Week 5

Title

Simulate a cloud scenario using CloudSim and run a scheduling algorithm that is not present in CloudSim.

Requirements

1. Java JDK and JRE
2. CloudSim archives (CloudSim4)
3. Eclipse IDE

Theory

A) CloudSim

1. CloudSim is an open-source framework, which is used to simulate cloud computing infrastructure and services.
2. It is developed by the CLOUDS Lab organization and is written entirely in Java.
3. 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.
4. If you were to deploy an application or a website on the cloud and wanted to test the services and load that your product can handle and also tune its performance to overcome bottlenecks before risking deployment, then such evaluations could be performed by simply coding a simulation of that environment with the help of various flexible and scalable classes provided by the CloudSim package, free of cost.

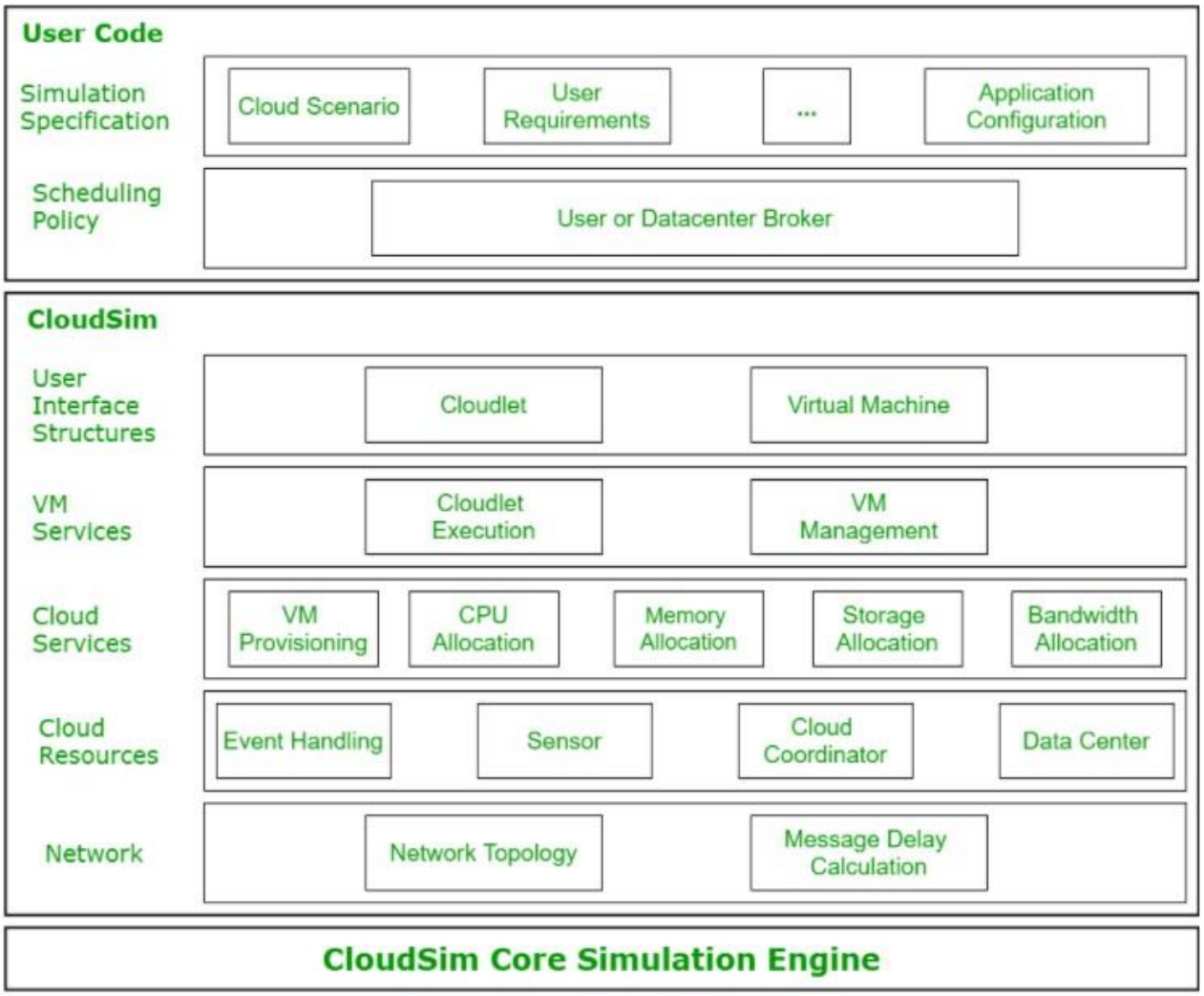
B) Benefits of CloudSim

1. No capital investment involved

2. Easy to use and Scalable
3. Risks can be evaluated at an earlier stage
4. No need for try-and-error approaches

C) Architecture

1. CloudSim has a layered architecture which separates the User Code and the simulation environment.
2. It can be depicted as follows



CloudSim Layered Architecture

D) CloudSim Components

- **Datacenter**: used for modelling the foundational hardware equipment of any cloud environment, that is the Datacenter. This class provides methods to specify the functional requirements of the Datacenter as well as methods to set the allocation policies of the VMs etc.
- **Host**: this class executes actions related to management of virtual machines. It also defines policies for provisioning memory and bandwidth to the virtual machines, as well as allocating CPU cores to the virtual machines.
- **VM**: this class represents a virtual machine by providing data members defining a VM's bandwidth, RAM, mips (million instructions per second), size while also providing setter and getter methods for these parameters.
- **Cloudlet**: a cloudlet class represents any task that is run on a VM, like a processing task, or a memory access task, or a file updating task etc. It stores parameters defining the characteristics of a task such as its length, size, mi (million instructions) and provides methods similarly to VM class while also providing methods that define a task's execution time, status, cost and history.
- **DatacenterBroker**: is an entity acting on behalf of the user/customer. It is responsible for functioning of VMs, including VM creation, management, destruction and submission of cloudlets to the VM.
- **CloudSim**: this is the class responsible for initializing and starting the simulation environment after all the necessary cloud entities have been defined and later stopping after all the entities have been destroyed.

E) SJF algorithm

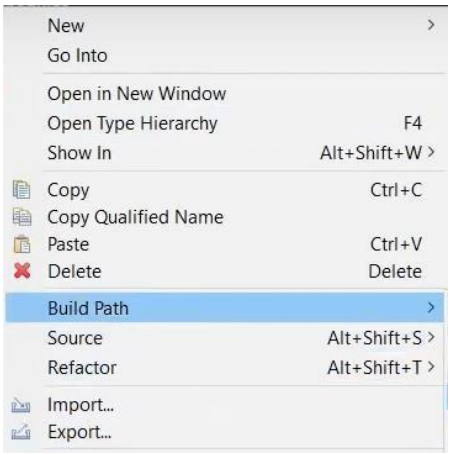
1. SJF stands for Shortest Job First
2. Shortest Job first has the advantage of having a minimum average waiting time among all scheduling algorithms.
3. It is a Greedy Algorithm.
4. It may cause starvation if shorter processes keep coming. This problem can be solved using the concept of ageing.
5. It is practically infeasible as Operating System may not know burst time and therefore may not sort them. While it is not possible to predict

execution time, several methods can be used to estimate the execution time for a job, such as a weighted average of previous execution times. SJF can be used in specialized environments where accurate estimates of running time are available.

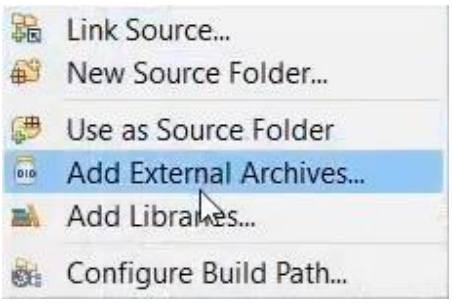
Steps

A) Installation of CloudSim and creation of simulation environment

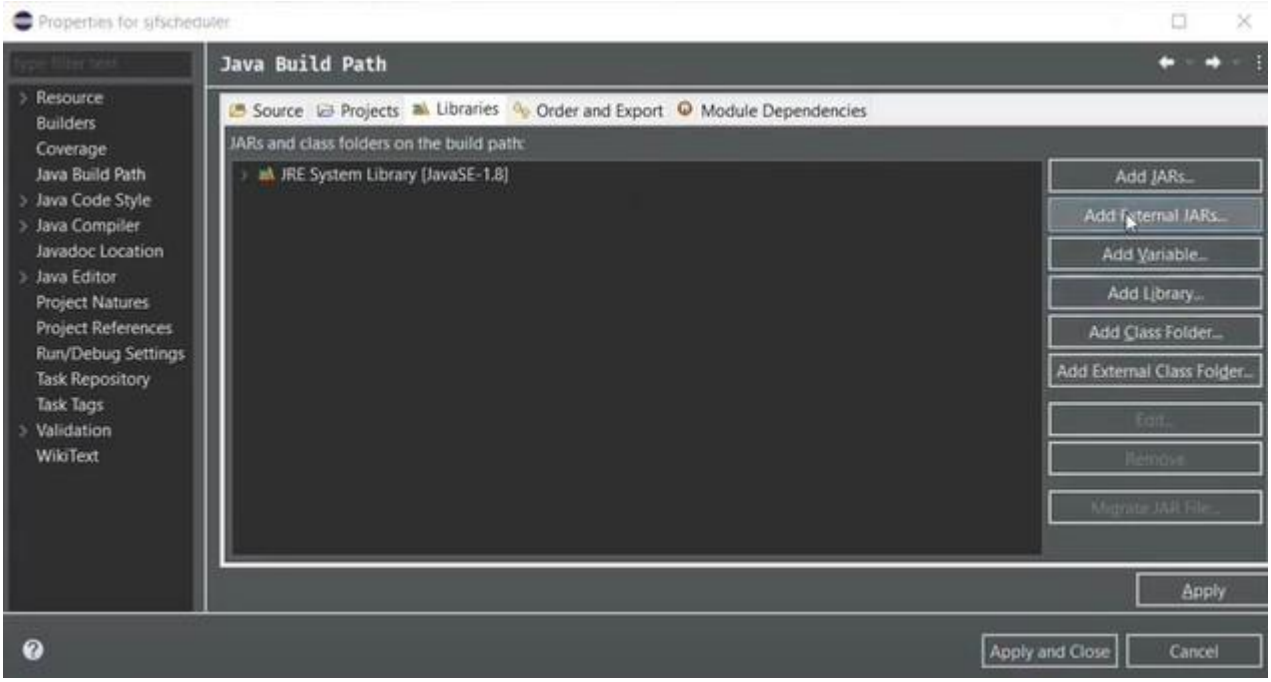
1. Visit https://github.com/Cloudslab/cloudsim/releases to download the CloudSim archives for CloudSim 4.
2. Extract the archive.
3. The jars folder of the extracted archive should contain the following files:
    a) cloudsim-4.0.jar
    b) cloudsim-examples.jar
4. Create a new Java Project using the Eclipse IDE.
5. Right click on the project root and select the Build Path option from the dropdown.



6. Select the Configure Build Path section from the extended dropdown



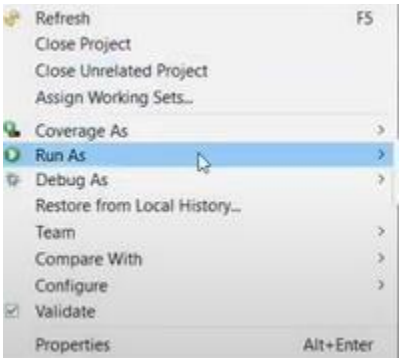
7. Select the Libraries section and click on Add External JARs field on the pop up



8. Navigate to the jars directory of the CloudSim archive and include the 2 jars in the project.
9. Create a new package in the src directory of the project.
10. Copy the code files for the constants, Data Center Creator, Data Center Broker, Matrix Generator and the SJF scheduler files from the https://github.com/suyash-more/Cloud-Computing-Projects/tree/master/Scheduling-Algorithm-in-CloudSim/src link.
11. Make sure that the package name provided in each file is the same as the previously created package.

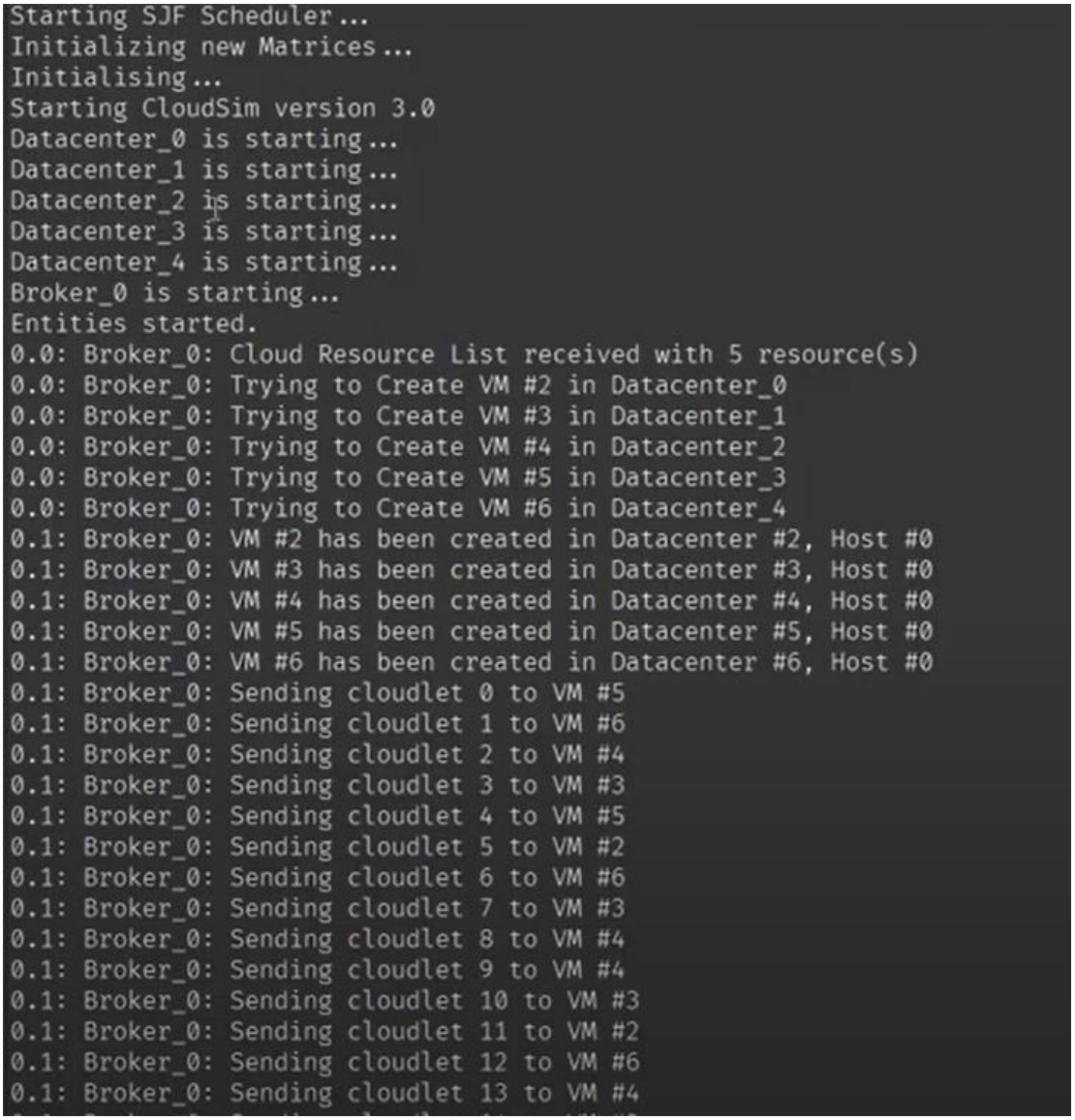
B) Execution of code

1. Right click on the project



2. Run the project as a Java Application (option in extended dropdown)

3. The result is displayed on the console


Starting SJF Scheduler...
Initializing new Matrices...
Initialising...
Starting CloudSim version 3.0
Datacenter_0 is starting...
Datacenter_1 is starting...
Datacenter_2 is starting...
Datacenter_3 is starting...
Datacenter_4 is starting...
Broker_0 is starting...
Entities started.
0.0: Broker_0: Cloud Resource List received with 5 resource(s)
0.0: Broker_0: Trying to Create VM #2 in Datacenter_0
0.0: Broker_0: Trying to Create VM #3 in Datacenter_1
0.0: Broker_0: Trying to Create VM #4 in Datacenter_2
0.0: Broker_0: Trying to Create VM #5 in Datacenter_3
0.0: Broker_0: Trying to Create VM #6 in Datacenter_4
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 #3, Host #0
0.1: Broker_0: VM #4 has been created in Datacenter #4, Host #0
0.1: Broker_0: VM #5 has been created in Datacenter #5, Host #0
0.1: Broker_0: VM #6 has been created in Datacenter #6, Host #0
0.1: Broker_0: Sending cloudlet 0 to VM #5
0.1: Broker_0: Sending cloudlet 1 to VM #6
0.1: Broker_0: Sending cloudlet 2 to VM #4
0.1: Broker_0: Sending cloudlet 3 to VM #3
0.1: Broker_0: Sending cloudlet 4 to VM #5
0.1: Broker_0: Sending cloudlet 5 to VM #2
0.1: Broker_0: Sending cloudlet 6 to VM #6
0.1: Broker_0: Sending cloudlet 7 to VM #3
0.1: Broker_0: Sending cloudlet 8 to VM #4
0.1: Broker_0: Sending cloudlet 9 to VM #4
0.1: Broker_0: Sending cloudlet 10 to VM #3
0.1: Broker_0: Sending cloudlet 11 to VM #2
0.1: Broker_0: Sending cloudlet 12 to VM #6
0.1: Broker_0: Sending cloudlet 13 to VM #4

```
1292.724: Broker_0: Cloudlet 0 received
1907.232: Broker_0: Cloudlet 5 received
2260.772: Broker_0: Cloudlet 1 received
2784.16: Broker_0: Cloudlet 3 received
2903.4: Broker_0: Cloudlet 2 received
3065.932: Broker_0: Cloudlet 11 received
4113.036: Broker_0: Cloudlet 4 received
4485.576: Broker_0: Cloudlet 18 received
4837.776: Broker_0: Cloudlet 20 received
4956.164: Broker_0: Cloudlet 6 received
5643.272: Broker_0: Cloudlet 8 received
5807.608: Broker_0: Cloudlet 21 received
6354.656: Broker_0: Cloudlet 7 received
6905.915999999999: Broker_0: Cloudlet 23 received
7719.535999999999: Broker_0: Cloudlet 24 received
8614.368: Broker_0: Cloudlet 12 received
8752.444: Broker_0: Cloudlet 10 received
8986.24: Broker_0: Cloudlet 9 received
10703.216: Broker_0: Cloudlet 15 received
10857.967999999999: Broker_0: Cloudlet 14 received
11948.996: Broker_0: Cloudlet 25 received
13310.556: Broker_0: Cloudlet 13 received
13635.776: Broker_0: Cloudlet 16 received
15582.328: Broker_0: Cloudlet 17 received
16230.772: Broker_0: Cloudlet 19 received
17007.956: Broker_0: Cloudlet 27 received
19003.152000000002: Broker_0: Cloudlet 22 received
19533.66: Broker_0: Cloudlet 28 received
22878.644: Broker_0: Cloudlet 26 received
25918.7: Broker_0: Cloudlet 29 received
25918.7: Broker_0: All Cloudlets executed. Finishing...
```

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========== OUTPUT ==========
Cloudlet ID    STATUS    Data center ID    VM ID        Time    Start Time    Finish Time    Waiting Time
    00         SUCCESS         05           05        1292.62       00.1           1292.72            00
    05         SUCCESS         02           02        1907.13       00.1           1907.23            00
    01         SUCCESS         06           06        2260.67       00.1           2260.77            00
    03         SUCCESS         03           03        2784.06       00.1           2784.16            00
    02         SUCCESS         04           04        2903.3        00.1           2903.4             00
    11         SUCCESS         02           02        1158.7       1907.23          3065.93           1907.13
    04         SUCCESS         05           05        2820.31       1292.72          4113.04           1292.62
    18         SUCCESS         02           02        1419.64       3065.93          4485.58           3065.83
    20         SUCCESS         02           02        352.2        4485.58          4837.78           4485.48
    06         SUCCESS         06           06        2695.39       2260.77          4956.16           2260.67
    08         SUCCESS         04           04        2739.87       2903.4           5643.27           2903.3
    21         SUCCESS         05           05        1694.57       4113.04          5807.61           4112.94
    07         SUCCESS         03           03        3570.5       2784.16          6354.66           2784.06
    23         SUCCESS         02           02        2068.14       4837.78          6905.92           4837.68
    24         SUCCESS         02           02        813.62       6905.92          7719.54           6905.82
    12         SUCCESS         06           06        3658.2       4956.16          8614.37           4956.06
    10         SUCCESS         03           03        2397.79       6354.66          8752.44           6354.56
    09         SUCCESS         04           04        3342.97       5643.27          8986.24           5643.17
    15         SUCCESS         06           06        2088.85       8614.37          10703.22           8614.27
    14         SUCCESS         03           03        2105.52       8752.44          10857.97           8752.34
    25         SUCCESS         03           03        1091.03       10857.97           11949           10857.87
    13         SUCCESS         04           04        4324.32       8986.24          13310.56           8986.14
    16         SUCCESS         06           06        2932.56       10703.22          13635.78           10703.12
    17         SUCCESS         06           06        1946.55       13635.78          15582.33           13635.68
    19         SUCCESS         04           04        2920.22       13310.56          16230.77           13310.46
    27         SUCCESS         06           06        1425.63       15582.33          17007.96           15582.23
    22         SUCCESS         04           04        2772.38       16230.77          19003.15           16230.67
    28         SUCCESS         06           06        2525.7       17007.96          19533.66           17007.86
    26         SUCCESS         04           04        3875.49       19003.15          22878.64           19003.05
    29         SUCCESS         04           04        3040.06       22878.64          25918.7            22878.54
Makespan using SJF: 4396.012266367984
```