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Optimization of Energy in WDM Passive Optical Network

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Abstract

With the increasing need for conserving the energy in communication, there is need to develop networks that provide better energy consumption. Passive Optical Network(PON)s are considered as one of the energy efficient access network technologies. In this paper we brief about the Particle Swarm Optimization(PSO) Algorithm which is used for WDM PON Network. The main aim of this paper is to show that using the PSO algorithm will provide an energy efficient output compared to other algorithms used for different topologies.

I. INTRODUCTION

Wavelength Division Multiplexing-Passive Optical Network (WDM-PON) is an access network technology that has the potential to significantly alter carrier infrastructures.

It creates a wavelength-based logical point-to-point architecture upon a physical point-to-multipoint fibre topology. WDM-PON is a simple concept that has the potential to become the unified access and backhaul technology of the future, carrying data from residential, business and carrier wholesale services on a single platform. Its long-reach capability and bandwidth scalability enables carriers to serve more customers from fewer active sites without compromising security and availability. WDM-PON uses WDM multiplexing/demultiplexing technology to ensure that data signals can be divided into individual outgoing signals that are connected to buildings or homes. This hardware-based traffic separation provides customers with the benefits of a secure and scalable point-to-point wavelength link but enables the carrier to retain very low fibre counts, yielding significantly lower operating costs.

WDM-PON has the native ability to span distances of 100km. This reach exceeds the capabilities of TDMA-based PON technologies such as Ethernet PON (EPON) and Gigabit PON (GPON) and enables carriers to bypass existing local offices (LOs), consolidating traffic into one central office.

Wavelength Division Multiplexing PON, or WDM-PON, is a non-standard type of passive optical networking, being developed by some companies. The multiple wavelengths of a WDM-PON can be used to separate Optical Network Units (ONUs) into several virtual PONs co-existing on the same physical infrastructure. Alternatively the wavelengths can be used collectively through statistical multiplexing to provide efficient wavelength utilization and lower delays experienced by the ONUs.

There is no common standard for WDM-PON nor any unanimously agreed upon definition of the term. By some definitions WDM-PON is a dedicated wavelength for each ONU as shown in fig1. Other more liberal

definitions suggest the use of more than one wavelength in any one direction on a PON is WDM-PON. PONs provide higher bandwidth than traditional copper based access networks. WDM-PON has better privacy and better scalability because of each ONU only receives its own wavelength.

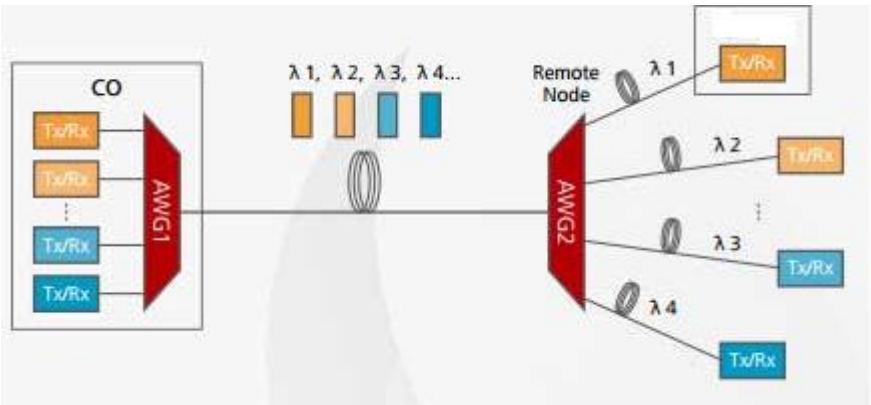


Fig 1. Architecture of WDM-PON

The OLT and ONU block diagram has many blocks which try to reduce the energy efficiency of the network. There are two states

a) Active state: In this state both Tx and Rx are off, thus the ONU is fully functional.
b) Sleep state: In this state it can neither transmit nor receive traffic.
c) Transmission State: In this state the Tx is ON and Rx is OFF.
d) Reception state : In this state the Tx is OFF and Rx is ON.

As there are four actual states as shown in fig 2, the change in the state would be AA, AS, SA and SS. These will make the ONU and OLT to get activated and start operating and send the data.

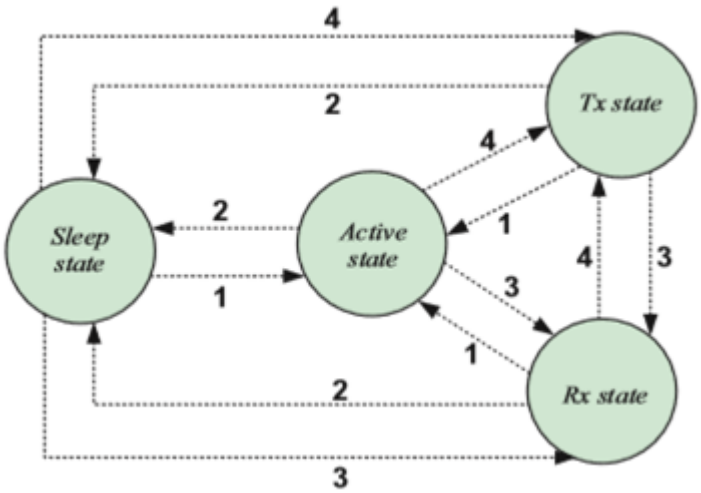
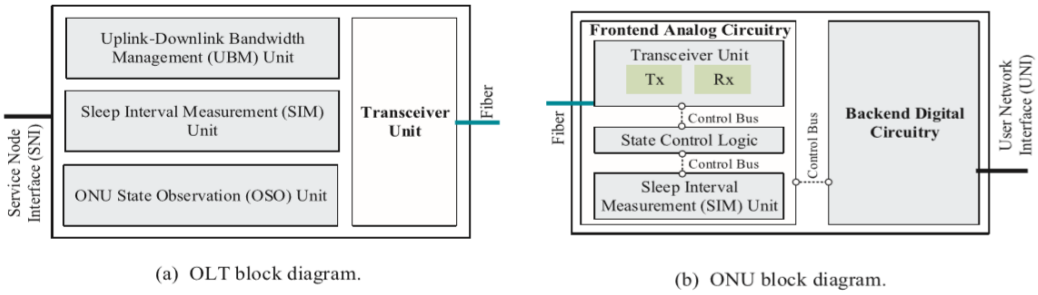


Fig 3.ONUstate diagram

II. Energy Efficient system configuration

EUDDA treats a strict and relaxed delay requirement traffic differently. EUDDA seeks to develop a sleep management policy in which meeting traffic delay requirement is given more priority over energy saving.

We propose an Energy-efficient Uplink and Downlink Delay Aware (EUDDA) scheme for WDM-PON system. The prime object of EUDDA is to meet both downlink and uplink traffic delay requirement while maximizing energy saving performance of ONUs as much as possible. In EUDDA, traffic delay requirement is given more priority over energy saving. Even so, it still can improve energy saving of ONUs noticeably. We evaluate performance of EUDDA in front of two existing solutions in terms of traffic delay, jitter, and ONU energy consumption. The performance results show that EUDDA significantly outperforms the other existing solutions.



(a) OLT block diagram. (b) ONU block diagram.

Fig 2 OLT, ONU block diagram of EUDDA

III. Optimization algorithms

To reduce the energy utilization in the WDM-PON network, there are many Meta heuristic algorithms such as, simulated annealing algorithm, FTS algorithm, ATS Algorithm, Tabu search algorithm and many optimization networks which may be used for different topologies.

FTS exploits the broadcasting nature of wireless channels and random encoding of rateless codes to reduce energy consumption while ensuring reliable delivery of packets to all nodes in the network. In the proposed scheme, different neighbors of a node share the responsibility of transmitting packets by sending only a fraction of encoded packets required by the node to successfully receive the data sent by the source. A detailed analysis of the performance of FTS is presented for grid and random deployment networks. Further, extensive simulations compare our scheme with present energy-efficient methods such as random linear coding, multipoint relaying, dominant pruning, and broadcast incremental power scheme.

Adaptive Tabu Search (ATS) is a modified version of original tabu search formula for combinational optimization problem suggested by Glover. This technique is very useful for solving non-linear continuous optimization problems. The modification which has been added into the new version is discredited continuous search space, back-tracking and adaptive radius.

Out of all those algorithms in the paper we have used particle swarm optimization (PSO) algorithm which tries to reduce the energy required to execute the network topology.

In the PSO process, each particle keeps track of its coordinates in the space of interest, which are

associated with the best solution (fitness) it has achieved so far. Another best value tracked by the global version of the particle swarm optimizer is the overall best value, and its location, obtained so far by any particle in the population. At each time iteration step, the PSO concept consists of velocity changes of each particle toward local and global locations. Acceleration is weighted by a random term, with separate random numbers being generated for acceleration toward local and global locations.

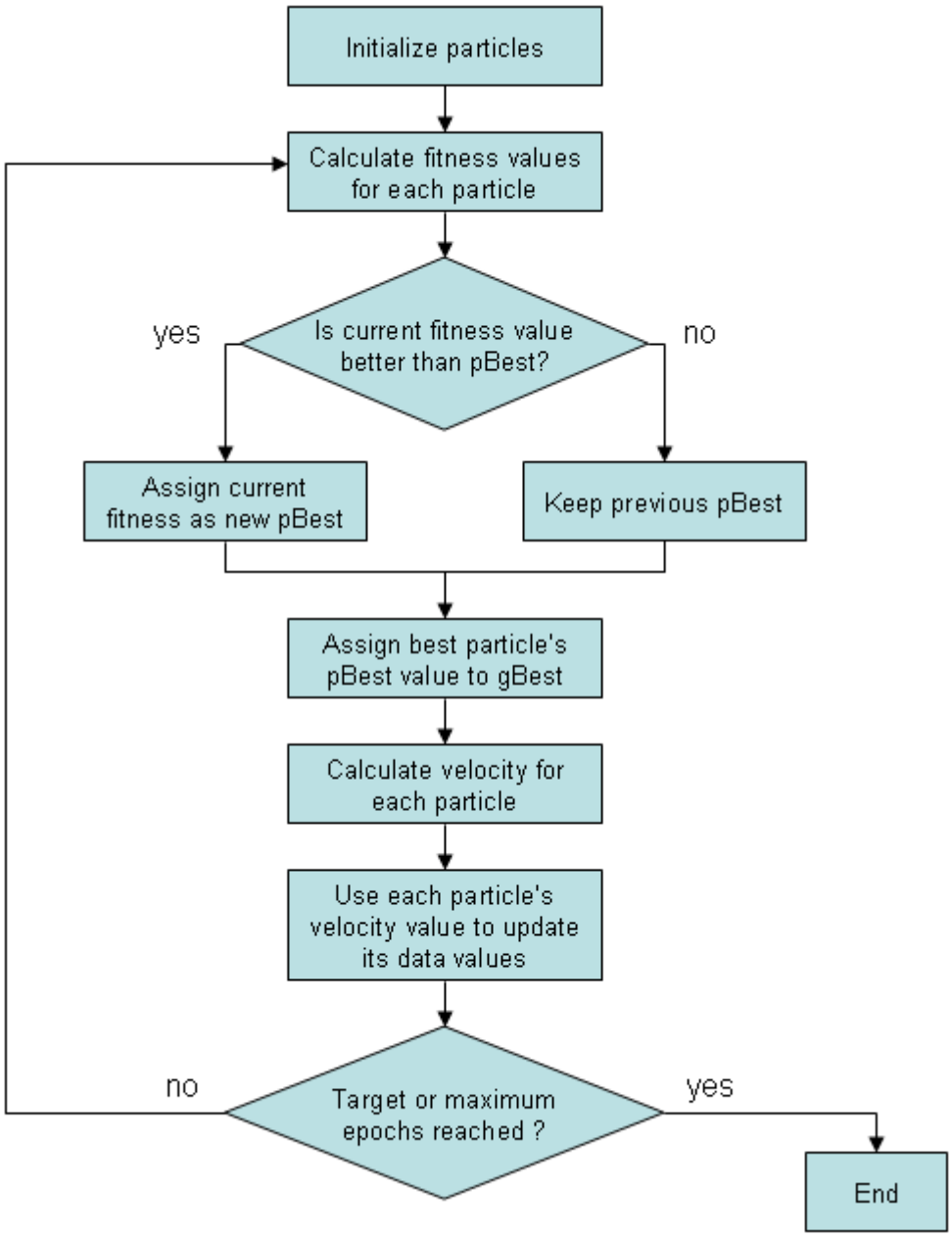


Fig 4. Particle Swarm Optimization algorithm flow chart

The algorithm keeps track of three global variables:

- Target value or condition
- Global best (gBest) value indicating which particle's data is currently closest to the Target
- Stopping value indicating when the algorithm should stop if the Target isn't found

Each particle consists of:

- Data representing a possible solution
- A Velocity value indicating how much the Data can be changed
- A personal best (pBest) value indicating the closest the particle's Data has ever come to the Target

The particles' data could be anything. In the flocking birds example above, the data would be the X, Y, Z coordinates of each bird. The individual coordinates of each bird would try to move closer to the coordinates of the bird which is closer to the food's coordinates (gBest). If the data is a pattern or sequence, then individual pieces of the data would be manipulated until the pattern matches the target pattern.

The velocity value is calculated according to how far an individual's data is from the target. The further it is, the larger the velocity value. In the birds example, the individuals furthest from the food would make an effort to keep up with the others by flying faster toward the gBest bird. If the data is a pattern or sequence, the velocity would describe how different the pattern is from the target, and thus, how much it needs to be changed to match the target.

Each particle's pBest value only indicates the closest the data has ever come to the target since the algorithm started. The gBest value only changes when any particle's pBest value comes closer to the target than gBest. Through each iteration of the algorithm, gBest gradually moves closer and closer to the target until one of the particles reaches the target.

IV. Results and Discussion

We can execute the algorithm in NS2 tool, and as we vary the number of node to 25,50,75 and 100, then we get the amazing results as we are comparing the result of PSO algorithm with other such as we feel that the PSO algorithm serves the purpose better.

	Energy consumed by the network			
Algorithm	N=25	N=50	N=75	N=100
ATS	71.35	123.70	178.36	259.15
FTS	56.26	97.71	159.33	225.65
PSO	51.6	83.75	149.13	216.05

Table 1. comparison of results

V. Conclusion

We conclude that when we are using WDM-PON as a network we can use swarm optimization algorithm and we can achieve the energy efficiency. From table 1 we can conclude that PSO algorithm consumes less power than the other algorithms.

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