TELECOM INFRA PROJECT

Phoenix
Technical Requirements

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1. Introduction

The real challenge for future Dense Wavelength Division Multiplexing (DWDM) networks is not only to cope with the increasing bandwidth requirements of Telecom Operators but also to provide true optical manageability of flexible networks.

This document describes the technical requirements for a Phoenix device that operators can deploy in current and future generations of telecom transport optical networks. The document describes the necessary hardware, software and standards compliancy requirements that the device needs to meet in order to be deployed in the networks of the specific operators participating in these requirements.

1.1 Why Phoenix?

Current DWDM networks are mostly build based on single vendor implementations where the entire set of devices used (transponders, ROADMs, amplifiers, etc.) are sourced from the same OEM. This situation does not facilitate the competition and the innovation in this specific layer of the transport network. Operators need open solutions that allow them to deploy more capacity faster and in a more optimised way.

Disaggregation is a key component for most of the operators today. By introducing disaggregated solutions, Mobile Network Operators (MNOs) will not only be able to source solutions/components (e.g. transponders, ROADMs, etc.) from different vendors, but also HW and SW from different technology providers, increasing the competition and driving total TCO down.

Phoenix is a disaggregated HW transponder/muxponder, an important component in DWDM systems as they extend network distance by converting short reach optical interfaces in WAN switches and routers into wavelengths. Transponders enable a reliable error-free optical communication link between traffic aggregation points, remote data centers and central office sites. In long haul and metro amplified links, the transponders map the signals into standard Optical Transport Network (OTN) layer, which support FEC and guarantee error-free transmission without the need of expensive regenerators.

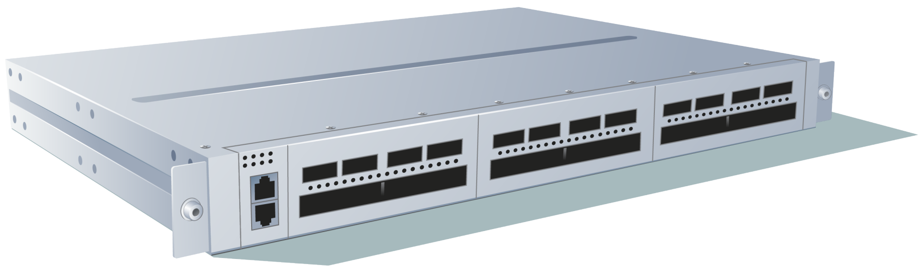

Figure 1. Phoenix Disaggregated Transponder/Muxponder

Phoenix is a flexible solution offering capacities from 100G up to 400G, depending on the application needs.

1.2 Goal

The goal of these requirements is to develop a solution that overcomes the most relevant challenges operators are facing nowadays when deploying transport networks.

Some of those challenges are:

1. Limited interoperability across vendors that brings significant operational challenges to enable multi-vendor environments.
2. Unreasonable licensing practices to enable third-party components or to leverage all the hardware resources available.
3. Lock-in to same-vendor pluggable modules.
4. Vendors providing monolithic platforms that makes it impossible to introduce innovation from other vendors in different parts of the device stack:
   a. Lack of open HW that can run different software flavours.
   b. Lack of open SW that allows extensibility or the execution of arbitrary agents.
   c. Lack of fully open APIs that allow external software to interact with the device.
5. Lack of features and tooling for zero touch provisioning and initial auto-configuration.
6. Slow development and introduction of standard YANG models in commercial transponders.

This technical requirements document aims to define an open and disaggregated platform based on commercial off-the-shelf components and open software that can replace traditional line optical transponder / muxponder solutions reducing deployment and operational costs while providing the scalability required for big data transport.

1.3 Scope of the document

The aim of this document is:

- To describe Phoenix main deployment scenarios.
- To describe Phoenix platform architecture and requirements that will need to be met by the system in terms of HW and SW features.
- To describe the management of Phoenix combined with SDN controllers.

The definition of a detailed low level TRS (Technical Requirement Specification) will be done immediately after the publishing of this document, as a basis for the technical discussion with candidate platform HW & SW manufacturers

1.4 Document Structure

This document is structured as follows:

- Chapter 0: Introduction
- Chapter 2: Deployment Scenarios
- Chapter 3: Platform Architecture & HW/SW specifications
- Chapter 4: Software Architecture
- Chapter 5: Integration with SDN Controllers or NMS
- Chapter 6: Glossary

2. Deployment Scenarios

In general, Phoenix shall be compliant with any WDM optical network, transforming closed traditional WDM networking into a fully flexible transport layer, easy to operate, control and provision for accelerated time-to-service and optimized total cost of ownership.

Phoenix will allow Operators to implement a Pay-As-You-Grow model where one or more Phoenix(s) can be added to an existing Operator optical network as per Figure 2, without service disruption, just connecting Phoenix to any free Mux/Demux port. Phoenix can be used to serve not only internal traffic demands but also to provide customer connectivity services (capacity).

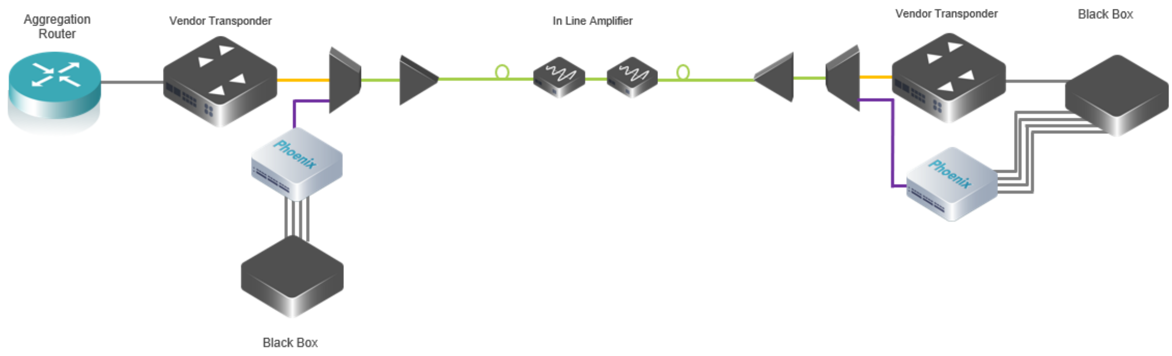

Figure 2. Aggregation of Phoenix Disaggregated Transponder/Muxponder to an existing network

Phoenix is applicable to almost any part of the network, from Metro to DCI. The scenarios under scope will be described in the sections below.

2.1 Metro/Backhaul

Phoenix could be used in a Metro or Backhaul scenario (Figure 3) covering several topological structures like point-to-point connection, ring based connections via daisy chaining or (R/F)OADM based, and horse-shoe like interconnections between two core routers.

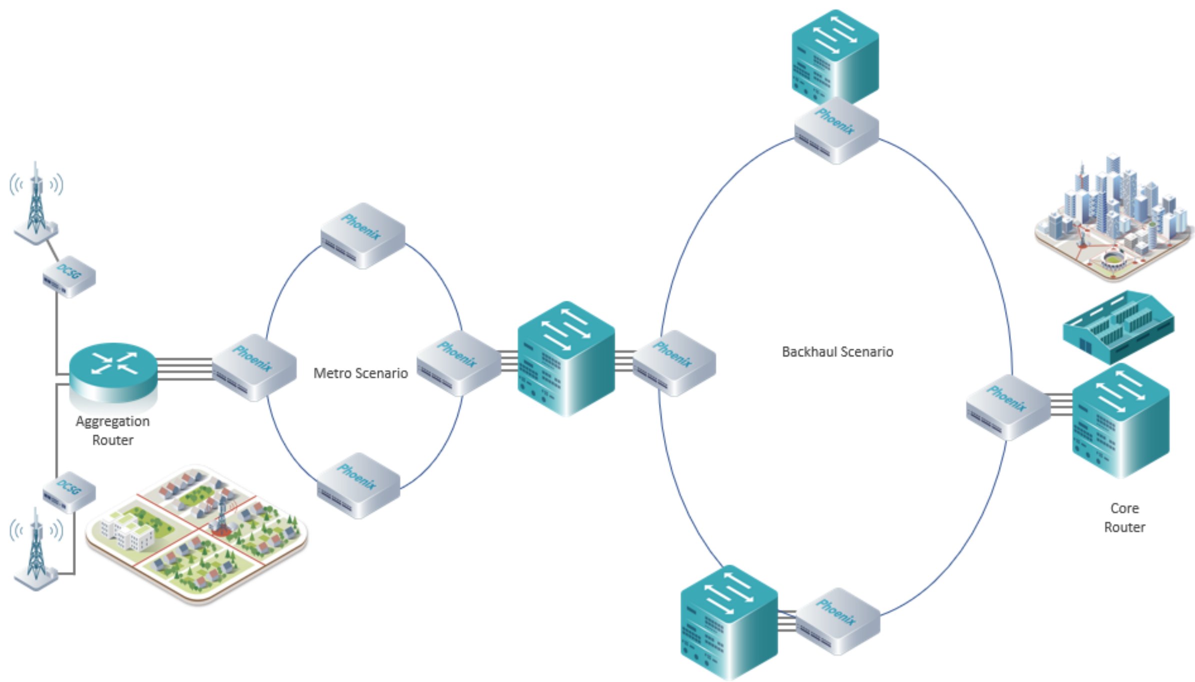

Figure 3. Phoenix in Metro/Backhaul Network

Thanks to the modularity and flexibility of the device, it can serve from 100G demands in the backhaul to high capacity metro.

2.2 Backbone

Long-Haul networks are at the backbone of the global network (Figure 4). Dominated by a small group of large transnational and global carriers, backbone networks connect MANs. As their application is transport, so their primary concern is capacity. Phoenix will help to prevent experiencing fiber exhaust as a result of high bandwidth demand.

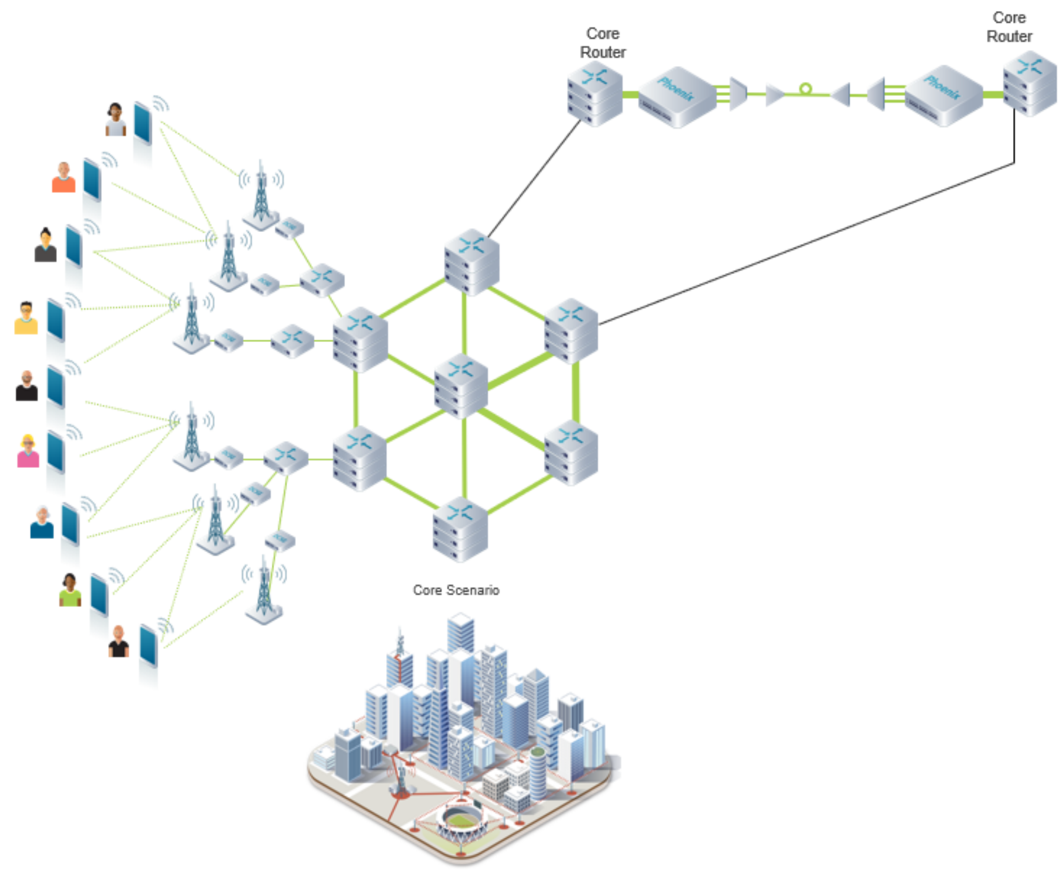

Figure 4. Phoenix in Backbone Network

2.3 Data Center Interconnection (DCI)

The explosion in demand for networks bandwidth is largely due to growth in data traffic. At the same time that network traffic volume is increasing, the nature of traffic itself is becoming more complex. Phoenix is designed to face this explosive growth in bandwidth demand. The device form factor and modularity is envisaged for direct applicability in DCI scenarios (Figure 5), although more and more operators and carrier networks are moving to DC form factors (racking & stacking, power, etc).

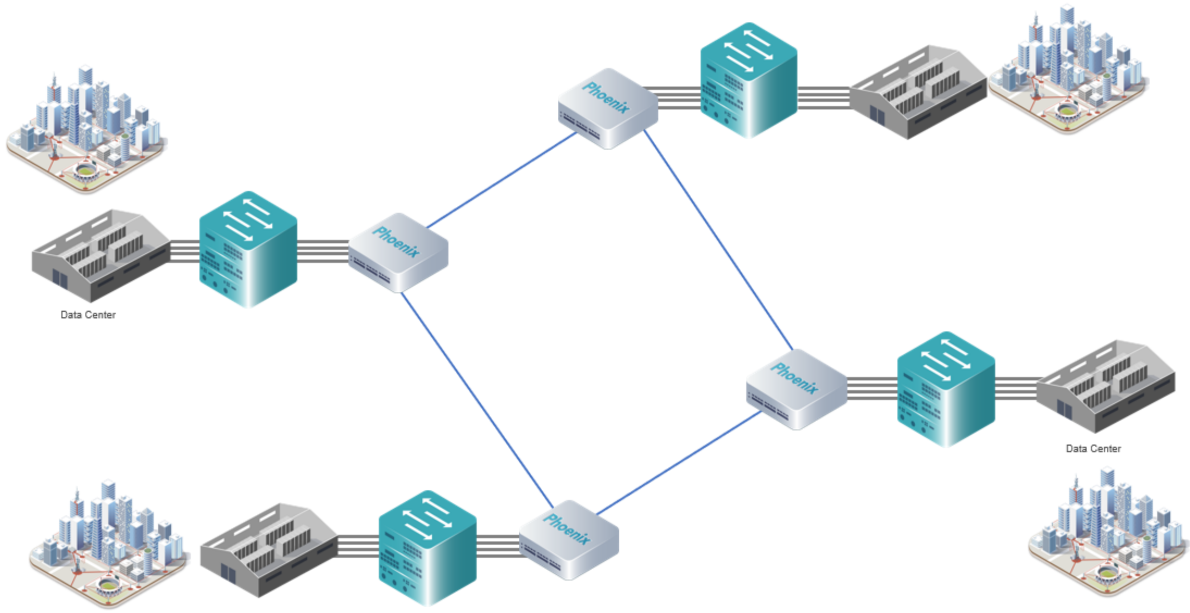

Figure 5. Data Center Interconnection (DCI) using Phoenix

3. Platform Architecture & Hardware/Software Specifications

Phoenix is an open and disaggregated transponder/muxponder which consist of commercial off-the-self HW and carrier grade software and open/standard-based APIs.

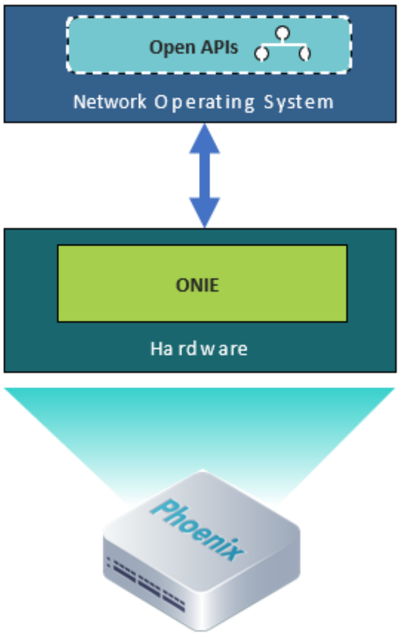

Figure 6. Phoenix Disaggregated Components

The HW system must not impose explicit restrictions that limit the SW that can run on it. In other words, the system must allow users to install arbitrary operating systems on it, even if those are implementations from a third-party. If the platform provides the capability to verify that the software has been signed with a particular certificate or cryptographic key, it must be possible to disable such verification at any time, through software/firmware configuration, without the need for any specific or additional license. Similarly, the system shall not block any pluggable optics based on the manufacturer.

Phoenix high level requirements:

- Disaggregated components. HW and SW from different technology providers.
- Configurable high-speed line interfaces from 100G to 400G, with different modulation formats & baud rates.

- Configurable FEC options.
- High speed client interfaces (100G and 400G).
- Full interoperability with 3rd party pluggable modules.
- Open APIs for automation: Like Netconf, gRPC and standard models support (OpenConfig/OpenROADM).
- Commercial off the shelf hardware and optimized design to reduce the platform cost (CAPEX).
- Reduced power consumption.

Phoenix shall support:

- High transport capacity. 4.8 TB is the minimum required system capacity.
- Minimum 3 sleds. Each sled shall support 4x400G uplinks (1.6 T/sled).
- High capacity short and long-haul reach with 100G/200G/400G wavelengths.
- 100G increments on the line optical transport for metro or long-haul applications.
- Easy integration over existing infrastructure, adopting the Open Line System approach. In any case, applicability as traditional alien wavelength approach shall also be possible (no restrictions)

3.1 Form Factor, Environmental and Power Supply Requirements

Phoenix will be used in standard telecom site locations with DC/AC power supplies. Phoenix shall be a 1RU – 3RU form factor (pizza box) with a maximum depth of 600mm (preferred less than 300mm) incl. space for fiber and power cables – able to fit in standard 19" and 21" racks maximum 600mm depth – As an open point, to analyse the feasibility of having a design With maximum 300 mm depth and no rear access

Phoenix shall be able to operate at temperatures from -40ºC to +70°C without impact on performance.

Phoenix airflow may be either front-to-back or side-to-side as long as the fan tray(s) is field replaceable.

Phoenix shall support Redundant Active/Active power supplies.

As described below, Phoenix shall be a modular platform with minimum 3 sleds that can be installed when required.

Figure 7. Phoenix New Sled installation

Each module must act independently from the others and the system shall be upgradable with no service interruption when a new module is installed.

Current definition of Phoenix device form factor & capacity does not prevent the definition of additional HW variants with higher number of ports and higher capacity/scalability in the future. In particular, the option of platform stacking for higher scalability including integrated management could be considered.

Phoenix shall support both AC and DC power supplies and the maximum power consumption per sled shall be 200W.

3.2 Line Interfaces

As mentioned previously, Phoenix shall support at least 3 sleds with 4 x 400G uplink interfaces (adjustable modulation format). Other sleds version for 100G or 200G uplink interfaces are also valid.

Phoenix shall support the following line interfaces related features:

- Long distance 500 km – 1750 km with 100G increments on the line
- Metro less than 60km to 200km with 100G increments on the line
- Flexgrid compliant
- Open Line System (OLS allow signal parameters configuration and reporting through the platform API)
- C & L Band wavelength support
- Modulation BPSK
- Modulation QPSK
- Modulation 8/16/32/64 QAM
- Modulation 100/200G QPSK
- Modulation 200/300/400G 16 QAM

3.3 Client Interfaces

In each of the sleds, Phoenix shall support any of below configurations:

- 16x100GE interfaces
- 8x100GE + 2x400GE
- 4x100GE + 3x400GE
- 4x400GE

In terms of capacity, Phoenix shall be able to cope with current traffic growth demand that required more bandwidth and pushes operators for never ending network upgrades. The client interfaces shall be:

- 100GE QSFP28
- 400GE QSFP-DD
- For each type of pluggable, support any variants available (ZR, LR4, CWDM4, PAM4)
- Optical Regen support with DAC (Direct Attach Cables)
- 400GE QSFP-DD to 4x100G QSFP28 break out cable
- OTN G.709 (OTU4) & BY100G (OTUCn) mappings line side.
- LLDP Snooping
- Ethernet auto-negotiation protocol to automatically select speed and duplex mode
- Jumbo frames at any of the Ethernet interfaces
- Flex-E (Optional: to be analysed and described in more detail)

3.4 Client port optical performance and reachability

The client ports shall be able to support QSFP+/QSFP28/QSFP-DD pluggable modules that can operate at the temperature range of -40°C to +70°C range and configurable by software. The platform shall be compatible with a pay as you grow model defined by software licences.

The platform shall be fully interoperable with any 3rd-party pluggable optics QSFP28/QSFP-DD, including ZR, LR4, CWDM4 and PAM4 types.

The system shall be compatible with third-party coloured WDM pluggable optics (tuneable & fixed).

3.5 Management Interfaces and Miscellaneous

The platform shall include 1 port (RJ45) for DCN Management and 2 ports (RJ45) for cascade management (several Phoenix units used) and 1 port USB for software installation.

Phoenix shall support Zero Touch Provisioning (ZTP). ZTP automates DAY 0 and DAY 1 configuration. ZTP will allow operators to deploy Phoenix in a more efficient way, limiting human intervention, reducing potential manual configuration errors and reducing the installation cost.

Others features that shall be supported:

- In band management without OSC and using GCC channels
- Out of band management (Using RJ45 port)
- Netconf API, supporting YANG modelling language
- gRPC API for streaming telemetry
- OpenConfig/OpenROADM data models
- T-API data models

3.6 Performances Monitoring

Phoenix provides strong value proposition around its services option:

- Client & line ports:
    - TX / RX power levels
    - laser bias & temperature
    - FEC: preFEC BER & Post-FEC BER
    - Corrected & uncorrected errors
    - Q-factor
    - OTN PM’s: SM/PM, ES/SES/UAS/BBE, TCM, TIM. Where applicable
- Line ports:
    - OSNR
    - Frequency offset
    - ODUk, OTUk, OPUk performance monitoring
    - Client ports: Ethernet PM’s – RMON, LLDP monitoring

- E2E latency / Round trip delay
- Performance monitoring on all Ethernet ports. This should include errors packets, drop packets, traffic utilisation/throughput, latency and packet jitter.
- Internal and network loopbacks

3.7 Synchronization

Time synchronization is critical feature for 5G deployments. Operators deploy centralised GPS receivers in certain locations of their network infra. From these points, phase and frequency signals are transmitted to each and every eNodeB in the network. Phoenix shall be able to transport these signals and be compliant with the related standards listed below.

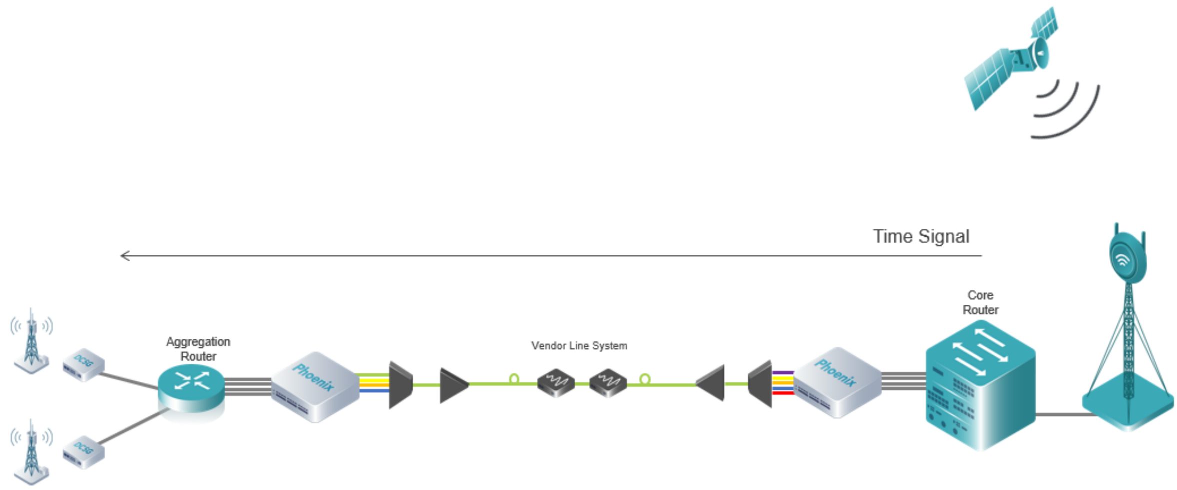

Figure 8. Time Synchronisation within Phoenix and existing network

Phoenix shall be able to support PTP Transparent clock or boundary clock. Also, SyncE signals to meet the ITU-T G.8262 wander generation MTIE/TEDV limits (ns) for ECC-option 1 after crossing OTN.

The platform shall support the following time sync requirements:

- SyncE signals to meet the ITU-T G.8262 wander generation MTIE/TEDV limits (ns) for ECC-option 1 after crossing OTN.
- SyncE jitter and wander accumulation according to G.8251
- Time synchronization from an external server is required through the NTP protocol.

- SyncE jitter and wander accumulation according to G.8251 provided that the insertion of OTN islands between a pair of SEC/EEC do not exceed 10 (ref ITU-T G.803 sync reference chain).
- ITU-T G.8271.1, ITU-T G.8273.2 (7.1), ITU-T G8273.2 (7.2/7.3/annex) and ITU-T G.8275.1

4. Software Architecture

Phoenix is being thought as a modular box that can run any SW on top of the selected HW versions. In order to ensure the maximum flexibility in terms of the SW that can be loaded in the Phoenix, it will be equipped with ONIE. ONIE will enable any operating system to run on top of the Phoenix.

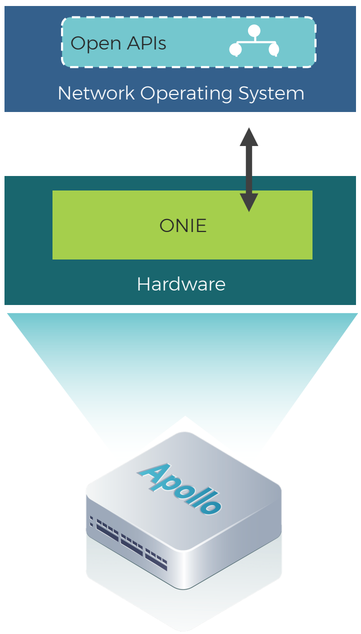

Figure 9. ONIE within Phoenix

ONIE defines an open source “install environment” that runs on routers and switches subsystem. This environment allows end SW suppliers to install the target NOS as part of the initial system setup.

Phoenix shall support or be compatible with SW components like TAI (Transponder Abstraction Interface). The Transponder Abstraction Interface is an API definition, developed by the OOPT project group within TIP that provides a vendor-independent way of controlling transponders from various vendors and implementations in a uniform manner. It greatly simplifies the integration work between a network operation system and the underlying optical hardware.

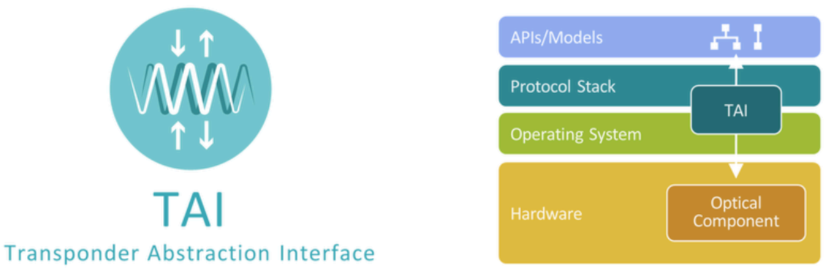

Figure 10. TAI model

5. Integration with SDN Controllers or NMS

In order to simplify the deployment, Phoenix shall support integration with 3rd party SDN controllers and Network Management Systems (NMS). Operators usually have their current line systems deployed together with a management system or SDN controller to manage that vendor solutions. Phoenix shall support open, standard-based APIs to enable the integration with the mentioned controller or NMS.

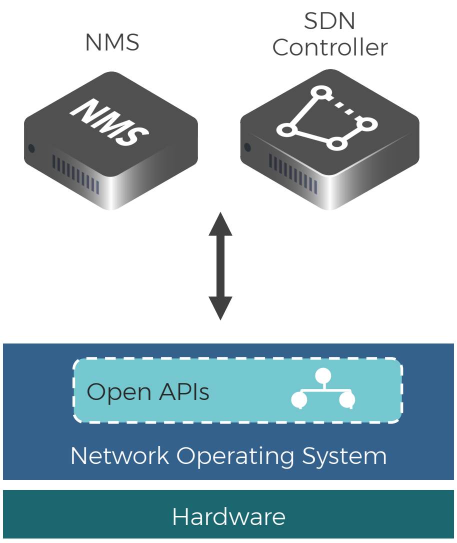

Figure 11. Phoenix Open APIs

With this architecture, operators can easily deploy Phoenix on their existing DWDM infra with easy, plug and play integration.

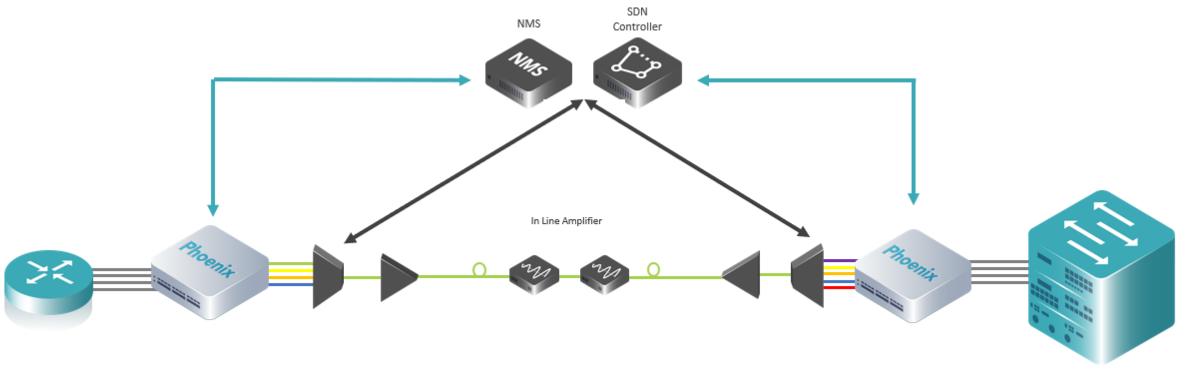

Figure 12. Phoenix integration with a pre-existing management framework

Phoenix shall support OpenConfig/OpenROADM data models for provisioning, management and performance control. As previously mentioned, Phoenix shall expose the following APIs:

- Netconf
- gRPC for streaming telemetry

Phoenix shall be able to be used with an Open Line System framework, where an SDN controller will be in charge of the managing the line system itself and the transponders; It is envisaged as a possible scenario the integration of Phoenix transponders via standard API's (Netconf, gRPC) and datamodels (OpenConfig/OpenROADM) into the Optical SDN controller (Optical domain controller) used in the network with the existing line system. This Optical SDN controller would be in charge of the configuration setup, optical power loop control and management of the overall optical solution with an Open Line System approach.

6. Glossary

3R's	Reshaping, Reamplification, Retiming
API	Application Programming Interface
DCI	Data Center Interconnection
CAPEX	Capital Expenditure
DCN	Data Communication Network
DWDM	Dense Wavelength Division Multiplexing
EOE	Electrical-Optical-Electrical
FEC	Forward Error Correction
GE	Gigabit Ethernet
HAL	Hardware Abstraction Layer
HW	Hardware
L0/L1	Layer 0 and Layer 1
LAN	Local Area Network
MAN	Metropolitan Area Networks
NMS	Network Management System
MNO	Mobile Network Operator
NOS	Network Operating System
OCP	Open Compute Project
OLS	Open Line System
ONIE	Open Network Install Environment
OTN	Optical Transport Network

ROADM	Reconfigurable Optical Add-Drop Multiplexer
SAN	Storage Area Network
SDH	Synchronous Digital Hierarchy
SDN	Software Defined Network
SW	Software
TAI	Transponder Abstraction Interface
TRS	Technical Requirement Specification
WDM	Wavelength Division Multiplexing
ZTP	Zero Tou