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Framework and Data Model for OTN Network Slicing

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Abstract

The requirement of slicing network resource with desired quality of

service is emerging at every network technology, including the

Optical Transport Networks (OTN). As a part of the transport network,

OTN can provide hard pipes with guaranteed data isolation and

deterministic low latency, which are highly demanded in the Service

Level Agreement (SLA).

This document describes a framework for OTN network slicing and a

YANG data model augmentation of the OTN topology model. Additional

YANG data model augmentations will be defined in a future version of

this draft.

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1. Introduction

The requirement of slicing network resource with desired quality of

service is emerging at every network technology, including the

Optical Transport Networks (OTN). As a part of the transport network,

OTN can provide hard pipes with guaranteed data isolation and

deterministic low latency, which are highly demanded in the Service

Level Agreement (SLA).

This document describes a framework for OTN network slicing and a

YANG data model augmentation of the OTN topology model. Additional

YANG data model augmentations will be defined in a future version of

this draft.

2. Use Cases for OTN Network Slicing

2.1. Leased Line Services with OTN

For end business customers (like OTT or enterprises), leased lines

have the advantage of providing high-speed connections with low

costs. On the other hand, the traffic control of leased lines is very

challenging due to rapid changes in service demands. Carriers are

recommended to provide network-level slicing capabilities to meet

this demand. Based on such capabilities, private network users have

full control over the sliced resources which have allocated to them

and which could be used to support their leased lines, when needed.

Users may formulate policies based on the demand for services and

time to schedule the resources from the entire network's perspective

flexibly. For example, the bandwidth between any two points may be

established or released based on the time or monitored traffic

characteristics. The routing and bandwidth may be adjusted at a

specific time interval to maximize network resource utilization

efficiency.

2.2. Co-construction and Sharing

Co-construction and sharing of a network are becoming a popular means

among service providers to reduce networking building CAPEX. For Co-

construction and sharing case, there are typically multiple co-

founders for the same network. For example, one founder may provide

optical fibres and another founder may provide OTN equipment, while

each occupies a certain percentage of the usage rights of the network

resources. In this scenario, the network O&M is performed by a

certain founder in each region, where the same founder usually

deploys an independent management and control system. The other

founders of the network use each other's management and control

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system to provision services remotely. In this scenario, different

founders' network resources need to be automatically (associated)

divided, isolated, and visualized. In addition, all founders have

independent O&M capabilities, and should be able to perform service-

level provisioning in their respective slices.

2.3. Wholesale of optical resources

In the optical resource wholesale market, smaller, local carriers and

wireless carriers may rent resources from larger carriers, or

infrastructure carriers instead of building their networks. Likewise,

international carriers may rent resources from respective local

carriers and local carriers may lease their owned networks to each

other to achieve better network utilization efficiency.

From the perspective of a resource provider, it is crucial that a

network slice is timely configured to meet traffic matrix

requirements requested by its tenants. The support for multi-tenancy

within the resource provider's network demands that the network

slices are qualitatively isolated from each other to meet the

requirements for transparency, non-interference, and security.

Typically, a resource purchaser expects to use the leased network

resources flexibly, just like they are self-constructed. Therefore,

the purchaser is not only provided with a network slice, but also the

full set of functionalities for operating and maintaining the network

slice. The purchaser also expects to, in a flexible and independent

manner, schedule and maintain physical resources to support their own

end-to-end automation using both leased and self-constructed network

resources.

2.4. Vertical dedicated network with OTN

Vertical industry slicing is an emerging category of network slicing

due to the high demand for private high-speed network interconnects

for industrial applications.

In this scenario, the biggest challenge is to implement

differentiated optical network slices based on the requirements from

different industries. For example, in the financial industry, to

support high-frequency transactions, the slice must ensure to provide

the minimum latency along with the mechanism for latency management.

For the healthcare industry, online diagnosis network and software

capabilities to ensure the delivery of HD video without frame loss.

For bulk data migration in data centers, the network needs to support

on-demand, large-bandwidth allocation. In each of the aforementioned

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vertical industry scenarios, the bandwidth shall be adjusted as

required to ensure flexible and efficient network resource usage.

2.5 End-to-end network slicing

An end-to-end network slice, such as a 5G network slice [TS28530] may span multiple technological and administrative domains. According to [I-D.ietf-teas-ietf-network-slice-definition], IETF network slice provides the required connectivity between different entities of an end-to-end network slice, with a specific commitment. An IETF network slice may be composed of network slices from underlying network domains that include OTN, in a combination of hierarchical (recursive) or sequential (stitched) manner. In this case, an OTN network slice is essentially a realization of an IETF network slice in OTN network domains.

3. Framework for OTN slicing

An OTN slice is a collection of OTN network resources that are used

to establish a logically dedicated OTN virtual network over one or

more OTN networks. For example, the bandwidth of an OTN slice is

described in terms of a total number or a specific set of OTN tributary slots ; the labels

may be specified as OTN tributary slots and/or tributary ports to

allow slice users to interconnect devices with matching

specifications.

The relationship between an OTN slice and an IETF network slice [I-D.ietf-teas-ietf-network-slice-definition] is for further discussions.

To support the configuration of OTN slices, an OTN slice controller

(OTN-SC) can be deployed either outside or within the SDN controller.

In the former case, the OTN-SC translates an OTN slice configuration

request into a TE topology configuration or a set of TE tunnel

configurations, and instantiate it by using the TE topology [RFC8795]

or TE tunnel [I-D.ietf-teas-yang-te] interfaces at the MPI (MDSC-to-

PNC Interface), as defined in the ACTN framework [RFC8453].

In the latter case, an Orchestrator or an end-to-end slice controller

may request OTN slices directly through the OTN slicing interface

provided by the OTN-SC. A higher-level OTN-SC may also designate the

creation of OTN slices to a lower-level OTN-SC in a recursive manner.

Figure 1 illustrates the OTN slicing control hierarchy and the

positioning of the OTN slicing interfaces.

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+--------------------+

| Provider's User |

+--------|-----------+

|CMI

+-----------------------+----------------------------+

| Orchestrator / E2E Slice Controller |

+------------+---------------------------+-----------+

| |

| |

| | NSC-NBI

| +------+-----------+

| | IETF Network |

| +---------------+ Slice Controller |

| | +---------+--------+

OTN-SC NBI | |OTN-SC NBI |

| | |

+------------+----+----+ OTN-SC NBI |OTN-SC NBI

| OTN-SC +---------------+ |

+------------+---------+ | |

|MPI | |

+------------|-------------------------|----|--------+

| SDN | +-------+----+-------+|

| Controller | | OTN-SC ||

| | +-------+------------+|

| | |Internal API |

|+-----------+-------------------------+------------+|

|| PNC/MDSC-L ||

|+-----------------------+--------------------------+|

+------------------------|---------------------------+

|SBI

+-----------+----------+

|OTN Physical Network |

+----------------------+

Figure 1 - Positioning of OTN Slicing Interfaces

A particular OTN network resource, such as a port or link, may be

sliced in two modes:

o Link-based slicing, where a link and its associated link

termination points (LTPs) are dedicatedly allocated to a

particular OTN network slice.

o Tributary-slot based slicing, where multiple OTN network slices

share the same link by allocating different OTN tributary slots in

different granularities.

Additionally, since an OTN switch is typically designed to be fully non-blocking switchable at the lowest ODU container granularity, , it is desirable to specify just the total number of tributary slots in the lowest granularity (e.g. ODU0) when configuring tributary-slot based slicing on links and ports internal to an OTN network. In multi-domain OTN network scenarios where separate OTN network slices are created on each of the OTN networks and are stitched at inter-domain OTN links, it is necessary to specify matching tributary slots at the endpoints of the inter-domain links. In some real network scenarios, OTN network resources including tributary slots are managed explicitly by network operators for network maintenance considerations. Therefore an OTN slice controller shall support configuring an OTN slice with both options.

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4. YANG Data Model for OTN Slicing Configuration

4.1. OTN Slicing YANG Model for MPI

4.1.1. MPI YANG Model Overview

An SDN controller (PNC or MDSC) exposes to the OTN-SC set of

available resources for OTN slicing in the form of an abstract TE

topology. When the OTN-SC receives slice configuration from the NBI,

it translates the configuration into a colored graph on the

abstract TE topology, by marking corresponding link resources on the

TE topology received from the SDN controller with a slice identifier

and OTN-specific resource requirements, e.g. the number of ODU time

slots. When the SDN controller receives the slice configuration, it

shall create a new virtual TE link for each of the colored links to

hold the reserved OTN time slots for time slot-based slicing. These

resultant virtual links are then included in the TE topology

advertisement to the OTN-SC.

4.1.2. MPI YANG Model Tree

module: ietf-otn-slice

augment /nw:networks/nw:network/nt:link/tet:te/tet:te-link-

attributes:

+--rw (otn-slice-granularity)?

+--:(link)

| +--rw slice-id? uint32

+--:(link-resource)

+--rw slices\* [slice-id]

+--rw slice-id uint32

+--rw (technology)?

| +--:(otn)

| +--rw otn-ts-num? uint32

| +--rw ts-list? string

+--ro sliced-link-ref? ->

../../../../../nt:link/link-id

Figure 2 - OTN network slicing tree diagram

4.1.3. MPI YANG Code

<CODE BEGINS>file "ietf-otn-slice@2021-02-22.yang"

module ietf-otn-slice {

yang-version 1.1;

namespace "urn:ietf:params:xml:ns:yang:ietf-otn-slice";

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prefix "otnslice";

import ietf-network {

prefix "nw";

reference "RFC 8345: A YANG Data Model for Network Topologies";

}

import ietf-network-topology {

prefix "nt";

reference "RFC 8345: A YANG Data Model for Network Topologies";

}

import ietf-te-topology {

prefix "tet";

reference

"RFC8795: YANG Data Model for Traffic Engineering

(TE) Topologies";

}

import ietf-otn-topology {

prefix "otntopo";

reference

"I-D.ietf-ccamp-otn-topo-yang: A YANG Data Model

for Optical Transport Network Topology";

}

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Editor: Victor Lopez

<mailto:victor.lopezalvarez@telefonica.com>";

description

"This module defines a YANG data model to configure an OTN

network slice realization.

The model fully conforms to the Network Management Datastore

Architecture (NMDA).

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(https://trustee.ietf.org/license-info).

This version of this YANG module is part of RFC XXXX; see

the RFC itself for full legal notices.";

revision "2021-02-22" {

description

"Initial Version";

reference

"draft-zheng-ccamp-yang-otn-slicing-01: Framework and Data

Model for OTN Network Slicing";

}

/\*

\* Groupings

\*/

grouping otn-link-slice-profile {

choice otn-slice-granularity {

default link;

case link {

leaf slice-id {

type uint32;

description

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"Slice identifier";

}

}

case link-resource {

list slices {

key slice-id;

description

"List of slices.";

leaf slice-id {

type uint32;

description

"Slice identifier";

}

choice technology {

case otn {

leaf otn-ts-num {

mandatory true;

type uint32;

description

"Number of OTN tributary slots allocated for the

slice.";

}

leaf ts-list {

type string {

pattern "([1-9][0-9]{0,3}(-[1-9][0-9]{0,3})?"

+ "(,[1-9][0-9]{0,3}(-[1-9][0-9]{0,3})?)\*)";

}

description

"A list of allocated tributary slots ranging

between 1 and 4095. If multiple values or

ranges are given, they all must be disjoint

and must be in ascending order.

For example 1-20,25,50-1000.";

reference

"RFC 7139: GMPLS Signaling Extensions for Control

of Evolving G.709 Optical Transport Networks";

} }

}

leaf sliced-link-ref {

config false;

type leafref {

path "../../../../../nt:link/nt:link-id";

}

description

"Relative reference to virtual links generated from

this TE link.";

}

}

}

}

}

/\*

\* Augments

\*/

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augment "/nw:networks/nw:network/nt:link/tet:te/"

+ "tet:te-link-attributes" {

when "../../../nw:network-types/tet:te-topology/"

+ "otntopo:otn-topology" {

description

"Augmentation parameters apply only for networks with

OTN topology type.";

}

description

"Augment OTN TE link attributes with slicing profile.";

uses otn-link-slice-profile;

}

}

<CODE ENDS>

Figure 3 - OTN network slicing YANG model

4.2. OTN Slicing YANG Model for OTN-SC NBI

TBD.

5. Manageability Considerations

To ensure the security and controllability of physical resource

isolation, slice-based independent operation and management are

required to achieve management isolation.

Each optical slice typically requires dedicated accounts,

permissions, and resources for independent access and O&M. This

mechanism is to guarantee the information isolation among slice

tenants and to avoid resource conflicts. The access to slice

management functions will only be permitted after successful security

checks.

6. Security Considerations

<Add any security considerations>

7. IANA Considerations

<Add any IANA considerations>

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TBD

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