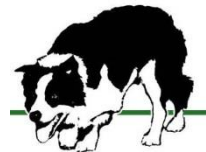


# Top-to-Bottom Service Delivery Using Coordinated YANG Models

Qin Wu <[bill.wu@huawei.com](mailto:bill.wu@huawei.com)>

Adrian Farrel <[adrian@olddog.co.uk](mailto:adrian@olddog.co.uk)>

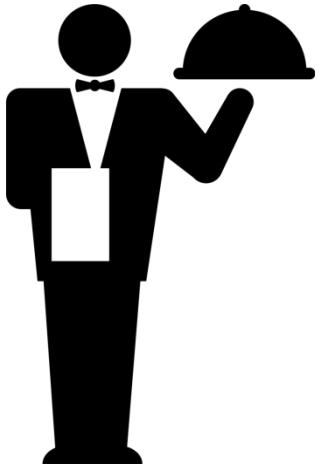


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# Agenda

- Background
  - Services, SDN, YANG, and Automation
- Services
  - What are they? How are they supported
- Abstraction and Control of TE Networks (ACTN)
  - Virtual Networks, control components and interfaces
- Enhanced Services
- Service Mapping
- Network Slicing

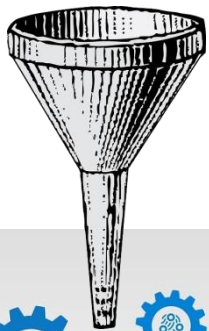
# It's All About Services



- Network providers don't provide networks!
  - They provide services: that's where the money is
- Services are provided on top of an operator's network
- Services are value-added connectivity
  - Site-to-Internet
  - Site-to-site
  - Multi-site-to-multi-site
- Advanced services provide virtual networks
  - VPNs: L2VPN (VLAN, eTree, etc.), L3VPN
  - Abstracted topology
- So, network providers **do** provide networks

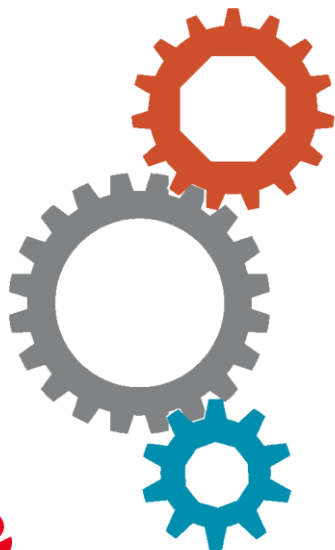
# Automation Is Important

- Rapid rise in the provisioning of services
- Number of customers increases
- Range of services multiplies
- Customers expect dynamic, flexible, responsive changes
- Can only be achieved using automation



# SDN Is Key

- SDN is the buzzword of the decade
- Software control of distributed resources
  - Facilitates network management and enables programmatically efficient network configuration
  - Based on a shared architecture of orchestrators and controllers
  - Provided through software APIs and common data models



# YANG Models Are Everywhere

- Data models are an essential tool for SDN
- A model describes a system
  - Allows it to be modelled, observed, and controlled
- YANG is today's modelling language of choice
  - Replaced MIBs in the IETF
  - Used widely in Open Source
- Hundreds of YANG models have been written
  - Sometimes multiple models for the same thing
- Gradual increase in standardization
  - Enables interworking of components from different vendors and Open Source projects



# What Is A Service Model?

- Customers (or operators of client networks) need to:
  - Request services
  - Negotiate what will be delivered
  - Vary the service
  - Monitor the service
- A data model is perfect for this
- A service model is:
  - A YANG model that describes a service
  - Specific to the service (L3VPN, L2VPN, L1 connectivity)
  - Generalized for all network providers
- Service models allow for comparison of service offerings
- Facilitate automation of service procurement and delivery

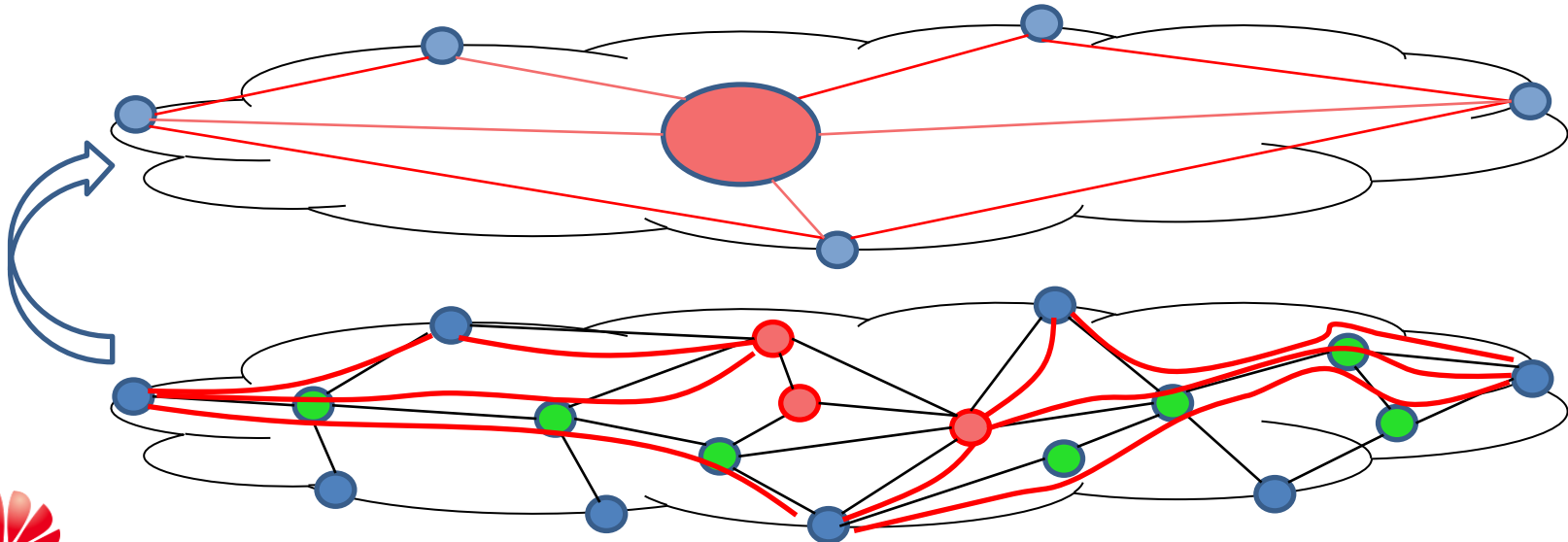
# How Are Services Supported?

- Services are built on top of connectivity
  - Connectivity is links, nodes, and tunnels
- Connectivity may need to be provisioned to support services
  - On demand
  - Predictively
- Connectivity can be reconfigured
- Virtual connectivity
  - Tunnels and abstract nodes can be created from network resources
- Services use the tunnels and nodes to deliver traffic
  - Resources may be shared or dedicated



# Virtual Networks (VNs)

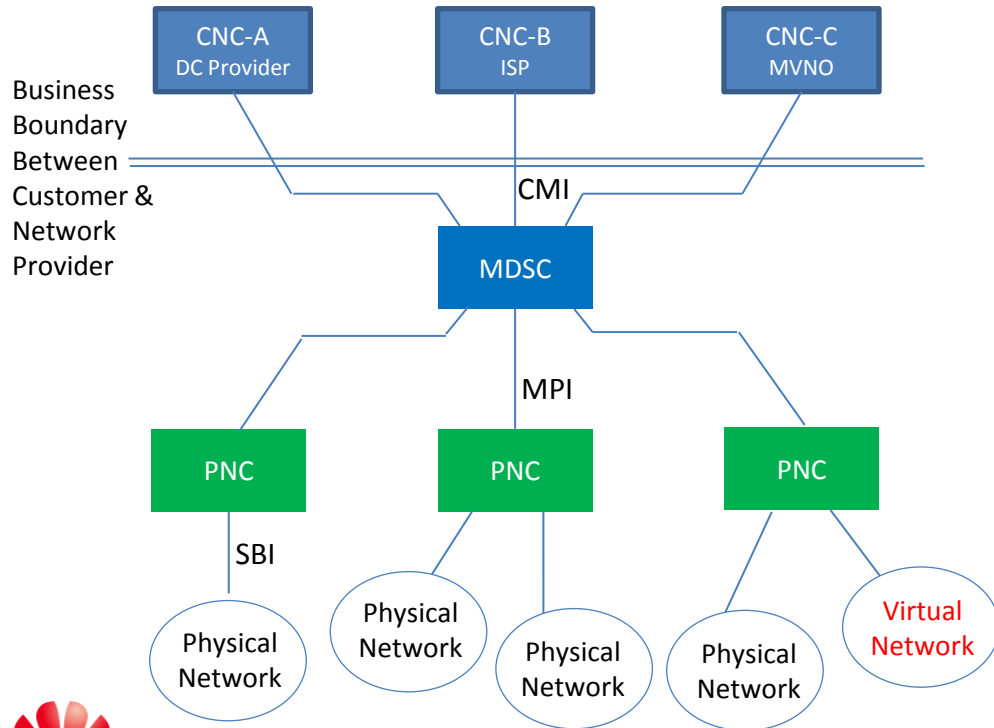
- Network abstraction aggregates resources into
  - Virtual links (made from TE tunnels across links and nodes)
  - Abstract nodes (made from nodes and links)
- Describes edge-to-edge connectivity with certain qualities
- Available connectivity can be presented to the VN user (customer)
  - They can manipulate the VN as their own private network



# Abstraction and Control of TE Networks (ACTN)

- Abstraction is a way of representing connectivity across a TE network
- This allows a server network to present connectivity options to a client
- ACTN is an architecture for requesting and managing abstractions
- A customer (a client) requests connectivity from an operator
  - Delivered as a VN or a TE topology
- ACTN components map the customer requests to network resources
  - Orchestration can select and instruct networks
  - Controllers can program the network devices
  - TE links (tunnels), abstract nodes, and virtual networks are constructed
  - Services are mapped to the TE resources

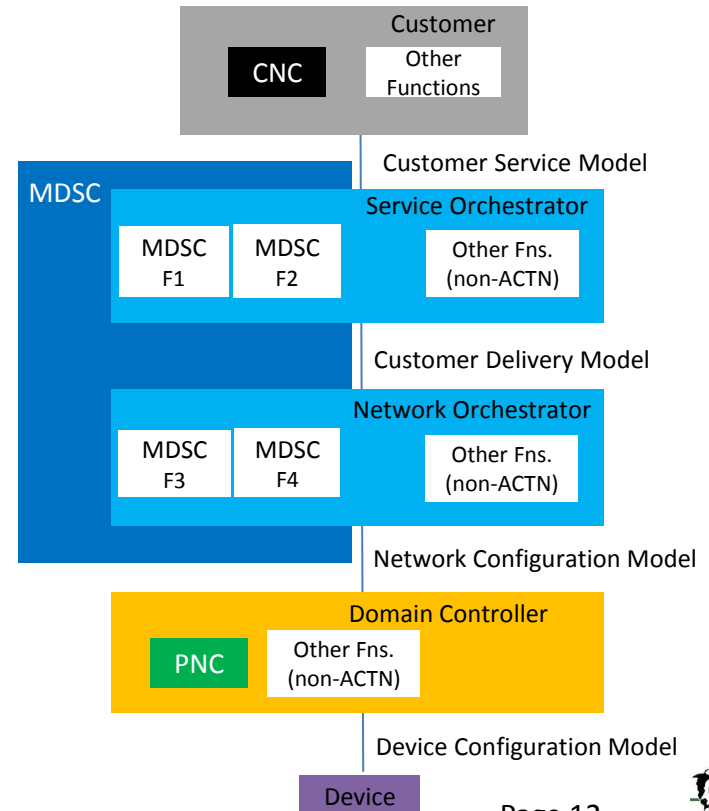
# Base ACTN Architecture



- Three components
  - Customer Network Controller
    - Formulates requests for clients/customers
  - Multi-Domain Service Coordinator
    - Maps service requests to one or more underlying network
  - Provisioning Network Controller
    - Classic SDN controller
    - With or without control plane
- Three interfaces
  - CNC-MDSC Interface (CMI)
  - MDSC-PNC Interface (MPI)
  - Southbound Interface (SBI)
- Note separation of Customer and Network Provider
- Note recursive nature for carrier's-carrier

# Functional Split of MDSC Functions in Orchestrators

- SDN architecture can be mapped to ACTN
- Key features are:
  - Service orchestration
  - Network orchestration
  - Domain control
- MDSC function can be split between orchestrators
- Additional functions may be provided alongside
- YANG models serve as the interfaces
  - Categorized per RFC 8309

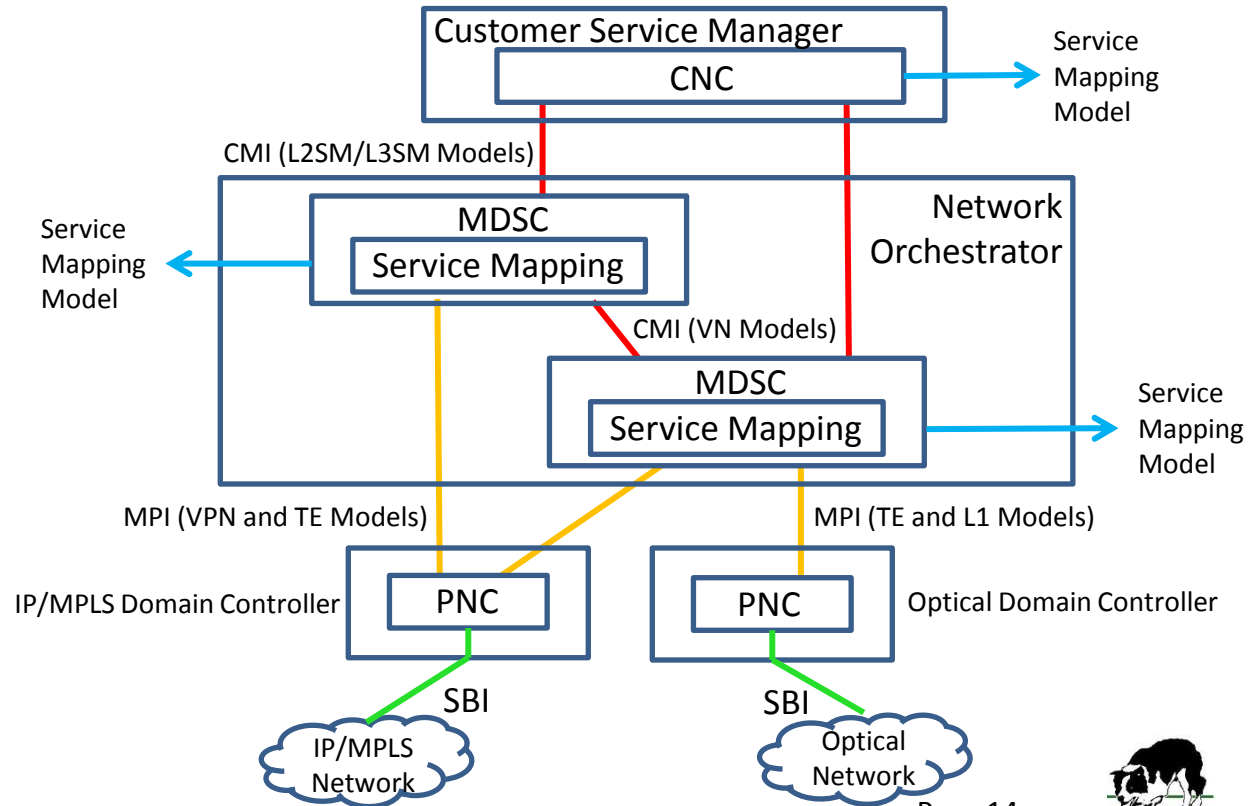


# Enhanced Service Definition

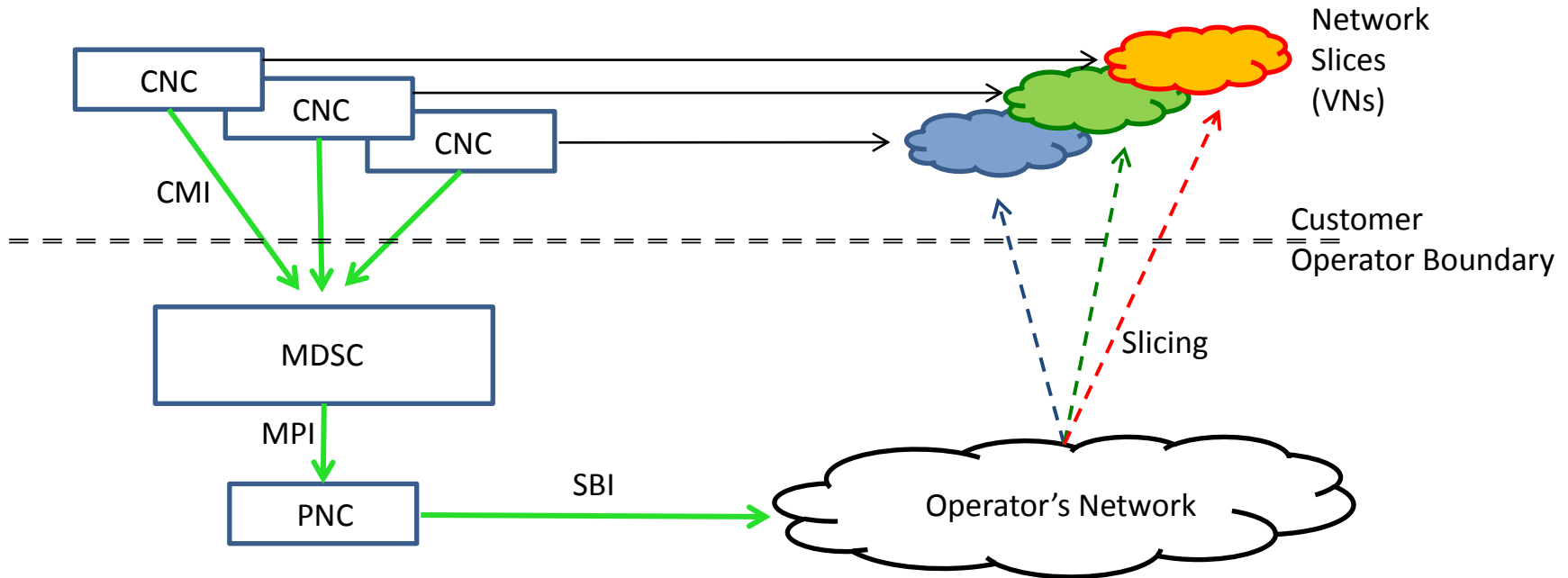
- Quality of Service
- Existing service models (L3SM, L2SM, L2CSM)
  - Basic function of connectivity and association
  - Bandwidth is the main “quality” defined
- New uses of services command additional qualities
  - Latency limits
  - Resiliency/redundancy
  - Isolation
    - Changes to one service must have no effect on other services
- Achieved by augmentation of basic service models
  - Key input to MDSC at the CMI

# Understanding How Services Are Mapped

- ACTN maps service requests to underlying network constructs
  - Services to VNs and TE
  - VNs to TE
- Service Mapping Model exposes this
  - Critical for diagnostics
  - Also enables direct control



# Network Slicing – The Key to 5G



- Virtual Networks (VNs) are slices of the Operator's Network
- They are “private” slices of the nodes and links
- Help to guarantee specific service types



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- Mapping model
  - Traffic Engineering and Service Mapping Yang Model
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# Questions?

Qin Wu <bill.wu@huawei.com>

Adrian Farrel <adrian@olddog.co.uk>