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Abstraction and Control of TE Networks (ACTN) Abstraction Methods

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Abstract

Abstraction and Control of Traffic Engineering (TE) Networks (ACTN) refers to the set of virtual network operations needed to orchestrate, control and manage large-scale multi-domain TE networks, so as to facilitate network programmability, automation, and efficient resource sharing.

As the ACTN architecture considers abstraction as one of the important building blocks, this document describes a few alternatives methods of abstraction for both packet and optical networks. This is an important consideration since the choice of the abstraction method impacts protocol design and the information it carries.

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[1. Introduction](#)

Abstraction and Control of TE Networks (ACTN) describes a method for operating a Traffic Engineered (TE) network (such as an MPLS-TE network or a layer 1 transport network) to provide connectivity and virtual network services for customers of the TE network. The services provided can be tuned to meet the requirements (such as traffic patterns, quality, and reliability) of the applications hosted by the customers. More details about ACTN can be found in [Section 2](#).

Abstraction is defined in [[RFC7926](#)] as:

Abstraction is the process of applying policy to the available TE information within a domain, to produce selective information that represents the potential ability to connect across the domain. Thus, abstraction does not necessarily offer all possible connectivity options, but presents a general view of potential connectivity according to the policies that determine how the domain's administrator wants to allow the domain resources to be used.

Connectivity referred to this document is TE path through a series of connected domains as used in [[RFC7926](#)].

As the ACTN architecture considers abstraction as one of the important building blocks, this document discusses a few alternatives for the methods of abstraction for both packet and optical networks. This is an important consideration since the choice of the abstraction method impacts protocol design and the information it carries.

The purpose of this document is to find a common agreement on the factors and methods of abstraction. These abstraction factors and methods may in turn impact implementations and protocol design.

[2. Abstraction Factors in ACTN Architecture](#)

This section provides abstraction factors in the ACTN architecture. [[ACTN-Frame](#)] describes the architecture model for ACTN including the entities (Customer Network Controller (CNC), Multi-domain Service

Coordinator (MDSC), and Physical Network Controller (PNC) and their interfaces.

The MDSC oversees the specific aspects of the different domains and builds a single abstracted end-to-end network topology in order to coordinate end-to-end path computation and path/service provisioning. In order for the MDSC to perform its coordination function, it depends on the coordination with the PNCs which are the domain-level controllers especially as to what level of domain network resource abstraction is agreed upon between the MDSC and the PNCs.

As discussed in [[RFC7926](#)], abstraction is tied with policy of the networks. For instance, per an operational policy, the PNC would not be allowed to provide any technology specific details (e.g., optical parameters for WSON) in its update. In such case, the abstraction level of the update will be in a generic nature. In order for the MDSC to get technology specific topology information from the PNC, a request/reply mechanism may be employed.

In some cases, abstraction is also tied with the controller's capability of abstraction as abstraction involves some rules and algorithms to be applied to the actual network resource information (which is also known as network topology).

[TE-Topology] describes YANG models for TE-network abstraction. [[PCEP-LS](#)] describes PCEP Link-state mechanism that also allows for transport of abstract topology in the context of Hierarchical PCE.

There are factors that may impact the choice of abstraction and presents a number of abstraction methods. It is important to understand that abstraction depends on several factors:

- The nature of underlying domain networks: Abstraction depends on the nature of the underlying domain networks. For instance, packet networks may have different level of abstraction requirements from that of optical networks. Within optical networks, WSON may have different level of abstraction requirements than the OTN networks.
- The capability of the PNC: Abstraction depends on the capability of the PNCs. As abstraction requires hiding details of the underlying resource network resource information, the PNC capability to run some internal optimization algorithm impacts the feasibility of abstraction. Some PNC may not have the ability to abstract native topology while other PNCs may have such an ability to abstract actual topology by using sophisticated algorithms.

- Scalability factor: Abstraction is a function of scalability. If the actual network resource information is of small size, then the need for abstraction would be less than the case where the native network resource information is of large size. In some cases, abstraction may not be needed at all.
- The frequency of topology updates: The proper abstraction level may depend on the frequency of topology updates and vice versa.
- The capability/nature of the MDSC: The nature of the MDSC impacts the degree/level of abstraction. If the MDSC is not capable of handling optical parameters such as those specific to OTN/WSN, then white topology abstraction may not work well.
- The confidentiality: In some cases where the PNC would like to hide key internal topological data from the MDSC, the abstraction method should consider this aspect.
- The scope of abstraction: All of the aforementioned factors are equally applicable to both the MPI (MDSC-PNC Interface) and the CMI (CNC-MDSC Interface).

[ACTN-Framework] defined the following three levels of topology abstraction and their descriptions:

- . White topology: this is a case where the PNC provides the actual network topology to the MDSC without any hiding or filtering.
- . Black topology: the entire domain network is abstracted as a single virtual node (see the definition of virtual node in [\[RFC7926\]](#)) with the access/egress links without disclosing any node internal connectivity information.
- . Grey topology: this abstraction level is between black topology and white topology from a granularity point of view. we may further differentiate from a perspective of how to abstract internal TE resources between the pairs of border nodes:
 - o Grey topology type A: border nodes with a TE links between them in a full mesh fashion
 - o Grey topology type B: border nodes with some internal abstracted nodes and abstracted links

3. Build Method of Grey Topology

This section discusses two different methods of building a grey topology:

- . Automatic generation of abstract topology by configuration ([Section 3.1](#))
- . On-demand generation of supplementary topology via path computation request/reply ([Section 3.2](#))

3.1. Automatic generation of abstract topology by configuration

The "Automatic generation" method is based on the abstraction/summarization of the whole domain by the PNC and its advertisement on MPI interface once the abstraction level is configured. The level of abstraction advertisement can be decided based on some PNC configuration parameters (e.g. provide the potential connectivity between any PE and any ASBR in an MPLS-TE network as described in [section 3.3.1](#))

Note that the configuration parameters for this potential topology can include available B/W, latency, or any combination of defined parameters. How to generate such tunnel information is beyond the scope of this document. [Appendix A](#) provides one example of this method for the WSON case.

Such potential topology needs to be periodically or incrementally/asynchronously updated every time that a failure, a recovery or the setup of new VNs causes a change in the characteristics of the advertised grey topology (e.g. in our previous case if due to changes in the network is it now possible to provide connectivity between a given PE and a given ASBR with a higher delay in the update).

3.2. On-demand generation of supplementary topology via path compute request/reply

The "on-demand generation" of supplementary topology is to be distinguished from automatic generation of abstract topology. While abstract topology is generated and updated automatically by configuration as explained in [Section 3.1.](#), additional supplementary topology may be obtained by the MDSC via path compute request/reply mechanism. Starting with a black topology advertisement from the

PNCs, the MDSC may need additional information beyond the level of black topology from the PNCs. It is assumed that the black topology advertisement from PNCs would give the MDSC each domain's the border node/link information as described in Figure 2. Under this scenario, when the MDSC needs to allocate a new VN, the MDSC can issue a number of Path Computation requests as described in [ACTN-YANG] to different PNCs with constraints matching the VN request.

An example is provided in Figure 4, where the MDSC is requesting to setup a P2P VN between AP1 and AP2. The MDSC can use two different inter-domain links to get from Domain X to Domain Y, namely the one between ASBRX.1 and ASBRY.1 and the one between ASBRX.2 and ASBRY.2, but in order to choose the best end to end path it needs to know what domain X and Y can offer in term of connectivity and constraints between the PE nodes and the ASBR nodes.

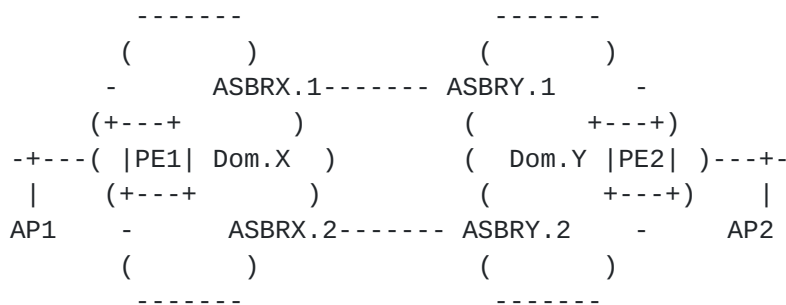


Figure 4: A multi-domain networks example

A path computation request will be issued to PNC.X asking for potential connectivity between PE1 and ASBRX.1 and between PE1 and ASBRX.2 with related objective functions and TE metric constraints. A similar request will be issued to PNC.Y and the results merged together at the MDSC to be able to compute the optimal end-to-end path including the inter domain links.

The info related to the potential connectivity may be cached by the MDSC for subsequent path computation processes or discarded, but in this case the PNCs are not requested to keep the grey topology updated.

4. Protocol/Data Model Requirements

This section provides a set of requirements that may impact the way protocol/data model is designed and the information elements thereof which are carried in the protocol/data model.

It is expected that the abstraction level be negotiated between the CNC and the MDSC (i.e., the CMI) depending on the capability of the CNC. This negotiated level of abstraction on the CMI may also impact the way the MDSC and the PNCs configure and encode the abstracted topology. For example, if the CNC is capable of sophisticated technology specific operation, then this would impact the level of abstraction at the MDSC with the PNCs. On the other hand, if the CNC asks for a generic topology abstraction, then the level of abstraction at the MDSC with the PNCs can be less technology specific than the former case.

The subsequent sections provide a list of possible abstraction levels for various technology domain networks.

4.1. Packet Networks

- For grey abstraction, the type of abstraction and its parameters MUST be defined and configured/negotiated.
 - o Abstraction Level 1: TE-tunnel abstraction for all (S-D) border pairs with:
 - . Maximum B/W available per Priority Level
 - . Minimum Latency
 - o Other Level (TBD)

4.2. OTN Networks

For OTN networks, max bandwidth available may be per ODU 0/1/2/3 switching level or aggregated across all ODU switching levels (i.e., ODUj/k). Clearly, there is a trade-off between these two abstraction methods. Some OTN switches can switch any level of ODUs and in such case there is no need for ODU level abstraction.

- For grey abstraction, the type of abstraction and its parameters MUST be defined and configured/negotiated.
 - o Abstraction Level 1: Per ODU Switching level (i.e., ODU type and number) TE-tunnel abstraction for all (S-D) border pairs with:

- . Maximum B/W available per Priority Level
 - . Minimum Latency
- o Abstraction Level 2: Aggregated TE-tunnel abstraction for all (S-D) border pairs with:
 - . Maximum B/W available per Priority Level
 - . Minimum Latency
- o Other Level (TBD)

4.3. WSON Networks

For WSON networks, max bandwidth available may be per lambda/frequency level (OCh) or aggregated across all lambda/frequency level. Per OCh level abstraction gives more detailed data to the MDSC at the expense of more information processing. Either OCh-level or aggregated level abstraction should factor in the RWA constraint (i.e., wavelength continuity) at the PNC level. This means the PNC should have this capability and advertise it as such. See the Appendix for this abstraction method.

- For grey abstraction, the type of abstraction MUST and its parameters be defined and configured/negotiated.
 - o Abstraction Level 1: Per Lambda/Frequency level TE-tunnel abstraction for all (S-D) border pairs with:
 - . Maximum B/W available per Priority Level
 - . Minimum Latency
 - o Abstraction Level 2: Aggregated TE-tunnel abstraction for all (S-D) border pairs with:
 - . Maximum B/W available per Priority Level
 - . Minimum Latency
 - o Other Level (TBD)

Examples: these examples show how to compute WSON grey topology Abstraction Level 1 and Level 2. These examples illustrate that the encoding of an abstraction topology can be impacted by the configured/negotiated abstraction level in the ACTN interfaces.

This section provides how WSON grey topology abstraction levels 1 and 2 can be computed at a PNC. These examples illustrate that the

encoding of an abstraction topology can be impacted by the configured/negotiated abstraction level at the MPI.

. Abstraction Level 1: Per Lambda/Frequency level TE-tunnel abstraction for all (S-D) border pairs:

For each (S-D) border node pair,

- 1) The concept of a lambda plane: A lambda plane is a confined optical topology with respect to a given lambda value. If an OMS link has the wavelength of the given lambda available, it is included, otherwise excluded.
- 2) Calculate the maximal flow between S and D in every lambda plane. Max flow computation is restricted to each lambda plane is for OCh wavelength continuity.
- 3) Convert each feasible lambda plane with OCh wavelength continuity to B/W equivalent encoding; Send this per lambda level encoding for (S-D) to the MDSC;

. Abstraction Level 2: Aggregated TE-tunnel abstraction for WSON for all (S-D) border pairs

For each (S-D) border node pair,

- 1) The concept of a lambda plane: A lambda plane is a confined optical topology with respect to a given lambda value. If an OMS link has the wavelength of the given lambda available, it is included, otherwise excluded.
- 2) Calculate the maximal flow between S and D in every lambda plane. Max flow computation is restricted to each lambda plane is for OCh wavelength continuity.
- 3) Add up the max flow values across all lambda planes. This is the maximal number of OCh paths that can be setup between S and D at the same time.
- 4) Convert the max number of OCh paths to B/W equivalent encoding; Send this encoding as max B/W for (S-D) to the MDSC;

5. Acknowledgements

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