Using YANG for the Dissemination of the Traffic Engineering Database within Software Defined Elastic Optical Networks

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Application-Based Network Operations
Functional Components

- RFC 7491 "Standardized" components
- Policy Management
- Network Topology
  - LSP-DB
  - TED
  - Inventory Management
- Path Computation and Traffic Engineering
  - PCE, PCC
  - Stateful & Stateless
  - Online & Offline
  - P2P, P2MP, MP2MP
- Multi-layer Coordination
  - Virtual Network Topology Manager
- Network Signaling & Programming
  - RSVP-TE
  - ForCES
  - OpenFlow
  - Interface to the Routing System
  - Emerging technologies: Segment Routing & Service Function Chaining

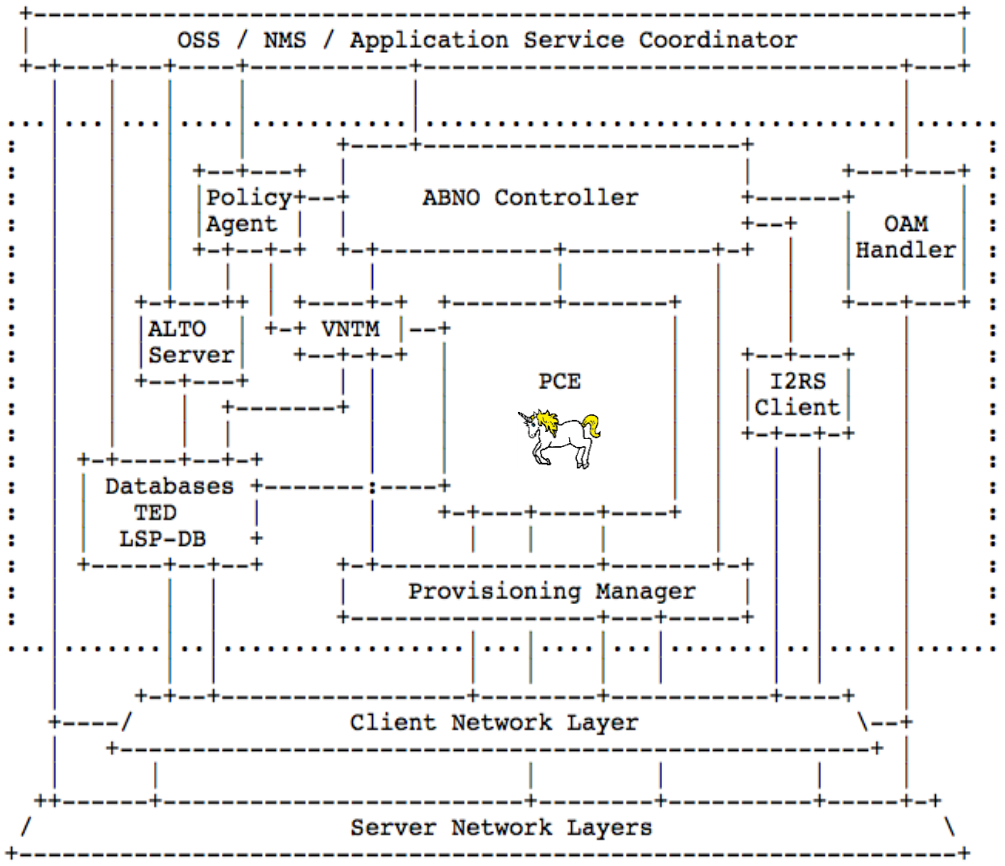
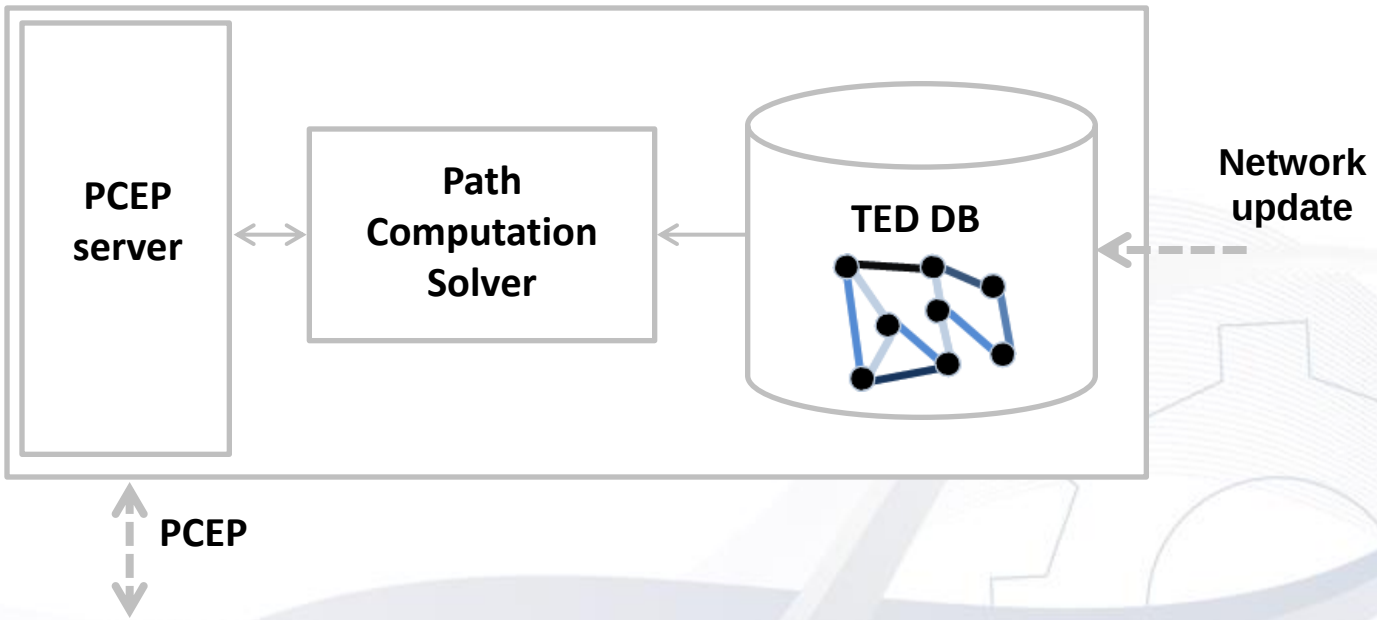


Figure 1: Generic ABNO Architecture

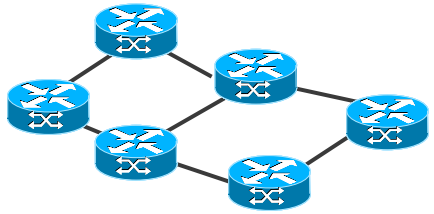
The Traffic Engineering Database

- Traffic Engineering Database (TED) is essential internal component of a PCE
  - provides the updated snapshot of the controlled network and its resources
  - PCE algorithms resort to TED as primary information source input

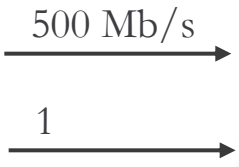


What does the TED store?

- The topology of the controlled network
  - Nodes
  - Links
  - Nodes/Links connectivity



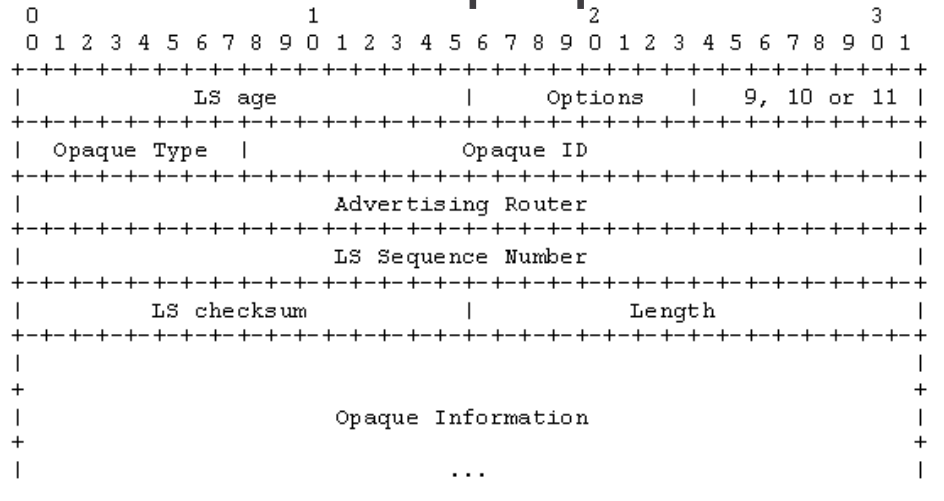
- The available resources and attributes
  - Available Link Bandwidth
  - Link Metrics (e.g., costs)

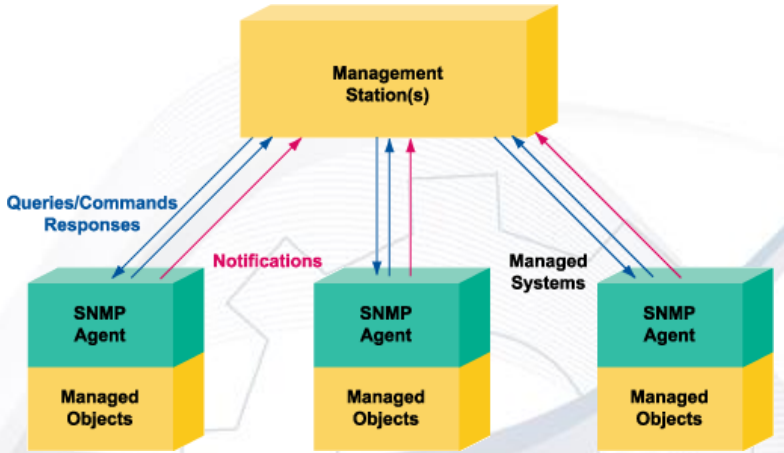


TED Update

- Different mechanisms may be used
  - **Passive OSPF-TE or IS-IS-TE peering**
    - TE info updated by means of Opaque Link State Advertisement or Link State PDU
  - Management-based (e.g., SNMP or YANG)
  - PCEP Notifications

OSPF Opaque LSA



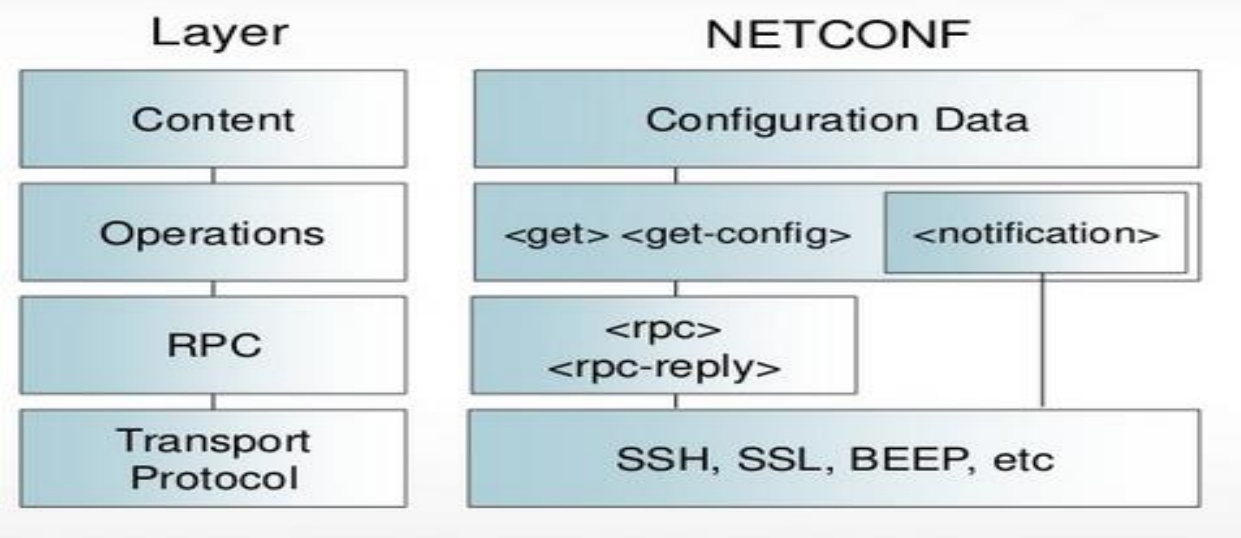


Topology Synchronization: OSPF-TE or IS-IS-TE

- Usual link-states IGPs with traffic engineering extensions
  - the standard IP routing protocols (OSPF and IS-IS)…
  - … extended to provide TE data base synchronization
- States of links in the area
  - metrics, Shared Risk Link Groups, admin. groups/resource classes
  - reservable bandwidth, unreserved bandwidth
  - Optical switching capability (packet, L2, TDM, lambda, slice, fiber)
  - unnumbered links (Node ID + port ID) may be used
- Optionally some node information
  - TE router ID
  - TE capabilities
- Optionally some inter-domain TE-links connected to the area
  - no IGP adjacency
  - area-scoped flooding of configured parameters

NETCONF & YANG

- NETCONF is the configuration protocol and YANG is able to model configuration data, state data, operations, and notifications
- YANG definitions directly map to XML content



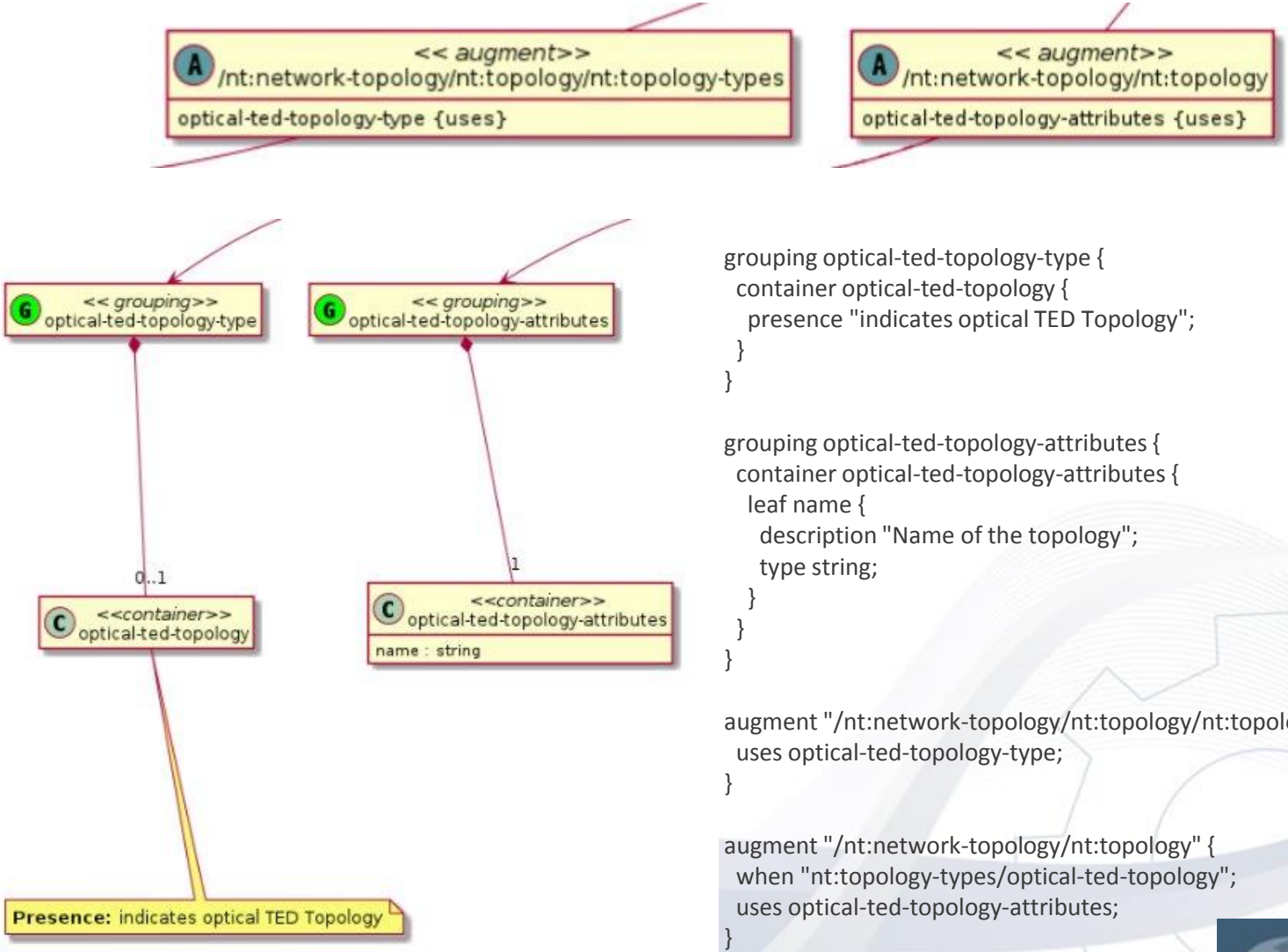
NETCONF & YANG Design Goals

- The design goals for NETCONF, included:
  - Distinction between configuration and state data
  - Multiple configuration data stores:
  - Candidate, running, startup
  - Configuration change validations
  - Configuration change transactions
  - Selective data retrieval with filtering
  - Extensible Remote Procedure Call (RPC) mechanism
- Key YANG Capabilities
  - Human readable, easy to learn representation
  - Hierarchical configuration data models
  - Reusable types and groupings (structured types)
  - Extensibility through augmentation mechanisms
  - Supports the definition of operations (RPCs)
  - Formal constraints for configuration validation
  - Data modularity through modules and sub-modules
  - Versioning rules and development support

Dissemination of Flexi-Grid Network Information

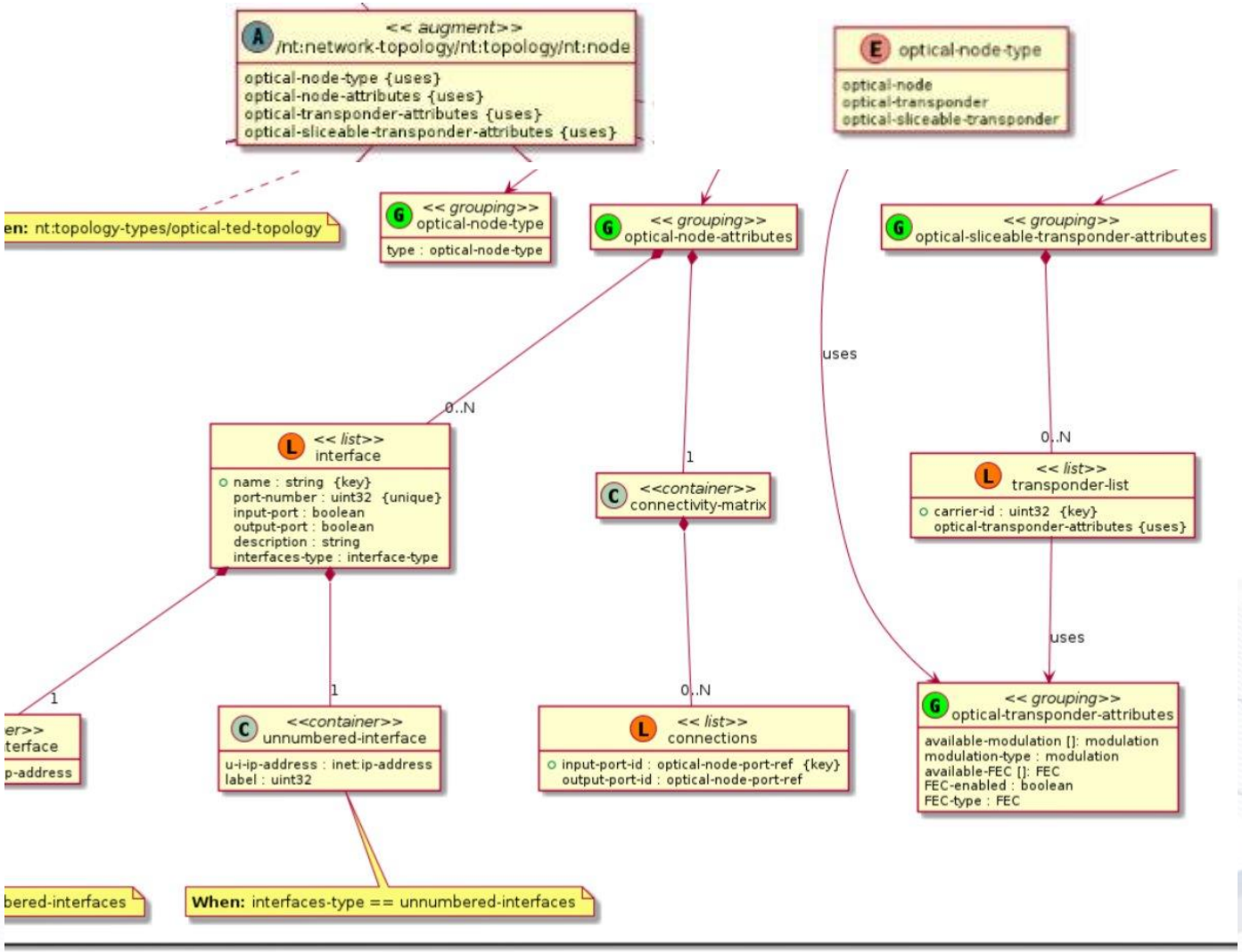
- The YANG model we propose is spilt into two modules:
  - Optical TED
    - Includes: optical-node, optical-transponder and optical-link; optical-sliceable-transponders
    - Each element is defined as a container and includes a set of attributes. The module also includes the data types for the type of modulation, the optical technology such as Forward Error Correction (FEC).
  - Media Channel (two types)media channel
    - An (effective) frequency slot supported by a concatenation of media elements (fibers, amplifiers, filters, switching matrices.)
    - Network Media Channel: is a media channel that transports an Optical Tributary Signal.

Augmented Topology

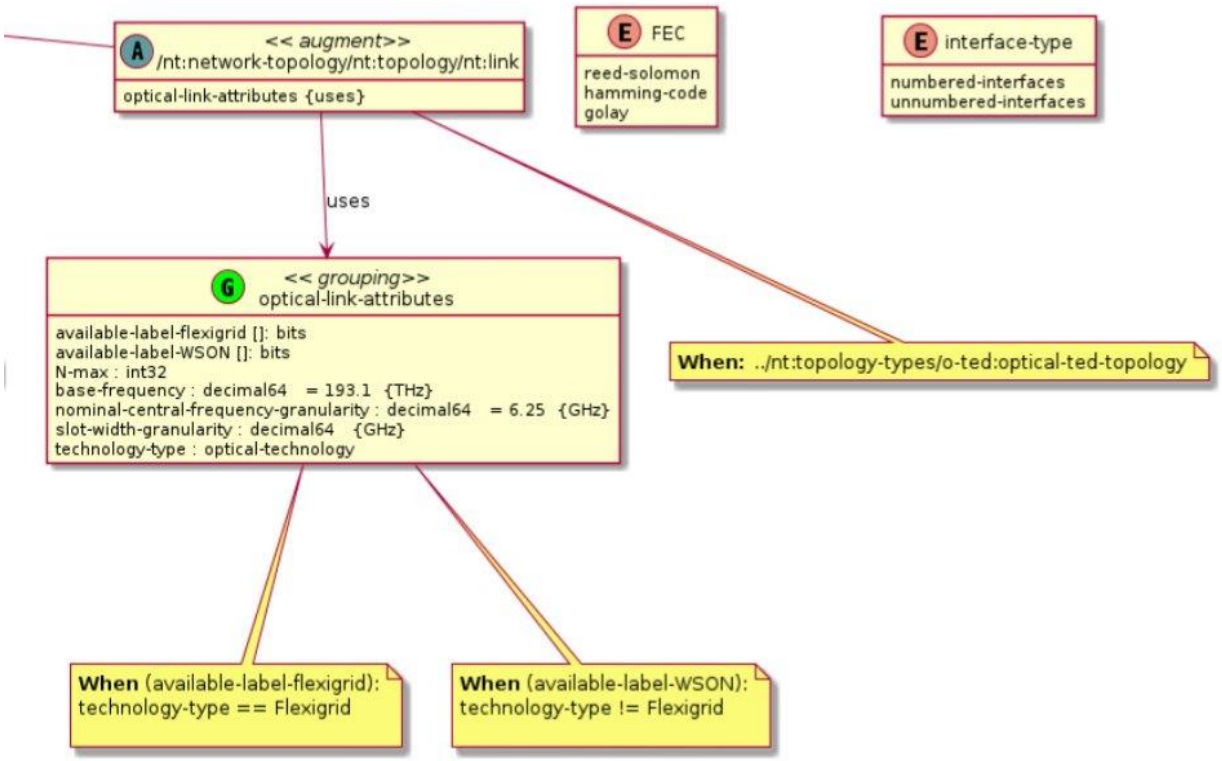



```
grouping optical-ted-topology-type {
  container optical-ted-topology {
    presence "indicates optical TED Topology";
  }
}

grouping optical-ted-topology-attributes {
  container optical-ted-topology-attributes {
    leaf name {
      description "Name of the topology";
      type string;
    }
  }
}

augment "/nt:network-topology/nt:topology/nt:topology-types" {
  uses optical-ted-topology-type;
}

augment "/nt:network-topology/nt:topology" {
  when "nt:topology-types/optical-ted-topology";
  uses optical-ted-topology-attributes;
}
```

Augmented Nodes



Augmented Links




```
augment "/nt:network-topology/nt:topology/nt:link" {
  when "../nt:topology-types/o-ted:optical-ted-topology";
  uses optical-link-attributes;
}
```

Impact on Standardisation

- A key output of YANG model development effort for Elastic Optical Networks has been a contribution to the IETF, in the form of an Internet-Draft within the "Common Control and Measurement Plane" (CCAMP) working group
  - "A YANG data model for WSON and Flexi-Grid Optical Networks"
  - The CCAMP working group is responsible for standardizing a common control plane and a separate common measurement plane for technologies found in the Internet.
- Most recently (December, 2014) the IETF created a new working group entitled "Traffic Engineering Architecture and Signaling" (TEAS).
  - This new working group is responsible for defining MPLS and GMPLS traffic engineering architecture, standardizing the signaling protocol, and identifying required related control-protocol functions, i.e., routing and path computation element functions and developing YANG models for network topologies and technology specific network attributes.
- Our objective will be to progress the YANG model defined and discussed in this paper within the new TEAS working group, and eventually publish our proposal as the IETF Internet RFC Standard YANG model to model Flexi-Grid nodes, transponders, links, and available media channels.

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Thank You!

Any comments or questions are welcome.

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