A solution for Synchronization Problem of Interconnected Metro Access and Metro Core Ring Networks

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Abstract— This work presents studies of an interconnected Multi-Ring Network (MRN) architecture in which a Metropolitan Access (MA) Ring is interconnected by a Metropolitan Core (MC) Ring. The interconnection of MC and MA networks is made via hub node that is in charge of the synchronization between them. The synchronization of two rings while assuring the traffic routed efficiently from the MA to the MC networks is the major problem in this architecture. To solve this problem, we propose a new mechanism called Common-Used Timer Mechanism (CUTM) inspired from CoS-Upgrade Mechanism (CUM) to create optical packets well filled in the hub. CUTM is developed and also integrated as a module to the software Network Simulator 2 (NS2), to simulate the behavior of the MRN considered. We compare the performance of this mechanism with the opportunistic one. The results have shown that, compared to existing solutions, the CUTM enhances the network throughput, packet filling creation ratio and optimizes the use of resources. Also, it solves the synchronization problem.

I. INTRODUCTION

Metropolitan ring networks are usually used to connect the high speed backbone networks with the high speed access networks. The metro rings can be interconnected transparently through single access node (Hub node) or multiple access nodes. Ring topologies have been widely adopted and studied for MAN: Resilient Packet Ring (RPR), DBORN [1] and ECOFRAME (French ANR Project). ECOFRAME [2] pays special attention to the deployment of optical technologies "low cost" to ensure good network performance. ECOFRAME ring uses fixed optical packet size and separately data and control channels. In [3] the end-to-end metropolitan performance of a multi-ring architecture has been investigated. We consider two interconnected rings (Metro Access (MA) and Metro Core (MC)) via hub node that is in charge of the synchronization. In [4] a new architecture to integrate in a transparently way MA and MC ring networks has been presented. In [5] new devices to interconnect MA and MC Ring networks have been studied. However, the synchronization problem between the networks has been neglected and a major research opportunity exists in this sense. In this paper, we present a new mechanism Common-Used Timer Mechanism (CUTM) to create optical packets well filled which helps to solve the synchronization problem. The results in terms of waiting time, throughput, end-to-end delay and jitter are compared with the opportunistic mechanism. The rest of this study is organized as follows. In section II, existing optical MAN have been summarized and the architecture studied is presented. In section III, our proposed mechanism is introduced. In section IV, our simulation scenario is described and the simulation results are presented. Finally, we conclude our work.

II. NETWORKS INTERCONNECTION

The studied architecture is composed of two segments: Metro Access (MA) with architecture DBORN and Metro Core (MC) with ECOFRAME (Fig. 1). The interconnection is made via hub node. We distinguish two traffic flows: 1) the traffic flowing from the MA to the MC through the hub 2) the traffic flow circulating in the MC. In an access node of MA, the electronic packets are encapsulated in optical packets and transported through the hub. In hub O/E/O conversion is used to build new optical packets well filled coming from different nodes and going to same destination, and then the packets are stored in the queue. The creation of new optical packets is made using three mechanisms: 1) electronic packets coming from different access nodes can be combined together 2) combined with local electronic packets of the hub 3) two combinations mentioned, totally according to class of service. Therefore, it is needed to synchronize packet transmission at hub. Packet creating process introduces the delay which helps to synchronize the two rings by using electronic buffers. The transmission time slots of two rings have different sizes. L1 corresponds to the transmission time of a packet in MA and L_2 in MC. The correlation of the variables L_1 and L_2 is a problem of synchronization. Another problem is the impact of synchronization shift Δt on the network performance.

III. COMMON-USED TIMER MECHANISM

Some mechanisms have been proposed in literature to decide the time to create optical packets. A well known scheme is the opportunistic mechanism (if a slot in transit is free, the optical packet will be built and sent to the destination otherwise no creation). The purpose of this mechanism is to reduce the load of the hub and use fewer resources. In [6] the authors propose CUM to improve the filling ratio of the packets.

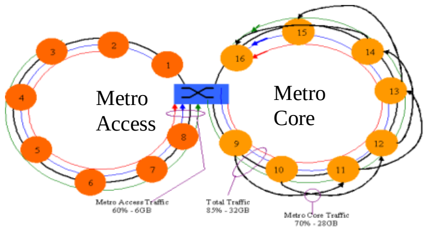

Figure 1. Networks Interconnected.

This mechanism can be used not only for the access nodes but also for the hub to create fixed size optical packet, so it uses static or dynamic timers to decide when the optical packet are constructed. By improving the limitations of CUM (it uses several timers and buffers), we propose CUTM which uses a single timer and single optical buffer for all classes of service. CUTM has three processes: 1) taking optical packet arrived, open it and convert it into electronic packet. After that, the electronic packet will be put to the buffer corresponding to their CoS. If there is a timer running, no new timer is created until this timer has expired. 2&3), the electronic packets are selected one after another from the queue in order of priority until the optical packet is full or there is not packet in the queue. The service class of optical packet is defined by the higher class of service of electronic packets.

IV. NUMERICAL RESULTS

The traffic flows are shown in network is shown in the Fig. 1. We simulate the network with 3 scenarios (Table 1) and evaluate the waiting time in the hub, throughput, jitter and delay by simulations using NS2 tool. Firstly, we fix the value of Δt = 1µs and study the interaction of L_1 and L_2 depending on the bandwidth and packet size in each network. The results in Fig. 2 show the waiting time in hub with CUTM. It is independent of L1&L2 correlation, and depends on the capacity of the MC. With the “opportunistic” mechanism, the performance of hub does not depend on the capacity of MC. Fig. 3 shows the throughput obtained by the scenario 3, it means that the mechanism “opportunistic” uses the network resources less effectively than mechanism CUTM. Now, we analyze the impact of Δt in varying from 1µs to 21µs (20µs = 2 x L_2) on the performance of network and hub. The Fig. 4 shows that the value of Δt does not impact on the network performance but a little change of waiting time in the hub (around 0.05ms). The results are the same with the “opportunistic” mechanism. Our results show that the "opportunistic" mechanism is better than CUTM. However, the filling ratio of CUTM is better than the mechanism "opportunistic". Also, CUTM mechanism saves more bandwidth than the mechanism "opportunistic".

V. CONCLUSIONS

This work has considered MAN architecture of two ring networks: the synchronous DBORN as the MA and ECOFRAME as MC. We have proposed the CUTM mechanism to solve the problem of synchronization. By analyzing the simulation results, we found that the CUTM can solve this problem. CUTM provides good network utilization.

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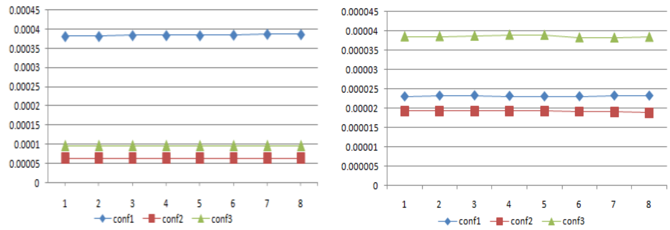
TABLE I. SIMULATION SCENARIOS

	Scenario 1		Scenario 2		Scenario 3	
	Metro Access	Metro core	Metro Access	Metro core	Metro Access	Metro core
Bit rate	10Gb/s	10Gb/s	10Gb/s	40Gb/s	10Gb/s	40Gb/s
Optical packet size	10µs – 12500 octets	10µs - 12500 octets	10µs – 12500 octets	5µs – 25000 octets	10µs – 12500 octets	10µs – 50000 octets
Load	35% - 3.5Gb	50% - 5Gb	60% - 6Gb	70% - 28Gb	60% - 6Gb	70% - 28Gb
Node traffic	437.5Mb/s	2.5Gb/s	750Mb/s	14Gb/s	750Mb/s	14Gb/s



a) CUTM Mechanism b) Opportunistic Mechanism

Figure 2. Waiting time in hub Δt = 1µs vs CoS.

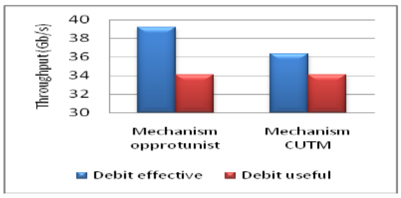
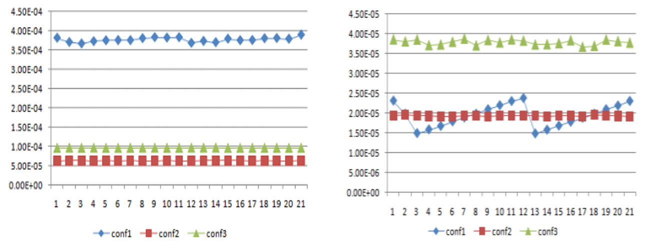


Figure 3. Throughput for scenario 3.



a) CUTM Mechanism b) Opportunistic Mechanism

Figure 4. Waiting time in hub Δt = 1µs to 21 µs.