Power Management in TDM PON using Fuzzy

Akanksha Vyas[1],
Student SIMS

Vandana Dubey
Asst. Professor ,SIMS

Abstract—**Passive optical network (PON) is a part of telecommunication network which is characterized by point to multipoint architecture. PON has huge potential to use optical fiber for high speed and data rate, but they are prone to high power consumption. This attracted the attention of many to come up with many different policies, energy efficient strategies, and protocols. Exponential growth in demand of more and more data, voice, and information processing requires something solutions high on bandwidth and less on power consumption. This can be achieved by implementing proper power management with PON which is not available in Time Division Multiplexing (TMD) PON. Power management is done thorough sleep scheduling scheme. In sleep scheduling scheme transceiver of ONU is put off when there is no data transmission. The aim of this paper is to decrease power consumption for delay sensitive and delay insensitive traffic. A fuzzy rule table is constructed with prediction of average inter arrival time of frame on the basis of outcome sleep time and power is evaluated. Proposed method offer effective power efficiency than previous inter arrival time method.**

***Index Terms*—Fuzzy logic, Inter arrival time, OLT, ONU, sleep scheduling, TDM-PON**

I. INTRODUCTION

TECHNOLOGY is heart of information exchange in day to day life. Continuous growth either in commercial or non-commercial or personal areas developed various devices such as telephone, computer, modem, smart TV, smart phones etc. for information exchange in communication. The telephone network supports this triple play service (voice, video and data) and provides interactive means of information exchange between sources to destination with number of ways.

The rate of traffic growth over the telecoms network in the past twenty five years and is predicted to increase 32% per year for the next four years and the number of devices connected to IP networks will be twice as high as the global population in 2015 [1].This is partially due to the *exponential growth* in internet users and new communication platform. People spent more time in online services. Which raise the demand of high bandwidth application, which can connect local, national as well as international system.

Now days, power management constitutes an issue of paramount importance. In this perspective, PON has attracted the attention of the researchers, with emphasis laid on the design and implementation of energy efficient strategies and protocols. An effective method to reduce the energy consumption in access networks is sleep mode policies at the ONUs, which provides power saving.

Architecture of PON consists of one Optical Line Terminal (OLT) functionalized as a central office, one passive optical splitter implemented in the remote node, and multiple optical Network Units (ONUs) residing at user premises. The OLT plays role of distributor, arbitrator, and aggregator of traffic [2]. In the upstream direction (from ONUs to the OLT), multiple ONUs share a single link and traffic may collide, so each ONU is assigned a specific time slot for transmission. The OLT distributes the fiber capacity using an upstream bandwidth arbitration mechanism to avoid collisions. In the downstream direction (from the OLT to ONUs), data frames are broadcast to all ONUs using different wavelength. ONUs filters and accepts data addressed to them. However, ONUs consistent listen and examine downstream channel, which results in wasting significant energy of ONU, called as overhearing.

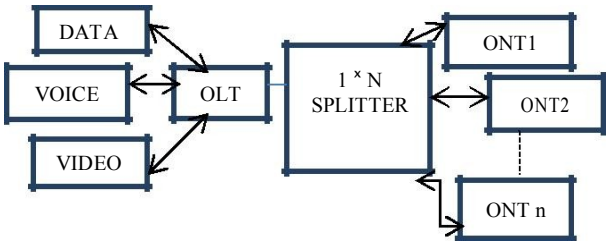

Fig.1 General Schematic of PON Architecture

With comparison to other wired access technology PON consumes less power, which can be further increased through proper sleep scheduling and power management method. Energy efficient Ethernet (EEE) is scheduled to be standardized in IEEE 802.3az by 2010 ,sleep scheduling is discussed in IEEE 802.3az standard[3].In sleep scheduling, ONUs turn off the transceiver in order to save energy, when there is no data transmission. ONUs wakes up before next communication with the OLT. When ONU is in sleep stateincoming data is buffered at OLT. A power management with efficient scheduling for the sleep and wake-up period among multiple ONUs is a challenging task. There is two state of ONU, active state and sleep state.Mainly four methods for sleep scheduling:

In *Power shedding* method ONU transceiver is always active. In *ONU dozing* technique, ONU transmitter can be in sleep state for certain periods of time while the ONU receiver is always in active state all time. In *deep sleep* scheme transmitter as well as receiver of the ONU remains completely power off for the entire duration of the sleep state. Only some necessary functions remain optionally active, like activity detection and some local timing. In *fast sleep mode,* ONU goes through a periodic sleep cycles, each composed by a sleep and an active period. By putting the ONU in off state power is saved which in turn provides effective utilization of network

The rest of the paper is organized as follows. In Section II, explains system model and various parameters for power management in PON. Section III gives simulation result. Section IV gives conclusion.

II.PROPOSED POWER MAMANGEMENT SCHEMES IN PON

Power management in TDM PON is achieved through sleep scheduling schemes. Unnecessary ON of ONU caused wastage of power, which can be caught dawn using proper sleep and wakeup schemes.

A. SYSTEM MODEL

TDM-PON system has one OLT, *1: N* splitter and multiple N ONUs. Here bandwidth is divided in time slots. EveryOLT has a buffer which store frame when ONU is in sleep state. Efficient scheduling is achieved by fast sleep mode. Message exchange for this method is explained through timing diagram of Fig. 2. The OLT plays a role of monitor which concentrate over the downstream traffic for each ONU and sends a Request message to the ONU that includes the sleep time *T*. We assume here that the OLT has all the information about presence or absence of downstream traffic on the basis of the downstream frame interval, *i*. The sleep time is enabled when some
threshold condition is verified. It can be calculated as

{ (1)

Where *Ts* and i_{th} denote the predetermined sleep time and the threshold of the downstream frame interval respectively.

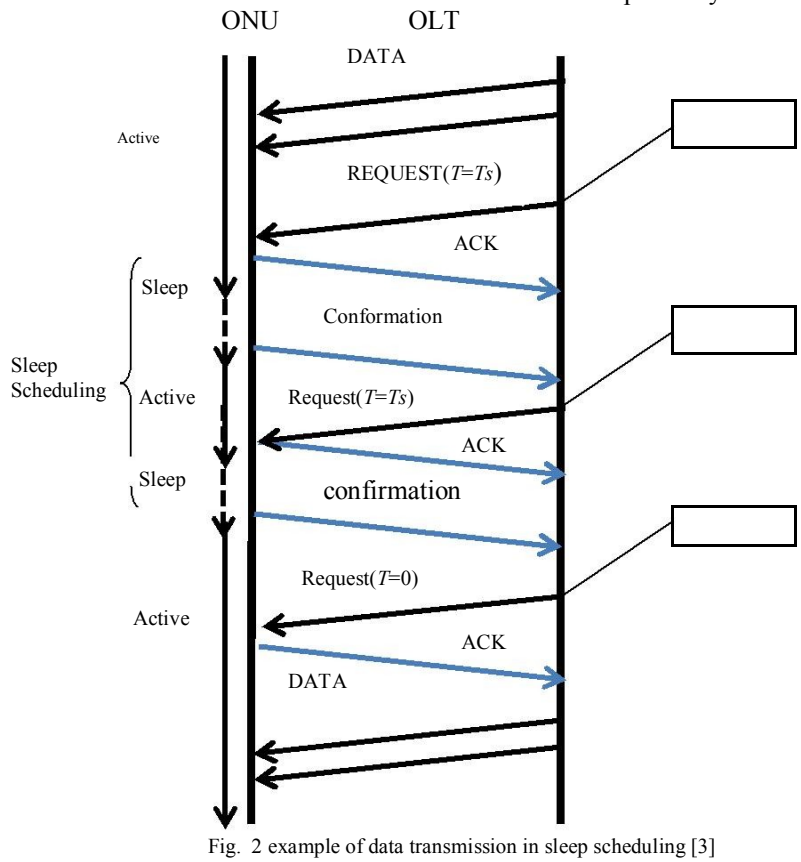

Fig. 2 example of data transmission in sleep scheduling [3]

B. System Parameters

Inter arrival time: The frames are generated at the OLT intended for ONU follows a Poisson distribution. Thus the associated inter-arrival times will follow an exponential distribution.

First step is to evaluate Current distribution of inter-arrival times. This is accomplished by means of an arithmetic average computed on *n* samples [5]:

() Σ ( ) (2)

Traffic load: In this paper we consider delay sensitive and delay insensitive traffic case for sleep time and power calculation. Threshold of both condition is depends on Average and wake up time. For delay sensitive traffic scheme sleep period is short, QoS works as prime factor. On the other hand for delay insensitive traffic scheme QoS is not a big issue, sleep period is long.

Sleep Time: It is defined as time (in ms) for which ONU trans-receiver is off.

Power: It is defined as power (in W) consumed by each ONU for information exchange. It is inversely proportional to sleep time.

$$Power = P_{active} - Sleep\ Ratio * (P_{active} - P_{sleep}) \quad (3)$$

Where,
P_{active} = Power of ONU in active state
P_{sleep} = Power of ONU in sleep state
Sleep Ratio = time spent in sleeping

C. Methodology

Fuzzy logic is used to calculate overall sleep time using inter arrival time and wake up time.

1. Calculate inter arrival time of current frame distribution.
2. Set wakeup time duration in between 0 to 12 ms
3. Calculate sleep time for each ONU using fuzzy logic.
4. Calculate power consumed by each

ONU. D. Algorithm

Input: Two input parameter is used for fuzzification i.e. prediction of inter arrival time and wakeup time.
Output: Power consumption based on fuzzy decisions.

Decide the *power consumption* on the following rules of fuzzy.

if((iat==Short)&&(*Wakeup Time*==Short)
Power= Excellent
else if((iat==Medium)&&(*Wakeup Time*==Medium))
Power = Good
else if((iat==Large)&&(*Wakeup Time*==Large))
Power = Poor

Where iat is inter arrival time of frames calculated by average formula (1).

Fuzzy logic has a unique feature that it can generate output or result on the basis of random estimated input information. One could not calculate inter arrival time accurately because generation of frames is defined as random function of time.

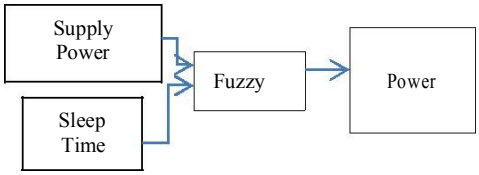

Fig.3 Generation of Power using Fuzzy Logic

III. Simulation Results and Analysis

Several parameters were fixed for the simulation part, including number of ONU's and frames.

TABLE I
SIMULATION PARAMETERS

S.NO	PARAMETER	VALUE
1	No. of Frames	100
2	Wake up time	1ms
3	Active power(P active)	10 W
4	Sleep power (p sleep)	2 W
5	Tolerance	10 ms
6	No. of ONU	37
7	No. of OLT	1
8	Splitter	1

Some assumptions are made as

a) Upstream traffic is discarded.
b) Idle period is discarded.

Same calculation is done 10 times and average of this represents the final result. Coding and simulation is done in MATLAB. The system designing is verified from the below graph. Fig.4 represents the previous technique for Power calculation which is based on inter arrival time and Fig.5 represent the proposed technique which is based on fuzzy power calculations. Below case is verifying the delay sensitive scheme of power calculation. In previous method power is decreasing linearly with respect to average inter arrival time. On the other hand it decreases exponentially in proposed method.

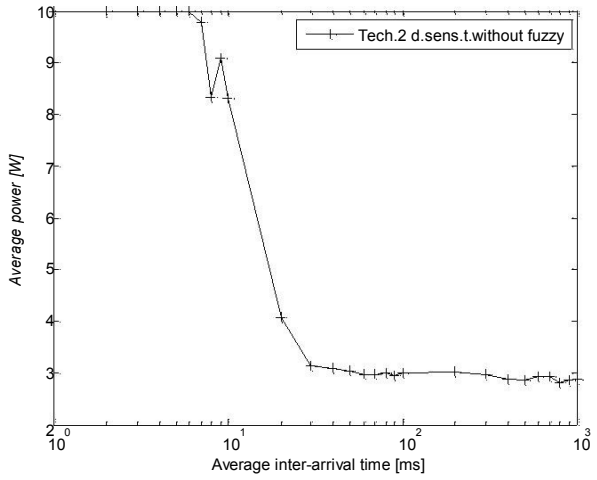

Fig.4 Previous Average Power calculation

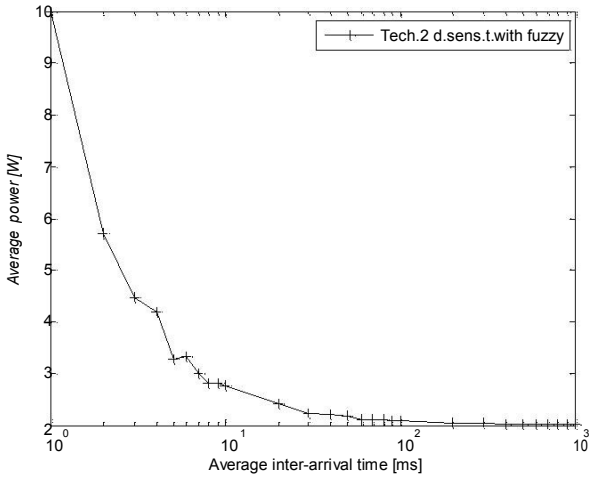

Fig.5 Proposed fuzzy based Average Power calculation

Following table compare both the technique on different parameter:

TABLE II
COMPARISION OF DELAY SENSITIVE TECHNIQUE

S.NO	AVG INTER ARRIVAL TIME IN ms	AVG POWER	NODES	AVG POWER	NODES
		Conventional ESA technique		Proposed fuzzy based ESA technique	
1	1-10	10-8	10	10-3	10
2	10-100	4-3	9	3-2	9
3	100-1000	3	8	2	9

Similarly, delay insensitive traffic scheme is also verified using below graphs of Fig.6 and Fig. 7. The input and output parameters are in both schemes.

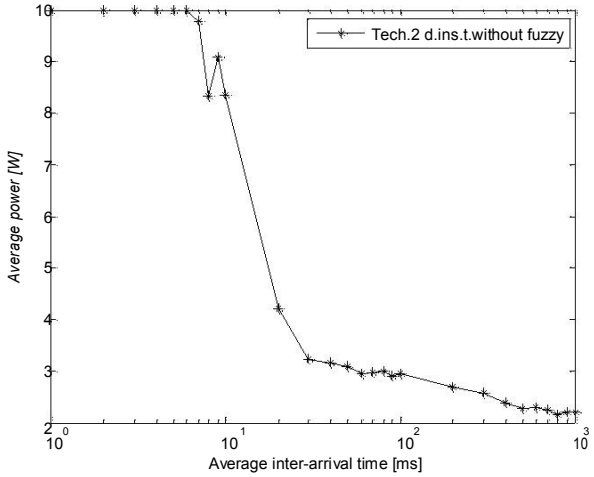

Fig.6. Previous Average Power calculation

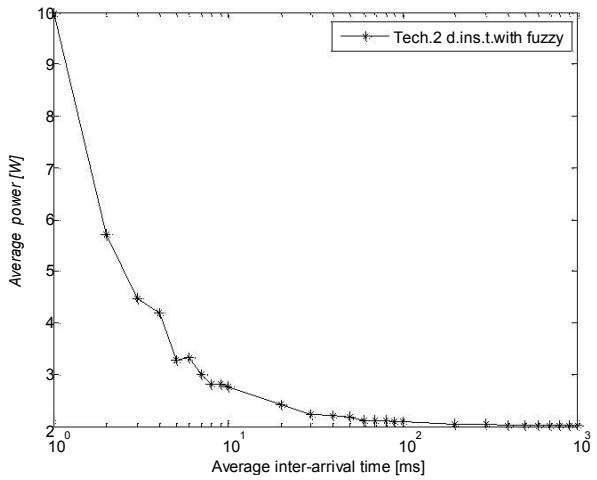

Fig. 7 Proposed fuzzy based Average Power calculation

TABLE III
COMPARISION OF DELAY INSENSITIVE TECHNIQUE

S.NO	AVG INTER ARRIVAL TIME IN ms	AVG POWER	NODES	AVG POWER	NODES
		Conventional ESA technique		Proposed fuzzy based ESA technique	
1	1-10	10-8	8	10-3	10
2	10-100	8-3	10	3-2	9
3	100-1000	3-2	9	2	9

IV. CONCLUSION AND FUTURE WORK

This paper has proposed fuzzy based power management for energy saving in PON. Proposed method enhance the power utilization from the previous average technique of inter arrival time. The level of power utilization is rise by 0.9 from the previous one as shown from graph. Further we will perform simulation for calculating delay latency.

REFERENCES

[1] J. McGeough, ―Semiconductor Optical Amplifiers to Extend the Reach of Passive Optical Networks ‖ ,*School of Engineering in the College of Science and Engineering,*University of Glasgow ,2012

[2] Y. Yan and L. Dittmann, ―Analysis of Sleep-Mode Downlink SchedulingOperations in EPON Systems‖ , *IEEE* ,2010

[3] R. Kubo and J. Kani and H. Ujikawa and T. Sakamoto, Y. Fujimoto and N. Yoshimoto, and H. Hadama , ―Study andDemonstration of Sleep and Adaptive Link Rate Control Mechanisms for Energy Efficient 10G-EPON‖ , *Optical Society of America*,2010

[4] S.Wong and L. Valcarenghi and S. Yen and D. Campelo and S. Yamashit and L.Kazovsky, ―Sleep Mode for Energy Saving PONs:Advantages and Drawbacks‖ *IEEE*,2009

[5] M. Fiammengo, ―Sleep mode scheduling technique for energy saving in TDM-PONs‖ , *Master of Science Thesis Stockholm*, Sweden , 2011

[6] S.Wong and L. Valcarenghi and S. Yen and D. Campelo and S. Yamashit and L.Kazovsky , ―Energy Management Mechanism for Ethernet Passive Optical Networks (EPONs)‖ , *IEEE Communications Society,*2010

[7] J. Jung and W. Yang and Y.Chon Kim, ―A Bandwidth Allocation Algorithm for Improving QOS in EPON with Sleep Mode‖ , *IEEE*,2012

[8] M. Tripathy and K. Gaur and S. Sharma and G.Virdi , ―Energy Efficient Fuzzy Logic Based Intelligent Wireless SensorNetwork‖ , *Progress In Electromagnetics Research Symposium Proceedings*, Cambridge, USA, 2010

[9] I. Hwang and Z.Shyu and K.Huang , ―Fuzzy Logic Embedded in Prediction-Based DBA for Differentiated Services on EPONs‖ , *Tamkang Journal of Science and Engineering,*2009, Vol. 12, No. 1, pp. 73_84 ,

[10] www.mathworks.in/products/matlab

