FOG COMPUTING BASED RADIO ACCESS NETWORK IN 5G WIRELESS COMMUNICATIONS

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***Abstract*— The requirement of 5G also known as fifth generation wireless is for the purpose of facing the huge levels of growth in the data traffic of mobiles and simultaneously reducing consumption of power. A heterogeneous network that has technologies with multiple access along with base stations that are large in number with the aim to increase the capacity and the coverage of the network. Management of spectrum, allocation of bandwidth, channel state information, routing of data, assignment of power transmission as well as management of energy are the basic operations of the network. Designs of allocation with cross-layer resources are utilized to improve the operations of the network. C-RAN or Cloud radio access network is a unit that is centralized and baseband unit or BBU which pools conflicts with signal processing of a large scale and edge catching. To avoid this issue, a cross-layer design based on F-RAN architecture is made use of. This provides communication in a peer to peer style between the end user and the data center. This technique also addresses issues in implementation with higher quality and better services for the users of mobile. The approach of Cross-layer design along with F-RAN has been tested with an NS2 simulator and was found that its performance was better than that of the AODV protocol.**

Keywords: Baseband unit, Centralized/Cloud platform, Distributed Environment, Edge caching, High Power Nodes, Fog computing based radio access network (F-RAN), Packet reallocation, Quality of services, Signal processing, User Equipment (UE).

I. INTRODUCTION

When compared with the wireless communication system of the fourth generation or 4G the 5G or the fifth generation might prove better in terms of quality like coverage of network, capacity of system as well as cost of infrastructure. In order to achieve this [6],C-RAN or the cloud radio access network is proposed combining technologies that have emerged from industries in information technology and communication through wireless by the incorporation of cloud computing into RAN or the processing or radio signals. C-RANs have faced challenges in the fronthaul that is constrained and BBU or the Baseband Unit pool. An important need for this processing is a fronthaul with inter-connection possessing low latency and high bandwidth. A fronthaul that is pragmatic is delayed most of the time which as a consequence decreases the efficiency of the energy gains and also the spectral efficiency.

In networks like these the control planes as well as the user are decoupled, HPN or High Power Nodes are evident and provision of seamless coverage are performed normally when the RRH or the Remote Radio Heads are used for the provision of data of high speed for the transmission of packet traffic inside the user plane. BBU pools and the HPNs are connected by means of backhaul links for the co-ordination of interference. C-RAN also possesses the trait of attaining a network quality that is massive.

Firstly, as the social applications that are based on the location become more well known the fronthaul data of traffic that is between the centralized pool of BBU and the RRh makes a surge of unwanted information which makes the constraint situation worse. The C-RANs fail to take advantage of the storage capacity and processing capability of the edge devices like the UE or the user equipment and their capacity of storage as well as the RRHs within the cluster-scale which is an ideal approach that can bring down the burden of the BBU pool and the fronthaul.

Adding to [2], the operators are in the need to employ a large number of RRHs as well as HPNs inside C_RANs to ensure that the peak capacity needs are satisfied and to avoid wastage when the delivery traffic is not as large as needed. To rectify this an evolution in the approach which includes radio access networks that are novel and architectures of networks with advanced technologies have to be used.

Fog computing is an environment that is distributed as it's the cloud computing's extension. This can bring a huge amount of communication, configuration, storage, control, management and measurement to the edge of any network instead of network channel establishment for utilization of cloud and storage [7], and this brings an extension to the old style of cloud computing to a network edge.

It has to be noted that this is also known as edge cloud computing, the one that moves the applications, computing content and the data away from the points in the center to the extreme points of the network that are logical. The network

access based on the fog has a virtual platform that contains a pool of resource for the end user. On the basis of fog computing the CRSP or collaboration radio signal processing is not only used in a BBU pool that is centralized or in C-RANs, but also in RRH and in user equipment that are smart. To support this effectively two smart UEs can be integrated on the CRRM or the cooperative radio resource management and also the on-device processing.

Further, [5], the objectives that are user-centric can be attained by a technique that can adapt from device to device or D2D, distributed coordination, wireless relay and centralized cooperation of a large scale. To bring in the edge devices of fog computing the RRH can be extended to the F-AP or the access point based on fog computing by equipping a caching, CRRM and CRSP capacity.

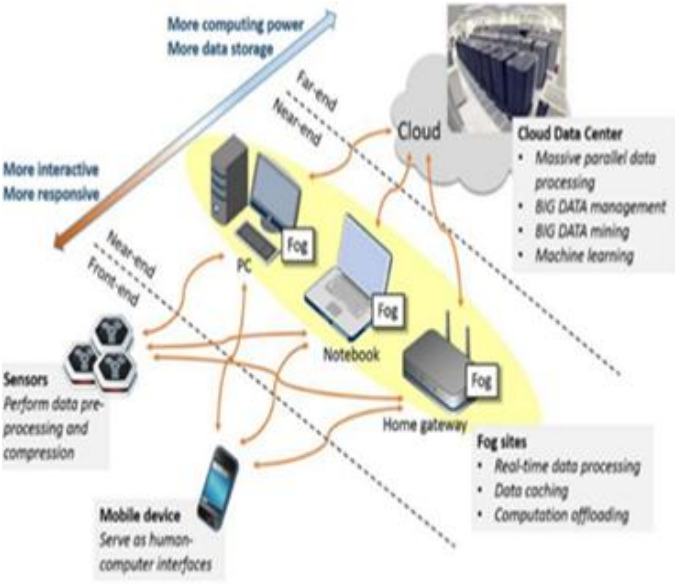


Fig. 1. F-RAN Network Architecture

A computing platform of mobile fog that can give a good portfolio of various applications and services has been made as a proposal. The design which is a large scale programming model and a service that is sensitive to latency within the access network of the radio. A F-RAN network and its architecture with an edge cloud have be seen as per fig. 1 and the simulation and its performance corresponding to this is shown as a result of the experiment.

II. FOG COMPUTING BASED RADIO ACCESS NETWORK (F-RAN) ARCHIECTURE

F-RAN architecture is here to overcome issues of C-RAN. It needs micro-clouds to enable the local processing unit's functions. As the implementation of fog computing is done it begets less complexity, awareness of location, less latency and better quality of services (QoS) [8].

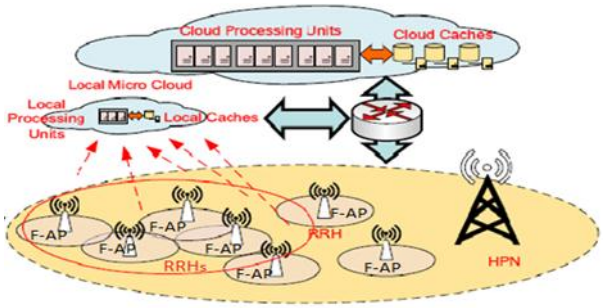


Fig. 2(a) Solutions for C-RAN Network Architecture

In these C-RAN architectures, the functions and storing of all functions of CRSP are done in a cloud server that is centralized and needs billions of UEs in order to make a transmission and exchange of data quickly to the BBU pool. These are control functions that are centralized and moved from the BBU pool from the C-RANs taken to the fog layer of HPN. At the same time some of the UEs access the HPN to bring down the burden that is on the fronthaul of the F-RANs. Also, two major worries are huge transmission and delay which leads to a burden on the C-RANs fronthaul. An easy way for F-RAN is by stopping transmission of the torrent of data which is sent to the BBU pool and do part processing of the signals in the local RRhs and also the smart UEs in the access layer. As per fig. 2(a), logic fog layer has communication that is distributed and the functions of storage.

A. Logical structure of F-RAN

The architecture of the F-RAN system consists of an outward physical layer, a network access layer and finally a cloud computing layer. Fig 2(b) clearly illustrates the F-APs and also F-UEs that are in the outward physical layer and finally the network access layer together, formulate a layer known as fog computing layer. In the physical layer, Adjacent F-UEs that are present in the physical layer are capable of communication with one another by means of D2D mode or the relay modes based on F-UE. In layer [8] of the network access, F-APs as well as HPNs are present. In case of the C-RANs, access to the HPN is made by all F-UEs for obtaining the relevant system information for signaling, that can complete the functions relating to the control plane. Further the F-APs are utilized for the forwarding as well as the processing of all the data received. They are further interfaced to the pool of BBU in the layer of cloud computing with the fronthaul links whereas on the other hand an interfacing is made for the F-APs to the pool of BBU using backhaul links that point out that the fronthaul links are in a larger scale and are duly processed in the pool of BBU and there is only a coordination that exists between the pool of BBU and that of the HPN that can be seen over the links that are backhaul.

In the logic fog layer, four different kinds of clustering of clouds exist. These are communications that are centralized globally, the storage cloud and the centralized and controlled cloud, the distributed and the logical communication cloud and finally the distributed and logical storage cloud. The storage cloud along with the distributed and logical storage cloud together isolate in the form of a centralized cloud present C-RANs [11], where the centralized control cloud is made use of

for the completions of the control plane functions that are within the HPNs. The logical communication clouds that are distributed within the F-APs and also the F-UEs are necessary for the local functions of CRRM and CRSP where the logical storage that is distributed denotes the caching and storing in edge devices

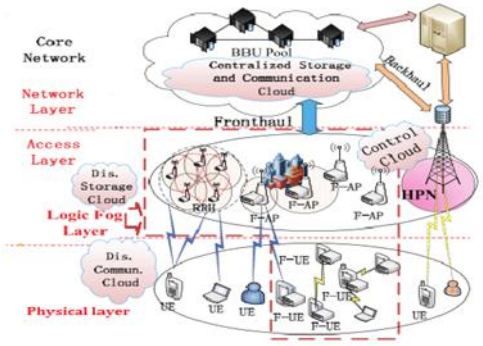


Fig. 2(b) Logical structure of F-RAN

For the avoidance of traffic that is offloaded in a direct way from the cloud server that is centralized, certain local traffic has to be delivered from the adjacent RRHs which is denoted by F-RANs and F-APs and sometimes smart UEs which are F-UEs in order to save the usage of the fronthausl that is constrained and bring down the delay in transmission.

B. Edge Cache Based Scheduling

The process of Edge caching makes the user closer to the content that is used for downloading speed improvement in the 5G network. This caching is a communication that is peer-to-peer that is shared between the RRHs in the cluster scale. The interference management here can give a high degree of transmission when there is low requirement for storage. When the ratio is higher hit the efficiency of the energy is derived by the capacity for caching and computing at the edge devices. Furthermore, it gives a quick access to content and its retrieval from the F-UEs by making use of the local micro cloud servers and caches.

C. F-RAN with Software Defined Network (SDN)

The cloud computing layer This is a work defined by software and has attributes of caching and centralized computing which can be derived from the C-RANs. All the units of signal processing may work with each other in huge BBU pools and further share the overall signaling of the F-RANs, the data rate of traffic, and also the channel information. Here the operator has to upgrade to the BBU pool in order to ensure that increase in capacity is well accommodated [21]. Implementation of the BBU pool is comparatively easier and the processing and scheduling for the coordination of inter-tier interferences that exist between HPNs or high power nodes and the RRHs/F-APs is completed based on the CoMP approach which is large scale and centralized. This type of centralized caching enables the storage of all traffic of the global packet.

The framework of fog computing helps to implement the concept of SDN in which the initial proposals of vehicular network takes place and the one that helps resolves problems related to vehicular networks, connectivity that can be intermittent, loss rate of high packets and collisions. A paradigm in networking and computing which is SDN is perhaps the most important of all topics that the IT industry has seen. Communication layers of data and control are separated here. Control here becomes a donating and centralized server, a communication path that is identified by the server is followed by the nodes. Implementation that is distributed may be required by the centralized server. As the SDN decouples both the control and the data planes by means of controllers and enables the independent design of the software from that of the hardware [10]. F-RANs as The RAN and the F-RAN that belongs to the 5G systems are sometimes ubiquitously converged along with SDN being the core network. With the integration of the CRRM procedure with that of the CRSP as edge devices that are within F-RANs the originally designed SDN controlling for the purpose of core networks that were wired is being extended not only to the physical but also to the network layer thereby ensuring the achievement of better control of network. The F-RANs and the SDNs have to make a definition of slices that need isolation of the CRRM and the CRSP in all the edge devices thereby providing networks that are not interfering to the different coordinators. For all the interfaces belonging to different devices that are highly flexible the SDN is nothing but the identification of a basic enabler in order to get the configurability and the flexibility of the F-RANs. More than this the SDN is an approach that is centralized and when F-RAN's prominence increases it impacts the manner of distribution of the edge devices. Therefore it is a major challenge to achieve in an F-RAN condition an apt SDN. The locations as well as the status of the devices have to be reported immediately to the SDN on the basis of which the decisions of the controllers of SDN can be effectively made as it has a heavy load on the fronthaul where the metrics of the F-RAN comes down.

D. Topology for F-RAN

There two different topologies for layers that are fog logical. The first one being a Mesh-like Topology and the second one a Tree-like topology. In the former, the multicast may lead to a higher coverage of network and in the latter this may not happen. The fronthaul links that are constrained in terms of capacity may be decreased by both of the cross-layer topologies. There is also a very high probability of the same link being shared by two or even more types of data flow.

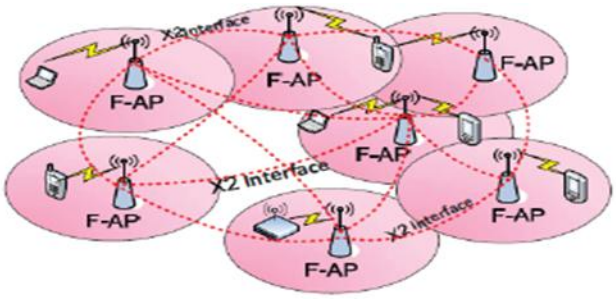


Fig. 2(c) F-RAN with Mesh-like Topology

Multicast capability compresses The flow of the unicast may be compressed into a single flow by compresses of a multicast capability thereby needing a rate of data that is much

lower [7]. Also, Fig 2(c) illustrates that in case of F-APs that are adjacent to each other an interconnection takes place and various new types of topology is formed for the implementation of the local distributed.

III. CROSS-LAYER RESOURCE ALLOCATION WITH F-RAN

Cross-layer Design is a modeling wireless networks with the same layering concepts as wired networks does not adequately address the significant differences between mostly-reliable wired links and mostly-variable wireless links. The concept of cross-layer design to mitigate the impacts of wireless links and transports feedback dynamically via the layer boundaries to enable the loss of services. The related techniques are essential in the design of next-generation wireless networks and useful for improve a quality of services. The optimal coordinated scheduling for F-RANs considering the cross-layer optimization of multiple objectives for the delay-aware circumstance is often complex because there is diverse interference among F-UEs with different transmission modes. Hence, an opportunity to extend these concepts to further explores physical-to-application cross-layer design [3].

The physical layer contains numerous of fog user equipments (F-UEs), which access to any other layer of cross-layer framework. The F-node is used to forward and functioning a packet from the layer to layer. With the use of SDN, F-RAN layer provide to mitigate the heavy load in the centralized cloud server and to minimize the power consumption. However, the data forwarding flow in SDN is highly at the internet protocol (IP) layer, and how to combine the functions of MAC and physical layer in F-RANs is not moving straightforward for edge devices.

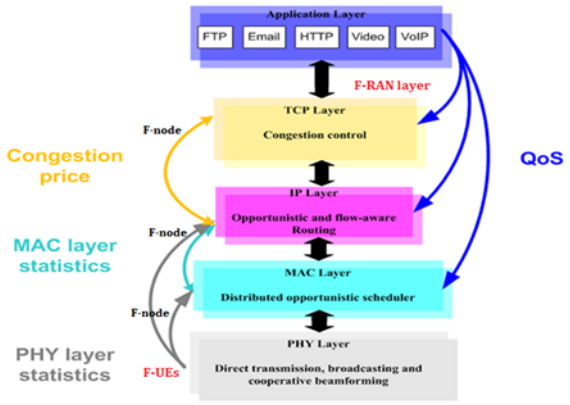


Fig. 3. Fog computing in Cross-layer Design

The cross-layer control mechanism provides a feedback on concurrent quality information for the adaptive setting of control parameters [4].The control scheme apply,

- The observed quality parameters.
- The statistically computed control input to parameter settings and mode switches.

Fig. 3 show that the cross-layer design revisited with the proprietary hardware components that manage a single network layer should give way to open sub-systems that expose internal state information to associate sub-systems at different layers. While transparent and layered networking allows for simplified and modular design, it prevents service integration and precise resource allocation and control.

The radio access network must be able to exhibits operational and performance statistic. And then to take input about configuration and operational requirements from higher protocol layers, applications, and services. Instead of relying on each layer to individually optimize based on inferred operations [5], the system can operate as a whole to optimize system performance based on informed cross-layer exchanges of information.

Moreover, to sharing of information across existing elements, that the creation of a distributed infrastructure for gathering real-time information about the network and its usage, building dynamic models of overall system behavior, and optimize network behavior at various levels and applying insights obtained to control. Cross-layer mobile architecture exhibits an application programming interface (API) at each layer in the system together with mechanisms to allow information to traverse this API in both directions such as reporting and control which subject to policies, expressed as sets of rules.

IV. EXPERIMENTAL RESULT

The logical structure of F-RAN with cross-layer architecture fig 4(a) comprise of three layers. Those are physical layer, fog layer, cloud layer. The physical layer contains number of base stations (nodes) which are access with fog layer and cloud server.

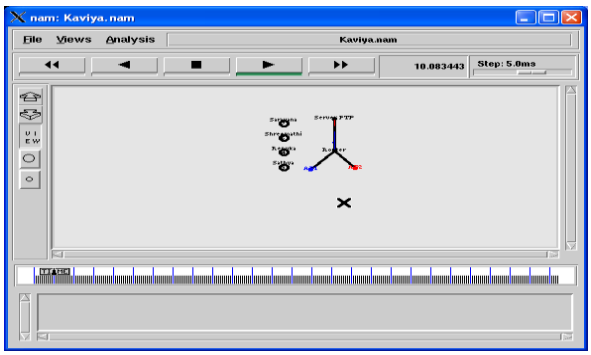


Fig.4(a)(i).

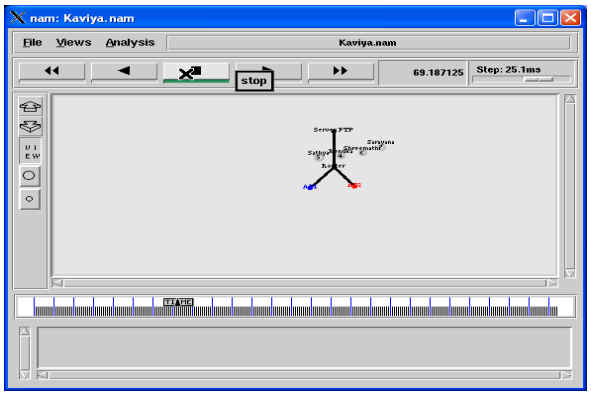


Fig. 4(a)(ii). Simulation Result for Logical Structure of F-RAN

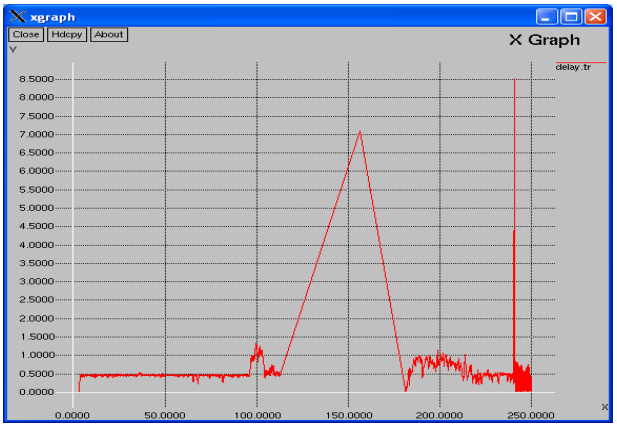


Fig. 4(b). Variation of Delay

The figure 4(b) defines the delay of the packet. The experiment was running 25 seconds of time. The x-axis is indicated as number of nodes and y-axis is indicated as number of packet send in a period time. Most commonly packets get send towards the destination can be reached. Thus the accessed nodes are more in C-RAN (existing system) since the network overload is increased, while using Cross-layer with F-RAN framework, the nodes are exchange their information and the packets will delivery within the time period.

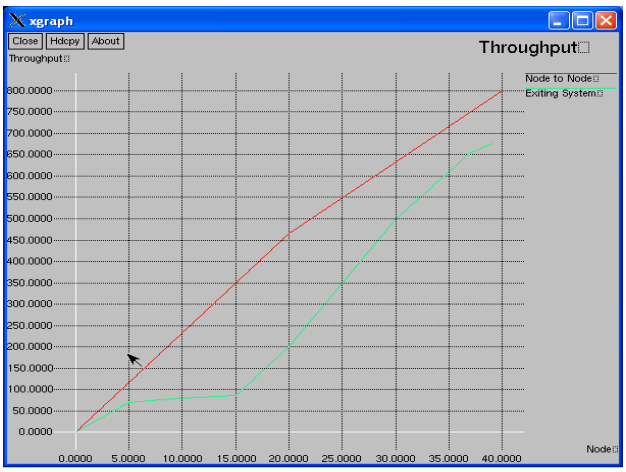


Fig. 4(c). Throughput Rate in F-RAN

The figure 4(c) defines the throughput between base stations. The experiment was running 20 seconds of time. The Simulation time is taken as x-axis and packet delay is taken as y-axis. The packets get send towards the destination can be reached. Thus the packet delay has been increased by using Parallel multi-cell cooperation processing [9] in C-RAN since the energy consumed by each node is less. But the framework of F-RAN with cross-layer increases the energy efficiency.

V. CONCLUSION

Fog computing based radio access network with cross-layer architecture for 5G wireless communication has to be proposed in order to access the data fast enough. Compared with the traditional centralized cloud computing based C-RANs, Cross layer F-RANs are providing a cluster-scale for network coverage, massive mobile data traffic. The two important metrics of F-RAN is to throughput and delay, which is highly improved in F-RAN using distributive cluster–scale cloud server interference management, cooperative radio signal processing and cooperative radio resource management.

To achieve an efficient quality of services (QoS), the simulation results are shown. Our proposed design and operation approaches demonstrate how to construct the envisioned network, i.e. the numbers of RRHs and types of cloud server, and sleep scheduling of RRHs for an energy-efficient optical power transmission.

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