Handling Mobile Network Congestion with Assembly line Control Algorithm

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***Abstract*— Congestion control is a major issue facing Mobile Network as a result of an increase in the number of telephone subscribers and new services introduced. All existing techniques in literature for controlling congestion are centred on two principles which are either to reject excessive traffic to prevent overutilization of network resources or re-routing excess load if an overload occurs. Re-routing of the excess load has not been properly handled with an appropriate algorithm. This study proposed and implemented a load balancing scheme for congestion control in Mobile Network using Assembly Line Balancing to ensure even distribution of load and re-routing a new load to the least-loaded or idle server. The result from the implementation in this study shows that assembly line balancing for load balancing process reduced the congestion on the mobile network and also reduced the number of time that a subscriber used when a call is sent to a Base Station.**

Keywords: Mobile Network, load balancing scheme, Assembly Line Balancing

I. INTRODUCTION

A mobile network is an interconnected combination of nodes that is able to connect in the absence of existing network infrastructure to form a wireless network. Each node in the mobile network can stand as a router that forwards packets for other nodes. The node can also serve as an endpoint to the user, thus making the router free to initiate moves that cause network topologies to change in a dynamic and unpredictable way [1]. Mobile Internet Service (MIS) happen to be one the fastest growing services and according to [2], the International Telecommunication Union (ITU) revealed that there are 1.2 billion active mobile-broadband subscriptions to these services in the world. This fastest growing market has made the mobile telecommunications operators to implement network performance optimization mechanisms. Mobile network performance is a crucial issue that affects service provider and telecommunication regulators with the sole purpose of satisfying their subscribers. Service providers monitor and optimize the network constantly to achieve the best performance and satisfy regulator target metric for the major performance indicators (KPI) [3]. In a telecommunication environment, there are three key factors for evaluating the quality of services (QoS) of an operator and these are accessibility, retainability and connection (voice) [4].

A communications network may be denoted as a graph G = (V, E), where V denotes the vertices (set of nodes), and E denotes the edges (set of links). In this case, the nodes are hosts, switches and routers while the physical connections among the nodes are the links [5]. Information can be transferred from one node to another in the form of data-packets as long as there are links between them [6].

Congestion occurs when resource demands exceed the capacity [7]. In a distributed computing there are inevitable fluctuations when some network nodes are heavily-loaded, and some are lightly-loaded or idle if there is high demand for resources of a particular node. Load balancing plays important roles in system efficiency improvement. To maintain and improve the efficiency and effectiveness of the system, two important metrics are employed which are Responsiveness and System throughput. Also, there are two key algorithms used for load balancing; the static and the dynamic load balancing algorithms [7]. Dynamic Load Balancing Algorithm has more potential in term of performance than static algorithms when the state of the information is used to improve the quality of their decisions.

Despite the fact that different dynamic load balancing methods have been proposed by the different studies to reduce the congestion problem, still, some nodes are heavily-loaded while some are idle or lightly loaded which lead to congestion. This study proposed Assembly Line Balancing (ALB) to ensure even distribution of loads (calls) among the nodes (servers). The techniques re-direct new loads to idle or lightly-loaded nodes and transfer the loads on heavily-loaded servers to idle or lightly-loaded servers. This reduces congestion and increases the performance of communication network to chieve the customers' satisfaction.

II. RELATED STUDIES

Some methods have been proposed by different studies to reduce congestions. A study by [8], proposed Artificial Neural Networks (ANN) which is a mathematical tool and was initially inspired by the functioning of the human brain in information processing. With accessibility to relevant historical traffic data, ANN was able to model the mobile network behaviour to predict the event of network irregularities [8].

A study by [9], used some kind of optimization techniques to reduce congestion problem found on the GSM network in Nigeria. Here, the study claimed that to reduce the problem of congestion, the following needed to be done which are; implementation of dynamic half rate decoding, national roaming agreement between operators, regionalization and merging of GSM networks. The load balancing algorithm is one of the techniques that reduce congestion for better network performance. The technique used in the study provides re-routing algorithm to reduce the congestion totally.

A study [10], worked on dynamic channel allocation model with one-level buffering for congestion control in GSM network with the aim of preventing loss of calls and degradation when it comes to the quality of service of calls. The technique employed was based on Markov chain. The study employed the object-oriented principle to determine the robustness of the scheme using three performance metrics: resource utilization, average queue length and blocking probabilities. The outcome of the results from the model shows that the proposed scheme in the study has better performance benefits over fixed threshold techniques. Although, Markov chain is a powerful technique the author failed to provide an algorithm to re-route the calls (loads) to reduce congestion.

Some studies have worked on either Base Station Controller (BSC) level only or both BTS and BSC of the network [11]. For example, a study [12], evaluated the performance of GSM-1900 BSC utilization using eight months daily traffic data and established peak hour for the network. The performance indicators used are peak hour traffic, TCH mean holding time, TCH Utilization, congestion on TCH, drop a call on TCH, congestion on CCH and drop a call on CCH. The work showed that traffic increase from Monday through Friday and forecasted traffic over time using regression analysis. Also, [13] used network accessibility, service retainability and network coverage to evaluate quality of service (QoS) on BSC of four GSM networks in Nigeria. The result in this work revealed that the QoS of GSM network is not reliable [11].

A study [14], combined two techniques; dynamic load balancing and call admission control (CAC) to re-direct calls to cells that are less busy within a BSC area. The two techniques were executed using JAVA program and real-life call data record (CDR) were obtained from Globacom Nigeria Limited. To measure performance result, the Probabilities of New Call Blocking and Handoff Call Dropping (NCBP and HCDP) were used [14]. The two probabilities were computed for CAC and the combined scheme. The output got showed that there is a significant decrease in the values of NCBP and HCDP of cells considered for the new combined scheme when compared with that of the CAC only. However, this technique can only work in clusters with many BTS. Some cells in the BSC area will still be busy while some will still be idle if load balancing scheme cannot achieve the balances within the shortest time.

Therefore, this study proposes an Assembly Line Balancing (ALB) algorithm to ensure even distribution of loads (calls) to reduce congestion for better GSM network performance. The technique made use of re-routing algorithm to totally reduce congestion.

III. SYSTEM DESIGN

The quantitative measure of assembly line balancing is used to ensure that no server (node) is overloaded or heavily loaded. This method enhances the load balancing scheme to achieve the best load-server distribution. This load-server distribution solution is based on Server Processing Time (SPT), and Server Ground Score (SGS) is some calls (loads) already allocated to a server. While the Composite index of Variation value (CV) allows the consideration of both SPT and SGS. The diagram in figure 1 depicts the proposed system for implementation using JAVA platform with abstract call data record which will be taken from (UCI) data repository.

The time taken by the server to process a call is T and value of T_t is calculated by adding all call processing times and dividing it by n [15] which is shown in equation 1. This is an ideal SPT for every server in the system to achieve a zero balance delay.

$$T_t = \frac{1}{n}\sum_{i=1}^{n} t_i \qquad (1)$$

Where t_i is the time taken to process load, T_t is target/ideal SPT and n is the number of servers.

After the calls have been distributed to servers, the difference in SPT can be achieved based on the load-server assignment solution for n [15]. So the value of DT is calculated as it is shown in equation 2.

$$DT = \frac{1}{T_t}\frac{1}{n}\sum_{i=1}^{n}(T_a - T_t)^2 \qquad (2)$$

Where T_a is the actual SPT, DT is the normalized difference in time of SPT.

The value of Y_t is a target SGS for each server to achieve maximum SGS balance [15]. This can be calculated as shown in equation 3.

$$Y_t = \frac{1}{n}\sum_{i=1}^{n} y_i \tag{3}$$

After the loads (calls) have been distributed to individual servers, the value of Y_a is calculated by adding y_i for all loads assigned to a server [15]. Difference in loads assigned to a server is DY which can be calculated in equation 4.

$$DY = \frac{1}{Y_t}\frac{1}{n}\sum_{i=1}^{n}(Y_a - Y_t)^2 \tag{4}$$

Where Y_a is the actual SGS

The weight average calculated from DT and DY is CV which can be calculated using equation 5. The addition of weight value assigned to SPT and SGS must be equal to 1.

$$CV = WT \times DT + WY \times DY \tag{5}$$

Where WT is the weight in SPT, WY is the weight in SGS and DY is the normalized difference in load of SGS.

Therefore, SPT must achieve a zero balance delay while all SGSs must have an equal total number of loads (calls) based on SPT. The algorithm described in [14] is used to achieve the best load balance solution for congestion control in GSM network as shown in figure 2.

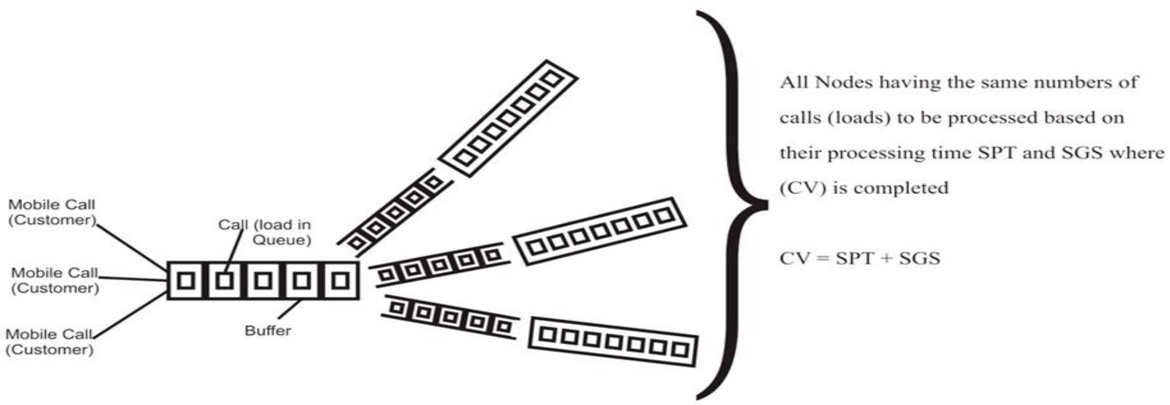

Fig1: Architecture for Proposed Congestion Controlled System

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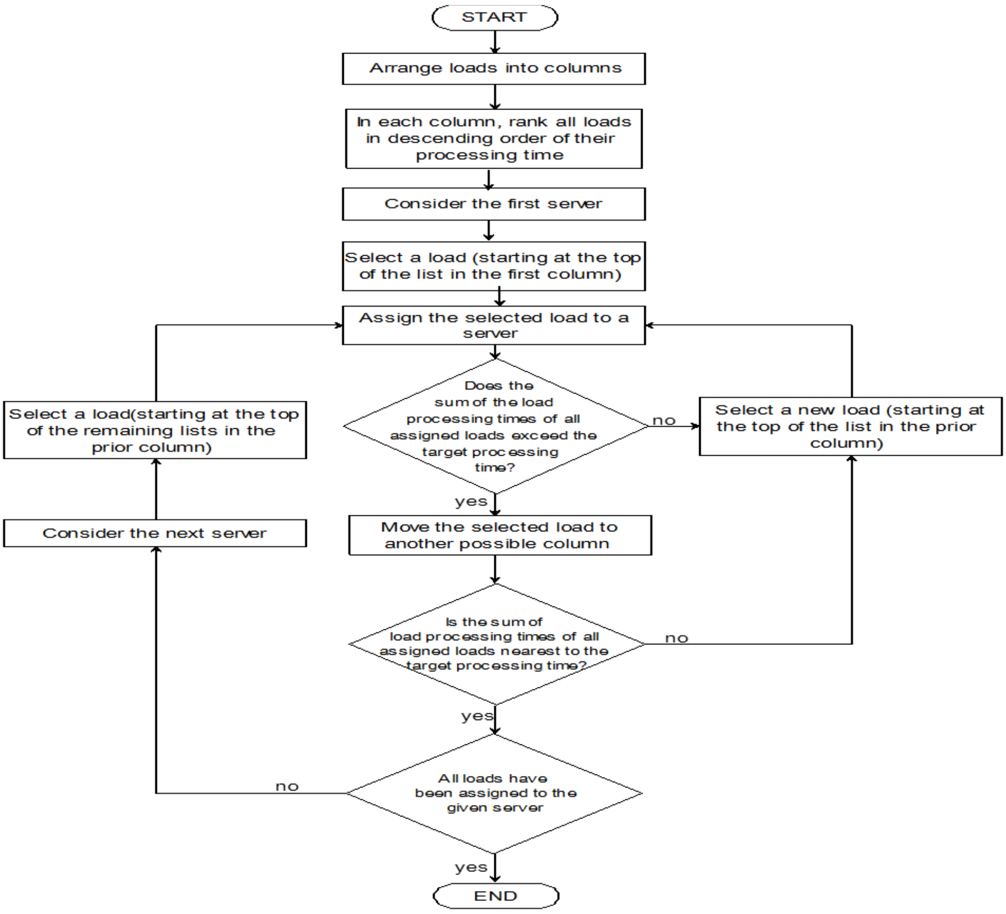

Fig 2: Heuristic Method of Assembly Line Balancing for Load Balancing Scheme [16]

Load balancing is achieved by computing CV to gather information about a server's status. The load will be re-directed (R_d) to the least loaded server. If any of the servers are heavily loaded, the decision variable in equation 6 shows how the load is re-directed to the least loaded server.

$$\begin{cases} 1 \text{ if the server (s) is heavily loaded, } R_d \text{ the load to least loaded servers} \\ 0 \text{ otherwise} \end{cases} \qquad (6)$$

Every new load is directed to least loaded server as it is shown in figure 3

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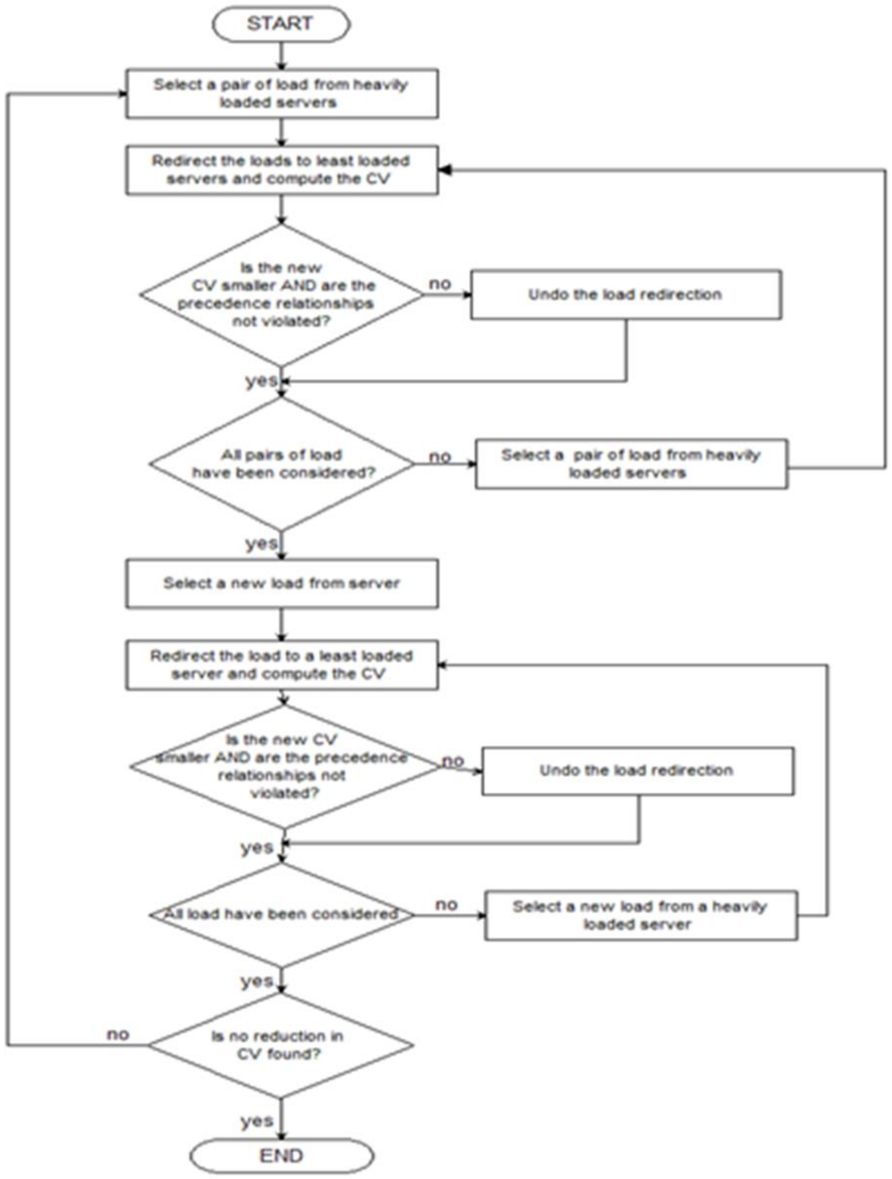

Figure 3: Flowchart for redirecting a new load to least loaded server (Adapted from [17])

IV. RESULT AND DISCUSSION

Java language implemented in the NetBeans IDE 8.2 was used. The graphical interface (GUI) is provided in figures.4 and 5 to show the simulation of load balancing among five servers used to test the system.

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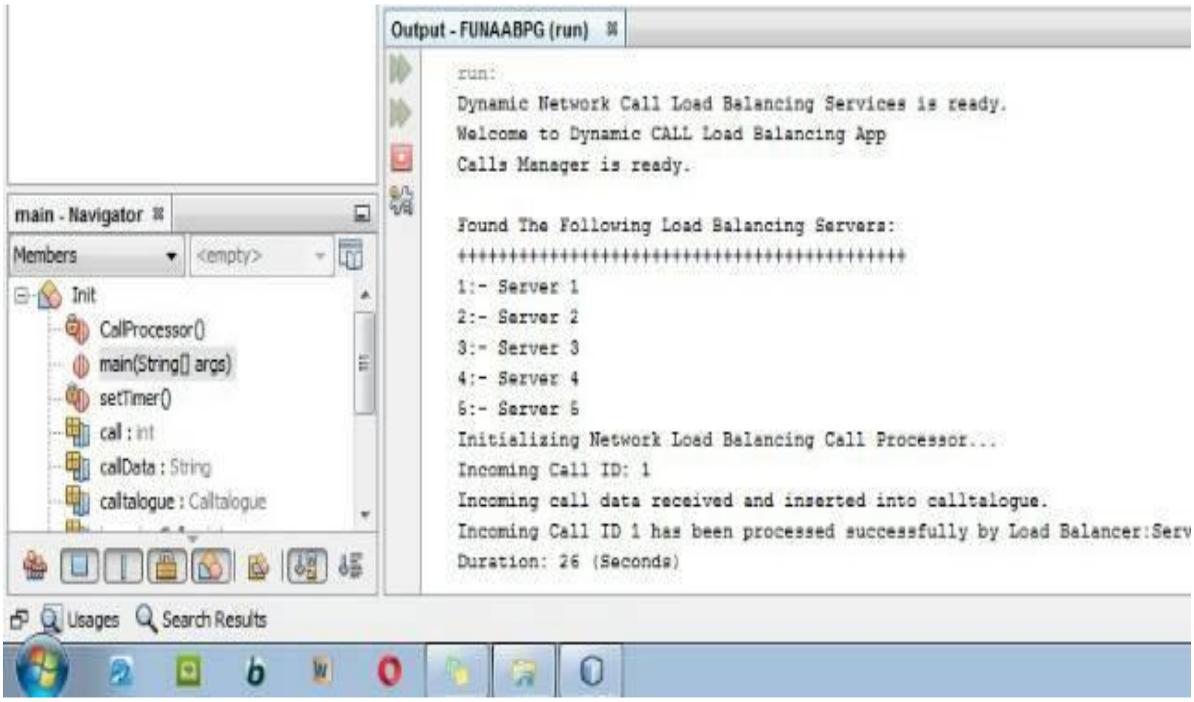

Figure 4: Logs of Load Balancing Activities

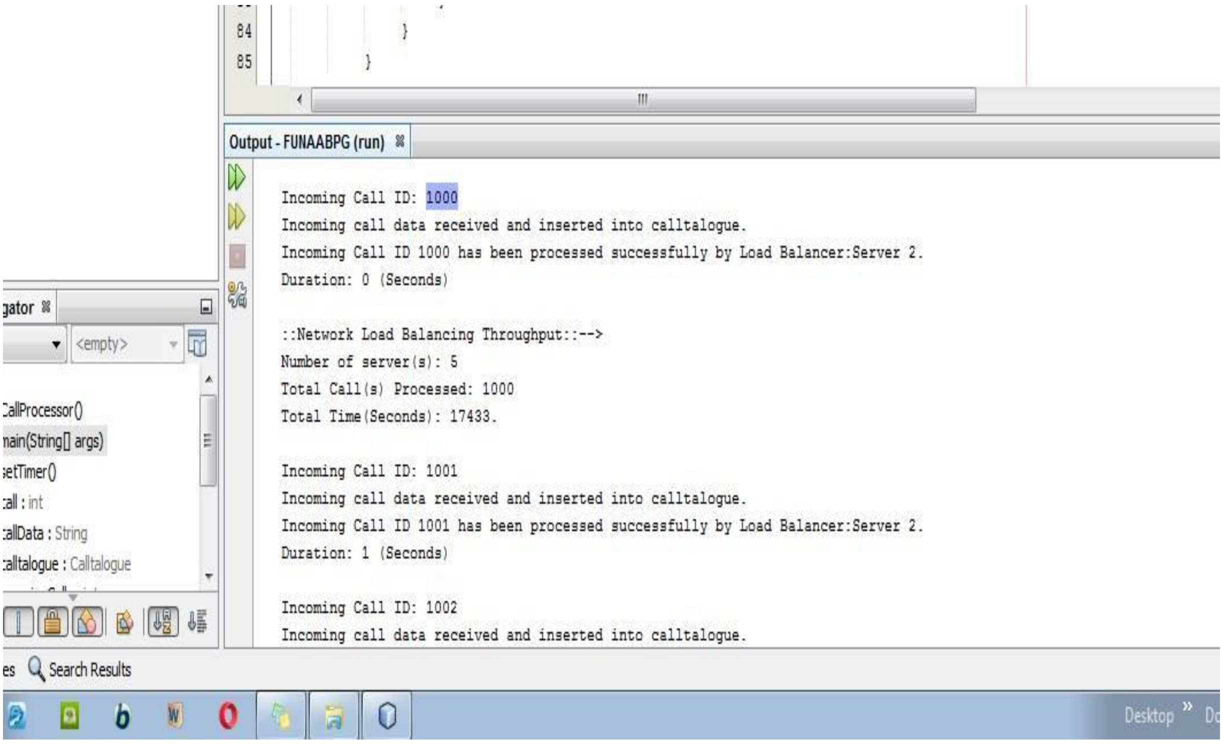

Figure 5: Logs of Load Balancing Activities

This study used five (5) mobile network servers to test the load balancing activity, the servers received some calls (loads) from different subscribers concurrently. These loads were evenly distributed among these servers, and the congestion was drastically reduced. The sample of load balancing simulation results was presented in table 1 to show the system throughput and system response time and Figure 6 depicts extracted data from load balancing simulation.

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Table 1: Sample of load balancing simulation result

Call ID	Response time (seconds)
400	4
401	1
499	5
500	2
1000	1
1001	1
1002	1.7

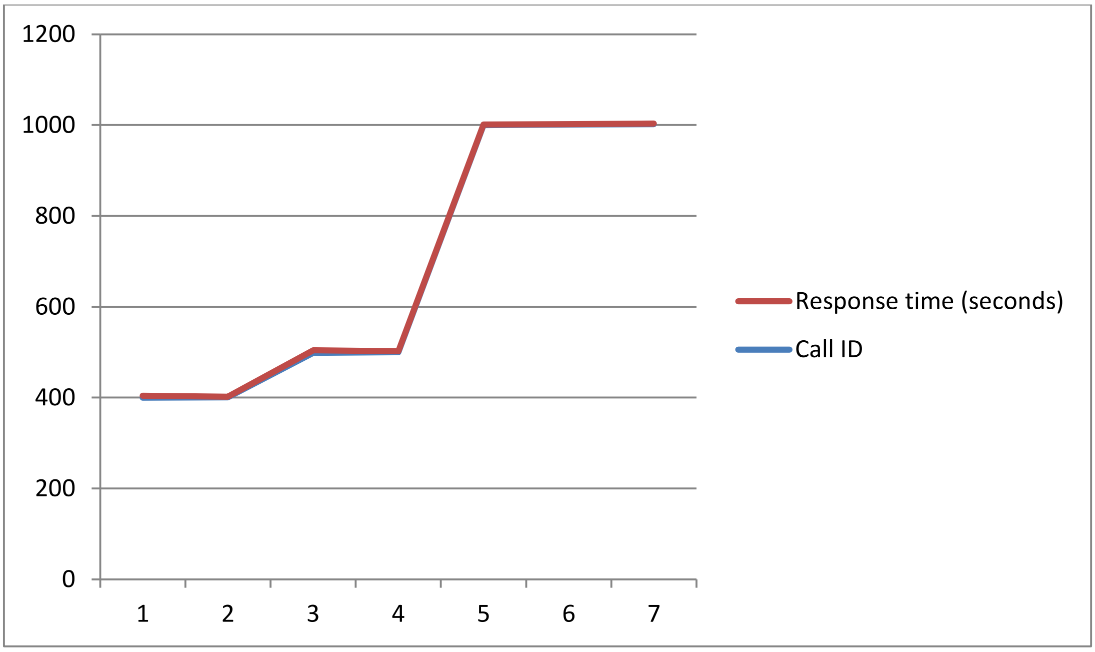

Figure 6: Chart depicts extracted data from load balancing simulation result

The results of load balancing simulation show that the maximum amount of time that servers used to process incoming call is 5seconds while sometimes they used 1seconds to process some calls. It was ascertained in this study that assembly line balancing for load balancing process reduced the congestion on the mobile network and also reduced the number of time that a subscriber used when a call is sent to a Base Station.

V. CONCLUSION

Load balancing scheme is one of the techniques that can reduce congestion, the assembly line balancing used in this study reduced the congestion that prevents call loses and dropped call. This study concluded that congestion would always occur in a distributed computing if there is over-utilization of a particular resource (heavily-loaded) while some resources are under-utilized (idle). The load balancing scheme with appropriate re-routing algorithm is therefore proposed as the solution for decongestion to enhance the performance of the mobile network.

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