Simulation of BRKSS Architecture for Data Warehouse Employing Shared Nothing Clustering

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ABSTRACT

The BRKSS Architecture is based upon shared nothing clustering that can scale-up to a large number of computers, increase their speed and maintain the work load. The architecture comprises of a console along with a CPU that also acts as a buffer and stores information based on the processing of transactions, when a batch enters into the system. This console is connected to a switch (p-ports) which is again connected to the c-number of clusters through their respective hubs. The architecture can be used for personal databases and for online databases like cloud through router. This architecture uses the concept of load balancing by moving the transaction among various nodes within the clusters so that the overhead of a particular node can be minimised. In this paper we have simulated the working of BRKSS architecture using JDK 1.7 with Net beans 8.0.2. We compared the result of performance parameters such as turnaround time, throughput and waiting time with existing hierarchical clustering model.

Keywords-- BRKSS Architecture, Shared Nothing Clustering, Buffer, Cloud, Router, Switch, Hubs, Load Balancing, Databases, Turnaround Time, Throughput, Waiting Time, Ports

I. INTRODUCTION TO BRKSS ARCHITECTURE

A substantial amount of work has been done to enhance the performance of data warehouses in many different ways. In this paper, an architecture named as BRKSS Architecture \cite{1} is simulated, which is based upon shared nothing clustering that can scale-up to a large number of computers, increase their speed and maintain the work load. The architecture comprises of a console along with a CPU that also acts as a buffer and stores information based on the processing of transactions, when a batch enters into the system. This console is connected to a switch (p-ports) which is again connected to the c-number of clusters through their respective hubs. The architecture can be used for personal databases and for online databases like cloud through router. As shown in Figure 1, the BRKSS Architecture comprises of multiple nodes connected by a high speed LAN. A piece node has its own Processor (P), Memory (M) and Disk (D).
Maximum Possibility of Clusters and Nodes

Here, the number of clusters formed and the number of nodes depend upon the number of ports in the switch. Two ports of the switch will be used for connecting with the console and the router. Suppose that ‘d’ is the number of nodes in each cluster. In Table–1, the table gives an idea about the maximum number of clusters that could be formed. Here, up to 64 port switch have been shown which could be increased based on how much large is the data warehouse.

|          | 8   | 16  | 32  | 64  |
|----------|-----|-----|-----|-----|
| Number of Switch Ports |     |     |     |     |
| Number of Hubs         | 6   | 14  | 30  | 62  |
| Number of Clusters     | 6   | 14  | 30  | 62  |

II. PROPOSED ALGORITHM

To overcome the limitations of load balancing in shared nothing clustering Inter-query Parallelism has been implemented in the proposed algorithm where many diverse queries or transactions are executed in parallel with one another on many processors. This will not only increase the throughput but will also scale up the system.

The steps of the algorithm are stated below:

Step–1 : Consider the number of transactions entering into the system in a batch mode. [Suppose ‘m’ numbers of transactions are there in a batch]

Step–2: Check the number of clusters. [Suppose ‘c’ be the number of clusters]

Step–3: Calculate the maximum value for each cluster (maxc) and node (maxn).

\[ \text{max}_c = \frac{m}{c} \]
\[ \text{max}_n = \frac{\text{max}_c}{d} \]

Where, \( \text{max}_c = 0 \) and \( \text{max}_n = 0 \) initially and \( d \) is the number of nodes in a cluster.

Step–4 : Distribute all the transactions evenly in the cluster based upon the \( \text{max}_c \) value and in the nodes based upon \( \text{max}_n \) value.

Node Based

Step–5 : Now, calculate \( \text{max}_q = \frac{\text{max}_n}{10} \)

Where, \( \text{max}_q \) is the number of transactions that will enter into the MLFQ apiece time for execution and also calculate \( \text{rem}_n = \text{max}_n - \text{max}_q \) for apiece node

Where, \( \text{rem}_n \) is the remaining number of transactions of a node.

Step–6 : Now for Node based Load Balancing, perform MLFQ Scheduling in apiece node.

Step–6 (a) : Allocate a ready queue to the processor of all the nodes and split the ready queue into ‘q’ number of queues.

Step–6 (b) : Put highest priority to \( q_0 \) as \( q_0 \) is the first queue and lowest priority to \( q_n \) as \( q_n \) is the last queue.

Step–6 (c) : Perform Round Robin Scheduling from \( q_0 \) to \( q_{n-1} \) and FCFS in \( q_n \).

Step–6 (d) : Follow the MLFQ rules while performing the scheduling.

Considering two jobs A and B entering into the queue, apply the following rules:

**Rule–1** : If Priority (A) > Priority (B), A will run (B doesn’t).

**Rule–2** : If Priority (A) = Priority (B), A and B both run in RRS.

**Rule–3** : When a job enters the system, it is placed at the highest priority, that is, the topmost queue.

**Rule–4** : Once a job uses up its time allotment at a given level (regardless of how many times it has given up the CPU), its priority is reduced, that is, it moves down one queue. This is called the Gaming Tolerance.

**Rule–5** : After some time period S, move all the jobs in the system to the topmost queue. This is also known as Priority Boost.

The above rules are applicable for a transaction or a query as well.

Step–6 (e) : At the end of apiece transaction, take up a new one from \( \text{rem}_n \).
Step–6 (f): After time interval $t_c$ status regarding the number of executed transactions and the remaining transactions will be send to the buffer from apiece node of a cluster.

Step–7: If value of $\text{rem}_a$ does not become 0 within time $t_c$ perform Node Based Load Balancing through Push Migration approach.

Step–7 (a): After receiving the status, check in the buffer.
- If $\text{rem}_a = \text{max}_a / 2$ in all the nodes, then situation is stable, continue with the execution and move to Step–9.
- If $\text{rem}_a > \text{max}_a / 2$ in all the nodes, then give them more time to reach the stable situation and then move to Step–9.
- If $\text{rem}_a = \text{max}_a / 2$ in half of the nodes and $\text{rem}_a > \text{max}_a / 2$ in other half, then give some time for execution so that most of the nodes would either reach to $\text{rem}_a < \text{max}_a / 2$ or $\text{rem}_a = \text{max}_a / 2$. Then move to Step–9.
- If in most of the nodes $\text{rem}_a$ is much less than $\text{max}_a / 2$ and in a few nodes $\text{rem}_a = \text{max}_a / 2$, then continue with the execution and after that move to Step–9.
- If $\text{rem}_a$ is much less than $\text{max}_a / 2$ in maximum nodes and in some nodes $\text{rem}_a > \text{max}_a / 2$, then start performing load balancing.

Step–7 (b): When condition 7 (a) (v) occurs in the node(s), then send a signal to the console through switch.

Step–7 (c): Console in return will send an instruction to the node(s) to submit the remaining transactions $\text{rem}_a$.

Step–8: Continue Step–7(a) to Step–7 (d) until $\text{max}_a$ gets executed.

Step–9: With the end of all the transactions, again a new $\text{max}_a$ will enter and repeat the above steps. Cluster Based

If after $t_c$ time, the console does not get any information regarding a particular cluster, then it will assume that a fail over has occurred in the cluster. Then the console will perform cluster based load balancing to shift the load of the fail over cluster to the rest of the active clusters.

Step–10: After time interval $t_c$, console will check the executed transactions $\text{max}_a$ and the remaining transactions $\text{rem}_a$ for apiece cluster and a copy of rem will be send to the buffer.

Step–11: Perform Cluster Based Load Balancing through Push Migration approach when cluster fail over will take place.

Step–11 (a): After time $t_c$ check in the buffer.
- If $\text{rem}_a = \text{max}_a / 2$ in all the active clusters, then situation is stable, continue with the execution and wait for condition 11 (a) (v) to occur.
- If $\text{rem}_a > \text{max}_a / 2$ in all the active clusters, then give them more time to reach the stable situation and wait for condition 11 (a) (v) to occur.
- If $\text{rem}_a = \text{max}_a / 2$ in half of the active clusters and $\text{rem}_a > \text{max}_a / 2$ in other half, then give some time for execution so that most of the clusters will either reach to $\text{rem}_a < \text{max}_a / 2$ or $\text{rem}_a = \text{max}_a / 2$ and wait for condition 11 (a) (v) to occur.
- If in most of the active clusters $\text{rem}_a$ is much less than $\text{max}_a / 2$ and in a few active cluster $\text{rem}_a = \text{max}_a / 2$, then continue with the execution and wait for condition 11(a) (v) to occur.
- If $\text{rem}_a$ is much less than $\text{max}_a / 2$ in all the active clusters, then performs load balancing.

Step–11 (b): Redistribute $\text{rem}_a$ of the fail over cluster into the other active clusters that would satisfy the condition $\text{rem}_a < \text{max}_a / 2$ in the active clusters.

Step–12: Continue Step–11 (a) and Step–11 (b) until $\text{m}$ gets executed.

Step–13: At the end of all the transactions, again a new batch will enter and repeat the above steps.

Example: Suppose the number of transactions ($m$) in one batch is 1, 80, 000, number of clusters ($c$) = 3 and number of nodes in apiece cluster ($d$) = 4.

Then,
- $\text{max}_a = (1,80,000/3) = 60,000$
- $\text{max}_a = (60,000/4) = 15,000$

The stable condition for apiece node is given by:
- $\text{max}_a / 2 = 7500$
- $\text{max}_a / 10 = 1500$

Node Based Load Balancing

Number of transactions entering into the MLFQ will be either $\text{max}_q$ or multiplicand of $\text{max}_q$ like:

1500 * 1 = 1500
1500 * 2 = 3000
1500 * 3 = 4500
1500 * 4 = 6000

At every interval, a status about the nodes will be send to the console. The console will get information about the remaining transactions of apiece node ($rem_n$) and will decide whether continuous execution or load balancing is required or not.

Initially,

| Nodes | $d1$ | $d2$ | $d3$ | $d4$ |
|-------|------|------|------|------|
| Executed Transactions ($max_\ell$) | 0 | 0 | 0 | 0 |
| Remaining Transactions ($rem_\ell$) | 15,000 | 15,000 | 15,000 | 15,000 |

**After $t_1$ Interval,**

| Nodes | $d1$ | $d2$ | $d3$ | $d4$ |
|-------|------|------|------|------|
| Executed Transactions ($max_\ell$) | 1,500 | 1,500 | 1,500 | 1,500 |
| Remaining Transactions ($rem_\ell$) | 13,500 | 13,500 | 13,500 | 13,500 |

**After $t_2$ Interval,**

| Nodes | $d1$ | $d2$ | $d3$ | $d4$ |
|-------|------|------|------|------|
| Executed Transactions ($max_\ell$) | 6,000 | 6,000 | 3,000 | 4,500 |
| Remaining Transactions ($rem_\ell$) | 7,500 | 7,500 | 10,500 | 9,000 |

**After $t_3$ Interval,**

| Nodes | $d1$ | $d2$ | $d3$ | $d4$ |
|-------|------|------|------|------|
| Executed Transactions($max_\ell$) | 6,000 | 6,000 | 1,500 | 1,500 |
| Remaining Transactions($rem_\ell$) | 1,500 | 1,500 | 9,000 | 7,500 |

After third Iteration in $d1$ and $d2$, $rem_n$ is much less than their $max_n / 2$ and in $d4$, $rem_n$ is stable, but in $d3$, $rem_n > max_n / 2$, so, Node Based Load Balancing is performed. Here, 1,500 transactions would be taken away from $d3$, making it stable and then putting that load into either $d1$ or $d2$. 

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Load Balancing is given in the table below:

| Nodes                  | \(d_1\) | \(d_2\) | \(d_3\) | \(d_4\) |
|------------------------|---------|---------|---------|---------|
| Executed Transactions (\(\text{max}_a\)) | 6,000   | 6,000   | 1,500   | 1,500   |
| Remaining Transactions (\(\text{rem}_n\))  | 1,500   | 1,500   | 9,000   | 7,500   |

New table after Load Balancing:

If remaining transactions are transferred to \(d_1\), then the final table will be as given below:

| Nodes                  | \(d_1\) | \(d_2\) | \(d_3\) | \(d_4\) |
|------------------------|---------|---------|---------|---------|
| Executed Transactions (\(\text{max}_a\)) | 6,000   | 6,000   | 1,500   | 1,500   |
| Remaining Transactions (\(\text{rem}_n\))  | 3,000   | 1,500   | 7,500   | 7,500   |

If remaining transactions are transferred to \(d_2\), then the final table will be as given below:

| Nodes                  | \(d_1\) | \(d_2\) | \(d_3\) | \(d_4\) |
|------------------------|---------|---------|---------|---------|
| Executed Transactions (\(\text{max}_a\)) | 6,000   | 6,000   | 1,500   | 1,500   |
| Remaining Transactions (\(\text{rem}_n\))  | 1,500   | 3,000   | 7,500   | 7,500   |

While performing the above iterations, a status about all the nodes and their clusters would go to the console and it will get updated on a regular basis.

Cluster Based Load Balancing

The console will get information in the time interval \(\tau\) about the executed number of transactions, that is, \(\text{max}_a\) and a copy of all the remaining transactions \(\text{rem}_n\). So, when fail over of any cluster occurs, then the console will send the unexecuted copy of transactions of the fail over cluster to the other clusters.

Initially,

| Clusters | \(c_1\) | \(c_2\) | \(c_3\) |
|----------|---------|---------|---------|
| Executed Transactions (\(\text{max}_a\)) | 0       | 0       | 0       |
| Remaining Transactions (\(\text{rem}_n\))  | 60,000  | 60,000  | 60,000  |
| After \(\tau\), interval, Clusters | \(c_1\) | \(c_2\) | \(c_3\) |
| Executed Transactions (\(\text{max}_a\)) | 20,000  | 20,000  | 30,000  |
| Remaining Transactions (\(\text{rem}_n\))  | 40,000  | 40,000  | 30,000  |
At the end of $t_1$ interval, console will have the status of $\text{max}_e$ and a copy of $\text{rem}_c$ within it, till $t_2$ execution ends successfully. After that it will hold a copy of $\text{rem}_c$ and status of $\text{max}_e$ till $t_3$ execution ends successfully.

| After $t_2$ interval, | Clusters | $c_1$ | $c_2$ | $c_3$ |
|-----------------------|----------|-------|-------|-------|
| Executed Transactions ($\text{max}_e$) | FAIL OVER | 10,000 | 10,000 |
| Remaining Transactions ($\text{rem}_c$) | 40,000 | 30,000 | 20,000 |

In $t_2$, a fail over occurs and the console that is holding the value of $\text{rem}_c$ from $t_1$ interval will distribute it to the other active clusters until they themselves come to a value much less than $\text{max}_e/2$.

| After $t_3$ interval, | Clusters | $c_1$ | $c_2$ | $c_3$ |
|-----------------------|----------|-------|-------|-------|
| Executed Transactions ($\text{max}_e$) | FAIL OVER | 15,000 | 15,000 |
| Remaining Transactions ($\text{rem}_c$) | 40,000 | 15,000 | 5,000 |

### III. SIMULATION OF THE ALGORITHM AND RESULT ANALYSIS

The BRKSS algorithm has been simulated by using JDK 1.7 with Netbeans 8.0.2 and the database has been maintained by MySQL. The algorithm takes the following user inputs: number of cluster, number of nodes, user queries which may be numerous at a particular time period. User queries are the transaction that determines the performance of a DW. The output is obtained for Turnaround Time, Waiting Time and Throughput for a given set of inputs and the result is compared with existing pseudo mesh schema.

I have discussed the results for three cases, which are shown in Table 3.1, Table 3.2 and Table 3.3. Also, the comparative result analysis of the proposed and existing hierarchical clustering model is displayed graphically.
**Simulation Results of BRKSS algorithm for 10 nodes and 2 clusters**

*Table 3.1*

| No. of transactions | Type of architecture | Turnaround time | Throughput  | Waiting time |
|---------------------|----------------------|-----------------|-------------|--------------|
| 100                 | BRKSS                | 486             | 7993368     | 486          |
|                     | Existing             | 1049            | 6391461     | 649          |
| 500                 | BRKSS                | 2674            | 8358360     | 2674         |
|                     | Existing             | 3506            | 6673616     | 3103         |
| 600                 | BRKSS                | 3041            | 10801256    | 3041         |
|                     | Existing             | 4160            | 8127600     | 3759         |
| 700                 | BRKSS                | 3406            | 11850384    | 3406         |
|                     | Existing             | 5033            | 10582072    | 4600         |
| 800                 | BRKSS                | 3971            | 14539848    | 3970         |
|                     | Existing             | 5330            | 12751888    | 4945         |
| 1000                | BRKSS                | 4825            | 13598344    | 4809         |
|                     | Existing             | 6598            | 8127904     | 6212         |

*Graphical Representation*

**BRKSS Turnaround Time**

![Graph of BRKSS Turnaround Time](https://ssrn.com/abstract=3555614)

**BRKSS Throughput**

![Graph of BRKSS Throughput](https://ssrn.com/abstract=3555614)
Comparison with Existing Model

**BRKSS Waiting Time**

![BRKSS Waiting Time Graph](https://ssrn.com/abstract=3555614)

**Turnaround Time Comparison**

![Turnaround Time Comparison Graph](https://ssrn.com/abstract=3555614)

**Throughput Comparison**

![Throughput Comparison Graph](https://ssrn.com/abstract=3555614)
**Graphical Representation**

**Waiting Time Comparison**

![Graph of Waiting Time Comparison](image)

**Simulation Results of BRKSS algorithm for 20 nodes and 5 clusters**

Table 3.2

| No. of transactions | Type of architecture | Turnaround time | Throughput | Waiting time |
|---------------------|----------------------|-----------------|------------|--------------|
| 100                 | BRKSS                | 547             | 6643584    | 532          |
|                     | Existing             | 1138            | 6174360    | 755          |
| 500                 | BRKSS                | 2795            | 9754000    | 2795         |
|                     | Existing             | 3670            | 6629392    | 3223         |
| 600                 | BRKSS                | 3267            | 13243136   | 3267         |
|                     | Existing             | 4177            | 8125200    | 3776         |
| 700                 | BRKSS                | 3837            | 12896984   | 3837         |
|                     | Existing             | 4593            | 12287472   | 4208         |
| 800                 | BRKSS                | 4408            | 13232920   | 4408         |
|                     | Existing             | 5427            | 12731096   | 5026         |
| 1000                | BRKSS                | 5595            | 13390704   | 5593         |
|                     | Existing             | 6661            | 8109856    | 6276         |

**BRKSS Turnaround Time**

![Graph of BRKSS Turnaround Time](image)

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Comparison with Existing Model

Turnaround Comparison

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Throughput Comparison

Waiting Time Comparison

Simulation Results of BRKSS algorithm for 12 nodes and 3 clusters

Table 3.3

| No. of transactions | Type of architecture | Turnaround time | Throughput       | Waiting time   |
|---------------------|----------------------|-----------------|------------------|----------------|
| 100                 | BRKSS                | 432             | 11655368         | 432            |
|                     | Existing             | 1052            | 5887560          | 648            |
| 500                 | BRKSS                | 2402            | 10755200         | 2402           |
|                     | Existing             | 3646            | 9174184          | 3176           |
| 600                 | BRKSS                | 2890            | 11939640         | 2890           |
|                     | Existing             | 4093            | 8126504          | 3707           |
| 700                 | BRKSS                | 3581            | 11901064         | 3581           |
|                     | Existing             | 4895            | 10673280         | 4509           |
| 800                 | BRKSS                | 3772            | 14839744         | 3772           |
|                     | Existing             | 5195            | 12756376         | 4794           |
| 1000                | BRKSS                | 5199            | 12014528         | 5199           |
|                     | Existing             | 6813            | 8152160          | 6412           |
Graphical Representation

**BRKSS Turnaround Time**

**BRKSS Throughput**

**BRKSS Waiting Time**
Comparison with Existing Model

**Turnaround Comparison**

- **Turnaround Time in milliseconds**
  - BRKSS
  - Existing

| No. of Transactions | BRKSS | Existing |
|---------------------|-------|----------|
| 100                 |       |          |
| 500                 |       |          |
| 600                 |       |          |
| 700                 |       |          |
| 800                 |       |          |
| 1000                |       |          |

**Throughput Comparison**

- **Throughput in bits**
  - BRKSS
  - Existing

| No. of Transactions | BRKSS | Existing |
|---------------------|-------|----------|
| 100                 |       |          |
| 500                 |       |          |
| 600                 |       |          |
| 700                 |       |          |
| 800                 |       |          |
| 1000                |       |          |

**Waiting Time Comparison**

- **Waiting Time in milliseconds**
  - BRKSS
  - Existing

| No. of Transactions | BRKSS | Existing |
|---------------------|-------|----------|
| 100                 |       |          |
| 500                 |       |          |
| 600                 |       |          |
| 700                 |       |          |
| 800                 |       |          |
| 1000                |       |          |

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As discussed, this architecture is based upon shared nothing clustering that can scale-up to a large number of computers, increase their speed and maintain the workload. To support it the proposed algorithm has been simulated and the results shown that the performance of BRKSS is better than the existing algorithm.

IV. CONCLUSION

The simulation of BRKSS algorithm has given positive results in its favour when it is compared with existing hierarchical clustering algorithm in terms of turnaround time, throughput and waiting time. Also, the results are consistent for different permutations and combinations of nodes and clusters.

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