

Pandit Deendayal Energy University
School of Technology
Cloud Computing – Lab (20CP322P)
B.Tech-Computer Science & Engineering (Sem-VI)

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Lab 7 Assignment

Simulate a cloud scenario using CloudSim

Aim: To Simulate Cloud Environment by adding datacenters and cloudlets of different Topology.

Perform the following:

1. Create a datacenter with one host and run one cloudlet on it.
2. Create two datacenters with one host and a network topology each and run two cloudlets on them.
3. Create two datacenters with one host each and run cloudlets of two users with network topology on them.
4. Create two datacenters with one host each and run two cloudlets on them.
5. Create two datacenters with one host each and run cloudlets of two users on them.
6. Pause and resume the simulation, and create simulation entities (a DatacenterBroker in this example) dynamically.
7. *Perform VM migration between Datacenters considering them as different cloud providers.
 - a. Manually
 - b. Considering CPU Utilization threshold as criterion for VM migration.
 - c. When Simulation clock reaches at specific time.

*Note: (You may use CloudSim Plus for VM Migration)

Experiment:

◆ CloudSim Installation and Simulation of cloud environment using CloudSim:

Theory:

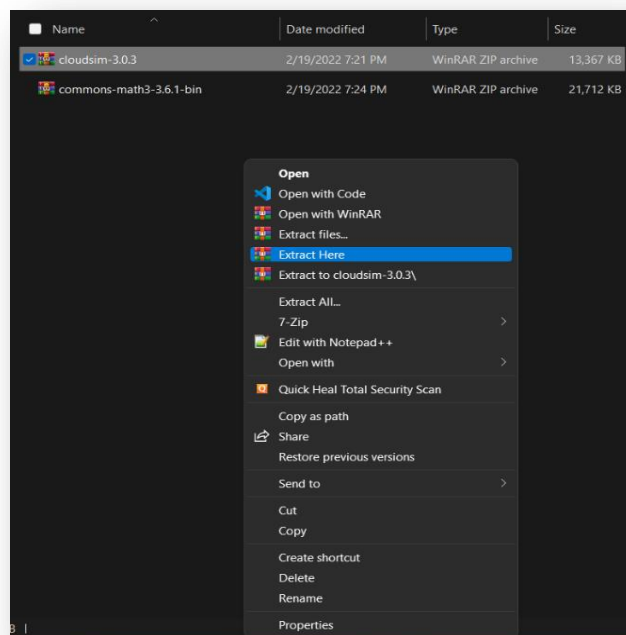
What is CloudSim?

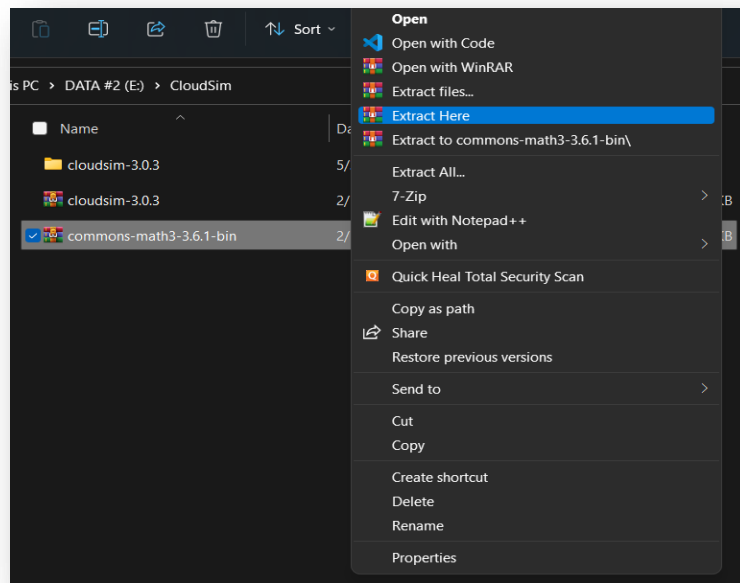
CloudSim is an open-source framework, which is used to simulate cloud computing infrastructure and services. It is developed by the CLOUDS Lab organization and is written entirely in Java. It is used for modelling and simulating a cloud computing environment as a means for evaluating a hypothesis prior to software development in order to reproduce tests and results.

Procedure:

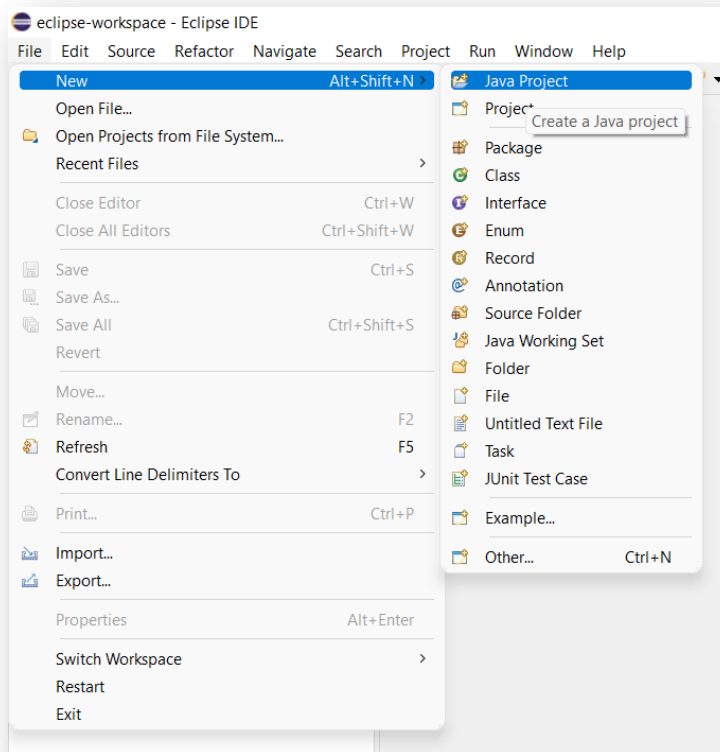
- Steps for installation of CloudSim on Windows:
 - Download/Install the following resources on your local system before you start to setup CloudSim.
 - Java Development Kit(JDK)
 - Eclipse IDE for Java developers
 - Download CloudSim source code
 - One external requirement of Cloudsim (common jar package of math-related functions)

Now unzip Eclipse, CloudSim and Common Math libraries to some common folder.

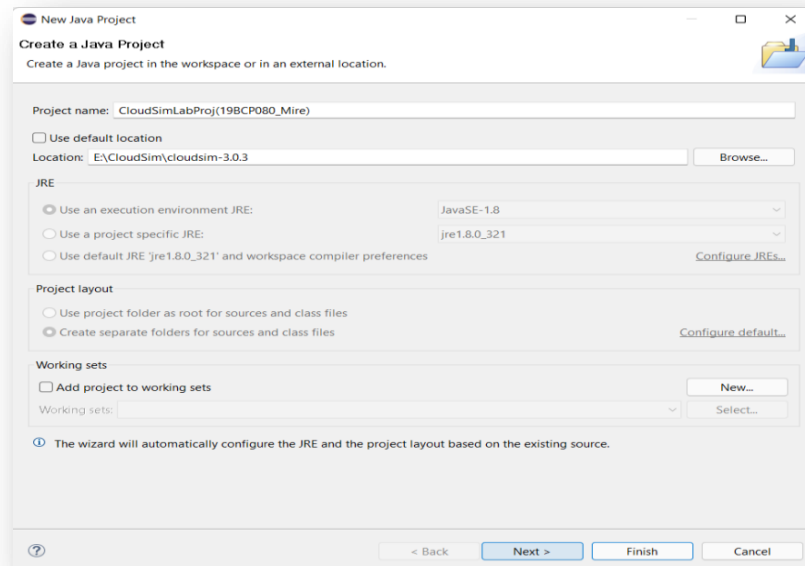




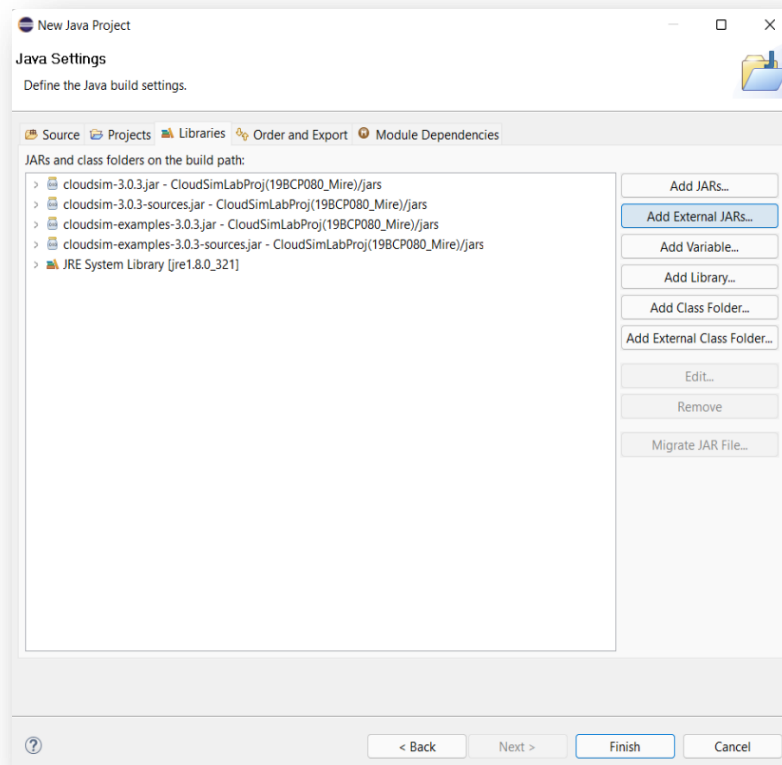
Open Eclipse and navigate the menu: File → New → Java Project, to open the ‘New Java Project’ wizard.



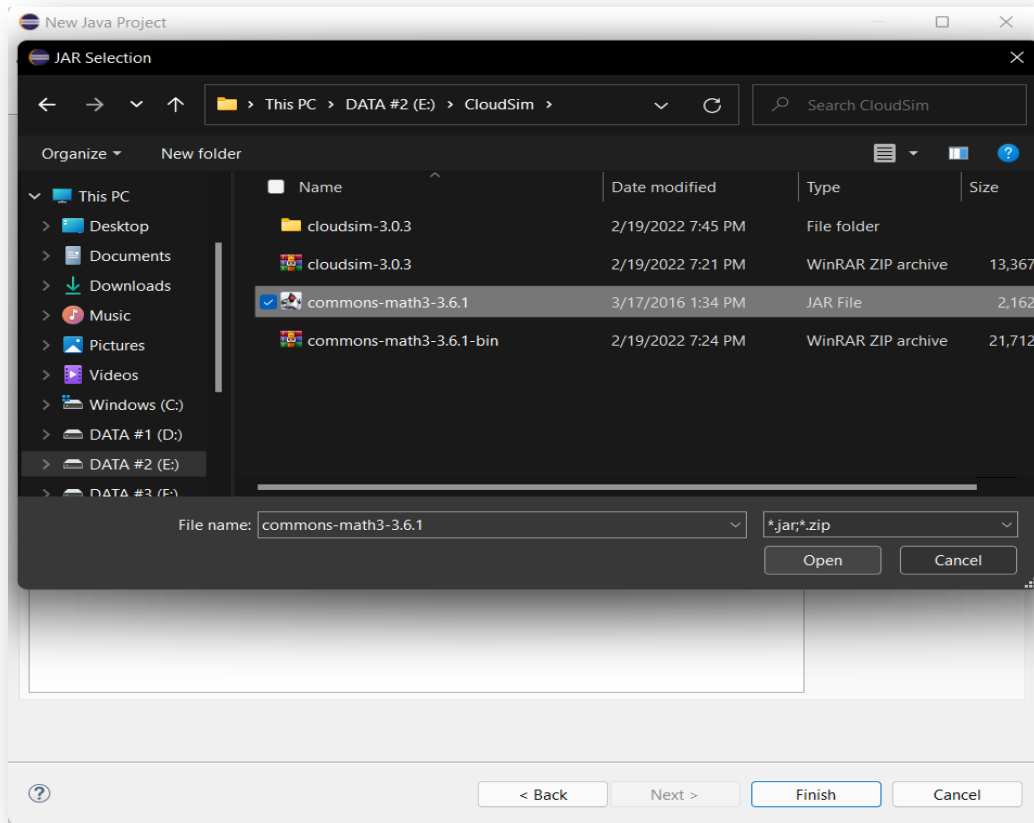
Provide the name to your java project. After then unselect the 'Use default location' option and then click on 'Browse' to open the path where you have unzipped the CloudSim project and then click 'Next' to set project settings. (Make sure you navigate the path till you can see the bin, docs, examples etc folder in the navigation plane.)



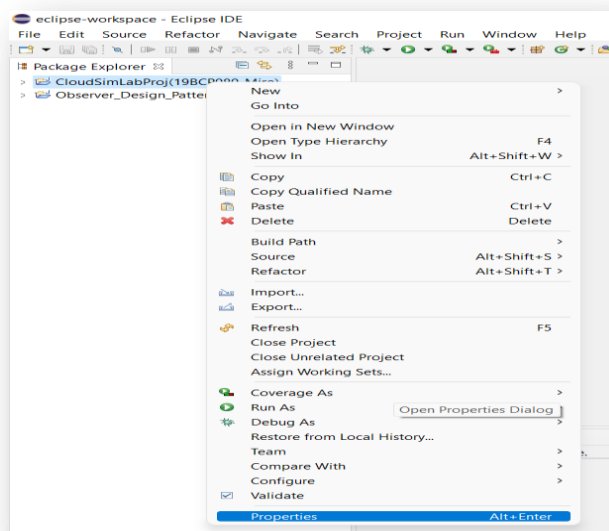
→ Now open 'Libraries' tab and if you do not find commons-math3-3.x.jar (here 'x' means the minor version release of the library which could be 2 or greater) in the list then simply click on 'Add External Jar'.

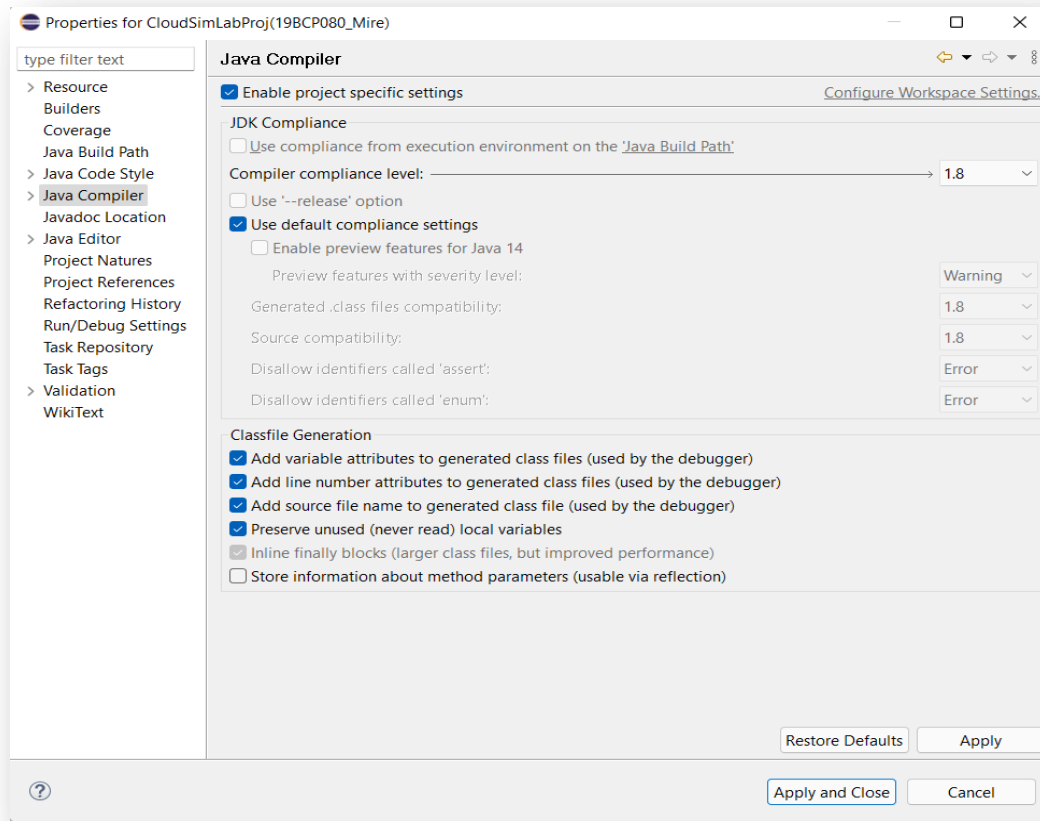


→ Once you have clicked on 'Add External JARs' Open the path where you have unzipped the commons-math binaries and select 'Commons-math3-3.x.jar' and click on 'open', and after then click on 'Finish'.

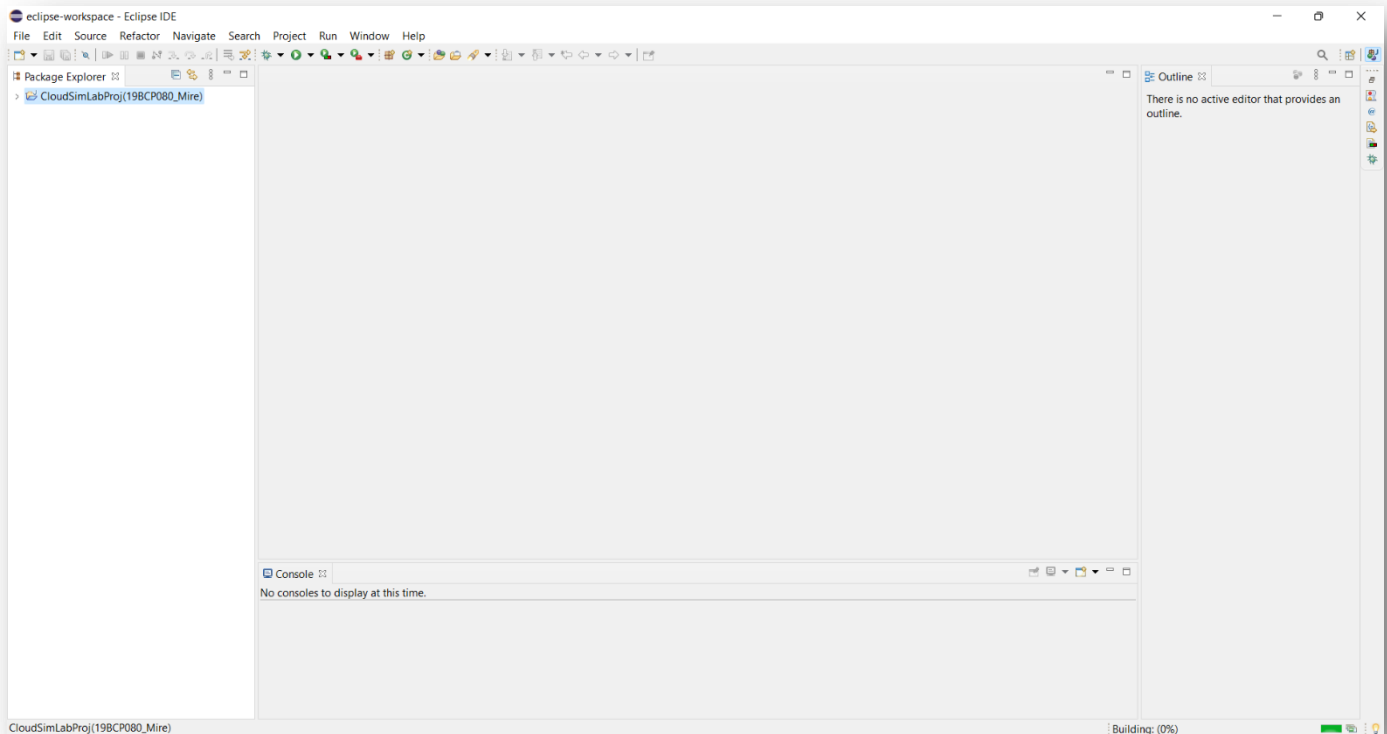


→ To avoid getting an error, you have to download and install the latest java version from Oracle/Java website. And second you have to do some modifications in the eclipse project, and for this, do as per following steps and after modification click on 'Apply and Close'.

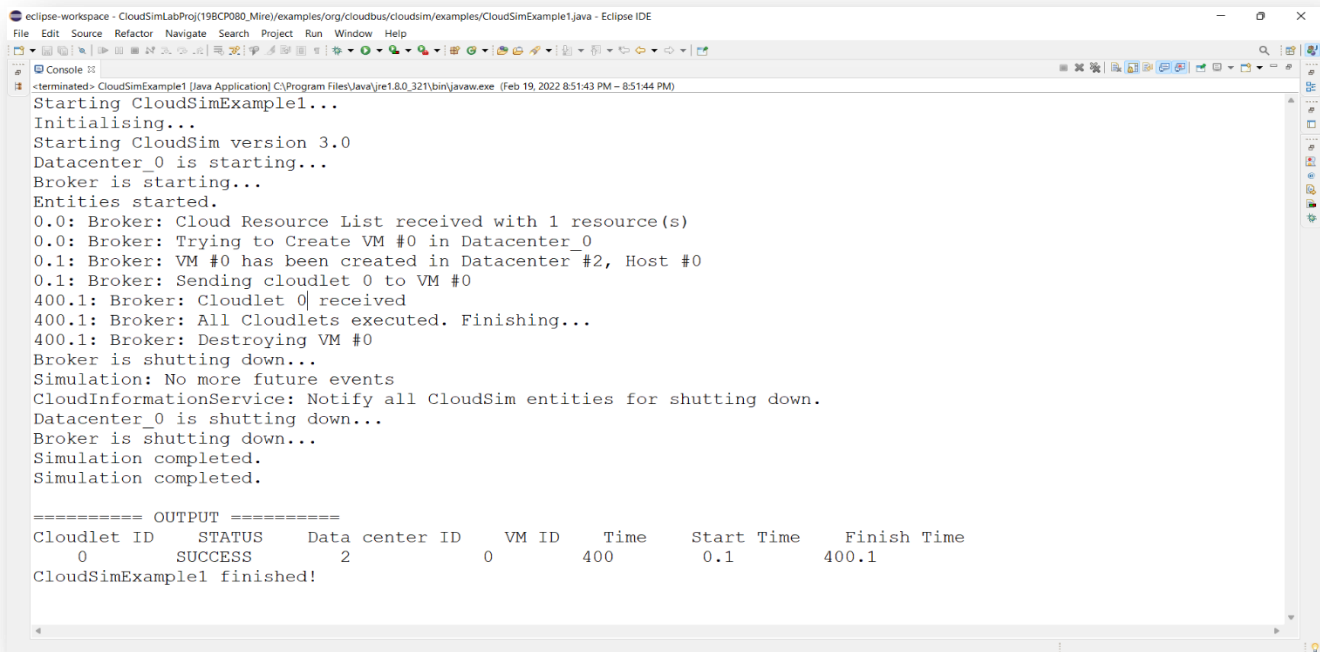




After CloudSim is configured, you will see the following final screen.



- ◆ [Task- 1]: Create a datacenter with one host and run one cloudlet on it.
→ Output:

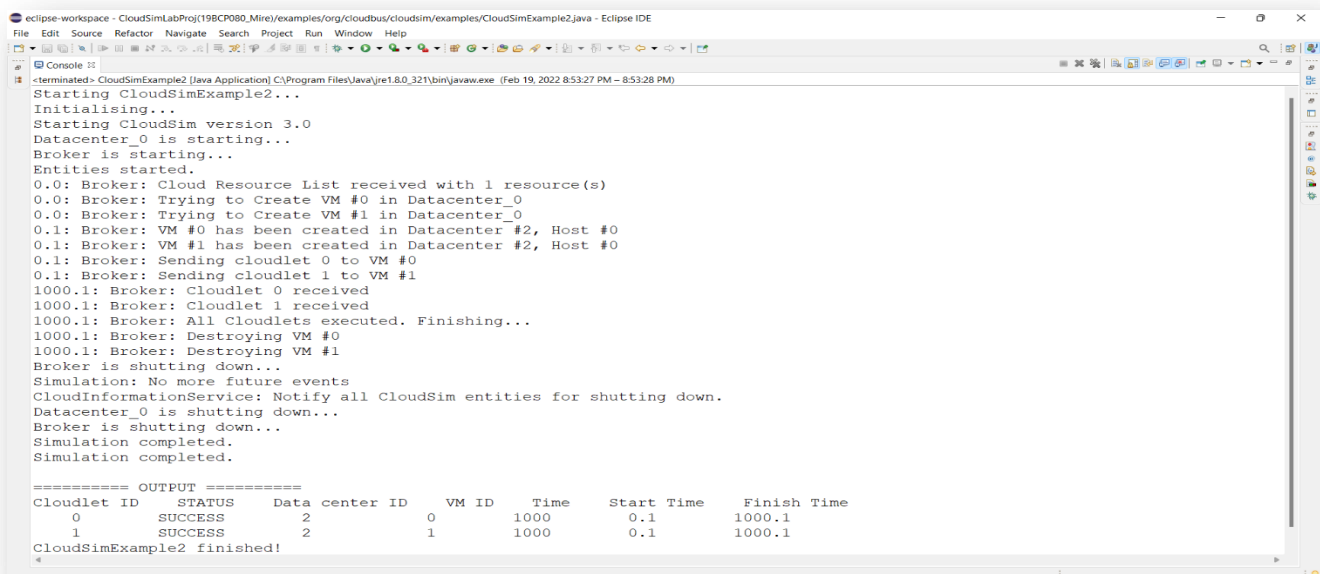


```
<terminated> CloudSimExample1 [Java Application] C:\Program Files\Java\jre1.8.0_321\bin\javaw.exe (Feb 19, 2022 8:51:43 PM - 8:51:44 PM)
Starting CloudSimExample1...
Initialising...
Starting CloudSim version 3.0
Datacenter_0 is starting...
Broker is starting...
Entities started.
0.0: Broker: Cloud Resource List received with 1 resource(s)
0.0: Broker: Trying to Create VM #0 in Datacenter_0
0.1: Broker: VM #0 has been created in Datacenter #2, Host #0
0.1: Broker: Sending cloudlet 0 to VM #0
400.1: Broker: Cloudlet 0 received
400.1: Broker: All Cloudlets executed. Finishing...
400.1: Broker: Destroying VM #0
Broker is shutting down...
Simulation: No more future events
CloudInformationService: Notify all CloudSim entities for shutting down.
Datacenter_0 is shutting down...
Broker is shutting down...
Simulation completed.
Simulation completed.

===== OUTPUT =====
Cloudlet ID   STATUS   Data center ID   VM ID   Time   Start Time   Finish Time
0            SUCCESS   2                0       400    0.1          400.1
CloudSimExample1 finished!
```

- ◆ [Task- 2]: Create two datacenters with one host and a network topology each and run two cloudlets on them.

→ Output:

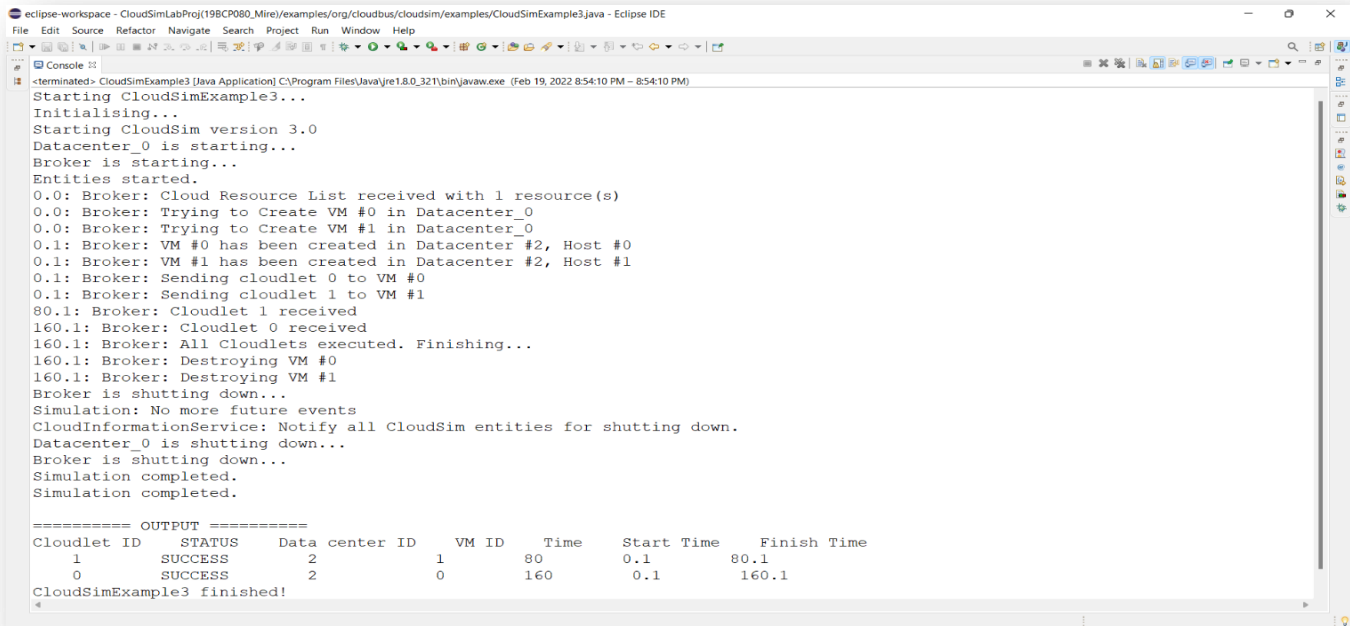


```
<terminated> CloudSimExample2 [Java Application] C:\Program Files\Java\jre1.8.0_321\bin\javaw.exe (Feb 19, 2022 8:53:27 PM - 8:53:28 PM)
Starting CloudSimExample2...
Initialising...
Starting CloudSim version 3.0
Datacenter_0 is starting...
Broker is starting...
Entities started.
0.0: Broker: Cloud Resource List received with 1 resource(s)
0.0: Broker: Trying to Create VM #0 in Datacenter_0
0.0: Broker: Trying to Create VM #1 in Datacenter_0
0.1: Broker: VM #0 has been created in Datacenter #2, Host #0
0.1: Broker: VM #1 has been created in Datacenter #2, Host #0
0.1: Broker: Sending cloudlet 0 to VM #0
0.1: Broker: Sending cloudlet 1 to VM #1
1000.1: Broker: Cloudlet 0 received
1000.1: Broker: Cloudlet 1 received
1000.1: Broker: All Cloudlets executed. Finishing...
1000.1: Broker: Destroying VM #0
1000.1: Broker: Destroying VM #1
Broker is shutting down...
Simulation: No more future events
CloudInformationService: Notify all CloudSim entities for shutting down.
Datacenter_0 is shutting down...
Broker is shutting down...
Simulation completed.
Simulation completed.

===== OUTPUT =====
Cloudlet ID   STATUS   Data center ID   VM ID   Time   Start Time   Finish Time
0            SUCCESS   2                0       1000    0.1          1000.1
1            SUCCESS   2                1       1000    0.1          1000.1
CloudSimExample2 finished!
```

◆ [Task- 3]: Create two datacenters with one host each and run cloudlets of two users with network topology on them.

→ Output:

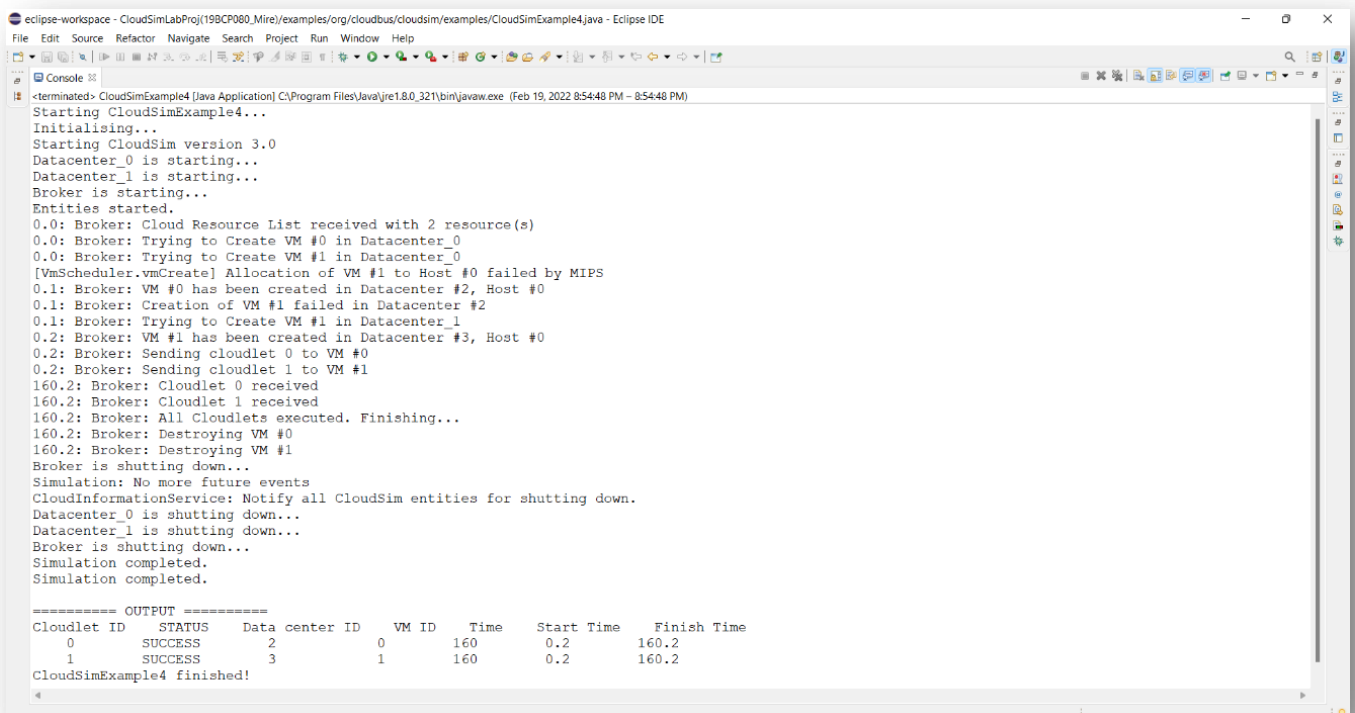


```
eclipse-workspace - CloudSimLabProj(198CP080_Mire)/examples/org/cloudbus/cloudsim/examples/CloudSimExample3.java - Eclipse IDE
File Edit Source Refactor Navigate Search Project Run Window Help
<terminated> CloudSimExample3 [Java Application] C:\Program Files\Java\jre1.8.0_321\bin\javaw.exe (Feb 19, 2022 8:54:10 PM - 8:54:10 PM)
Starting CloudSimExample3...
Initialising...
Starting CloudSim version 3.0
Datacenter_0 is starting...
Broker is starting...
Entities started.
0.0: Broker: Cloud Resource List received with 1 resource(s)
0.0: Broker: Trying to Create VM #0 in Datacenter_0
0.0: Broker: Trying to Create VM #1 in Datacenter_0
0.1: Broker: VM #0 has been created in Datacenter #2, Host #0
0.1: Broker: VM #1 has been created in Datacenter #2, Host #1
0.1: Broker: Sending cloudlet 0 to VM #0
0.1: Broker: Sending cloudlet 1 to VM #1
80.1: Broker: Cloudlet 1 received
160.1: Broker: Cloudlet 0 received
160.1: Broker: All Cloudlets executed. Finishing...
160.1: Broker: Destroying VM #0
160.1: Broker: Destroying VM #1
Broker is shutting down...
Simulation: No more future events
CloudInformationService: Notify all CloudSim entities for shutting down.
Datacenter_0 is shutting down...
Broker is shutting down...
Simulation completed.
Simulation completed.

===== OUTPUT =====
Cloudlet ID   STATUS   Data center ID   VM ID   Time   Start Time   Finish Time
1            SUCCESS   2                1       80     0.1          80.1
0            SUCCESS   2                0       160    0.1          160.1
CloudSimExample3 finished!
```

◆ [Task- 4]: Create two datacenters with one host each and run two cloudlets on them.

→ Output:



```
eclipse-workspace - CloudSimLabProj(198CP080_Mire)/examples/org/cloudbus/cloudsim/examples/CloudSimExample4.java - Eclipse IDE
File Edit Source Refactor Navigate Search Project Run Window Help
<terminated> CloudSimExample4 [Java Application] C:\Program Files\Java\jre1.8.0_321\bin\javaw.exe (Feb 19, 2022 8:54:48 PM - 8:54:48 PM)
Starting CloudSimExample4...
Initialising...
Starting CloudSim version 3.0
Datacenter_0 is starting...
Datacenter_1 is starting...
Broker is starting...
Entities started.
0.0: Broker: Cloud Resource List received with 2 resource(s)
0.0: Broker: Trying to Create VM #0 in Datacenter_0
0.0: Broker: Trying to Create VM #1 in Datacenter_0
[VmScheduler.vmmCreate] Allocation of VM #1 to Host #0 failed by MIPS
0.1: Broker: VM #0 has been created in Datacenter #2, Host #0
0.1: Broker: Creation of VM #1 failed in Datacenter #2
0.1: Broker: Trying to Create VM #1 in Datacenter_1
0.2: Broker: VM #1 has been created in Datacenter #3, Host #0
0.2: Broker: Sending cloudlet 0 to VM #0
0.2: Broker: Sending cloudlet 1 to VM #1
160.2: Broker: Cloudlet 0 received
160.2: Broker: Cloudlet 1 received
160.2: Broker: All Cloudlets executed. Finishing...
160.2: Broker: Destroying VM #0
160.2: Broker: Destroying VM #1
Broker is shutting down...
Simulation: No more future events
CloudInformationService: Notify all CloudSim entities for shutting down.
Datacenter_0 is shutting down...
Datacenter_1 is shutting down...
Broker is shutting down...
Simulation completed.
Simulation completed.

===== OUTPUT =====
Cloudlet ID   STATUS   Data center ID   VM ID   Time   Start Time   Finish Time
0            SUCCESS   2                0       160    0.2          160.2
1            SUCCESS   3                1       160    0.2          160.2
CloudSimExample4 finished!
```


◆ **[Task- 5]: Create two datacenters with one host each and run cloudlets of two users on them.**

→ *Output:*

```
eclipse-workspace - CloudSimLabProj(198CP080_Mire)/examples/org/cloudbus/cloudsim/examples/CloudSimExample5.java - Eclipse IDE
File Edit Source Refactor Navigate Search Project Run Window Help
<terminated> CloudSimExample5 [Java Application] C:\Program Files\Java\jre1.8.0_321\bin\javaw.exe (Feb 19, 2022 8:55:10 PM - 8:55:11 PM)
Starting CloudSimExample5...
Initialising...
Starting CloudSim version 3.0
Datacenter_0 is starting...
Datacenter_1 is starting...
Broker1 is starting...
Broker2 is starting...
Entities started.
0.0: Broker1: Cloud Resource List received with 2 resource(s)
0.0: Broker2: Cloud Resource List received with 2 resource(s)
0.0: Broker1: Trying to Create VM #0 in Datacenter_0
0.0: Broker2: Trying to Create VM #0 in Datacenter_0
[VmScheduler.vmCreate] Allocation of VM #0 to Host #0 failed by MIPS
0.1: Broker1: VM #0 has been created in Datacenter #2, Host #0
0.1: Broker1: Sending cloudlet 0 to VM #0
0.1: Broker2: Creation of VM #0 failed in Datacenter #2
0.1: Broker2: Trying to Create VM #0 in Datacenter_1
0.2: Broker2: VM #0 has been created in Datacenter #3, Host #0
0.2: Broker2: Sending cloudlet 0 to VM #0
160.1: Broker1: Cloudlet 0 received
160.1: Broker1: All Cloudlets executed. Finishing...
160.1: Broker1: Destroying VM #0
Broker1 is shutting down...
160.2: Broker2: Cloudlet 0 received
160.2: Broker2: All Cloudlets executed. Finishing...
160.2: Broker2: Destroying VM #0
Broker2 is shutting down...
Simulation: No more future events
CloudInformationService: Notify all CloudSim entities for shutting down.
```

```
Datacenter_0 is shutting down...
Datacenter_1 is shutting down...
Broker1 is shutting down...
Broker2 is shutting down...
Simulation completed.
Simulation completed.
=====> User 4
===== OUTPUT =====
Cloudlet ID   STATUS   Data center ID   VM ID   Time   Start Time   Finish Time
0            SUCCESS      2               0       160     0.1          160.1
=====> User 5
===== OUTPUT =====
Cloudlet ID   STATUS   Data center ID   VM ID   Time   Start Time   Finish Time
0            SUCCESS      3               0       160     0.2          160.2
CloudSimExample5 finished!
```

◆ [Task- 6]: Pause and resume the simulation, and create simulation entities (a DatacenterBroker in this example) dynamically.

→ **Output:**

eclipse-workspace - CloudSimLabProj\198CP080_Mire\examples/org/cloudbus/cloudsim/examples/CloudSimExample7.java - Eclipse IDE
 File Edit Source Refactor Navigate Search Project Run Window Help
 Console
 <terminated> CloudSimExample7 [Java Application] C:\Program Files\Java\jre1.8.0_321\bin\javaw.exe (Feb 19, 2022 8:56:09 PM - 8:56:15 PM)
 Starting CloudSimExample7...
 Initialising...
 Starting CloudSim version 3.0
 Datacenter_0 is starting...
 Datacenter_1 is starting...
 Broker_0 is starting...
 Entities started.
 0.0: Broker_0: Cloud Resource List received with 2 resource(s)
 0.0: Broker_0: Trying to Create VM #0 in Datacenter_0
 0.0: Broker_0: Trying to Create VM #1 in Datacenter_0
 0.0: Broker_0: Trying to Create VM #2 in Datacenter_0
 0.0: Broker_0: Trying to Create VM #3 in Datacenter_0
 0.0: Broker_0: Trying to Create VM #4 in Datacenter_0
 0.1: Broker_0: VM #0 has been created in Datacenter #2, Host #0
 0.1: Broker_0: VM #1 has been created in Datacenter #2, Host #0
 0.1: Broker_0: VM #2 has been created in Datacenter #2, Host #0
 0.1: Broker_0: VM #3 has been created in Datacenter #2, Host #1
 0.1: Broker_0: VM #4 has been created in Datacenter #2, Host #0
 0.1: Broker_0: Sending cloudlet 0 to VM #0
 0.1: Broker_0: Sending cloudlet 1 to VM #1
 0.1: Broker_0: Sending cloudlet 2 to VM #2
 0.1: Broker_0: Sending cloudlet 3 to VM #3
 0.1: Broker_0: Sending cloudlet 4 to VM #4
 0.1: Broker_0: Sending cloudlet 5 to VM #0
 0.1: Broker_0: Sending cloudlet 6 to VM #1
 0.1: Broker_0: Sending cloudlet 7 to VM #2
 0.1: Broker_0: Sending cloudlet 8 to VM #3
 0.1: Broker_0: Sending cloudlet 9 to VM #4

```
200.0: The simulation is paused for 5 sec

Adding: Broker_1
Broker_1 is starting...
200.0: Broker_1: Cloud Resource List received with 2 resource(s)
200.0: Broker_1: Trying to Create VM #100 in Datacenter_0
200.0: Broker_1: Trying to Create VM #101 in Datacenter_0
200.0: Broker_1: Trying to Create VM #102 in Datacenter_0
200.0: Broker_1: Trying to Create VM #103 in Datacenter_0
200.0: Broker_1: Trying to Create VM #104 in Datacenter_0
200.1: Broker_1: VM #100 has been created in Datacenter #2, Host #1
200.1: Broker_1: VM #101 has been created in Datacenter #2, Host #0
200.1: Broker_1: VM #102 has been created in Datacenter #2, Host #1
200.1: Broker_1: VM #103 has been created in Datacenter #2, Host #0
200.1: Broker_1: VM #104 has been created in Datacenter #2, Host #1
200.1: Broker_1: Sending cloudlet 100 to VM #100
200.1: Broker_1: Sending cloudlet 101 to VM #101
200.1: Broker_1: Sending cloudlet 102 to VM #102
200.1: Broker_1: Sending cloudlet 103 to VM #103
200.1: Broker_1: Sending cloudlet 104 to VM #104
200.1: Broker_1: Sending cloudlet 105 to VM #100
200.1: Broker_1: Sending cloudlet 106 to VM #101
200.1: Broker_1: Sending cloudlet 107 to VM #102
200.1: Broker_1: Sending cloudlet 108 to VM #103
200.1: Broker_1: Sending cloudlet 109 to VM #104
320.096: Broker_0: Cloudlet 0 received
320.096: Broker_0: Cloudlet 5 received
320.096: Broker_0: Cloudlet 1 received
```

```

320.096: Broker_0: Cloudlet 6 received
320.096: Broker_0: Cloudlet 2 received
320.096: Broker_0: Cloudlet 7 received
320.096: Broker_0: Cloudlet 4 received
320.096: Broker_0: Cloudlet 9 received
320.096: Broker_0: Cloudlet 3 received
320.096: Broker_0: Cloudlet 8 received
320.096: Broker_0: All Cloudlets executed. Finishing...
320.096: Broker_0: Destroying VM #0
320.096: Broker_0: Destroying VM #1
320.096: Broker_0: Destroying VM #2
320.096: Broker_0: Destroying VM #3
320.096: Broker_0: Destroying VM #4
Broker_0 is shutting down...
519.996: Broker_1: Cloudlet 101 received
519.996: Broker_1: Cloudlet 106 received
519.996: Broker_1: Cloudlet 103 received
519.996: Broker_1: Cloudlet 108 received
519.996: Broker_1: Cloudlet 100 received
519.996: Broker_1: Cloudlet 105 received
519.996: Broker_1: Cloudlet 102 received
519.996: Broker_1: Cloudlet 107 received
519.996: Broker_1: Cloudlet 104 received
519.996: Broker_1: Cloudlet 109 received
519.996: Broker_1: All Cloudlets executed. Finishing...
519.996: Broker_1: Destroying VM #100
519.996: Broker_1: Destroying VM #101
519.996: Broker_1: Destroying VM #102
519.996: Broker_1: Destroying VM #103
519.996: Broker_1: Destroying VM #104

```

```

Broker_1 is shutting down...
Simulation: No more future events
CloudInformationService: Notify all CloudSim entities for shutting down.
Datacenter_0 is shutting down...
Datacenter_1 is shutting down...
Broker_0 is shutting down...
Broker_1 is shutting down...
Simulation completed.
Simulation completed.

```

```

===== OUTPUT =====

```

Cloudlet ID	ID	STATUS	Data	center ID	VM ID	Time	Start Time	Finish Time
0		SUCCESS	2	0	0	320	0.1	320.1
5		SUCCESS	2	0	0	320	0.1	320.1
1		SUCCESS	2	1	1	320	0.1	320.1
6		SUCCESS	2	1	1	320	0.1	320.1
2		SUCCESS	2	2	2	320	0.1	320.1
7		SUCCESS	2	2	2	320	0.1	320.1
4		SUCCESS	2	4	4	320	0.1	320.1
9		SUCCESS	2	4	4	320	0.1	320.1
3		SUCCESS	2	3	3	320	0.1	320.1
8		SUCCESS	2	3	3	320	0.1	320.1

```

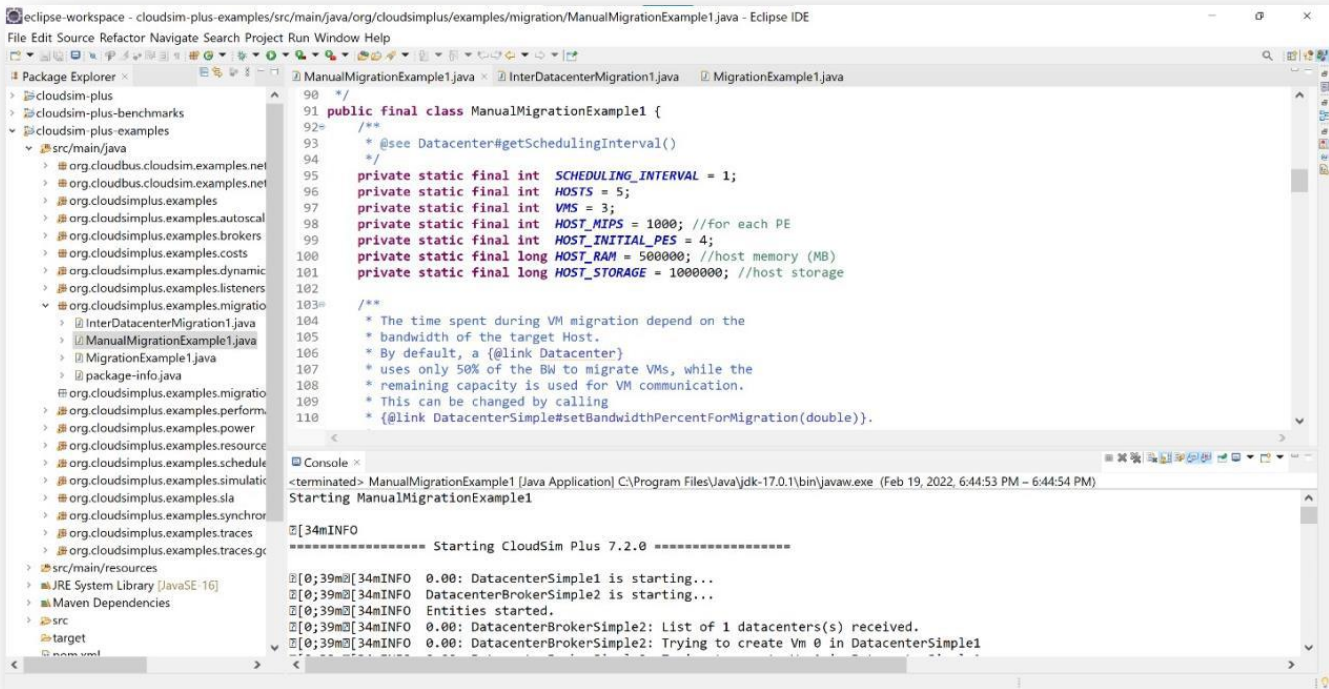
CloudSimExample7 finished!

```

◆ [Task- 7]: Perform VM migration between Datacenters considering them as different cloud providers.

- Manually
- Considering CPU Utilization threshold as criterion for VM migration.
- When Simulation clock reaches at specific time.

→ Output:



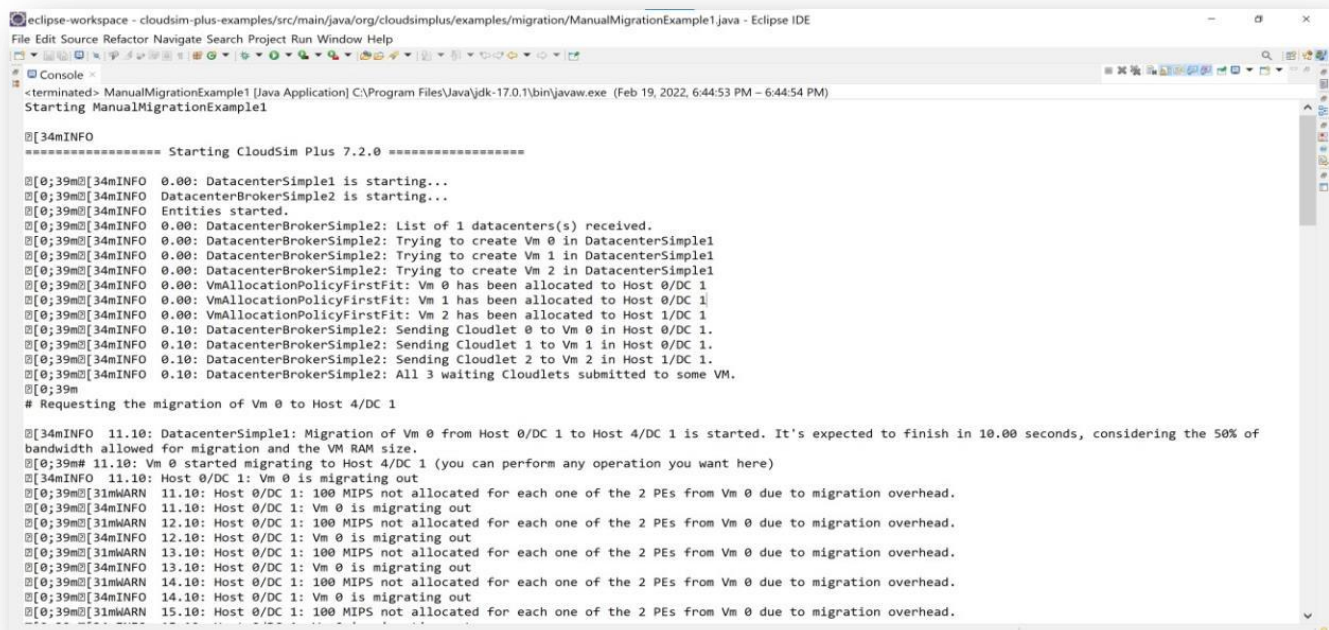
The screenshot shows the Eclipse IDE with the file `ManualMigrationExample1.java` open. The code defines a class `ManualMigrationExample1` with static final variables for simulation parameters: `SCHEDULING_INTERVAL`, `HOSTS`, `VMS`, `HOST_MIPS`, `HOST_INITIAL_PES`, `HOST_RAM`, and `HOST_STORAGE`. It also includes a comment about the time spent during VM migration depending on the bandwidth of the target host and the default 50% bandwidth used for migration.

The console output shows the following messages:

```
<terminated> ManualMigrationExample1 [Java Application] C:\Program Files\Java\jdk-17.0.1\bin\javaw.exe (Feb 19, 2022, 6:44:53 PM - 6:44:54 PM)
Starting ManualMigrationExample1

[34mINFO
===== Starting CloudSim Plus 7.2.0 =====

[0;39m[34mINFO 0.00: DatacenterSimple1 is starting...
[0;39m[34mINFO DatacenterBrokerSimple2 is starting...
[0;39m[34mINFO Entities started.
[0;39m[34mINFO 0.00: DatacenterBrokerSimple2: List of 1 datacenters(s) received.
[0;39m[34mINFO 0.00: DatacenterBrokerSimple2: Trying to create Vm 0 in DatacenterSimple1
```



The console output continues with the following messages:

```
[0;39m[34mINFO 0.00: DatacenterSimple1 is starting...
[0;39m[34mINFO DatacenterBrokerSimple2 is starting...
[0;39m[34mINFO Entities started.
[0;39m[34mINFO 0.00: DatacenterBrokerSimple2: List of 1 datacenters(s) received.
[0;39m[34mINFO 0.00: DatacenterBrokerSimple2: Trying to create Vm 0 in DatacenterSimple1
[0;39m[34mINFO 0.00: DatacenterBrokerSimple2: Trying to create Vm 1 in DatacenterSimple1
[0;39m[34mINFO 0.00: DatacenterBrokerSimple2: Trying to create Vm 2 in DatacenterSimple1
[0;39m[34mINFO 0.00: VmAllocationPolicyFirstFit: Vm 0 has been allocated to Host 0/DC 1
[0;39m[34mINFO 0.00: VmAllocationPolicyFirstFit: Vm 1 has been allocated to Host 0/DC 1
[0;39m[34mINFO 0.00: VmAllocationPolicyFirstFit: Vm 2 has been allocated to Host 1/DC 1
[0;39m[34mINFO 0.10: DatacenterBrokerSimple2: Sending Cloudlet 0 to Vm 0 in Host 0/DC 1.
[0;39m[34mINFO 0.10: DatacenterBrokerSimple2: Sending Cloudlet 1 to Vm 1 in Host 0/DC 1.
[0;39m[34mINFO 0.10: DatacenterBrokerSimple2: Sending Cloudlet 2 to Vm 2 in Host 1/DC 1.
[0;39m[34mINFO 0.10: DatacenterBrokerSimple2: All 3 waiting Cloudlets submitted to some VM.
[0;39m
# Requesting the migration of Vm 0 to Host 4/DC 1

[34mINFO 11.10: DatacenterSimple1: Migration of Vm 0 from Host 0/DC 1 to Host 4/DC 1 is started. It's expected to finish in 10.00 seconds, considering the 50% of
bandwidth allowed for migration and the VM RAM size.
[0;39m[34mINFO 11.10: Vm 0 started migrating to Host 4/DC 1 (you can perform any operation you want here)
[34mINFO 11.10: Host 0/DC 1: Vm 0 is migrating out
[0;39m[31mWARN 11.10: Host 0/DC 1: 100 MIPS not allocated for each one of the 2 PEs from Vm 0 due to migration overhead.
[0;39m[31mWARN 11.10: Host 0/DC 1: Vm 0 is migrating out
[0;39m[31mWARN 12.10: Host 0/DC 1: 100 MIPS not allocated for each one of the 2 PEs from Vm 0 due to migration overhead.
[0;39m[31mWARN 12.10: Host 0/DC 1: Vm 0 is migrating out
[0;39m[34mINFO 12.10: Host 0/DC 1: Vm 0 is migrating out
[0;39m[31mWARN 13.10: Host 0/DC 1: 100 MIPS not allocated for each one of the 2 PEs from Vm 0 due to migration overhead.
[0;39m[34mINFO 13.10: Host 0/DC 1: Vm 0 is migrating out
[0;39m[31mWARN 14.10: Host 0/DC 1: 100 MIPS not allocated for each one of the 2 PEs from Vm 0 due to migration overhead.
[0;39m[31mWARN 14.10: Host 0/DC 1: Vm 0 is migrating out
[0;39m[34mINFO 14.10: Host 0/DC 1: Vm 0 is migrating out
[0;39m[31mWARN 15.10: Host 0/DC 1: 100 MIPS not allocated for each one of the 2 PEs from Vm 0 due to migration overhead.
```