Poster: SDN based Energy Management System for Optical Access Network

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***Abstract*—In recent years, Passive Optical Network (PON) is developing rapidly in the access network, in which the high energy consumption problem is attracting more and more attention. In the paper, SDN (Software Defined Network) is first introduced in optical access networks to implement an energy-efficient control mechanism through OpenFlow protocol. Some theoretical analysis work for the energy consumption of this architecture has been conducted. Numeric results show that the proposed SDN based control architecture can reduce the energy consumption of the access network, and facilitates integration of access and metro networks.**

***Index Terms*—SDN, optical access network, energy, OpenFlow, controller.**

I. Introduction

Today, the Internet has become a truly high energy-consuming industry. If we do not take effective energy-saving measures, as of 2025, energy consumption will increase to 1.5TW, accounting for 75% of the world's total energy consumption in 2010 [1]. According to statistics, the access network energy consumption accounts for about 70% of the total energy consumption of the Internet [2]. And PON (Passive Optical Network) is hot in broadband access technologies. Therefore, energy consumption of PON systems occupies an important position in the Internet energy consumption. The relevant study work has started for a long time. IEEE has released 802.3az EEE energy efficiency standards in EPON networks. [3] proposed an adaptive handshake protocol to shutdown ONU. [4] presents two 10G-EPON energy saving method.

II. System Architecture

A. Sleep/Awake Mechanisms

The classical SDN architecture consists of controller, OpenFlow protocol stack, and the physical PONs framework.

The energy saving feature in OLTs isnt included in most of the studies which mainly concentrate on ONUs energy saving now. But recent study shows that there is enormous energy-saving potential in OLTs operation. In EPON system, we can close idle port modules in the uplink/downlink board, and idle boards to save energy consumption in the OLT. This architecture achieves combination of OLTs and ONUs energy-saving.

We propose a like-periodic bi-EMM algorithm based on a modification of IPACT, which is called EMM-UDS.

In this algorithm, the state of ONU is divided into three types: awake mode (called So_1), sleep mode (called So_2),and critical mode (called So_3).The state of OLT is divided into three types, too: awake mode (called Sl_1), port sleep mode (called Sl_2),and board sleep mode (called Sl_3).

In Sl_1,OLTs several modules open normally; in Sl_2, idle port module is turned off; in Sl_3, marching board is turned off. There are a number of cards inserted general OLT devices, each card will be in three modes.

We suppose there is a simple EPON system with only one OLT and two ONUs (ONU1 and ONU2). In the cycle time when OLT polls over the downstream ONUs, ONU1 is allocated length of T_1, while ONU2 is allocated length of T_2. For ONU1, upstream bandwidth is $BWup1$, upstream traffic is $Qup1$, downstream bandwidth is $BWdn1$, and downstream traffic is $Qdn1$; and for ONU2, upstream bandwidth is $BWup2$, upstream traffic is $Qup2$, downstream bandwidth is $BWdn2$, and downstream traffic is $Qdn2$.

In fact, the required time to complete data transmission for ONU1 is $T_1^{'}$.

$$T_1^{'} = \max\{(\frac{Qup1}{BWup1}), (\frac{Qdn1}{BWdn1})\} \geq T_1 \tag{1}$$

Similarly, the required time to complete data transmission for ONU1 is $T_2^{'}$.

$$T_2^{'} = \max\{(\frac{Qup2}{BWup2}), (\frac{Qdn2}{BWdn2})\} \geq T_2 \tag{2}$$

And the actual time to complete a polling cycle is $Tcycle^{'}$.

$$Tcycle^{'} = T_1^{'} + T_2^{'} \geq Tcycle \tag{3}$$

The difference between $Tcycle$ and $Tcycle^{'}$ is $Delta$.

$$Delta = Tcycle - Tcycle^{'} \tag{4}$$

It is waste of energy when there is no upstream and downstream traffic in Delta, obviously. The algorithm in this paper based on EMM-UCS, considers both upstream and downstream traffic to make OLT into Sl_2, and ONUs into So_2.

B. Communication Process

1) : At the end of assigned time slot, ONU sends State_frame status frame to OLT, which contains the ONU upstream queue length information;

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2) : After receiving the frame State_frame, OLT sends State_report message to the controller. The message body contains the queue length of each OLTs port and each ONU upstream queue length information;

3) : According to obtained information, the controller executes energy saving components algorithm to determine whether to make OLT or ONU into the sleep condition. If so, State_reply message is sent to the OLT, specifying the appropriate ONU and OLTs port into sleep mode. The message body contains the sleep time T, OLT port number and other necessary information.

4) : OLT receives the sleep command, and transmits the Sleep_frame to the specified ONU. And then, OLT makes specified port into Sl_2

5) : ONU enters into So_2, and starts the countdown. At the end of timing, ONU enters into So_3 while OLTs port linked to this ONU has been changed into Sl_1. ONU recalculates the buffer queue length, and send State_frame state frame to OLT.

6) : OLT summaries new data which comes from ONU and own state information, send State_report message to controller.

7) : Through the algorithm implementation, if controller confirms that there is no need to be awake at this time, it will send State_reply message to the OLT, specifying the appropriate ONU and OLTs port into sleep mode. Among this message, all the parameters are passed to recalculate.

8) : OLT sends new Sleep_frame frame to ONU, and makes its own port go into Sl_2 again.

9) : The same as step (5), ONU enters into So_2, and starts the countdown. At the end of timing, ONU enters into So_3 while OLTs port linked to this ONU has been changed into Sl_1. ONU recalculates the buffer queue length, and send State_frame state frame to OLT again.

10) : OLT summaries information, and sends State_report message to controller.

11) : Through the algorithm implementation, if controller confirms that it is time to make ONU and OLTs port work normally, it will send State_reply message to the OLT, specifying the appropriate ONU into So_1, OLTs port into Sl_1. Among this message, all the parameters are passed to recalculate.

12) : OLT sends Awake_frame frame to the specified ONU. ONU enters So_1 from So_3.

III. ANALYSIS AND RESULT

To verify the results, we conducted a simulation by using C++ programming language. The various parameters for simulation of the EPON are almost the same as [5].

Using almost the same simulation conditions as [5],we get Fig.1 and Fig.2. Fig.1 shows the influence of two algorithms on the ONUs wake-up time. We can find that, without considering the effects of downward flow, EMM-UDSs effect is almost the same as EMM-UCS in [5]. And ONUs awake time is just a little shorter when the access network is in high load condition, because of its complicated process.

Fig.2 shows the influence of two algorithms on the OLT wake-up time. We can find that, OLTs awake time with EMM-UDS algorithm is obviously shorter when network traffic is small; and when network traffic is high, awake time with either EMM-UCS or EMM-UDS is nearly zero.

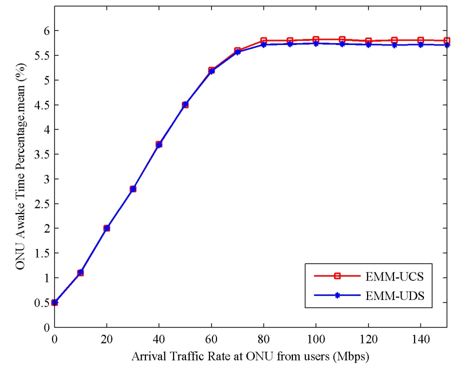

Fig. 1. SDN architecture

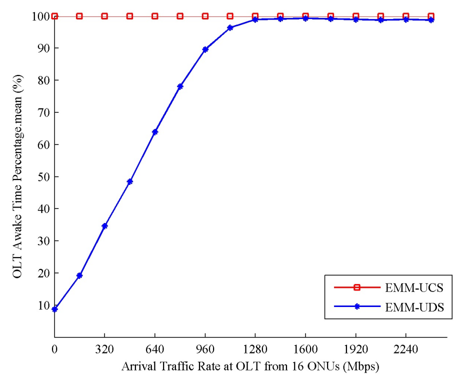

Fig. 2. SDN architecture

IV. CONCLUSION

After the above analysis, we can get this conclusion: Compared to the existing access network energy management system, the SDN based optical access network energy management system is able to achieve a more reasonable sleep, and help reduce optical access network energy consumption.

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