SDN Research Group
Internet-Draft
Intended status: Standards Track
Expires: April 21, 2016

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October 19, 2015

Cooperating Layered Architecture for SDN
draft-contreras-sdnrg-layered-sdn-04

Abstract

Software Defined Networking proposes the separation of the control plane from the data plane in the network nodes and its logical centralization on a control entity. Most of the network intelligence is moved to this functional entity. Typically, such entity is seen as a compendium of interacting control functions in a vertical, tight integrated fashion. The relocation of the control functions from a number of distributed network nodes to a logical central entity conceptually places together a number of control capabilities with different purposes. As a consequence, the existing solutions do not provide a clear separation between transport control and services that relies upon transport capabilities.

This document describes a proposal named Cooperating Layered Architecture for SDN. The idea behind that is to differentiate the control functions associated to transport from those related to services, in such a way that they can be provided and maintained independently, and can follow their own evolution path.

Status of This Memo

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1. Introduction

Software Defined Networking (SDN) proposes the separation of the control plane from the data plane in the network nodes and its logical centralization on a control entity. A programmatic interface is defined between such entity and the network nodes, which functionality is supposed to perform traffic forwarding (only). Through that interface, the control entity instructs the nodes involved in the forwarding plane and modifies their traffic forwarding behavior accordingly.

Most of the intelligence is moved to such functional entity. Typically, such entity is seen as a compendium of interacting control functions in a vertical, tight integrated fashion.

This approach presents a number of issues:

- Unclear responsibilities between actors involved in a service provision and delivery.

- Complex reuse of functions for the provision of services.

- Closed, monolithic control architectures.

- Difficult interoperability and interchangeability of functional components.

- Blurred business boundaries among providers.

- Complex service/network diagnosis and troubleshooting, particularly to determine which segment is responsible for a failure.

The relocation of the control functions from a number of distributed network nodes to another entity conceptually places together a number of control capabilities with different purposes. As a consequence, the existing solutions do not provide a clear separation between services and transport control.

This document describes a proposal named Cooperating Layered Architecture for SDN (CLAS). The idea behind that is to differentiate the control functions associated to transport from those related to services, in such a way that they can be provided and maintained independently, and can follow their own evolution path.

Despite such differentiation it is required a close cooperation between service and transport layers and associated components to provide an efficient usage of the resources.

2. Terminology

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 RFC2119 [RFC2119].

This document makes use of the following terms:

- Transport: denotes the transfer capabilities offered by a networking infrastructure. The transfer capabilities can rely upon pure IP techniques, or other means such as MPLS or optics.

- Service: denote a logical construct that make use of transport capabilities. This document does not make any assumption on the functional perimeter of a service that can be built above a transport infrastructure. As such, a service can be an offering that is offered to customers or be invoked for the delivery of another (added-value) service.

- SDN intelligence: refers to the decision-making process that is hosted by a node or a set of nodes. The intelligence can be centralized or distributed. Both schemes are within the scope of this document. The SDN intelligence relies on inputs form various functional blocks such as: network topology discovery, service topology discovery, resource allocation, business guidelines, customer profiles, service profiles, etc. The exact decomposition of an SDN intelligence, apart from the layering discussed in this document, is out of scope.

Additionally, the following acronyms are used in this document.

CLAS: Cooperating Layered Architecture for SDN

FCAPS: Fault, Configuration, Accounting, Performance and Security

SDN: Software Defined Networking

SLA: Service Level Agreement

3. Architecture overview

Current operator networks support multiple services (e.g., VoIP, IPTV, mobile VoIP, critical mission applications, etc.) on a variety of transport technologies. The provision and delivery of a service independently of the underlying transport capabilities requires a separation of the service related functionalities and an abstraction of the transport network to hide the specificities of underlying transfer techniques while offering a common set of capabilities.

Such separation can provide configuration flexibility and adaptability from the point of view of either the services or the transport network. Multiple services can be provided on top of a common transport infrastructure, and similarly, different technologies can accommodate the connectivity requirements of a certain service. A close coordination among them is required for a consistent service delivery (inter-layer cooperation).

This document focuses particularly on:

- Means to expose transport capabilities to external services.

- Means to capture service requirements of services.

- Means to notify service intelligence with underlying transport events, for example to adjust service decision-making process with underlying transport events.

- Means to instruct the underlying transport capabilities to accommodate new requirements, etc.

An example is to guarantee some Quality of Service (QoS) levels. Different QoS-based offerings could be present at both service and transport layers. Vertical mechanisms for linking both service and transport QoS mechanisms should be in place to provide the quality guarantees to the end user.

CLAS architecture assumes that the logically centralized control functions are separated in two functional blocks or layers. One of the functional blocks comprises the service-related functions, whereas the other one contains the transport-related functions. The cooperation between the two layers is considered to be implemented through standard interfaces.

Figure 1 shows the CLAS architecture. It is based on functional separation in the NGN architecture defined by the ITU-T in [Y.2011].

Two strata of functionality are defined, namely the Service Stratum, comprising the service-related functions, and the Transport Stratum, covering the transport ones. The functions on each of these layers are further grouped on control, management and user (or data) planes.

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                                   North Bound Interface

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      | Service Stratum                     ||             |
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      |                       ...........................  |
      |                       . SDN Controller          .  |
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      |  |              |     .  |  Control Pl. |     | .  |
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      | Transport Stratum                   ||             |
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      |                       . SDN Controller          .  |
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Figure 1: Cooperating Layered Architecture for SDN

In the CLAS architecture both the control and management functions are the ones logically centralized in one or a set of SDN controllers, in such a way that separated SDN controllers are present

in the Service and Transport strata. Furthermore, the generic user or data plane functions included in the NGN architecture are referred here as resource plane functions. The resource plane in each stratum is controlled by the corresponding SDN controller through a standard interface.

The SDN controllers cooperate for the provision and delivery of services. There is a hierarchy in which the Service SDN controller requests transport capabilities to the Transport SDN controller. Furthermore, the Transport SDN controller interacts with the Service SDN controller to inform it about events in the transport network that can motivate actions in the service layer.

The Service SDN controller acts as a client of the Transport SDN controller.

Despite it is not shown in the figure, the Resource planes of each stratum could be connected. This will depend on the kind of service provided. Furthermore, the Service stratum could offer an interface towards external applications to expose network service capabilities to those applications or customers.

This document does assume that SDN techniques can be enabled jointly with other distributed means (e.g., IGP).

3.1. Functional strata

As described before, the functional split separates transport-related functions from service-related functions. Both strata cooperate for a consistent service delivery.

Consistecy is determined and characterized by the service layer.

Communication between these two components could be implemented using a variety of means (such as [I-D.boucadair-connectivity-provisioning-protocol], Intermediate-Controller Plane Interface (I-CPI) [ONFArch], etc).

3.1.1. Transport stratum

The Transport stratum comprises the functions focused on the transfer of data between the communication end points (e.g., between end-user devices, between two service gateways, etc.). The data forwarding nodes are controlled and managed by the Transport SDN component. The Control plane in the SDN controller is in charge of instructing the forwarding devices to build the end to end data path for each communication or to make sure forwarding service is appropriately setup. Forwarding may not be rely on the sole pre-configured

entries; dynamic means can be enabled so that involved nodes can build dynamically routing and forwarding paths. Finally, the Management plane performs management functions (i.e., FCAPS) on those devices, like fault or performance management, as part of the Transport stratum capabilities.

3.1.2. Service stratum

The Service stratum contains the functions related to the provision of services and the capabilities offered to external applications. The Resource plane consists of the resources involved in the service delivery, such as computing resources, registries, databases, etc. The Control plane is in charge of controlling and configuring those resources, as well as interacting with the Control plane of the Transport stratum in client mode for requesting transport capabilities for a given service. In the same way, the Management plane implements management actions on the service-related resources and interacts with the Management plane in the Transport stratum for a cooperating management between layers.

3.1.3. Recursiveness

Recursive layering can happen in some usage scenarios in which the Transport Stratum is itself structured in Service and Transport Stratum. This could be the case of the provision of a transport services complemented with advanced capabilities additional to the pure data transport (e.g., maintenance of a given SLA [RFC7297]).

3.2. Plane separation

The CLAS architecture leverages on the SDN proposition of plane separation. As mentioned before, three different planes are considered for each stratum. The communication among these three planes (and with the corresponding plane in other strata) is based on open, standard interfaces.

3.2.1. Control Plane

The Control plane logically centralizes the control functions of each stratum and directly controls the corresponding resources. [RFC7426] introduces the role of the control plane in a SDN architecture. This plane is part of an SDN controller, and can interact with other control planes in the same or different strata for accomplishing control functions.

3.2.2. Management Plane

The Management plane logically centralizes the management functions for each stratum, including the management of the Control and Resource planes. [RFC7426] describes the functions of the management plane in a SDN environment. This plane is also part of the SDN controller, and can interact with the corresponding management planes residing in SDN controllers of the same or different strata.

3.2.3. Resource Plane

The Resource plane comprises the resources for either the transport or the service functions. In some cases the service resources can be connected to the transport ones (e.g., being the terminating points of a transport function) whereas in other cases it can be decoupled from the transport resources (e.g., one database keeping some register for the end user). Both forwarding and operational planes proposed in [RFC7426] would be part of the Resource plane in this architecture.

4. Required features

A number of features are required to be supported by the CLAS architecture.

- Abstraction: the mapping of physical resources into the corresponding abstracted resources.

- Service parameter translation: translation of service parameters (e.g., in the form of SLAs) to transport parameters (or capabilities) according to different policies.

- Monitoring: mechanisms (e.g. event notifications) available in order to dynamically update the (abstracted) resources' status taking in to account e.g. the traffic load.

- Resource computation: functions able to decide which resources will be used for a given service request. As an example, functions like PCE could be used to compute/select/decide a certain path.

- Orchestration: ability to combine diverse resources (e.g., IT and network resources) in an optimal way.

- Accounting: record of resource usage.

- Security: secure communication among components, preventing e.g. DoS attacks.

5. Communication between SDN Controllers

The SDN Controller residing respectively in the Service and the Transport Stratum need to establish a tight coordination. Mechanisms for transfer relevant information for each stratum should be defined.

From the Service perspective, the Service SDN controller needs to easily access transport resources through well defined APIs to access the capabilities offered by the Transport Stratum. There could be different ways of obtainign such transport-aware information, i.e., by discovering or publishing mechanisms. In the former case the Service SDN Controller could be able of handling complete information about the transport capabilities (including resources) offered by the Transport Stratum. In the latter case, the Transport Stratum exposes available capabilities e.g. through a catalog, reducing the amount of detail of the underlying network.

On the other hand, the Transport Stratum requires to properly capture Service requirements. These can include SLA requirements with specific metrics (such as delay), level of protection to be provided, max/min capacity, applicable resource constraints, etc.

The communication between controllers should be also secure, preventing denial of service.

6. Deployment scenarios

Different situations can be found depending on the characteristics of the networks involved in a given deployment.

6.1. Full SDN environments

This case considers the fact that the networks involved in the provision and delivery of a given service have SDN capabilities.

6.1.1. Multiple Service strata associated to a single Transport stratum

A single Transport stratum can provide transfer functions to more than one Service strata. The Transport stratum offers a standard interface to each of the Service strata. The Service strata are the clients of the Transport stratum. Some of the capabilities offered by the Transport stratum can be isolation of the transport resources (slicing), independent routing, etc.

6.1.2. Single service stratum associated to multiple Transport strata

A single Service stratum can make use of different Transport strata for the provision of a certain service. The Service stratum interfaces each of the Transport strata with standard protocols, and orchestrates the provided transfer capabilities for building the end to end transport needs.

6.2. Hybrid environments

This case considers scenarios where one of the strata is legacy totally or in part.

6.2.1. SDN Service stratum associated to a legacy Transport stratum

An SDN service stratum can interact with a legacy Transport stratum through some interworking function able to adapt SDN-based control and management service-related commands to legacy transport-related protocols, as expected by the legacy Transport stratum. The SDN controller in the Service stratum is not aware of the legacy nature of the underlying Transport stratum.

6.2.2. Legacy Service stratum associated to an SDN Transport stratum

A legacy Service stratum can work with an SDN-enabled Transport stratum through the mediation of and interworking function capable to interpret commands from the legacy service functions and translate them into SDN protocols for operating with the SDN-enabled Transport stratum.

6.3. Multi-domain scenarios in Transport Stratum

The Transport Stratum can be composed by transport resources being part of different administrative, topological or technological domains. The Service Stratum can yet interact with a single entity in the Transport Stratum in case some abstraction capabilities are provided in the transport part to emulate a single stratum.

Those abstraction capabilities constitute a service itself offered by the Transport Stratum to the services making use of it. This service is focused on the provision of transport capabilities, then different of the final communication service using such capabilities.

In this particular case this recursion allows multi-domain scenarios at transport level.

Multi-domain situations can happen in both single-operator and multi-operator scenarios. Multi-operator scenarios will be addressed in future versions of the document.

In single operator scenarios a multi-domain or end-to-end abstraction component can provide an homogeneous abstract view of the underlying heterogeneous transport capabilities for all the domains.

7. Use cases

This section presents a number of use cases as examples of applicability of this proposal

7.1. Network Function Virtualization

To be completed

7.2. Abstraction and Control of Transport Networks

To be completed.

8. IANA Considerations

TBD.

9. Security Considerations

TBD. Security in the communication between strata to be addressed.

10. References

10.1. Normative References

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