Aiding OpenFlow Controller by Enhancing OpenFlow’s Control Model, and Behavior of Flows

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Keywords:
OpenFlow, Control Model, Future Internet.

Abstract:
The Internet; is one of the greatest means of communication over the current and past centuries. It plays an important role in our lives as it delivers information, helps people to communicate, and acts as mean of making profit. Due to its importance, researchers have been studying ways to improve the Internet and to provide new services and capabilities to it.

One of the concepts studied by researchers is the flow concept, where a flow is a sequence of packets from a source computer to a destination, which may be another host, a multicast group, or a broadcast domain and could consist of all packets in a specific transport connection. Grouping sequence of packets into flows is reasonable, because different services (applications) have different characteristics and require different levels of network support, and thus flows can be used to group packets and then apply some rules for each group.

On 2008, OpenFlow [1] was first introduced by Stanford University. OpenFlow provides a new way to control flows on the network equipment by the OpenFlow controller (which is a dedicated server for managing flows) through using the OpenFlow Protocol. It enables more flexibility in decision making by splitting the decision making from packet forwarding. Where decision making can be done and modified by the OpenFlow controller according to layer 2, 3 and VLAN headers, while the forwarding or routing is still done by routers or switches. Moreover, OpenFlow defines actions to be performed on flows e.g. collection of statistics or usage data, forwarding packets, dropping packets, or manipulating packet’s headers. This flexibility and the wide range of actions enable OpenFlow to play a crucial role in developing the future Internet. However, despite OpenFlow’s flexibility, there have been many concerns about its scalability; due to the tight coupling between the controller and the network equipment. This indicates that the controller can be a bottleneck in this system. However there have been many efforts to solve this problem, as in [2].

This paper proposes two enhancements of OpenFlow; aiming to tackle the previously mentioned problem in a different manner, by enhancing the behavior of some OpenFlow’s flow-table entries (OF-flows) and by providing an enhanced control model for OpenFlow. Those enhancements will help to relieve some load off the controller; also will help to make OpenFlow self-aware and able to react when under heavy loads. The proposed enhancements are: Network equipment to equipment OF-flow installation (NE-NE-FI), and a new type of OF-flows that are the proactive OF-flows, and they do not impose radical changes to OpenFlow, but can be an extension to OpenFlow.

A- Network equipment to equipment OF-flow installation (NE-NE-FI):

According to the current OpenFlow design; OF-flows can be programmed solely by the controller (controller to equipment OF-flow installation (C-NE-FI) ). This has many advantages like, having tight control over all of the equipment by the controller. However, those advantages come with some cost. Like the probability of the controller to be a bottleneck. This was confirmed by, Michael Jarschel et al. who concluded in [4] that “When using OpenFlow in high speed networks with 10 Gbps links, today's controller implementations are not able to handle the huge number of new flows.”.
By using NE-NE-Fi, the controller does not have to program (install) OF-flows to each network equipment one by one; instead it can ask the equipment to spread this OF-flow to other equipment on behalf of the controller. And thus relieving some load off the controller. Also, the NE-NE-Fi method can be used to make the OpenFlow network more self-aware by having the network equipment cooperate and carry loads for each other upon the need by having the overloaded equipment delegating some of its OF-flows to another network equipment.

B- Proactive OF-flows:

According to OpenFlow, whenever an OF-flow is installed into a network equipment, the equipment will start matching against it. This means that the OF-flow is activated and used as soon as it is installed. However, this behavior imposes difficulties in dealing with cases that require precise timing, since everything has to be done by the controller on time. Centralized control would be of a greater advantage, if it can handle precisely timed OF-flows. And to provide OpenFlow with this ability, we designed a new type of OF-flows, Proactive OF-Flows; that are installed into the network equipment as inactive OF-flows, which means that those proactive OF-flows will not be used by the equipment that they are installed unless a certain condition activates them.

To activate proactive OF-flows, in order to use them. We designed three conditions that can be used separately or as a combination to activate proactive OF-flows. First is to receive a dedicated activation packet with a special activation token that can be sent by the controller, or a host, or another network equipment (by adding to the proactive OF-flow a list of addresses of network equipment having the same proactive OF-flow, to be used by the equipment whose proactive OF-flow has been activated to activate the same OF-flow on the rest of the equipment in the list.). The second is to have an activation OF-flow, where an OF-flow can be set as a condition to activate an inactive proactive OF-flow, and so whenever this activation OF-flow is matched then the associated proactive OF-flow will be activated. The third, a specific time is set to activate an inactive proactive OF-flow.

In order to, assess the effectiveness of our enhancements to reduce load off the controller (by counting different operations carried out by controller, e.g. equipment statistics pull, route processing, etc.), and the rate of success in achieving their goals. We are building three sets of simulations that we will run on the OMNET++ simulator [3], where each compares the case of regular OpenFlow to our enhanced one. At the current time, building an OpenFlow router on OMNET++ has been accomplished, however the rest of the simulation is being built. The first set of simulation is to assess NE-NE-Fi’s efficiency to reduce load off loaded equipment through their self-aware cooperation. The second will assess NE-NE-Fi’s efficiency to distribute OF-flows to a group of equipment. The third, aims to assess the proactive OF-flows’ efficacy.

References:


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