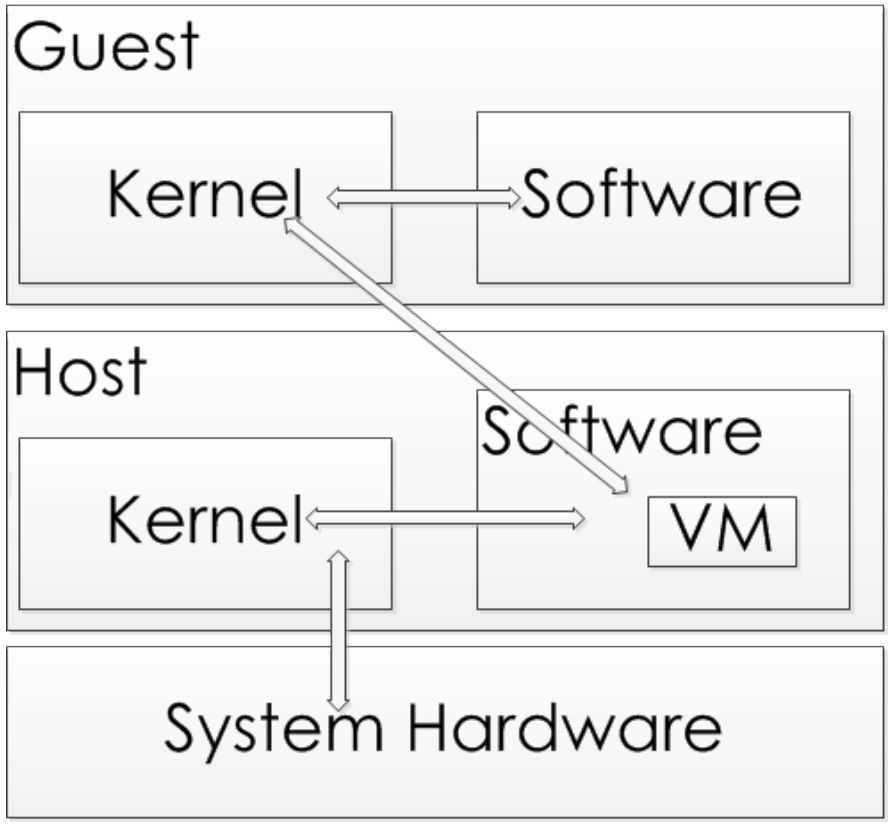
Source: Cloud Computing Bible.

Types of Virtualization

- Emulation
- Para virtualization
- Full Virtualization

Emulation

- In emulation, virtual machine simulates hardware.
- It is independent of the underlying host system hardware.
- Guest operating system is not modified.

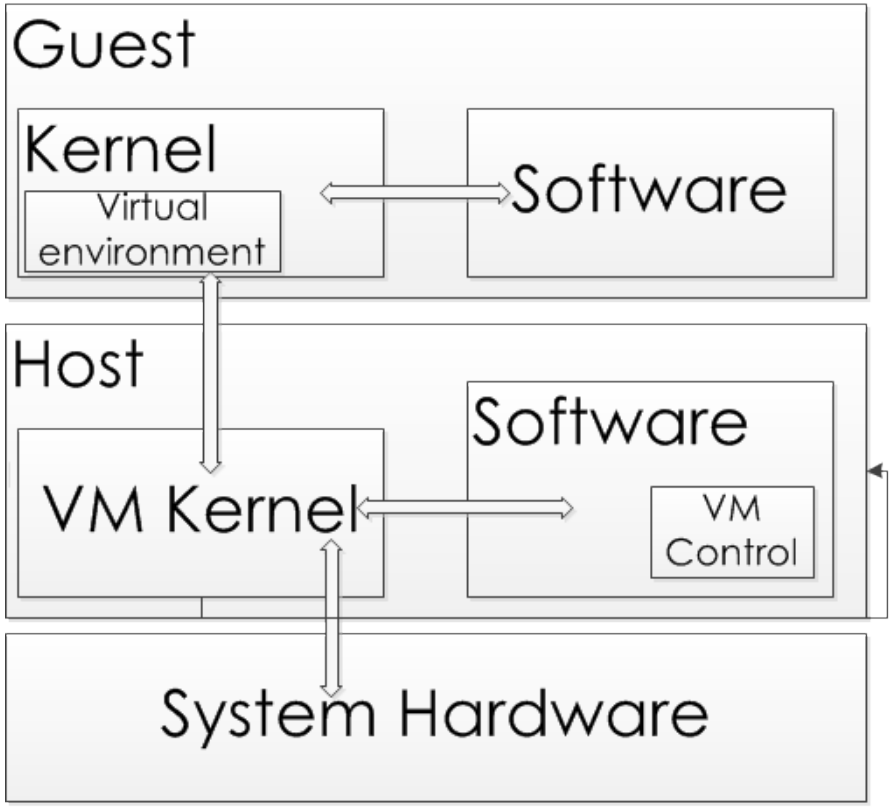


Emulation

Source: Cloud Computing Bible.

Para Virtualization

- Host operating system provides a virtual machine interface through with guest OS interacts with the host machine hardware.
- Guest operating system is modified to interact with the host machine hardware.

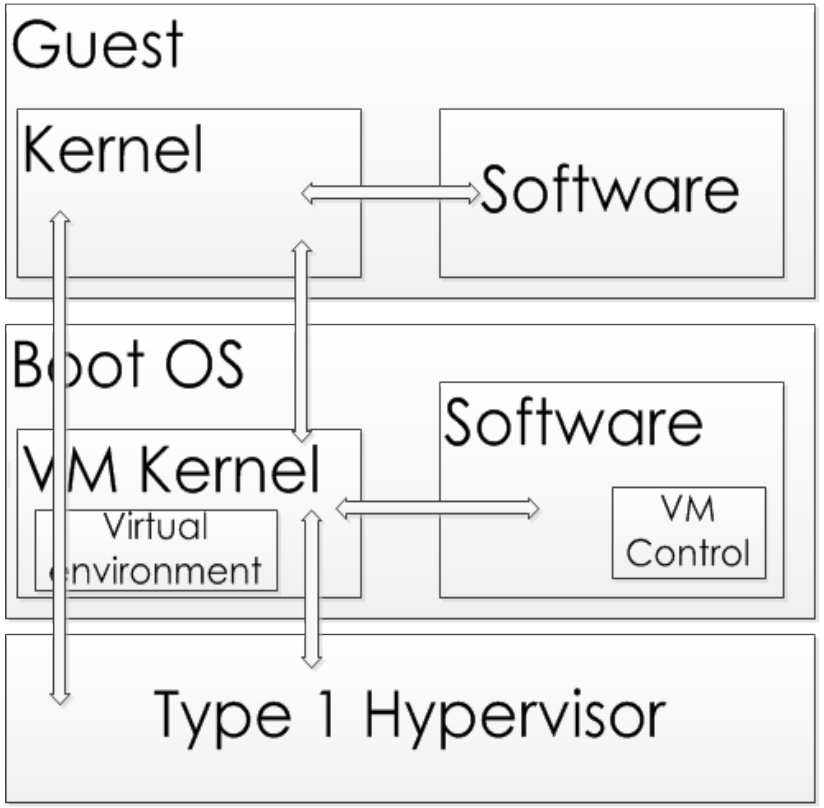


Para Virtualization

Source: Cloud Computing Bible.

Full Virtualization

- VM is installed as type 1 hypervisor directly on top of hardware.
- All operating systems communicates directly with the hypervisor.
- Guest operating system is not modified.
- Guest operating system is faster than other virtualization.



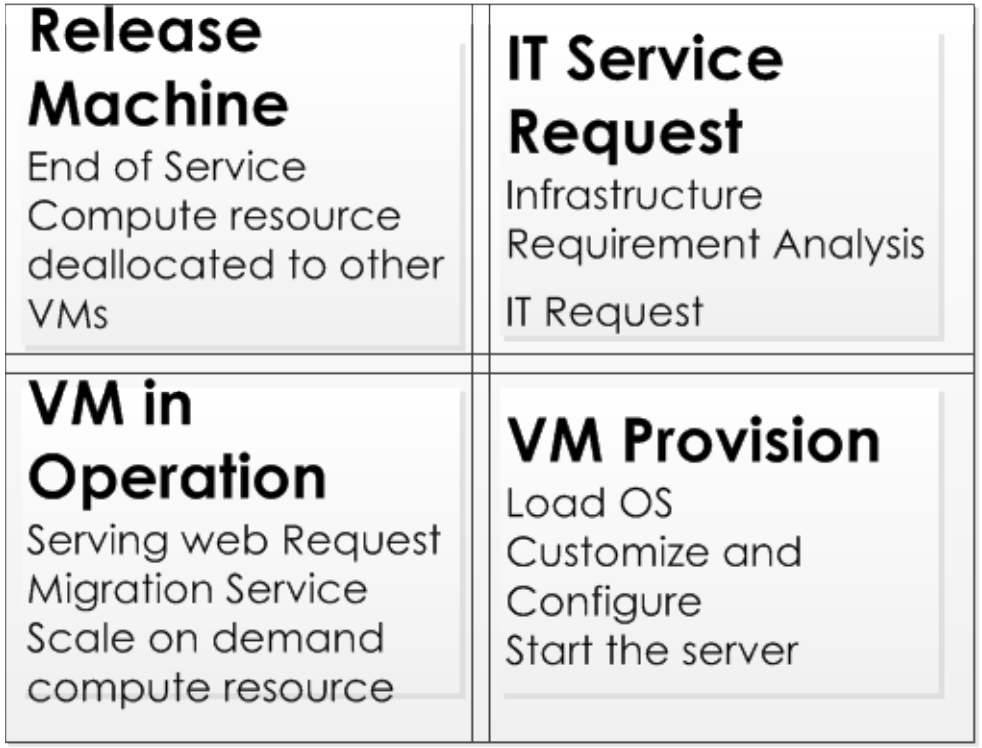
Full Virtualization

Source: Cloud Computing Bible.

Virtual Machine Lifecycle

- Let us assume that a request for creating a new server for a particular service has come from consumer .
- The request is delivered to the IT department.
- The IT department do the following--
  - Check the resource pool of the server's pool.
  - Match the resource specifications with the requirements.
  - Start provisioning the needed the virtual machines.
- After provisioning, it is delivered to the consumer.

Virtual Machine Lifecycle (contd)



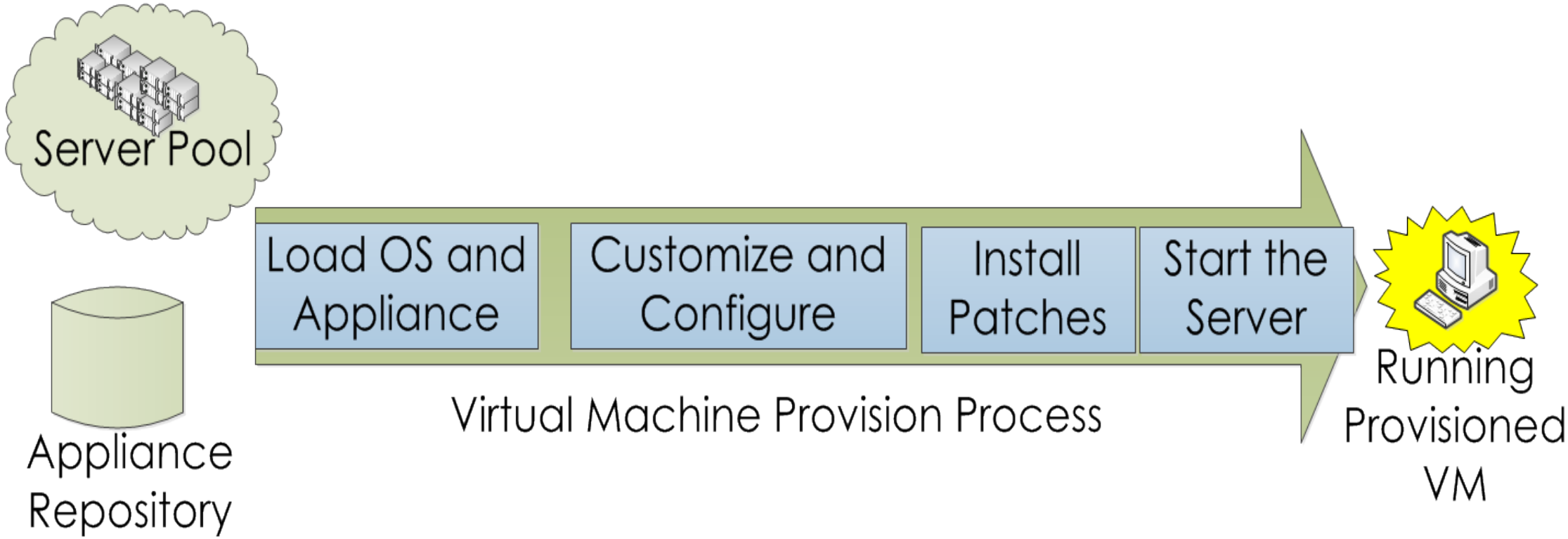
Virtual Machine Life Cycle

Source: Cloud Computing: Principles and Paradigms.

VM Provisioning Process

- VM provisioning the process of making ready the VM according to requirements.
- The provisioning steps are ---
  - Select a server from a pool of available servers with required OS template.
  - Load the appropriate software (device drivers, middleware and required application software) in selected server.
  - Customize and configure the machine.
  - Configure the associated network and storage.

VM Provisioning Process (contd)



Source: Cloud Computing: Principles and Paradigms.

CloudLightning Approach

- This architecture is constructed to address the challenges associated with heterogeneous cloud.
- It is composed of components and services with self-organization and self-management support.
- This approach describes how specialized hardware can be seamlessly integrated and complexity of resource management can be handled considering heterogeity in cloud computing.

Infrastructure Organization of CloudLightning

- The architecture of CloudLightning is similar to warehouse scale computer.
- It is composed of cells.
- Each cell composed of different racks.
- Each rack composed of different computational resources.

Hardware Organization of CloudLightning

- Physical server is partitioned into different group based on geographical locations or regions called cells.
- Each cell is composed of heterogeneous computational resources, known as Compute Resource Fabric.
- There are five primary computational hardware are considered .
  - Commodity servers (CPUs)
  - Servers with GPU accelerators.
  - Servers with MIC accelerators
  - Servers with FPGA accelerators
  - Non-uniform Memory Access Scale high-performance computer

Hardware Organization of CloudLightning (contd)

- In conventional data centre, physical racks are used to hold the computational resources.
- The physical racks in conventional data centre has no explicit identity.
- CloudLightning introduces a virtual component called vRacks.
- Each vRacks contains a group of physical servers that share common properties such as hardware types, hardware compatibility and network connection.

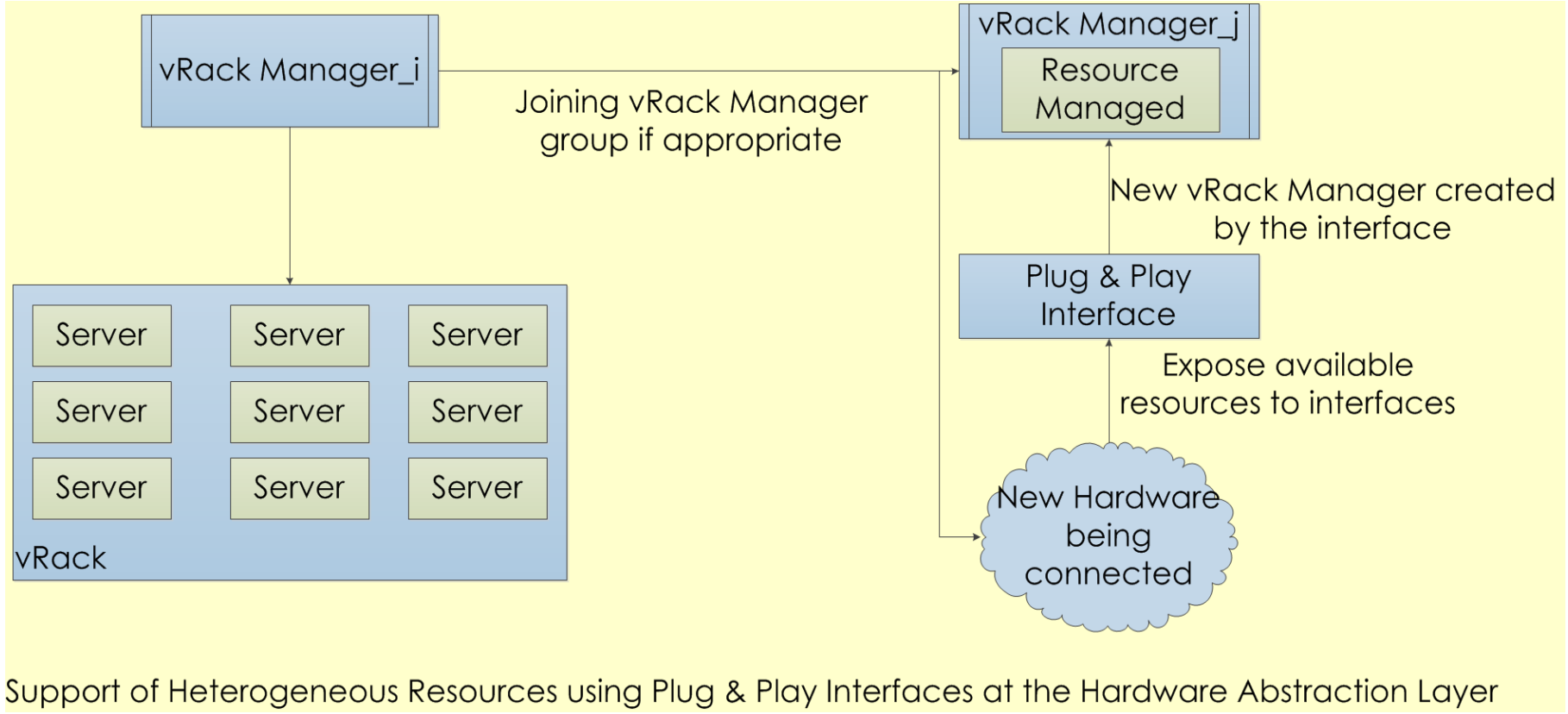
Resource Abstraction in CloudLightning

- The hardware abstraction layer (HAL) provides a logical view of the underlying hardware to the cloud management layer.
- The resources are placed into vRacks by the HAL.
- The initial size of a vRack is determined by the type of the resources to be managed.
- A vRack can also communicate with other vRacks to transfer or pull resources.

Resource Abstraction in CloudLightning (contd)

- A dedicated Plug & Play interface adds new resources to the to the CloudLightning system.
- The newly added hardware provides its specification to the Plug & Play interface.
- The interface creates CloudLightning specific resource instance (CL-Resources) from the specification of newly added hardware.
- The newly created CL-Resources is attached with a suitable vRack and managed by a designated vRack Manager.

Resource Abstraction in CloudLightning (contd)



Support of Heterogeneous Resources using Plug & Play Interfaces at the Hardware Abstraction Layer

Source: Heterogeneity, High Performance Computing, Self-Organization and the Cloud.

Cloud Management Layer of CloudLightning

- In this layer, a cell manger is associated with each cell.
- The cell manager perform the following functions ---
  - Receives Application Requirement documents
  - Acquire CL-Resources
    - User can select resources found by Resource Discovery phase (resource reservation is required).
    - System can also assign appropriate resources according to requirement (resource reservation not required).

Cloud Management Layer of CloudLightning (contd)

- The operations of cloud management layer are divided into following stages --
  - CL-Resource Discovery.
  - The CL-Resource Selection.
  - Resource Acquisition.
  - Coalition Lifecycle Management.

CL-Resource Discovery of Cloud Management Layer

- The CL-Resource discovery is initiated by the cell manager after receiving Application Requirements Document from gateway.
- The Application Requirements Document contains blueprint of service requirements.
- The discovery process ---
  - locate all of the possible CL-Resources that can satisfy specified requirements.
  - Determine the information about the dynamically changing capabilities and capacities of vRack managers.
  - Instructs vRack managers to reserve the resources.
  - Forward the resource discovery information to the resource selection stage.

CL-Resource Selection of Cloud Management Layer

- Determine the resource sets required for fulfilling consumer specified criteria.
- Selects one of resource set which minimizes the overhead of cloud service provider.
- A vRack Manager manages all of the CL-Resources associated its own vRack.
- Each vRack Manager has three functional components ---
  - Resource Acquisition component
  - Coalition Lifecycle Management component
  - Self-Organization Agent .

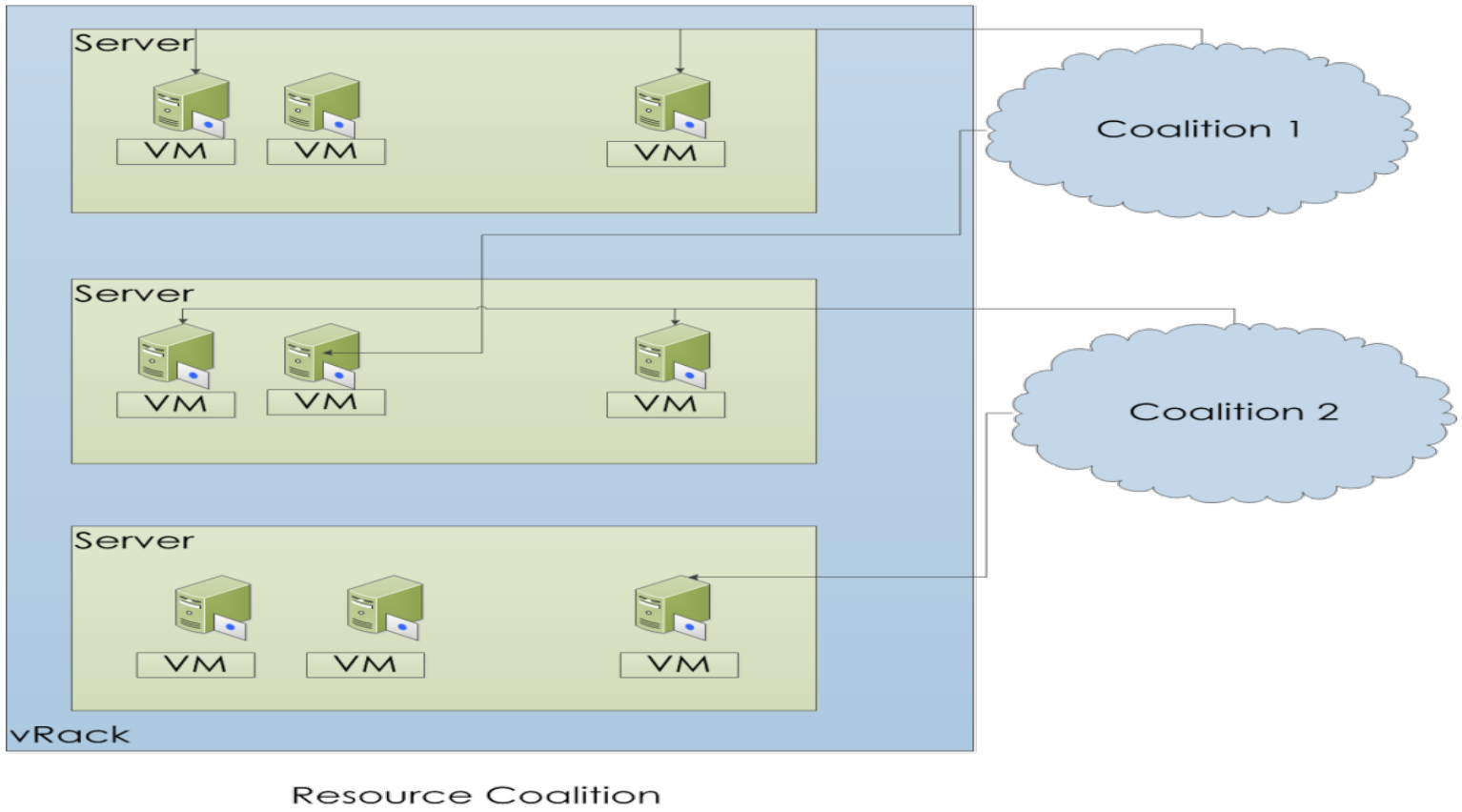
CL-Resource Selection of Cloud Management Layer (contd)

- Resource Acquisition Component— This component is activated by Cell Manager and acquires CL-Resources selected in the CL-Resource Selection stage .
- Coalition Lifecycle Management Component—
- A coalition is a special type of CL-Resource and represents a set of homogeneous set of resources within a single vRack .
- There are two types of Coalition ---
  - Static Coalitions
  - Dynamic Coalitions

CL-Resource Selection of Cloud Management Layer (contd)

- Static Coalitions — The coalition formed by vRack Manager from fixed set of CL-Resource is persistent and called static coalitions.
- Dynamic Coalitions — The vRack Manager constructs dynamic coalitions by dynamically creating some or all CL-Resources.
- A coalitions may exist within a single server or it can span multiple servers.
- If the coalitions spans multiple vRack, then different vRack Manager communicates with adjacent vRack Managers.

CL-Resource Selection of Cloud Management Layer (contd)



Source: Heterogeneity, High Performance Computing, Self-Organization and the Cloud.

CL-Resource Selection of Cloud Management Layer (contd)

- Self-Organization Agent—
  - vRack Managers organize themselves into groups and determine local optimum strategy for CL-Resource management.
  - Self-Organisation Agent maintains data about vRack Managers within a group and exchange local state information within vRack Managers.
  - Exchange power management decision among the servers within a vRack.
  - Helps to migrate servers from one vRack to another vRack.

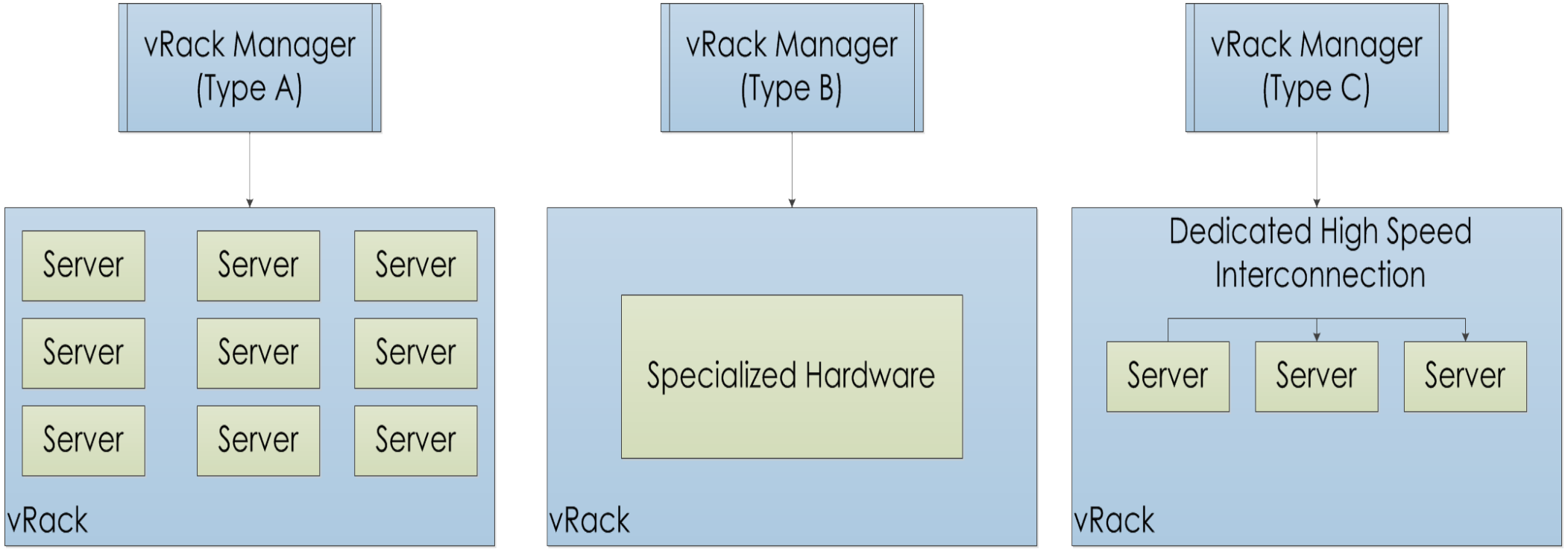
Classification of vRack Managers

- There are three types of vRack Managers —
  - Type-A vRack Managers
  - Type-B vRack Managers
  - Type-C vRack Managers
- Type-A vRack Managers ---
  - Manage a set of homogeneous resources.
  - These managers can be commodity hardware or CPU-GPU pairs or CPU-Data Flow Engine pairs or CPU-MIC pairs.

Classification of vRack Managers (contd)

- Type-B vRack Managers ---
  - are more specialised.
  - Manages a set of HPC machine considered as single CL-Resource.
- Type-C vRack Managers ---
  - Manages a set of hardware resources collocated on a high speed interconnect.

Classification of vRack Managers (contd)



Source: Heterogeneity, High Performance Computing, Self-Organization and the Cloud.

Load Management

Cloud Load Balancing

- The overloaded and underloaded situation in the cloud can cause different system failure and affects the power consumption, execution time.
- The different types of load in cloud are ---
  - Memory load
  - Computation (CPU) load
  - Network load
- The load balancing in cloud may be among physical hosts or VMs.
- The load balancer distributes the dynamic workload among different host or virtual machine.

Performance metrics that effects load balancing

- Expected Time to Compute (ETC) matrix: The distribution of tasks into a set of VM is expressed as ETC matrix. The each entry ETC_{ij} is the ratio between the length of the task i in MIPS to processing speed of VM j.
- Throughput (TP): It denotes the number of user requests or tasks are executed per unit time by a virtual machine. System performance is proportional to throughput of the system.
- Thrashing (TH): In a cloud environment thrashing occurs when a number of VMs are spending more time in migration than executing.

Performance metrics that effects load balancing

- Accuracy: It determines the perfection of task execution.
- Predictability: It is the degree used for the prediction of task allocation, task execution, and task completion according to the available cloud resources (virtual machines). The better prediction improves the load balancing performance of the cloud computing.
- Scalability: It is the capability of the system to perform under unexpected circumstances and a measure of load balancing performance of the cloud when system load increases. In a scalable cloud system, rescaling is done at regular intervals.
- Makespan: It is the total time required to complete all tasks submitted to the system. Makespan of the system is the maximum time taken by the host running over the data center.

Performance metrics that effects load balancing

- Migration time: It is the time to migrate a task from one VM to another. The migration can be from one VM to another within a single host or different hosts.
- Associated Cost: The associated cost depends on the resource utilization. The cloud user tries to depreciate the cost of resource provisioning by degrading the on-demand resource cost and over-subscribed resource cost of over-provisioning and under-provisioning.
- Energy Consumption: It is the amount of energy consumption to execute load balancing algorithms on different resources.

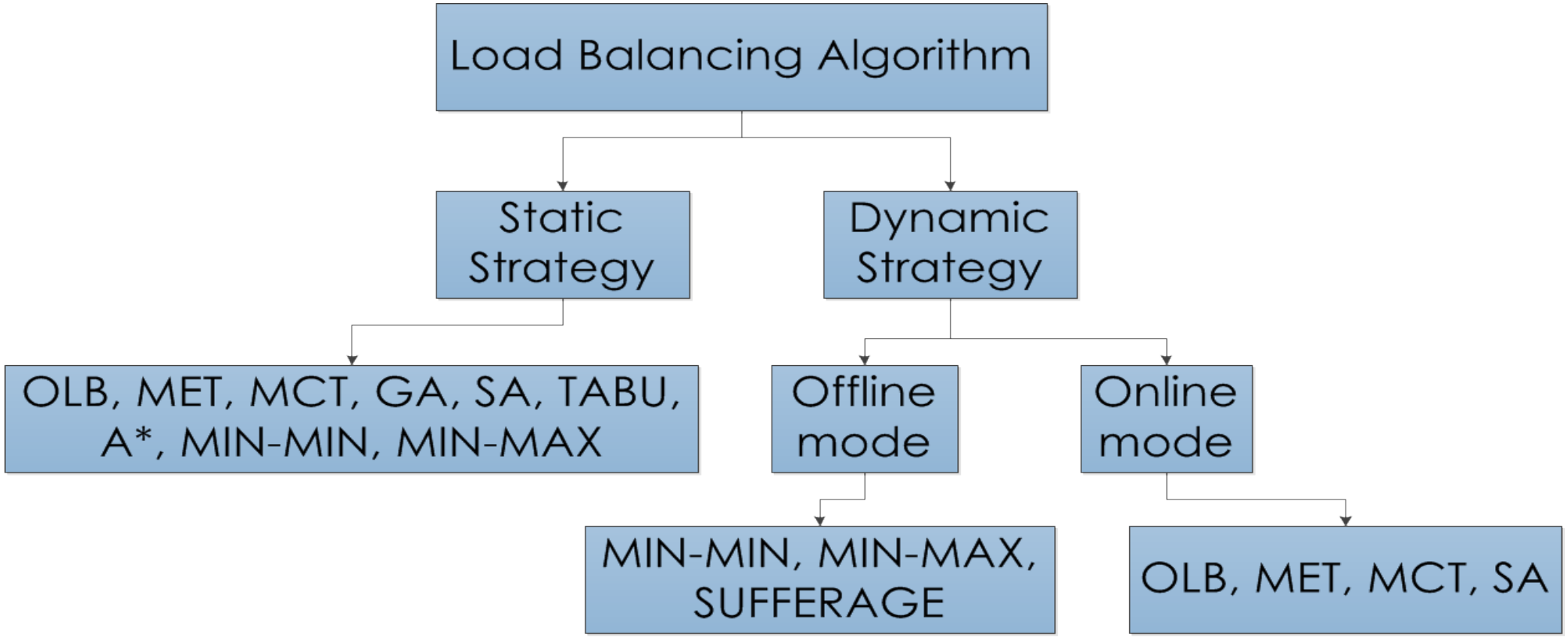
Classification of Load Balancing Algorithm

- The task allocation algorithm in cloud depends on the current state of the VM.
- The load balancing algorithms make a fair allocation of resources.
- The objectives of the load balancing are twofold—
  - achieve a high user satisfaction.
  - improve the stability of the system.
- Resource management plays a major role in the cloud load balancing algorithm.

Classification of Load Balancing Algorithm

- The multi-objective load balancing in cloud is NP-complete problem.
- The objectives of the load balancing algorithms are ---
  - Energy saving
  - Makespan minimization
  - Throughput maximization
- Load balancers are used for load balancing in cloud.
- Researchers use different types of heuristic for load balancing in cloud.

Heuristic Strategies of Load Balancing in Cloud



Source: Load balancing in cloud computing: A big picture

Heuristic Strategies of Load Balancing in Cloud (contd)

- Static Strategies: The static strategies in cloud uses two assumptions—
  - Initial task arrival.
  - Availability of physical machines at the beginning.
- The resource updates in these strategies are done after the task allocations.
- Examples of static strategies are OLB, MET, MCT, GA, Switching Algorithm, TABU, A algorithm, Min-Min, Min–Max.

Heuristic Strategies of Load Balancing in Cloud (contd)

- Dynamic Strategies: In these strategies, load distribution is done at runtime. Dynamic strategies are classified into two types ---
  - Off-line mode (Batch mode)
  - On-line mode.
- Batch Mode Dynamic Strategies --- In these strategies,
  - task is allocated only at predefined time.
  - It is used to measure the execution time of a set of tasks.
  - Examples are --- Max–min, Min-min, Sufferage algorithm.

Heuristic Strategies of Load Balancing in Cloud (contd)

- Online or Immediate mode Dynamic Strategies --- In this strategies,
  - task is allocated to a computing node as soon as it arrives at the scheduler.
  - Each task is scheduled only once.
  - Examples are --- OLB, MET, MCT, SA.
- OLB (Opportunistic load balancing): OLB heuristic used in both static and dynamic strategies.
  - This heuristic initially selects a machine randomly, allocates the task and then finds next available machine.
  - In online mode, a task is allocated to a VM based on different parameters such as execution time.

Heuristic Strategies of Load Balancing in Cloud (contd)

- OLB (Opportunistic load balancing):
  - The task execution is done at VM level.
  - In online mode, a task is allocated to a VM based on different parameters such as execution time.
  - The advantage of OLB is to increase host machine utilization for better efficiency and proper load balancing.
  - The disadvantage of OLB is poor make-span when multiple objectives are considered simultaneously.

Heuristic Strategies of Load Balancing in Cloud (contd)

- MET (Minimum Execution Time):
  - This heuristic technique used in both static and dynamic (Online mode) strategy.
  - This strategy maps each task to VM.
  - The scheduler allocates each task according to lowest execution time.
  - It tries to enhance the make-span of the system through balancing of cloud resources.
  - The disadvantage of this algorithm is not to consider machine ready time. It also shows load variations in machines.

Heuristic Strategies of Load Balancing in Cloud (contd)

- MCT (Minimum Completion Time):
  - It is used in both static and dynamic (Online mode) strategy.
  - This strategy maps each task to VM.
  - It uses ready-to-execute time and the expected execution time of the tasks for load balancing.
  - It allocates the task in the machine which has least completion time.

Heuristic Strategies of Load Balancing in Cloud (contd)

- Min-Min:
  - The basic Min-Min selects minimum size task and chooses a cloud resource (VM) that has the minimum capacity.
  - This algorithm uses a queue for task allocation. After allocating a task from queue it is removed from queue and next task is allocated.
  - It is suitable for small scale distributed system.
  - The improved Min-Min algorithm not only optimizes the load, but also optimizes the make-span and resource utilization.

Heuristic Strategies of Load Balancing in Cloud (contd)

- Load Balanced Improved Min-Min:
  - In Load Balanced Improved Min-Min (LBIMM) algorithm, tasks are first partitioned into two groups—group A and B.
  - Group A tasks are of higher priority.
  - Group B tasks are of lower priority.
  - Scheduler first schedules group A tasks and then group B tasks.
  - The load balancing algorithms balance the load of different machines after tasks allocation.

Heuristic Strategies of Load Balancing in Cloud (contd)

- Min-Max:
  - The basic Min-Max algorithm selects the task with larger size and chooses a cloud resource (VM) that has the minimum processing capacity.
  - This algorithm uses a queue for task allocation. After allocating a task from the queue it is removed from queue and the next task is allocated.
  - It is suitable for small scale distributed system.
  - The augmented Max–Min algorithm keeps a task status table and expected completion time of tasks.

Heuristic Strategies of Load Balancing in Cloud (contd)

- Genetic Algorithm (GA):
  - GA algorithm is population and chromosome based.
  - The fitness value of the chromosome are energy consumption, make-span and throughput.
  - The basic steps are selection, crossover and mutation.
  - In load balancing the total number of tasks arrived at the system are considered as chromosome.

Heuristic Strategies of Load Balancing in Cloud (contd)

- Simulated annealing (SA):
  - This type of algorithm is used to solve unconstrained and bound-constrained optimization problems.
  - At each iteration, a new point is generated based on some probability distribution.
  - It avoids local minima and finds the global optimized solution.
  - In load balancing, this algorithm is used to map the jobs with resources.

Heuristic Strategies of Load Balancing in Cloud (contd)

- Tabu Search (TS):
  - It is a meta-heuristic based solution.
  - This method uses adaptive memory that performs a more elastic search behavior.
  - The algorithm effectively handles 500 nodes and 1000 data center locations.

Heuristic Strategies of Load Balancing in Cloud (contd)

- A-star Search:
  - A-star search algorithm is extensively applied as a graphic searching algorithm.
  - This heuristic algorithm combines the benefits of both depth-first search and breadth-first search algorithm.
  - It supports two lists, the first list act as a priority queue of the tasks and the second list has the processing capacity of all VMs.
- Switching Algorithm:
  - This algorithm is used in the cloud environment for the migration of tasks or VMs.
  - Using this method, we can achieve the fault tolerant property.

Storage Access Protocols

Types of Cloud Storage

- Cloud Storage type is classified into two types—
  - Unstructured storage types
  - Structured key-value store
- Message Queues are temporary storage structure to store the messages passed among multiple cloud applications. E.g. Microsoft MSMQs, IBMs MQ series etc.
- Block devices are like traditional storage type and store bytes in sequential order.
- Cloud Applications can format block devices according to their requirements.

Types of Cloud Storage (contd)

- RDBMS store is a cloud storage, similar to traditional RDBMS storage.
- In RDBMS store, cloud applications can use SQL server instances hosted in the cloud infrastructure.

Storage Type	AWS	Windows Azure	Google AppEngine
Unstructured	yes	yes	yes
Structured	yes	yes	yes
Message queues	yes	yes	yes
Block Devices	yes	yes	No
RDBMS	yes	yes	No

Unstructured Storage Types

- It is similar to traditional file system but the logical view is different from simple sequence of bytes.
- Cloud storage service providers offer read/write based unstructured storage types.
- This storage type can include file up to size 1 TB.
- It provides different interfaces for doing IO.
- Examples are Amazon Web Services (AWS), Windows Azure, and Google Blobstore.

Amazon Simple Storage Service

- Simple Storage Service (S3) is one of the earliest storage service providers in the cloud.
- S3 consists of buckets and objects and under one storage account buckets and objects are created.
- Buckets are like directories, and each of them may have one or more objects.
- The maximum size of each S3 object is 5GB and access is sequential in nature.

Amazon Simple Storage Service (contd)

- Buckets in S3 can not be nested and only provides two level of hierarchy.
- The naming of a bucket is unique within a storage account.
- The naming of an object is unique with respect to a bucket or the account where the object is created.
- Moving or renaming an object is supported via copying.
- Objects are write once, means that once written, they cannot be updated in place.
- The objects can have multiple versions and redo and undo operation is permitted on the objects.

Amazon Simple Storage Service (contd)

- The high availability of Objects are done by replication.
- S3 does not have locking for multiple writes, which results in lack of synchronization.
- S3 provides resume-able downloads and integration with the Bit-torrent protocol.
- It also does not encrypt data stored in objects.
- Consumer is responsible for encryption and decryption of data.
- S3 provides Bucket Grant policies and specialized signed URI for the consumers.

List of Operations Support in Amazon S3

Operation	Description
Create Bucket	Create a new bucket.
Delete Bucket	Delete a bucket. Only an empty Bucket can be deleted.
List Buckets	List the buckets that are defined in a single storage account.
Get Bucket Policy	Retrieve the policy associated with the Bucket.
Set Bucket Policies	Set user defined bucket policies.

List of Operations Support in Amazon S3

Operation	Description
Get Bucket ACL	Get the bucket Access Control List as defined.
Set Bucket ACL	Set the bucket Access Control List.
List Objects	List the objects in a given bucket.
Put Object	Create or update an object with a new version.
Post Object	Create or update an object with a specific version.

Windows Azure Blob Storage

- Windows Azure blob store is provided through Windows blob account.
- A user can create one or more account and within each account one or more container can be created to store data.
- Containers are like directories and under one container one or more blob storage can be created.
- There are two different types of blob storage --- block blobs and page blobs.
- In a block blob, each blob is composed of a finite number of blocks and maximum size of a block is 4 MB.

Windows Azure Blob Storage

- The maximum size of a block blob can be 200 GB and the blocks of a blob may have different sizes.
- The access of a block blob is sequential and immutable.
- A page blob consists of a sequence of pages each of which has a fixed size of 512 KB.
- The maximum size of a page blob can be 1 TB and supports random access read and write.
- The communication to the storage system can be secured using HTTPS instead of HTTP.

List of Operations Support in Windows Azure Blob Storage

Operation	Description
List Container	List the containers that are defined in a single storage account.
Create Container	Create a new container. A container can only be created underneath a storage account. Nesting of containers is not supported.
Delete Container	Delete a container and the blobs.
Get Container ACL	Get the container Access Control List as defined.

List of Operations Support in Windows Azure Blob Storage

Operation	Description
Set Container ACL	Set the container Access Control List.
List Blobs	List the blobs in a given container.
Put Blob	Create a new blob (block or page).
Put Block	Create a new block.
Put Block List	Create a new block list or replace the old block list of a block blob.
Get Block List	Get block list of a particular blob.
Put Page	Create a new set of page ranges or delete a range.

List of Operations Support in Windows Azure Blob Storage

Operation	Description
Copy Blob	Copy a blob to a new blob in the same account.
Delete Blob	Delete a blob.
Lease Blob	Request for an exclusive one minute lease lock for the blob.
Snapshot Blob	Create a new read only snapshot copy of the blob.

Google BlobStore

- Google's BlobStore stores unstructured data.
- HTTP Post request is used to generate a blob and it supports flat namespace.
- Under a single account, a blob is unique.
- Each blob has binary data and a metadata and after successful completion of storing a blob, AppEngine returns an opaque key to access the blob.
- The metadata of a blob, accessible using the blob key, is stored in Google DataStore from where different properties of the blob can be retrieved.

Google BlobStore

- Each blob stored in the blob storage is immutable.
- Java and python libraries are provided to create and access a blob.
- The maximum size of a blob can be 2 GB.

List of Operations Support in Google BlobStore

Operation	Description
Create Blob	Create a blob in the user App- Engine account.
Delete Blob	Delete a blob.
Fetch Data	Retrieve a range of bytes from a blob.
Fetch Blob Key	Fetch Blob Key.

Structured Key-Value Pair

- In this storage an object is a collection of pair <key, value>, where key is used to access the value.
- This storage does not support any schema.
- The set of objects are grouped to create a complex objects.
- Examples are Amazon's SimpleDB and Microsoft Azure's Table.

Amazon SimpleDB

- The data model of SimpleDB consists of domain which represents collection of objects known as items.
- Each item consists of set of attributes.
- In every item within a domain, a key is defined which is unique across all the items in the same domain.
- In SimpleDB, the maximum size of each domain is 10 GB.
- Each item is replicated across a set of nodes in an Amazon data centre.
- SimpleDB provides REST and SOAP interfaces.

Windows Azure Table

- It has three levels --- tables, entities and properties.
- Properties are represented by key, value pair.
- The maximum size of an entity can be up to 1 MB and the maximum number of properties are 256.
- The first two mandatory properties are partition key and row key.
- Partition key is used to partition the entities within the same table.
- Within a single partition, row key is used to identify a single entity.
- System generates timestamp when a new entity is created.

Functions and Benefits of the Services and Storage

Benefits of Cloud Storage

- Usability and accessibility --- User can drag and drop the files in cloud storage similar to local storage and stored file can be accessed from anywhere with internet connection.
- Disaster Recovery --- In cloud storage, a backup is maintained for the stored data which helps to recover the data in case of failure of local storage.
- Security --- Cloud Service provider implements different types of security policy to protect the privacy of the data.

Benefits of Cloud Storage

- Cost Savings --- Business owners can save money by storing data into cloud storage instead of investing to acquire data store.
- Easy Sharing --- Data stored in cloud can be shared easily.
- Automation --- Consumer can store and maintain data with minimal human intervention.
- Synchronization --- Data stored in cloud can be automatically synchronized with the data stored in local storage.

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Thank You!!