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Greener Centralized Networks Using Software Defined Networks

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Abstract

Power saving and energy efficiency for data centers and the internet have been gaining attention since the number of users have been growing dramatically in the past couple of years. In this paper we are going to talk about three different approaches for more energy efficient centralized wired networks. All three solutions use Software Defined Networks (SDN) as the base of the solution.

Keywords: *Energy efficiency, Routing, Ethernet, Centralized, Software Defined Networks (SDN), OpenFlow*..

1. Introduction

The importance of energy efficient or energy aware networks and network devices have increased in the past decade. Research in [1] shows that the internet alone consumes 2-8% of the total energy consumption in the United States. Therefore, making it very important to introduce energy efficient networks for the ISPs. By doing so they will cut-down on there bills, which will allow them to add to their profits. Since SDN has a central controller, this introduces new opportunities to lower the power consumption in the networks. That is possible because the controller has all the needed information in the network like traffic loads and link utilization between the switches, so it can decide whether a switch or a link could go to sleep or can be power off and it could change the topology of the network, which will help in saving a high percentage of power saving. Most of the related work done in this field was on destructed systems or on end devices like cellular phones or end switches which do not really have an effect on the total power consumption of the network. In this paper we will review three approaches descended in [2] and [3]. The first approach that we will talk about in this paper will discuss adding now instructions on the OpenFlow protocol to further allow the controller of the energy aware OpenFlow switches to save more energy. The second approach will determine whether to put the switch sleep or let it stay awake depending on the node utilization. The third approach will do the same thing but it will check the link utilization to put the link utilization.

This paper will be organized as follows: in section 2 brief introduction to SDN and OpenFlow. Section 3 will discuss the first approach which is adding the new instructions to allow for more control over the power efficiency of the network. Section 4 will discuss setting the node to sleep due to low utilization. Section 5 will discuss setting a node to sleep due to low traffic on a given node. Section 6 will be the conclusion.

2. SDN AND OPENFLOW

2.1 Software Defined Networks

Software Defined Networks is a relatively new concept in the networking field. It is composed of a central controller that does all the routing computations and runs the OSPF protocol. Then it builds what is called a flow table. A flow table contains rules and policies as shown in (Fig.1). That flow table tells the OpenFlow switch where to forward the packets to which port or to swhich IP [1].

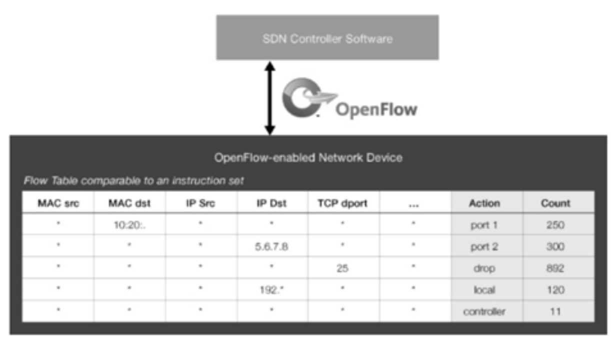

Fig. 1 Flow table Entry [1]

2.2 OpenFlow

OpenFlow is the protocol that regulates the connection between the controller and the switches. In networks that do not run OpenFlow the switches are the elements that compute the routing tables and run the routing tables, so OpenFlow switches are layer two switches. Fig. 2 shows the OpenFlow switch architecture.

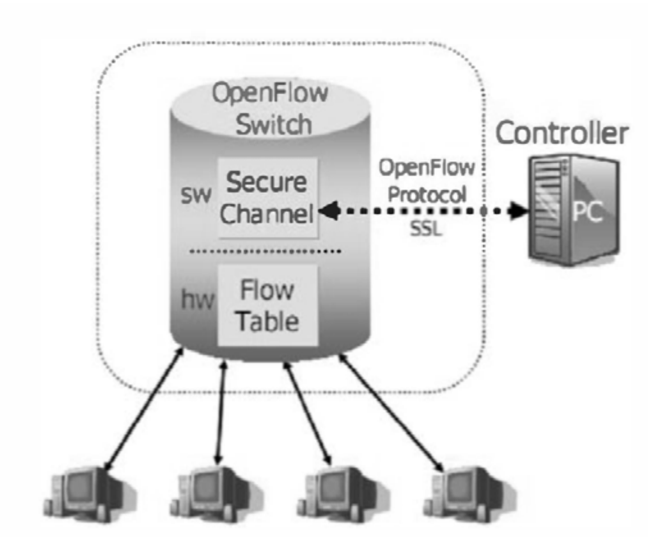

Fig. 2 The Flow Table Entry [2]

Some of the control messages that are implemented in OpenFlow include packet received, get status and send packet out [2].

3. First Approach

In this approach the authors of [2] new hardware which is the OCR (OpenFlow Switch Controller) with added power saving functionality and extended the messages that are sent from the controller to the OpenFlow switch to include OFPT-ORT-MOD, OFPT-LINECARD-MOD and OFPT-SWITCH-MOD. Where OFPT-ORT-MOD allows the controller to instruct the OCR to turn on/off the switch. OPTF-LINECARD-MOD gives the controller the power to turn on/off the line card, links or adjust the link rate. Finally, OFPT-ORT-MOD which allows the controller to control the power consumption of the switch by changing the clock rate of the switch for example. By adding the added power saving functionality and the new OpenFlow messages the authors estimated that the power saving could go up to 25% to 40%.

4. Second Approach

In this approach the status of the link is monitored, and when the utilization of a node drops below a certain threshold the link goes to sleep. Now knowing that the link is put to sleep we have to know when to wake it up, and what happens when it goes to sleep? The answer to this questions will be later discussed because it apply to approach two and three. This approach decreased the power consumption of the network by 7% for the sleeping node. This method and the upcoming method introduce network congestion, where both methods introduced 15% congestion but in this approach the congestion happens more often.

4.1 Going to Sleep

the first approach in [3] the link goes to sleep when the total utilization of the link drops below 30%. This threshold was set by the authors of [3] and can be changed to better fit the network. After the controller puts the node go to sleep it recalculates the shortest path and updates the flow tables for the switchers, but this time it needs to find the shortest path for less number of nodes.

4.2 Waking Up

As the authors mentioned in [3] waking up a link is harder than putting it to sleep. In the low utilization method the link is woken when the utilization of another link is higher than 90% because that is when network congestion is likely to accrue. When that happens the controller calculates the network congestion if it wakes up one of the sleeping nodes, if the congestion falls below the threshold then it wakes up that node. If the congestion remains higher than the threshold after waking up that single node the controller checks the congestion after waking up another single node and so on traversing through the list of nodes that are put to sleep. Finally, of the controller does not find a single node to wake up that deals with congestion it wakes up all the sleeping nodes. That is done to simplify the calculation of the process and not to introduce added delay.

5. Third Approach

The third and final approach that we are going to discuss in this paper is the sleep when low link utilization. In this the link will sleep when the link utilization drops below 30%. when that happens the controller recalculates the shortest path again and pushes the new flow tables to the active switches. Then the wake up method is like the previously mentioned approach, but here the controller checks the congestion of the the link. It starts waking up the links when the utilization of any given link is higher than 90%. Finally, this approach only introduced 15% congestion once in the when they tested this approach.

6. Conclusion

In this paper we went though three approaches and all of them depend on SDN. Which shows that having a centralized controller to compute the routing operations will ease up energy saving in the network. However, we don't have to stick to a single approach for example we can combine the first approach with third approach to get even higher energy saving.

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