Analysis of Tolerance and Sleep Time in Sleep Mode Scheduling Energy Saving Technique in Time Division Multiplexing Passive Optical Networks

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Abstract - Huge energy resources (electricity) are consumed by the telecom-equipments in broadband enable access technologies. There is current need to minimize the energy consumption in access network technologies especially in passive optical network. This paper aims to analysis and observes the energy consumption in Sleep Mode Scheduling Technique Energy Saving in TDM-PON by analysing tolerance and sleep time parameters.

Keywords - Optical line terminal, Optical network unit, PON- Passive Optical Network, Downstream Traffic, Power Saving Method, TDM-PON, sleep mode and synchronization.

I. INTRODUCTION

It is estimated that 2-10% of the CO2 produced by human activity comes from Information and Communications Technologies (ICT) [3]. Such emissions are expected to rise steadily in the next years, due to the increase of users and increased utilization. Today most of access network segment is based on energy-demanding technologies and wireless access. However, even with the introduction of optical fibre in the access, the energy consumption is forecast to grow with the average access bit rate ssincrease [4]. Furthermore, the energy per bit requested by Optical Network Units (ONUs) of Passive Optical Networks (PONs) is at the top among the communications network devices.

II. PASSIVE OPTICAL NETWORKS

PON is a shared medium in which a fibre is passively split into many end user connections. The term passive refers only to the optical splitter, which work independently of external electrical power. Each end user has an ONU while the fibre terminates at a central office in an OLT (optical line terminal), which requires electrical power. Between the OLT and the ONU may be one or two stages of passive splitters which split the connection to multiple end points. The signal generated at core network need to be send towards requested ONU.

III. Power Saving Techniques

The common objective of all power saving techniques is to put ONU into lower power states. The power saving states into three categories: Power *shedding*, dozing, and sleeping. The approaches mainly differ in the behavior of the ONU transmitter and receiver. In general, the ONU transmitter is already burst-mode capable, i.e. it can turn on and off quickly during idle time slots to avoid adding noise contribution to the other ONU upstream data. On the other hand, turning ONU receiver on and off is far more challenging because the operation will require synchronization overhead to recover the clock from downstream data.

During lower power states, the ONU also faces the choice to select what part of functions and services to turn off. In the power shedding mode, used when the ONU operates under battery power, the ONU powers off or reduces the power to non-essential part of functions and services only. In the dozing mode, the ONU keeps all the downstream functions operational but turns off the transmitter and ignores OLT bandwidth request when ONU does not have upstream traffic to send. In the sleeping mode, on the other hand, the ONU turns off virtually all the functions and services to gain the greatest power saving potentials. Sleeping mode into two sub-categories: *deep sleep* and *fast sleep*. In deep sleep mode, all ONU functions are turned off and any incoming downstream or upstream traffic is lost. In fast sleep mode the ONU maintains the timing (free-running and not synchronized to OLT) and traffic detection functions to maintain the ability to wake up from the sleep mode. Whenever new traffic arrives. During the transitional wake up time, the OLT would buffer the downstream traffic until ONU is fully awake. In the dynamic power save mode, the ONU shares similar transmitter and receiver behavior to the dozing mode but the operations of the ONU functions and services are more similar to the fast sleep mode.

IV. POWER SAVING METHOD

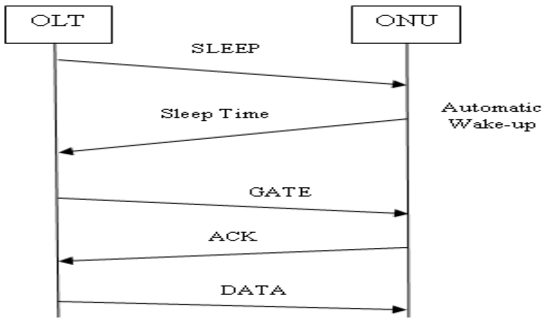


Fig. 1 Basic Concept of Power Saving Method.

When there is no data to be sent then OLT requests ONU to go to sleep mode by sending sleep message to ONU. The ONU puts itself to sleep mode and switches off. The user network interface goes to sleep mode as well. The user network interface is inactive in power ignoring scheme as well when network is idle. The sleep time for ONU is fixed at 2 msec. The ONU wakes up automatically after this sleep time. The OLT back end circuitry will continuously monitor for signal arrival. Between this duration, if signal arrives, the OLT signals ONU to wake up by sending GATE message. The ONU will acknowledge this message by sending ACK signal and ONU become active and start receiving data from OLT. During this transition process, from sleep to active or active to sleep some power is consumed as well but still less then power wastage during idle mode.

V. Sleep Mode Scheduling Energy Saving Technique in TDM-PON

In a TDM-PON (time division multiplexing PON) network the length of inactivity periods strongly depends on the particular applications that the customer is using and on the traffic load conditions throughout the whole network. Despite these factors, still it is possible to obtain an estimation of the idle period. This can be achieved by exploiting the statistical properties of the traffic, but some error must be tolerated. The tolerance level mainly depends on the service-specific requirements because different service types usually require different frame rates and show different sensitivities to traffic delay. This thesis investigates and proposes a *sleep mode* technique where the length of the sleep periods for each ONU is computed with a statistical method by monitoring the inter-arrival times between downstream frames. The scheduling mechanism is then divided into two different methods in order to preserve quality of service when delay-sensitive services are active but save more energy when the traffic is not so critical in terms of latency.

VI. RESULTS AND DISCUSSION

In Sleep Mode Scheduling Technique Energy Saving in TDM-PON, the tolerance level mainly depends on the service-specific requirements because different service types usually require different frame rates and show different sensitivities to traffic delay and sleep time (Fig. 2) are important parameters to study by analysing its effect on power usage.

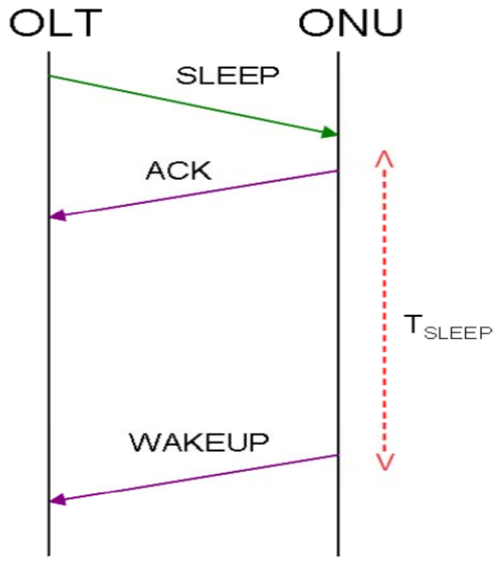
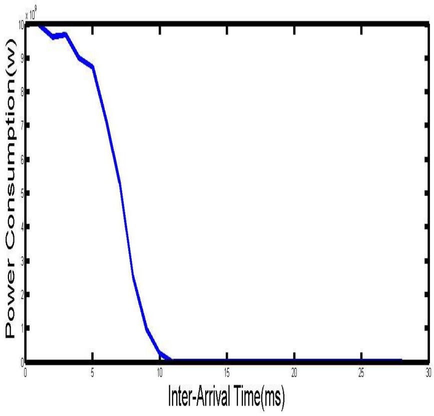


Fig. 2 Basic Concept of Sleep Time (Tsleep).



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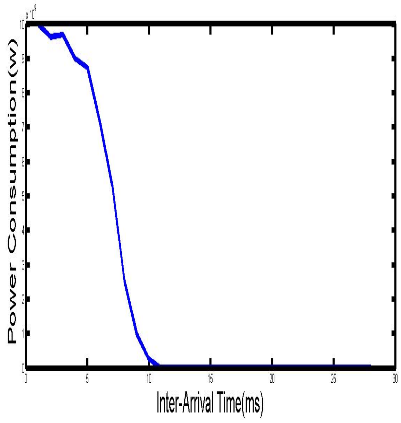

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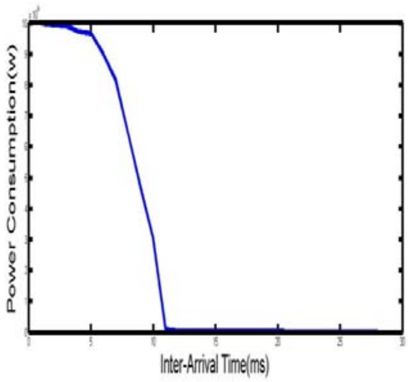

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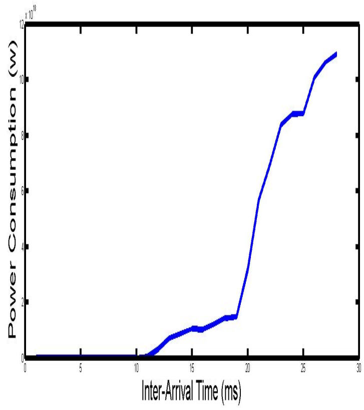

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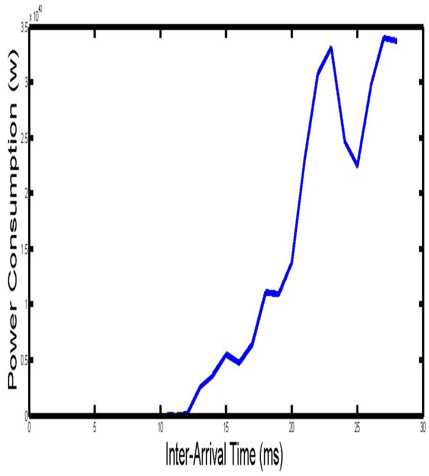

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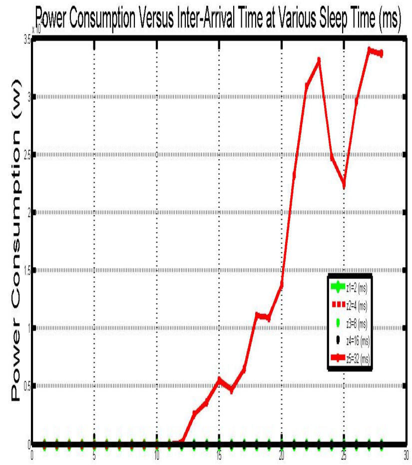
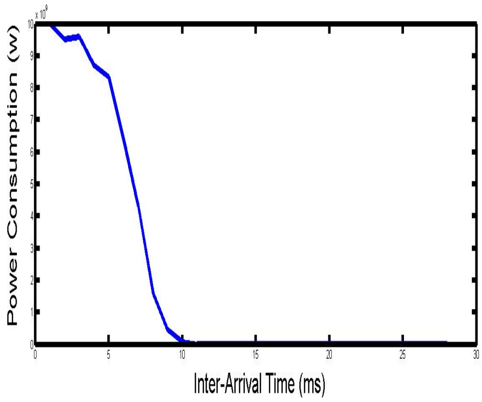
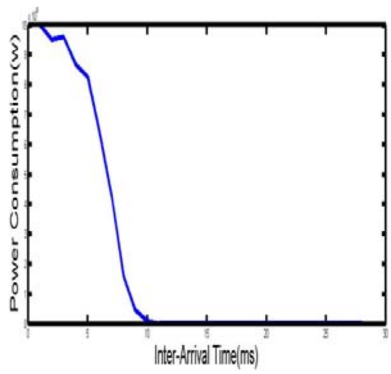


(f)

Fig. 3 Power Consumption Versus Inter-Arrival Time at various Sleep Time (a) 2ms (b) 4ms (c) 8ms (d) 16ms (e) 32ms (f) Superimposed Graph of various Sleep Time.



(a)



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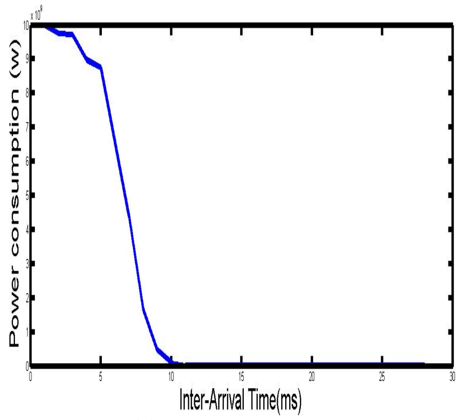

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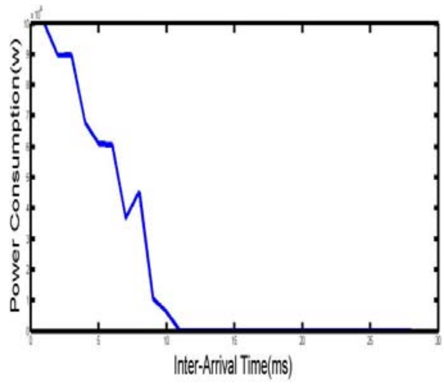

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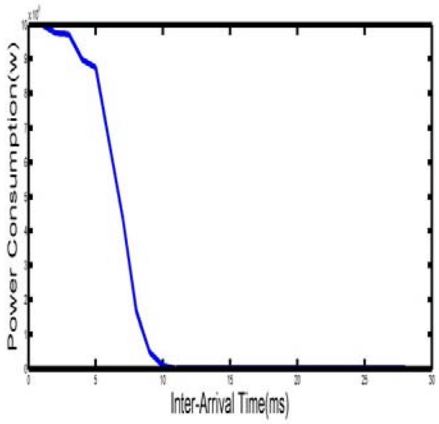

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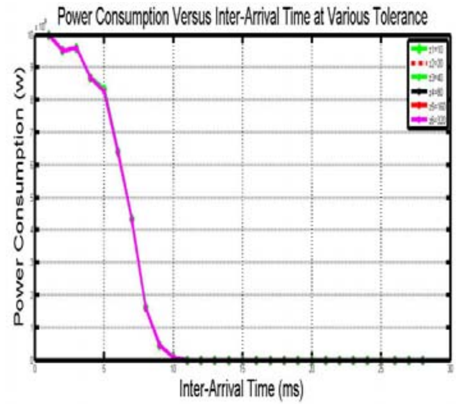

(f)

Fig. 3 Power Consumption Versus Inter-Arrival Time at various Tolerances (a) 10 ms (b) 20 ms (c) 40ms (d) 80 ms (e) 160 ms (f) Superimposed Graph of various Tolerances.

In the graph 6.1 (a) of power consumption versus inter-arrival time at Sleep Time =2 ms, the minimum value is 20.73 and maximum value is 1e+10. Its standard deviation 3.682e+9. The graph 6.1 (b) is having standard deviation 3.792e+09, mean is 2.263e+09 and mode is 1288.

Similarly, the graph 6.1(c) is having minimum value 1.933e+07 and range 9.981e+09. For the graph 6.1 (d) mean is 2.984e+09. The values of graph 6.1 (e), minimum value are 1e+10, maximum value is 1.093e+19 and mean is 2.911e+18.Its standard deviation is 3.984e+18.

In the graph 6.2 (a) of power consumption versus inter-arrival time at tolerance =10 ms having minimum value 20.73 and maximum value 1e+10. Its standard deviation 3.682e+9. For the graph 6.2 (b) the minimum value 9.429 and its maximum value remains same to previous graph maximum value. The minimum value of graph 6.2 (c) 5.44 and maximum value appear to be 1e+10. There is little change in values of graph 6.2 (d). The range remains same for all graphs of power consumption versus inter-arrival time at various tolerance as graph 6.2 (e) i.e. 1e+10.

So these above Graphs values give an analytical view that sleep time manipulation much affect the system working rather than tolerance manipulation.

VII. Conclusion

The Power Usage in Sleep Mode Scheduling Technique Energy Saving in TDM-PON method has been investigated under Tolerance and sleep time parameters. It is visualised through these graphs that sleep time is having impact on power usage of the system but tolerance is little role to play in. In future scope, this system will be analysis with WDM-PON.

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