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Hybrid Tier-4 IoT fog orchestrated Data-Center Design for Low Latency Diffusion in Nigeria Health Care System.

T.C. Ewunonu[1],S. U. Nnebe[2], V.E. Idigo[3] andB.I. Bakare[4]
[1](Department of Cyber Security, Federal University of Technology,Owerri, Nigeria.)
[2,3](Department of Electronic &Computer Engineering, NnamdiAzikiwe University , Awka, Nigeria.)
[4](Department of Electrical Engineering, Rivers State University, Port Harcourt, Nigeria.)

ABSTRACT : *Day by day, information of any organization is increasing as the World is becoming paperless. Cloud based data processing is becoming popular especially in mission critical systems such as Health care. But there are some questions on how the data centers that are imagining will be shaped. What elements and standards of data centers will be maintained to attain future data demand? How to cope up with ongoing technological changes and increasing scalability? 2N+I hybrid Tier 4 robust and recursive two-layer design in the reengineered recursive routing chain architecture RRCA-Restful-Application Programmable Interface(R-API) transactional network model for fully redundant infrastructure cloud data Centre networks is therefore proposed for low latency diffusion. High speed switching is realized with a multi-protocol label analytic controller (MLAC) and virtual logical aggregation network (API) segmentation. The Hybrid Tier-4 fog orchestrated IoT Data-Center enables health care system Fog layer devices to transmit sensed data streams into the Cloud data centers housing an expert system for deterministic processes. Transactional process scalability issues, network process convergence and downtime, transactional process latency, throughput and network congestion are highly improved efficiently as quality of service is enhanced.*

KEYWORDS: *Data Center, Health Care System, Fog Orchestrated, Network Scalability, Latency Throughput*

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I. INTRODUCTION

Data center can be said to be a physical environment facility intended for housing computer systems, associated components and staff that maintains them. The necessary physical environment facility encompasses power supplies with the possibility to ensure backup power, necessary communication equipment, redundant communication cabling systems, air conditioning, fire suppression and physical security devices for staff entrances. It may be said to be an infrastructure comprising of large number of servers interconnected by a network. Data centres are classified according to uptime as Tier1, Tier 2, Tier 3 and Tier 4 [1]. A Tier 4 data center is an enterprise class data center with redundant and dual-powered instances of servers, storage, network links and power cooling equipment. It is the most advanced type of data center tier, where redundancy is applied across the entire data center computing and non-computing infrastructure. A Tier 4 data center is also known as a Level 4 data center. A Tier 4 data center combines and exceeds features and capabilities of all preceding data center layers. It provides end-to-end fault resistance by deploying and maintaining entire data center infrastructure duplicates. It is the last level/tier of data centres introduced by the Uptime Institute. Being an enterprise class data center, Tier 4 data center guarantees 99.995% availability with just about 26.3 minutes of downtime per year. This being said, it is obvious that the highest Tier to be defined, which is the Tier 4, represents the highest level of performance [2]. Altogether, of the many advantages provided by a Tier 4 Data Center, a significant feature is the Fault-tolerant functionality. This enables the site infrastructure to sustain unplanned failures that would otherwise adversely affect the critical load. The Tier 4 classification indicates the most robustly designed data center to be found thus making a Tier 4 Data center the most obvious choice for corporations globally [3]; [2].

But with the emerging diverse applications in data centers, the demands on quality of service (Qos) have also become diverse, such as high throughput and low latency of deadline sensitive flows. QoS management schemes is needed to have been explored for the survivability of cloud computing and Internet of things (IoT) clusters. With the ever increasing proliferation of smart devices in today's world, together with an exponential rise in wireless data demand, network usage is already creating significant burden on existing cellular networks. There is a near absence of optimal handling algorithms for IoT node joins or exits in clusters in Tier 4 Data centres thereby affecting QoS managements and latency especially when deployed in a health care system (HCS) environment [4]. Data center networks are expected to enable massive connectivity for a wide range of applications. The traditional way of providing security services for data center is difficult to support these applications flexibly and effectively. This implies that supporting security services will inevitably result in the additional networking operations and complexities, imposing the extra network end-to-end delay and latency. To support the latency critical service, in existing current data center systems, there is need to employ an hybrid enterprise class data centre tier with improved redundant and dual powered instances of servers and fog orchestrated computing modeling facility. This paper therefore presents a Hybrid Tier-4 fog orchestrated IoT Data-Center Design for Low Latency Diffusion in Nigeria Health Care System.

However, Data centers can be classified in different aspects depending upon characteristics. Based on the destination, there are four different type of datacenters[5]: Corporate data centers, Web hosting data centers, providing computer infrastructure as a service, Data centers that provide Turnkey Solutions and Data centers that use the technology to Web 2.0. Data Center energy expert Jonathan Koomey identified four types of data centers [6]viz: Public cloud providers (Amazon, Google), Scientific computing centers (national laboratories), Co-location centers (private 'clouds' where servers are housed together) and 'in-house' data centers (facilities owned and operated by company using the servers). To evaluate the quality and reliability, Data center standard are measured [7]. This standard also indicates the hosting ability of a data center. The Uptime Institute (https://uptimeinstitute.com) is the IT industry's most trusted and adopted global standard for the proper design, building and operation of data centers as backbone of the digital economy. Uptime Institute tier standards provide a data center classification as follows: Tier 1 data center (99.611% minimum uptime), Tier 2 data center (99.741% minimum uptime), Tier 3 data center (99.982% minimum uptime), and Tier 4 data center (99.995% minimum uptime). The data center tier levels, requirement and utilization places are [8] shown in the table l:

Table1: Data center Tier levels[8]

Tier Levels	Requirements	Applications
1	• Single non-redundant distribution path serving the IT equipment • Non redundant capacity components • Basic site infrastructure with expected availability of 99.671% • Annual downtime 28.8 hours due to site	Utilized by small Businesses
2	• Meets or exceeds all Tier 1 requirements • Redundant site infrastructure capacity components with expected availability of 99.741% • 99.749% Uptime • Partial redundancy in power and cooling • Annual downtime 22 hours due to site	Utilized by medium Businesses
3	• Meets or exceeds all Tier 2 requirements • Multiple independent distribution paths serving the IT equipment • All IT equipment must be dual-powered and fully compatible with the topology of a site's architecture • Concurrently maintainable site infrastructure with expected availability of 99.982% • No more than 1.6 hours of downtime per year • N+1 fault tolerant providing at least 72hours power outage protection • Annual downtime 1.6 hours due to site	Utilized by larger Businesses
4	• Meets or exceeds all Tier 3 requirements • All cooling equipment is independently dual-powered, including chillers and heating, ventilating and air-conditioning (HVAC) systems • Fault tolerant site infrastructure with electrical power storage and distribution facilities with expected' availability of 99.995% • 2N+ I fully redundant infrastructure (the main difference between tier 3 and tier 4 data centers) • 96 hour power outage protection • Annual downtime 0.4 hours due to site	Utilized by Enterprise Corporations

From the table 1, Tier 4 design requires double the infrastructure of a Tier 3 design. Tier 3 and Tier 4 data center specifications require IT equipment to have dual power inputs.

II NON-RECURSIVE TRADITIONAL DATACENTER NETWORK ARCHITECTURE

All online services and Web application sits on datacenter network for availability network services and data. Two common underlying networks Infrastructure for e-health application performance efficiency are e-health datacenter network architecture and e-health process Network Topology. Datacenters are the foundations that support every applications and enterprise operations in e-health systems. In fact, they are large-scale and have data-intensive communications, but the main challenge is how to build a robust scalable but secure cloud based network availability model that delivers significant aggregate bandwidth and excellent quality of service (QoS) for e-commerce platform. As revealed in literature, most efforts geared towards the following architectures; Fat-tree, Monson, DCell, BCube, Fincom, VL2, DPillar and DCCN, have been used in recent years based on their switch and server centric classification for e-commerce operation **[**9**]**.In context, the physical network topology of most legacy process networks is typically organized as a three layer hierarchy illustrated in Figure 1

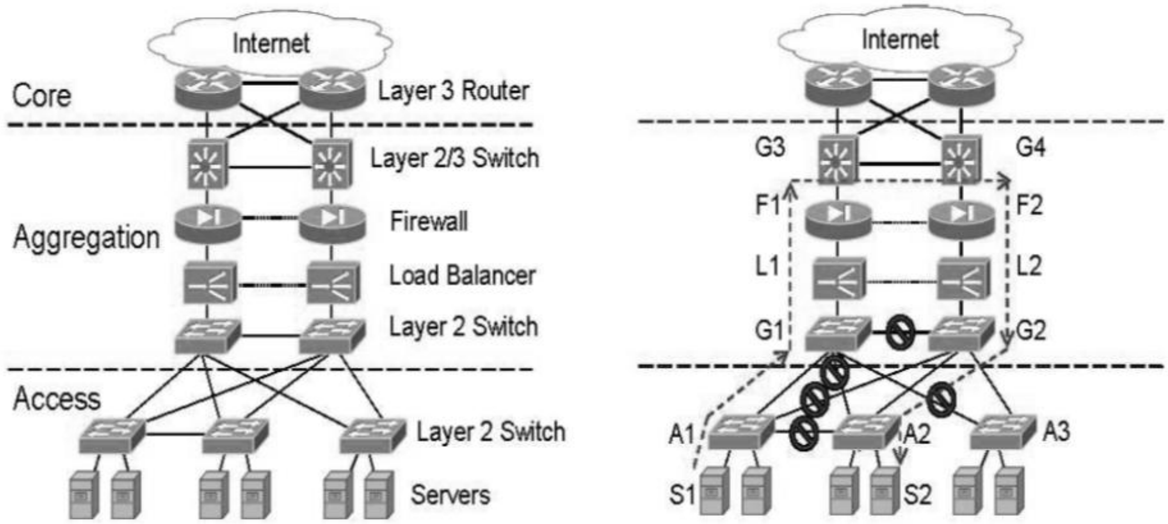

Fig. 1: Three-layer legacy process topology including Firewalls [9]

As in Figure 1, the process network model comprises e-access switches, e-aggregation switches and e-core switches. The e-access switches are connected to the backed e-servers such as database servers, application servers and web servers. The aggregation switches are used for the aggregation of the access switches while the core switches provide routing to and fro the enterprise core network. In designing a data center network using three-tier design model, the main consideration is scalability since it is based on hierarchical design. Hence new aggregation switch pairs are added with no need to modify the existing aggregation pairs. In this model, full mesh is not required as data center core switches do the routing. From the legacy process network topology layout above, its limitations could be summarized as follows [9]:

2.1 Transactional process Scalability Issues

The rapid growth of online/web services and applications that runs on e-commerce networks makes scalability a key design factor for all modern networks. A scalable process network has the potential for incremental expansion by adding more e-servers into the already operational structure without affecting the performance of the already existing running e-servers. Legacy e-health process networks are not scalable. Hence, when the number of e-commerce application as well as its end users increases, the network will either be congested or break down entirely.

2.2 Transactional Network process convergence and downtime

Legacy e-health process networks have problems of convergence and downtime thereby affecting functional operations. Inadequate security could affect business continuity especially in cases of unavailability owing to downtime.

2.3 Transactional process Latency

In this case, this refers to the total time taken for e-health data packets to move from one location to another network location. The legacy e-health process network architecture generates over 30% network latency in e-switching and traffic delay thereby negatively affecting responsiveness to business demands and services.

2.4 Transactional Throughput

Throughput in commercial online transaction processing must have very high throughput especially with read, insert, update and delete intensive designs. Since the application is used by numerous IoT patient endpoints, the key aims of recursive in the context of e-health systems are availability, speed, concurrency and recoverability.

Throughput describes the capacity of a system to transfer data. Since the demand for data exchange is extremely large compared with other networks, the first design goal is to maximize the throughput. In cases where there are no retransmissions, maximization of the throughput is equivalent to maximizing the link utilization. The amount of bandwidth allocated to different types of packets affect throughput. Due to the bulky architecture of the legacy networks which results to about 30% network latency in e-switching, the overall throughput is negatively affected.

2.5 Transactional Network Congestion

These networks have variety of middle-boxes (e.g., Firewalls, load balancers and SSL off-loaders, web caches and intrusion prevention boxes) to protect, manage and improve the performance of applications and services. Existing networks have limited supports for middle-boxes. Hence, a typically overload of path selection mechanisms that compels traffic through the desired sequences of middle boxes placed on the network path is unavoidable. These create unnecessary bottlenecks and congestion.

Thus, from reviewed literature on few existing Data centre networks for e-commerce systems, no particular network scheme or system has proved to be most effective to suite the peculiarity of the mission critical systems and environment such as health care delivery. Hence, the current work will primarily develop a hybrid Tier 4 IoT fog orchestrated robust and recursive two-layer design in the reengineeredRestful-Application Programmable Interface(R-API)transactional network model for network availability. This comprises the IoT user account domain, access/virtualization layer and hybrid speed redundancy layer. The advantages of two-layer legacy process model design include:

i. The number of devices used is greatly reduced which offers significant security on the network as well as simplifies device management, reduces the number of system failure points, and allows tighter security control.
ii. Design simplicity due to fewer switches and so fewer managed node.
iii. Reduced network latency since the number of switch hops has been reduced.
iv. Reduced network design oversubscription ratio.

III MATERIALS AND METHOD

The core materials and tools employed in the research include e-access switches, e-core/e-aggregation switching modules, multi-protocol label analytic controller (MLAC), Virtual machines (VM) and IoT Edge sensors.

The existing three layer Data centre (DCN) process network model was reengineered to two-layer process network model and integrated into the development of the proposed recursive routing network (RRN) system to ensure network availability. The e-aggregation layer is embedded into the e-core layer exploring port density, aggregation throughput and over subscription requirements. In this case, the e-access switches that are used for e-server connectivity are mapped in high density e-core/e-aggregation switching modules. These e-switches offer the switching and routing functionalities for access switching interconnections and the various server virtual local area networks (APIs).

Hence, the proposed process network model has the e-aggregation of access switches at the e-core layer instead of the normal e-aggregation layer similar to the three-layer design model. This aggregation of the e-access switches at the core layer allows for more flexibility and easier support for secured virtualization. However, for the two-layer network model, the connection between aggregation switch pairs is fully meshed with high bandwidth so as to avoid bottlenecks in the network.

3.1 Model Design formulation

Let Recursive-DCN be an acronym chosen for the reengineered R-API transactional DCN. Recursive-DCN was designed to have four subnets (subnet 1-4) which were called Recursive-DCN_{sa}, Recursive-DCN_{sb}, Recursive-DCN_{sc}, Recursive-DCN_{sd} interconnected as shown in figure 2, where *s* is a subnet factor for A1a, B1b, C1c, and D1d such that s > 0. Each Recursive-DCN uses High Performance Computing (HPC) servers and a Multi-Protocol Label Switch (MLS) layered in recursively defined architecture following DCell formation. Since the reengineering of Recursive-DCN is for efficient web application integration, only one (4-port) MLAS and few servers are needed. So, four subnets are chosen as in Figure 2. Virtual server instances are enabled on the HPC servers in the network.

Servers in each Recursive-DCN_s are connected to MLS port corresponding to it, and owing to the running virtual instances V*i*, a commodity 4-port switch with 40GB/s per port serve the design purpose. Also, each of the Recursive-DCN_s is interconnected to each other through the MLAS ports. The HPC server used in this work has two ports for redundancy (in Gigabytes). Each server is assigned a 2-tuple (a1, a0) in consonance with its ports (a1, a0 are the redundant factors) together with a API ID (1 to 1005). Cisco Ws-C3560-44Ps-E IOS version 15.2 was leveraged for MLAS used in this work; hence, the number 1005 is the maximum number of API that can be created in it. The switch is a multilayer commodity switch that has an open-flow capability.

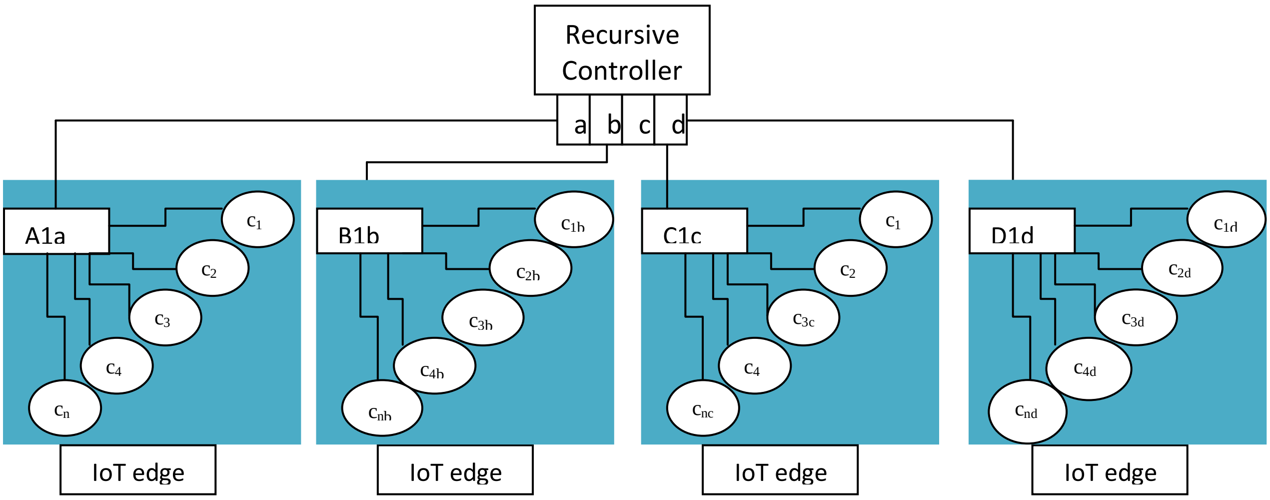

Fig 2: Re-engineered R-AP transactional IoT model (Computational Analytic service)

This open-flow capability together with its API capability was leveraged upon to improve the overall data center network security. Each server has two links in Recursive-DCN$_s$. One connects to an MLAS, hence to other servers within its own subnets. The other server connects to a server in other Recursive-DCN$_s$ through its API segmentation. This is as shown in figure 3. Recursive-DCN$_s$ servers have virtual instances running on it and are fully connected with every other virtual node in the architecture.

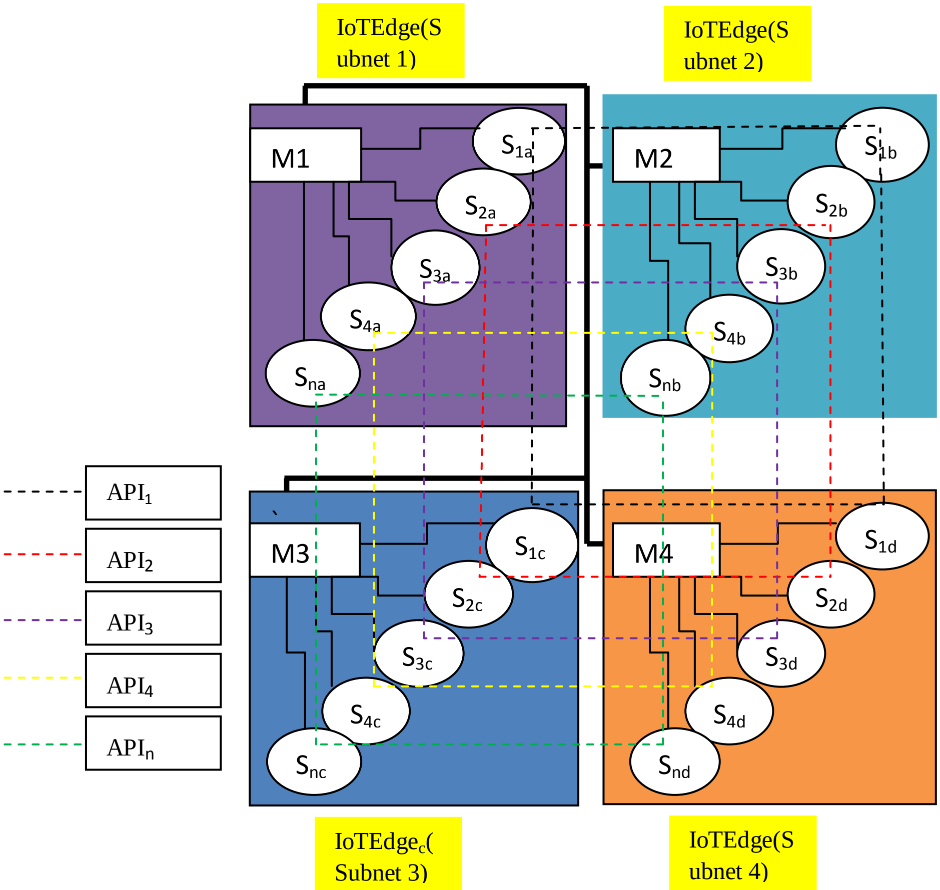

Fig. 3: Recursive-DCN Logical architecture with Secure R-API Mapping

IV RESULTS AND DISCUSION

4.1Cloud Data Stream Bandwidth Utilization

From the Edge Fog application perspective, data stream bandwidth utilization deals with the network capacity to transmit data from the fog orchestrated edge data centre to the cloud. Compared with the traditional tier 4, 3 layer infrastructure-DCell TCP algorithm and LaSDaAoptimization algorithm and 2 layer model recursive routing chain algorithm RRCA, bandwidth is optimally utilized in the proposed Hybrid Tier 4 Data centre-TCP. Figure 4 shows the Plot of IoT Data stream bandwidth availability for the traffic workload. In the proposed scheme, when the number of IoT edge devices is between 200 and 2000, it was observed that the oscillatory trends tend to be stable as the average number of edge devices used per unit of time increases gradually. The trend indicates that the system bandwidth utilization capacity is considerably high especially with the hybrid 2 layer model TCP R-API algorithm. Therefore, the system can do more processing using recursive routing Algorithm-TCP compared with other algorithms. The maximum bandwidth utilization profiles for 2 layer recursive routing chain algorithm (RRCA)-TCP (R-API), 3 layer DCell-TCP (R-API), and 3 layer LaSDaA-TCP (R-API) are 82.2%, 16.57%, and 1.23% respectively. This shows that the proposed 2 layer RRCA algorithm DCN can carry substantial data streams and be stabilized at the maximum workload.

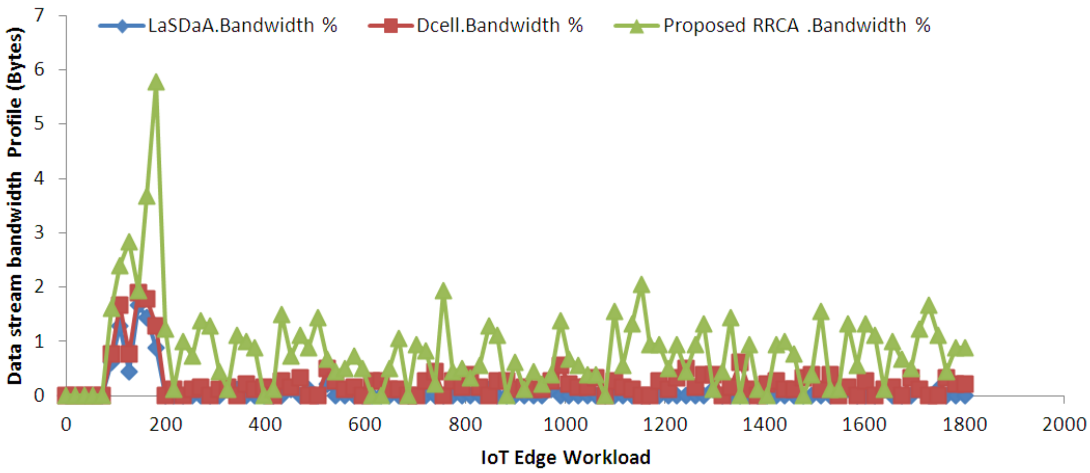

Fig. 4: IoT data stream bandwidth Vs Edge Workload

4.2 Cloud Data Congestion Profile

In Figure 5, congestion fault tolerance refers to the ability of the system to withstand queuing jobs or workload without crashing. With too many traffic workloads from end-users, the effects of the introduced algorithms were investigated. Looking at the proposed scheme, when the number of IoT edge devices is between 200 and 2000, it was observed that the congestion profiles for RRCA-TCP (R-API), DCell-TCP (R-API) and LaSDaA-TCP (R-API) gave 16.67%, 33.33% and 50% respectively. This implies that elasticity resulting from the auto-scaling algorithm reduced the effect of congestion to the barest minimum as shown in Figure 5.

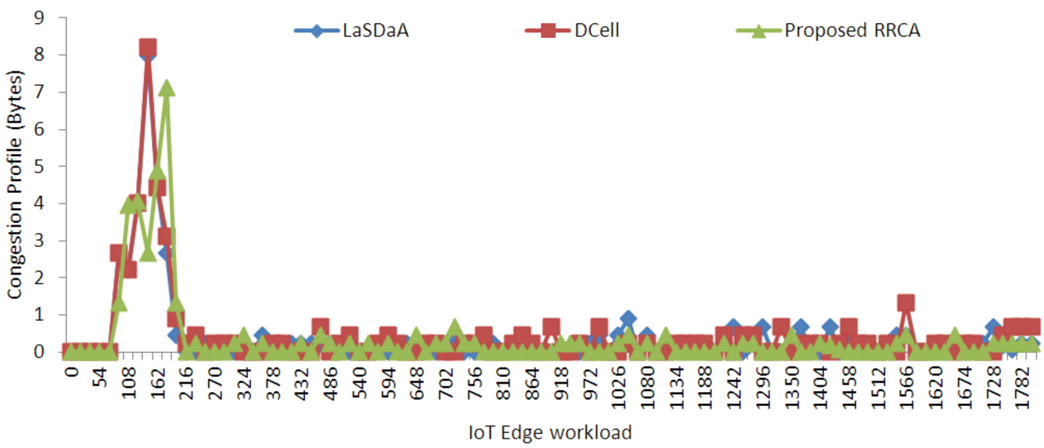

Fig.5: IoT Edge data stream Congestion Profile

4.3 IoT Edge-to-Cloud Data stream Latency

Figure 6 shows the plot of the IoT edge data stream latency profile against the traffic workload. Latency explains how fast the network is in packet/data stream delivery. From the Edge Fog application perspective, data stream latency deals with the bi-directional edge to Cloud traffic flows. Compared with both the IoT edge to Cloud Fog orchestration infrastructure optimization algorithm, a relatively low latency behavior was observed in the proposed 2 layer tier data centre RRCA-TCP. From the proposed scheme, when the number of edge devices is between 200 and 2000, it was observed that the latency profiles for the proposed 2 layer tier data centre RRCA-TCP (R-API), DCell-TCP (R-API), and LaSDaA-TCP (R-API) gave 10%, 30%, and 60% respectively. This shows that the proposed algorithm can carry substantial data streams and stabilize at the maximum workload in the Data centre Architecture.

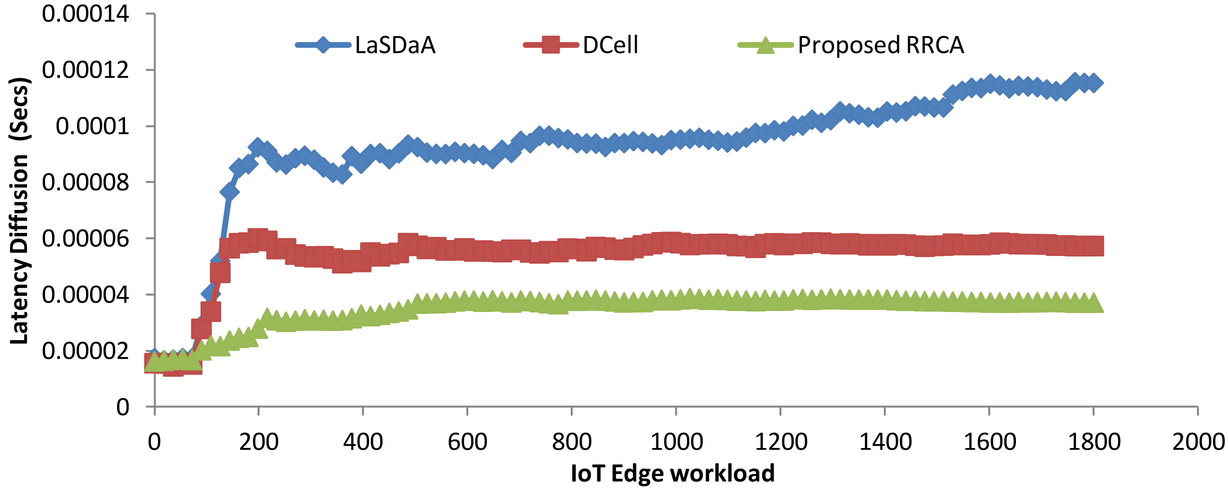

Fig. 6: IoT Edge-to-Cloud latency Profile

IV. CONCLUSION

This paper has presented an Hybrid Tier-4 IoT fog orchestrated Data-Center Design for Low Latency Diffusion in Nigeria Health Care System. The development of an efficient health management scheme and model occupies a central position to improving the health care system of developing nations. The observation that the common existing few models and schemes have limitations amplifies the need for their improvement. The system has shown to offer optimized resource utilization, scalability, maximized throughput and maintain low latency response even on heavy traffic workloads. This has made room for a robust hybrid data centre model for health care support system in context. For improved efficiency and quality of service management oftransactional process scalability issues,network process convergence and downtime, transactional process latency, throughput and network Congestion of these schemes, the improved Hybrid Tier-4 fog orchestrated IoT Data-Center is indeed a necessary strategy and scheme to explore.

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