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Delay minimization in Passive optical Network by using Adaptive Filters

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***ABSTRACT* :-**
This paper proposes the technique to reduce Delay and Energy to improve cost of Passive Optical Network. We have different Filters to remove dispersion so that delay and energy will be minimized. The optimization of bandwidth in Passive Optical Network is carried out with different approaches leading to various parameters of Delay, Energy Savings. Main focus is on Dynamic Bandwidth Allocation algorithm because it results in improved energy savings, both at the Optical Line Terminal and at the Optical Network Unit. Mainly the performance of algorithm is evaluated in terms of average delay, percentage of energy savings at Optical Network Unit and percentage of energy savings at Optical Line Terminal. In the basic term: wavelength allocation, grant sizing and grant scheduling is discussed.

Keywords :
Dynamic Bandwidth Allocation, Adaptive Filters, Dispersion Removal, Delay Minimization, Energy Savings

1. INTRODUCTION

1.1Overview of Optical Network

Optical network are high-capacity telecommunication network lying on optical technologies and components that provide routing, grooming and restoration at the wavelength level as well as wavelength-based services. It uses Optical Fibers for data transmission. The header is then extracted, processed and a routing decision is made based on the information provided in the header and the routing protocol. The packet is then queued at the output port, transformed back into its optical form and transmitted towards its final destination.

1.2Types of Optical Network

There are 3 types of optical network: active, FTT-X and passive

1.2.1 Active Optical Networks

These uses electrically powered switching equipment such as router to manage signal distribution and direct signals to specific customers. This switch opens and closes in diverse ways to direct the incoming and outgoing signals to the proper place. They require at least one switch aggregator for every 48 subscribers. This is characterized by a single fibre which carries all traffic to a remote node close to the end users from the central office. It is also often denoted as Active Ethernet Network, since equipment needed to provide TV, telephony and Internet are connected through the common Ethernet standard. The remote node contains an active element, which processes the data frames that are sent from the central office to the remote node, and forwards only frames to the respective network units. From the remote node to network units, individual fibres are run to each cabinet/curb, home, building etc. based on the type of solution that is implemented.

1.2.2 Passive Optical Networks

Passive optical networks have high bandwidth Point-to-Multipoint optical fibre network based on the Asynchronous Transfer Mode, Ethernet or TDM.PONs rely on light waves for data transfer. Only passive optical components are used such as optical fibre, splices and splitters. PONs minimizes the fibre deployment in both the local exchange office and the local loop. PONs provides higher bandwidth due to deeper fibre penetration, offering gigabit per second solutions.
The PON is an access network based on Optical Fibre. It is designed to provide virtually unlimited bandwidth to the subscriber. A passive Optical network is a single, common optical fiber that uses a passive optical splitter to divide the signal towards individual subscribers. PON is named passive because other than at the central office there is no active element within the access network. A PON enables an service provider to deliver a true triple play offering of voice, video and data, an important component of the data offering .PON are getting more widespread in rollout of Fiber To The Home infrastructure. [1]

1.3Architecture of Passive Optical Network

The elements of passive optical networks are:
Optical Line Terminal
Passive Optical Splitter
Optical Network Unit

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The Optical Line Terminal is the chief element of the network and is usually placed in the Local Exchange. It is a network element with PON line card, basically a aggregation switch. Optical Splitter is an inactive device with single input and multiple outputs. Optical power at input is split evenly between outputs. Not only signal travels from input to the outputs, signal can also travel from the output to the input. Splitters can be located anywhere in between CO and Subscriber premises. It is used to connect an optical port of OLT with multiple subscribers.It provides several interfaces for accessing triple play services and in the upper side it linked with the OLT via optical splitter. Although PON uses 1490 nm for the downstream wavelength and 1310 nm for the upstream wavelength. Signals are inserted or extracted from the fibre with a coarse wavelength division multiplexer filter at the CO and subscriber premises. The communication lane from the OLT to the ONU is referred to as downstream and reverse path as upstream. The downstream and upstream signal is carried over the same fibre. In the downstream direction the signal sent by the OLT arrives at the splitter's input and later the similar signal reaches every ONU. [2]

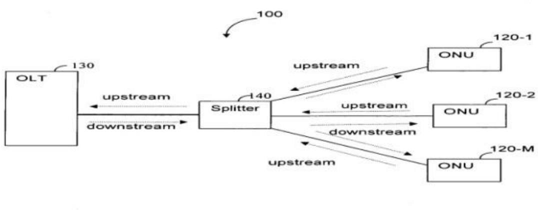

FIG. 1

1.4 Components of WDM Passive Optical Network

The components of WDM Passive Optical Network are:-

Wavelength Division Multiplexer
Optical Isolator
Optical Circulator
Fiber Optic Filter

Wavelength Division Multiplexers are optical components in which power is divide or combined based on the wavelength composition of the optical signal. Dense Wavelength Division Multiplexers are optical components that split power over at least four wavelengths. Wavelength insensitive couplers are passive optical components in which power is divide or combined independently of the wavelength composition of the optical signal. A given component may combine and divide optical signals simultaneously, as in (duplex) bidirectional transmission over a single fiber. Passive optical components are data format transparent, combining and dividing optical power in some predetermined ratio (coupling ratio) regardless of the information content of the signals. They can be thought of as wavelength splitters and combiners.

An optical isolator is a two-port passive component that allows light in a given wavelength range to pass through with low attenuation in one direction, while isolating providing a high attenuation for light propagating in the reverse direction. Isolators are used as both primary and in-line components in laser diode modules and optical amplifiers, and to decrease noise caused by multi-path reflection in high bit-rate and analog transmission systems.

An optical circulator operates in a similar way to an optical isolator, apart from that the reverse propagating light wave is directed to a third port for output, instead of being lost. It can be used for bidirectional transmission, as a kind of branching component that distributes and isolates optical power among fibers, based on the direction of the light wave propagation.

A fiber optic filter is a component with two or more ports that supplies wavelength sensitive loss, isolation and/or return loss. These are in-line, wavelength selective, components that permit a specific range of wavelengths to pass through (or reflect) with low attenuation for classification of filter types) [3]

2. RELATED WORK

The research work performed in this field by different researchers is presented as follows:

A narrative Dynamical Wavelength Scheduled Wavelength Division Multiplexing Passive Optical Network architecture, in which the number of the available upstream wavelength channels is greatly less than that of Optical Network Units is proposed. The feasibility of the proposed WDM-PON, which enables dynamically scheduling upstream data in the Time Division Multiplexing and WDM scheme from ONU to Optical Line Terminal is experimentally demonstrated [1]. A kind of elastic optical access network based on Wavelength-Division Multiplexing PON and Orthogonal Frequency-Division Multiplexing technology is proposed in which finer bandwidth allocation granularity and a flexible wavelength switch are realized. The transmission performance of the system in both uplinks and downlinks is simulated. An improved dynamic bandwidth allocation algorithm is proposed that has been shown to be the most effective in reducing the blocking rate and bandwidth fragmentation [2].Energy-proficient framework is proposed that optimizes the number of active wavelengths and uses sleep/doze mode to progress the power savings of a delay-constrained time and wavelength division multiplexed passive optical network. The performance of both algorithms is evaluated in terms of average delay, percentage of energy savings at the optical network unit, and percentage of energy savings at the optical line terminal [3]. The impact of optical network unit parameters (e.g., transceiver tuning time) and other passive optical network parameters (e.g., reconfiguration period) on optical line terminal energy savings and average frame delay is evaluated while dynamic wavelength allocation is performed periodically. Results show that the average frame delay is mainly affected by tuning time and reconfiguration period with lower absolute values if only one optical network unit buffers traffic during tuning [4]. The given method is based on backup wavelength pre-assignment and a detection process. Since the backup wavelengths are pre-assigned, the method shortens the service outage time and balances traffic loads among the active optical line terminal ports after. High-level reliability cost-effectively is gained. Through system demonstrations using media access control boards and λ-selective burst-mode transceivers used for symmetric 40-Gb/s WDM/TDM-PONs [5] .Optical Network Unit will go to sleep/doze manner into Dynamic Bandwidth Allocation algorithms to decrease ONU energy consumption. The scheduling order of data transmission, control message exchange, sleep period, and doze period defines an energy-efficient method under the ESPON [6]. The consequence of sub channel delay on bandwidth synthesis to eradicate the phase step phenomenon is examined. Sub channel delay was compensated to zero by changing calculated clock cycles of the attached data valid signals [7]. The Approach is based on Long-Rum incremental cost (LRIC) method. Cost evolution curves for individual systems as well for whole FTTH WDM and TDM networks are examined [8]. The comparison of advantages and disadvantages of different multiplexing techniques with specific reference to WDM-based networks is argued. The modulation and encoding techniques are proposed [9].The maximum input data rate to the Optical Network Units to achieve λ-tuning without upstream data-frame loss while varying values for buffer size and λ-tuning time of the transceivers in ONUs and the DWA cycle is theoretically analyzed. [10]

3. PROPOSED WORK

3.1Problem Formulation

To increase bandwidth utilization, it is enviable that the OLT dynamically allocates a variable time slot to each ONU based on the instantaneous bandwidth demand of the ONU's. In current PON deployments, each ONU processes the complete signal bandwidth even if the user employs only a fraction of it. Resource allocation in single channel is defined as bandwidth management problem. **Grant scheduling** and **grant sizing** are the two methods widely used to improve the bandwidth with respect to wavelength. In this method, Optical Line Terminal has to decide about not only when and for how long to grant an upstream transmission to Optical Network Unit but also on which of supported wavelength channels to grant upstream transmission to make efficient use of transmission resource. In this, total available upstream bandwidth of each wavelength in one cycle is calculated along with its weight factor both in fixed and dynamic wavelength allocation cycle. So this leads to proper utilization of bandwidth in WDM Passive Optical Networks.

3.2 Proposed Work

Three techniques or algorithms are mainly used Dynamic Wavelength and Bandwidth Allocation algorithm. By the DWBA, both upstream and downstream traffic wavelengths are dynamically arranged to carry traffic of different ONU groups and effectively and save energy.

Dynamic Bandwidth Allocation algorithm:- The goals of DBA algorithm are: Maximum fiber bandwidth utilization, Fairness and respect of priority, Minimum delay introduced.

4. RESULTS AND ANALYSIS

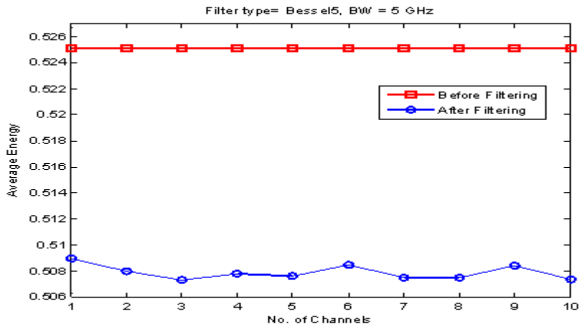

Figure 4.1 Energy consumption before and after filtering for 10 Channels for bandwidth=5GHZ

In this graph, Average Energy is reduced for 10 channels at bandwidth= 5GHz by using Bessel 5 filter.

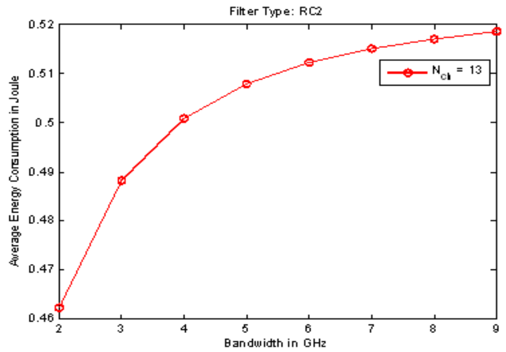

Figure 4.2 Average Energy for 13 Channels for Filter=RC2

The above graph indicates that Average Energy consumption increases with increase of bandwidth for 13 channels.

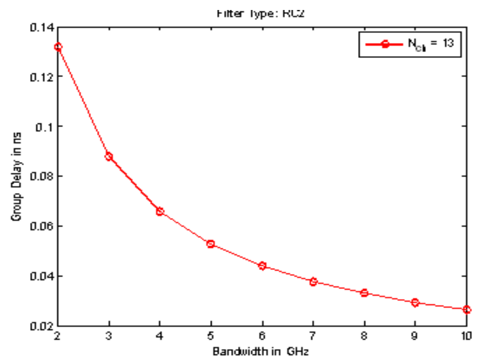

Figure 4.3 Delay for 13 Channels for Filter=RC2

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The above graph showing the value of group delay decreases with the bandwidth increase for 13 channels.

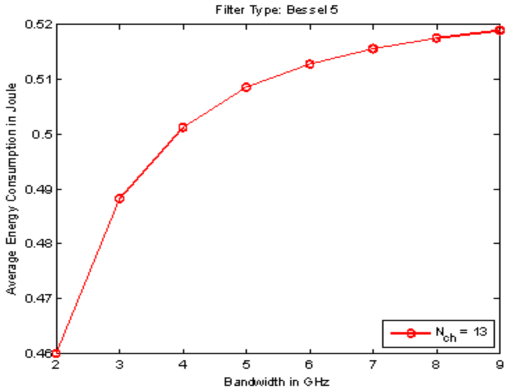

Figure4.4 Average Energy for 13 Channels for Filter=Bessel5

In the above figure, Average Energy is changing with the change in bandwidth. It is increasing as we increase bandwidth.

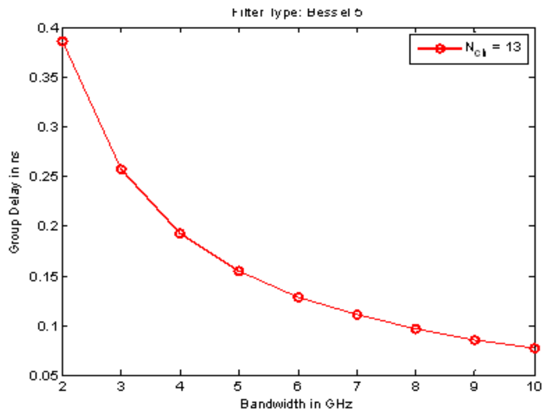

Figure 4.5 Delay for 13 Channels for Filter=Bessel5

The above graph indicates that group delay is reducing with the enhancement of bandwidth.

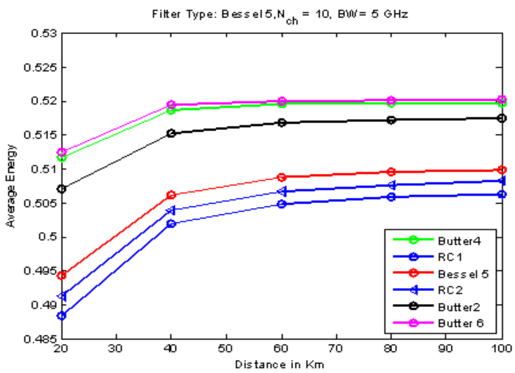

Figure 4.6 Comparison of Average Energy for different filters and different distance

The above graph showing the Average Energy for 10 channels for different filters used at BW= 5GHZ.Different filters used for the evaluation are :- Butterworth 4th order filter, RC 1 filter, Bessel 5 filter, RC2 filter, Butterworth 2nd order filter, Butterworth 6 th order filter. Energy Consumption has minimum value for RC1 filter and maximum value value for Butterworth 6 filter.

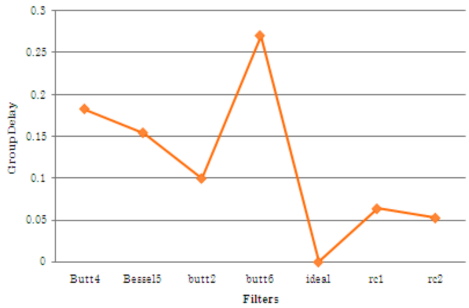

Figure 4.7 Group Delay values for different filters

The above graph indicates the value of Group Delay changing with the change of different filters used for the performance evaluation. Group Delay has minimum value for RC2 filter and maximum value for Butterworth 6 filter

S.No.	Filter	Average Delay(ns)	Average Energy(joules)
1	Butt4	0.183	0.5196
2	Bessel5	0.1545	0.5098
3	Butt2	0.0999	0.5175
4	Butt 6	0.2706	0.5203
5	RC 1	0.0637	0.5062
6	RC 2	0.0527	0.5079

Table 4.1 Average Delay and Average Energy for 10 Channels at BW=5GHZ for different filters

The existing delay was 22.462 ns and now it reduces and the minimum value is 0.0527 ns by using filter RC2.Similarly, the existing energy was 0.5251 joules and now it diminish and the minimum value is 0.5062 joules by using RC1 filter.

The performance metrics used in the evaluation are energy-consumption and average delay. The average delay is measured as the interval from the time the frame arrives at the data buffer until the time it departs the buffer. The average delay values are calculated for adaptive filters.Field experiments results show that the sub-channel delay compensation is effective.

5. CONCLUSION AND FUTURE SCOPE

All the parameters that are evaluated are described in brief. With the main fiber, additional fiber is used to propagate the signal with minimum Delay and Energy consumed. Adaptive filters are used to reduce dispersion and so average delay and average energy will be reduced so cost of passive optical network will improve. Delay and Energy values are evaluated for different filters. At the receiver, the different wavelengths need to be de-multiplexed. This can be achieved by optical band pass filters or an AWG. Finally, the binary data stream is restored by a decision circuit.

Evaluating and comparing the current developed mechanism in terms of different traffic classes is an interesting issue to help us improve the real value of the proposed scheme for our future work. For future work, existing mechanism can be extended to support QoS for different traffic classes. A comparative study of existing mechanism for different coding techniques, bit rates, input power and fiber length can be considered.

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