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Optimal Bandwidth Utilization and Energy Efficiency in C-RAN for 5G Wireless Communication

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Abstract: ***Mobile communication play a vital role in human life and a new era is yet to evolve with 5G Technology. Cloud Radio Access Network (C-RAN) with Remote Radio Head (RRH) and Baseband unit (BBU) pool is meant for high spectrum efficiency and considered to be as a dominant realization of mobile networks with open platform supporting green infrastructure and paves way for emerging technology in 5G mobile networks. This blooming technology provides a pioneering approach to encounter the requirements and progress the network to deliver coverage, innovative services and lower support costs. This results in enhancement of network performance, in addition with resource utilization. This paper proposes a BBU and RRH association scheme with opportunistic coordinated selective forwarding using duplicate detection distributed Ex-or to utilize the appropriate bandwidth, reduce the latency of transmitted packets and thereby reducing energy consumption in future wireless communication. Results reveals that opportunistic coordinated selective forwarding method yields better performance in all aspect for 5G communication system.***

Index Terms**:** ***Bandwidth utilization, C-RAN, Latency, Opportunistic coordinated selective forwarding, Throughput.***

I. INTRODUCTION

C-RAN is an architecture which supports 5G networks in an efficient manner with lot of flexibilities and functionalities. The explosion of up gradation and innovations in mobile networks pave a way for future 5G into bloom [1]. In general, traditional RAN makes an impact to move on to innovative features achieved by means of C-RAN [2]. CRAN splits up the traditional base stations into RRH and BBU [14], [17]. The CRAN centralize processing of BBU in a way that resources could be managed and allocated dynamically on demand resulting in resource efficiency [13], [18]. RRHs can be disseminated in some specific areas, mostly urban areas with heavy traffic loads featured with cost efficient manner [9], [10]. Mostly RRH transmits heavy data rate RF signals to mobile terminal in the downlink and forward the baseband signals from the mobile terminal to the central processing unit in the uplink.

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The baseband signal processing is directed in BBU which is connected by means of an optical fiber to RRH. It comprises of a component whose purpose is scheduling and processing the incoming signals from different cell sites to virtual base station and enhancing radio resource allocation. Though UMTS improves the data rate, the cost and competiveness remains as challenge, which creates an impact to shift over to C-RAN for some better enhancements [11], [8]. The exploitation of massive MIMO increases the robustness that consist of array of antennas in both transmitter and receiver which relies on future broadband development
with secure and energy efficiency [3]. The handover reduction mechanism and cooperative interference management ensure the intra-coalition interference among RRH's suppression [4], [5]. The resource efficiency is made as in [6]. The implementation of virtualization technology exploits the flexibility in the C-RAN system which paves way to distribute or group processing between virtual base station entities and sharing the resources among the multiple operators [14], [15], [17]. The unpredictable traffic can be optimized as in [7], [18].The optimal way to reduce the energy consumption and simultaneously increase in bandwidth utilization is achieved by opportunistic coordinated selective forwarding in CRAN by incorporating distributed Ex-or to detect and eliminate the generation of duplicate packets thereby improving the efficiency in all aspects for future 5G communication.

II. PROPOSED METHODOLOGY

The opportunistic selective forwarding method finds an optimal way for better path routing to increase the utilization of bandwidth. The primary user component (PUC) transmits the packets based on the participation time. Also it checks for replication and computing the expected cost, managing the neighbor broadcasting which in turn allocates the channel resources dynamically. After updating energy, it is possible to achieve the replication-less transmission with the updation of access time and finally reach to the secondary user component (SUC). Fig. 1 shows the block diagram of packet transfer from PUC to SUC. Using node's transmission span, each packet is classified by its participating time. Whenever a packet is transmitted, the count gets increase from initial state of zero. Replication of packets is assessed if the span is high and ordered according to priorities. Once the packets reach the upper span limit, it is dropped.

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There are many ways of occurrence of packet replication in a network. Consider a scenario that, if a sender sends packets and it reaches the receiver. On receiving the packets, receiver tends to send the acknowledgement and in the case of no acknowledgement, the sender retransmits the packets which might cause replication of packets thereby, unwontedly it consumes more bandwidth and leads to wastage of energy. The expected cost and forward list of node is calculated on the basis of neighbor nodes to ensure reduced energy consumption. The purpose is to select the subset of neighboring nodes as forward list such that the expected cost for sending the packet to the destination is reduced. The neighbor nodes broadcast their information at some proper intervals and the information get stored in the routing table and MAC table for further check of replicating packets. If the same sequence number for a packet gets repeated, it comes to a conclusion of replication and hence duplicate packets are detected. The distributed EX-OR provides a better solution for eliminating the duplicate packets.

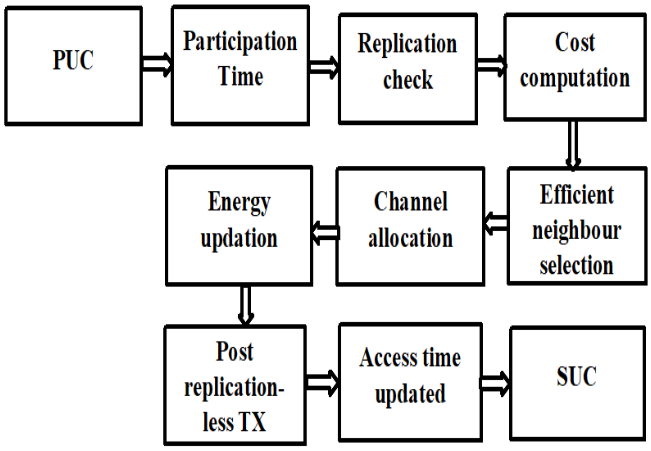

Figure 1 Block diagram of opportunistic coordinated selective forwarding in C-RAN

The distributed EX-OR checks for transmission state and node state for avoiding replication. If the same sequence numbers for packets is encountered, then it will eliminate the duplicate packets. If both the packets seem to be same by sensing the node information in MAC table, it will not allow the further transmission and drops the packet or else it provides further transmission ie., same packets means it drops the packet and for distinct packets, it allows forwarding of packets ensuring bandwidth utilization and leads to enhancing throughput as well as ensures low energy consumption.

III. RESULTS AND DISCUSSION

The network simulator 2 (NS2) is a simulation tool of discrete events. It is popular for its reliability and modular nature. It uses two languages such as C++ for defining the internal mechanism and Object oriented Tool command language (OTcl) for configuration of objects and scheduling of discrete events. The NS2 is widely used for networking domain especially for creation of nodes, mobility of nodes and describing the routing mechanisms [19].

The parameters considered to enhance the reliability are discussed below with their corresponding results. In the following figures, the blue color curve indicates the opportunistic forwarding with distributed Ex-or showing the enhanced result comparing with existing method i.e., the graph and partitioning method which is indicated by red color and the opportunistic selective forwarding without distributed Ex-or indicated by the green color.

The initial energy is taken as 10 joules, transmitted power as 0.6 watts, received power as 0.3 watts, idle power as 0.1 watts and sense power as 0.05 watts for all the parameters viz, bandwidth utilization, energy consumption, latency, residual energy and throughput. The data rate is 1Mbps, number of mobile nodes and number of packets in queue length are 50 in each case.

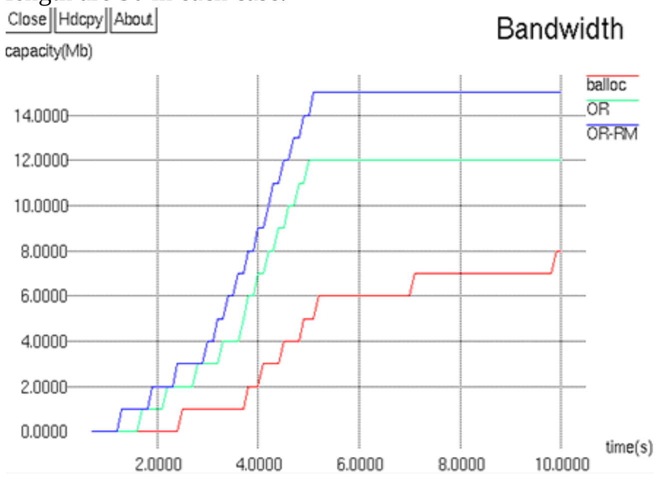

Figure 2 Bandwidth utilization of CRAN using opportunistic selective forwarding

The bandwidth is considered to be foremost parameter in terms of all aspects. Fig. 2 portrays the bandwidth utilization in C-RAN. The x axis indicates time in seconds and y axis specifies capacity in Mb. On the analysis of bandwidth utilization in C-RAN, at the time of 10 seconds the capacity for existing graph and partitioning method is 8 Mb while for opportunistic without distributed Ex-or and with distributed Ex-or are 12 Mb and 14.5 Mb respectively. This ensures a greater increase in bandwidth utilization with the comparison of existing method and opportunistic method without distributed Ex-or. The energy consumed by the packets play a vital role in cost estimation and efficiency of the system.

Fig. 3 justifies that the opportunistic with distributed Ex-or method consumes only 15 joules of energy whereas opportunistic without distributed Ex-or and existing method consume about 18 joules and 25 joules of energy respectively over the time interval of 10 seconds which symbolize decrease in energy consumption in comparison with existing method and opportunistic method without distributed Ex-or. Here x axis indicates time in seconds and y axis specifies energy in joules. Fig. 4 shows the latency graph which gains the optimal result by using this opportunistic method.

The buffer utilization gets increased due to elimination of duplicate packets as shown in the graph. Here x axis marks the scale of buffer in Mb and y axis marks the latency scale in ms. In existing graph and partitioning method, for 8 Mb of buffer, the latency is high (275 ms) while the opportunistic method without distributed.

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Ex-or has the decreased latency (90 ms) and the latency for opportunistic method with distributed Ex-or is just 30 ms as mentioned in y axis. Simultaneously the buffer utilization keeps on increasing as shown in the figure. Thus the latency also reduced to a large extent in
opportunistic selective forwarding method in comparison with the existing methods.

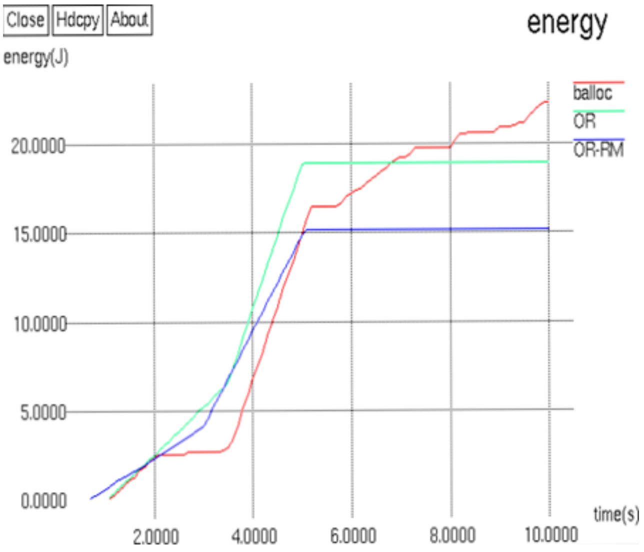

Figure 3 Energy Consumption of CRAN using opportunistic selective forwarding

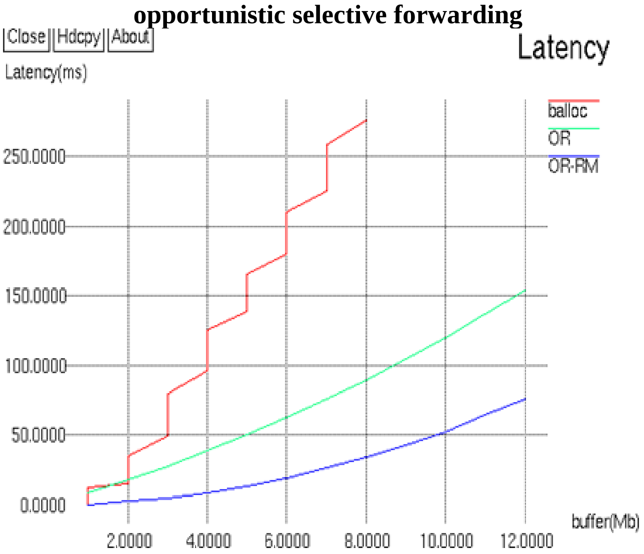

Figure 4 Latency of C-RAN using opportunistic coordinated selective forwarding

The residual energy as in Fig. 5 in contrast to energy consumption has an increase in opportunistic method which can be considered as saving energy. The x axis shows the node ID and y axis shows the energy in joules. In the graph, a node possesses the minimum energy of 9.3 joules and maximum energy of 10.8 joules for opportunistic method with distributed Ex-or while for opportunistic method without distributed Ex-or, it is observed that minimum energy is 7.1 joules and maximum energy is 8.1 joules and in the case of existing method the min and max energy are about 6.5 joules and 7.8 joules respectively. Thus the opportunistic method with distributed Ex-or which is indicated has more residual energy compared to existing method and opportunistic method without distributed Ex-or. Throughput decides the quality of a communication in wireless system.

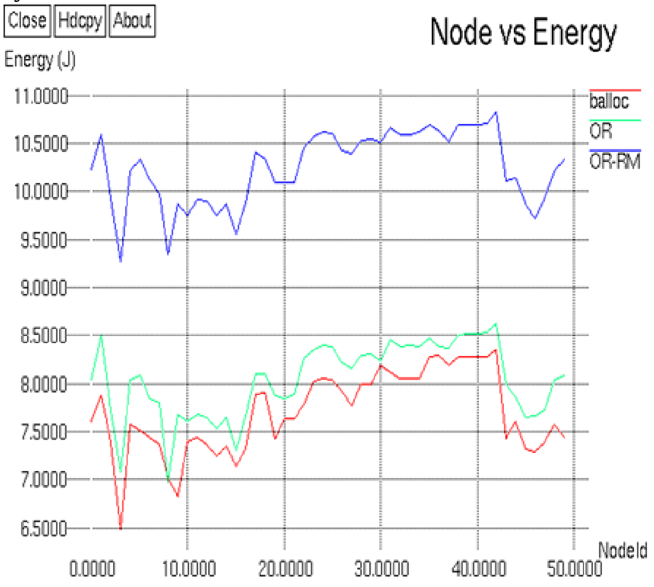

Figure 5 Residual energy of C-RAN using Opportunistic selective forwarding

Increase in throughput, decrease the number of errors. Fig. 6 shows throughput graph which indicates the number of packets transferred per unit time. The x axis describes time in seconds and y axis as throughput in Kbps. At the time interval of 5 seconds the opportunistic method with distributed Ex-or has 450 kbps throughput while opportunistic method without Ex-or and existing methods have 375 Kbps and 50 Kbps respectively. It portrays escalation in opportunistic method with distributed Ex-or in comparison with existing method and opportunistic method without distributed Ex-or. Table I shows the comparison results of existing method, opportunistic methods with and without distributed Ex-or. The increase in throughput ensures the maximum data rate with less bit error, which is considered to be a vital factor in 5G wireless communication.

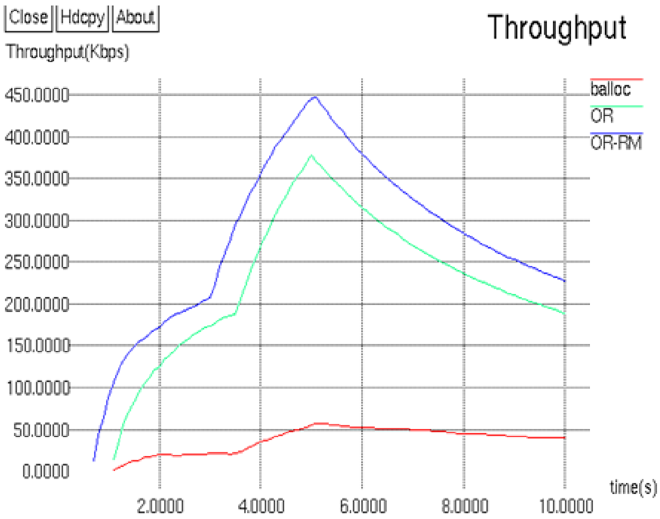

Figure 6 Throughput of CRAN using opportunistic selective forwarding

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IV. CONCLUSION AND FUTURE SCOPE

The C-RAN guarantees for high network flexibilities and supports for multi functionalities and is an emerging new technology, with low capital expenditure (CAPEX) and operational expenditure (OPEX) with green infrastructure. Transmission in 5G technology is been analyzed with various parameters under different schemes for efficient transmission of data. Analysis results reveals that, the opportunistic coordinated selective forwarding with distributed Ex-or delivers enormous flexibilities by providing the optimal bandwidth utilization as well as low energy consumption with supplement of reduced latency and increased throughput. Thus ensuring a reliable and efficient method for 5G scenario. Future scope could be decreasing the power consumption in massive MIMO and modelling of mm wave fading effects with suitable optimization techniques which could pave way for less cost, enhanced data rate and global coverage.

TABLE I COMPARISON CHART OF EXISTING AND PROPOSED METHOD

Methodology	Bandwidth Utilization (Mbps)	Energy Consumption (J)	Latency (ms)	Residual Energy (J)		Throughput (Kbps)
Existing Method	8	25	275	6.5	7.8	50
Opportunistic without Ex-or	12	18	90	7.1	8.1	375
Opportunistic with Ex-or	14.5	15	30	9.3	10.8	450

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