Cloud Computing Simulation tools

Agenda

- Discussion on Cloud Computing Simulation tools
- Exploring CloudSim tool by understanding
  - Various Components of CloudSim
  - Workflow of the CloudSim tool
  - Execution of CloudSim Examples

Presentation Outlines

- Cloud Computing
- Simulation Tools
- Introduction to CloudSim Tool
  - Versions
  - Features
  - Limitations
  - Purposes
- Prerequisites
- How to use CloudSim
  - Installation

Presentation Outlines

- Architecture of CloudSim
  - Block Diagram
  - Execution Flow
  - Information of Components
- Execution of CloudSim
- Demo implementation of research problem

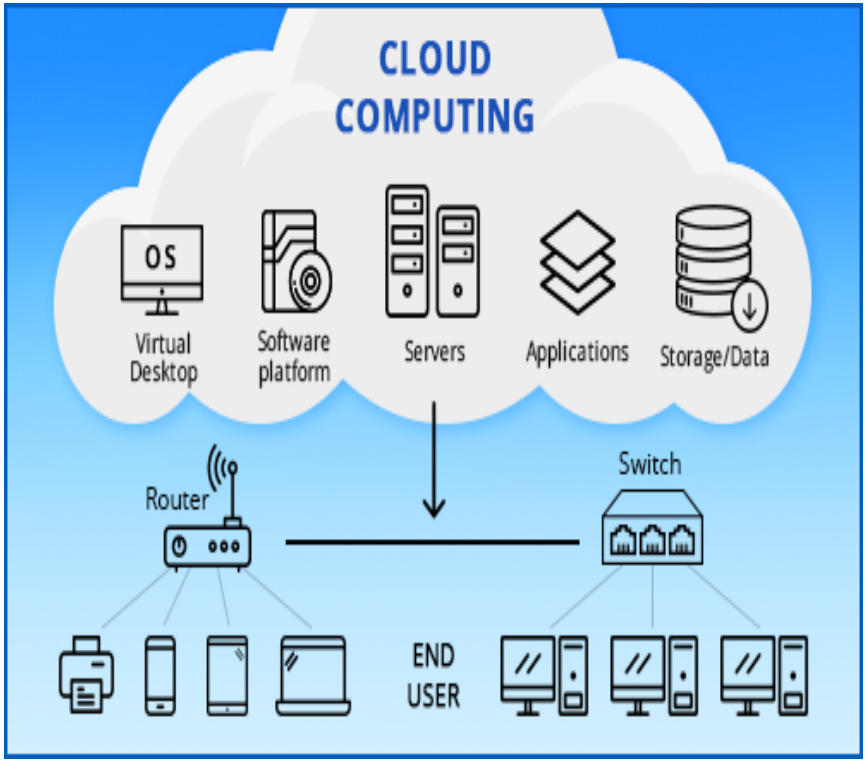
Introduction to Cloud Computing

Definition

Using a network of **remote servers hosted on the Internet** to store, manage, and process data, rather than a local server or a personal computer.

Services provided by Cloud Computing,

- Infrastructure as a Service (IaaS),
- Platform as a Service (PaaS)
- Software as a Service (SaaS)



Services of Cloud Computing

- SaaS examples:
  - BigCommerce, Google Apps, Salesforce, Dropbox, MailChimp, ZenDesk, DocuSign, Slack, Hubspot.
- PaaS examples:
  - AWS Elastic Beanstalk, Heroku, Windows Azure (mostly used as PaaS), Force.com, OpenShift, Apache Stratos, Magento Commerce Cloud.
- IaaS examples:
  - AWS EC2, Rackspace, Google Compute Engine (GCE), Digital Ocean, Magento 1.

Components of Cloud Computing

Network infrastructure

Storage infrastructure.

Computing resources

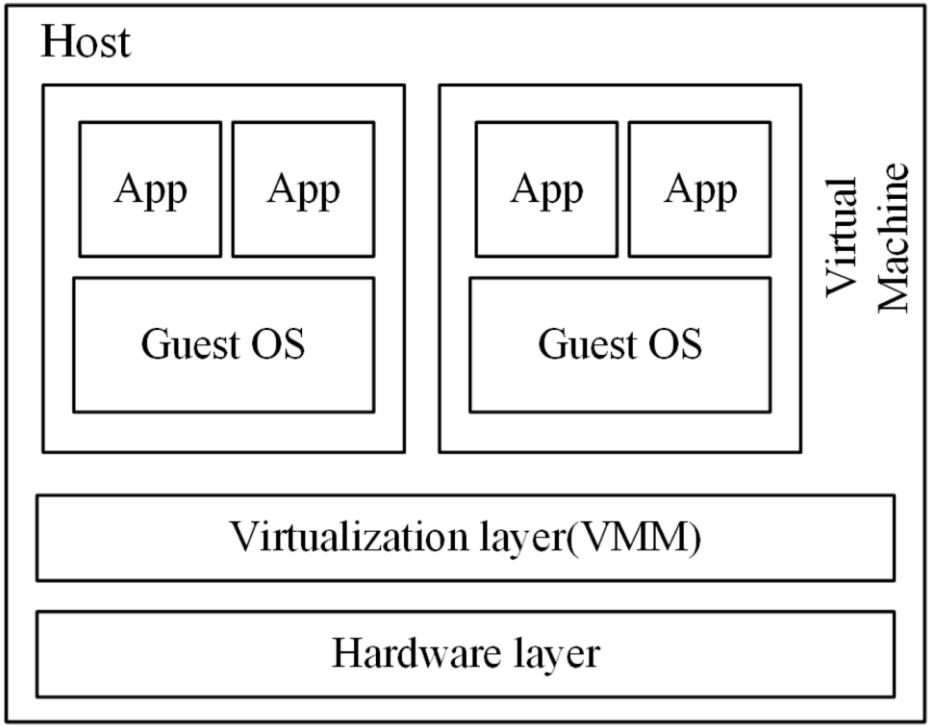
- Components of a data center include processing, memory, and network connectivity that drive applications, routers, switches, firewalls, storage systems, servers, and application-delivery controllers.

Components of Cloud Computing

Host: Server that **accepts connections from clients** who request a service function.

A cloud host is a server that provides services to customers via **multiple connected servers** that comprise a cloud.

A virtual machine is an **emulated computer system** created using software.



Simulation Tools

What is Simulation?

Without creating an actual structure we see the results by modeling a dummy structure having same parameters.

Why Simulation is Required?

Cloud computing requires a large amount of infrastructure and huge amount of money is required for it.

To know the feasibility of cloud for a particular application we simulate it.

Cloud Computing Simulation Softwares/Tools

Open Source Cloud Computing Simulators

- GreenCloud
  - Simulation environment for **energy-aware** cloud computing data centres.
  - Modelling of the **energy consumed by the data centre's** IT equipment
- iCanCloud
  - Simulation platform supports the simulation of **large storage networks**
  - Predicting the trade-offs between cost and performance of a given set of applications executed in specific hardware.

- EMUSIM
  - Integrated Emulation and Simulation(EMUSIM).
  - **Combines emulation and Simulation** (CloudSim) to enable more accurate models
- GroudSim
  - Designed for **scientific applications** on grid and cloud environments.
- DCSim (Data Centre Simulation)
  - Framework for performing **high-end experiments on data centre** management techniques
- CloudAnalyst
  - **GUI based simulator** derived on the bases of CloudSim
  - Evaluation of social network tools according to the **geographical distribution of users and data centres**.

CloudSim Tool

CloudSim is a simulation toolkit that supports the **modeling and simulation of the core functionality of cloud**.

Developed in the CLOUDS Laboratory, at the Computer Science and Software Engineering Department of the University of Melbourne.

Provides environment to

- Test application services in a **repeatable** and **controllable** environment.
- Tune the **system bottlenecks** before deploying apps in an actual cloud.
- Experiment with **different workload mix** and resource performance scenarios.

Features

- Large scale Cloud computing data centers
- Virtualized server hosts, with customizable policies for provisioning host resources to virtual machines
- Application containers
- Energy-aware computational resources
- Data center network topologies and message-passing applications
- Dynamic insertion of simulation elements, stop and resume of simulation
- User-defined policies for allocation of hosts to virtual machines and policies for allocation of host resources to virtual machines

Limitations

- Not Suitable for real-time applications, security algorithms, platform implementations, etc
- No Graphical User Interface (GUI) is available

Frequently used for

- Load Balancing of resources and tasks
- Task scheduling and its migrations
- Optimizing the Virtual machine allocation and placement policies
- Energy-aware Consolidations or Migrations of virtual machines
- Optimizing schemes for Network latencies for various cloud scenarios

Versions of CloudSim

- CloudSim 1.0 beta
- CloudSim 2.X
  - CloudSim 2.0
  - CloudSim 2.1
  - CloudSim 2.1.1
- CloudSim 3.X
  - CloudSim 3.0.1
  - CloudSim 3.0.2
  - CloudSim 3.0.3 (Stable Version)
- CloudSim 4.0 (Latest release)
- CloudSim 5.0 (Pre-release)

Versions of CloudSim

CloudSim 1.0 to CloudSim 2.0 : New Simulation Core, Improvement In Schedulers

CloudSim 2.X to CloudSim 3.0 : New Vm Scheduler, New Datacenter Network Model, New Vm Allocation And Selection Policies Etc.

CloudSim 3.X to CloudSim 4.0 : Added support for Container virtualization, Bugfixes

CloudSim 4.0 to CloudSim 5.0 : VM extensions with performance monitoring, Work with other simulation models such as Software-defined Networks (SDN) / Service Function Chaining (SFC).

Other Related Tools

Cloudsim 3.x.x became base for many other tools

- CloudSimEx
  - Set of **extensions** for the CloudSim simulator
    - Web session modeling, Better logging utilities, Utilities for generating CSV files for statistical analysis, Automatic id generation, Utilities for running multiple experiments in parallel, MapReduce simulation.
- EdgeCloudSim
  - Simulation environment **specific to Edge Computing** scenarios
    - Experiments that considers both computational and networking resources
- WorkflowSim
  - Support of workflow preparation and execution
    - With an implementation of a stack of workflow parser, workflow engine and job scheduler.

- CloudReports
  - Graphic tool that **simulates distributed computing environments** based on the Cloud Computing paradigm
- CloudAnalyst
  - Evaluation of social networks tools according to **geographic distribution of users** and data centers.
- iFogSim
  - Enables modelling and **simulation of Fog computing** environments.
  - Evaluation of resource management and scheduling policies across edge and cloud resources under different scenarios

Prerequisites

Basic understanding of,

- Java Programming
- Object Oriented Concepts
- Cloud Computing
- IDEs like Eclipse or NetBeans

Classes of CloudSim

Datacenter

Models the **core infrastructure-level services**, that will consist set of Hosts which is responsible for managing VMs during their life cycle.

Host

Physical computing node in a Cloud with processing capabilities, memory, storage and scheduling policy for allocating processing cores to Virtual Machines

VM

Models a Virtual Machine. Host can simultaneously instantiate multiple VMs and allocate cores based on processor sharing policies(Space shared, Time shared).

Cloudlet

Models the **cloud-based application services** which are commonly deployed in the data centers. Each cloudlet has a pre-assigned **instruction length**.

CloudletScheduler

Determines **how the available CPU resources of VM are divided among Cloudlets**. Two type of policies are offered:

- Space-shared (CloudletSchedulerSpaceShared)
- Time-shared (CloudletSchedulerTimeShared)

VMScheduler

Determines how processing cores of a host are allocated to virtual machines.

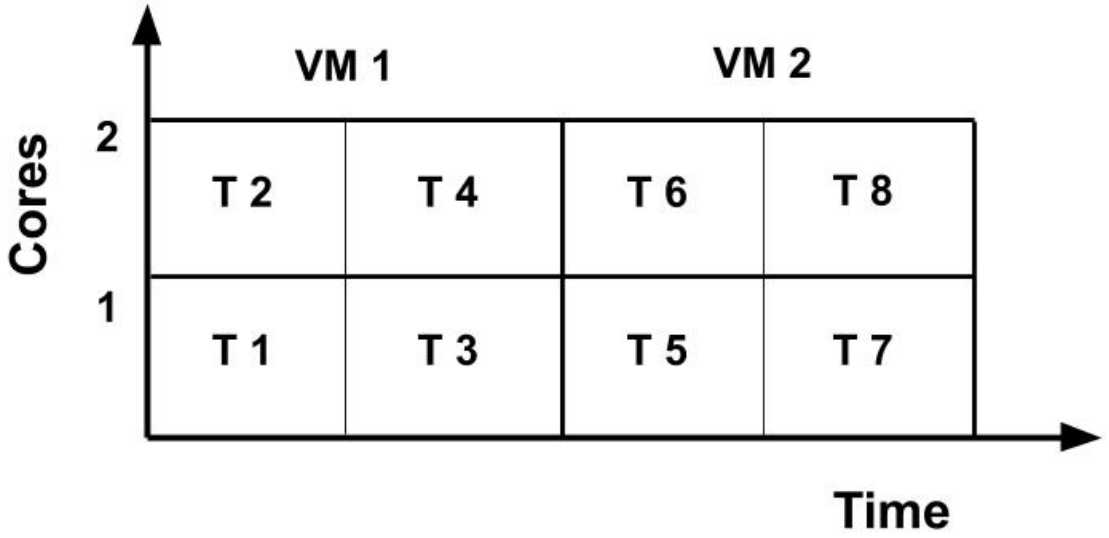
Space-Shared Policy: To assign specific CPU cores to specific VMs.

- **Sequential allocation** of processing unit to VMs.

Time-Shared Policy: To dynamically distribute the capacity of a core among VMs.

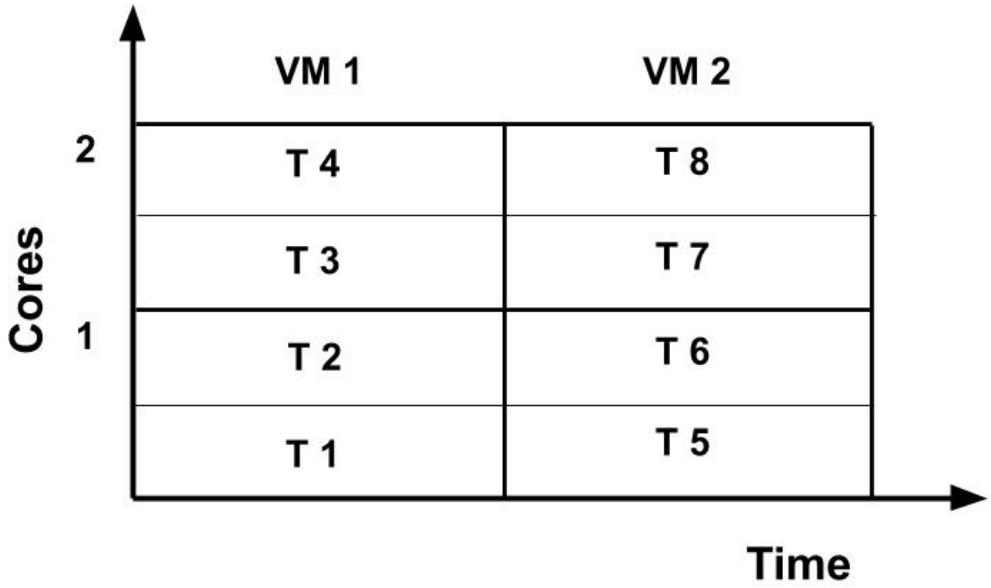
- **Concurrent allocation** of processing unit to VMs.

Space Shared for VMs and Tasks



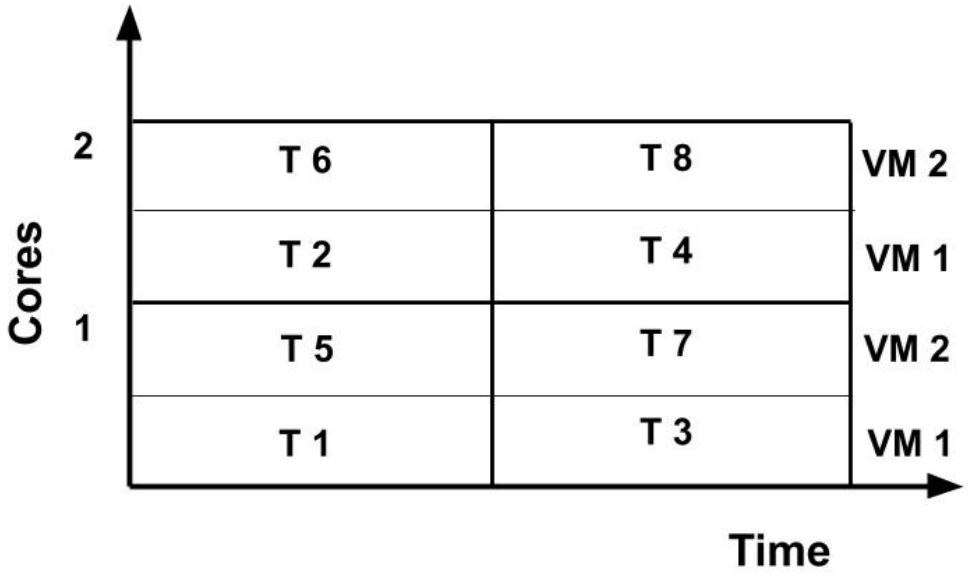
Space-shared provisioning for VMs and tasks

Space-shared for VMs and time-shared for tasks



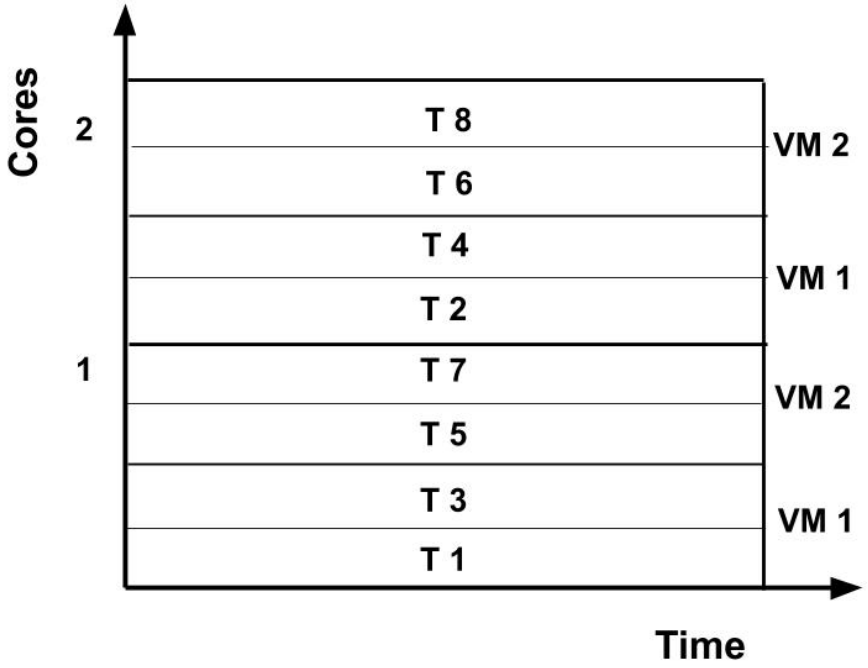
Space-shared provisioning for VMs and time-shared provisioning for tasks

Time-shared for VMs, space-shared for tasks



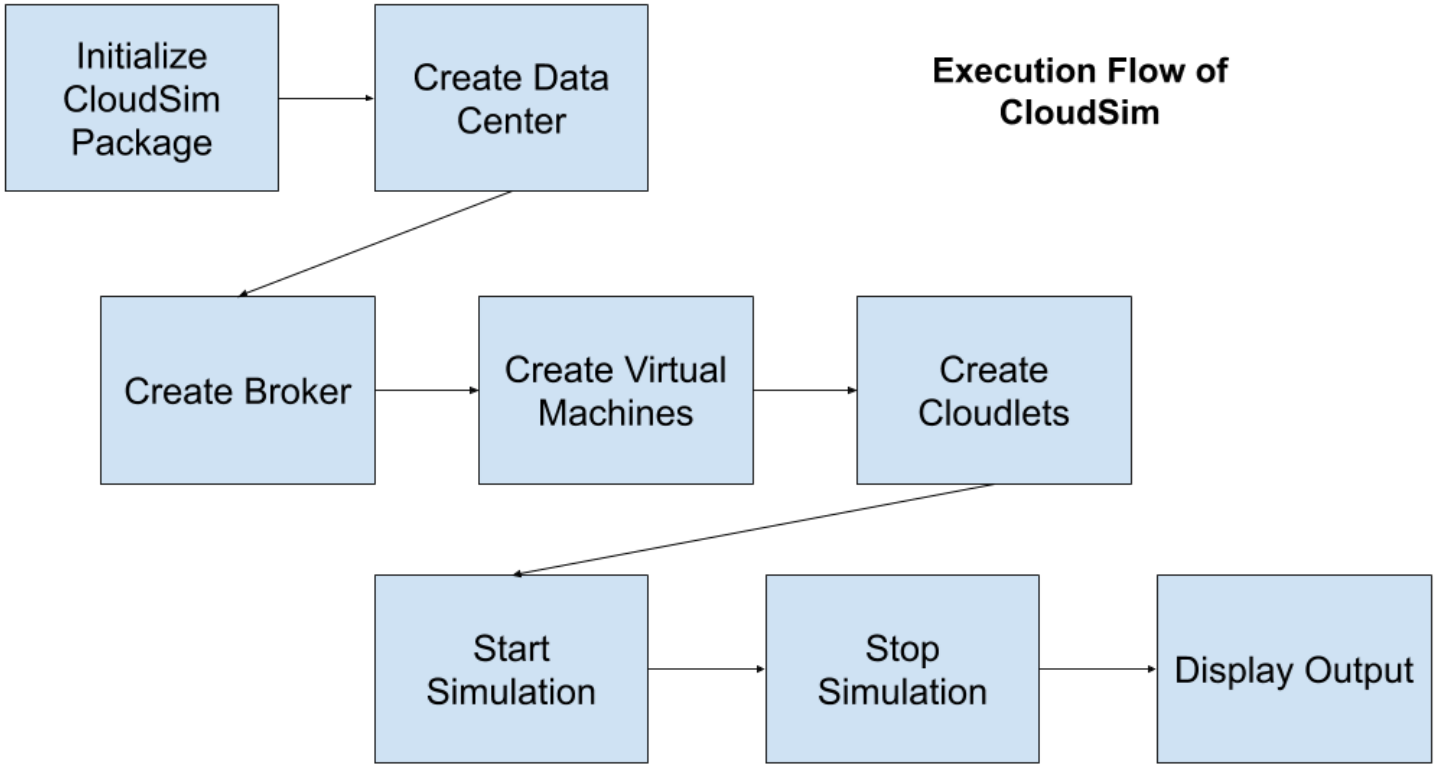
Time-shared provisioning for VMs, space-shared provisioning for tasks

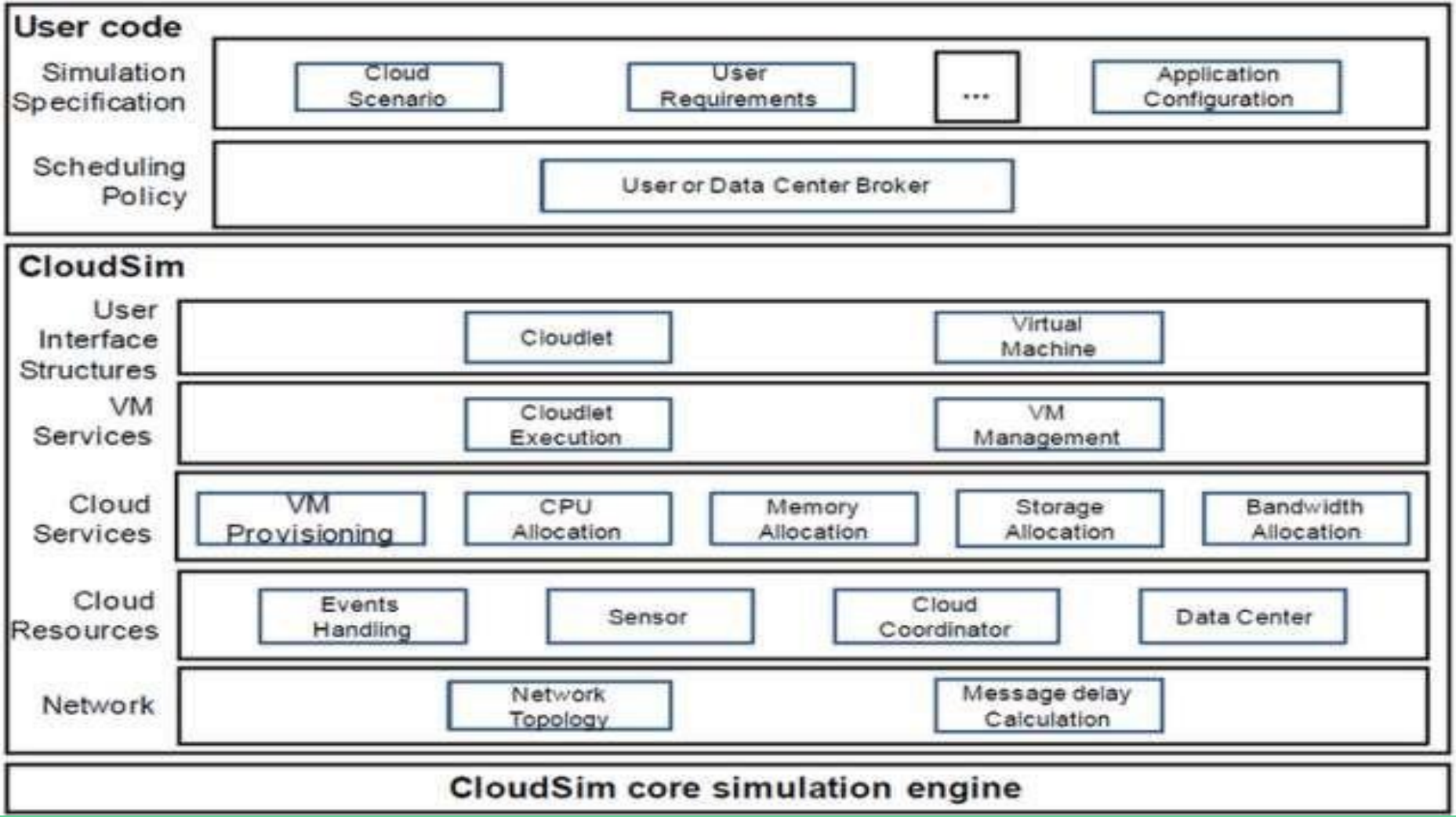
Time-shared for VMs and tasks



Time-shared provisioning for VMs and tasks.

Execution Flow of CloudSim




User code
Simulation Specification
Cloud Scenario
User Requirements
...
Application Configuration
Scheduling Policy
User or Data Center Broker
CloudSim
User Interface Structures
Cloudlet
Virtual Machine
VM Services
Cloudlet Execution
VM Management
Cloud Services
VM Provisioning
CPU Allocation
Memory Allocation
Storage Allocation
Bandwidth Allocation
Cloud Resources
Events Handling
Sensor
Cloud Coordinator
Data Center
Network
Network Topology
Message delay Calculation
CloudSim core simulation engine

Architecture of CloudSim

1. **Network Layer**: This layer of CloudSim has responsibility to make **communication** possible between different layers.
2. **Cloud Resources:** This layer includes different main **resources** like datacenters, cloud coordinator (ensures that different resources of the cloud can work in a **collaborative** way) in the cloud environment.
3. **Cloud Services**: This layer includes different service provided to the user of cloud services. This include Information as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).
4. **User Interface:** This layer provides the interaction between user and the simulator.

Configuring CloudSim

Software Requirement: JDK1.7+, Eclipse or NetBeans, CloudSim 3.0

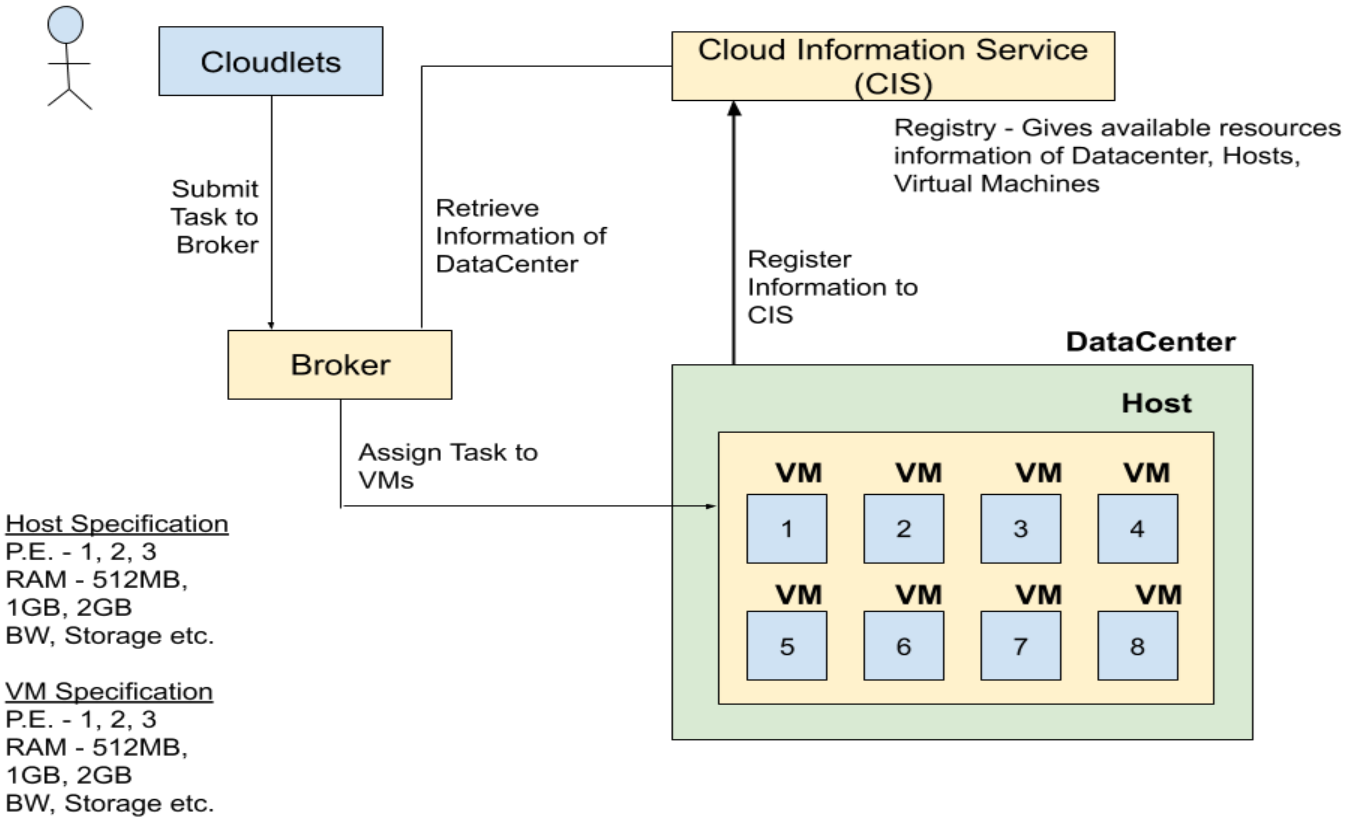
Installation Steps:

- Download Eclipse or NetBeans IDE
  - https://www.eclipse.org/downloads/download.php?file=/technology/epp/downloads/release/kepler/SR1/eclipse-java-kepler-SR1-win32-x86_64.zip
- Download and Extract CloudSim Package
  - https://github.com/Cloudslab/cloudsim/releases
- Download Java (JDK)
  - https://www.oracle.com/java/technologies/javase-java-archive-javase6-downloads.html

Setting up CloudSim Project

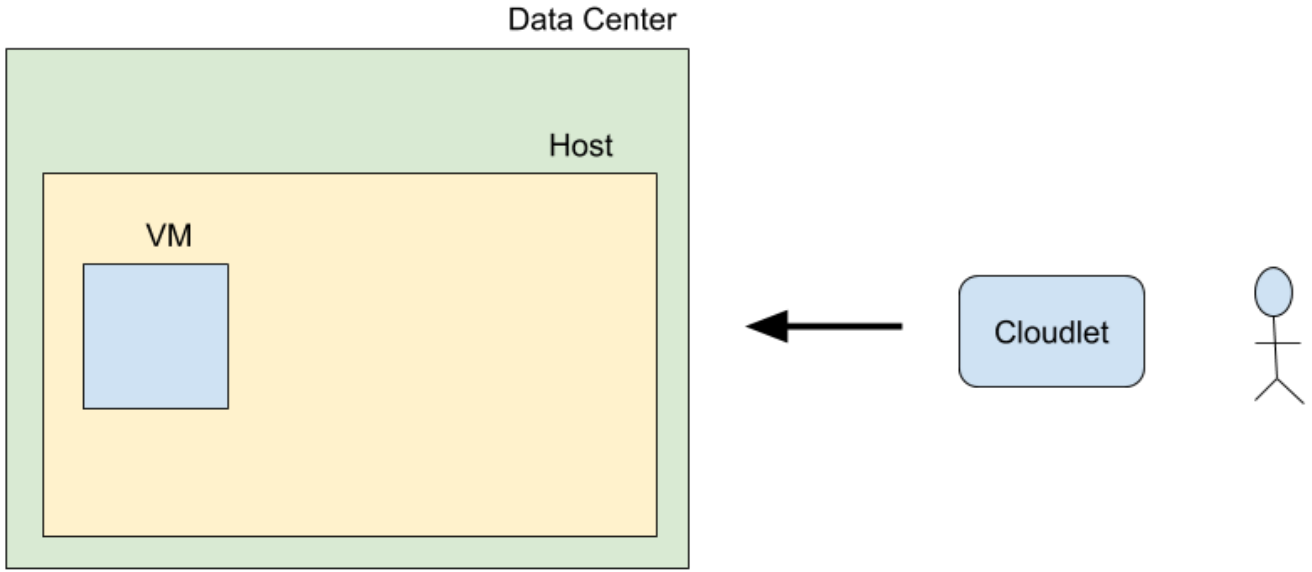
1. Open Eclipse and go to Menu Section, then click File, keep on clicking New and finally select java project
2. Enter project name and uncheck the default location of your project.
3. Browse for extracted cloudsim folder and click finish.
4. If some errors generated after finishing the wizard, goto the properties of cloudsim project then select Java Compiler and change jdk version to 1.7
5. Click on Apply and Close and let the project Build.

Architecture of CloudSim



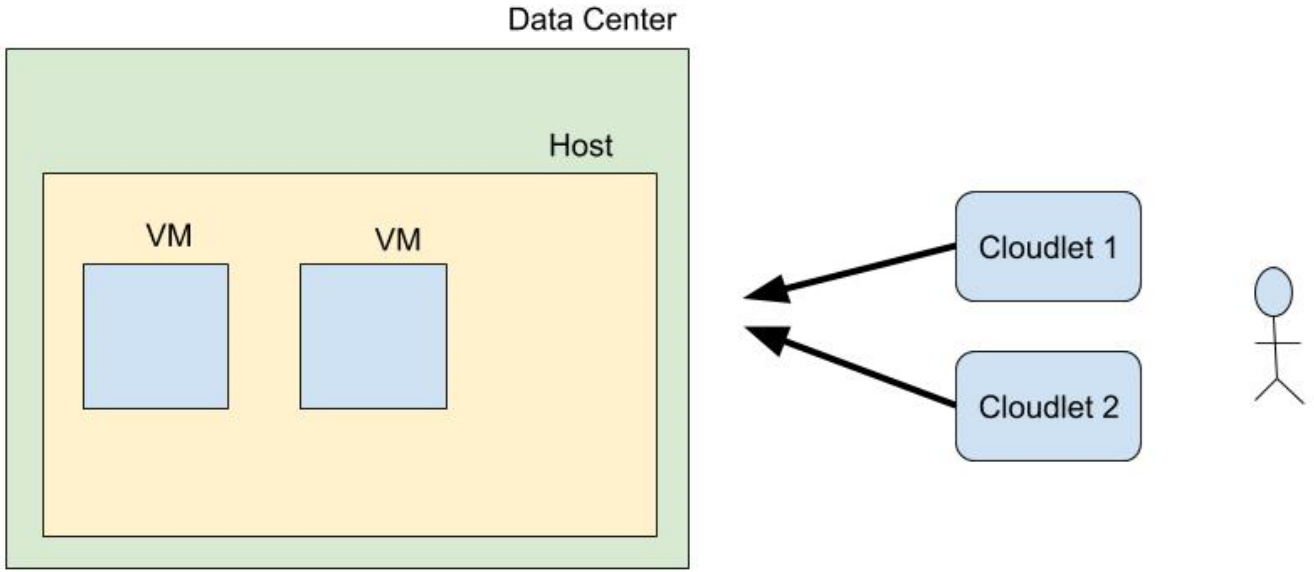
Execution of Example 1

Create datacenter with one host and run one cloudlet on it



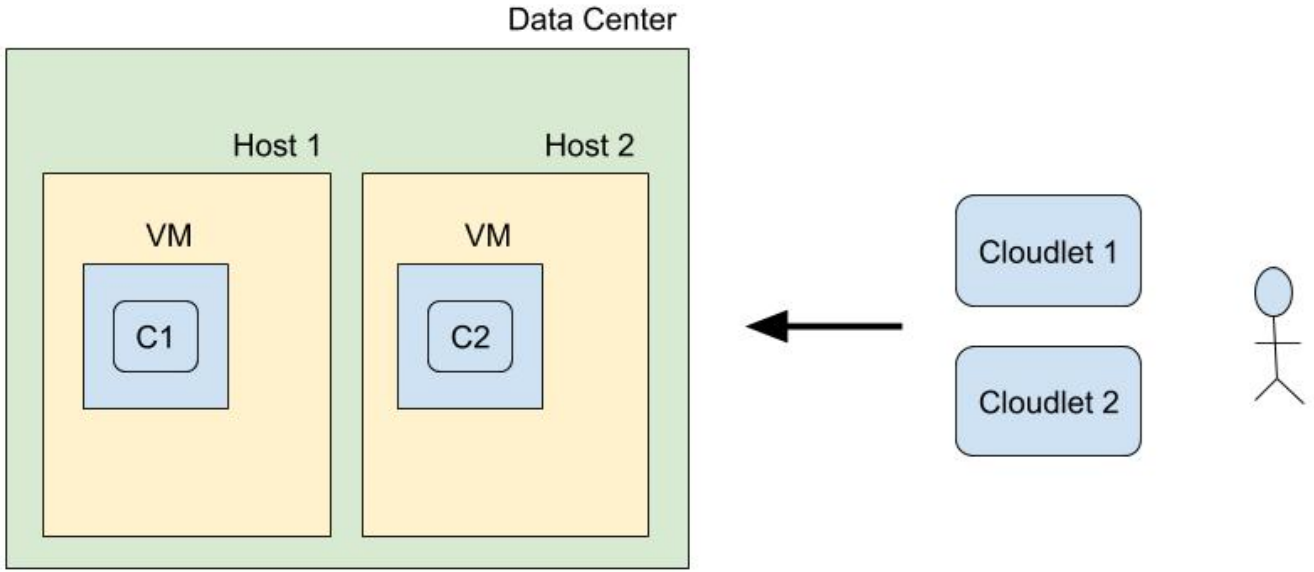
Execution of Example 2

Create a datacenter with one host and run two cloudlets on it.



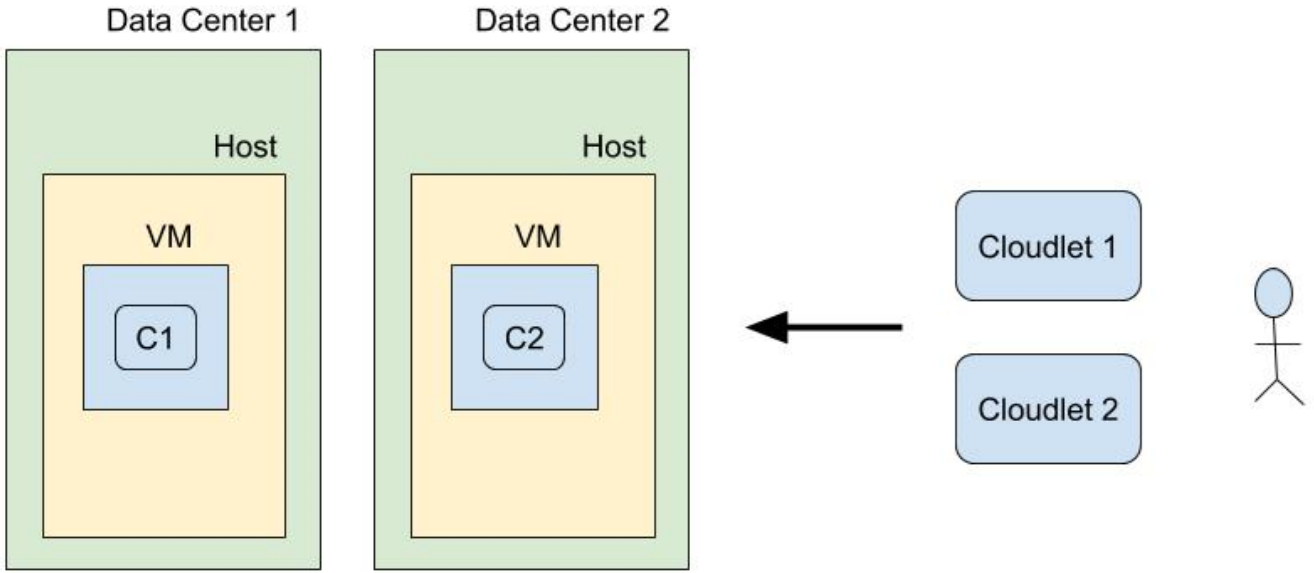
Execution of Example 3

Create a datacenter with two hosts and run two cloudlets on it.



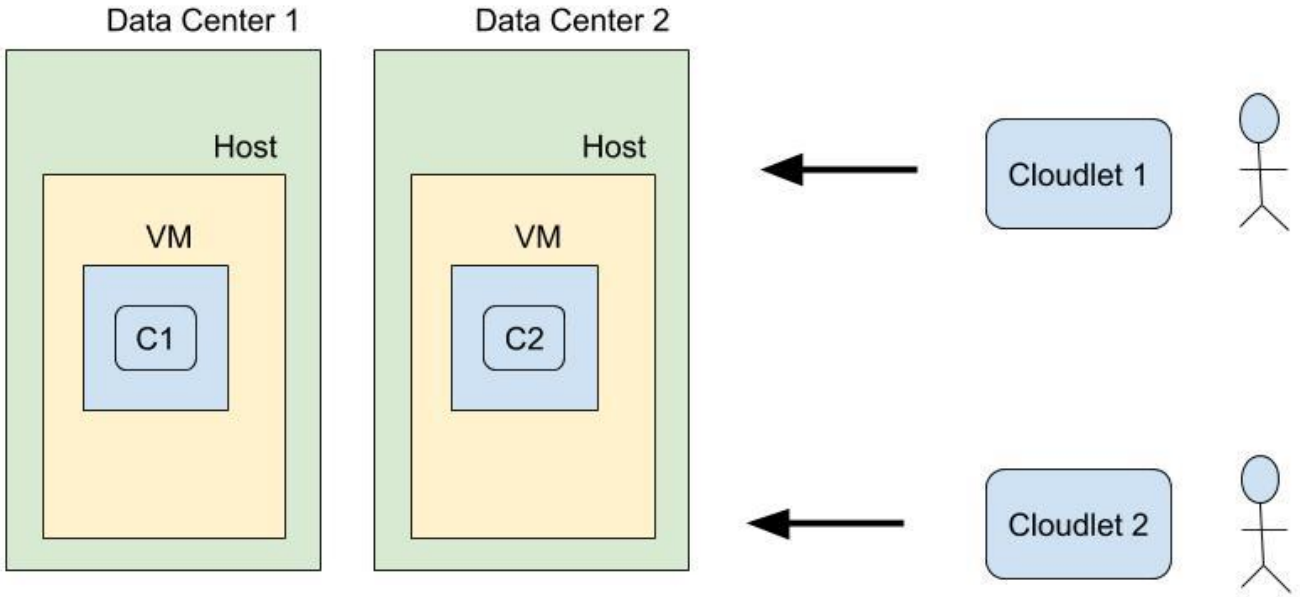
Execution of Example 4

Create two datacenters with one host each and run two cloudlets on them.



Execution of Example 5

Create two datacenters with one host each and run cloudlets of two users on them.



Execution of Example 6

Shows how to create scalable simulations.

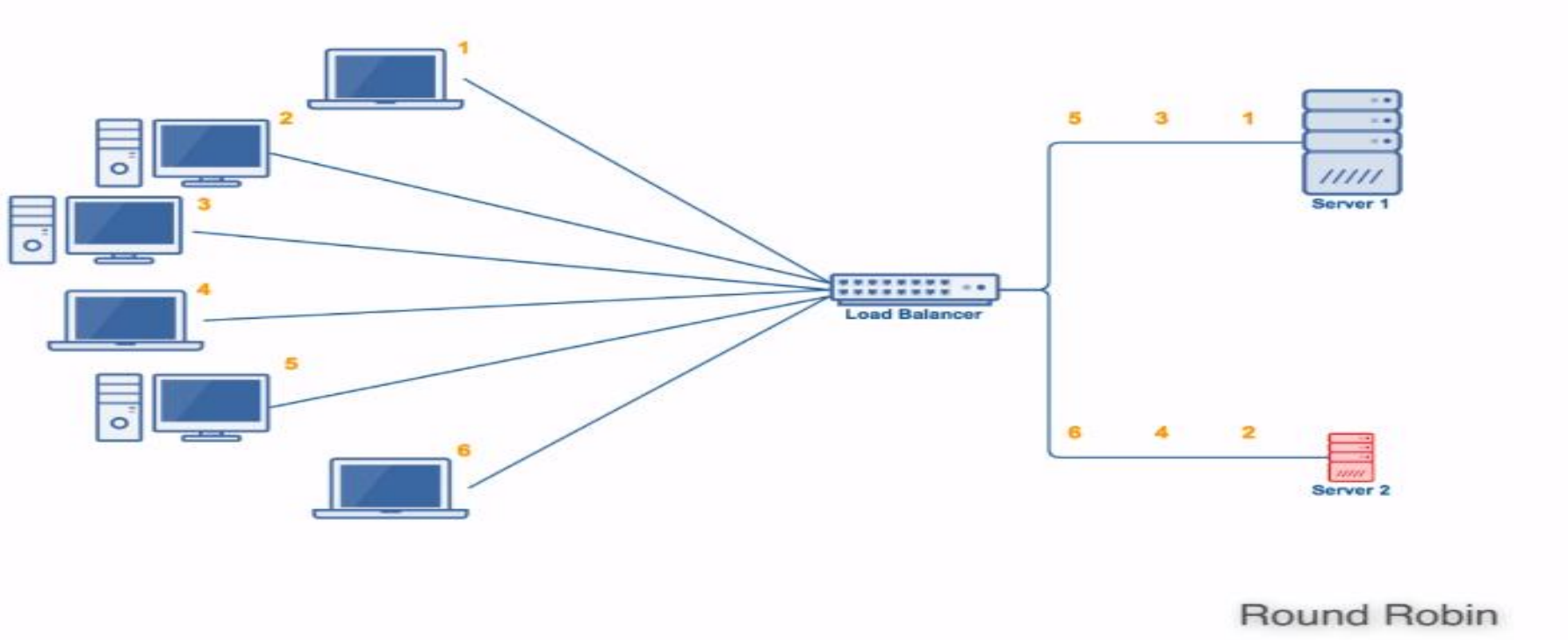
Execution of Example 7

Shows how to pause simulations.

Execution of Example 8

Shows how to add entities in run time.

Load Balancing Algorithms



Demo Research Problem Implementation

- Suppose we have
  - 7 Cloudlets/Tasks/Jobs
  - 4 Virtual Machines

Task No.	Task Length(MI)	Task Priority
T0	50000	60
T1	30000	20
T2	40000	50
T3	70000	90
T4	80000	70
T5	10000	30
T6	60000	40

VM No.	VM MIPS
V0	40
V1	60
V2	130
V3	90

Here, Task having Highest Credit will allocated to Strongest VM.

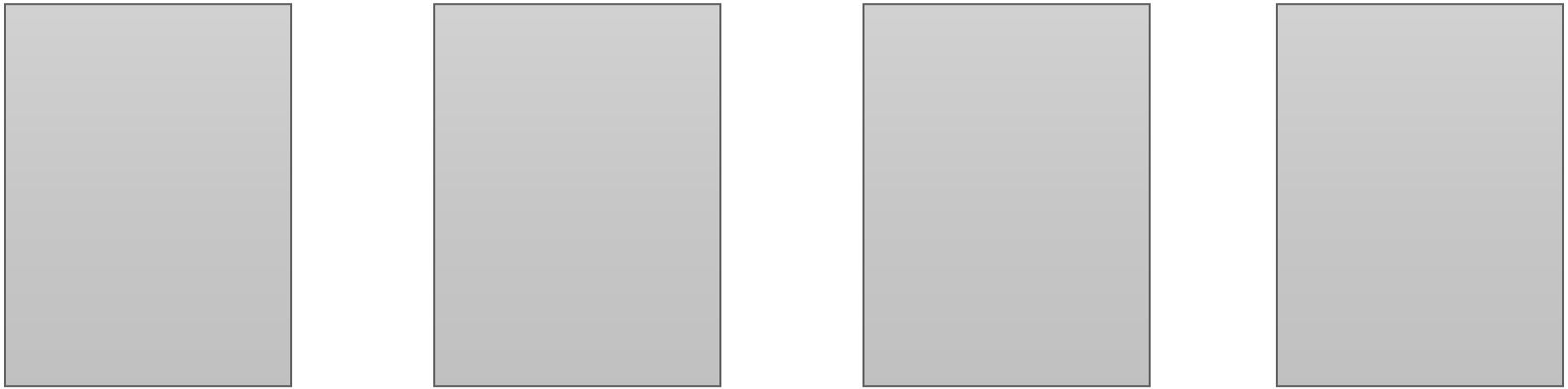
- Task T3 on VM2
- Task T0 on VM3
- Task T2 on VM1
- Task T4 on VM0
- Task T6 on VM2
- Task T1 on VM3
- Task T5 on VM1

Load Balancing Approach for allocating tasks on VM

Expected Completion Time = Length of Task / Speed of VM (MIPS) * Number of Pe(s)
i.e. ECT of Task 0 For VM 0, ECT = 50000/50 = 1000

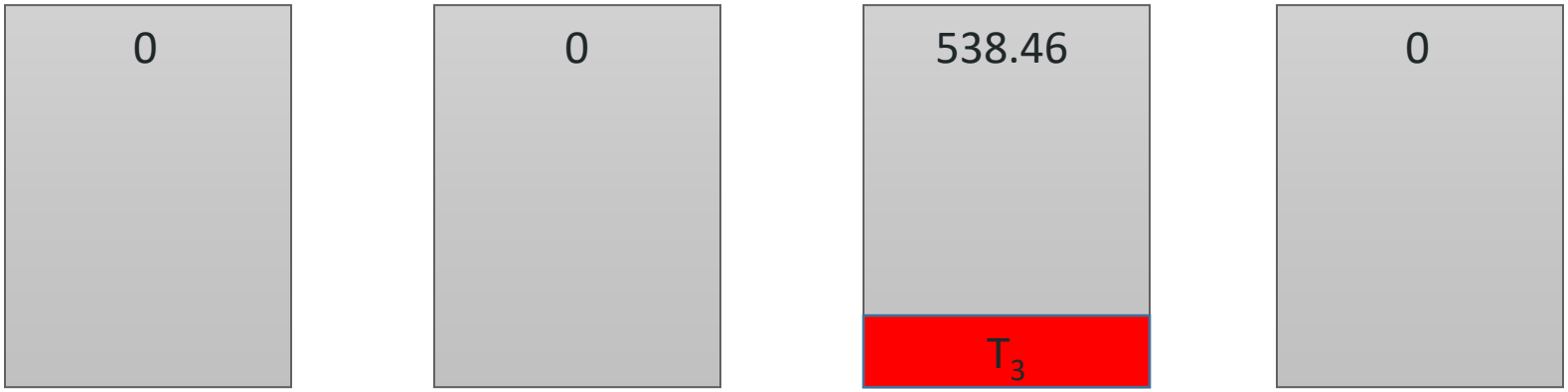
Task Length	VM_0 40_{mips}	VM_1 60_{mips}	VM_2 130_{mips}	VM_3 90_{mips}
ECT_3 70000	1750	1166.66	538.46	777.77
ECT_0 50000	1250	833.33	384.61	555.55
ECT_2 40000	1000	666.66	307.69	444.44
ECT_4 80000	2000	1333.33	615.38	888.88
ECT_6 60000	1500	1000	461.53	666.66
ECT_1 30000	750	500	230.76	333.33
ECT_5 10000	250	166.66	76.92	111.11

➢ Allocation of Task to VM Based on ECT Value



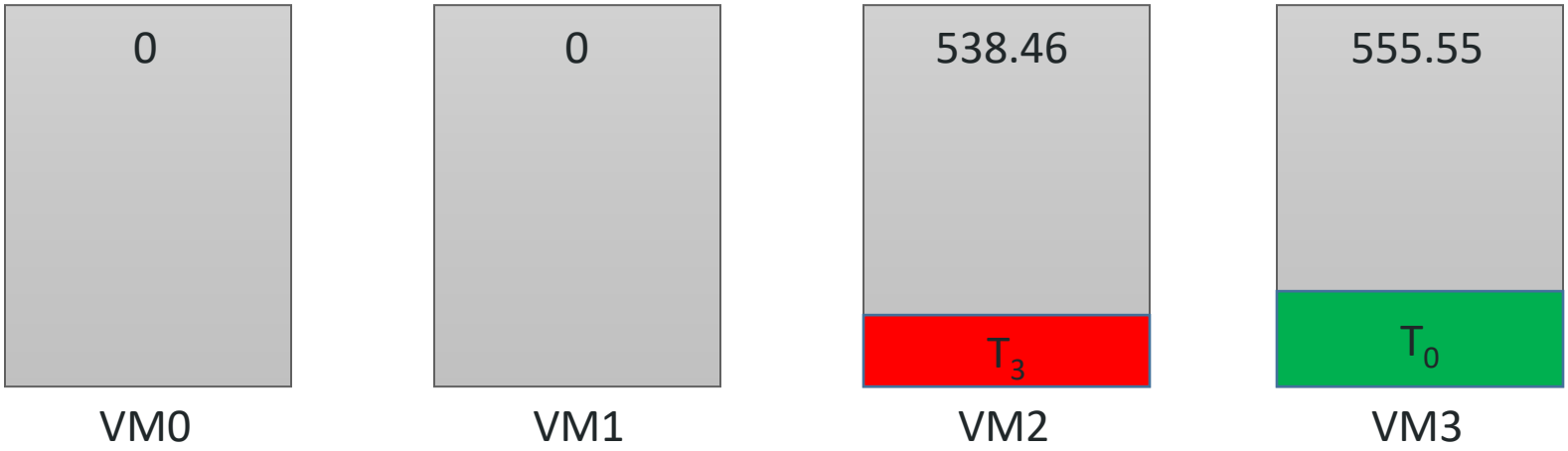
Current Load On VM

Load on VM	VM_0	VM_1	VM_2	VM_3
ECT of Task	0	0	0	0
Current Load	0	0	0	0
Before Assign Task	0	0	0	0
After Assign Task	0	0	0	0
Total Load	0	0	0	0



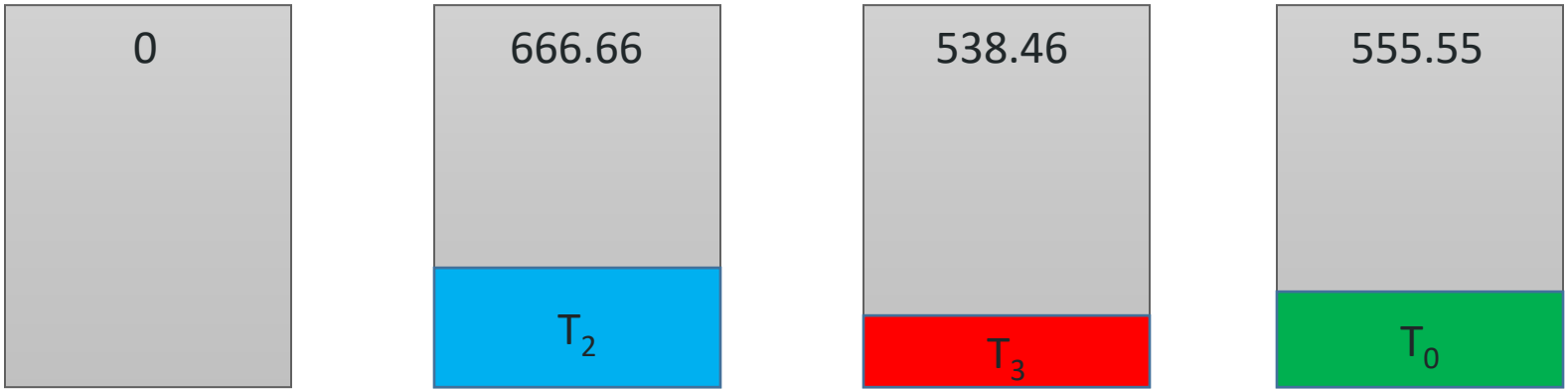
Current Load On VM

Load on VM	VM_0	VM_1	VM_2	VM_3
ECT of Task T_3	1750	1166.66	538.46	777.77
Current Load	0	0	0	0
Before Assign Task	+1750	+1166.66	+538.46	+777.77
After Assign Task	=1750	=1166.66	**=538.46**	=777.77
Total Load	0	0	**538.46**	0



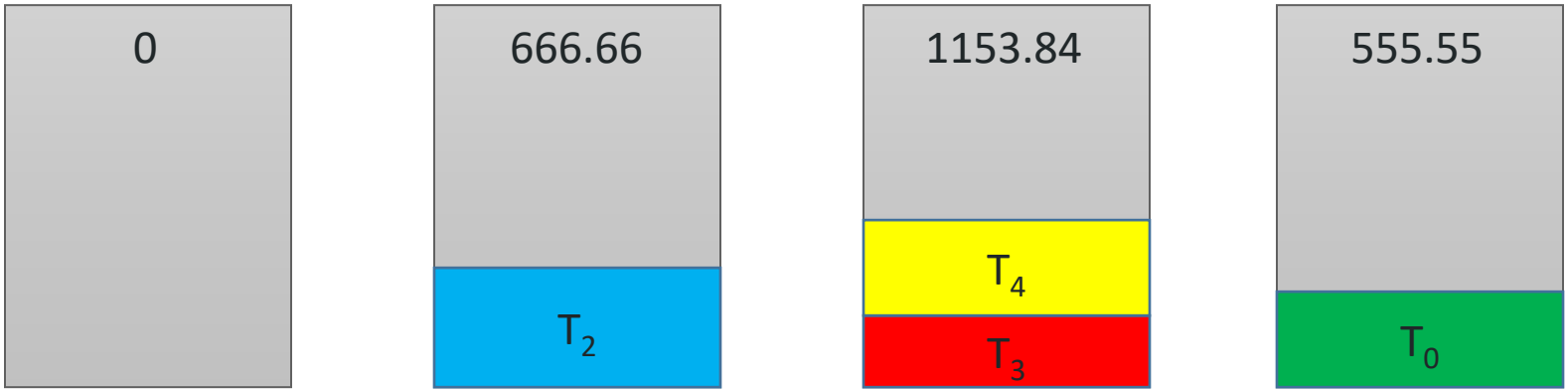
Current Load On VM

Load on VM	VM_0	VM_1	VM_2	VM_3
ECT of Task T_0	1250	833.33	384.61	555.55
Current Load	0	0	538.46	0
Before Assign Task	+1250	+833.33	+384.61	+555.55
After Assign Task	=1250	=833.33	=923.09	**=555.55**
Total Load	0	0	538.46	**555.55**



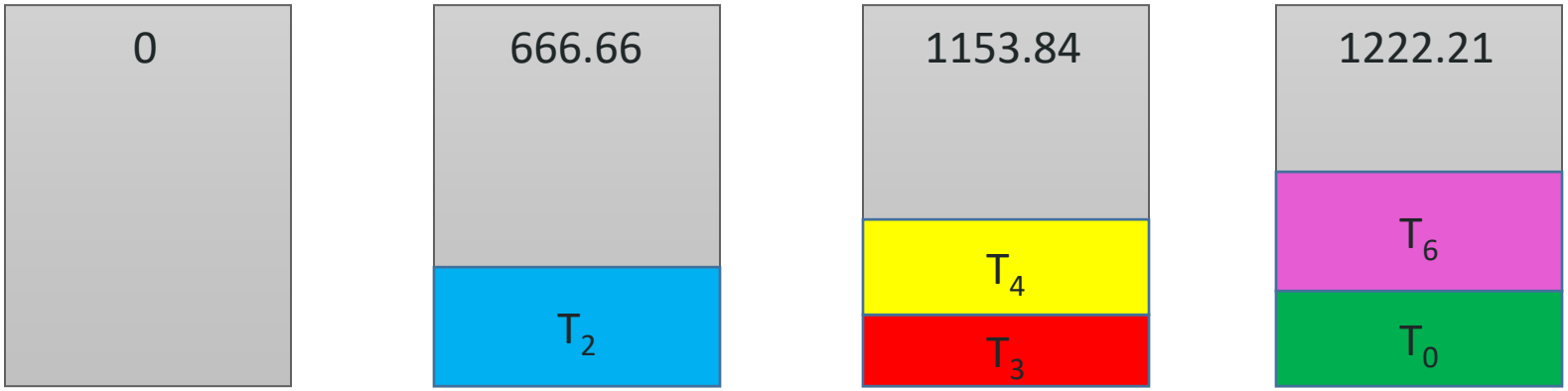
Current Load On VM

Load on VM	VM_0	VM_1	VM_2	VM_3
ECT of Task T_2	1000	666.66	307.69	444.44
Current Load	0	0	538.46	555.55
Before Assign Task	+1000	+666.66	+307.69	+444.44
After Assign Task	=1000	**=666.66**	=846.15	=999.99
Total Load	0	**666.66**	538.46	555.55



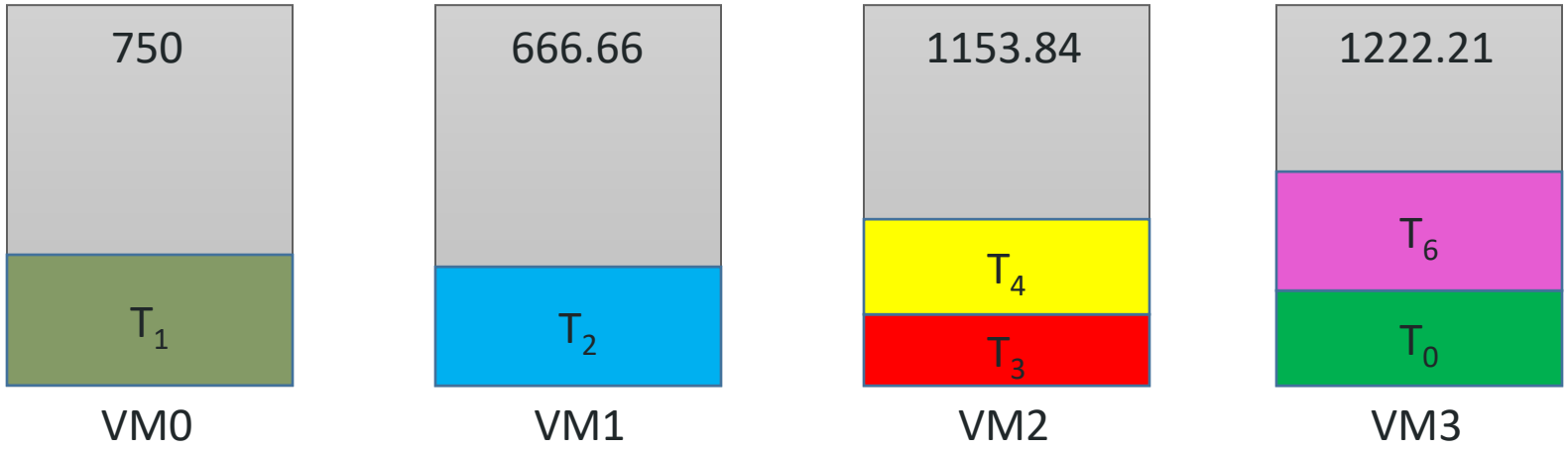
Current Load On VM

Load on VM	VM_0	VM_1	VM_2	VM_3
ECT of Task T_4	2000	1333.33	615.38	888.88
Current Load	0	666.66	538.46	555.55
Before Assign Task	+2000	+1333.33	+615.38	+888.88
After Assign Task	=2000	=1999.99	**=1153.84**	=1444.43
Total Load	0	666.66	**1153.84**	555.55



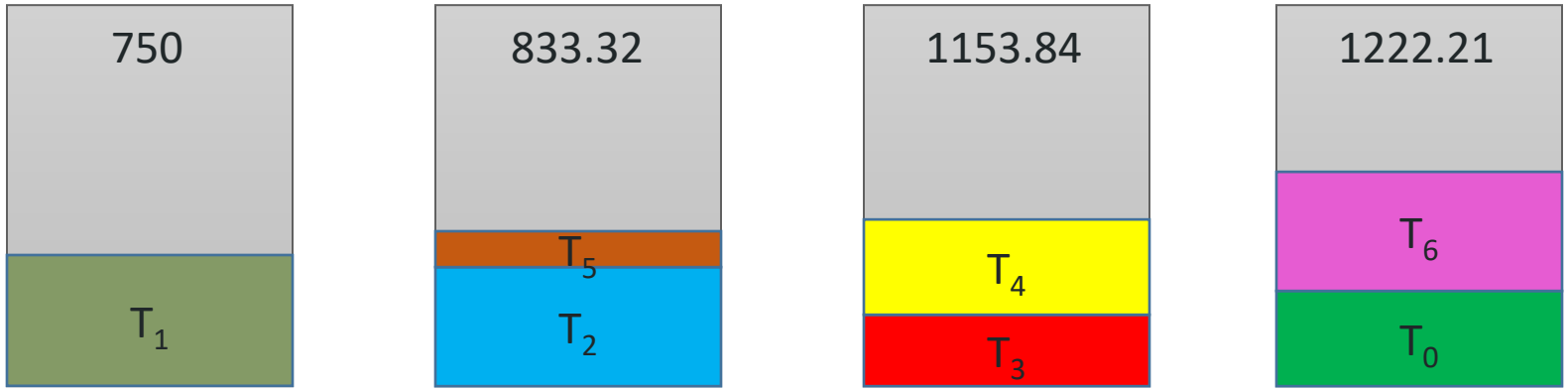
Current Load On VM

Load on VM	VM_0	VM_1	VM_2	VM_3
ECT of Task T_6	1500	1000	461.53	666.66
Current Load	0	666.66	1153.84	555.55
Before Assign Task	+1500	+1000	+461.53	+666.66
After Assign Task	=1500	=1666.66	=1615.37	**=1222.21**
Total Load	0	666.66	1153.84	**1222.21**



Current Load On VM

Load on VM	VM_0	VM_1	VM_2	VM_3
ECT of Task T_1	750	500	230.76	333.33
Current Load	0	666.66	1153.84	1222.21
Before Assign Task	+750	+500	+230.76	+333.33
After Assign Task	**=750**	=1166.66	=1384.6	=1555.54
Total Load	**750**	666.66	1153.84	1222.21



Current Load On VM

Load on VM	VM_0	VM_1	VM_2	VM_3
ECT of Task T_5	250	166.66	76.92	111.11
Current Load	750	666.66	1153.84	1222.21
Before Assign Task	+250	+166.66	+76.92	+111.11
After Assign Task	=1000	**=833.32**	=1230.76	=1333.32
Total Load	750	**833.32**	1153.84	1222.21

Thank You.