Next Generation in LTE for Optical Mobile Backhaul Networks

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***Abstract* - With the introduction of new technologies & smart devices, there has been tremendous increase in the mobile traffic growth resulting in increased energy consumption. LTE Advanced which is a standard for high speed data also introduced new offer like high data rate to users. This in turn will result in rapid growth of loads along with wider bandwidth requirements. Moreover direct communication between base stations has made any-to-any node communication possible. Here, in this paper we are analyzing the latency in such next generation mobile backhaul networks & also comparing different technologies that support multicast support.**

***Index Terms* - OSS,TWIN, POADM, CoS, Mobile Backhaul**

I. INTRODUCTION

Our technologies are being updated day by day. The vast application of mobile networking demands for higher data rates with speedy operation. Mobile traffic is growing fastly with the advancements in smart devices. The upcoming new technologies will also introduce additional traffic. This makes the mobile operators to seek backhaul solutions with improved capacity with reduced latency. Thus latency plays an important role in mobile backhaul networks. Market opts technology favoring latency as low as possible. The evolution of optical transport technologies has provided energy efficient solution to cellular networks. Optical Slot Switching (OSS) is one such energy efficient switching technology to interconnect evolved base stations in LTE A mobile backhaul networks. LTE-A uses direct node-to-node communication that improves coverage, cell-edge throughput and system efficiency.

Optical slot switching is a networking technology which can provide statistical multiplexing. In this paper comparing two such sub-wavelength switching granularity technologies namely Packet optical add/drop multiplexer (POADM) & Time Domain Interleaved Network (TWIN) that are applied to mobile networks. POADM is an OSS technology that natively supports any-to-any node communication that provides sub-wavelength switching granularity which made it widely acceptable in LTE-A mobile backhaul applications. This concept is adapted to metropolitan networks with ring topology that combines optical packet granularity and optical transparency together. The transparency is ensured in such a way that it has option to include packets at any desired wavelengths while unnecessary packets can also be deleted. POADM ring has several data channels along with a control channel which carries all sorts of information. Each node is interconnected with one or more clients. Data coming from/going to client is encapsulated/decapsulated with fixed size data packets named as slots. Each node will decide to add or drop the packets according to information in control channel. This transparency helps to reduce power consumption to a considerable rate which makes it more efficient than ETHERNET rings.

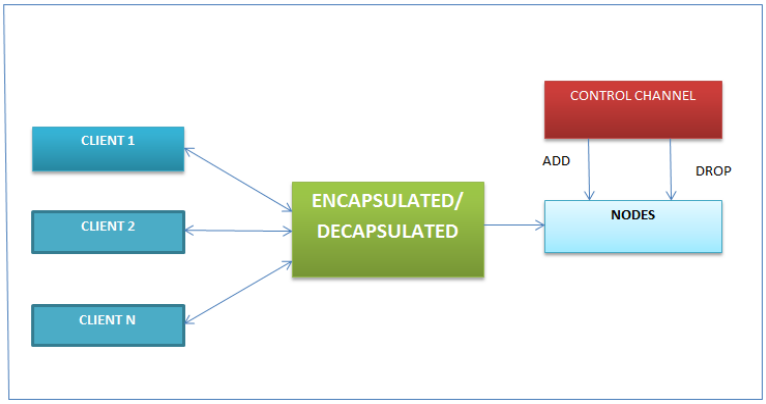

Figure 1. POADM Ring

II. TWIN NETWORKS

TWIN network consist of core nodes with passive devices and smart edge nodes with transponders. Each transponder has fast wavelength tunable transmitter and burst mode wavelength receiver. Optical splitters/couplers and wavelength blockers

are used to implement core nodes. With appropriate tuning at the emitter a source can send a burst to any node. Thus TWIN is employed in physically meshed networks.

III. DIFFERENTIATED CLASS OF SERVICE

For analyzing the latency in the network we are considering two Class of Services (CoS)- Real Time (RT) and Non Real Time (NRT). HTTP, FTP and email are examples of non real time data traffic where as video conferencing, voice over IP etc are real time data traffic. RT traffic is latency sensitive. The data coming from/going to clients is encapsulated/decapsulated within fixed size packets called slots. The time required by the source node to generate and transmit a packet across the network to its destination node is known as latency. Real time traffic is sensitive to such delay in packet delivery and hence needs delay as low as possible. Now we are going to analyze the latency in the mobile backhaul network by considering two conditions.

(1) With CoS management

(2) Without CoS management

A. Without CoS Management

Without class of service the packets arriving to the nodes are mixed and treated equally. At the node, the packet arriving from the clients are placed in a temporary queue. From this queue each packet is passed on to the optical slots. As each packet enters the optical slot then the temporary queue is emptied accordingly. The packet placed in optical slot waits for its insertion into the channel. In order to give an alert to optical slot regarding the arrival of each data packets a global timer is there which triggers according to packet arrival. Since there is no class of differentiation between real time and non real time traffic timer value decides the slot formation. The global timer is selected in such a manner so as to respect the strictest traffic latency constraint. The latency constraint that is Considered is coordinated Multi Point (CoMP) signaling. Coordinated multipoint allows multiple base stations to communicate simultaneously. Slot formation without CoS is shown in figure 2.

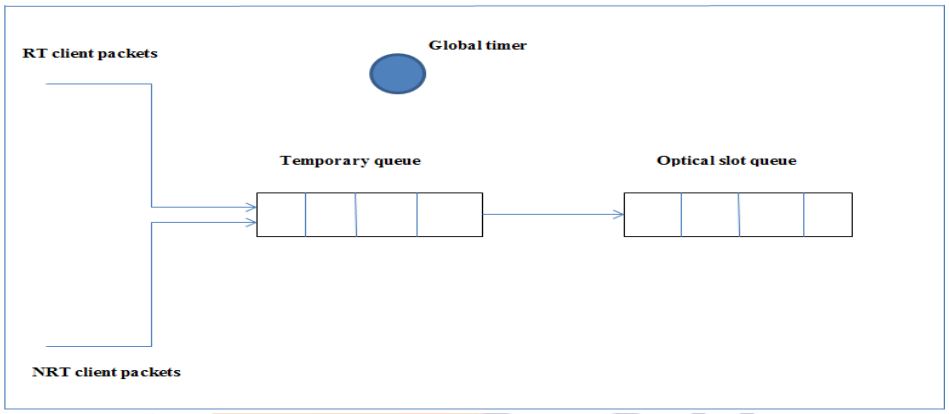

Figure 2. Slot formation without CoS

B. With CoS Management

Here class of service is being mentioned in the packets that are passed to the temporary packet queue. Separate temporary queues are there to handle real time and non real time data traffic. Along with destination node, per CoS is mentioned in the temporary queue, such that optical slot has packets containing same CoS. The introduction of per CoS enables to send real time traffic prior to non real time traffic. CoS differentiation and channel insertion is performed at the time of slot formation. CoS cannot be carried out in between intermediate nodes. Thus with the CoS the node can easily distinguish between client packets. Since the priority is higher for RT Traffic during channel insertion RT traffic is handled first. Thus optical transparency is preserved.

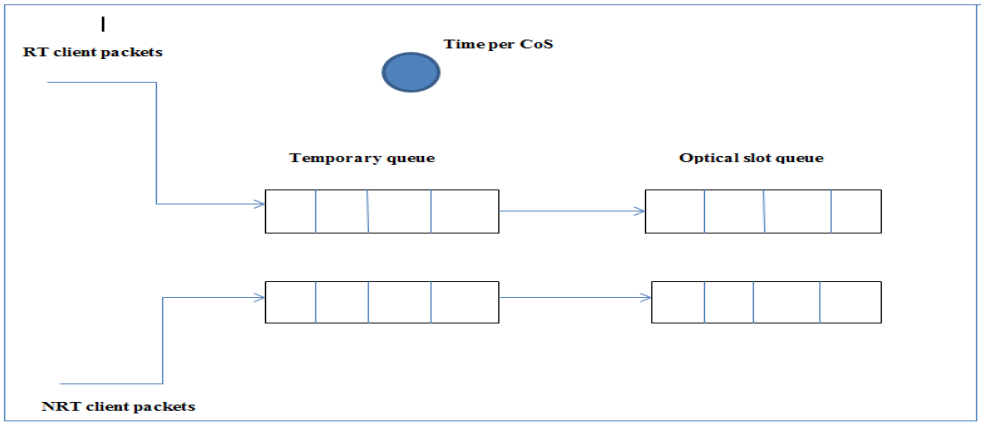

Figure 3. Slot Formation with CoS management

IV. SYSTEM REQUIREMENTS

Operating System: Ubuntu 10

Tool needed: Network Simulator 2 (NS2)

Packages Needed : NS Allinone -2.35

Languages: Tool Command Language (TCL), C++

NS is an object oriented discrete event simulator targeted at network researching. It provides substantial support for routing and multicast traffic.

V. SIMULATIONS AND RESULTS

The proposed converged architecture along with the reservation protocol and dynamic bandwidth allocation scheme were implemented in the NS 2 simulator framework and evaluated through extensive simulation experiments. Specifically we simulated an LTE backhaul network with 8 evolved node base stations (eNBs), interconnected in a fiber ring with a 2 km diameter. An Optical Line Termination (OLT) was connected to the ring with a 20km bidirectional feeder fiber. Modeled communication between each source-destination pair of eNBs and between each OLT-eNBs pairs as separate traffic sources that generate packets according to a self-similar process. Wavelength capacity was set to 1 Gbps and buffer size of eNBs to 3MB. Finally the DBA cycle time for LAN traffic cycle was set to 2ms.

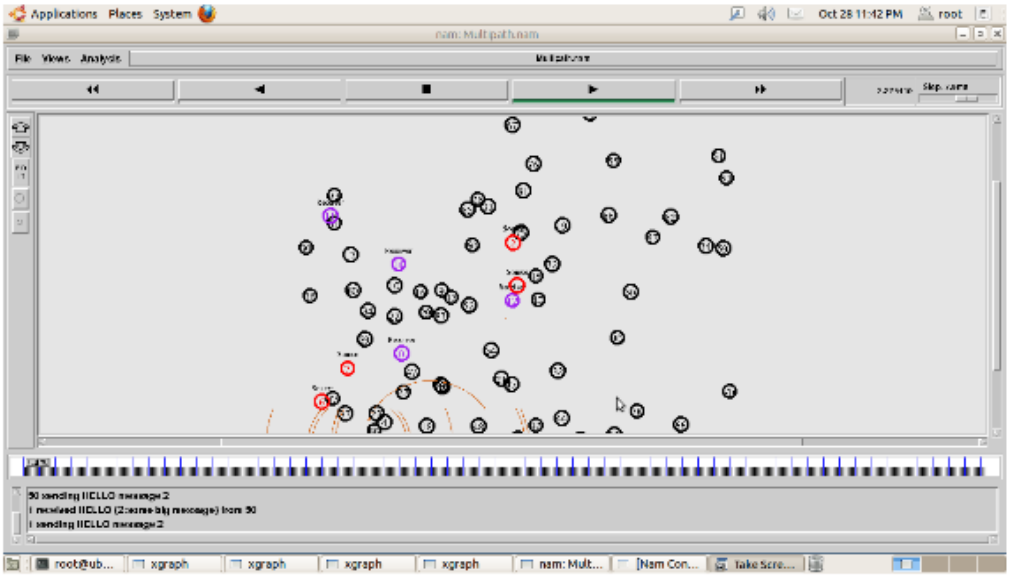

Figure 4. Communication between different types of nodes

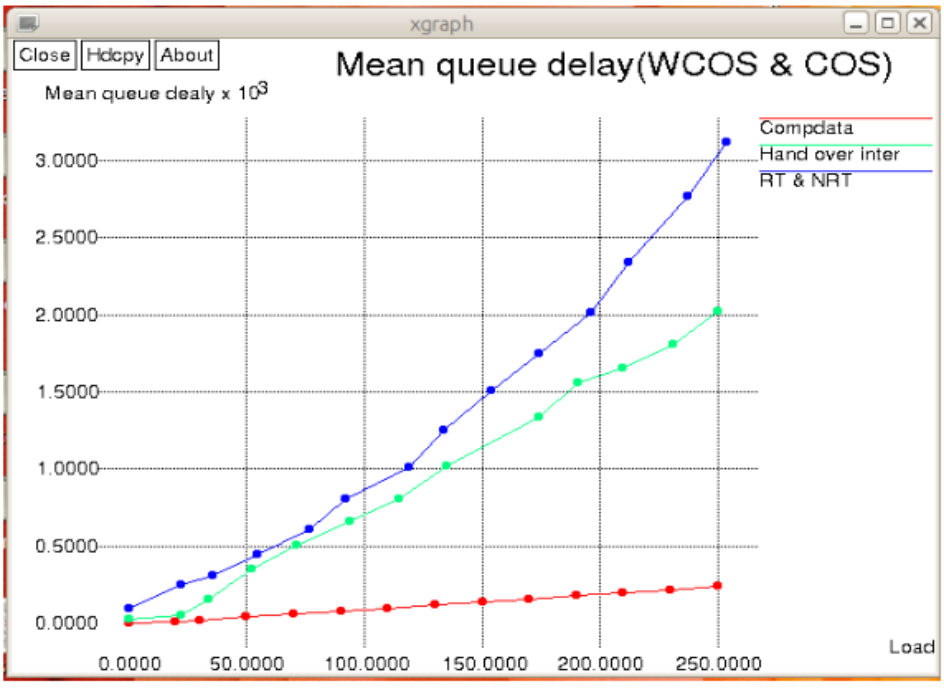

Figure 5. Mean queue delay

Figure 5 gives the mean queue delay comparison with and without CoS.It is clear from the graph that delay is reduced to a considerable amount with the introduction of CoS. Without CoS the mean delay is much higher compared to previous one. RT traffic experiences almost no losses whereas NRT traffic experiences high losses when the load increases.

VI. CONCLUSION

Thus it is clear from the above work that OSS is a good methodology that fulfills latency constraints in next generation LTE-A mobile backhaul networks. With the help of CoS it is possible to support more traffic with very less delay in handling packets. Quality of service (QoS) in POADM can be offered through

(1) Wavelength division multiplexing (WDM) which avoid collisions
(2) Time domain techniques that solve contention
(3) Deflection routing that reshapes traffic profile & increase acceptable load.

The sub-wavelength granularity decreases the power consumption and also increases the optical transparency & supports multi cast traffic. Along with POADM networks as an alternative TWIN networks can be used as it can communicate to any node through a single burst. CoMP improves the performance of mobile users at the edge of the cell by the cooperation of neighboring cells

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