HillClimb@Cloud
Cloud Computing and Virtualization
MEIC-IST

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Abstract

This paper talks about the first phase of a project that makes usage of code instrumentation to obtain metrics to create a Load Balancer and Auto Scaler for a Cloud Based Solution.

1. Introduction

This project consists on developing a Load Balancer and Auto-Scaler for a program running on Amazon Web Services that searches for the maximum value of a map using different search strategies (A*, BFS, DFS). For that, we instrumented the code so we could produce metrics about the running instances and adapt the system to get the maximum value of the instances running in AWS at a minimum cost.
Although this project uses a specific program to load the instances its objective is to be able to generalize the procedure in a way that the Load balancer and auto scaler would work even if the given program is completely different.

2. Architecture

For this checkpoint we have AWS running instances of a WebServer which receives the requests from the client. To manage the load we made use of a classic Load Balancer of Amazon Web Services along with a Auto Scaling Group to manage the running instances and to allow a scale mechanism while we don't implement our own Load Balancer and Auto Scaler for next phase of the project.

2.1. Template Instance

We created a Linux instance based on the Linux AMI AWS - t2.micro image, which is the one eligible for free tier usage on AWS. It has a single core (up to 3.3 Ghz) and 1 GB of RAM. The Linux distribution was updated and extra packages needed for running the WebServer and BIT were installed. We loaded the Web Server that takes the requests to the instance and altered on-boot scripts to start up the Web Server every time that the system is booted.
We created an AMI so that we could replicate the instance and use it on a Load Balancer and Auto Scaling Group.

2.2. Load Balancer

We created a Classic Load Balancer on AWS. The Load Balancer receives HTTP requests on its port 80 and redirects it to the instances also using HTTP protocol but on port 8000. For the security group we allowed every communication coming to port 22 that uses SSH protocol (to allow remote access) and every message that uses HTTP to port 80 and 8000. The instances verification is made by pinging in a 30 seconds interval the Web Server running in the instances using HTTP protocol on the port 8000. An instance is flagged as unhealthy after 2 failed pings from the LB and deemed as healthy if pinged successfully 10 consecutive times.
To fulfill the ping requests we modified the Web Server to answer to null queries so the LB can simply make an HTTP to http://instanceip/climb.

2.3. Auto Scaling Group

We created an Auto Scaling Group on AWS that increases the number of instances by 1 if the average CPU utilization is over 60 % in a period of 5 minutes and decreases the number of instances by 1 (to a minimum of 1 instance) if the average CPU utilization of all instances is under 40% for a period of 5 minutes. This allows to scale up in a situation of continuous heavy load while not scaling down instantly if we get a slight pause of incoming requests. We want to be careful shuting down instances as they take some time starting up and if we get a temporary decrease and terminate them and then we might get back to a state where we can't deal with all requests that turns to a higher response time to those requests. To avoid this we wait to see if the decrease of requests (lower CPU usage) is not temporary (hence the 5 minutes under 40% CPU load). Also if for some reason an instance becomes unhealthy (unresponsive or the WebServer crashed for some reason) then the auto-scaler will terminate that instance and start another.

2.4. Security Group

3. Instrumentation

We used BIT (Bytecode Instrumenting Tool) presented in the laboratories to to alter the Java Class Byte Code of the program so we could measure the metrics that we wanted in a way that would help us decide the cost of replying to a certain request.
This metrics need to be heavily weighted as they might give a big overhead to the the original program. To store this metrics we created a class called Metrics, which stores all of the counter for each type of metric. We guarantee that each thread only counts its own metrics by using a ConcurrentHashMap to store all the metrics, where the key is the Thread ID and the Value is the Metrics Object (containing all the metrics). At the end of each request we store permanently the results of the instrumentation and remove the Metrics file from the HashMap, this allows to reset the counters for that specific thread.
With the metrics it's also stored the parameters given to program so we can associate those with the load it creates and in the future compare them with new requests.

3.1. Metrics Used

We decided to try a few simple metrics. Instructions run, Basic Blocks, Methods Called, Branches Queries, Branches Taken and Branches not taken. We ran the instrumented Web Server on an instance of AWS and made some requests (one at a time) while tracking the time it took to reply to each request. We obtained a table with all the values and concluded that some metrics grew linearly with the time to reply a request. Those metrics were Instructions Run, Basic Blocks, Branches and Branch not Taken.
Methods Called and Branch Taken were inconsistent because they depended on the search algorithm being used and do not necessarily mean a higher cost to reply to a request as different methods could have different number of instructions which could mislead the cost of the request.
As the other metrics scaled linearly with the time to reply to the request we can associate a higher number on this metrics to a more CPU intensive task. We decided to stick with Basic Blocks and Branches not Taken due to its linear grow matched with response time to the request and also because they provided the lower overhead to the running code.

3.2. Storing the metrics

After each request we are storing the Metrics object on a binary file locally to the machine and we also add those metrics to a table on Dynamo-DB. Each request has its own file with its metrics and it's named by its by a sequence id local to the instance.
To later access this binary file we also create a Java Class, LogReader, which reads the metrics binary files and prints those values so that we can use the values in next stage to calculate the cost of a request to system.

4. Future Work

4.1. Metrics

At this point of the project the Web Server at the end of every request it writes the metrics to a local (to the instance) binary file and it also writes them to a table on Dynamo-DB. At this time we don't have a common key between all instances (we're using the Thread ID), eventually a metric that is on the table will be overwritten by another metric, which we don't want. With this in the next phase we should design a synchronized identifier to use with all instances metrics.

4.2. Load Balancer

We will stop using AWS LB and will create a special instance to run as the Load Balancer that will use the metrics generated by the Worker Servers to decide the cost of a request and to which Worker should the new request be sent to. We will compare new requests with old requests that we already ran and will try to match them to find out the cost of the new one and decide the better instance to run it.
The Load Balancer will also send information to the new Auto Scaler so it can make decisions on the number of instances that should be running.

4.3. Auto Scaler

Just as the LB we will stop using the default AWS Auto Scaler and create our own auto scaler on a special instance to manage the running instances that will receive feedback from the LB and depending of the state of the system it will increase or decrease the number of instances running.

5. Appendix - Metrics Measurements

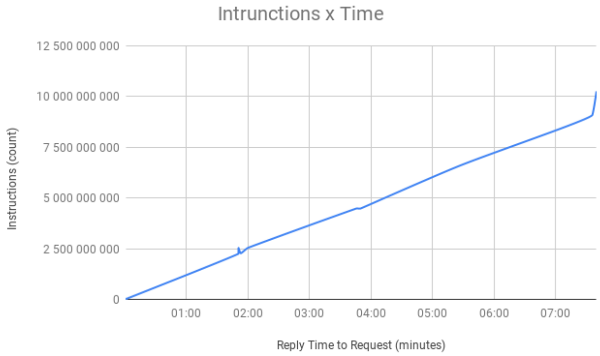


Figure 1

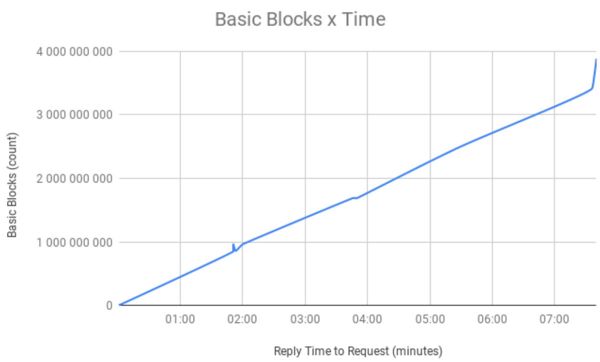
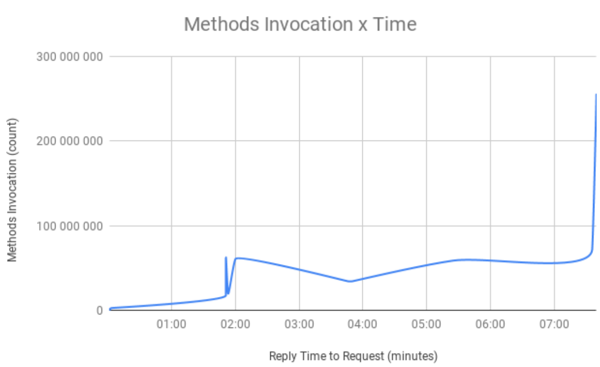


Figure 2



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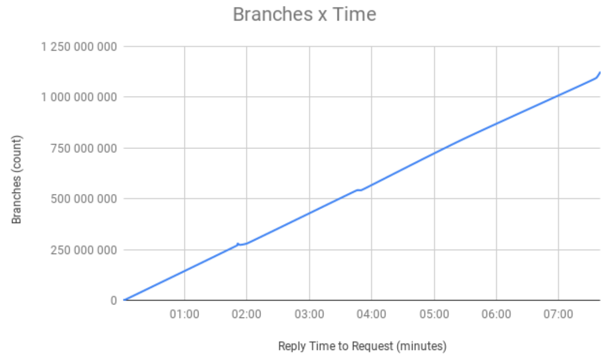

Figure 4

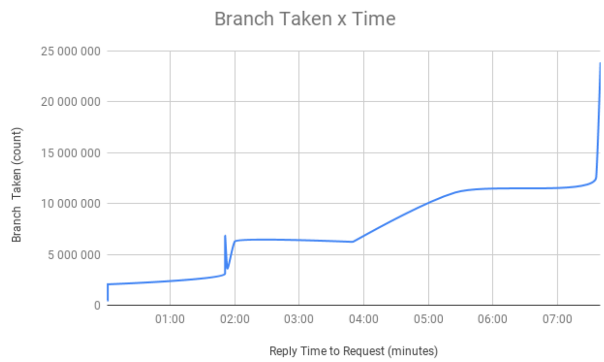

Figure 5

Figure 6