Performance Analysis of Cloud Radio Access Network using Cross Layer Approach

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Abstract— Radio access technology is conventionally divided into cells with a base station at the centre of each cell servicing mobiles within the cell. A mobile can communicate with more than one base stations belonging to more than one cells in its proximity. In conventional networks, the decision to service a mobile is taken care by the base stations. As the number of mobiles and load increases, the communication and computation overhead at the base station increases exponentially. Due to limited processing capabilities of the edge base stations in comparison to core network, a significant amount of latency is induced in the network for the service decisions like handoff, uplink power management, bandwidth allocation and QOS provisioning. In this paper we have proposed cross layer architecture for taking service and providing decision to core of the network from the edge of the network. By the use of cross layer based technique base station collects the information of bandwidth from the MAC layer and delay from the physical layer. Combining these two matrices then overall bandwidth is calculated. The proposed system with cross layered architecture we can get less wastage of energy, low latency and better packet delivery ratio and more throughputs even at more nodes. A simulation result suggests that the proposed system is more effective and gives better performance than the present system.

Key words: C-RAN, RRH, BBU, Cross layer, Cross layer resource allocation, Energy consumption, Throughput, Packet delivery ratio, Latency

I. INTRODUCTION

The Radio Access Network (RAN) is the mainly essential part of a cellular network. They unable to manage new wireless improvement techniques to accomplish user data rates also not compatible with today's user data rate requirements [1]. Cloud Radio Access Network (C-RAN) is an innovative model for broadband wireless access that gives a higher degree of collaboration and communication among Base Stations (BSs), where all the computational resources of BS are collectively present in a central location. The C-RAN architecture consists of base band unit (BBU), radio remote head (RRH), and mobile nodes. Generally BBU's are at the core of the network that is which actually constructs the infrastructure of the network. RRH are at the edge of network. BBU is one from where the resources are allocated. All the BBU's are connected to the RRH by means of fiber links. All the RRH are connected with a several mobile nodes wirelessly. This architecture supports cooperative method like alleviating interference, joint scheduling, beam forming also flexible [5]. Additionally in C-RAN, by adjusting cluster size also by means of applying best resource it is easier to dynamically adjust the cluster size and apply best resource distribution approach improvement in the capacity and energy efficiency of system can be achieved [4]. Furthermore, reduction of Capital expenditure (CAPEX) and operational expenditure (OPEX) through virtualization technique constructing virtual base stations can be achieved [7].

Taking Service decision for mobile user at the core of the network has been proved that flexibility in upgrading network. Computing the resources at the core of the network reduces the delay as core consists of virtual base stations. In order to fully utilize the performance of cloud radio access network, cross layer design concept has been used and for monitoring the performance metrics like Throughput, packet delivery ratio, energy wasted and Latency.

II. SYSTEM MODEL

A. Brief about Proposed Mechanism

Centralized cloud radio access network is proposed. In this architecture we are taking the service provisioning decision to core of the network from the edge of the network [2]. In the proposed system link access and channel sharing will be resolved at the cloud in the core. By using the cloud computing infrastructure multiple clusters of servers can calculate the optimum topology with link management. This enables the network to compute the links and channel sharing based on much complex data like bandwidth and power and in a more efficient way, as the cloud has a large cluster of computers for computation. The frequent changes of link quality variations are observed at the edge and are sent to the cloud. The collaborative cluster computing at the cloud ensures a centralized optimization process and decision making. This enables easier upgrading the network. Less congestion and flexibility. In this we have adopted a cross layer scheme in order to monitor the performance metric such as packet delivery ratio, throughput, and latency.

B. Cross Layer Design

Cross layer design (CLD) is characterized as a different approach from the reference architecture model that does not permit direct correspondence involving non-adjacent layers also does not allow to share variables (e.g., TCP/IP or OSI) [3]. By Cross-layer design it is possible to underline the improvement in network performance by facilitating various layers of the Communication stack to distribute state information or to manage their activities so as to optimize network performance jointly.

C. Cross Layer Based Resource Allocation

Implementation of a cross layer scheme at the RRH edges. Whenever a mobile generates a data it is handled by RRH, in the RRH physical layer computes the delay and MAC layer computes the bandwidth. The delay and bandwidth received by these lower layers then mitigated to the network layer of RRH. This information is sent to the BBU which then give it to the cloud for decision making.

At the RRH edges where nodes collect information from the observations from each layer and create a Multi-Metric cost. The cost is given as

$$\text{Cost}=(Bi)^{1/n}=\sum_{k=0}^{n}\binom{n}{k}P^k d^{n-k}$$

Where Bi is the bandwidth of the i^{th} RRH, shared among n mobiles. P^k The power loss for transmitting to all k nodes in a cell and d is the delay of transmitting to k^{th} node. Bandwidth is calculated at the MAC and Network layer. MAC bandwidth is channel contention of a single RRH node, where as Network bandwidth is obtained through a series of probe exchange. Hence, Bandwidth B can be defined as

$B=B_{(MAC)}+B_{(Network)}$

$B_{(Network)}$ is further defined as the average factor of round trip time.

$B_{(Network)}=1/\mathrm{T}\sum_{k=0}^{n}(1-\mathrm{Trtt})\mathrm{B}$

Where T is the round trip time of B bytes to mitigate to a RRH from a mobile and back.

III. PROPOSED METHODOLOGY

A. Simulation Model and Parameters

To simulate our proposed system we are using OMNET++. In our model of simulation, we are taking 8 nodes and all nodes have same transmission range of 100 meters. Each node is having a simulation time of 500s.

We use OMNET++ to simulate our network. OMNET++ is a network simulator and is designed for movement modeling of telecommunication network, set of rules modeling, modeling of queuing network etc. The basic architecture of the OMNET++ basically has got two parts one is GNED graphical network definition and the other one is a source file which is C++ file. The GNED defines the individual parts present in the simulation.

Simulation parameters	Simulation values
Minimum number of nodes	8
Channel type	Wireless channel
MAC	802.11
Packet size	4096
Simulation time	500s
Transmission range	100m
Mobility Model	Random WP
Protocol	DSR
Channel delay	0.0001
Channel data rate	5.04858e+6
Channel error rate	1e-5

Table 1: Simulation Settings and Parameters

B. Performance Parameters

We evaluate the performance of C-RAN based on the following parameters.

1) Throughput: The amount of data packets transferred from one node to another node in a specified amount of load. Typically throughput is measured in terms of Kbits per second.
2) Packet delivery ratio: this refers to the proportion of total amount of successfully data packets delivered to the total number of data packet transmitted from the source to the destination.
3) Energy consumed: This parameter indicates the amount of energy utilized for processing.
4) Latency: the amount of time taken by the data packet to travel from one node to another node.

IV. RESULTS AND DISCUSSIONS

A. Throughput Comparison under Number of Nodes

When number of nodes (mobile users) increases, throughput of the proposed system with cross layer shows better performance as compared to the throughput of the present system without cross layer as shown in Figure 4.1.

B. Packet Delivery Ratio Comparison under Number of Nodes

As shown in figure 4.2, the proposed system achieves better packet delivery ratio than the present system because computation of resources at the core of the network.

C. Latency Comparison under Number of Nodes

Cross layer based system gives low latency compared to present system that is without cross layer shown in figure 4.3, because in the proposed system we are taking the decision of allocating resources at the core of the network rather than at the edge of network as in case of present system.

D. Energy Consumption Comparison under Number of Nodes

By using cross layered architecture approach we can get less wastage of energy than the conventional system shown in figure 4.4 because conventionally we are taking service decision at the RRH edges and this are low powered and requires more energy to calculate and allocate resources.

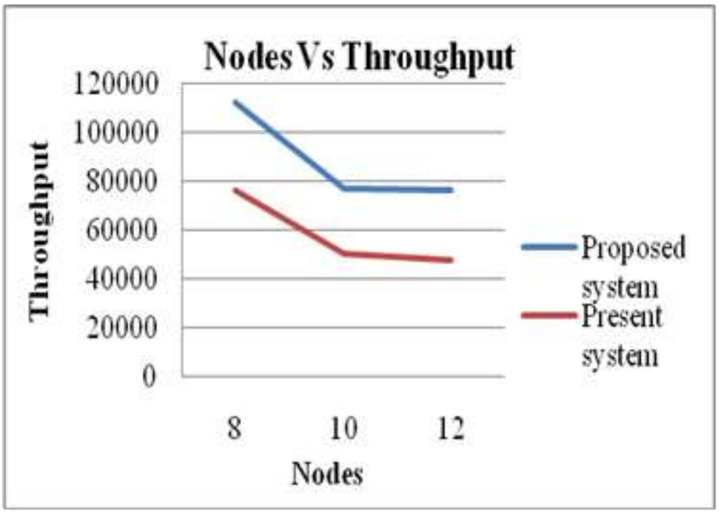

Fig. 1: Nodes Vs. Throughput

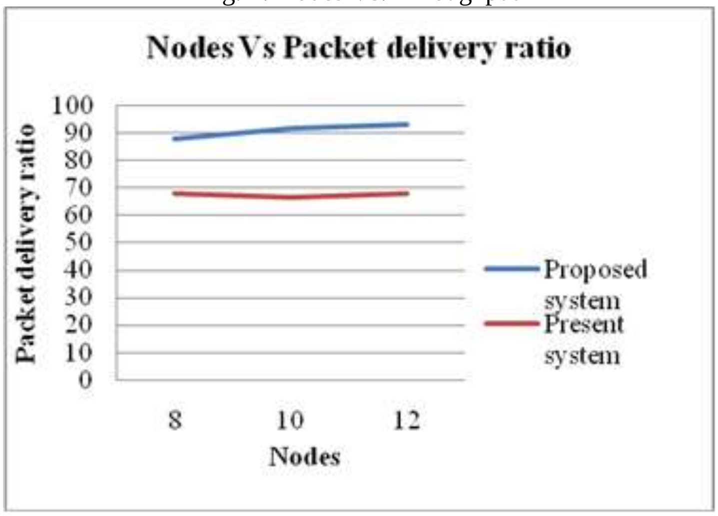

Fig. 2: Nodes Vs Packet Delivery Ratio

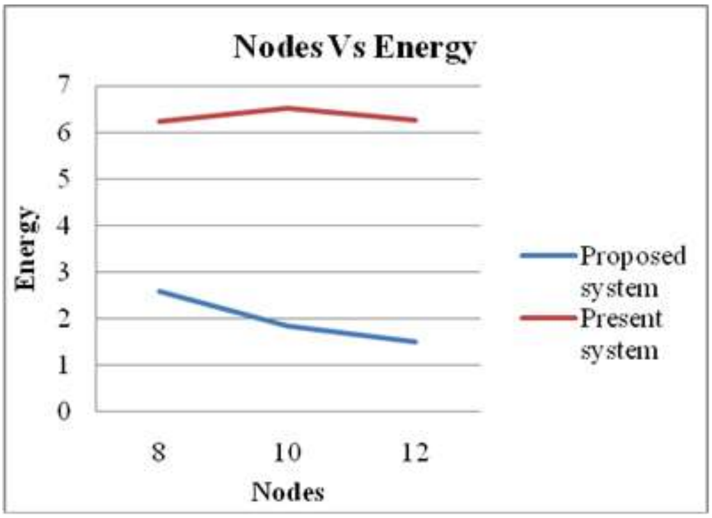

Fig. 3: Nodes Vs Energy

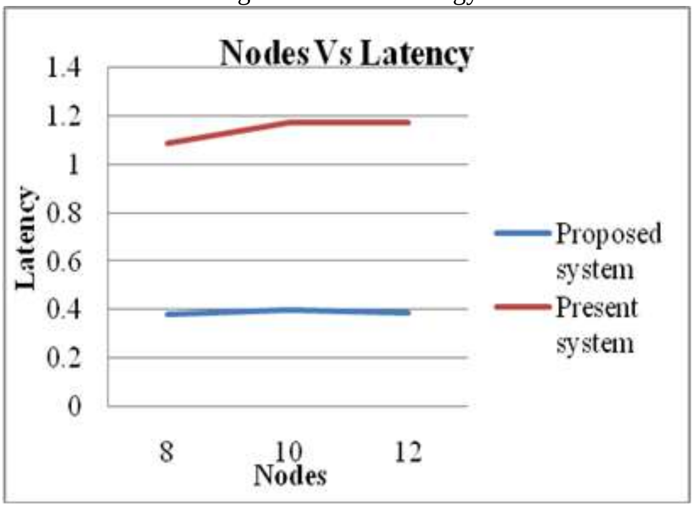

Fig. 4: Nodes Vs Latency

V. CONCLUSION

As compared to the conventional system, the proposed system with cross layered architecture shows better performance in terms of minimization in the consumption of energy even at more number of nodes, as well as more throughput, better packet delivery ratio and also offers low latency. As compared to the edge based resource allocation mechanism, the result of the core base computing and allocation of resources and the cross layered based BW calculation and resource allocation mechanism shows that it improves the current state of art of network layered based calculation at the edge significantly.

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