Forwarding and Control Element Separation
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L. Zeng
<Tsinghua University>

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Consistent Control Mechanism in Software Defined Network
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Abstract

This document introduces a consistent control mechanism in the framework of Software Defined Network (SDN), which is one method to achieve forwarding and control element separation. In detail, this mechanism uses a centralized control element to control multiple forwarding elements.

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1. Introduction

Software Defined Network (SDN) is proposed in recent years, and is considered as a promising way to separate forwarding plane and control plane [FORCES-SDN]. In detail, SDN is an approach to networking in which control is decoupled from hardware and given to a software application.

2. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC-2119 [RFC2119].

In this document, these words will appear with that interpretation only when in ALL CAPS. Lower case uses of these words are not to be interpreted as carrying RFC-2119 significance.

3. Software Defined Network Framework

A logical view of the SDN architecture is shown in Figure 1, which consists of three layers: infrastructure layer, control layer and application layer.

```
   +--------------------------------------------------------------+
   |  +--------------------------------------------------------+  |
   |  |                          +---------------------+       |  |
   |  |                          |                     |       |  |
   |  |  Application          +--+------------------+--+       |  |
   |  |                       |                     |          |  |
   |  |     Layer          +--+------------------+--+          |  |
   |  |                    |Business Applications|             |  |
   |  |                    +---*------*------*---+             |  |
   |  +------------------------|------|------|-----------------+  |
   |                           |API   |API   |API                 |
   |  +------------------------|------|------|-----------------+  |
   |  |             +----------*------*------*---------------+ |  |
   |  |             |               +----------------+       | |  |
   |  |             | SDN           |                |       | |  |
   |  |             | Control    +--+-------------+--+       | |  |
   |  |   Control   | Software   |                |          | |  |
   |  |    Layer    |         +--+-------------+--+          | |  |
   |  |             |         |Network Services|             | |  |
   |  |             |         +----------------+             | |  |
   |  |             +------------**--------------------------+ |  |
   |  +--------------------------||-------------------------+  |  |
   |                             ||Control Data Plane Interface|  |
   |                             ||(e.g., OpenFlow [FORCES-OF])|  |
   |  +--------------------------||----------------------------+  |
   |  | Infrastructure           ||                            |  |
   |  |      Layer               ||                            |  |
   |  | +--------------+   +-----**-------+   +--------------+ |  |
   |  | |Network Device|   |Network Device|   |Network Device| |  |
   |  | +--------------+   +--------------+   +--------------+ |  |
   |  |          +--------------+    +--------------+          |  |
   |  |          |Network Device|    |Network Device|          |  |
   |  |          +--------------+    +--------------+          |  |
   |  +--------------------------------------------------------+  |
   +--------------------------------------------------------------+
```

Figure 1 Software-Defined Network Architecture

In infrastructure layer, network devices are only in charge of executing the forwarding functions. Network control intelligence is logically centralized in control layer. In particular, a centralized SDN based controller is in charge of controlling function. In the controller, different network control functions can be developed as customized. As to application layer, different kinds of business applications are deployed. Between application layer and control layer, a set of APIs (Application Programming Interfaces) are designed, which allows business applications to use network control services in control layer. Also, control data plane interface is designed between control layer and infrastructure layer, which is used to interchange control and forwarding information between the controller and network devices.

In the SDN architecture, the controller uses flow entry to control multiple network services, where the forwarding function is executed. In each network service, there exists a flow table to store flow entries sent by the controller. The controller can add/delete/modify flow entries to each network service.

4. Control Problem in SDN Framework

In SDN framework, the controller uses flow entries to control forwarding behavior of different network devices. In particular, there are special security channel between the controller and network devices to transform flow entry information.

Since multiple network devices make up a distributed system, control problem exists in SDN framework. In detail, it is difficult for the controller to update multiple flow entries simultaneously, due to different latency of different special security channels. If these flow entries are written into network devices at different time, data packets may follow the wrong control instruction and be incorrectly deal with, leading to system chaos, packets loss, service deteriorate, and etc.

Due to this control problem, it is necessary to study consistent flow control mechanism for SDN framework. The consistent flow control problem is defined as follows: when the controller updates flow table in multiple network devices, each data packet flowing through the network must be processed according to a single network control configuration, either the old control configuration or the new control configuration, but not a mixture of both configurations, or other uncertain rules.

5. Consistent Flow Control Mechanism

A consistent flow control mechanism is proposed in this section. In an update event, the controller updates flow entries from an old flow configuration to a new flow configuration in a set of network devices.

First, the controller divides these network devices into two parts.

1) Entry Network Device (END): the first network device in the set of network devices, in which data packet is handled with the now flow configuration.

2) Other Network Device (OND): other network devices in the set of network devices, except for the END.

Then, the controller divides flow entries in both configurations into four parts:

1) New Flow Entry (NFE): new flow entry only in new configuration.

2) Shared Flow Entry (SFE): flow entry existing in both configuration.

3) Deleted Flow Entry (DFE): old flow entry only in old configuration.

4) Modified Flow Entry (MFE): different control behavior of the same data packet in two configurations.

The important steps of proposed consistent flow control mechanism are introduced as follows:

Step 1: the controller analyzes network devices and two sets of flow configurations, which are respectively divided into several parts.

Step 2: In END, the controller uploads all data packets influenced by this update event, except for the packets controlled by SFE.

Step 3: The controller writes NFE in OND, and then waits for an end-to-end network latency.

Step 4: The controller finishes all updates in OND, including adding MFE and deleting DFE.

Step 5: The controller finishes all updates in END, and stops uploading data packets from EDN.

6. Security Considerations

This requirements document does not raise in itself any specific security issues.

7. IANA Considerations

IANA does not need to take any action for this draft.

8. Conclusions

This document provides a consistent control mechanism in the framework of Software Defined Network (SDN). In detail, this mechanism uses a centralized control element to control multiple forwarding elements.

9. References

9.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

9.2. Informative References

[FORCES-SDN] McKeown N. "Ooftware-defined networking", INFOCOM keynote talk, 2009.

[FORCES-OF] McKeown N, Anderson T, Balakrishnan H, et al. "OpenFlow: enabling innovation in campus networks", ACM SIGCOMM Computer Communication Review, 2008, 38(2), pp. 69-74.

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Authors' Addresses

Lieguang Zeng
Department of Electronic Engineering, Tsinghua University
Department of Electronic Engineering, Tsinghua University, Beijing,
China

Email: zenglg@mail.tsinghua.edu.cn

Ye Zhou
Department of Electronic Engineering, Tsinghua University
Department of Electronic Engineering, Tsinghua University, Beijing,
China

Email: yetiero@gmail.com

Mao Yang
Department of Electronic Engineering, Tsinghua University
Department of Electronic Engineering, Tsinghua University, Beijing,
China

Email: yangmao210@163.com

Yong Li
Department of Electronic Engineering, Tsinghua University
Department of Electronic Engineering, Tsinghua University, Beijing,
China

Email: liyong07@tsinghua.edu.cn

Depeng Jin
Department of Electronic Engineering, Tsinghua University
Department of Electronic Engineering, Tsinghua University, Beijing,
China

Email: jindp@mail.tsinghua.edu.cn

Li Su
Department of Electronic Engineering, Tsinghua University
Department of Electronic Engineering, Tsinghua University, Beijing,
China

Email: lisu@tsinghua.edu.cn