CS441: HW3

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Description

Design a Scala application that simulates a cloud organization and clients with the cloudsimplus framework.

Parameters required for a simulation.

- Number of Cloudlets
- Cloudlet Configuration
- VM Configuration
- Allocation Policies
- Scheduling Polices
- Network Topology
- Host Configuration

SaaS: client has control over only the number of cloudlets and the type of service.

PaaS: Number of cloudlets and Cloudlet Configuration is controlled by the client.

IaaS: Cloudlet Configuration and VM configuration is controlled by the client.

The different services provide different control levels to the clients. - SaaS, PaaS, IaaS.

Although essentially, they are all the same since the only difference between the simulations are where they get their configurations from. Once the configurations are got, they are all allocated to VMs and executed in the Datacenter with the help of allocation and scheduling policies.

Project Structure

The main simulation file-simulation.scala contains the main() for this application. It also has functions that simulate different situations.

- ServiceSim. It simulates SaaS, PaaS, IaaS when called with the name of the service and the path for the client and datacenter config files.
- dcNetwork: establishes a network of Datacenters each belonging to Iaas, Paas, Saas services. A simulation is run on this network using cloudlets and vm configurations from clients of each datacenter all together.
- scalingServiceSim: a scaling version of the serviceSim function. Can scale horizontally when needed, to provide for waiting cloudlets (configure scheduleInterval in the datacenter config to let the simulation know how long to let a cloudlet wait before creating a new vm)

ConfigReader: reads the config files and set parameters for the stated service (iaas, paas, saas). An instance of this class is created in the beginning and is passed around to the helper function which make use of the parameters.

helperfunctions: contains all the helper functions required in the simulation process like datacenter, vm, cloudlet, host generation.

Simulations

Service Simulations

SaaS

In SaaS, the client has control over the software therefore, the number of instances and the what each instance is. (Software Instance is the cloudlet)

The Host controls the VM Config, Allocation & Scheduling Polices, Network Topology, Host Configurations.

The ConfigReader will read the parameters from the appropriate config files accordingly when specified.

PaaS

The Client has control over the cloudlet configuration and partial control over the vm configuration.

The datacenter controls the Allocation & Scheduling, Network Topology, Host Configurations

IaaS

The client controls vm config, cloudlet config completely.

The datacenter controls the host configurations and the policies.

Scaling Simulation

Applicable for all three services - IaaS, PaaS, SaaS.

When there aren't enough VMs i.e. when the cloudlets wait for more than a specified time, new VMs are created to accommodate them. This is usually done in SaaS since the datacenter is the only one in control of the VMs and the responsibility lies on it to scale and balance load.

```
20:05:23.753 [sbt-bg-threads-1] INFO  Datacenter - 0.00: NetworkDatacenter1 is starting...
20:05:23.754 [sbt-bg-threads-1] INFO  DatacenterBroker - DatacenterBrokerSimple2 is starting...
20:05:23.754 [sbt-bg-threads-1] INFO  CloudSim - Entities started.
20:05:23.757 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.00: DatacenterBrokerSimple2: List of 1 datacenters(s) received.
20:05:23.757 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.00: DatacenterBrokerSimple2: Trying to create Vm 0 in NetworkDatacenter1
20:05:23.757 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.00: DatacenterBrokerSimple2: Trying to create Vm 1 in NetworkDatacenter1
20:05:23.767 [sbt-bg-threads-1] INFO  VmAllocationPolicy - 0.00: VmAllocationPolicySimple: Vm 0 has been allocated to Host 0/DC 1
20:05:23.769 [sbt-bg-threads-1] INFO  VmAllocationPolicy - 0.00: VmAllocationPolicySimple: Vm 1 has been allocated to Host 1/DC 1
20:05:23.769 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.10: DatacenterBrokerSimple2: Sending Cloudlet 0 to Vm 0 in Host 0/DC 1.
20:05:23.769 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.10: DatacenterBrokerSimple2: Sending Cloudlet 1 to Vm 1 in Host 1/DC 1.
20:05:23.770 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.10: DatacenterBrokerSimple2: Sending Cloudlet 2 to Vm 0 in Host 0/DC 1.
20:05:23.770 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.10: DatacenterBrokerSimple2: Sending Cloudlet 3 to Vm 1 in Host 1/DC 1.
20:05:23.770 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.10: DatacenterBrokerSimple2: Sending Cloudlet 4 to Vm 0 in Host 0/DC 1.
20:05:23.771 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.10: DatacenterBrokerSimple2: Sending Cloudlet 5 to Vm 1 in Host 1/DC 1.
20:05:23.771 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.10: DatacenterBrokerSimple2: All 6 waiting Cloudlets submitted to some VM.
20:05:23.778 [sbt-bg-threads-1] WARN  CloudletScheduler - 0.90: CloudletSchedulerTimeShared: Cloudlet 2 requested 900 MB of Ram but just 10
20:05:23.778 [sbt-bg-threads-1] WARN  CloudletScheduler - 0.90: CloudletSchedulerTimeShared: Cloudlet 2 requested 900 Mbps of Bandwidth but
20:05:23.779 [sbt-bg-threads-1] WARN  CloudletScheduler - 0.90: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 MB of Ram but no amou
20:05:23.779 [sbt-bg-threads-1] WARN  CloudletScheduler - 0.90: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 Mbps of Bandwidth but
20:05:23.781 [sbt-bg-threads-1] INFO  HorizontalVmScalingSimple - 0.90: HorizontalVmScalingSimpleVm 0: Requesting creation of Vm -1 to rece
20:05:23.781 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.90: DatacenterBrokerSimple2: List of 1 VMs submitted to the broker during simula
20:05:23.782 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.90: DatacenterBrokerSimple2: Trying to create Vm 2 in NetworkDatacenter1
20:05:23.782 [sbt-bg-threads-1] WARN  CloudletScheduler - 0.90: CloudletSchedulerTimeShared: Cloudlet 3 requested 900 MB of Ram but just 10
20:05:23.784 [sbt-bg-threads-1] WARN  CloudletScheduler - 0.90: CloudletSchedulerTimeShared: Cloudlet 3 requested 900 Mbps of Bandwidth but
20:05:23.784 [sbt-bg-threads-1] WARN  CloudletScheduler - 0.90: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 MB of Ram but no amou
20:05:23.785 [sbt-bg-threads-1] WARN  CloudletScheduler - 0.90: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 Mbps of Bandwidth but
20:05:23.785 [sbt-bg-threads-1] INFO  HorizontalVmScalingSimple - 0.90: HorizontalVmScalingSimpleVm 1: Requesting creation of Vm -1 to rece
20:05:23.786 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.90: DatacenterBrokerSimple2: List of 1 VMs submitted to the broker during simula
20:05:23.786 [sbt-bg-threads-1] INFO  DatacenterBroker - 0.90: DatacenterBrokerSimple2: Trying to create Vm 3 in NetworkDatacenter1
20:05:23.787 [sbt-bg-threads-1] INFO  VmAllocationPolicy - 0.90: VmAllocationPolicySimple: Vm 2 has been allocated to Host 2/DC 1
20:05:23.787 [sbt-bg-threads-1] INFO  VmAllocationPolicy - 0.90: VmAllocationPolicySimple: Vm 3 has been allocated to Host 3/DC 1
20:05:23.787 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.53: CloudletSchedulerTimeShared: Cloudlet 2 requested 900 MB of Ram but just 10
20:05:23.787 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.53: CloudletSchedulerTimeShared: Cloudlet 2 requested 900 Mbps of Bandwidth but
20:05:23.787 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.53: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 MB of Ram but no amou
20:05:23.789 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.53: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 Mbps of Bandwidth but
20:05:23.789 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.53: CloudletSchedulerTimeShared: Cloudlet 3 requested 900 MB of Ram but just 10
20:05:23.789 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.53: CloudletSchedulerTimeShared: Cloudlet 3 requested 900 Mbps of Bandwidth but
20:05:23.790 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.53: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 MB of Ram but no amou
20:05:23.790 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.53: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 Mbps of Bandwidth but
20:05:23.790 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.90: CloudletSchedulerTimeShared: Cloudlet 2 requested 900 MB of Ram but just 10
20:05:23.791 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.90: CloudletSchedulerTimeShared: Cloudlet 2 requested 900 Mbps of Bandwidth but
20:05:23.791 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.90: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 MB of Ram but no amou
20:05:23.791 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.90: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 Mbps of Bandwidth but
20:05:23.792 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.90: CloudletSchedulerTimeShared: Cloudlet 3 requested 900 MB of Ram but just 10
20:05:23.792 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.90: CloudletSchedulerTimeShared: Cloudlet 3 requested 900 Mbps of Bandwidth but
20:05:23.792 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.90: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 MB of Ram but no amou
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20:05:23.792 [sbt-bg-threads-1] WARN  CloudletScheduler - 4.90: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 Mbps of Bandwidth but
20:05:23.793 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.43: CloudletSchedulerTimeShared: Cloudlet 2 requested 900 MB of Ram but just 10
20:05:23.793 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.43: CloudletSchedulerTimeShared: Cloudlet 2 requested 900 Mbps of Bandwidth but
20:05:23.793 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.43: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 MB of Ram but no amou
20:05:23.793 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.43: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 Mbps of Bandwidth but
20:05:23.794 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.43: CloudletSchedulerTimeShared: Cloudlet 3 requested 900 MB of Ram but just 10
20:05:23.794 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.43: CloudletSchedulerTimeShared: Cloudlet 3 requested 900 Mbps of Bandwidth but
20:05:23.794 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.43: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 MB of Ram but no amou
20:05:23.795 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.43: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 Mbps of Bandwidth but
20:05:23.796 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.54: CloudletSchedulerTimeShared: Cloudlet 2 requested 900 MB of Ram but just 10
20:05:23.796 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.54: CloudletSchedulerTimeShared: Cloudlet 2 requested 900 Mbps of Bandwidth but
20:05:23.796 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.54: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 MB of Ram but no amou
20:05:23.796 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.54: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 Mbps of Bandwidth but
20:05:23.797 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.54: CloudletSchedulerTimeShared: Cloudlet 3 requested 900 MB of Ram but just 10
20:05:23.797 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.54: CloudletSchedulerTimeShared: Cloudlet 3 requested 900 Mbps of Bandwidth but
20:05:23.805 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.54: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 MB of Ram but no amou
20:05:23.806 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.54: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 Mbps of Bandwidth but
20:05:23.807 [sbt-bg-threads-1] INFO  DatacenterBroker - 5.54: DatacenterBrokerSimple2: Cloudlet 0 finished in Vm 0 and returned to broker.
20:05:23.807 [sbt-bg-threads-1] INFO  DatacenterBroker - 5.54: DatacenterBrokerSimple2: Cloudlet 1 finished in Vm 1 and returned to broker.
20:05:23.808 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.65: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 MB of Ram but just 10
20:05:23.808 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.65: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 Mbps of Bandwidth but
20:05:23.808 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.65: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 MB of Ram but just 10
20:05:23.809 [sbt-bg-threads-1] WARN  CloudletScheduler - 5.65: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 Mbps of Bandwidth but
20:05:23.809 [sbt-bg-threads-1] WARN  CloudletScheduler - 10.65: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 MB of Ram but just 1
20:05:23.809 [sbt-bg-threads-1] WARN  CloudletScheduler - 10.65: CloudletSchedulerTimeShared: Cloudlet 4 requested 900 Mbps of Bandwidth bu
20:05:23.810 [sbt-bg-threads-1] WARN  CloudletScheduler - 10.65: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 MB of Ram but just 1
20:05:23.810 [sbt-bg-threads-1] WARN  CloudletScheduler - 10.65: CloudletSchedulerTimeShared: Cloudlet 5 requested 900 Mbps of Bandwidth bu
20:05:23.810 [sbt-bg-threads-1] INFO  DatacenterBroker - 10.65: DatacenterBrokerSimple2: Cloudlet 2 finished in Vm 0 and returned to broker
20:05:23.811 [sbt-bg-threads-1] INFO  DatacenterBroker - 10.65: DatacenterBrokerSimple2: Cloudlet 3 finished in Vm 1 and returned to broker
20:05:23.811 [sbt-bg-threads-1] INFO  DatacenterBroker - 15.65: DatacenterBrokerSimple2: Requesting Vm 2 destruction.
20:05:23.811 [sbt-bg-threads-1] INFO  DatacenterBroker - 15.65: DatacenterBrokerSimple2: Requesting Vm 3 destruction.
20:05:23.813 [sbt-bg-threads-1] INFO  Datacenter - 15.65: NetworkDatacenter: Vm 2 destroyed on Host 2/DC 1.
20:05:23.814 [sbt-bg-threads-1] INFO  Datacenter - 15.65: NetworkDatacenter: Vm 3 destroyed on Host 3/DC 1.
20:05:23.814 [sbt-bg-threads-1] INFO  DatacenterBroker - 15.65: DatacenterBrokerSimple2: Cloudlet 4 finished in Vm 0 and returned to broker
20:05:23.814 [sbt-bg-threads-1] INFO  DatacenterBroker - 15.65: DatacenterBrokerSimple2: Cloudlet 5 finished in Vm 1 and returned to broker
20:05:23.815 [sbt-bg-threads-1] INFO  CloudSim - 20.65: Processing last events before simulation shutdown.
20:05:23.815 [sbt-bg-threads-1] INFO  DatacenterBroker - 20.65: DatacenterBrokerSimple2 is shutting down...
20:05:23.816 [sbt-bg-threads-1] INFO  DatacenterBroker - 20.65: DatacenterBrokerSimple2: Requesting Vm 1 destruction.
20:05:23.816 [sbt-bg-threads-1] INFO  DatacenterBroker - 20.65: DatacenterBrokerSimple2: Requesting Vm 0 destruction.
20:05:23.816 [sbt-bg-threads-1] INFO  Datacenter - 20.65: NetworkDatacenter: Vm 1 destroyed on Host 1/DC 1.
20:05:23.817 [sbt-bg-threads-1] INFO  Datacenter - 20.65: NetworkDatacenter: Vm 0 destroyed on Host 0/DC 1.
20:05:23.817 [sbt-bg-threads-1] INFO  CloudSim - Simulation: No more future events
20:05:23.817 [sbt-bg-threads-1] INFO  CloudInformationService - CloudInformationService0: Notify all CloudSim Plus entities to shutdown.
20:05:23.818 [sbt-bg-threads-1] INFO  CloudSim -
================== Simulation finished at time 20.65 ==================
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20:05:23.819 [sbt-bg-threads-1] INFO  simulator$ - Created VM list: [Vm 0, Vm 1, Vm 2, Vm 3]
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                                        SIMULATION RESULTS
|Cloudlet|Status |DC|Host|Host PEs |VM|VM PEs   |CloudletLen|CloudletPEs|StartTime|FinishTime|ExecTime
|--------|-------|--|----|---------|--|---------|-----------|-----------|---------|----------|--------
|      ID|       |ID|  ID|CPU cores|ID|CPU cores|         MI|  CPU cores|  Seconds|   Seconds| Seconds
|       0|SUCCESS| 1|   0|        6| 0|        2|        800|          4|        0|         5|       5
|       1|SUCCESS| 1|   1|        6| 1|        2|        800|          4|        0|         5|       5
|       2|SUCCESS| 1|   0|        6| 0|        2|        800|          4|        0|        11|      10
|       3|SUCCESS| 1|   1|        6| 1|        2|        800|          4|        0|        11|      10
|       4|SUCCESS| 1|   0|        6| 0|        2|        800|          4|        0|        16|      15
|       5|SUCCESS| 1|   1|        6| 1|        2|        800|          4|        0|        16|      15
[success] Total time: 9 s, completed 27 Nov, 2022 8:05:23 PM
```

You can see the new VMs created to meet the requirements.

Datacenter Network Simulation

A network of 3 datacenters - each for each service is created. They are connected through the brite topology and the whole of the VMs and cloudlets created are submitted to the network. The simulation optimizes and allocates cloudlets to VMs accordingly.

Observation

- For similar configurations - the scheduling policy doesn't matter very much. They are almost the same.
- In a combination of TimeShared(1 Dc) and SpaceShared(2 Dc) datacenters

```
21:52:08.365 [sbt-bg-threads-1] INFO  simulator$ - Total cost of simulation = 118.27828888888888 $
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                                    SIMULATION RESULTS
|Cloudlet|Status |DC|Host|Host PEs |VM|VM PEs   |CloudletLen|CloudletPEs|StartTime|FinishTime|ExecTime
|--------|-------|--|----|---------|--|---------|-----------|-----------|---------|----------|--------
|      ID|       |ID|  ID|CPU cores|ID|CPU cores|         MI|  CPU cores|  Seconds|   Seconds| Seconds
|       5|SUCCESS| 1|   5|        6| 5|        2|        800|          4|       12|        16|       4
|      12|SUCCESS| 1|   0|        6| 0|        6|        800|          1|       12|        78|      66
|      13|SUCCESS| 1|   1|        6| 1|        6|        800|          1|       12|        78|      66
|       8|SUCCESS| 1|   2|        6| 2|        2|        800|          4|       12|        78|      66
|      14|SUCCESS| 1|   2|        6| 2|        2|        800|          1|       12|        78|      66
|       9|SUCCESS| 1|   3|        6| 3|        2|        800|          4|       12|        78|      66
|      15|SUCCESS| 1|   3|        6| 3|        2|        800|          1|       12|        78|      66
|      10|SUCCESS| 1|   4|        6| 4|        2|        800|          4|       12|        78|      66
|      16|SUCCESS| 1|   4|        6| 4|        2|        800|          1|       12|        78|      66
|      11|SUCCESS| 1|   5|        6| 5|        2|        800|          4|       12|        78|      66
|      17|SUCCESS| 1|   5|        6| 5|        2|        800|          1|       12|        78|      66
```

The completely timeshared simulation runs more expensive.

```
21:53:58.913 [sbt-bg-threads-1] INFO  simulator$ - Total cost of simulation = 129.41333333 $
```

- Utilization Ration impacts the execution time.
- FaaS is a special case of Platform as a Service and therefore they can be used interchangably.
- The cost of execution, which depends on the time duration of the execution, memory, storage and the bandwidth used during the execution, plays a vital role in selecting a service provider. Datacenters with same number & configurations of VMs & hosts can provide different Total cost.
- Simple scheduler is the worst scheduler of all. RoundRobin and FirstFit produce similar results. BestFit usually provides the better result but most of the time, the difference between BestFit and the first two aren’t very big.
