WHITE PAPER

A Financial Analysis of the Operational Benefits of MPLS-TP Transport Networks

NETWORK STRATEGY PARTNERS

MANAGEMENT CONSULTANTS TO THE NETWORKING INDUSTRY

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Network Strategy Partners, LLC (NSP)

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Executive Summary

MPLS-TP is a standard under development by the IETF for packet optical transport networks. The key objective of the IETF effort is to provide a universal standard for packet optical transport that maintains many of the operational characteristics associated with SONET/SDH and OTN and is compatible with existing IP/MPLS networks. Some of the specific goals of MPLS-TP are:

- Maintain backwards compatibility with existing IP/MPLS networks
- Preserve the look-and-feel of optical transport networks while providing common, multi-layer operations, resiliency, control, and multi-technology management
- Provide control and deterministic usage of network resources
- Support static (management-plane-based) or dynamic (control-plane-based) LSP/PWE provisioning
- Support protection methods similar to SONET/SDH (50 msec)
- Support smooth integration with legacy TDM transport networks as well as legacy packet networks (IP/MPLS)

An important aspect of MPLS-TP is OAM. The requirements of MPLS-TP OAM have been jointly approved by the ITU-T and the IETF and have been published as RFC 5860, "Requirements for OAM in MPLS-TP Networks". The basis of the requirements, and a keystone of the MPLS-TP OAM protocols, is that they should provide the complete set of OAM capabilities that are both supported by legacy transport network technologies and applicable in packet-switched networks. Recently there has been a proposal in the IETF to allow a modified version of Y.1731, the OAM protocol used in Carrier Ethernet networks, to be used for MPLS-TP OAM. For the purposes of this paper we will call this approach "Proprietary Transport Extensions" or PTE.

The PTE approach to OAM defeats one of the main objectives of MPLS-TP—to maintain backwards compatibility with existing IP/MPLS networks. Y.1731 PDUs and protocol functions utilize Ethernet MAC addressing. In addition, some Y.1731 functions rely on Ethernet multicast addressing and the properties of multipoint-to-multipoint links. No specification exists for adapting Y.1731 functions to network types with different topology and addressing characteristics, such as MPLS-TP. Therefore, in order for Y.1731 to be used in MPLS-TP networks the protocol will need to be modified. This will result in an OAM protocol which is neither backwards compatible with IP/MPLS networks or Carrier Ethernet networks.

An additional disadvantage of PTE is that separate OAM management domains need to be maintained for both the PTE Carrier Ethernet network and the IP/MPLS network. MPLS-TP has the advantage of a single OAM management domain from end-to-end as illustrated in Figure 1.

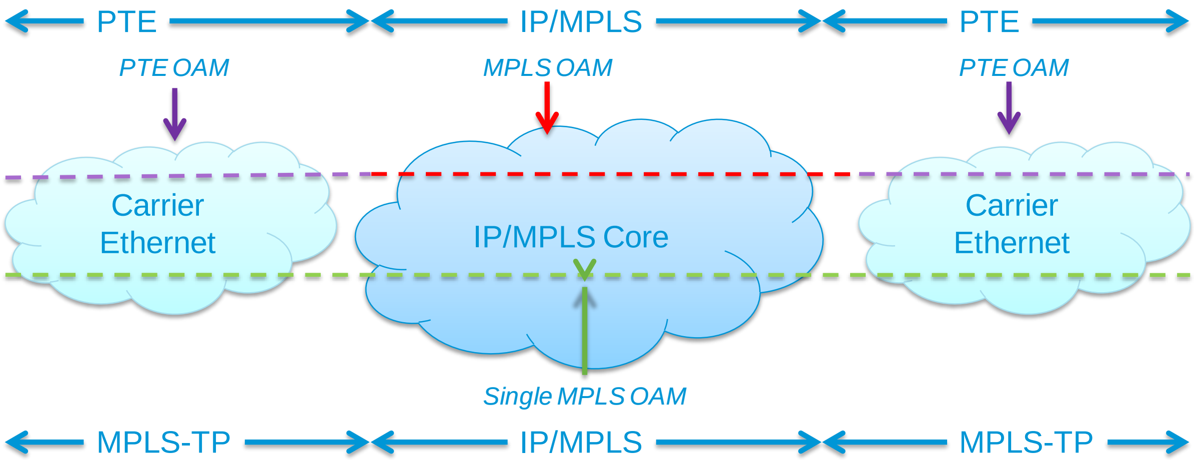

Figure 1. Comparison of OAM management domains for MPLS-TP and PTE

While there are many technical reasons for maintaining compatibility with existing MPLS networks, the focus of this paper is on the financial benefits of maintaining a backwards compatible OAM protocol. Specifically the operations expenses of a standards based MPLS-TP network using RFC 5860 OAM with a MPLS-TP network using a modified version of Y.1731 is examined and compared. In this paper the Y.1731 network is called a Proprietary Transport Extensions (PTE) network.

MPLS-TP with RFC 5860 OAM is backwards compatible with existing IP/MPLS networks. Many of the operational processes, procedures, and systems, therefore, can be shared between the existing IP/MPLS network and the new MPLS-TP network. Using an OPEX model developed by Network Strategy Partners, a hypothetical MPLS-TP network is compared with a PTE network over five-years. The results, presented in Figure 2, show substantial savings which are due to the fact that MPLS-TP with RFC 5860 OAM leverages existing MPLS processes and systems while PTE does not. The body of this paper presents the detailed assumptions and results of this OPEX analysis.

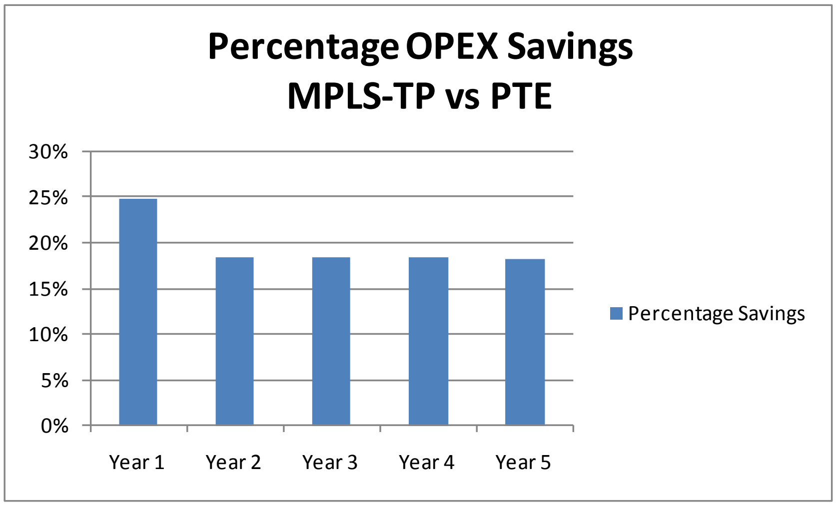

Figure 2. Percentage of savings using an MPLS-TP standard network vs. PTE

OPEX Model Assumptions and Results

Service provider operations processes, procedures, and systems are large and complex; new systems sometimes require years before they are gracefully assimilated into operations systems. The overall level of effort required to operate the networks will be minimized, therefore, if new technologies and systems can leverage existing operational processes. This is the primary reason that a key objective of the MPLS-TP project is to maintain compatibility with existing IP/MPLS networks and to preserve the look and feel of existing TDM transport networks.

Specifically the categories of OpEx where MPLS-TP is less expensive than PTE are:

- OSS System Integration and Software Expenses
- Engineering, Facilities, and Installation (EF&I)
- Network Care (Fault Management, Performance Management, and Configuration Management)
- Training
- Testing and Certification

The assumptions and results for each of these OPEX categories are presented in the following sections of this paper.

General Assumptions

This model uses a bottom-up approach to calculating OPEX using estimates for the hours required for different types of labor to carry out specific tasks. Three categories of labor are considered in this model:

- **Hands-on-Technician**: Technicians working in Central Offices doing physical equipment configuration and maintenance. This includes cabling, replacing cards, and maintaining facilities.
- **Tier 1 Engineer**: First level engineers working in Network Operations Centers and Central Offices. These engineers work on software configuration, provisioning, and first level fault management activities.
- **Tier 2 Engineer**: Advanced engineers working in Network Operations Centers. These engineers work on software configuration, performance management, and escalated fault management activities.

Labor Tier	$/hour
Hands-on Technician	$ 45
Tier 1 Engineer	$ 60
Tier 2 Engineer	$ 90
Labor Inflation Rate	3%

Table 1. Fully loaded labor rates for three tiers of technicians and engineers

In some cases OPEX is calculated using estimates for hours of each labor tier required per transport switch. For the purposes of this paper we assume that there are 100 Carrier Ethernet switches in the transport network with an annual growth rate of 15%.

OSS System Integration and Software Expenses

The processes and procedures used by service providers for managing transport networks are tightly coupled to OSS systems. New transport technologies require OSS software enhancements and system integration. MPLS-TP is a subset of MPLS and many OSS systems already support MPLS. PTE will use a new standard for OAM and consequently will require additional OSS development activities. MPLS-TP, therefore, requires less OSS integration expense than PTE.

There are multiple stages of work required to integrate a new system into a service provider's OSS. The stages of work are:

- **Business Process Design**: In this first step the fundamental business processes used to operate and maintain the network are defined and documented.
- **OSS Software Specification**: After the business processes have been defined, functional and design specifications are written for the OSS software enhancements.
- **OSS Software Coding**: After the software specifications are reviewed and accepted then the software enhancements to the OSS are coded.
- **OSS Software Test and Integration**: After the software is coded it must be integrated and tested in the overall OSS system.

The assumptions used in this model for the OSS integration labor hours are depicted in Table 2. It is assumed that PTE requires 50% more hours for OSS integration than MPLS-TP because existing IP/MPLS routers are already supported by the OSS. Most of the effort required for OSS system integration is required by Tier 2 labor. This is because business process design, software specification, and coding is done by Tier 2 level engineers. However, testing is carried out with a combination of Tier 1 and Tier 2 engineers.

	MPLS-TP (Labor Hours)			PTE (Labor Hours)		
OSS System Integration and Testing	Hands-on	Tier 1	Tier 2	Hands-on	Tier 1	Tier 2
Business Process Design	0	0	2500	0	0	3750
OSS Software Specification	0	0	1500	0	0	2250
OSS Software Coding	0	0	4000	0	0	6000
OSS Software Test and Integration	0	2000	2000	0	3000	3000

Table 2. Labor hours required for OSS system integration and testing

The total OSS Integration and Testing expenses are compared for both MPLS-TP and PTE in Figure 3. The OSS expenses are all incurred in year 1 of the analysis.

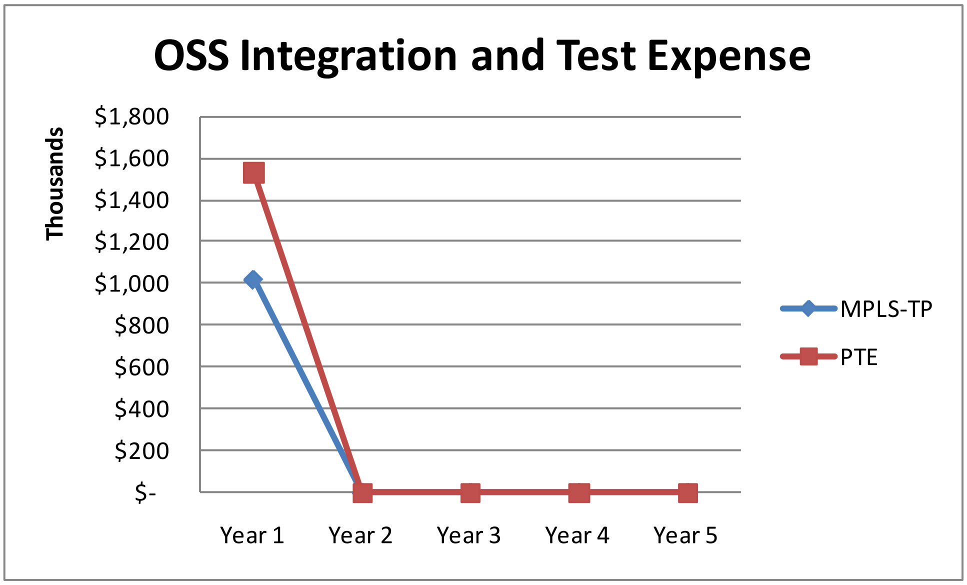

Figure 3. OSS Integration and Test Expense comparison of MPLS-TP and PTE

Engineering, Furnishing, and Installation (EF&I)

EF&I are the expenses associated with engineering and installing new network equipment. System design and configuration for MPLS-TP will be faster than for PTE because it is more like existing MPLS networks.

EF&I includes all the work needed to plan and engineer any network infrastructure and facilities (cabling, power, heat and air conditioning, etc.), to install the equipment in the office, and to configure the equipment so that it can be turned up as part of network inventory ready for use to provide services. EF&I is quantified by using hours per chassis for the three separate tiers of labor. In Table 3 the number of hours required per chassis is specified for each of the EF&I functions.

Network engineering is the planning and designing of the Carrier Ethernet transport network and equipment. This is carried out by Tier 2 network engineers. The assumption is that PTE network engineering takes 25% more hours than MPLS-TP network engineering because standard MPLS procedures and knowledge used in current IP/MPLS networks cannot be reused for PTE.

Facilities planning include physical building facilities, cabling, space, heat, cooling, and power requirements for the equipment. This is a Tier 2 labor function and the assumption is that there is no difference between MPLS-TP and PTE.

Equipment Installation and configuration includes physical installation and software configuration of equipment. It is assumed that there is no difference in physical installation between MPLS-TP and PTE (Hands-on labor is the same). It is also assumed, however, that MPLS-TP has a higher level of efficiency for software configuration than PTE. The assumptions are shown in Table 3.

	MPLS-TP (Hours per Chassis)			PTE (Hours per Chassis)		
EF&I	Hands-on	Tier 1	Tier 2	Hands-on	Tier 1	Tier 2
Network Engineering	0	0	20	0	0	25
Facilities Planning	0	0	20	0	0	20
Equipment Installation and Configuration	10	20	10	10	25	15

Table 3. Labor hours required for EF&I for MPLS-TP and PTE

A comparison of the five-year expenses for EF&I is presented in Figure 4. EF&I expenses are only incurred as new systems are added to the network. The greatest expenses are incurred in year 1, therefore, with additional expenses occurring in later years as new switches are added to the network.

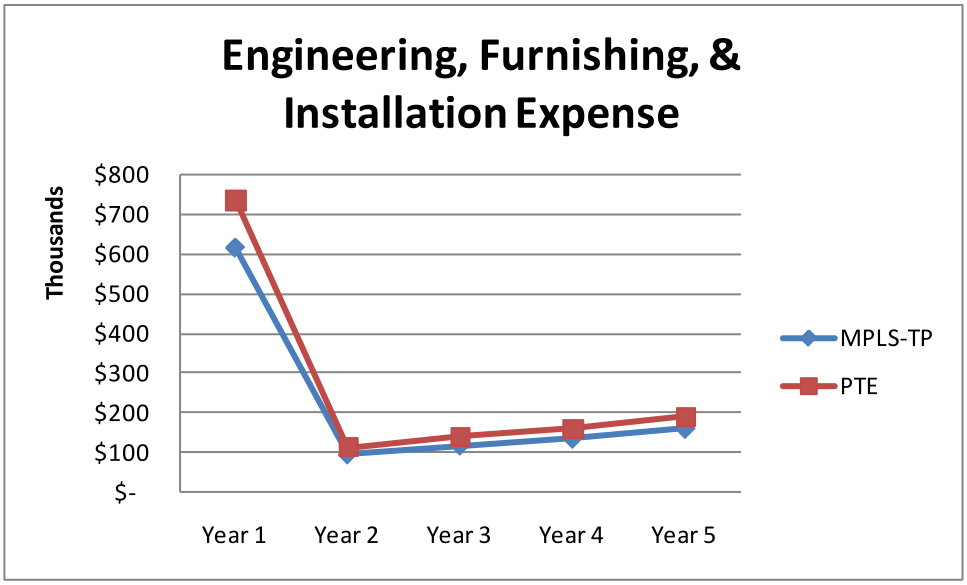

Figure 4. Engineering, Furnishing, and Installation Expense comparison of MPLS-TP and PTE

Network Care

This category includes most of the NOC activities associated with managing a transport network. This includes provisioning, configuration management, fault management, and performance management. Since many NOCs already manage IP/MPLS networks, less additional labor costs are required to manage MPLS-TP versus PTE. This is partly a result of PTE using a different standard for OAM (Y.1731) than MPLS. Using consistent OAM across all MPLS networks reduces network care expenses.

The main functions of network care are:

- Configuration management
- Fault management
- Performance management

It is assumed that there is no difference between MPLS-TP and PTE for Hands-on labor since there should be no real difference in the physical management of the network. However, it is assumed that there is about a 25% improvement in efficiency for engineers (Tier 1 and Tier 2) doing logical configuration, fault, and performance management due to the similarities of MPLS-TP with existing MPLS networks. The assumptions for network care are presented in Table 4.

	MPLS-TP (Hours per Chassis per Year)			PTE (Hours per Chassis per Year)		
Network Care	Hands-on	Tier 1	Tier 2	Hands-on	Tier 1	Tier 2
Configuration Mgt	0	30	10	0	35	12
Fault Mgt	4	5	20	4	7	25
Performance Mgt	0	5	10	0	7	12

Table 4. Labor hours required for Network Care for MPLS-TP and PTE

A comparison of the total operational expenses for Network Care is presented in Figure 5 Network Care expenses are on-going operational expenses that increase as the network grows.

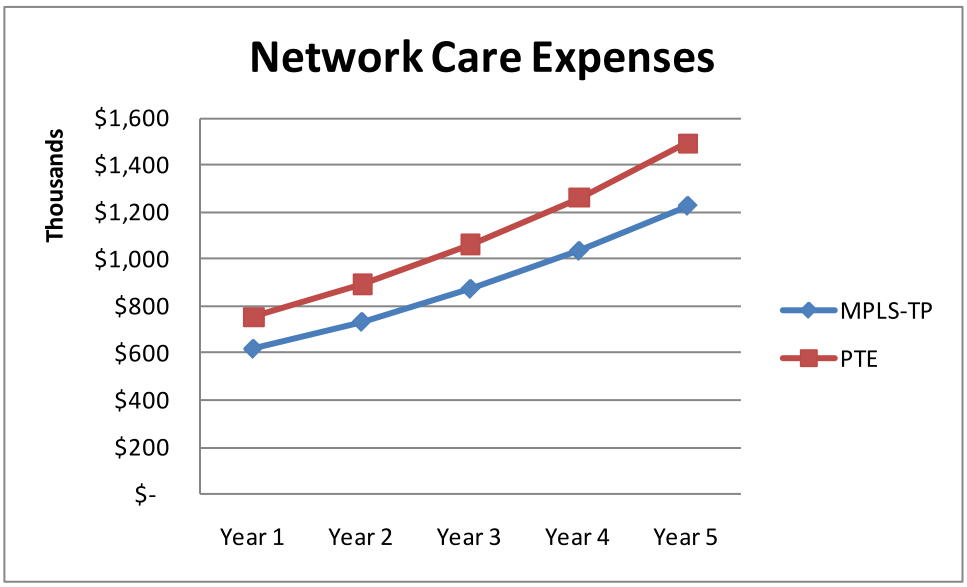

Figure 5. Network Care Expense comparison of MPLS-TP and PTE

Training

Since service providers already have staff trained on MPLS, the level of training required for MPLS-TP will be lower than the training required for PTE. The assumptions for the hours of training are presented in Table 5. This table specifies the number of people trained in each labor category, the hours of training required in the first year for each labor category, and the hours required in later years. It is assumed that more hours of training are required in year 1 than in later years. Only 40% of the year 1 training is required in each year 2-5. It is also assumed that there is a 25% efficiency advantage for training on MPLS-TP versus PTE for all categories of labor.

	MPLS-TP			PTE		
Training	Hands-on	Tier 1	Tier 2	Hands-on	Tier 1	Tier 2
Number of People trained	20	10	5	20	10	5
Hours of Training Year 1	80	80	120	100	100	150
People Hours of Training in Year 1	1600	800	600	2000	1000	750
Year N training vs Year 1 training	40%	40%	40%	40%	40%	40%

Table 5. Labor hours required for Training for MPLS-TP and PTE

The total training expenses for MPLS-TP versus PTE are presented in Figure 6. Training expenses are greatest in the first year but continue at a lower rate in years 2-5.

Figure 6. Training Expense comparison of MPLS-TP and PTE

Test and Certification

All new hardware and software releases must go through a testing and certification process before being released into the network. Service providers already have trained engineers, acquired test equipment, created test automation, and regression testing for MPLS networks. This allows service providers to share test cases and automation between IP/MPLS equipment and MPLS-TP equipment. The same cannot be said for PTE because it is a fundamentally different standard.

The default assumptions for testing and certification are presented in Table 6. There are three primary functions:

- Test case development – writing the test cases
- Test case automation – automating the test cases with automated testing tools
- Executing the test cases

The test case development and automation are carried out by Tier 2 labor. The test case execution is carried out by Tier 1 labor. In all cases a 25% advantage for MPLS-TP is assumed. It is assumed that two major releases per year are deployed in the network.

	MPLS-TP (hours per release)			PTE (hours per release)		
Test & Certification	Hands-on	Tier 1	Tier 2	Hands-on	Tier 1	Tier 2
Test case development	0	0	300	0	0	375
Test case automation	0	0	400	0	0	500
Test case execution	0	500	0	0	625	0

Table 6. Labor hours required for Test and Certification for MPLS-TP and PTE

The five-year test and certification expenses for both MPLS-TP and PTE are compared in Figure 7. Test and certification expenses are on-going expenses because two new releases are deployed in the network each year.

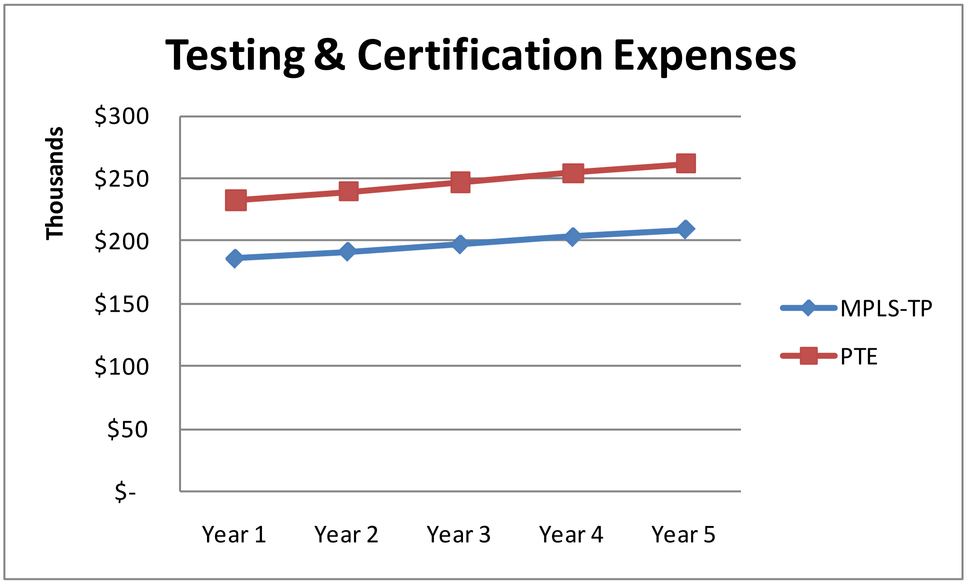

Figure 7. Test and Certification Expense comparison of MPLS-TP and PTE

Conclusion

The key objective of the MPLS-TP standard is to create a packet optical transport network with operational procedures that are similar to existing TDM transport networks and protocols that are backwards compatible with existing IP/MPLS networks. The recent proposal in the IETF to allow a modified version of Y.1731 to be used for MPLS-TP OAM defeats one of the main objectives of MPLS-TP—to maintain backwards compatibility with existing IP/MPLS networks. In this paper this approach is called Proprietary Transport Extensions or (PTE). A detailed OPEX model shows that OPEX over a five-year period is lower for MPLS-TP than PTE. A summary of the results of this analysis are presented in Figure 8. The chart presents a breakdown of the OPEX expenses. For OSS Integration, EF&I, Network Care, Training, and Test and Certification the MPLS-TP network results in a more cost effective solution than the PTE network.

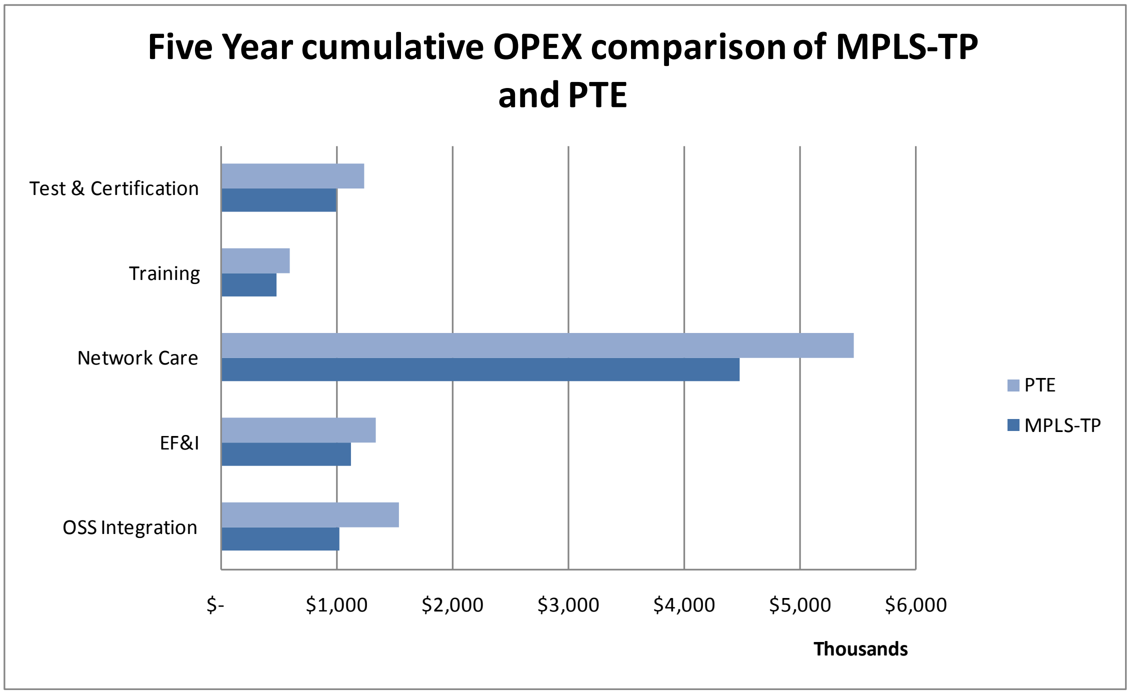

Figure 8. Break down of five year cumulative OPEX for MPLS-TP and PTE

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