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Implementation and Analysis of pCell Data Center In Ethernet Technology

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Abstract: **In this paper we present the implementation of the idea behind the pCell data center that receives and execute multiple requests at a single time unlike the conventional technology which is 1:1. The pCell is a radio based technology which is said to be impossible to implement in laboratory environment. Thus we have collaborated the essence of the pCell technology to its ancestor Distributed Input Distributed Output (DIDO) to architect a data center for an Ethernet based network. The aim is to conclude that working principle of the pCell data center can be recreated in laboratory environment. First we describe the architecture and then we present the experimental results which conclude the working of the created data center.**

***Keywords*—pCell; Data Center;DIDO; Ethernet**

I. INTRODUCTION

An exponential increase in the number of data users and the invention of numberless data hungry applications has produced an alarming need to find a solution for channeling and controlling data rate traffic. The statistics by the Cellular Telecommunication Industry Association (CTIA) i.e. submitted to Federal communication Commission (FCC) a dramatic dip in the data transfer speed in the next decade or two if the current technology is continued without any extraordinary changes [1]. The 4G does not seem to be able to deal with the pressure of the demand so the hopes of the future rely on Long Term Evolution (LTE) and 5G.

The simplest form of multiuser wireless system is MIMO (Multiple Input Multiple Output). Topology consisting of multiple transceiver stations is presented in the simplest form, N antenna connecting U users [2, 3]. MIMO technology is also presented as one of the breakthrough but it mainly emphasis on the propagation on data rather that processing multiple requests at the same time. The advantage of the de-centralized cellular architecture was explored in [4]. It showed that by enabling co-operation between base stations can enhance cell edge performance. It relies mostly on multileveled propagation path rather the changing the end node configuration. Thus contain many limitations depending on the geographical aspect of the settled topology. Also the spatial multiplexing gain is at most 4 times [5, 6].

Another technology that redefined wireless system was DIDO, which is also said to be implemented in mass production not in laboratory. It claims to provide full data rate to all user sharing the bandwidth of the spectrum. DIDO was proposed for unlimited number of simultaneous user and claimed to eliminate the interference between them using customized data center that receives multiple data streams simultaneously by Shannon fanon coding and different modulation techniques [7].

The pCell technology seems the cutting- edge technology to enhance the bandwidth usage and provide full bandwidth to the user with high speed [8]. The pCell cell formation is based on a SPR (Software Programmable Radio) which is impossible to be implemented in laboratory environment. Another attractive feature of the pCell architecture is the Data Center that accepts and processes many data streams at once [9]. The concept mentioned for pCell seems like the one mentioned for DIDO, which was its ancestor but the two technologies follow different approach to obtain multiple data stream processing. The pCell works on Virtual Radio Instance (VRI) that allocates an entire LTE protocol stack to user equipment. This forms the functional equivalent of dedicated LTE.

As any of the above technologies mentioned, other than MIMO, is impossible to implement in laboratory environment [8, 9], we propose architecture to recreate the working of pCell, inspired by both DIDO and MIMO. The routing protocol used is Enhanced Interior Gateway Routing Protocol (EIGRP) [10]. The data center working is recreated in Ethernet technology. The objective was to confirm whether the working technology of pCell data center can be recreated using components of conventional technology and analyze the working of the same.

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II. BRIEFING ON PCELL TECHNOLOGY

With the exponential increase in the number of mobile users seen every year it is now crucial to come up with the technologies that can provide good communication services at high speed. The pCell is one unique technology that stands out in this regard. While other technologies revolve around the need of avoiding intersection between cells, pCell harness that weakness of traditional technology and create a new cell at every point of intersection. The uniqueness and the completely different approach of this idea attracted our attention. Also being a new technology, i.e. launched in 2015, provides the huge potential of exploration.
The pCell technology synthesizes a tiny, personal cell for each LTE device thus delivering consistent high data rates and eliminating congestion. It claims to allow all equipped mobile devices within a pCell coverage area to each receive 100% of the available theoretical bandwidth capacity. As we are unable to achieve the VRI and SPR in laboratory environment we have concentrated our work on pCell data center that again, cannot be recreated in lab but its working result can be i.e. receiving and processing many data stream at once.

III. THE SYSTEM MODEL

The system model is Fast Ethernet topology following IEEE 802.3 standards.

A. UE(User Euipment)

Each UE group is connected to the network differently.

- PC0, PC1 and PC2 is connected to a switch via copper cable 100baseT Fast Ehernet. The switch connects the three UE to the network. As shown in Fig. 1, the UE GRP1consists of three UEs, PC0,PC1 and PC2.
- PC3 is directly connected to the network using copper crossover wire 100baseT Fast Ethernet.
- PC4, PC5 and PC6 i.e UE GRP2 is connected to a hub via copper cable 100baseT Fast Ethernet. The switch connects the three UE to the network.
- Laptop 0 is connected to a wireless router.
- All the later ends connect to routers.

B. Routers

The routing protocol used for the network is EIGRP (Enhanced Interior Gateway Routing protocol). It is especially designed by Cisco for the Cisco routers. It automates configurations and routing decisions.

 The level one router are multilayered i.e., R0, R1 and R3. All three uses NM-2FE2W module. They are connected to each other via copper cross overs. The whole configuration is connected to multilayer switch0.

- Level two routers are generic again using NM-2FE2W module. R23, R24, R25 and R26 are connected to MSwitch0, Mswitch1 via 100baseT copper FE.
- Router 1 is connected to wireless router via copper straight fast Ethernet (100baseT).

C. Multilayer Switches

Two 3560-24PS switches are used the network.

- MSwitch0 is connected to level 1 routers via 100baseT (copper straight FE). It is also connected to two servers, providing network security, DNS, NTP and HTTP services.
- MSwitch1 is connected to four servers via 100baseT copper FE that provide SMTP services to separate group of nodes.

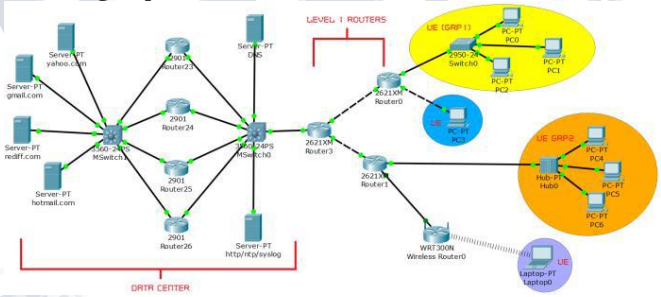

Fig. 1. Network topology

D. Summary of Topology

All the nodes are divided into groups. Each group is directly or via switch/hub/wireless router connected to a level 1 router. The level one router topology is connected to Mswitch0 which in also connected to two servers. Mswitch0 is connected to level 2 routers (4 routers). These routers are connected to Mswitch1 which is then connected to 4 severs.

IV. DATA CENTER ARCHIETECTURE

The topology from Mswitch0 to the four servers is serving the purpose of the data center. The whole architecture is inspired by MIMO, DIDO and pCell.

A. Architecture

The data center of pCell can be understood as an array of antenna with multiple server in which each antenna is communicating to one antenna at other end. DIDO is quite same as that but it talks about one server processing only.

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The recreation of pCell data center can also be taken as a recreation of DIDO data center as they both serve the same purpose i.e. receiving and processing multiple streams of data simultaneously. But here as we have used many server which fits the understanding version of pCell (It actually is one server only with different protocol for each UE thus giving the illusion on one server each UE).

We have used EIRGP routing to route the data path in such a manner that each data stream follows a certain path. For example, the data stream from group1 of nodes i.e. R0, R1 and R3 will travel to yahoo.com server via R23. In similar way R3 is routed to gmail.com via R24, Group2 of nodes including R4, R5 and R6 is routed to rediffmail.com via R25 and Laptop0 is routed to Hotmail.com via R26.

Each server can communicate to each other to ensure that there is a connectivity of services between all nodes. The autonomous number of the group of nodes is different for every node to generate simultaneous packets from different nodes at the same time during simulation. Email service is activated in each node to enable SMTP services. The outgoing and incoming server is assigned as same the node is routed to.

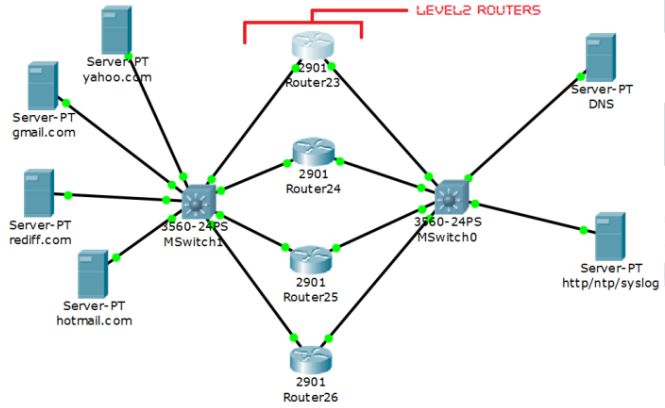

Fig. 2. Data Center topology

This allows the multiple data streams to enter the Mswitch1 and then goes to respected server for processing. Thus four interconnected server's captures and process the data simultaneous. Thus the working of pCell data center is recreated. Accordingly, a detailed comparison amongst the existing pCell network topology and the proposed architecture has been presented in Table. 1 [9].

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pCell Sample Network	Proposed Ethernet Architecture
pWaves configured with a fibre interface.	PC connected via copper cross over.
LOS radios that connect to pWaves configured for 1000BASE-T (i.e., copper Gigabit Ethernet)	Wireless Router connected to laptop.
The uplink port of a 1000BASE-T switch that connects to pWaves configured for 1000BASE-T	The uplink port is connected to switch that connects to PC via copper straight through.
An Artemis Hub composed of 32 pWave radios that connect to up to 32 antennas through coaxial cables.	A hub connected to 3 PCs via copper straight through.
pCell data center can be understood as an array of antennas. Each antenna responds to one corresponding antenna formed by pWaves at intersection node.	Routing of multilayer switches and router is done in a way that path to each server is unique. Each UE group has its own service provide server. If we put the whole data center in a cloud it imitates as the pCell data center.

B. Limitations

The software used for creation and simulation of the network has customizable configurations but the simulation options were limited. It was a challenge to get an effective way to generate simultaneous messages from every node as there is still a time difference of milliseconds in the production of data packet. The packet density was not available in bits per second so the whole packet number at per node per density has to be taken into consideration.

To get the delay graph to actually figure out whether this model is better than the conventional one, we need a more powerful simulation tool. The work can be carried out in GNS3 software using Wireshark simulation.

V. SIMULATION RESULTS

The software used for design and simulation is Cisco Packet Tracer. The filters Used was SMTP with ICMP/ARP/EIRGP.

A. ICMP (Internet Control Message Protocol)

Ping Graph helps find and diagnose network problems by graphing ping times and estimated bandwidth available on multiple connections.

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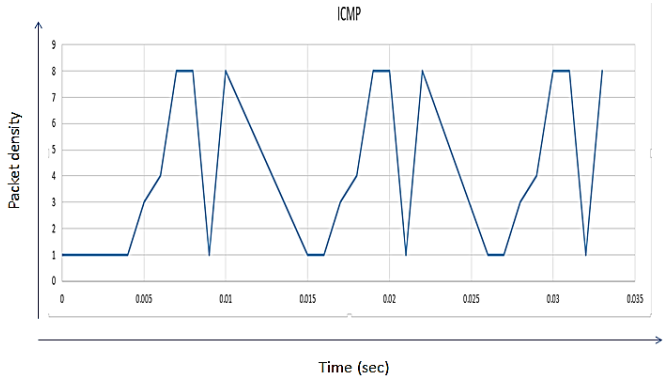

Fig. 3. ICMP graph of packet density v/s time

The periodic peaks show that the ping time is periodic for a group of nodes to similar connection and each group sends Message at single time.

B. ARP (Address Resolution Protocol)

ARP is used for translating IP address To Ethernet MAC address.

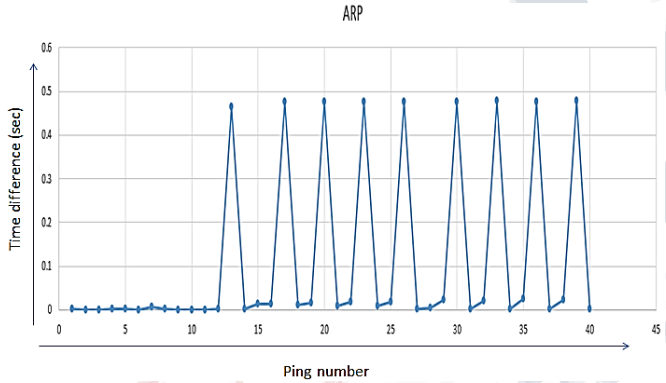

Fig. 4. ARP graph; Time difference v/s ping number

Peaks in ARP graph suggests that the routers are working properly and routing is being done periodically and the same time by a level of routers.

C. EIGRP(Enhanced Interior Gateway Routing Protocol)

Two EIGRP graphs were planned to be generated. First one is the Packet density graph to confirm the replication of working of pCell data Center. Second one was the delay graph which was not produced because of software limitations. EIGRP is the fastest routing technique which can also isolate nodes by assigning different autonomous number to the routes.

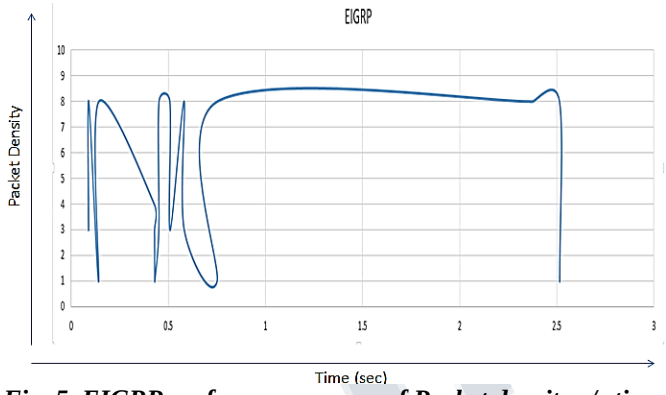

Fig. 5. EIGRP performance curve of Packet density v/s time

The Packet Density graph is generated between Mswitch1 packet density and time (sec). The high points in graph shows the number of packets going in and out of the switch at a time. Density graph at highest point at most of the time shows that the routing is being down in bulk thus showing recreation of many: many data center.

VI. CONCLUSION

After recreating pCell data center we have concluded that the working of pCell can be replicated in laboratory environment to some extent as using design inspiration from DIDO and MIMO. The customized data center is expensive to make as it contains many elements. The graph produced proved that the working result of the pCell data center is recreated but due to the limitation of the software used the performance parameters were not available. However, the work can be continued in other higher performance software. We are suggesting GNS3 as it will give precise delay. Thus, we conclude that it is possible to recreate pCell data center working result in Ethernet network. However, the worth and economical aspects can be judged after further research in the direction.

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