Transport Northbound Interface:
The Need for Specification and Standards Coordination

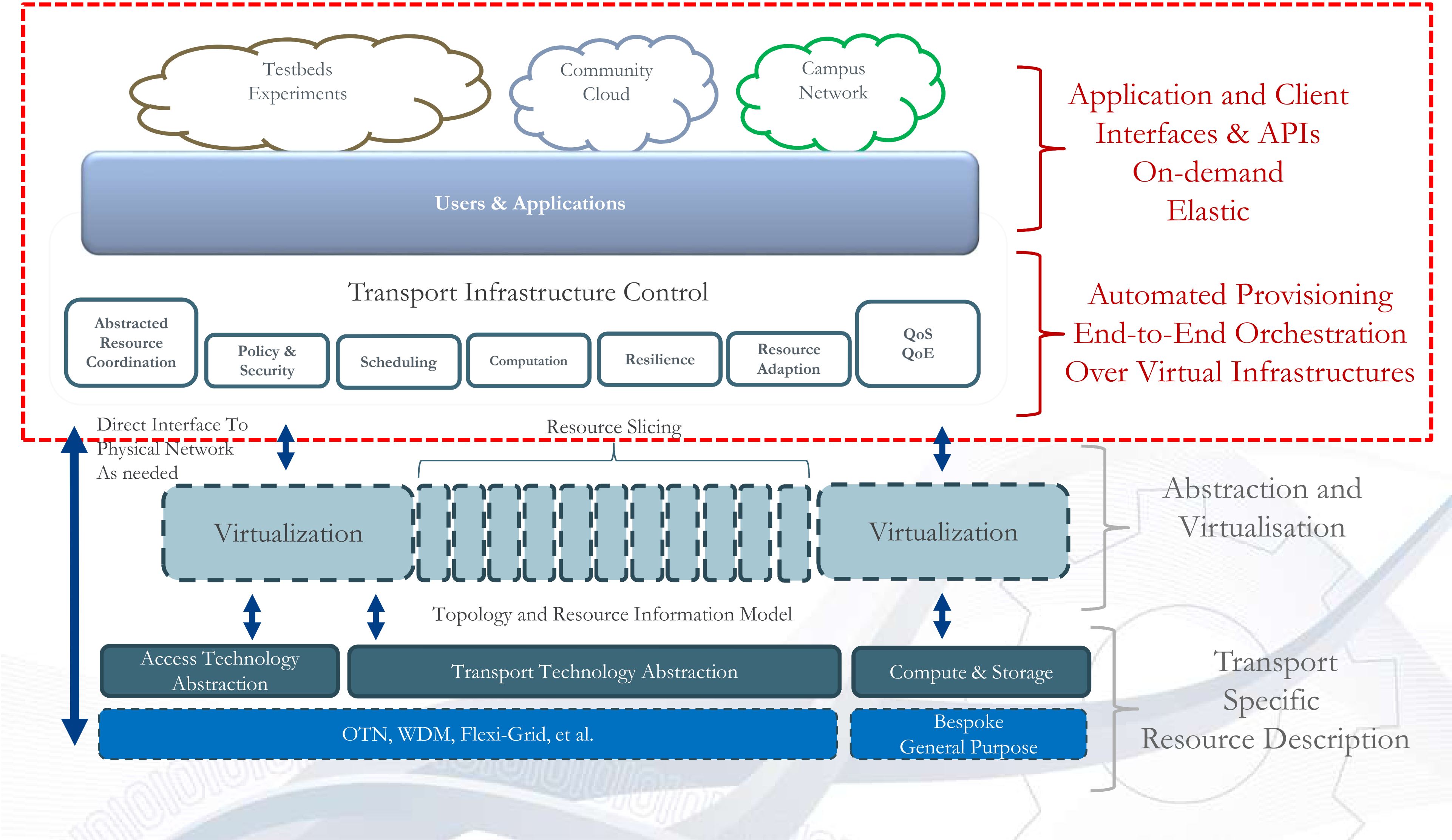
May 16, 2017

D. King, C. Rotsos, University of Lancaster
I. Busi, F. Zhang, Huawei Technologies
N. Georgalas, British Telecom

Requirements for Transport Control
Management and operation of resources

- Need for network programmability, automation, resource sharing, and service elasticity / adaptability
- Southbound
  - Exploiting network abstraction
    - Representation of underlay resources
    - Network slicing
- Northbound
  - Managing resource requests, network slicing and presentation, via an interface to customers and applications.
    - Customer-initiated Resource Setup
    - Network Partitioning
    - Automation and Orchestration
    - Internetworking with existing technologies and support systems
    - Support for future technologies

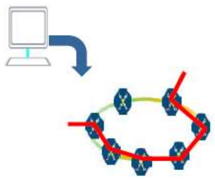
Transport Network Control Framework
Functional Components for Transport Controller



Transcport Network Services

Key use cases and requirements

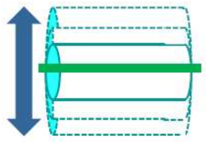
Service Management



Automated service creation covering L0 to L3

Addressing
- Time to service
- Ease of operation
- Service differentiatio

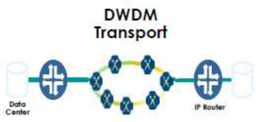
Elastic bandwidth provisioning



Creation of elastic services with automatic or "on request" changes in bandwidth

Dealing with
- Statistical bandwidth sharing
- Dynamic data flow changes

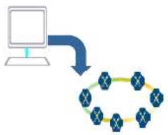
Datacenter interconnections



Automatic load dependent fast service creation

Matching
- Hypergrowth in data volume
- Extremely dynamic traffic pattern

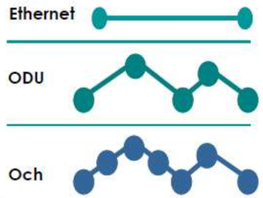
Network or Transport as a Service (NaaS / TaaS)



Fully automate service requests incl. network planning and equipment configuration

Addressing
- Non-automated Operational processes
- High network complexity

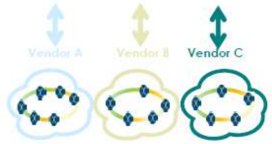
Multi-layer network management



Multilayer optimized L0-3 system with
- common workflows
- automatic routing
- interworking

Dealing with
- Heterogeneous technologies
- Optimized layer usage

Multi-vendor support



One standardized SDN control interface for easy integration of 3rd party vendors

Dealing with
- Different control interfaces
- Missing control IF between vendors

Transport Network Services
North Bound Interface

- A northbound interface (NBI) is the interface to a component of higher function or layer
  - The lower layer's NBI, interfaces to the higher layer's southbound interface (SBI)
    - NBIs are used by Applications that connect to the NMSs/EMSs/Controller or to other Applications
  - All the protocols listed as potential SBIs, can be used as NBIs as well.
- Existing NBI Protocols and Data Representations
  - The latest trends in the market place evolve towards using new protocols and formats. Those are design for simplicity and agility. They include:
    - Representational state transfer (REST)
    - Asynchronous JavaScript And XML (AJAX)
    - JavaScript Object Notation (JSON)
  - Message-Oriented Middleware (MoM) Protocols
    - New models driven by Apps – Controller connectivity requirements push the emergence of MoMs
      - Advanced Message Queuing Protocol (AMQP)
      - Simple Text Oriented Message Protocol (STOMP)
      - MQTT
      - OpenWire
      - Extensible Messaging and Presence Protocol (XMPP)

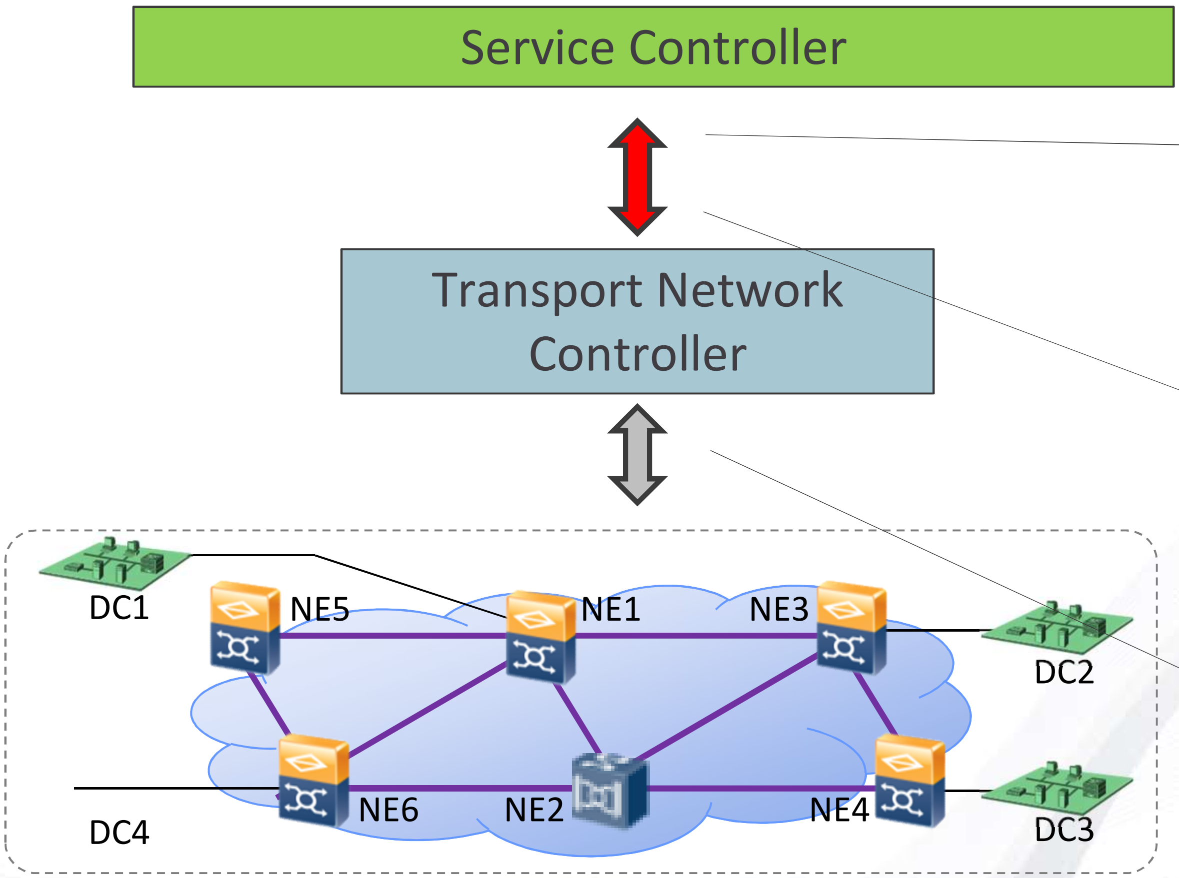
Transport Network Services
Defining Northbound Interface Capabilities

- User Intent
  - Transport models should maintain separation between high-level user intent and the operational state of the network
  - Maintain separation between user service request, including all constraints, and the actual service and connection state in the network
- Resource State Management
  - Network and service objects should support the following states: administrative state, operational state, and lifecycle state
  - Administrative state and operational states are well understood.
  - Lifecycle state is defined by the ONF to model the following entity lifecycle states: planned state, potential state, installed state, in conflict state, and pending removal state

Transport Network Services
Defining Northbound Transport API Requirements

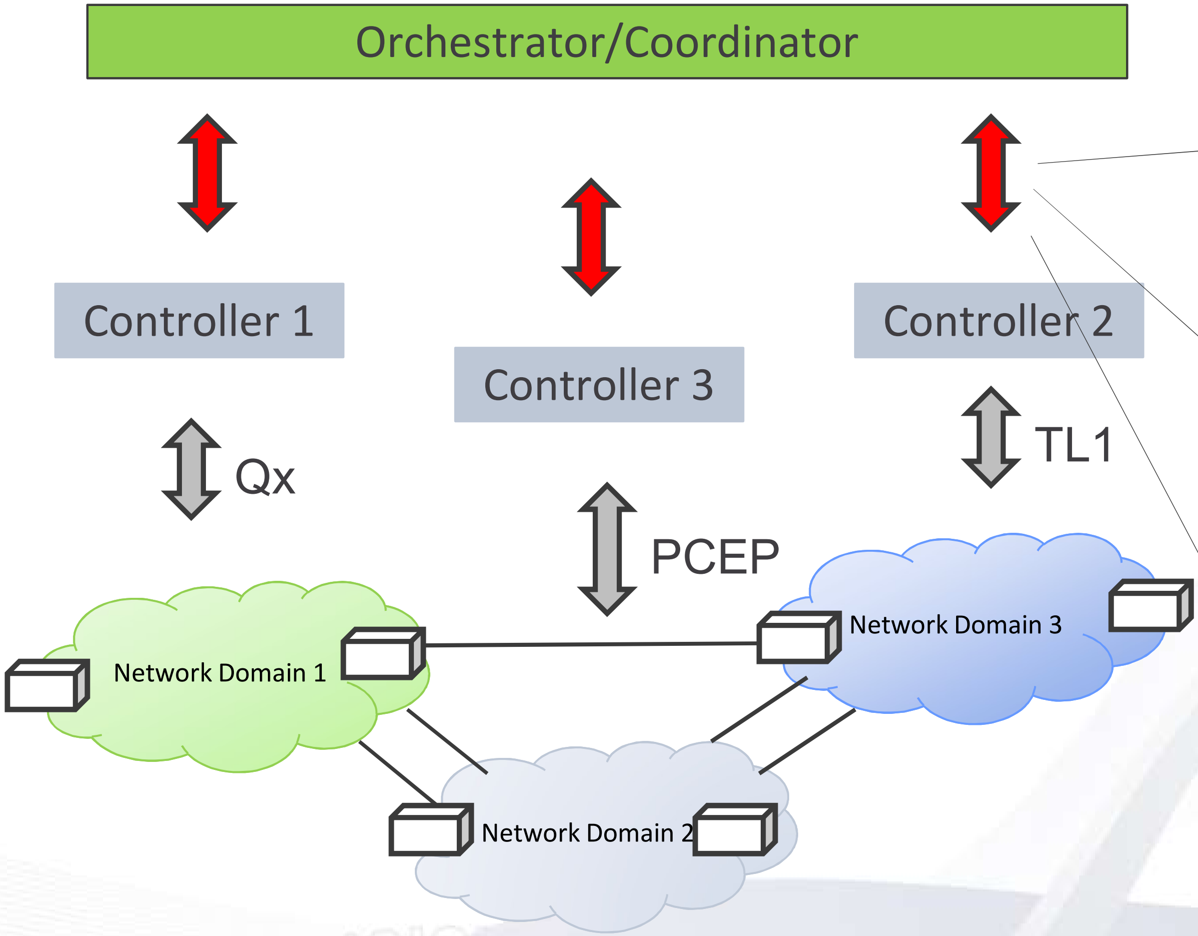
- Service and Resource Identifiers:
  - Network and service objects and would include a unique entity ID provided by the controller.
  - The identifier would be chosen such that the same entity in a real network topology will always be identified through the same ID, even if the model is instantiated in separate data stores.
  - Controllers may choose to capture semantics in the identifier, for example to indicate the type of entity.

Transport Network Control Framework
Resource Model Requirements: Use Case 1



1. The ability to obtain the information about the set of access links between connection points and transport networks.
2. The capability to send a request for a service, as well as retrieve a list of service requests and their statuses.
3. (optional) Acquisition of underlay topology (abstract or not) may indeed be able to give DC providers more control over resource usage.

Transport Network Control Framework
Resource Model Requirements: Use Case 2

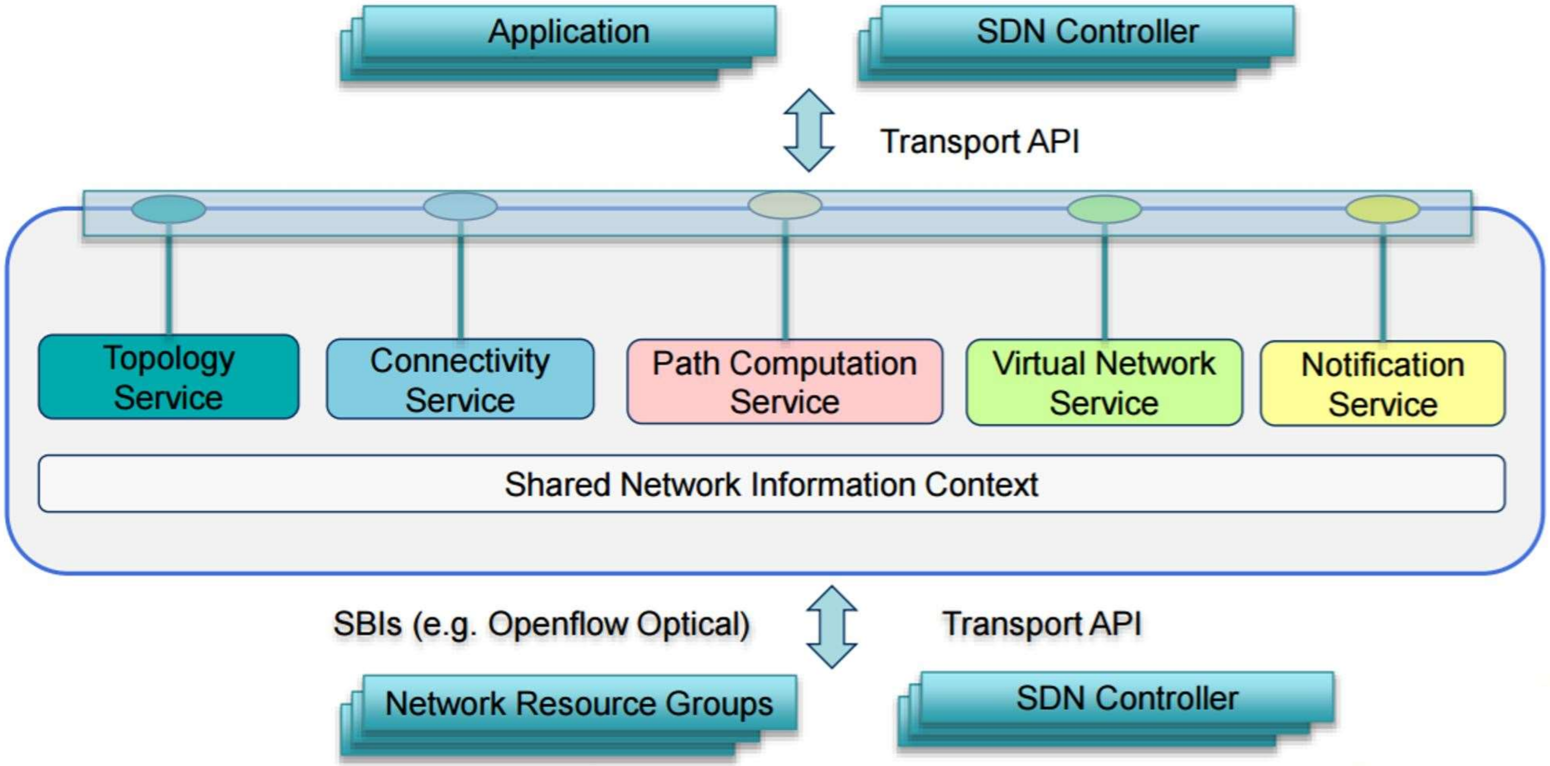


1. Functions mentioned in Use Case 1

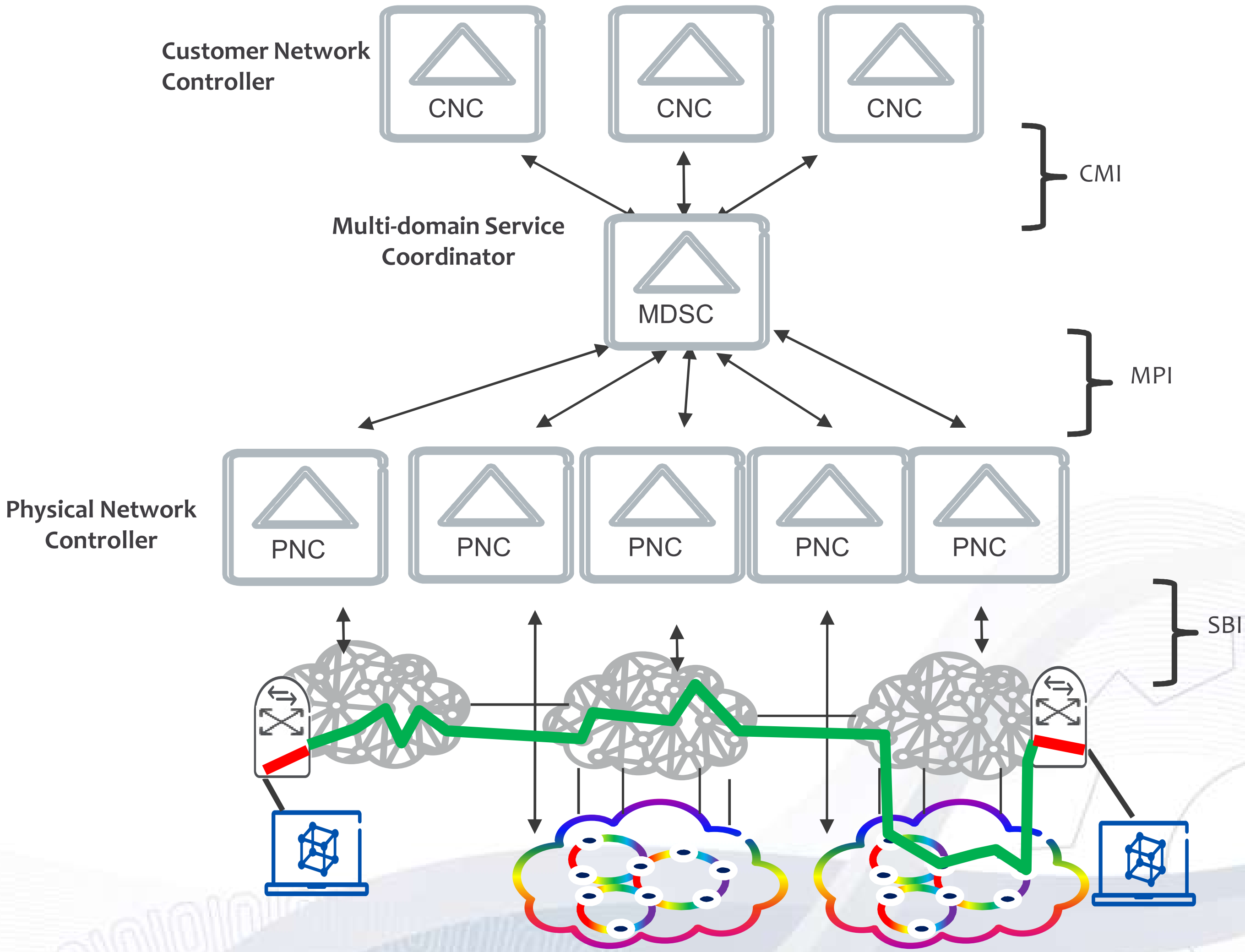
1. Access to the topologies reported by each controller, including inter-domain links

1. The ability to set up, delete and modify tunnels, be it within one domain or across multiple domains.

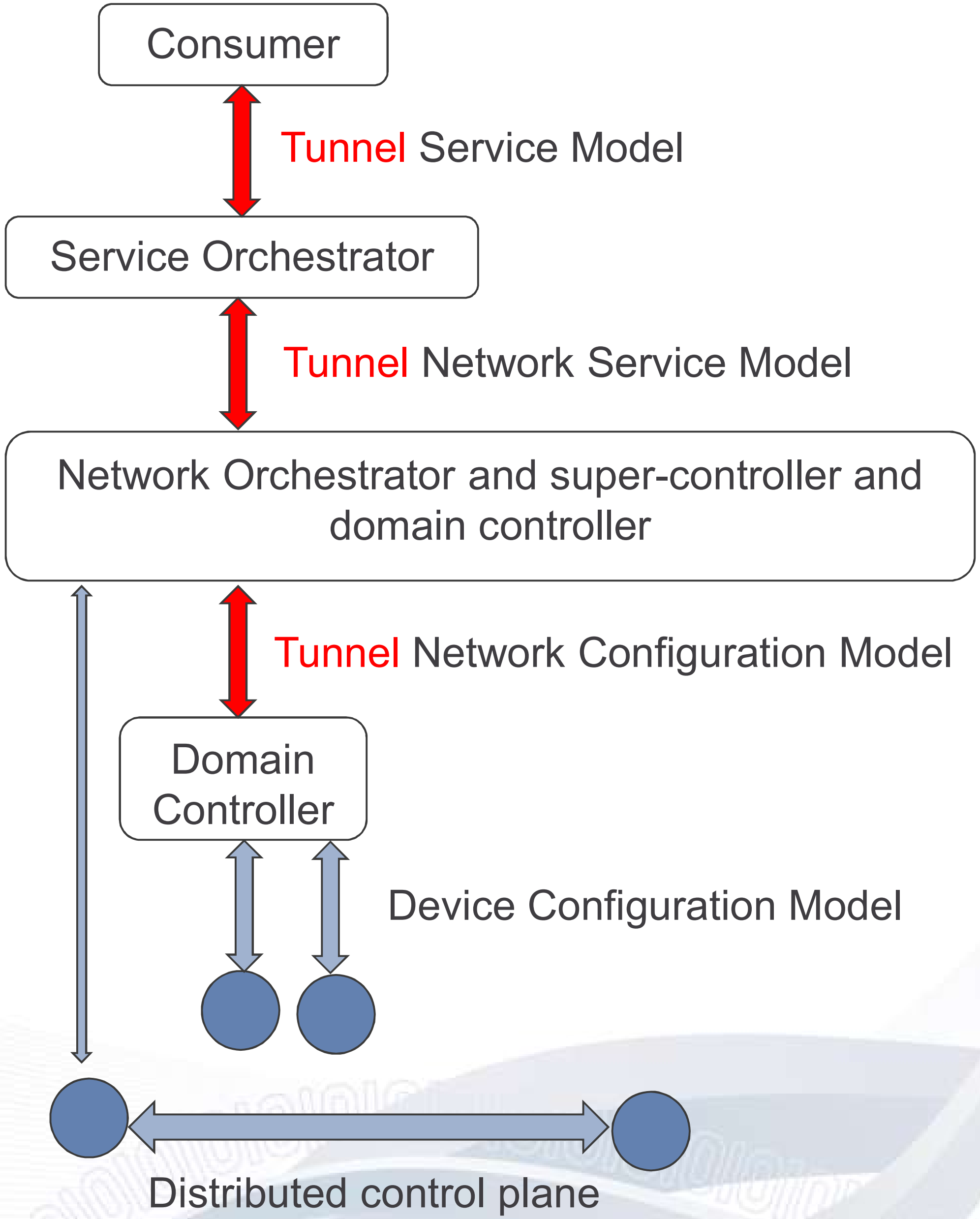
Transport Network Control Framework
ONF Transport Architecture



Transport Network Control Framework
IETF Abstraction and Control of TE Network (ACTN)



There is an Obvious Hierarchy



- Do we need separate models?
- Can we map the hierarchy to the models?
- What is a consumer?
  - One network can be the customer of another network

Transport Network Control Methods
ONF Common Information Model (CIM)

- The vision: "A single industry-wide common open model"
  - Promoting a common vision of a single industry-wide-open-model, core IM development has been performed in collaboration among ONF (Information Modeling Project), ITU-T SG15 (Q14/15), and the TM Forum; with information sharing with other SDOs, including MEF, OIF, BBF, IETF, ETSI NFV, 3GPP, …
    - The first result of this collaboration effort is the release of the Core Model 1.0, which has been
    - Published in ONF TR-512 and
    - Consented in ITU-T Recommendation G.7711

Transport Network Control Methods
ONF Common Information Model (CIM)

- Partitioned into major units:
  - Core
  - Forwarding Technologies
  - Intent
  - Specific views
- Divided into sub-models for development independence
  - Sub-model structure can be changed to match current development needs

Transport Network Control Methods
ONF Common Information Model (CIM)

- New Additions
  - Optical & wireless extensions
    - Packet-optical integration PoC
    - Wireless transport PoC
  - Interoperability
    - TTPs
    - Flow objectives
    - 1.3 in hardware
    - Atrium (7 switches)
    - 1.3 conformance spec (basic, single-table)
  - Evolution
    - PIF

Transport Network Control Methods
ONF Transport API (T-API)

- All TAPI interaction between an API provider (e.g. SDN Controller) and an API Client (e.g. Application, Orchestrator or another SDN Controller) occur within a shared "Context"
- TAPI provider creates(provisions) one or more Connections in response to a successful **ConnectivityService** request
  - Knowledge of Topology is needed to understand the Route of a Connection
  - Route of a Connection is described as a list (series) of lower-level Connections
- A TAPI provider may expose one or more abstract Topology within the shared Context
- A Topology is expressed in terms of Nodes and Links between them.
  - Links terminate on **NodeEdgePoints**, Nodes aggregate **NodeEdgePoint**
  - **NodeEdgePoint** and **ConnectionEndPoints** have a server-client/mux-demux, etc relationship in terms of data-plane signal hierarchy

Transport Network Control Methods
IETF Transport Service Model

```
module: ietf-transport-service
   +--rw transport_service
   |  +--rw service* [service-id]
   |     +--rw service-id              uint32
   |     +--rw service-name?           string
   |     +--rw source
   |     |  +--rw node-id?   node-id
   |     |  +--rw tp-id?     tp-id
   |     +--rw destination
   |     |  +--rw node-id?   node-id
   |     |  +--rw tp-id?     tp-id
   |     +--rw service-type?           service-types
   |     +--rw supporting-tunnel* [name]
   |     |  +--rw name    string
   |     +--rw bandwidth               decimal64
   |     +--rw SLA?                    SLAtypes
   |     +--rw intended-policies
   |        +--rw schedule
   |           +--rw schedules
   |              +--rw schedule* [schedule-id]
   |                 +--rw schedule-id          uint32
   |                 +--rw start?               yang:date-and-time
   |                 +--rw schedule-duration?   string
   |                 +--rw repeat-interval?     string
   +--rw service-state
```

Transport Network Control Models
IETF YANG Models

LANCASTER UNIVERSITY

WG

ID

Transport NBI Requirements: draft-zhang-ccamp-transport-yang-gap-analysis

Topology related

- **Topology Model:** draft-ietf-i2rs-yang-network-topo
  - **TE Topo model**:draft-ietf-teas-yang-te-topo
    - **L0 Topo Model**： draft-ietf-ccamp-wson-yang
    - **OTN Topo Model**： draft-zhang-ccamp-l1-topo-yang
      - **Flexi-grid topo model**： draft-vergara-ccamp-flexigrid-yang

Tunnel related

- **TE Tunnel Model**： draft-ietf-teas-yang-te
  - **ODU Tunnel**： draft-sharma-ccamp-otn-tunnel-model

Ancillary

Service Model： draft-zhang-teas-transport-service-model

VN Service Model： draft-lee-teas-actn-vn-yang

Path Comp.： draft-busibel-teas-yang-path-computation

Schedule grouping： draft-liu-netmod-yang-schedule

Transport Network Control Gaps
Open Issues Include…

- Constrained (asymmetrical/blocking) nodes
- Intra-node metrics
- Topology updates
- Telemetry collection
- Name/address spaces
- Topology relationships
- Topology attributes
- Topology negotiation
- Integration with packet technologies

Transport Network Control Gaps
Constrained Nodes

- Most topology service descriptors do not support the notion of exposing or communicating blocking and constrained nodes.
  - This means that if a topology service provider exposes to a client a topology with at least one node with constrained connectivity
  - There is no way for the provider to communicate the connection limitations to the client, thus making the provided TE topology unfit for the client's path computations

Transport Network Control Gaps
Intra-node Metrics

- There are limited methods for topology service providers to articulate to the client what it would cost for a potential path
  - In terms of delay) to cross a node from interface (Node Edge point) A to interface B.
  - Nodes (especially composite abstract nodes) may contribute to overall path costs much more than links connecting the nodes along the path, this fact makes the provided topology unfit for the client’s path selection optimizations.

Transport Network Control Gaps
Topology Updates

- On going topology service updates after the consumer has requested and received a topology from one of its providers
  - It is imperative that as soon as this done the provider starts updating the client (continuously and in unsolicited way) with changes happening to the topological elements and their attributes that the client has expressed interest in - otherwise, the client would be forced to make decisions on stale information.

Transport Network Control Gaps
Telemetry

- Automated collections process by which measurements are made and other data collected at remote points and used for resource provisioning and optimisation
  - There are no known open and mature modeling activities related to telemetry streaming for transport network services

Transport Network Control Gaps
Topology Attributes

- Both IETF TE Topology model, and T-API Topology nodes and links require updates to for important attributes
  - Specifically, T-API nodes, have no analogues to the Connectivity matrix attribute and the TE container describing nodes switching and termination capabilities/limitations respectively
- In some cases the topology service does not have a concept of important edge characteristics for a TE tunnel

Transport Network Control Gaps
Topology Link Attributes

- Important topology link attributes are missing, including:
  - Administrative groups (administrative colours) - an attribute describing the link's association with pre-defined groups of links
  - Groups could be used as constraints in the client's path selection/optimization algorithms
  - Link protection/restoration capability - an attribute that could be also used as a path computation constraint or path optimization criterion
  - Link properties defining whether the link is:
    - A. actual (with committed network resources) or potential;
    - B. static (with pre-established and always-in-place server layer connectivity supporting the link) or dynamic (for which the

Transport Network Control Gaps
Topology Negotiation and Reconfiguration

- The topology service client has no say as to how the abstract topologies exposed to the consumer by its providers should look like
- The only option for the consumer is to consume the provided topologies as offered
- This is a serious disadvantage because it is the consumer (not providers) that knows which topologies suite best the consumers needs

Transport Network Control Gaps
Integration with Packet Technologies

- It is not clear how non-IETF models can be integrated into the packet traffic engineering layer
  - The IETF TE Topology model is naturally and intimately integrated with IP/MPLS layer models defined for IP/MPLS layer traffic engineering

Transport Network Control Gaps
Connectivity Service Protection

- It is not possible for a T-API Connectivity service client to request from a provider a protected service
- The inability to request protected connectivity services from a provider leaves the T-API Connectivity service client with the problem of protecting its own traffic against the network's failures

Transport Network Control Gaps
Success of the Transport API

- The success of T-SDN as an architecture and set of interfaces depends adoption of open standardized interfaces
  - to/from T-SDN controllers, linking them flexibly into various
  - Addressing identified gaps and open issues
  - Supporting hierarchies and confederations
- Unification or consolidation of models would be required to avoid industry confusion
  - Specifications and standard proposals include:

    ONF, MEF, IETF, Open ROADM, Open Config, et al.
- Currently, the two most popular such interfaces are:
  - Core information model Developed by ONF
    - Transport API (T-API) Specification
  - RESTCONF/YANG [RFC7950] developed by IETF
    - With YANG TE Topology and TE Tunnels models, with additional transport technology specific augmentations as required

Questions?

Daniel King
Senior Researcher (BT & Intel Co-Lab) at Lancaster University
ONF Research Associate
MEF Research Council Member
IETF Simplified Use Policy Abstraction (SUPA) Co-Chair
IETF Transport Northbound Interface Design Team Co-Chair

d.king@lancaster.aco.uk

The authors are also grateful to the UK Engineering and Physical Sciences Research Council (EPSRC) for funding the TOUCAN project (EP/L020009/1), which supported much of the work presented in this paper and presentation.