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The way this simulation was set was we have one broker with x hosts. Each host contains 1 physical machine that runs virtual machines based on user inputs. The user has a lot of control over what parameters go into each host and virtual machine. The structure follows very closely to IaaS as the consumer in simulations can control applications, middleware and operating system. Since these are simulations its possible to change to host as well but that would not be very realistic in real life unless it would be your own host you would like to upgrade. The reason I went for this setup is to allow the users the control as much of the simulation as possible am I putting too much trust in the user, possibly.

Some limiting factors of these simulations would involve the map and reduce functions as these cloudlets aren't actual data that would make for a good map and reduce example. This limited the map and reduce to assigning random map values to the split cloudlets and if two or more had the same random id they got reduced to one cloudlet. This is a far stretch from what happens when cloudlets contain real data and the shards are more randomized. Another limitation is the way pricing works as vms don't actually charge for ram or storage usage which also leaves a lot of questions as to what the actual charges will be.

I choose the cloudlet model that allows for different cpu usages as I felt this allowed to give more accurate test results instead of using the given models from cloud2sim that utilized 100% of the cpu all the time. This also allowed me to calculate the costs of running different cloudlet lengths and different virtual machine set ups. After multiple tests I realized all these numbers are predetermined for the most part anyways so no difference can actually be concluded other than that less cpu utilization means it takes longer to finish a cloudlet.

The unit tests I created are to help make sure the user does not mess up the config files as it can get pretty confusing after staring at them for 30 hours probably due to lack of sleep. The tests will also make sure all cloudlets complete and that you did not exceed your maximum virtual machines based on host specifications. There is also a test that ensures a proper config file was given just in case.

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Simulation 1 test results. This was testing having 100 cloudlets that required 2 cores each with 30 virtual machines with 1 core. Each cloudlet took longer to process causing an increase in cost. This compared to the cost of cutting our virtual machines in half and doubling our cores, so we have 15 dual core vms shows a better price to run the simulation. The dual core vms also on average utilize slightly more of the cpu as each task can support dual cores.

30 vms , 1 core

```
19:14:01.604 [main] INFO MyCloudSim -     91        SUCCESS        2                1        9599.94$        50.55%
19:14:01.604 [main] INFO MyCloudSim -     92        SUCCESS        2                2        9599.94$        50.55%
19:14:01.605 [main] INFO MyCloudSim -     93        SUCCESS        2                3        9599.94$        50.55%
19:14:01.605 [main] INFO MyCloudSim -     94        SUCCESS        2                4        9599.94$        50.55%
19:14:01.605 [main] INFO MyCloudSim -     95        SUCCESS        2                5        9599.94$        50.55%
19:14:01.605 [main] INFO MyCloudSim -     96        SUCCESS        2                6        9599.94$        50.55%
19:14:01.605 [main] INFO MyCloudSim -     97        SUCCESS        2                7        9599.94$        50.55%
19:14:01.606 [main] INFO MyCloudSim -     98        SUCCESS        2                8        9599.94$        50.55%
19:14:01.606 [main] INFO MyCloudSim -     99        SUCCESS        2                9        9599.94$        50.55%
19:14:01.606 [main] INFO MyCloudSim -     ###Total Cost: 815994.0$    Total time:3199.98
```

15 vms, 2 cores

```
19:13:18.110 [main] INFO MyCloudSim -     90        SUCCESS        2                0        8399.99$        49.23%
19:13:18.110 [main] INFO MyCloudSim -     91        SUCCESS        2                1        8399.99$        49.23%
19:13:18.110 [main] INFO MyCloudSim -     92        SUCCESS        2                2        8399.99$        49.23%
19:13:18.110 [main] INFO MyCloudSim -     93        SUCCESS        2                3        8399.99$        49.23%
19:13:18.110 [main] INFO MyCloudSim -     94        SUCCESS        2                4        8399.99$        49.23%
19:13:18.111 [main] INFO MyCloudSim -     95        SUCCESS        2                5        8399.99$        49.23%
19:13:18.111 [main] INFO MyCloudSim -     96        SUCCESS        2                6        8399.99$        49.23%
19:13:18.111 [main] INFO MyCloudSim -     97        SUCCESS        2                7        8399.99$        49.23%
19:13:18.111 [main] INFO MyCloudSim -     98        SUCCESS        2                8        8399.99$        49.23%
19:13:18.111 [main] INFO MyCloudSim -     99        SUCCESS        2                9        8399.99$        49.23%
19:13:18.111 [main] INFO MyCloudSim -     ###Total Cost: 803997.15$    Total time:2799.99
```

This simulation shows the importance of creating virtual machines that better match the required workload as the number of cores required for a task increases it will increase the time it takes for a virtual machine to finish its tasks making cost increase.

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The other simulation will be showing that creating virtual machines with maximum cores will have better results given random workloads. Lets first start with 50 virtual machines with 1 core each. On average with 100 cloudlets with lengths 20000-80000 the cost is $26500-$28500

```
18:21:11.171 [main] INFO MyCloudSim -     91        SUCCESS        2              41        1959.93$        49.33%
18:21:11.172 [main] INFO MyCloudSim -     92        SUCCESS        2              42        2749.8$        49.07%
18:21:11.172 [main] INFO MyCloudSim -     93        SUCCESS        2              43        2076.69$        49.02%
18:21:11.172 [main] INFO MyCloudSim -     94        SUCCESS        2              44        2865.54$        49.22%
18:21:11.172 [main] INFO MyCloudSim -     95        SUCCESS        2              45        4362.09$        50.0%
18:21:11.172 [main] INFO MyCloudSim -     96        SUCCESS        2              46        2264.73$        48.99%
18:21:11.172 [main] INFO MyCloudSim -     97        SUCCESS        2              47        3293.67$        49.29%
18:21:11.172 [main] INFO MyCloudSim -     98        SUCCESS        2              48        3398.16$        49.34%
18:21:11.172 [main] INFO MyCloudSim -     99        SUCCESS        2              49        4002.3$        49.68%
18:21:11.172 [main] INFO MyCloudSim -     ###Total Cost: 276043.71$    Total time:1523.17
```

Now if we increase the number of cores so we have 25 dual core machines we see a decrease in cost and total time on average. The cost went to an average of around $25000-$27000 and on average finished 200-300 milliseconds faster

```
18:24:48.627 [main] INFO MyCloudSim -     92        SUCCESS        2              17        1711.98$        47.85%
18:24:48.627 [main] INFO MyCloudSim -     93        SUCCESS        2              18        1886.01$        48.03%
18:24:48.627 [main] INFO MyCloudSim -     94        SUCCESS        2              19        3660.19$        49.37%
18:24:48.627 [main] INFO MyCloudSim -     95        SUCCESS        2              20        2411.53$        48.33%
18:24:48.627 [main] INFO MyCloudSim -     96        SUCCESS        2              21        1532.97$        47.89%
18:24:48.627 [main] INFO MyCloudSim -     97        SUCCESS        2              22        1493.25$        48.13%
18:24:48.627 [main] INFO MyCloudSim -     98        SUCCESS        2              23        3061.12$        49.16%
18:24:48.627 [main] INFO MyCloudSim -     99        SUCCESS        2              24        3045.47$        49.24%
18:24:48.627 [main] INFO MyCloudSim -     ###Total Cost: 267575.37$    Total time:1280.36
```

For the last part of this simulation we take it to an extreme and demonstrate 1 virtual machine with 50 cores. This drops the average cost to run to 23300-26800 and the average time decreased by another 100 milliseconds.

```
18:26:32.448 [main] INFO MyCloudSim -     94        SUCCESS        2              0        2389.63$        48.88%
18:26:32.448 [main] INFO MyCloudSim -     95        SUCCESS        2              0        2528.01$        49.08%
18:26:32.448 [main] INFO MyCloudSim -     96        SUCCESS        2              0        1293.9$        49.35%
18:26:32.448 [main] INFO MyCloudSim -     97        SUCCESS        2              0        1294.52$        49.33%
18:26:32.448 [main] INFO MyCloudSim -     98        SUCCESS        2              0        2903.82$        48.95%
18:26:32.448 [main] INFO MyCloudSim -     99        SUCCESS        2              0        2853.48$        49.15%
18:26:32.449 [main] INFO MyCloudSim -     ###Total Cost: 236881.36$    Total time:1131.6
```

This simulation shows we need another variable for cost that increases based on the number of cores you assign to a virtual machine otherwise it will almost always be better to just create one super computer instead.