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Part 1:

Modify one of the example programs to implement a simulation: create two data centers each with one host and run two cloudlets on them. The cloudlets run in Vms with different MIPS. Compare the results.

**Response:**

* We created two datacenters with “CreateDateCenter()” method named “Datacenter\_0” and “Datacenter\_1”.
* Both the Datacenters contain one computer i.e., Host (created by new Host) with two CPUs or cores in the program which is showed as “Pe”.
* In this example we have used “Space Shared” VM allocation policy.
* It means that only one VM can run on each Pe (CPU). As each Host has only one Pe, only one VM can run on each Host.
* We have created two virtually machine with different MIPS, VMw1 with MIPS 250 and VM2 with MIPS 500, all other configurations are same except MIPS.
* After that we have created two cloudlets and both the cloudlets have the same configuration then we have bounded cloudlet1 with vm1 and cloudlet2 with vm2 using “broker.bindCloudToVm() “. This will ensure the broker will submit the bound cloudlets only to the specific VM.

At last, we start the simulation with “CloudSim.startSimulation();”

**Explanation and analysis of the running results for the Assignment1 part 1 :**

1. **At 0.0** User received Cloud Resource List with 2 Resources.

* At 0.0 User try to create VM#0 and VM#1 on Datacenter\_0 but we get an error message for VM#1 which is “ **[VmScheduler.vmCreate] Allocation of VM #1 to Host #0 failed by MIPS** ” it is because we have used “space shared” VM allocation policy in which a computer can only hold one virtual machine at a time, so when we try to create second virtual machine in the same host (Computer), it won’t get created and displayed an error message.

1. **At 0.1** VM #0 has been created in “Datacenter\_0” which has “Datacenter #2” as an ID. Also, at 0.1 it will display a message “**0.1: Broker: Creation of VM #1 failed in Datacenter #2**” because of space shared allocation policy.

* When we change allocation policy to time shared, system will **not** throw an error. As it is space shared, after this the user goes to another resource Datacenter\_1 “**0.1: Broker: Trying to Create VM #1 in Datacenter\_1**” as first resource is failed to create VM.

1. **At 0.2** VM #1 has been created in “DataCenter\_1” which has “Datacenter#3” as an ID.
2. **At 0.2** Cloudlet 0 and Cloudlet 1 are sending to VM #0 and VM #1 respectively as we already have bounded cloudlet1 with vm1 and cloudlet2 with vm2.
3. **At 2.0** User sends cloudlets **only** when all the virtual machine is created on datacenter not before that.
4. As we know “time” required for a user to receive cloudlet depends on two factors which are given below:
5. Length of a cloudlet
6. MIPS of a CPU

In this example, Length of both the cloudlets is 1000.

* MIPS for VM#0 = 250
* MIPS for VM#1 = 500
* Then time would be (0.2 + (1000/250) = 160.2) for Cloudlet 0 and (0.2 + (1000/500) = 80.2) this can be seen from below message which is printed on console.

**80.2**: Broker: Cloudlet 1 received

**160.2**: Broker: Cloudlet 0 received

**7**. Finally, after execution Cloudlet 0 Cloudlet 1 are received to the user, both Datacenter\_0 and Datacenter\_1 shut down.

* Finally, we will conclude the output which is shown below :

Starting Assignment1part1...

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.vmCreate] 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

80.2: Broker: Cloudlet 1 received

160.2: Broker: Cloudlet 0 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

1 SUCCESS 3 1 80 0.2 80.2

0 SUCCESS 2 0 160 0.2 160.2

CloudSimExample4 finished!

* Cloudlet with ID 1 has a status “success” and executed on second Datacenter (ID DataCenter #3) with VM #1 (Second virtual machine) and total time required would be (80+ 0.2) = 80.2.
* Similarly, Cloudlet with ID 0 has a status “success” and executed on First Datacenter (ID DataCenter #2) with VM #0 (First virtual machine) and total time required would be (80+ 0.2) = 80.2.

Results for same MIPS(Part-1)Graphical user interface, text, application

Description automatically generated

Results with different MIPS (Part -1)

Graphical user interface, text, application

Description automatically generated

**Part 2**:

Write a program to implement a scalable simulation, using 40 virtual machines to run 80 cloudlets.

**Response:-**

* As per the question, I have updated the CloudSimExample6 in the creation of VM and cloudlets with these lines “createVM(brokerId,40);” and in “ createCloudlet(brokerId,80); ” . We will create 40 VMs and 80 Cloudlets.
* We have created two datacenters (Datacenter\_0 and Dataccenter\_1).
* We have created two computers with 4 CPUS and 2 CPUS respectively and both the computers have timeshared allocation policy.
* It means that more than one VM can run on each Pe.

**Explanation and analysis of the running results for the Assignment1 part 2 :**

1. **At 0.0:** User receives 2 resources.
2. **At 0.0** User try to create all 40 virtual machines from 0 to 39 on Datacenter\_0 “0.0: Broker: Trying to Create VM #0 in Datacenter\_0”.
3. We got an error message “[**VmScheduler.vmCreate] Allocation of VM #6 to Host #0 failed by RAM**”, it is because we know there is two datacenters (Datacenter\_0, Datacenter\_1) with 4 and 2 CPUS respectively i.e. 6 CPUs in total and each CPU has MIPS 1000.
4. Also, each virtual machine has MIPS 1000 and because of the MIPS requirement by VMs, one CPU can at most accommodate only one VM. This is the reason VM #0 to VM #5 has been created i.e., total 6 virtual machines and we got an error for VM#6 to VM#39.
5. But specifically, we get error message, which is related to Ram, it is because host has Ram of 2048 MB and each Virtual machine demands RAM for 512 MB and Host #0 can only serve 4 VMs as (512 \*4) = 2048.
6. “[**VmScheduler.vmCreate] Allocation of VM #6** **to Host #1 failed by MIPS**” Then VM#6 tries to get created on Datacenter 2. We know that two VMs is already created on Datacenter 2 (Datacenter\_1) with total usage of 1024 (512\*2) RAM that is why we are not getting error related to RAM as for now 1024 MB still in not being used. This is the reason we got an error message related to MIPS not for RAM.
7. All VMs (VM #6 to VM #39) will be failed. These errors will get repeated for every VMs which are failed to create due to either RAM or MIPS issue.
8. **0.1** only 6 VMs are created (“0.1: Broker: VM #0 has been created in Datacenter #2, Host #0 “).
9. **At 0.1** Broker knows that till VM 6 is created. But all other VM from 7 to 40 are not created in DataCenter 1 (“Creation of VM #6 failed in Datacenter #2”) or DataCenter 2 (“Creation of VM #12 failed in Datacenter #3”).
10. As there are two cloudlets with 6 CPUS so in total 12 VMs will be created, it there is no issue with RAM, MIPS or BW. If requested resource is more than the available resource than there will be failure in creation of VM.
11. **At 0.2** User will come to know that 12 VMs will be created not more than that. First 6 VMs (VM #0 to VM#5) machines are created on first data center (Datacenter\_0) and the second 6 VMs (VM #6 to VM# 11) are created on the second data center (Datacenter\_1).
12. **At 0.2** user start to send cloudlet to virtual machine, now we have 12 VMs
13. “0.2: Broker: Sending cloudlet 0 to VM #0”, “0.2: Broker: Sending cloudlet 12 to VM #0”. This will repeat after every 12th virtual machine.
14. Now we can do the calculation, we have 12 CPUS on two datacenters and 80 cloudlets, So the repetition would be like, first VM#0 will hold 7 cloudlets #0, #12, #24, #26, #48, #60, #72 similarly for other VMs up to Vm#7, VM#8 toVm#11 i.e., last 4 will hold only 6 cloudlets. Only first 8 virtual machines will have 7 cloudlets and last 4 VMs would have 6 cloudlets.
15. Now the time required to receive cloudlet would be the(Length of Cloudlets/ MIPS of CPU) i.e. 1000/1000 = 1. As we know one virtual machine contains more than one cloudlet as a result **resource sharing** will takes place.
16. So, the time could be multiple of 7 or 6 (Approximately). As one cloudlet is sharing either 7 or 6 VMs.

**========== OUTPUT ==========**

Cloudlet ID STATUS Data center ID VM ID Time Start Time Finish Time

8 SUCCESS 3 8 6 0.2 6.2

20 SUCCESS 3 8 6 0.2 6.2

32 SUCCESS 3 8 6 0.2 6.2

44 SUCCESS 3 8 6 0.2 6.2

56 SUCCESS 3 8 6 0.2 6.2

68 SUCCESS 3 8 6 0.2 6.2

10 SUCCESS 3 10 6 0.2 6.2

22 SUCCESS 3 10 6 0.2 6.2

34 SUCCESS 3 10 6 0.2 6.2

46 SUCCESS 3 10 6 0.2 6.2

58 SUCCESS 3 10 6 0.2 6.2

70 SUCCESS 3 10 6 0.2 6.2

9 SUCCESS 3 9 6 0.2 6.2

21 SUCCESS 3 9 6 0.2 6.2

33 SUCCESS 3 9 6 0.2 6.2

45 SUCCESS 3 9 6 0.2 6.2

57 SUCCESS 3 9 6 0.2 6.2

69 SUCCESS 3 9 6 0.2 6.2

11 SUCCESS 3 11 6 0.2 6.2

23 SUCCESS 3 11 6 0.2 6.2

35 SUCCESS 3 11 6 0.2 6.2

47 SUCCESS 3 11 6 0.2 6.2

59 SUCCESS 3 11 6 0.2 6.2

71 SUCCESS 3 11 6 0.2 6.2

0 SUCCESS 2 0 6.99 0.2 7.19

12 SUCCESS 2 0 6.99 0.2 7.19

24 SUCCESS 2 0 6.99 0.2 7.19

36 SUCCESS 2 0 6.99 0.2 7.19

48 SUCCESS 2 0 6.99 0.2 7.19

60 SUCCESS 2 0 6.99 0.2 7.19

72 SUCCESS 2 0 6.99 0.2 7.19

1 SUCCESS 2 1 6.99 0.2 7.19

13 SUCCESS 2 1 6.99 0.2 7.19

25 SUCCESS 2 1 6.99 0.2 7.19

37 SUCCESS 2 1 6.99 0.2 7.19

49 SUCCESS 2 1 6.99 0.2 7.19

61 SUCCESS 2 1 6.99 0.2 7.19

73 SUCCESS 2 1 6.99 0.2 7.19

2 SUCCESS 2 2 6.99 0.2 7.19

14 SUCCESS 2 2 6.99 0.2 7.19

26 SUCCESS 2 2 6.99 0.2 7.19

38 SUCCESS 2 2 6.99 0.2 7.19

50 SUCCESS 2 2 6.99 0.2 7.19

62 SUCCESS 2 2 6.99 0.2 7.19

74 SUCCESS 2 2 6.99 0.2 7.19

4 SUCCESS 2 4 6.99 0.2 7.19

16 SUCCESS 2 4 6.99 0.2 7.19

28 SUCCESS 2 4 6.99 0.2 7.19

40 SUCCESS 2 4 6.99 0.2 7.19

52 SUCCESS 2 4 6.99 0.2 7.19

64 SUCCESS 2 4 6.99 0.2 7.19

76 SUCCESS 2 4 6.99 0.2 7.19

3 SUCCESS 2 3 6.99 0.2 7.19

15 SUCCESS 2 3 6.99 0.2 7.19

27 SUCCESS 2 3 6.99 0.2 7.19

39 SUCCESS 2 3 6.99 0.2 7.19

51 SUCCESS 2 3 6.99 0.2 7.19

63 SUCCESS 2 3 6.99 0.2 7.19

75 SUCCESS 2 3 6.99 0.2 7.19

5 SUCCESS 2 5 6.99 0.2 7.19

17 SUCCESS 2 5 6.99 0.2 7.19

29 SUCCESS 2 5 6.99 0.2 7.19

41 SUCCESS 2 5 6.99 0.2 7.19

53 SUCCESS 2 5 6.99 0.2 7.19

65 SUCCESS 2 5 6.99 0.2 7.19

77 SUCCESS 2 5 6.99 0.2 7.19

6 SUCCESS 3 6 7 0.2 7.2

18 SUCCESS 3 6 7 0.2 7.2

30 SUCCESS 3 6 7 0.2 7.2

42 SUCCESS 3 6 7 0.2 7.2

54 SUCCESS 3 6 7 0.2 7.2

66 SUCCESS 3 6 7 0.2 7.2

78 SUCCESS 3 6 7 0.2 7.2

7 SUCCESS 3 7 7 0.2 7.2

19 SUCCESS 3 7 7 0.2 7.2

31 SUCCESS 3 7 7 0.2 7.2

43 SUCCESS 3 7 7 0.2 7.2

55 SUCCESS 3 7 7 0.2 7.2

67 SUCCESS 3 7 7 0.2 7.2

79 SUCCESS 3 7 7 0.2 7.2

Assignment1part2 finished!

**Screenshot of output (Part 2): -**

Graphical user interface, text, application

Description automatically generated

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Graphical user interface, application

Description automatically generated

* Now the time required to receive cloudlet would be the(Length of Cloudlets/ MIPS of CPU) i.e. 1000/1000 = 1. As we know one virtual machine contains more than one cloudlet as a result **resource sharing** will takes place.
* So, the time could be multiple of 7 or 6 (Approximately). As one cloudlet is sharing either 7 or 6 VMs.
* The time for VM#0 to VM#7 (these VMs are sharing 4 cloudlets, so multiple of 7) would be 1\*7 = 7 and start time = 0.2
* Finish Time = Time + start time= 7+0.2 = **7.2**.
* For VM#8 to VM#11 (These VMs are sharing 6 cloudlets, so multiple of 6) would be 1\*6 = 6 and start time = 0.2
* Finish Time = Time + start time= 6+0.2 = **6.2.**