REQUEST LEVEL TRACING IN DISTRIBUTED BIG DATA SYSTEM FOR PERFORMANCE DIAGNOSTICS

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CONTENTS

PROBLEM STATEMENT

The goal of this project is to implement trace in distributed big-data systems and analyze the trace result for performance diagnostics. The Complete setup, analysis and visualization of the system is accomplished using Apache HBase, Apache Spark, YCSB and JFreeChart Java Library.

Apache HBase is the database under test. The data is stored in the region server block (HFile). HBase is an open source, distributed sorted map modeled after Google's BigTable. It is built on top of Apache Hadoop and is written in JAVA. It provides fast record lookups and updates for large tables and works above Hadoop Distributed File System (HDFS). It is no sql and no Schema Database.

HTrace is a tracing framework intended for use with complex, large-scale distributed systems written in java. This framework will help in tracing system behavior and reasoning performance issues by calculating the span ID for each and every node it is embedded into.

Yahoo Cloud Serving Benchmark (YCSB) is a performance testing tool released by Yahoo for evaluating the performance of different "key-value" and "cloud" serving stores. It has a HBase
Mode that will serve to stress test the system by entering numerous values.

PROJECT MOTIVATION

Apache Spark is an open-source in-memory data analytics cluster computing framework. Spark's in-memory primitives provide performance up to 100 times faster for certain applications, making it suitable for real time computation in contrast with MapReduce's batch processing which approximately takes more than 10 minutes for computing.

Advantages of Spark over Hadoop Map Reduce:

1. Spark has much lower per job and per task overhead. It gives it ability to be applied to the cases where Hadoop MR is not applicable. It is cases when reply is needed in 1-30 seconds.
2. Low per task overhead makes Spark more efficient for even big jobs with a lot of short tasks. As a very rough estimation - when task takes 1 second Spark will be 2 times more efficient then Hadoop MR.
3. Spark has lower abstraction then MR - it is graph of computations. As a result it is possible to implement more efficient processing then MR - specifically in cases when sorting is not needed. In other words - in MR we always pay for the sorting, but in Spark - we do not have to.
4. RDD (Resilient Distributed Data set): an RDD is the main abstraction of spark. It allows recovery of failed nodes by re-computation of the DAG while also supporting a more similar recovery style to Hadoop by way of checkpointing, to reduce the dependencies of an RDD. Storing a spark job in a

DAG allows for lazy computation of RDD's and can also allow spark's optimization engine to schedule the flow in ways that make a big difference in performance.

PROJECT DESIGN

The project is divided into a series of small sub-projects which are :

- ❑ Setup of HBase system in pseudo-distributed mode.
- ❑ Setup of HTrace framework.
- ❑ Collect HTrace data from the HBase pseudo-cluster.
- ❑ Deploy HBase with HTrace cluster in large computer cluster, use YCSB to stress-test the system.
- ❑ Data Analysis of the raw data received from HTrace using Apache Spark
- ❑ Visualize the data using JFreeChart Java Library.

LITERATURE REVIEW

HBASE

HBase is a database that provides real-time, random read and write access to tables meant to store billions of rows and millions of columns. It is designed to run on a cluster of commodity servers and to automatically scale as more servers are added, while retaining the same performance. In addition, it is fault tolerant precisely because data is divided across servers in the cluster and stored in a redundant file system such as the Hadoop Distributed File System (HDFS). When (not if) servers fail, your data is safe, and the data is automatically re-balanced over the remaining servers until replacements are online. HBase is a strongly consistent data store; changes you make are immediately visible to all other clients.

HBase is modeled after Google's Bigtable, which was described in a paper written by Google in 2006 as a "sparse, distributed, persistent multi-dimensional sorted map." So if you are used to relational databases, then HBase will at first seem foreign. While it has the concept of tables, they are not like relational tables, nor does HBase support the typical RDBMS concepts of joins, indexes, ACID transactions, etc. But even though you give those features up, you automatically and transparently gain scalability and fault-tolerance. HBase can be described as a key-value store with automatic data versioning.

You can CRUD (create, read, update, and delete) data just as you would expect. You can also perform *scans* of HBase table rows, which are always stored in HBase tables in ascending sort order. When you scan through HBase tables, rows are always returned in order by row key. Each row consists of a unique, sorted row key (think primary key in RDBMS terms) and an arbitrary number of columns, each column residing in a column family and having one or more versioned values. Values are simply byte arrays, and it's up to the application to transform these byte arrays as necessary to display and store them. HBase does not attempt to hide this column-oriented data model from developers, and the Java APIs are decidedly more lower-level than other persistence APIs you might have worked with. For example, JPA (Java Persistence API) and even JDBC are much more abstracted than what you find in the HBase APIs. You are working with bare metal when dealing with HBase.

HBase is a *distributed* database, meaning it is designed to run on a cluster of dozens to possibly thousands or more servers. As a result it is more complicated to install than a single RDBMS running on a single server. And all the typical problems of distributed computing begin to come into play such as coordination and management of remote processes, locking, data distribution, network latency and number of round trips between servers. Fortunately HBase makes use of several other mature technologies, such as Apache Hadoop and Apache ZooKeeper, to solve many of these issues. The figure below shows the major architectural components in HBase.

HBASE ARCHITECTURE

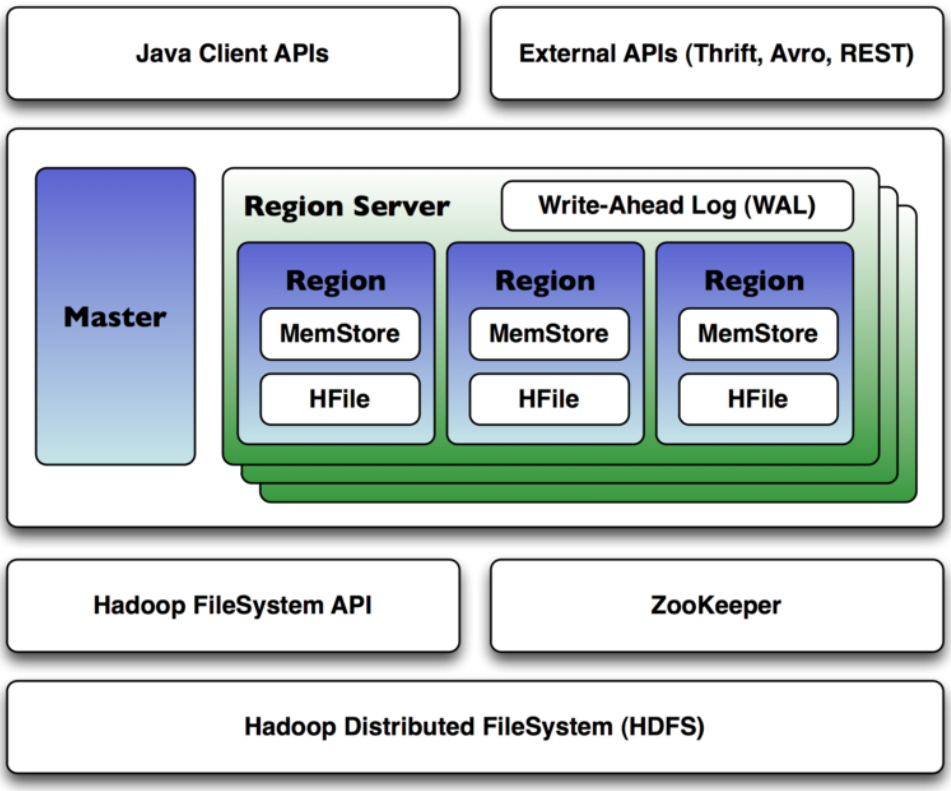


Figure 1: Hbase Architecture[3]

In the above figure you can see there is a single HBase master node and multiple region servers. (Note that it is possible to run HBase in a multiple master setup, in which there is a single active master.) HBase tables are partitioned into multiple regions with each region storing a range of the table's rows, and multiple regions are assigned by the master to a region server.

HBase is a *column-oriented* data store, meaning it stores data by columns rather than by rows. This makes certain data access patterns much less expensive than with traditional row-oriented relational database systems. For example, in HBase if there is no data for a given column family, it simply does not store anything at all; contrast this with a relational database which must store null values explicitly. In addition, when retrieving data in HBase, you should only ask for the specific column families you need; because there can literally be millions of columns in a given row, you need to make sure you ask only for the data you actually need.

HBase utilizes ZooKeeper (a distributed coordination service) to manage region assignments to region servers, and to recover from region server crashes by loading the crashed region server's regions onto other functioning region servers.

Regions contain an in-memory data store (MemStore) and a persistent data store (HFile), and all regions on a region server share a reference to the write-ahead log (WAL) which is used to store new data that hasn't yet been persisted to permanent storage and to recover from region server crashes. Each region holds a specific range of row keys, and when a region exceeds a configurable size, HBase automatically splits the region into two child regions, which is the key to scaling HBase.

As a table grows, more and more regions are created and spread across the entire cluster. When clients request a specific row key or scan a range of row keys, HBase tells them the regions on which those keys exist, and the clients then communicate directly with the region servers where those regions exist. This design minimizes the number of disk seeks required to find any given row, and optimizes HBase toward disk transfer when returning data. This is in contrast to relational databases, which might need to do a large number of disk seeks before transferring data from disk, even with indexes.

The HDFS component is the Hadoop Distributed Filesystem, a distributed, fault-tolerant and scalable filesystem which guards against data loss by dividing files into blocks and spreading them across the cluster; it is where HBase actually stores data. Strictly speaking the persistent storage can be anything that implements the Hadoop FileSystem API, but usually HBase is deployed onto Hadoop clusters running HDFS. In fact, when you first download and install HBase on a single machine, it uses the local filesystem until you change the configuration!

Clients interact with HBase via one of several available APIs, including a native Java API as well as a REST-based interface and several RPC interfaces (Apache Thrift, Apache Avro). You can also use DSLs to HBase from Groovy, Jython, and Scala.

YCSB

The goal of the YCSB project is to develop a framework and common set of workloads for evaluating the performance of different “key-value” and “cloud” serving stores. The project comprises two things:

- The YCSB Client, an extensible workload generator
- The Core workloads, a set of workload scenarios to be executed by the generator

Although the core workloads provide a well-rounded picture of a system’s performance, the Client is extensible so that you can define new and different workloads to examine system aspects, or application scenarios, not adequately covered by the core workload. Similarly, the Client is extensible to support benchmarking different databases. Although we include sample code for benchmarking HBase, Cassandra, Infinispan and MongoDB, it is straightforward to write a new interface layer to benchmark your favorite database.

A common use of the tool is to benchmark multiple systems and compare them. For example, you can install multiple systems on the same hardware configuration, and run the same workloads against each system. Then you can plot the performance of each system (for example, as latency versus throughput

curves) to see when one system does better than another.

HTRACE

Htrace is a tracing framework which answers the question – where is the time spent inside Hbase. It is a tracing framework that will analyze data logs of Hbase. HTrace is a tracing framework intended for use with complex, large-scale distributed systems written in java. Htrace Framework answers the question where the time is being spent inside HBase. This is inspired by Google Dapper which uses threaded through HBase and HDFS to tracks time spent in calls in a distributed system by tracking spans on different machines.

HTrace borrows Dapper's terminology:

1. Span
- Basic unit of work
- Segment of a remote call
- Contains Annotations
- Has a parent trace
- Can have multiple children spans
- Can have multiple annotations

2. Trace
- Grouping of spans

APACHE SPARK

Apache Spark is a fast and general-purpose cluster computing system. It provides high-level APIs in Java, Scala and Python, and an optimized engine that supports general execution graphs. We will be programming in Java.

Spark runs on Hadoop, Mesos, standalone, or in the cloud. It can access diverse data sources including HDFS, Cassandra, HBase, S3.

We will use Spark to perform Data Analysis of the type, which function has the most random behaviour in terms of the processing time. We will get the data over multiple traces and then aggregate to produce the Analysis. We will use two main function of the spark : Tuple and Filter for data analysis.

WORKFLOW

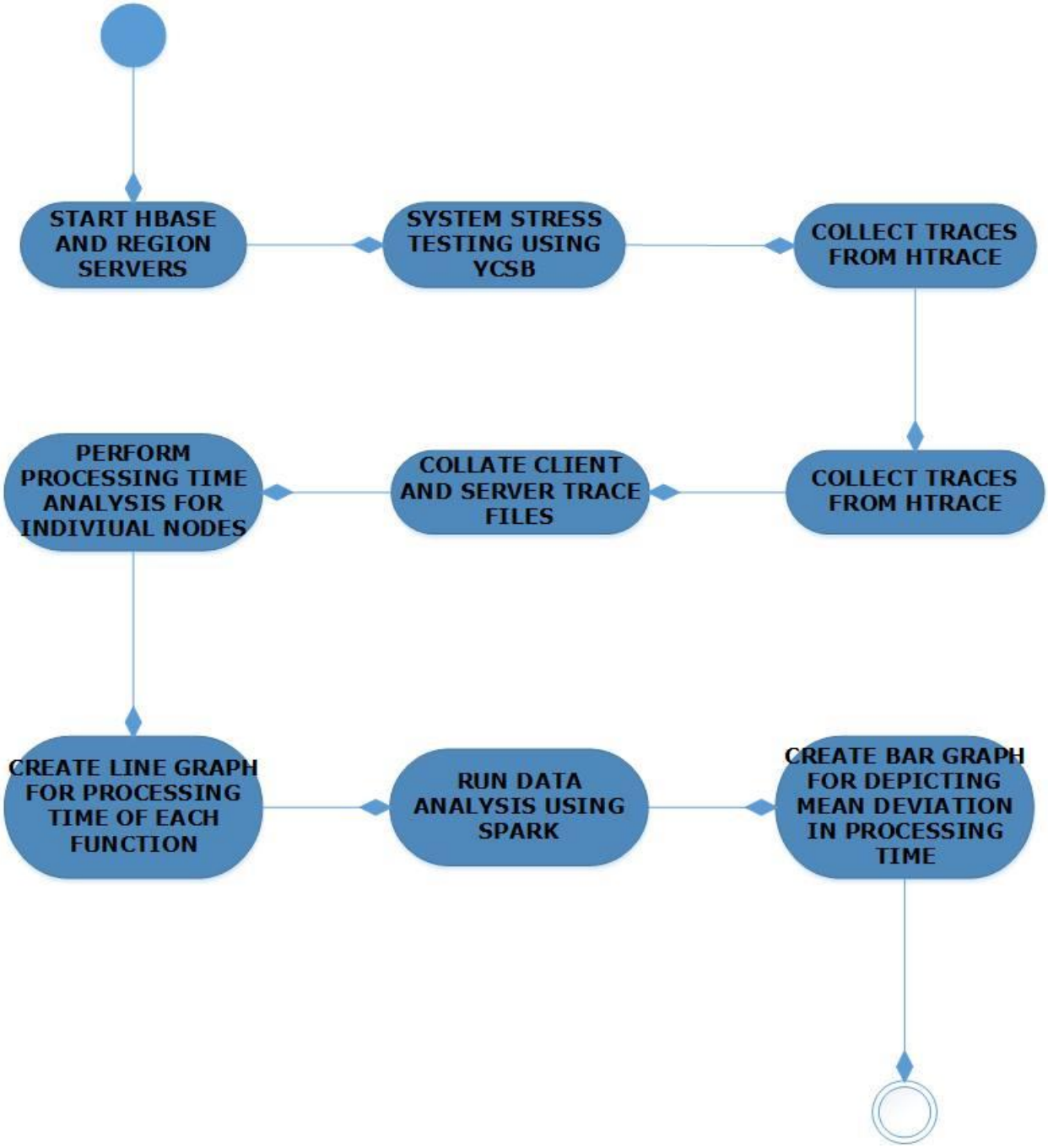


Figure: Workflow of the project

GRAPH

JFreeChart is an open source programming framework in Java, which allows the creation of a wide variety of both interactive and non-interactive charts. As for the project we are dealing with a large number of result points, a simple tabular documentation of the result will difficult to comprehend and thereby, not fit for analysis. Therefore, using a visual tool would benefit more for carrying out analysis on the data.

Changes run function of executable to point to our row and table in Htrace and analyzing multiple times

1. We will changes run function of executable to point to our row and table in Htrace. By doing this we will work on consistent data.

2. We will run analyze Result multiple times. By doing this we will work on more stable htrace data.
Code snippets:

```
Class Executable {
        public void run(){
                        Configuration conf = HBaseConfiguration.create();
                        SpanReceiverHost spanReceiverHost = SpanReceiverHost.getInstance(conf);
                        TraceScope ts = Trace.startSpan("Gets", Sampler.ALWAYS);
                        try {
                                HTable table = new HTable(conf, "t1");
                                Get get = new Get(Bytes.toBytes("user1234589")); ---------- 1
                                Result res = table.get(get);
                                for(int i = 0 ; I <=4 ; i++){                    ---------- 2
                                analyzeResult(res);
                                } }
                                catch(Exception e){ e.printStackTrace(); }
                                finally { ts.close(); }
                                spanReceiverHost.closeReceivers();
                          }
```

The code will generate data in the Server_htrace.out and the htrace.out. The data will be combined and will be input to the DataAnalysis.java file for processing and refining.

DATA ANALYSIS CODE

The DataAnalysis.java program is the crux of our project. It works on finding the processing time of each node obtained by the Htrace using a recursive method.
-Using FileWriter, we append the output of the result to the Htrace.out.txt file.

```
public FileWriter out=null;
  public static String filepath="/teaching/14f-cis655/proj-dtracing/DataAnalysis/";
out = new FileWriter(filepath+"Htrace_out.txt",false);
```

-To calculate the individual processing time of each node, the total processing time of the child node is reduced from the parent node. The child node is identified by its 'SpanID'. This done by comparing the 'SpanID' of the parent node with the 'ParentID' of all the nodes. When we find a hit, we again search for the child node of the given node. This process continues till we reach a leaf node. The first step is the calculation of the leaf node. After calculating the processing time of the leaf node, its processing time is subtracted from its parent node's processing. This way we keep on eliminating the processing time of all the child nodes for all the node and we end up with the processing time of each individual function.

```
        while ((line = br.readLine()) != null) {
                                        //System.out.println("the line is:"+line);
                                        StringBuffer result = new StringBuffer();
                                        String parentID = "";
                                        long start , stop ;
                                        long lowerprocessing = 0;
                                        StringTokenizer str = new StringTokenizer(line, DELIMITER);
                                        if (line.contains("\"ParentID\":" + spanID)){
                                        while (str.countTokens() > 0) {
                                                s = str.nextToken();
                                                // System.out.println(s);
                                                if (s.contains("SpanID")) {
                                                        StringTokenizer str1 = new StringTokenizer(s,
TOKEN);
                                                        String ss = str1.nextToken();
                                                        String ss1 = str1.nextToken();
//System.out.println("data we are getting from line: ":+ ss + " : value is " + ss1);
                                start = 0; stop = 0;
                        //  System.out.println("calling lower with parentID here = "+ ss1 + " ");
                                                        lowerprocessing = getLower(ss1);
                                          //System.out.println("lowerprocessing returned= "+ lowerprocessing+ " ");
                                //System.out.println("the line I am working on:"+line);
                                        StringTokenizer str_pid_forstartstop = new StringTokenizer(line, DELIMITER);
                                        while (str_pid_forstartstop.countTokens() > 0) {
                                            String spanstartstop = str_pid_forstartstop.nextToken();
                                                if (spanstartstop.contains("Start")) {

        //System.out.println("this is my start span field: "+ spanstartstop);
                                                                                StringTokenizer
spanstartstoptoken = new StringTokenizer(spanstartstop, TOKEN);
                                                                                String sp1 =
spanstartstoptoken.nextToken();
                                                                                String
spanvalue1 = spanstartstoptoken.nextToken();
```

```
        //System.out.println("start time is = "+ spanvalue1 + " ");
                                start = Long.parseLong(spanvalue1);
                                                                        }
                                                                        if
(spanstartstop.contains("Stop")) {

        //System.out.println("this is my stop span field: "+ spanstartstop);
                                                                        StringTokenizer
spanstartstoptoken = new StringTokenizer(spanstartstop, TOKEN);
                                                                        String sp1 =
spanstartstoptoken.nextToken();
                                                                        String
spanvalue1 = spanstartstoptoken.nextToken();

        //System.out.println("stop time = "+ spanvalue1 + " ");
                                stop = Long.parseLong(spanvalue1);
                                                                        }
                                  }
                                 processing += stop - start + lowerprocessing;
                                // System.out.println("the processing time inside is:"+ processing);
                                                                }
                                                        }
```

APACHE SPARK

The input to the Spark will be a file Htrace_out.txt produced by DataAnalysis.java. The contents of the file Htrace_out.txt is:

```
Gets:2619
Gets:2551
Gets:931
Gets:2425
RecoverableZookeeper.exists:224
RecoverableZookeeper.exists:113
RecoverableZookeeper.exists:45
RecoverableZookeeper.exists:120
```

The above content describes the processing time for each function. for ex: Gets:2619 describes that the function Gets took 2619 ms to complete its execution.

The below source code is of Spark:

```
public final class JavaTrace {
	private static final Pattern SPACE = Pattern.compile(" ");
	private static final Pattern COLON = Pattern.compile(":");

	static FileWriter out = null;
	static String flag = "";
	static int sum_gets = 0;
	static int max_gets = 0;
	static int sum_RZ = 0;
	static int max_RZ = 0;
	static int sum_RZ_exist = 0;
	static int max_RZ_exist = 0;
	static int sum_client = 0;
	static int max_client = 0;
	static int max_block = 0;
	static int sum_block = 0;

	public static void main(String[] args) throws Exception {

		if (args.length < 1) {
			System.err.println("Usage: JavaTrace <file>");
			System.exit(1);
		}
	SparkConf sparkConf = new SparkConf().setAppName("JavaTrace");
	out = new FileWriter("/teaching/14f-cis655/proj-dtracing/DataAnalysis/Data_Analysis.txt",
				false);
		JavaSparkContext ctx = new JavaSparkContext(sparkConf);
		JavaRDD<String> lines = ctx.textFile(args[0], 1);
/**
This function will filter the lines based on the function name and will return those lines.
**/
		Function<String, Boolean> filters = new Function<String, Boolean>() {
			public Boolean call(String s) {

				if (flag == "Gets")
					return s.contains("Gets");
				else if (flag == "ClientService.Get")
					return s.contains("ClientService.Get");
				else if (flag == "RecoverableZookeeper.exists")
					return s.contains("RecoverableZookeeper.exists");
				else if (flag == "HFileReaderV2.readBlock")
					return s.contains("HFileReaderV2.readBlock");
				else
					return s.contains("RecoverableZookeeper.getData");
```

```
                }
        };

/** Function to produce Tuple
**/
    PairFunction<String, String, String> keyData = new PairFunction<String, String, String>() {
                public Tuple2<String, String> call(String s) {
                        return new Tuple2(COLON.split(s)[0], COLON.split(s)[1]);
                }
        };

    /** RDD for Gets
                Gets **/

                flag = "Gets";
                JavaRDD<String> gets = lines.filter(filters);
                JavaPairRDD<String, String> gets_rdd = gets.mapToPair(keyData);
                long count_gets = gets.count();

                sum_gets = 0;
                max_gets = 0;

                List<Tuple2<String, String>> gets_output = gets_rdd.collect();
                for (Tuple2<String, String> tuple : gets_output) {
                        int val = Integer.parseInt(tuple._2());
                        if (val > max_gets)
                                max_gets = val;----------------------------------------------------1
                        sum_gets = sum_gets + val;
                        System.out.println(tuple._1() + ": " + tuple._2());
                }

                int mean_gets = sum_gets / (int) count_gets;-----------------------------------------2
                System.out.println(sum_gets + " :sum_gets , " + max_gets+ " :max_gets , " + count_gets `
                + " :count , " + mean_gets+ " :mean ");
        double deviation = ((double) (max_gets - mean_gets) / (double) mean_gets);----------------3
                System.out.println(deviation + " : times deviating from mean");
                StringBuffer st = new StringBuffer();
                st.append("Gets:").append(deviation).append("\n");
                out.write(st.toString());
```

Each function have multiple invocation and hence we calculate the average processing time(mean) for a function. Then we calculate the deviation of the maximum value(amongst the processing time of the instances) from the mean using mathematical calculation of (max-mean)/mean.

1. The max_gets will give the maximum value amongst all the occurances of the function “Gets”.
2. The mean_gets will give the average value(processing time) of the function “Gets”.
3. deviation will give the deviation of the max value with respect to the mean value for the function “Gets”.

We will have these three values for all the function in our Trace file. Then the Spark will produce a file Data_Analysis.txt will hold the values of the deviation of functions. The content of the file will be:
Gets:0.22900046926325668
RecoverableZookeeper.getData:2.6666666666666665
RecoverableZookeeper.exists:1.1638418079096045
HFileReaderV2.readBlock:2.75
ClientService.Get:3.650943396226415

With the help of above output we will generate the bargraph.

For the project we would be generating two types of graphs. One would be a line graph depicting processing time of each node per call. The other would be a Bar graph depicting ‘Mean deviation in Processing Time’ for each of the functions invoked’.

Creating a graph using JfreeChart is a two step process - First, creating a data set for plotting the graph. Second, Using the data set created, plotting a graph.

LINE GRAPH

The createDataset() method is responsible for reading data from the text file Htrace_out.txt. It returns a dataset of values and categories, which is used to plot the graph. Each line is read using BufferReader, and each token from the corresponding line is read. For the categories defines corresponding values are extracted and add to the dataset of that category.

- **Creating a dataset**

```
XYSeriesCollection dataset = new XYSeriesCollection();;
```

- **Adding value to the data set of all the series/Categories**

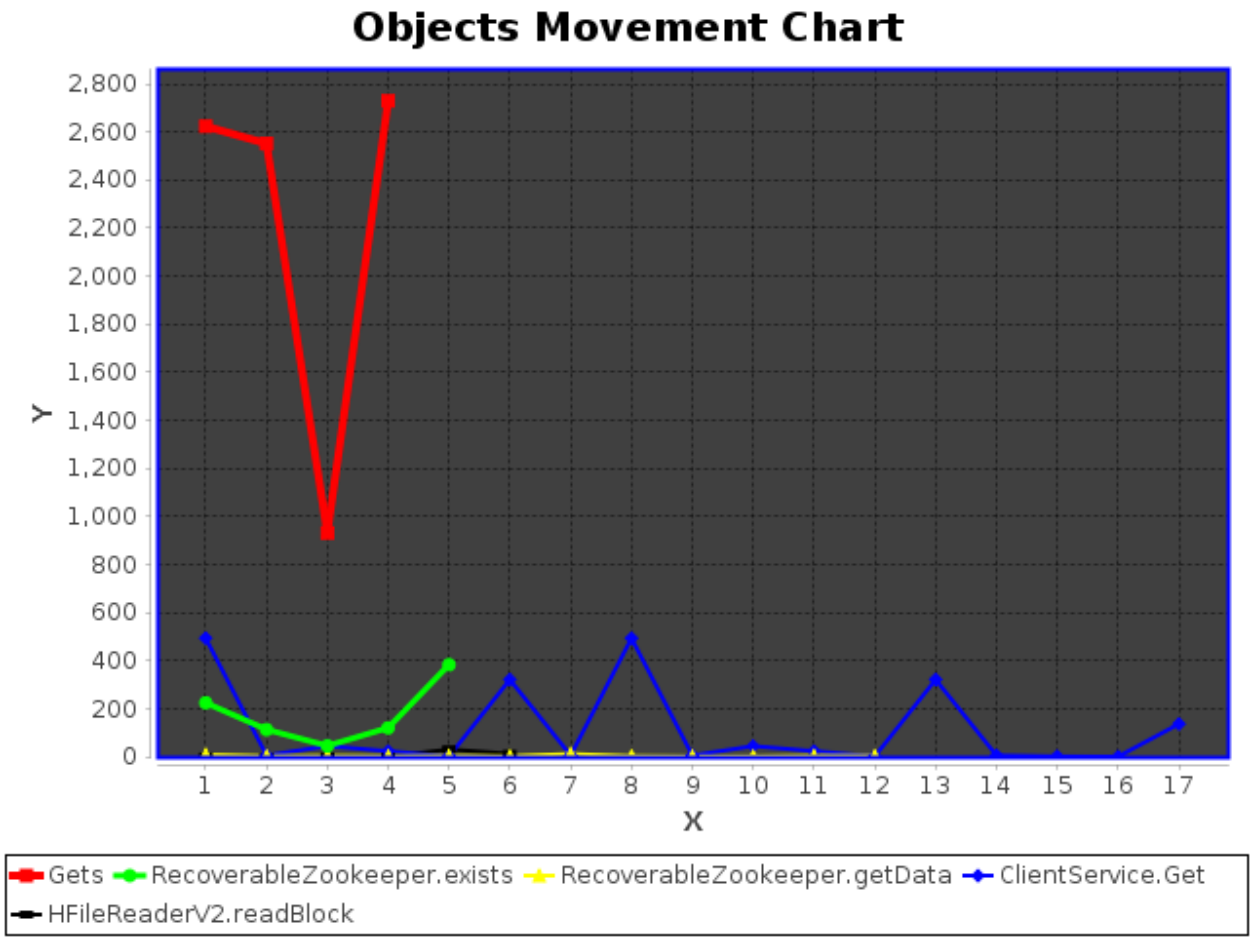
```
while ((line1 = br1.readLine()) != null) {
                StringBuffer result = new StringBuffer();
                String parentID = "";
                StringTokenizer str1 = new StringTokenizer(line1, TOKEN);
                String ss = str1.nextToken();
                String ss1 = str1.nextToken();
                int  yValue = Integer.parseInt(ss1);
                if(ss.equals("Gets")){
```

```
                    series1.add(++getCount, yValue);
                }
                if(ss.equals("RecoverableZookeeper.exists")){
                    series2.add(++RecCount, yValue);
                }
                if(ss.equals("RecoverableZookeeper.getData")){
                    series3.add(++RecDataCount, yValue);
                }
                if(ss.equals("ClientService.Get")){
                    series4.add(++clientCount, yValue);
                }
                if(ss.equals("HFileReaderV2.readBlock")){
                    series5.add(++Hfilecount, yValue);
                }                   }
        } finally {
            if (in != null) {
                    in.close();
            }           }
                    dataset.addSeries(series1);
                    dataset.addSeries(series2);
                    dataset.addSeries(series3);
                    dataset.addSeries(series4);
                    dataset.addSeries(series5);
                    return dataset;
```

- **Reading data from text file using FileReader**

```
in = new FileReader("/teaching/14f-cis655/proj-dtracing/DataAnalysis/Htrace_out.txt");
                br1 = new BufferedReader(in);
```

Running the above yields the following graph



The following chart depicts the processing time of each node per call. The Y axis - represents the processing time (in milli-second). The X axis represents the number of calls to a function.
The following graph however, isn't of much importance in analyzing the variation in the processing time of each of the function as it is possible that for a function with high mean value, the variation in terms of number would be large. However, percentage wise the difference may not be so significant. We require a graph for displaying the percentage variation in the processing time of the function. For this we have created another bar graph depicting variation in the processing time of each of the function mentioned above.

BAR GRAPH

For creating the second graph we calculate the mean value of each of the function using spark framework. This value is written into the DataAnalysis.txt. Later these values are extracted and using these values we plot the graph.

- **Creating a dataset**

```
final DefaultCategoryDataset dataset = new DefaultCategoryDataset();
```

- **Adding value to the data set of all the categories**

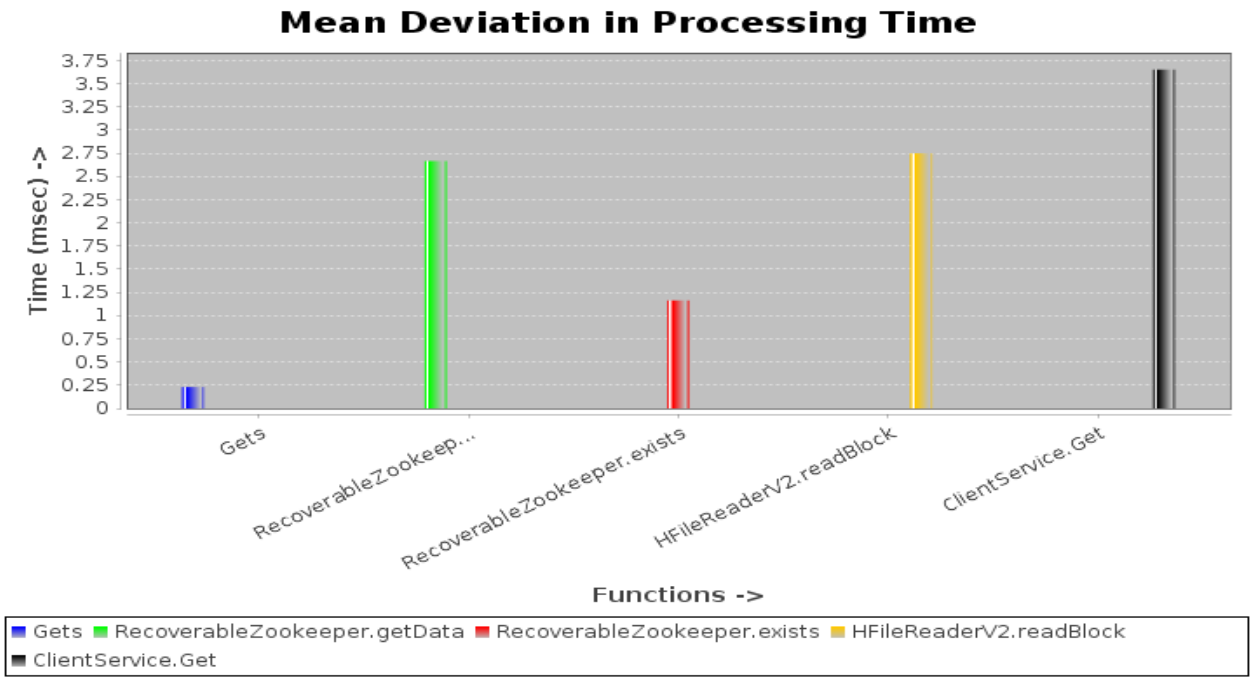
```
        FileReader in = null;
      BufferedReader br1=null;
      String TOKEN = ":";
while ((line1 = br1.readLine()) != null) {
                        StringBuffer result = new StringBuffer();
                        String parentID = "";
                        StringTokenizer str1 = new StringTokenizer(line1, TOKEN);
                        String ss = str1.nextToken();
                        String ss1 = str1.nextToken();
                        double yValue = Double.parseDouble(ss1);
                        if(ss.equals("Gets")){
                                dataset.addValue(yValue, series1, category1);
                        }
                        if(ss.equals("RecoverableZookeeper.exists")){
                                dataset.addValue(yValue, series2, category2);
                        }
                        if(ss.equals("RecoverableZookeeper.getData")){
                                dataset.addValue(yValue, series3, category3);
                        }
                        if(ss.equals("ClientService.Get")){
                                dataset.addValue(yValue, series4, category4);
                        }
                        if(ss.equals("HFileReaderV2.readBlock")){
                                dataset.addValue(yValue, series5, category5);
                        }
      }
```

- **Reading data from text file using FileReader**

```
in = new FileReader("/home/cis655stu/graph/Data_Analysis.txt");
        br1 = new BufferedReader(in);
```

-**Creating a new Instance of the chart**

```
       final CategoryDataset dataset = createDataset();
        final JFreeChart chart = createChart(dataset);
        final ChartPanel chartPanel = new ChartPanel(chart);
      chartPanel.setPreferredSize(new Dimension(500, 270));
        setContentPane(chartPanel);
```



The output received from the bar graph depicts the maximum amount of variation that each function occur. Analyzing this graph helps us to realize the bottleneck function in the system. The function with maximum variation depicts the most erratic behavior and needs to re- worked to provide a uniform behavior in terms of processing time.

SOURCE CODE OF THE PROJECT:

The source code of the project is present in Source_Code folder. This includes following files inside it.

1. DataAnalysis.java

   This Java file recursively compute time taken by each function from htrace.out and append it to Htrace_out.txt

2. XYLineChartExample.java

   This will generate XYLineChart.png file from Htrace_out.txt

3. JavaTrace.java

   Spark uses JavaTrace.java and generate Data_Analysis.txt file from Htrace_out.txt

4. BarChartDemo.java

   This will generate BarGraph.png file from generated file Data_Analysis.txt

5. graphDrawer.sh

   This script will generate tree graph from htrace.out

6. tracingAndAnalysis.sh

   This script will handle all the steps needed to execute the program after initial step of Hbase and YSCB. This can be extended to handle all these initial steps also.

HOW TO COMPILE AND RUN THE PROGRAM:

To compile DataAnalysis.java:

1. Go to /teaching/14f-cis655/proj-dtracing/DataAnalysis

2. Compile by javac DataAnalysis.java

3. Run by java DataAnalysis.java

To compile XYLineChartExample.java

1. Go to /teaching/14f-cis655/proj-dtracing/DataAnalysis

2. Compile by javac -cp ".:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jcommon-1.0.23/jcommon-1.0.23.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jfreechart-1.0.19/jfreechart-1.0.19-demo.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/Htrace_out.txt" XYLineChartExample.java

3. Run by javac -cp ".:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jcommon-1.0.23/jcommon-1.0.23.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jfreechart-1.0.19/jfreechart-1.0.19-demo.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/Htrace_out.txt" XYLineChartExample.java

To compile JavaTrace.java:

1. Go to /teaching/14f-cis655/proj-dtracing/spark/spark-1.1.0/

2. Run by ./bin/run-example JavaTrace /teaching/14f-cis655/proj-dtracing/DataAnalysis/Htrace_out.txt

To compile BarChartDemo.java:

1. Go to /teaching/14f-cis655/proj-dtracing/DataAnalysis

2. Compile by javac -cp ".:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jcommon-1.0.23/jcommon-1.0.23.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jfreechart-1.0.19/jfreechart-1.0.19-demo.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/Data_Analysis.txt" BarChartDemo.java

3. Run by java -cp ".:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jcommon-1.0.23/jcommon-1.0.23.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jfreechart-1.0.19/jfreechart-1.0.19-demo.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/Data_Analysis.txt" BarChartDemo.java

To run tracingAndAnalysis.sh

./tracingAndAnalysis.sh

To run graphDrawer.py

cat htrace.out | ./tools/graphDrawer.py

HOW TO CONFIGURE AND DEPLOY THE PROGRAM:

Setup YCSB:

http://cloudfront.blogspot.com/2013/02/how-to-benchmark-hbase-using-ycsb.html#.VFunt_ldUgh

Step 1:

Install maven

1.1 Go to http://maven.apache.org/download.cgi and download apache-maven-3.1.1-bin.tar.gz.

1.2 tar -zxvf apache-maven-3.1.1-bin.tar.gz -C /usr/local/

1.3 Edit the .bashrc file

To edit: cd ~ then vi .bashrc

Now add the following to this file:

#set maven environment

export M2_HOME=/usr/local/apache-maven-3.1.1

export MAVEN_OPTS="-Xms256m -Xmx512m"

export PATH=$M2_HOME/bin:$PATH

1.4 Check that java –version is still 1.7.0_07

Step 2:
Clone the YCSB git repository
2.1 sudo apt-get install git
2.2 git clone https://github.com/brianfrankcooper/YCSB.git
This will create a directory called YCSB inside your current directory.

Step 3:
Go to this YCSB directory and edit the pom.xml.
<hbase.version>0.92.1</hbase.version> to <hbase.version>0.99.0</hbase.version>
And in modules comment the following like this:
<modules>
<!--<module>cassandra</module>
<!--<module>gemfire</module>-->
<!-- <module>infinispan</module>
<!-- <module>mapkeeper</module>
<!--module>nosqldb</module-->
</modules>

Step 4:
Go to YCSB/hbase directory and the change the pom.xml so that the dependency look like this:
<dependency>
<groupId>org.apache.hbase</groupId>
<artifactId>hbase-client</artifactId>
<version>0.99.0</version>
</dependency>
<dependency>
<groupId>org.apache.hadoop</groupId>
<artifactId>hadoop-common</artifactId>
<version>2.4.0</version>
</dependency>

Step 5:
Now go back to YCSB directory and execute
mvn clean package
The build should be a success.

Step 6:
Step5 will create a directory named target inside your /YCSB/distribution/ directory. You will find the YCSB tar file here, ycsb-0.1.4.tar.gz in my case. Copy this file to some location of your choice and extract it. This will give you the ycsb-1.0.4 directory which contains all the important and necessary stuff.

Step 7:

Move inside the ycsb-1.0.4 directory where you will find a directory called /hbase-binding. Go inside the /hbase-binding and open the /lib directory situated there. Copy the following jars from your /HBASE_HOME/lib into this /lib directory:
1-slf4j-api-*.jar
2-slf4j-log4j12-*.jar
3-zookeeper-*.jar

Step 8:
You will find another directory named /conf inside /hbase-binding. You will find an xml file here named as hbase-site.xmlfile. Replace this hbase-site.xml file with the habse-site.xml present in your /HBASE_HOME/conf directory.

Step 9:
You are all set for testing your Hbase now. Start the Hadoop and Hbase processes and go inside ycsb-1.0.4. Now, issue the following command to load test your Hbase deployment:
apache@hadoop:/ycsb-0.1.4$ bin/ycsb load hbase -P workloads/workloada -p columnfamily=f1 -p recordcount=1000000 -p threadcount=4 -s | tee -a workloada.dat

Setup Spark:

Step 1:
Install the spark-1.1.0.tgz from the http://spark.apache.org/downloads.html

Step 2:
Gunzip and untar the above file in the relevant directory.
2.1 gunzip spark-1.1.0.tgz
2.2 chmod –R 775 spark-1.1.0.tar
2.3 tar xvf spark-1.1.0.tar
This will give you the folder for spark-1.1.0 in the directory where the command is executed.

Step 3:
Go to spark-1.1.0 directory and change the pom.xml so that the modules look like this:

```
<modules>
   <module>core</module>
  <!-- <module>bagel</module>
   <module>graphx</module>
   <module>mllib</module>
   <module>tools</module>
   <module>streaming</module>-->
   <!-- <module>sql/catalyst</module>
   <module>sql/core</module>
   <module>sql/hive</module>
   <module>repl</module> -->
```

```
    <module>assembly</module>
   <!-- <module>external/twitter</module>
    <module>external/kafka</module>
    <module>external/flume</module>
    <module>external/flume-sink</module>
    <module>external/zeromq</module>
    <module>external/mqtt</module>-->
    <module>examples</module>
  </modules>
```

Step 4:

Put your spark Java file (JavaTrace.java) in the directory
spark1.1.0/examples/src/main/java/org/apache/spark/examples

Step 5:

Go to spark-1.1.0 directory and execute the following command:
mvn –DskipTests clean package
The build should be a success.

Step 6:

Now you are ready to execute the code. To execute the code run the following command:
./bin/run-example JavaTrace

Change Executable.java in HTRACE

Step 1:
Change your Executable.java in the directory htrace-client/1_getTraces/editable/src/main

Step 2:
Go to directory htrace-client/1_getTraces/editable and execute the command:
ant
The build should be successful.

Change the .bashrc file

Change your .bashrc file in prder to set the environment variables:

export JAVA_HOME=/usr/lib/jvm/jdk1.7.0_07
export CLASSPATH=$CLASSPATH:$JAVA_HOME/lib

```
export PATH=$PATH:$JAVA_HOME/bin
#set maven environment
export M2_HOME=/usr/local/apache-maven-3.1.1
export MAVEN_OPTS="-Xms256m -Xmx512m"
export ANT_OPS="-Xms256m"
export ANT_HOME=/home/cis655stu/Documents/apache-ant-1.8.4
export PATH=$M2_HOME/bin:$PATH:$ANT_HOME/bin
export SPARK_HOME=/teaching/14f-cis655/proj-dtracing/spark-1.1.0-bin-hadoop2.4
export CLASSPATH=$CLASSPATH:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jcommon-*.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jfreechart-*.jar
```

JFREECHART:

We need jcommon-1.0.23.jar file and jfreechart-1.0.19.jar file to execute the barGraph.java and XYlinegraph.java .This can be downloaded from http://sourceforge.net/projects/jfreechart/files/.

HOW TO EXECUTE THE PROGRAM:

For executing the program, we have divided this into two steps: one basic initial step and then by running tracingAndAnalysis.

STEP 1 Basic Steps:

Following are the steps needed to be taken care for deployment of the program:

Creating table in Hbase

We will create a table in Hbase with table name “t1” using the command [create “t1”, “cf”]where

“cf” is the column family. We will insert a record into Hbase using the command [put ‘t1’, ‘ row1’,

‘cf:c1’, ‘value’] . Then we will scan the table to check of the data is feed in properly. [scan ‘t1’]

Starting local Regional server

Then, we will start local regional server. [Local-regionservers.sh start 1 2]

Starting YCSB

By default YCSB hits the “usertable” in Workload. In case we wish to hit another table , we need

to specify table = ‘table_name’ in the workload. In our case, the htrace runs the trace on table ‘t1’ and thus we need YCSB to hit ‘t1’. We will run this with command [bin/ycsb load hbase -P workloads/workloada -p columnfamily=f1 -p recordcount=1000000 -p threadcount=4 -s | tee -a workloada.dat]

Here, We are using

workload = workloada which is 50% read and 50% write.

Recordcount = 1,000,000

Threadcount = 4

STEP 1 Running TracingAndAnalysis.sh:

Generating htrace.out

This is done by going to /teaching/14f-cis655/proj-dtracing/htrace-client/1_getTraces/editable and then running ./tt_sh/runMain_woAnt.sh

Combining client and server htrace.out

cat /teaching/14f-cis655/tmp/server-htrace.out >> /teaching/14f-cis655/proj-dtracing/htrace-client/1_getTraces/editable/htrace.out

Generating vishual graph of htrace.out

This is done by below steps putting htrace.out to 2_analyseTraces folder. And then running visual.sh script.Below steps are required to run it.

1. cp 1_getTraces/editable/htrace.out 2_analyseTraces/
2. cd 2_analyseTraces/
3. rm graphs/* (Removing previous file)
4. ./tt_sh/visual.sh

Generating Analysis output File

We will run DataAnalysis.java that is present in /teaching/14f-cis655/proj-dtracing/DataAnalysis .And then run it by below commands.

1. javac DataAnalysis.java

2. java DataAnalysis

Generating LineGraph

Following command need run for generating Linegraph

1. javac -cp ".:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jcommon-1.0.23/jcommon-1.0.23.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jfreechart-1.0.19/jfreechart-1.0.19-demo.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/Htrace_out.txt" XYLineChartExample.java

2. java -cp ".:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jcommon-1.0.23/jcommon-1.0.23.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jfreechart-1.0.19/jfreechart-1.0.19-demo.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/Htrace_out.txt" XYLineChartExample

Running spark

Following command need run for running spark basically JavaTrace in examples folder.

1. cd /teaching/14f-cis655/proj-dtracing/spark/spark-1.1.0/

2. ./bin/run-example JavaTrace /teaching/14f-cis655/proj-dtracing/DataAnalysis/Htrace_out.txt

Generating Bargraph

Following command need run for generating Bargraph.

1. cd /teaching/14f-cis655/proj-dtracing/DataAnalysis

2. javac -cp ".:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jcommon-1.0.23/jcommon-1.0.23.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jfreechart-1.0.19/jfreechart-1.0.19-demo.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/Data_Analysis.txt" BarChartDemo.java

3. java -cp ".:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jcommon-1.0.23/jcommon-1.0.23.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/jfreechart-1.0.19/jfreechart-1.0.19-demo.jar:/teaching/14f-cis655/proj-dtracing/DataAnalysis/Data_Analysis.txt" BarChartDemo

A PROOF OF THE WORKING OF THE FINAL SYSTEM:

1. Graph output from Visual.sh

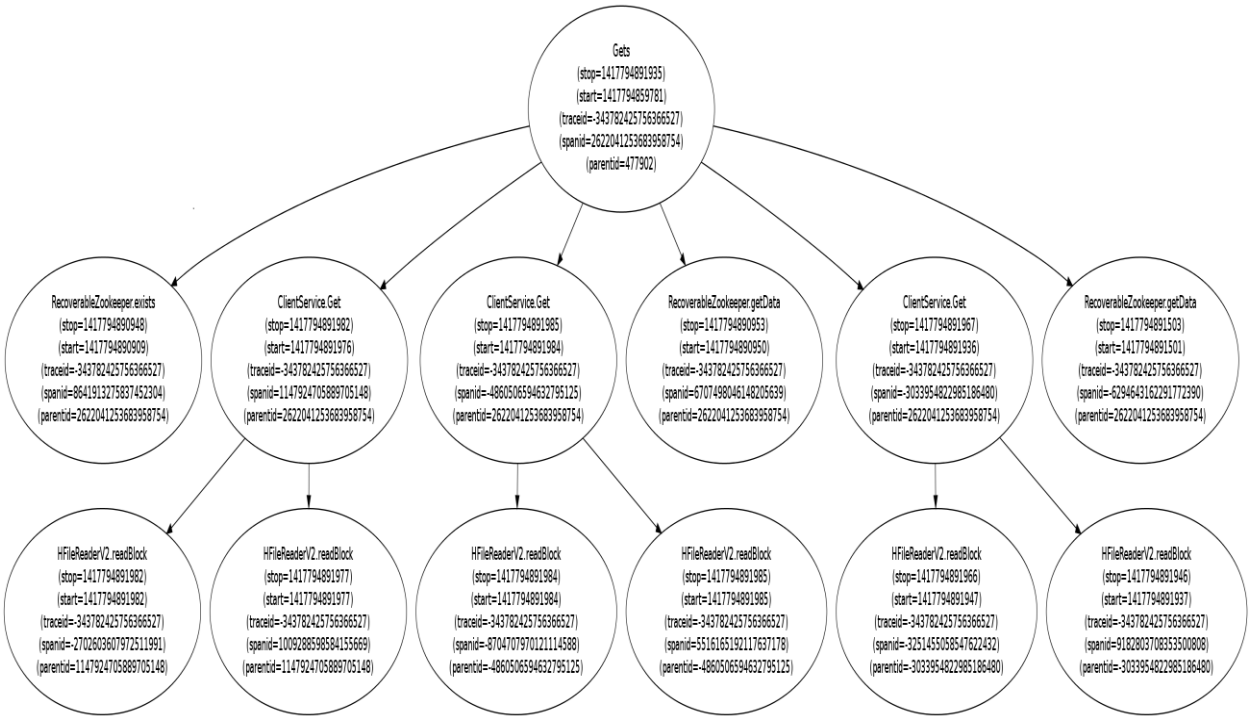


Figure 1. output graph 1

Figure 2. output graph 2

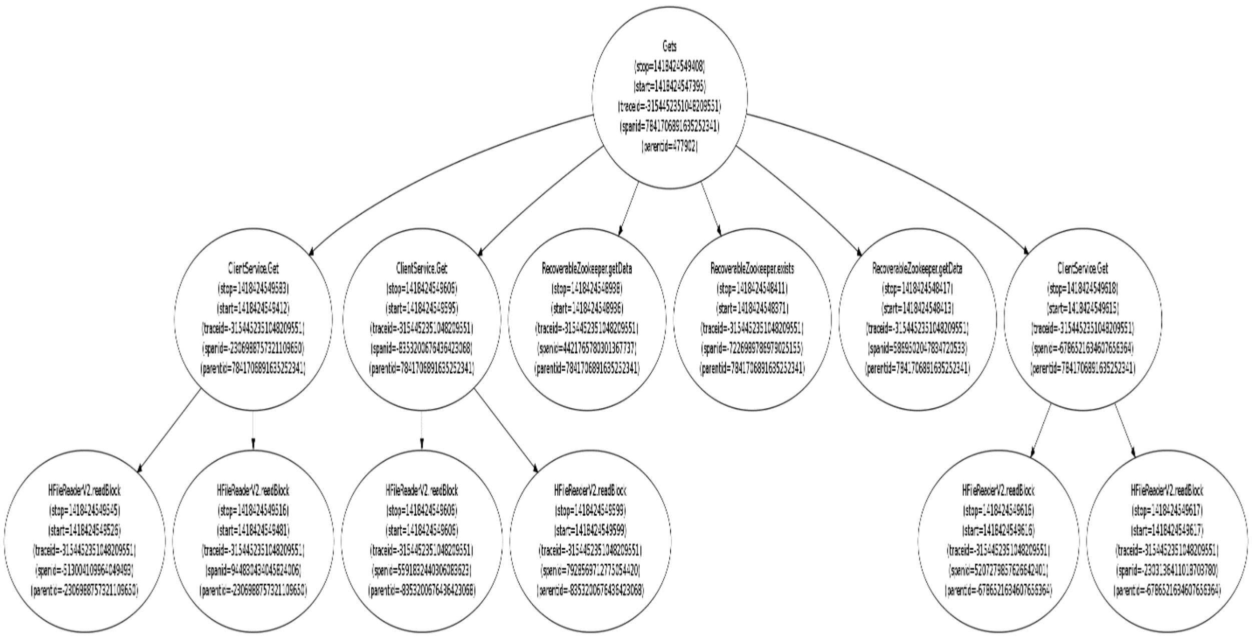


Figure 3. output graph 3

2. Output from tracingAndAnalysis.sh

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Generating htrace.out

==================================

row=k[#versions=5]: <cf=cf,cq=c1,ts=1417726318779,v=value1>,
<cf=cf,cq=c2,ts=1417729860917,v=value>, <cf=cf,cq=c3,ts=1417729864728,v=value>,
<cf=cf,cq=c4,ts=1417729868221,v=value>, <cf=cf,cq=c5,ts=1417729871981,v=value>,
row=k[#versions=5]: <cf=cf,cq=c1,ts=1417726318779,v=value1>,
<cf=cf,cq=c2,ts=1417729860917,v=value>, <cf=cf,cq=c3,ts=1417729864728,v=value>,
<cf=cf,cq=c4,ts=1417729868221,v=value>, <cf=cf,cq=c5,ts=1417729871981,v=value>,
row=k[#versions=5]: <cf=cf,cq=c1,ts=1417726318779,v=value1>,
<cf=cf,cq=c2,ts=1417729860917,v=value>, <cf=cf,cq=c3,ts=1417729864728,v=value>,
<cf=cf,cq=c4,ts=1417729868221,v=value>, <cf=cf,cq=c5,ts=1417729871981,v=value>,

==================================

Combining client and server htrace.out

==================================

Removing previous graph

==================================

Generating vishual graph

==========
i am here now
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53, 53, 115, 116, 117]}, u'TLAnnotations': [], u'Stop': 1418425795271L, u'Start': 1418425795270L,
u'ParentID': -6761360672279538273L, u'SpanID': -7112949532799832371L}]
Created 7 images.
graphs/2014-12-12 18:09:55.765943Gets.png
graphs/2014-12-12 18:09:55.985681Gets.png
graphs/2014-12-12 18:09:56.245677Gets.png
graphs/2014-12-12 18:09:56.382137Gets.png
graphs/2014-12-12 18:09:56.643656Gets.png

graphs/2014-12-12 18:09:56.901224Gets.png
graphs/2014-12-12 18:09:57.142094Gets.png
==========
Generating Analysis output File
==========
==========
Generating Graph
==========
Compiling LineGraph
Generating LineGraph

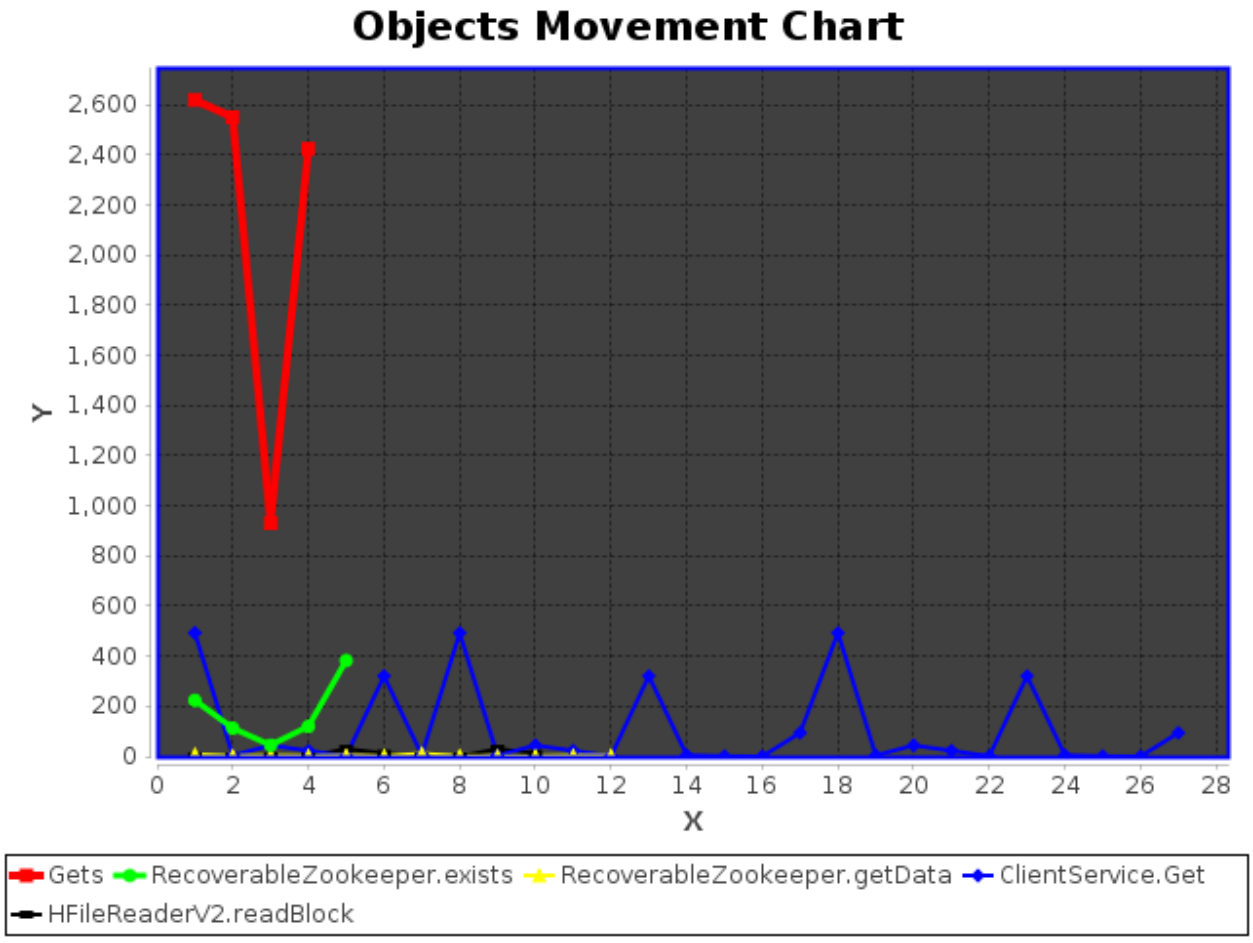

Figure: Line Graph

done
==========

Running spark
==========
Gets: 2619
Gets: 2551
Gets: 931
Gets: 2425
8526 :sum_gets , 2619 :max_gets , 4 :count , 2131 :mean
0.22900046926325668 : times deviating from mean
RecoverableZookeeper.getData: 8
RecoverableZookeeper.getData: 2
RecoverableZookeeper.getData: 3
RecoverableZookeeper.getData: 2
RecoverableZookeeper.getData: 3
RecoverableZookeeper.getData: 2
RecoverableZookeeper.getData: 11
RecoverableZookeeper.getData: 2
RecoverableZookeeper.getData: 1
RecoverableZookeeper.getData: 1
RecoverableZookeeper.getData: 3
RecoverableZookeeper.getData: 3
41 :sum_RZ_gd , 11 :max_gets , 12 :count , 3 :mean
2.6666666666666665 : times deviating_RZ from mean
RecoverableZookeeper.exists: 224
RecoverableZookeeper.exists: 113
RecoverableZookeeper.exists: 45
RecoverableZookeeper.exists: 120
RecoverableZookeeper.exists: 383
885 :sum_RZ_exist , 383 :max_RZ_exist , 5 :count ,177 :mean
1.1638418079096045 : times deviating from mean
HFileReaderV2.readBlock: 1
HFileReaderV2.readBlock: 0
HFileReaderV2.readBlock: 1
HFileReaderV2.readBlock: 0
HFileReaderV2.readBlock: 30
HFileReaderV2.readBlock: 12
HFileReaderV2.readBlock: 1
HFileReaderV2.readBlock: 0
HFileReaderV2.readBlock: 30
HFileReaderV2.readBlock: 12
87 :sum_HfileRead , 30 :max_Hfile , 10 :count , 8 :mean
2.75 : times deviating from mean
27 : Client count
ClientService.Get: 493
ClientService.Get: 4

ClientService.Get: 44
ClientService.Get: 23
ClientService.Get: 1
ClientService.Get: 321
ClientService.Get: 5
ClientService.Get: 493
ClientService.Get: 4
ClientService.Get: 44
ClientService.Get: 23
ClientService.Get: 1
ClientService.Get: 321
ClientService.Get: 5
ClientService.Get: 1
ClientService.Get: 0
ClientService.Get: 94
ClientService.Get: 493
ClientService.Get: 4
ClientService.Get: 44
ClientService.Get: 23
ClientService.Get: 1
ClientService.Get: 321
ClientService.Get: 5
ClientService.Get: 1
ClientService.Get: 0
ClientService.Get: 94
2863 :sum_client , 493 :max_client , 4 :count , 106 :mean
3.650943396226415 : times deviating from mean
Compiling Bargraph
Generating Bargraph
Done

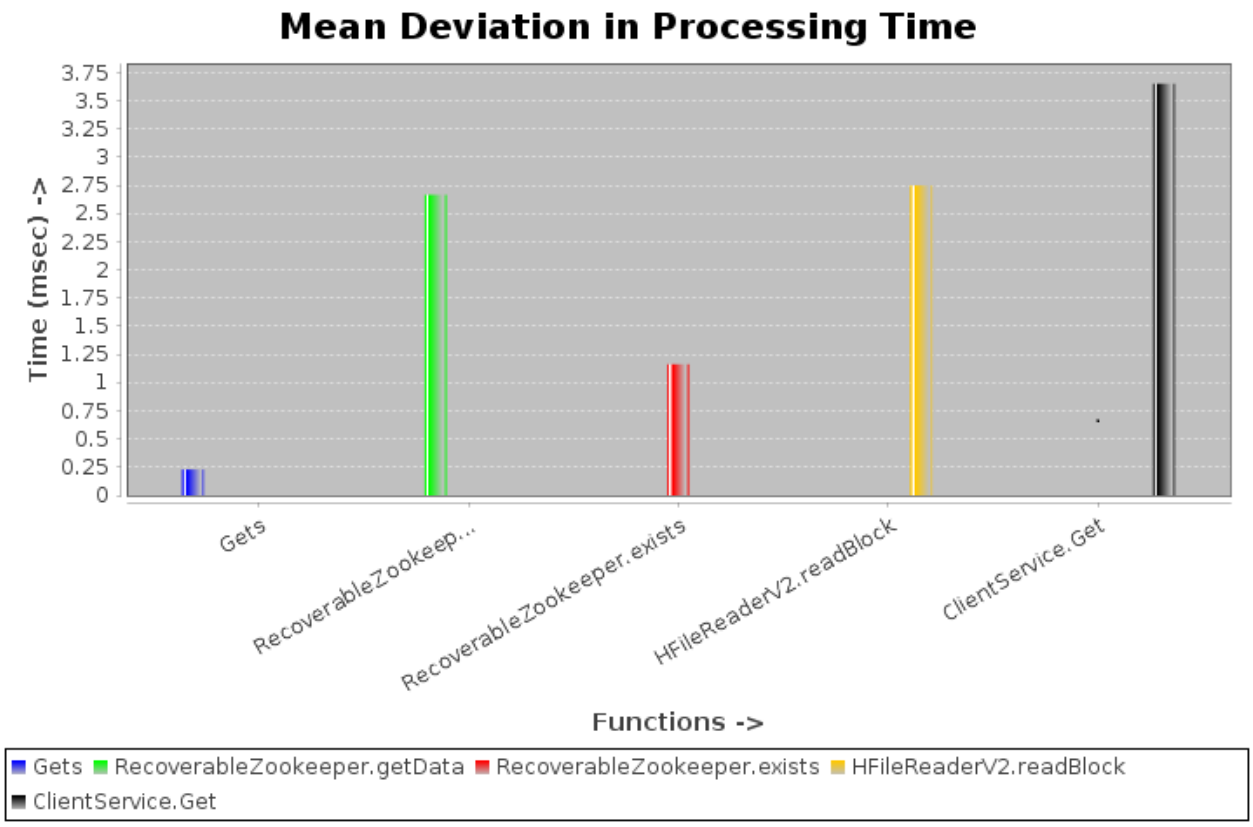

Figure: Final Data Analysis Bar Graph

SUMMARY AND CONCLUSION

The need for performance analysis is because of the fact that even though Big Data Cloud makes it easy to develop and run highly scalable applications, efficient provisioning and fine-tuning of these massively distributed systems remain a major challenge.

The primary application for Spark is to provide performance monitoring to identify the sources of latency. The above application gets the traces from the pseudo distributed servers and perform analysis on the trace data for performance, to find the function with the most random behavior in terms of processing time. The data over 4 traces is collected and the data is aggregated with the help of java class. It is further analysed by Spark to perform data analysis the outcome of which is represented using the barchart created with the help of JFreeChart. The output received from the bar graph depicts the maximum amount of variation that each function occur. Analyzing this graph helps us to realize the bottleneck function in the system which in our result is which in our result is the ClientServive.Get. The function with maximum variation depicts the most erratic behavior and needs to re- worked to provide a uniform behavior in terms of processing time so that the overall latency of the system is reduced.

Furthur enhancement to the project can be done by analysing the code to find how and what can be done to reduce the processing time of this function. Also further the script can be scheduled to execute in some regular intervals so that we get insight on how the system is behaving in real time.

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11. Sample code, https://github.com/sleberknight/basic-hbase-examples
12. JavaTrace.java , http://www.apache.org/licenses/LICENSE-2.0
13. BarChart.java and LineChart.java, http://www.object-refinery.com/jfreechart/guide.html

APPENDIX

A. IMPLEMENTED CODE:

This has been placed in Source_code folder.
BarChart

1. BarChartDemo.java
2. DataAnalysis.java
3. graphDrawer.py
4. JavaTrace.java
5. tracingAndAnalysis.sh
6. XYLIneChartExample.java

B. GENERATED OUTPUT FILES

This has been placed in OUT_PUT_FILES folder.

1. Data_Analysis.txt
2. Htrace.out
3. Htrace_out.txt

C. GENERATED PNG FILES

This has been placed in GENERATED PNG folder.

1. 2014-12-1217_49_10.726727Gets.png
2. 2014-12-1217_49_10.948306Gets.png
3. 2014-12-1217_49_10.345740Gets.png
4. BarGraph.png
5. XYLineChart.png