Fixed Innovative Bandwidth Utilization in TDM EPON

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Abstract

PON can be used by two technologies, which were developed APONs (ATM Passive Optical Networks) and EPONs (Ethernet Passive Optical Networks).With the development of services offered by the Internet, the “last mile” bottleneck problems continue to increase day by day.

Many algorithms were developed for making TDM EPON efficient like IPACT, Scheduling, Priority swapping etc. These all algorithms have problems like starvation, QoS, latency and channel under-utilization. We focused the efficient bandwidth utilization in TDM EPON by managing time slots within ONUs and reducing latency, starvation and increasing quality of service.

Our Fixed Innovative Bandwidth Algorithm is an intra-ONU bandwidth allocation algorithm, which is used to enhance the network performance by evaluating the parameters like channel underutilization, starvation, delay and Quality of Service. The issues which are lacking in the already made algorithms are being resolved with our proposed solution. The main problem is that the other solutions didn’t use the time slots which are guaranteed to their classes efficiently. In FIB Algorithm this issue is being resolved.

Keywords: Last Mile Solution, Qos (Quality of Services), FIB (Fixed Innovative Bandwidth) Algorithm, TDM (Time Division Multiplexing), Rahul Tiger

1. Introduction

Passive Optical Networks (PON’s) are point-to-multipoint optical networks. There are no active elements (such as amplifiers) in the signals path from source to destination. The elements used in such networks are passive combiners, couplers, and splitters.

PON technology is receiving more and more interest by the telecommunication industry as the “last Mile” solution. The “Last Mile” solution is also called “First Mile” solution.

1.1 PON Components

There are two types of PON components.

- 1.Active Network Elements:
- 2. Passive Network Elements.

1.1.1 Active Network Elements

Vendors of the Network elements mainly focus on active network elements such as CO chassis and ONU, because these elements can reduce the cost of laying network. The CO chassis is located at service provider‘s CO, head end. [1]

Optical Line Terminal (OLT):

This network element is placed in CO. it's functional units are dependent upon which type of multiplexing used TDM, WDM or hybrid, but main functional unit is transponder.[1]

Optical Network Unit (ONU):

The ONU provides interface between the customer‘s data, video and telephony networks and the PON. Its primary function is to receive traffic in optical format and then convert it to the user desired format (Ethernet, IP multicast etc.). [1]

1.1.2 Passive Network Element

These elements are placed between OLT and ONUs.
1. Optical Coupler/Splitter.

Optical Coupler:
An optical coupler consists of two fiber fused together. Simply, combine optical signals from multiple fibers into one.

Optical Splitter:
A coupler with only one input referred to as splitter.
Combiner:
A coupler with only one output referred to as combiner.

1.2 PON Topologies:

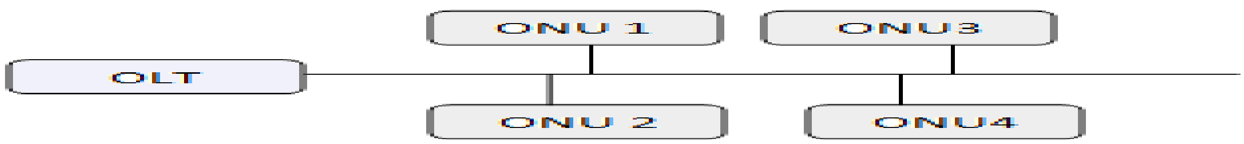


Fig. 1 Bus Topology [1]

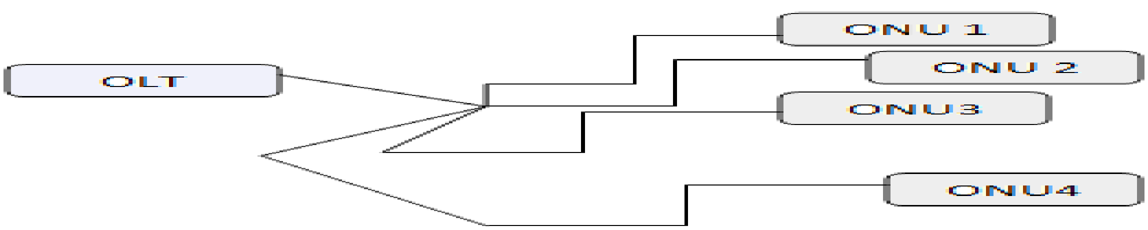


Fig. 2 Tree Topology [1]

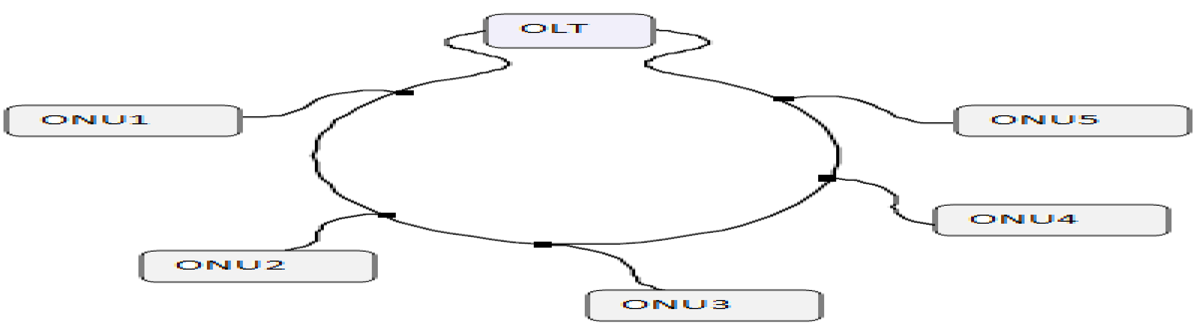


Fig. 3 Ring Topology [1]

PON Topologies

Ring Topology is better than others but mostly Tree Topology used.

1.3 Transmission in EPON:-

There are two types of transmission in EPON

1. Downstream(Broadcast from OLT to ONU's)
2. Upstream (Shared from ONU's to OLT)

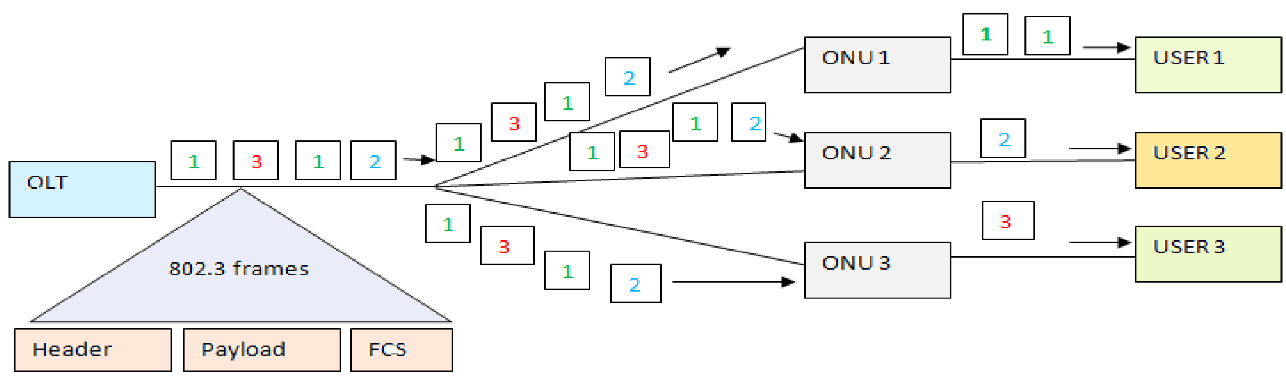


Fig. 4 Downstream Traffic in EPON [4]

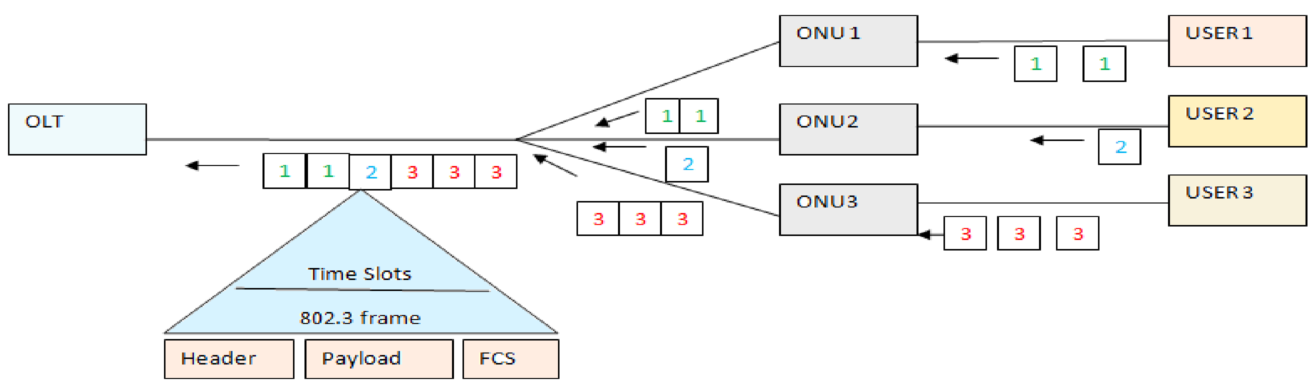


Fig. 5 Upstream Traffic in EPON [4]

2. Existing Solutions:-

In Scheduling algorithm (No class) Other than delays there is also one another aspect for the load management and bandwidth utilization by the ONUs, as we have to transmit the packets on the basis of the timeslot, if the size of the packet is greater than the timeslot being offered by the OLT, for transmission then that trace has to wait for the next time slot, this may cause channel underutilization, we can avoid it by implementing scheduling, at the ONUs. [3]

In Scheduling algorithm (With Class) We will implement the scheduling in the way that suppose there are five packets in the buffer, if the size of the first three and fifth one is up to that is offered by the timeslot, then we will not wait for the fourth packet that is not fitting in the timeslot, we will allow fifth one to move first in the timeslot, by doing so channel will not be underutilized, and less timeslots will be required for packet transmission. [3]

We can use different algorithms to fit packets in buffer queue such as first fit, best fit, prediction etc. [3]

An EPON network may be deployed for various scenarios but every ONU would host many users having different traffic types. Thus combined inter and intra-ONU algorithms (Priority Swapping) may have the following main challenges. [5]

1. Accommodating traffic fluctuations
2. Providing QoS to the traffic
3. Reducing OLT complexity by having priority scheduling within the ONU
4. Ensuring minimized packet loss
5. Protecting low priority traffic queues of ONUs from starvation

The three classes of the differentiated service are the EF class having the highest priority P1, the AF class with priority P2 and the BE class with priority P3. [5]
The algorithm swaps the priorities of these classes based on the relative buffer sizes of these classes. Three traffic schemes have been implemented by varyingα,β, γ (i.e., percentage distribution of incoming traffic) for EF, AF and BE service classes. The following table shows the variations inα,β, γ for our schemes. [5]

Three Major Problems in existing Solutions are:-

- Starvation
- Delays
- Quality of Service

3. Material and Methods

Our FIB Algorithm is an intra-ONU bandwidth allocation algorithm focusing to handle in better way parameters, like channel underutilization, starvation, delay and Quality of Service.
We have compared our solution with “priority swapping” and simple “scheduling” algorithm in which no classes were implanted for the purpose of quality of service.
As priority swapping contains three classes EF, AF and BE.
In our solution we have divided channel bandwidth in all these classes, according to following scheme.

Class EF	65%
Class AF	25%
Class BE	10%

This is the maximum bandwidth percentage that is allocated to classes when traffic of all classes is more than the allocated bandwidth of each class.
However if the traffic of any class is less than the allocated bandwidth percentage, then it can be used by the other classes.
The use of the remaining channel that is left by any class, is according to requirement of the classes, however if both the classes are competing for bandwidth then 75% is allocated to class A and 25% is allocated to class C.
Now scheduling is implemented in portion of each class so as to avoid remaining channel under utilization.

Network Traffic Schemes

Scheme	Class EF	Class AF	Class BE
	85%(3rd)	30%(arriving 1st)	25%(2nd)
	70%(3rd)	35%(2nd)	20%(arriving first)
	75%(arriving first)	25%(2nd)	35%(3rd)

Table 1

3.1 Comparative Analysis (Gantt Charts):

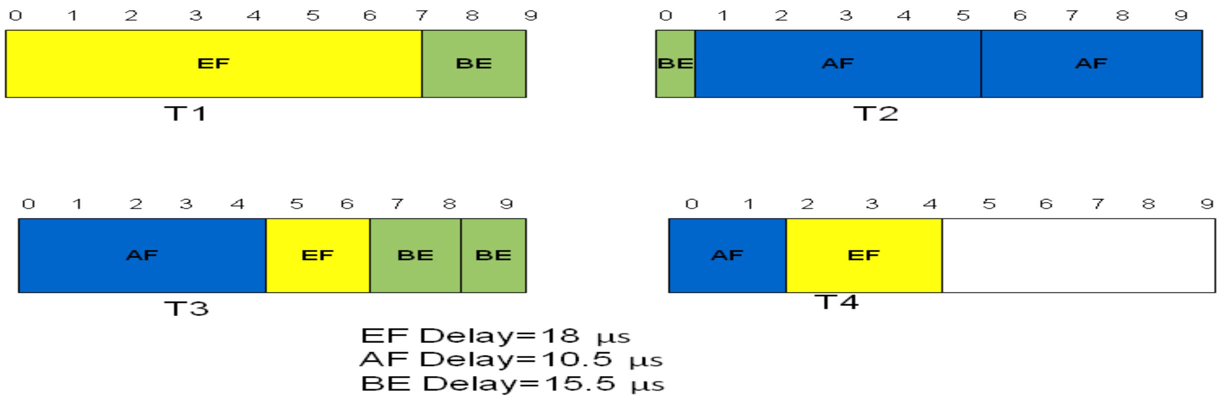
Network Traffic Schemes for scheduling (no class)

Delays experienced by the priority queues are on the basis of their turn, when any class has 2nd or 3rd priority it has to wait for the previous class to end transmission.

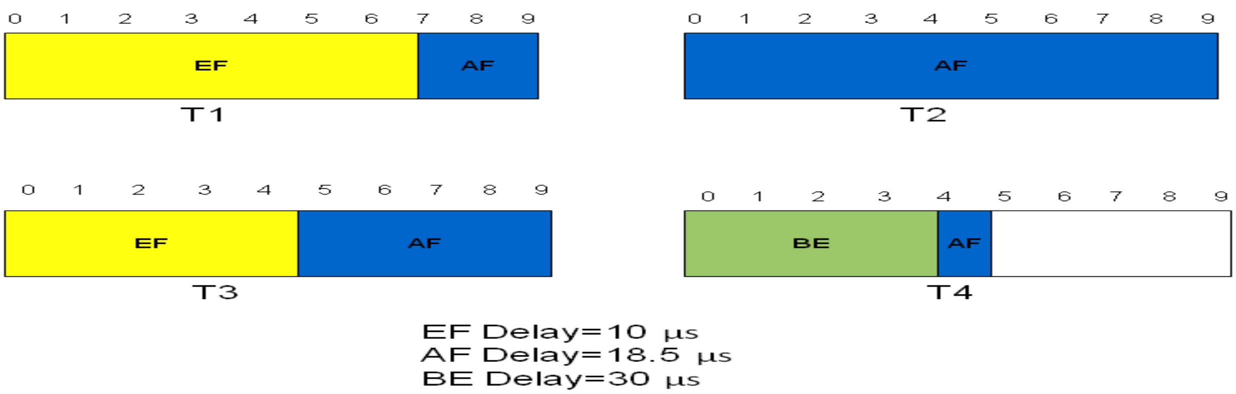
In no class solution no queue is implemented so bits have to move on the basis of their arrival, while in priority swapping data of that queue has to move that is given highest priority, in FIB algorithm always EF(if present) will move on first, on second AF(if present) and BE(if present) on third.

Priority Swapping and Proposed Solution:-

For No Class Solution



For Priority Swapping



For FIB Algorithm

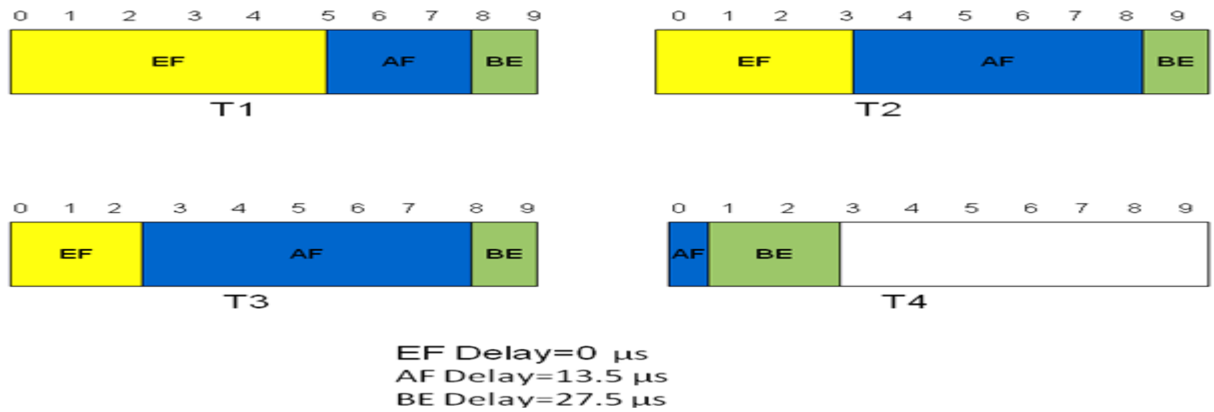


Fig. 6 Flow Charts

4. Results and Discussion

It is obvious from the graphs that in **No class Solution,** data that arrives first, occupies the timeslot. So at rush hours our important data may get very high delays and our communication is disturbed very much, such as in case of voice and video conferencing.

Priority swapping eliminates the case of high delays that are imposed on our urgent traffic, however on the basis of priority there is a high chance of starvation at rush hours, also total delay that is experienced by data is higher than no classes, and there is also chance of starvation.

FIB Algorithm is better than No Class Solution and Priority swapping because FIB eliminates the drawbacks such as starvation, Latency and Qos is eliminated allocating more bandwidth to the urgent data class.

All these three solutions are compared in a scenario in last page, for same traffic.

Delay of EF was high for "no class solution", because in this solution no priority is given to any class, delay for "priority swapping" is lesser because in some cases EF has priority; in "proposed solution" delay for EF is zero because data of EF moves always on first turn.

In the same way delay for "AF" and "BE" is lower in case of "proposed solution" than other two, reason was that in proposed solution every class is given some time in every timeslot, so no starvation occurs for any class in any timeslot. So total delay for "proposed solution" is lesser than other two, which leads to better quality of service in this case.

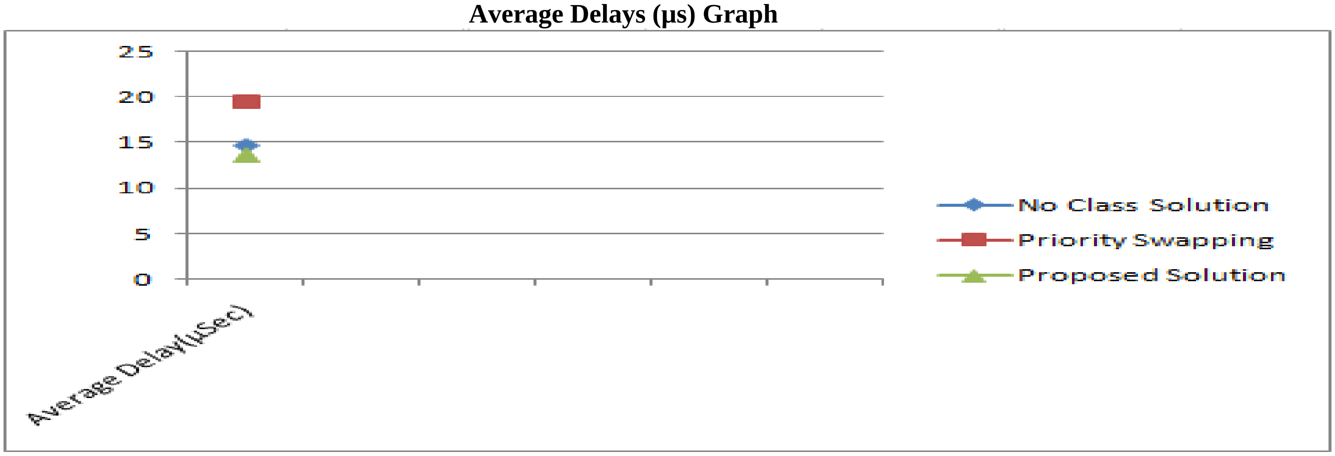
4.1 Total Delay Table & Graph:

Total Delay

	Delay(µs)EF	AF Delay(µs)	BE Delay(µs)	Average Delays
No Class Solution	18	10.5	15.5	14.66
Priority Swapping	10	18.5	30	19.5
Proposed Solution	0	13.5	27.5	13.66

Table 2

Average Delays (µs) Graph



Graph 1

5. Simulation Setup:

We designed a simulator using java for comparative analysis

Input for single ONU

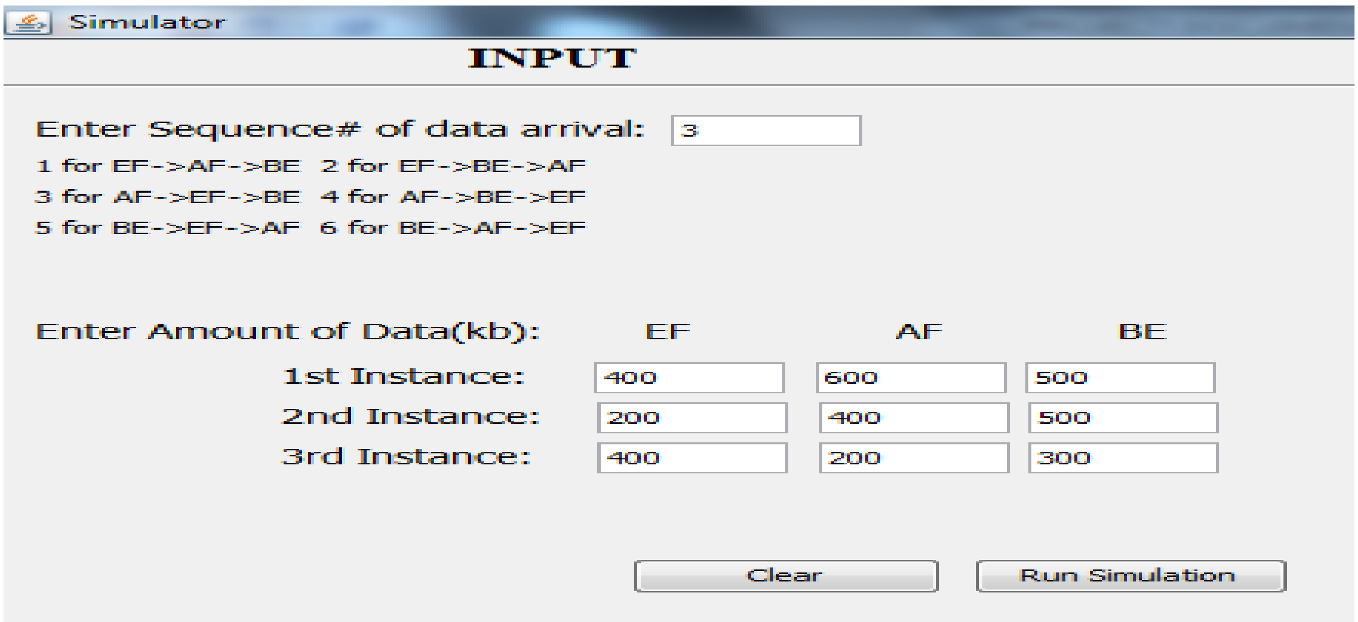
No. of Classes=3

No. of sequence of data entry=6

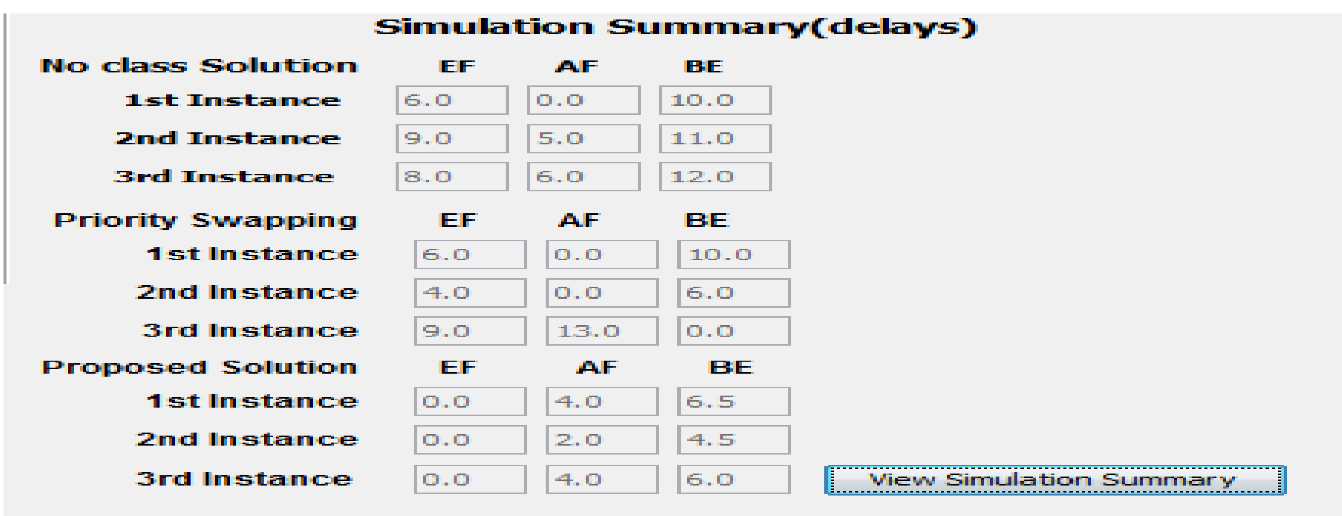
No. of Instances for any particular sequence=3

Output for single ONU

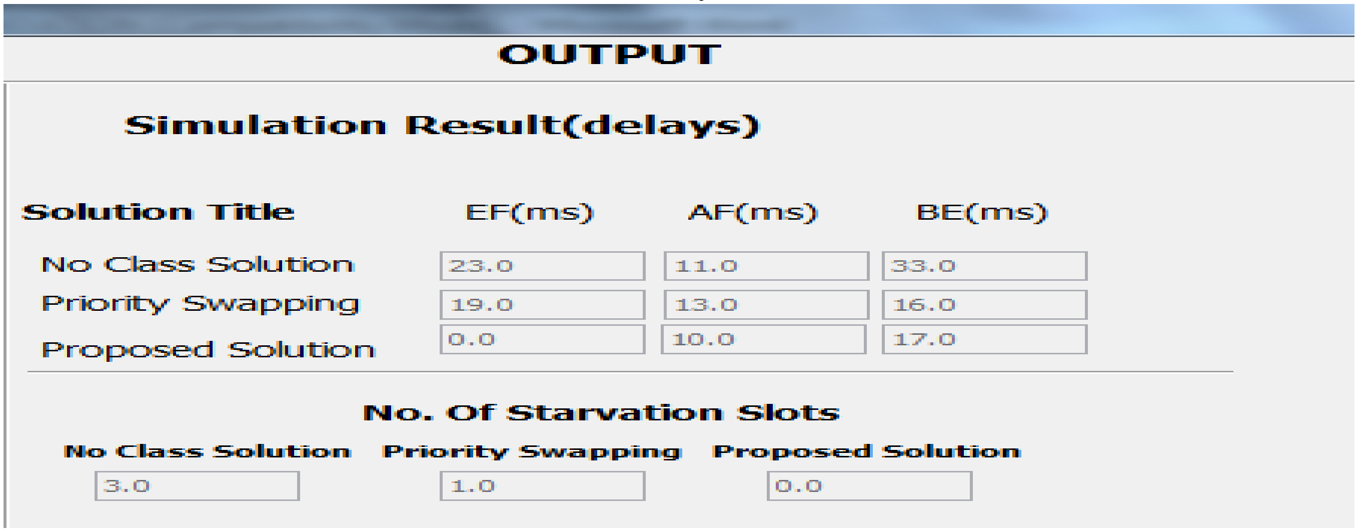
Delays and Starvation for one sequence of input. Summary of the Simulation can also be viewed (per instance)



Sequence No. of Data arrival &Inputs



Simulation Delays



OUTPUT

Simulation Result(delays)

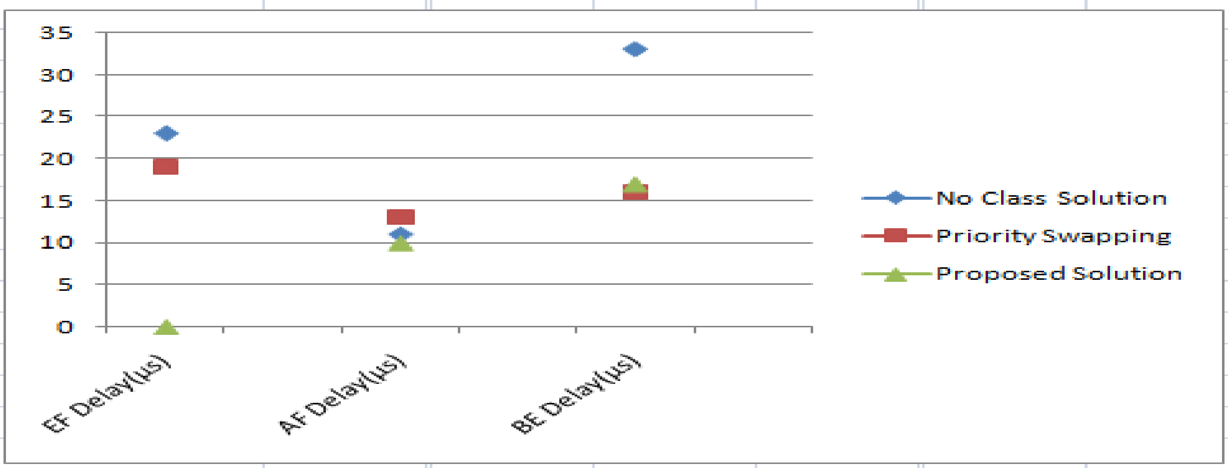
Solution Title	EF(ms)	AF(ms)	BE(ms)
No Class Solution	23.0	11.0	33.0
Priority Swapping	19.0	13.0	16.0
Proposed Solution	0.0	10.0	17.0

No. Of Starvation Slots

No Class Solution	Priority Swapping	Proposed Solution
3.0	1.0	0.0

Simulation Results

Total Delay				
	EF Delay(µs)	AF Delay(µs)	BE Delay(µs)	Total Delay(timeslots)
No Class Solution	23	11	33	67
Priority Swapping	19	13	16	48
Proposed Solution	0	10	17	27



Graph 2

Note: FIB Algorithm Delays is better than No class solution and Priority swapping

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6. Conclusion

It is concluded that, TDM EPON is the cost effective method of transmission in point to multi point networks. It will be better if it is changed according to proposed solution because the parameters which are affecting its QoS are handled in much better way in the proposed solution. Hence, it is concluded that TDM EPON is better technology till now if it is used with a better scheduler.

7. Future Directions

In future, work on QoS in rush hours can be done to make it more and more efficient with every aspect because in rush hours classes may suffer delays in sending their full traffic in one allocated timeslot. They have to wait for next time slots to send their full traffic which suffers in time delays but there will be no starvation because every class have allocated a fixed bandwidth in each timeslot.
Traffic can also be divided in more than three classes according to requirement so as to improve quality of service of our desired data.

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