# Common Labeling Option (CLO) for MPLS-TP over L1VPNs

**Abstract:** This document outlines the simplification, reliability, security, scalability and cost-efficiency benefits achievable through the natural synergies between the emerging MPLS-TP, L1VPN and physical layer optimization technologies and standards. Enabled by L1 isolation between unrelated network contracts that is made economical via L1 optimization, a case is made for a common MPLS-TP Label pattern that can be reused in any number of such MPLS-TP network contracts for maximized OAM efficiency gains. It is proposed that a suitable library of such common Label values, along with corresponding rules for interpreting them as forwarding instructions, is standardized, to allow parties to an MPLS-TP network contract to choose to use such Common Labeling Option (CLO), as a more automated alternative to contract-by-contract Labeling. This proposed standards option is non-disruptive; the CLO library Label values are to only have special significance in the packet-switching L1VPNs were CLO has been chosen to be used, but elsewhere the CLO Label values shall have no special status and can thus be used just as any other Label values.

## Introduction

Several business and wholesale network service contracts interconnect a set of network access points that is to remain static for the duration of the contract, which is often more than a year. For such a network segment to deliver packets between its static set of access points (APs), once-per-contract assigned AP addressing can be used. MPLS allows stacking such addressing tags, Label Stack Entries (LSEs), in packet overheads, and MPLS-TP allows assigning (a portion of) LSEs in such stacks from the network management systems (NMS). These techniques thus allow the once-per-contract assignment of LSEs for such by-definition non-dynamic addressing environments.

In parallel to the introduction of MPLS-TP at L2, there are emerging L1/0 network optimization techniques that allow unprecedented cost-efficiencies in providing L1/0 network capacity services, making per-contract dedicated L1/0 network connectivity services often more economical for high capacity, high performance and/or high security applications than connectivity services provided over packet-layer shared networks.

MPLS-TP and L1/0 optimization techniques thus are in a position to enable high cost-efficiency *and* high quality packet-switching L1VPNs, referred to occasionally as "L1.5VPNs", with significantly reduced administrative overhead, compared to using traditional L3/2 VPNs in the herein discussed applications. Moreover, note that via standardizing a set of MPLS-TP Label patterns to be used over such L1VPNs, these networks can provide transparent packet-switched connectivity among the APs of a given contract, without requiring any packet forwarding control information, e.g. forwarding look-up tables. In effect, the common standard set of rules for interpreting the common pattern of Label values replaces the need for instance specific forwarding instructions that would otherwise need to be configured for each packet forwarding point.

The rationale for standardizing such common Label interpretation semantics, the Common Labeling Option (CLO), as an optionally selectable alternative to case-by-case labeling, includes:

- There is no benefit of doing the same thing in a number of different ways, or re-doing multiple times what could be done once for all the cases of a given category.
- Many MPLS Labeling environments, e.g. backbone (wholesale) network segments between a set of MPLS routers, are by definition *static* for the duration of the often multi-year service contract.
- L1 isolation between unrelated network contracts that is made economical through L1 optimization enables reusing *common* Label pattern in any number of parallel customer or application subnetworks.
- The above factors create a case for using *static, common library based Labeling*, which obviously offers great simplification potential, in particular in the typical situation of per-contract-period statically labeled MPLS networks. The case for realizing this opportunity for simplification through using CLO is made particularly compelling due to that it is possible to achieve the MPLS labeling simplification without causing additional complexity elsewhere, as well as without causing loss of efficiency or flexibility.

## Applicability

The primary envisioned applications are cases where the MPLS LSPs are by-definition semi-permanent, with lifetime of their associated network service contracts i.e. often at least one year. The common Label interpretation semantics per CLO is to be considered as a simplified case of the general MPLS(-TP) standards for the per-contract static environments, i.e., as a standard-based Labeling option that the parties to a given MPLS-TP network contract can *optionally* agree to use, as a lower overhead and more secure alternative to doing contract-specific Label assignment.

**Motivation**

The existing GMPLS target architectures commonly have been based on multi-customer shared L1 pools with customer network separation at L2/3. These architecture models however were developed based on the now-historical assumption of having to rely on semi-fixed L1 -- and it is that no-longer-valid assumption *instead of the customer requirements* that called for packet-layer stat-muxing across different customer networks to realize the bandwidth efficiency gains of packet switching. However, with the ability to achieve the full network efficiency gains through the use of adaptive L1 *without having to mix unrelated traffic streams at packet layer*, the need for using multi-customer shared L1 and having to deal with the resulting L2/3+ complexity can in many cases be avoided. Also, note that since transparent packet-switched multi-point connectivity can be provided over L1.5VPNs using CLO, packet-switched multi-point customer network contracts can be provided with L1 simplicity (incl. without having to share L1 connection or packet-switching resources between different customer contracts), while achieving maximized network bandwidth efficiency.

As a business case, one can consider the huge market for simple but inefficient leased line services (inefficient especially when used for carrying packet traffic, as they increasingly are). Customer expectations for these services include simple SLAs and overall transparency, along with a need to get radically more capacity per dollar spent. Addressing this customer need would call for moving from a number of point-to-point leased lines to a multi-point packet-switched service, however such that preserves the L1 simplicity and transparency. An option to use a common standard MPLS-TP Label values with their associated interpretation rules per CLO over L1.5VPNs would enable offering a packet-switched service with the required simple SLAs and packet-layer transparency of the service. Moreover, the MPLS-TP switching equipment (such that were optimized for MPLS-TP-CLO) can be made very low cost, as well as highly reliable and scalable, compared to IP-MPLS equipment, enabling more cost-efficient delivery of high-performance network services.

**Key Features**

**Non-disruptive for existing MPLS(-TP) standards:** CLO for L1VPNs is not meant as any kind of rules for MPLS Labeling that would have any impact outside of the L1VPNs where that option has been chosen for use; rather, CLO should be defined as a known standard library Label *option* that can be used for MPLS-TP Labeling in by-definition-static network segments where there is a natural fit for it. MPLS-TP overall can naturally still be used over also shared L1 environments, and also the CLO option based MPLS-TP (wholesale) networks can still support IP-MPLS client services.

Therefore, the proposed standard pattern for Label values (and their accompanying semantics as forwarding instructions) per CLO that can optionally be used within L1 isolated network segments (e.g. L1VPNs) thus does not introduce any new type of generally reserved Label values. Rather, what is proposed is that, instead of using a *variable* set of locally-reserved Label values in by-definition static environments, the parties to a network contract should be able to agree to use a *constant* set of standard library based Label values.

Advantages of using the standard library based Labeling include OAM streamlining, and the avoidance for the need for packet-layer routing/switching/forwarding look-up tables at single-contract network segments (L1.5VPNs), as well as the avoidance for the need to populate and maintain such look-up tables, resulting in network operations simplification, hardware scalability, cost-efficiency and security benefits.

**Safe re-use of common pattern of Label value in any number of parallel contracts:** The L1 isolation between different MPLS-TP network contracts (e.g. via customer organization or user group specific L1VPNs) allows reusing the same CLO standard set of Label values between any number of customer contracts in parallel. Moreover, since any given packet forwarding engine at L1VPNs only sees packets from one (direct) source router of the single customer for the VPN, the full packet-switching flexibility across such VPNs can be achieved while re-using the same set of pre-known Label values also at all their APs. Note also that, with the utilization of adaptive L1, the OAM-simplifying L1 isolation between unrelated packet traffic streams can be implemented without any loss in network utilization efficiency or desired flexibility of connectivity.

The use of such standard (NMS) library based Labeling enables further network operations process automation, as well as faster and more cost-efficiently scalable network hardware implementations.

**Packet layer transparency:** The packet layer processing with L1.5VPNs is limited to merely *executing* the forwarding instructions that the set of MPLS routers place for such VPNs using the CLO format, and does not involve any manipulation of the packets delivered between the group of routers (more precisely, packet-switched APs) associated with a given VPN contract. Therefore, the MPLS routers see each others packet-layer transparently over the L1.5VPN, and run all their packet layer protocols directly among each others through such VPN that appears to the interconnected routers as a mesh of direct PPP links between them.

The MPLS routers, or generally the customer network segments beyond the APs to the herein discussed (wholesale) L1.5VPNs, can thus run, for instance, MPLS LDP to dynamically manage the Label allocations in the network segments outside the static MPLS-TP over L1.5VPN backbone. Note that the LDP (as well as any IP routing protocol) packets between the IP-MPLS based customer network segments interconnected through such L1.5VPN will be encapsulated in MPLS-TP-CLO frames just like any other packets passed over the L1.5VPN between the customer routers, and the L1.5VPN will thus deliver the LDP (and other routing control) packets exactly the same way as regular MPLS-TP-CLO labeled data packets.

Inverse ARP can be used to automate the tying of the MPLS-TP-CLO Label values to the neighboring router IP addresses over the L1.5VPNs in a straightforward manner, since in this networking mode, the L2 MPLS Label values to be used are pre-defined (assigned from CLO standard based NMS libraries), as are the rules for how the L1.5VPN interprets the CLO Labels as direct forwarding instructions, and therefore with these two 'knowns', the initially 'unknown' next hop router interface IP addresses can be resolved via inverse ARP queries and responses between the L1.5VPN connected routers.

**Layer independency:** The CLO standard itself (as an option to simplify Labeling in the by-definition static network segments) is to be completely independent of how the network layers both above and beneath the L2 MPLS-TP are implemented. CLO based MPLS-TP network shall be compatible with the existing, commonplace L1 network technologies. Likewise, CLO based MPLS-TP shall support any client layer traffic types. Typically, it is envisioned that the MPLS-TP-CLO is deployed as a wholesale bearer layer for IP-MPLS, or non CLO based MPLS-TP client layers.

However, for practical motivation for the standard proposal, the L1-optimized, L1-isolated customer subnetworks can be used as an emerging use case for where the CLO allows taking the OAM simplification beyond what is possible with shared L1 connection based networks, while providing all the flexibility and efficiency benefits of packet-switching. That does not mean that the CLO could not be used over non-L1-optimized and even multi-customer-shared L1 subnetworks; quite the opposite, by keeping the packet forwarding plane standard options (incl. CLO) independent of data transport plane implementations, there will remain full freedom for how the data plane should be implemented in any particular application.

**Key Benefits**

**OAM simplification:** Many of the multi-domain OAM (as well as data plane scalability) related challenges can be architecturally solved by replacing the need to resolve the next hop destination via forwarding lookup tables with a standard rule-set that the parties to the network contract can mutually agree to use. This considerably reduces administrative overhead and streamlines inter-domain MPLS networking. Thereby, CLO, which the enterprises and the network service providers can opt for (on contract by contract basis) in order to eliminate the need to replicate the Label assignment effort for each contract, will be of significant value to the service providers that bear the end-to-end responsibility of multi-sited customer network implementation across multiple administrative domains.

**Natural synergies between MPLS-TP and L1VPNs**: Emerging L1 optimization techniques will furthermore allow implementation of the MLST-TP-CLO based transparent, multi-point packet-switching L1VPNs with maximized bandwidth-efficiency -- and when considering also the minimized OAM costs -- at unprecedented levels of cost-effectiveness and operational simplicity.

**Making the simplification benefits of MPLS-TP a reality**: As discussed in the various contributions to MPLS-TP standards developments, the goal of TP of eliminating unnecessary complexity from the by-definition static network contract applications will only be realized if there are technology platforms that are specifically optimized for MPLS-TP. (http://en.wikipedia.org/wiki/MPLS-TP: "*MPLS-TP is expected to be a low cost L2 technology (if the limited profile to be specified is implemented in isolation) that will provide QoS, end-to-end OA&M and protection switching.*") To make a case for such streamlined MPLS transport network technologies, and thereby, to allow realizing the cost-efficiency benefits, there needs to be a large enough market application for related services -- and synergy benefits of MPLS-TP and L1VPNs can be instrumental in creating such a market opportunity. Maximizing the natural synergies between MPLS-TP and L1VPNs via standardization of CLO can therefore play the critical role in delivering for service providers the bottomline benefits being pursued by MPLS-TP.

**More cost-efficient, scalable and automated networks**: As discussed in the foregoing, through elimination the need to do the same things via multiple different ways or multiple times for same class of applications, MPLS-TP-CLO over L1VPNs mode of networking enables considerable further automation and streamlining both in network and service management systems as well as in MPLS-TP optimized network hardware.

**Existing contributions available for standards development**

OCS' technological contribution for this effort at this stage include the US patent application #12/390,387 that describes (one possibility for the) semantics of the CLO MPLS Label bit fields and accordant rules for how the packet forwarding engines at transparent packet-switching networks (L1.5 VPNs) should interpret such CLO Label bitfields. In particular, please see Table 1 on pages 28-30 of the application #12/390,387 for a possible CLO format.

OCS encourages contribution (requirements, functionality definition, performance objectives, implementation practices etc.) from all other organizations with an interest in enabling more cost-efficient MPLS networking through standards development.