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Requirements for Inter-Area MPLS Traffic Engineering

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Abstract

This document lists a detailed set of functional requirements for the support of inter-area MPLS Traffic Engineering (inter-area MPLS TE). It is intended that solutions that specify procedures and protocol extensions for inter-area MPLS-TE satisfy these requirements.

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Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC-2119](#).

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[1.](#) Introduction

The set of MPLS Traffic Engineering components, defined in [[RSVP-TE](#)], [[OSPF-TE](#)] and [[ISIS-TE](#)], which supports the requirements defined in [[TE-REQ](#)], is used today by many network operators to achieve major Traffic Engineering objectives defined in [[TE-OVW](#)] and summarized below:

- Aggregated Traffic measurement
- Optimization of network resources utilization
- Support for services requiring end-to-end QoS guarantees
- Fast recovery against link/node/SRLG failures

However, the current set of MPLS Traffic Engineering mechanisms have to date been limited to use within a single IGP area.

This document discusses the requirements for an inter-area MPLS Traffic Engineering mechanism that may be used to achieve the same set of objectives across multiple IGP areas.

Basically, it would be useful to extend MPLS TE capabilities across

IGP areas to support inter-area resources optimization, to provide strict QoS guarantees between two edge routers located within distinct areas, and to protect inter-area traffic against ABR failures.

This document firstly addresses current uses of MPLS Traffic Engineering within a single IGP area. This helps, then, in discussing a set of functional requirements a solution must or should satisfy in order to support inter-area MPLS Traffic Engineering. Since the scope of requirements will vary between operators, some requirements will be mandatory (MUST) whereas others will be optional (SHOULD). Finally, a set of evaluation criteria for any solution meeting these requirements is given.

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[3.](#) Terminology

LSR: Label Switching Router

LSP: Label Switched Path

TE-LSP: Traffic Engineering Label Switched Path

Inter-area TE-LSP : TE-LSP whose head-end LSR and tail-end LSR do not reside within the same IGP area or both head-end LSR and tail-end LSR are in the same IGP area but the TE LSP transiting path may be across different IGP areas.

IGP area: OSPF area or IS-IS level.

ABR: Area Border Router, router used to connect two IGP areas (ABR in OSPF or L1/L2 router in IS-IS).

CSPF: Constraint-based Shortest Path First.

SRLG: Shared Risk Link Group.

[4.](#) Current intra-area uses of MPLS Traffic Engineering

This section addresses architecture, capabilities and uses of MPLS-TE within a single IGP area. It first summarizes the current MPLS-TE architecture, then addresses various MPLS-TE capabilities, and finally lists various approaches to integrate MPLS-TE into routing. This section is intended to help defining the requirements for MPLS-TE extensions across multiple IGP areas.

[4.1.](#) Intra-area MPLS Traffic Engineering Architecture

The MPLS-TE control plane allows establishing explicitly routed MPLS LSPs whose path follows a set of TE constraints. It is used to achieve major TE objectives such as resource usage optimization, QoS guarantee and fast failure recovery. It basically consists of three main components:

- The routing component, responsible for the discovery of the TE topology. This is ensured thanks to extensions of link state IGP: [\[ISIS-TE\]](#), [\[OSPF-TE\]](#).
- The path computation component, responsible for the placement of the LSP. It is performed on the Head-End LSR thanks to a CSPF algorithm, which takes TE topology and LSP constraints as input.
- The signalling component, responsible for the establishment of the LSP (explicit routing, label distribution and resources reservation) along the computed path. This is ensured thanks to RSVP-TE [\[RSVP-TE\]](#)

[4.2.](#) Intra-area MPLS Traffic Engineering Applications

[4.2.1.](#) Intra-area resource optimization

MPLS-TE can be used within an area to redirect paths of aggregated flows away from over-utilized resources within a network. In a small scale, this may be done by explicitly configuring a path to be used between two routers. In a grander scale, a mesh of LSPs can be established between central points in a network. LSPs paths can be defined statically in configuration or arrived at by an algorithm that determines the shortest path given constraints such as bandwidth or other administrative constraints.

In this way, MPLS-TE allows for greater control over how traffic demands are routed over a network topology and utilize a network's resources.

Note also that TE-LSPs allow to measure traffic matrix in a simple and scalable manner. Basically, aggregated traffic rate between two LSRs is easily measured by accounting of traffic sent onto a TE LSP provisioned between the two LSRs in question.

[4.2.2.](#) Intra-area QoS guarantees

The DiffServ IETF working group has defined a set of mechanisms described in [[DIFF-ARCH](#)], [[DIFF-AF](#)] and [[DIFF-EF](#)] or [[MPLS-DIFF](#)] that can be activated at the edge or over a DiffServ domain to contribute to the enforcement of a (set of) QoS policy(ies), which can be expressed in terms of maximum one-way transit delay, inter-packet delay variation, loss rate, etc. Many Operators have some or full deployment of DiffServ implementations in their networks today, either across the entire network or at least at the edge of the network.

In situations where strict QoS bounds are required, admission control inside the backbone of a network is in some cases required in addition to current DiffServ mechanisms. When the propagation delay can be bounded, the performance targets, such as maximum one-way transit delay may be guaranteed by providing bandwidth guarantees along the DiffServ-enabled path.

MPLS-TE can be simply used with DiffServ: in that case, it only ensures aggregate QoS guarantees for the whole traffic. It can also be more intimately combined with DiffServ to perform per-class of service admission control and resource reservation. This requires extensions to MPLS-TE called DiffServ Aware TE and defined in [[DS-TE-PROTO](#)]. DS-TE allows ensuring strict end-to-end QoS guarantees. For instance, an EF DS-TE LSP may be provisioned between voice gateways within the same area to ensure strict QoS to VoIP traffic.

MPLS-TE allows computing intra-area shortest paths satisfying various constraints including bandwidth. For the sake of illustration, if the IGP metrics reflects the propagation delay, it allows finding a minimum propagation delay path satisfying various constraints like bandwidth.

[4.2.3](#). Fast recovery within an area

As quality sensitive applications are deployed, one of the key requirements is to provide fast recovery mechanisms, allowing guaranteeing traffic recovery on the order of tens of msecs, in case of network element failure. Note that this cannot be achieved by relying only on classical IGP rerouting.

Various recovery mechanisms can be used to protect traffic carried onto TE LSPs. They are defined in [\[MPLS-RECOV\]](#). Protection mechanisms are based on the provisioning of backup LSPs that are used to recover traffic in case of failure of protected LSPs. Among those protection mechanisms, local protection, also called Fast Reroute is intended to achieve sub-50ms recovery in case of link/node/SRLG failure along the LSP path [\[FAST-REROUTE\]](#). Fast Reroute is currently used by many operators to protect sensitive traffic inside an IGP area.

[FAST-REROUTE] defines two modes for backup LSPs. The first one, called one-to-one backup, consists in setting up a detour LSP per protected LSP and per element to protect. The second one called facility-backup consists in setting up one or several bypass LSPs to protect a given facility (link or node). In case of failure, all protected LSPs are nested into the bypass LSPs (benefiting from the MPLS label stacking property).

[4.3](#). Intra-area MPLS-TE and routing

There are several possibilities to direct traffic into intra-area TE LSPs:

- 1) Static routing to the LSP destination address or any other addresses.
- 2) IGP routes beyond the LSP destination, from an IGP SPF perspective (IGP shortcuts).
- 3) BGP routes announced by a (MP-)BGP peer that is reachable through the TE-LSP by means of a single static route to the corresponding BGP next-hop address (option 1) or by means of IGP shortcuts (option 2). This is often called BGP recursive

routing.

- 4) The LSP can be advertised as a link into the IGP to become part of IGP database for all nodes, and thus taken into account during SPF for all nodes. Note that, even if similar in concept, this is different from the notion of Forwarding-

Adjacency, as defined in [[LSP-HIER](#)], where the LSP is advertised as a TE-link into the IGP-TE, to become part of the TE database and taken into account in CSPF.

[5.](#) Problem Statement, Requirements and Objectives of inter-area MPLS-TE

[5.1.](#) Inter-Area Traffic Engineering Problem Statement

As described in [section 4](#), MPLS-TE is deployed today by many operators to optimize network bandwidth usage, to provide strict QoS guarantees and to ensure sub-50ms recovery in case of link/node/SRLG failure.

However, MPLS-TE mechanisms are currently limited to a single IGP area. The limitation comes essentially from the Routing and Path computation components and less from the signaling component. This is basically due to the fact that hierarchy limits topology visibility of head-end LSRs to their IGP area, and consequently head-end LSRs can no longer run a CSPF algorithm to compute the shortest constrained path to the tail-end as CSPF requires the whole topology to compute an end-to-end shortest constrained path.

Several operators have multi-area networks and many operators that are still using a single IGP area may have to migrate to a multi-area environment, as their network grows and single area scalability limits are approached.

Hence, those operators may require inter-area traffic engineering to:

- Perform inter-area resource optimization.
- Provide inter-area QoS guarantees for traffic between edge nodes located in different areas.
- Provide fast recovery across areas, to protect inter-area traffic in case of link or node failure, including ABR node failures.

For instance an operator running a multi-area IGP may have Voice gateways located in different areas. Such VoIP transport requires inter-area QoS guarantees and inter-area fast protection.

One possible approach for inter-area traffic engineering could consist of deploying MPLS-TE on a per-area basis, but such an approach has several limitations:

- Traffic aggregation at the ABR levels implies some constraints that do not lead to efficient traffic engineering. Actually such per-area TE approach might lead to sub-optimal resource utilization, by optimizing resources independently in each area. And what many operators want is to optimize their resources as a whole, in other words as if there was only one area (flat network).
- This does not allow computing an inter-area constrained shortest path and thus does not ensure end-to-end QoS guarantees across areas.

- Inter-area traffic cannot be protected with local protection mechanisms such as [[FAST-REROUTE](#)] in case of ABR failure.

Hence, existing MPLS TE mechanisms have to be enhanced to support inter-area TE LSPs.

[5.2](#). Motivations for inter-area MPLS-TE

For the reasons mentioned above, it is highly desired to extend the current set of MPLS-TE mechanisms across multiple IGP areas in order to support the intra area applications described in [section 4](#) across areas.

Basically, the solution MUST allow setting up inter-area TE LSPs, ie LSPs whose path crosses at least two IGP areas.

Inter-area MPLS-TE extensions are highly desired to provide:

- Inter-area resources optimization.
- Strict inter-area QoS guarantees.
- Fast recovery across areas, particularly in order to protect inter-area traffic against ABR failures.

It may be desired to compute inter-area shortest path that satisfy some bandwidth constraints or any other constraints, as currently possible within a single IGP area. For the sake of illustration, if the IGP metrics reflects the propagation delay, it may be needed to be able to find the optimal (shortest) path satisfying some constraints (e.g. bandwidth) across multiple IGP areas: such a path

would be the inter-area path offering the minimal propagation delay.

Thus the solution SHOULD provide the ability to compute inter-area shortest paths satisfying a set of constraints (i.e. bandwidth).

[5.3.](#) Key Objectives for an inter-area MPLS-TE solution

Any solution for inter-area MPLS-TE should be designed having as key objectives to preserve IGP hierarchy concept, and to preserve routing and signaling scalability.

[5.3.1.](#) Preserve the IGP hierarchy concept

The absence of a full link state topology database makes the computation of an end-to-end optimal path by the head-end LSR not possible without further signaling and routing extensions. There are several reasons that network operators choose to break up their network into different areas. These often include scalability and containment of routing information. The latter can help isolate most of a network from receiving and processing updates that are of no consequence to its routing decisions. Containment of routing information MUST not be compromised to allow inter-area traffic

engineering. Information propagation for path-selection MUST continue to be localized. In other words, the solution MUST entirely preserve the concept of IGP hierarchy.

[5.3.2.](#) Preserve Scalability

Being able to achieve the requirements listed in this document MUST be performed while preserving the IGP scalability, which is of the utmost importance. The hierarchy preservation objective addressed in the above section is actually an element to preserve IGP scalability. The solution MUST also not unreasonably increase IGP load which could compromise IGP scalability. In particular, a solution satisfying those requirements MUST not require for the IGP to carry some unreasonable amount of extra information and MUST not unreasonably increase the IGP flooding frequency.

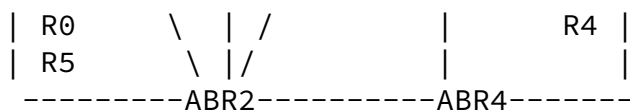
Likewise, the solution MUST also preserve scalability of RSVP-TE ([\[RSVP-TE\]](#)).

Additionally, the base specification of MPLS TE is architecturally structured and relatively devoid of excessive state propagation in terms of routing or signaling. Its strength in extensibility can also be seen as an Achilles heel, as there is really no limit to what is possible with extensions. It is paramount to maintain architectural vision and discretion when adapting it for use for inter-area MPLS-TE. Additional information carried within an area, or propagated outside of an area (via routing or signaling) should neither be excessive, patchwork, nor non-relevant.

Particularly, as mentioned in 5.2 it may be desired, for some inter-area TE LSP carrying highly sensitive traffic, to compute a shortest inter-area path satisfying a set of constraints like bandwidth. This may require an additional routing mechanism, as base CSPF at head-end can not longer be used due to the lack of topology and resources information. Such routing mechanism MUST not compromise the scalability of the overall system.

[6.](#) Application Scenario

```
---area1-----area0-----area2--
-----R1-ABR1-R2-----ABR3-----
|           \   |   /           |           |
```



- ABR1, ABR2: Area0-Area1 ABRs
- ABR3, ABR4: Area0-Area2 ABRs

- R0, R1, R5: LSRs in area 1
- R2: an LSR in area 0
- R4: an LSR in area 2

Although the terminology and examples provided in this document make use of the OSPF terminology, this document equally applies to IS-IS.

Typically, an inter-area TE LSP will be set up between R0 and R4 where both LSRs belong to different IGP areas. Note that the solution MUST support the capability to protect such an inter-area TE LSP from the failure on any Link/SRLG/Node within any area and the failure of any traversed ABR. For instance, if the TE-LSP R0->R4 goes through R1->ABR1->R2, then it can be protected against ABR1 failure, thanks to a backup LSP (detour or bypass) that may follow the alternate path R1->ABR2->R2.

For instance R0 and R4 may be two voice gateways located in distinct areas. An inter-area DS-TE LSP with class-type EF, is setup from R1 to R4 to route VoIP traffic classified as EF. Per-class inter-area constraint based routing allows routing the DS-TE LSP over a path that will ensure strict QoS guarantees for VoIP traffic.

In another application R0 and R4 may be two pseudo wire gateways residing in different areas. An inter-area LSP may be setup to carry pseudo wires.

In some cases, it might also be possible to have an inter-area TE LSP from R0 to R5 transiting via the backbone area (or any other levels with IS-IS). Basically, there may be cases where there is no longer enough resources on any intra area path R0-to-R5, while there is a feasible inter-area path through the backbone area.

[7.](#) Detailed requirements for inter-area MPLS-TE

[7.1.](#) Inter-area MPLS TE operations and interoperability

The inter-area MPLS TE solution MUST be consistent with requirements discussed in [\[TE-REQ\]](#) and the derived solution MUST be such that it will interoperate seamlessly with current intra-area MPLS TE mechanisms and inherit its capability sets from [\[RSVP-TE\]](#).

The proposed solution MUST allow provisioning at the head-end with end-to-end RSVP signalling (potentially with loose paths) traversing across the interconnected ABRs, without further provisioning required along the transit path.

[7.2.](#) Inter-Area TE-LSP signalling

The solution MUST allow for the signalling of inter-area TE-LSPs, using RSVP-TE.

In addition to the signaling of classical TE constraints (bandwidth, admin-groups^[99]), the proposed solution MUST allow the head-end LSR to explicitly specify a set of LSRs, including ABRs, by means of strict or loose hops for the inter-area TE LSP.

In addition, the proposed solution SHOULD also provide the ability to specify and signal certain resources to be explicitly excluded in the inter-area TE LSP path establishment.

[7.3.](#) Path optimality

In the context of this requirement document, an optimal path is defined as the shortest path across multiple areas taking into account either the IGP or TE metric [\[METRIC\]](#). In other words, such a path is the path that would have been computed making use of some CSPF algorithm in the absence of multiple IGP areas.

As already mentioned in 5.2, the solution SHOULD provide the capability to dynamically compute an optimal path satisfying a set of specified constraints defined in [\[TE-REQ\]](#) across multiple IGP areas. Note that this requirement document does not mandate that all inter-area TE LSPs require the computation of an optimal (shortest) inter-area path: some inter-area TE LSP paths may be computed via some mechanisms not guaranteeing an optimal end to end path whereas some other inter-area TE LSP paths carrying sensitive traffic could be computed making use of some mechanisms allowing to dynamically compute an optimal end-to-end path. Note that regular constraints like bandwidth, affinities, IGP/TE metric optimization, path

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diversity, etc, MUST be taken into account in the computation of an optimal end-to-end path.

[7.4.](#) Inter-Area MPLS-TE Routing

As already mentioned in 5.3, IGP hierarchy does not allow the Head-End LSR computing an end-to-end optimal path. Additional mechanisms are required to compute an optimal path. These additional mechanisms MUST not alter the IGP hierarchy principles.

Particularly, in order to maintain containment of routing information and preserve the overall IGP scalability, the solution SHOULD avoid the leaking across area of any dynamic TE Topology related information even in a summarized form.

Conversely, this does not preclude the leaking of non topology related information, that are not taken into account during path selection, such as static TE Node information like TE router ids or TE node capabilities.

[7.5.](#) Inter-Area MPLS-TE Path computation

Several methods may be used for path computation, as for instance:

- Per-area path computation based on ERO expansion on the Head-End LSR and on ABRs, with two options for ABR selection:
 - Static configuration of ABRs as loose hops at the head-end LSR.
 - Dynamic ABR selection.
- Inter-area end-to-end path computation, which may be based for instance on a recursive constraint based searching thanks to collaboration between ABRs.

Note that any path computation method may be used provided that it respect key objectives pointed out in 5.3.

In case a solution supports more than one method, it should allow the operator to select by configuration, and on a per-LSP basis, the desired option.

7.6. Inter-area Crankback Routing

Crankback routing, as defined in [[CRANKBACK](#)] may be used for inter-area TE-LSPs. Basically for paths computed thanks to ERO expansions with a dynamic selection of downstream ABRs, crankback routing can be used when there is no feasible path from a selected downstream ABR to the destination: The upstream ABR or Head-End LSR, selects another downstream ABR, and performs ERO expansion.

Note that such method does not allow computing and optimal path but just a feasible path.

Note also that there can be $O(N^2)$ LSP setup failures before finding a feasible path where N is the average number of ABR between two areas. This may have a non negligible impact on the LSP setup delay.

Crankback may also be used for inter-area LSP recovery: Basically in case a link/node/SRLG failure occurs in the backbone or tail-end area, the ABR upstream to the failure computes an alternate path and reroutes locally the LSP.

An inter-area MPLS-TE solution MAY support [[CRANKBACK](#)].

A solution that supports [[CRANKBACK](#)], MUST allow to activate/deactivate it via signaling, on a per-LSP basis.

7.7. Support of diversely routed inter-area TE LSPs

There are several cases where the ability to compute diversely routed TE LSP paths may be desirable. For instance, in case of LSP protection, primary and backup LSPs should be diversely routed. Another example is the requirement to set up multiple diversely routed TE LSPs between a pair of LSRs residing in different IGP areas. For instance when a single TE-LSP satisfying the bandwidth constraint could not be found between two end-points, a solution would consist of setting up multiple TE-LSPs such that the sum of their bandwidth satisfy the bandwidth requirement. In this case, it may be desirable to have these TE-LSPs diversely routed in order to minimize the impact of a failure, on the traffic between the two end-points.

Hence, the solution MUST be able to establish diversely routed inter-area TE LSPs, when diverse path exist. It MUST support all kinds of diversity (link, node, SRLG).

The solution SHOULD allow computing an optimal placement of diversely routed LSP. There may be various criteria to determine such an optimal placement. For instance the placement of two diversely routed LSPs, for load-balancing purpose may consists of minimizing their cumulative cost. The placement of two diversely routed LSPs for protection purpose may consists in minimizing the cost of the primary LSP while bounding the cost, or hop count of the backup LSP.

[7.8.](#) Intra/Inter-area Path selection policy

For inter-area TE LSPs whose head-end and tail-end LSRs reside in the same IGP area, there may be intra-area and inter-area feasible paths. In case the shortest path is an inter-area path, an operator may either want to avoid, as far as possible, crossing area and thus prefer selecting a sub-optimal intra-area path, or conversely may prefer to use a shortest path, even if it crosses areas. Thus, the solution should allow to enable/disable IGP area crossing, on a per-LSP basis, for TE LSPs whose head-end and tail-end reside in the same IGP area.

[7.9.](#) Reoptimization of inter-area TE LSP

The solution MUST provide the ability to reoptimize in a minimally disruptive manner (make before break) an inter-area TE LSP, should a more optimal path appear in any traversed IGP area. The operator should be able to parameter such a reoptimization on a timer or event-driven basis. It should also be possible to trigger such a reoptimization manually.

The solution SHOULD provide the ability to locally reoptimize and inter-area TE-LSP within an area, i.e. retaining the same set of transit ABRs. The reoptimization process in that case, MAY be

controlled by the head-end LSR of the inter-area LSP, or by an ABR. The ABR should check for local optimality of the inter-area TE LSPs established through it, based on a timer or triggered by an event. Option of providing manual trigger to check for optimality should also be provided.

In some cases it is important to restrict the control of reoptimization to the Head-End LSR only. Thus, the solution MUST allow to activate/deactivate ABR control of reoptimization, via signalling on a per LSP-basis.

The solution SHOULD also provide the ability to perform an end-to-end reoptimization, resulting potentially in a change on the set of transit ABRs. Such reoptimization can be controlled only by the HE LSR.

In case of head-end control of reoptimization, the solution SHOULD provide the ability for the inter-area head-end LSR to be informed of the existence of a more optimal path in a downstream area and keep a strict control on the reoptimization process. Hence, the inter-area head-end LSR, once informed of a more optimal path in some downstream IGP areas, could decide (or not) to gracefully perform a make-before-break reoptimization, according to the inter-area TE LSP characteristics.

[7.10](#). Inter-area LSP Recovery.

[7.10.1](#). Rerouting of inter-area TE LSPs

The solution MUST support rerouting of an inter-area TE LSP in case of SRLG/link/node failure or pre-emption. Such rerouting may be controlled by the Head-End LSR or by an ABR (see [section 7.6](#) on crankback).

[7.10.2](#). Fast recovery of inter-area TE LSP

The solution MUST provide the ability to benefit from fast recovery making use of the local protection techniques specified in [FAST-REROUTE] in both the case of an intra-area network element failure (link/SRLG/Node) and an ABR node failure. Note that different

protection techniques SHOULD be usable in different parts of the network to protect an inter-area TE LSP. This is of the utmost importance in particular in the case of an ABR node failure that typically carries a great deal of inter-area traffic. Moreover, the solution SHOULD allow computing and setting up a backup tunnel following an optimal path that offers bandwidth guarantees during failure along with other potential constraints (like bounded propagation delay increase along the backup path).

The solution SHOULD allow to protect ABRs while providing the same level of performances (recovery delay, bandwidth consumption) as provided today within an area.

Note that some signalling approaches may have an impact on FRR performances (recovery delay, bandwidth consumption). Typically, when some intra-area LSPs (LSP-Segment, FA-LSPs) are used to support the inter-area TE LSP, then the protection of ABR using [[FAST-REROUTE](#)] may lead to higher bandwidth consumption, and higher recovery delays. The use of [[FAST-REROUTE](#)] to protect ABRs, while ensuring the same level of performances, currently requires to use a single end-to-end RSVP session (contiguous LSP), with no use of any intra-area LSP. Thus, the solution MUST provide the ability, via signalling on a per-LSP basis, to allow/preclude the use of intra-area LSPs to support the inter-area LSPs.

[7.11](#). DS-TE support

The proposed inter-area MPLS TE solution SHOULD also satisfy core requirements documented in [[DSTE-REQ](#)] and interoperate seamlessly with current intra-area MPLS DS-TE mechanism [[DSTE-PROTO](#)].

[7.12. Hierarchical LSP support](#)

In case of large inter-area MPLS deployment potentially involving a large number of LSRs, it can be desirable/necessary to introduce some level of hierarchy in order to reduce the number of states on LSRs (it is worth mentioning that such a solution implies other challenges). Hence, the proposed solution SHOULD allow inter-area TE LSP aggregation (also referred to as LSP nesting) such that individual TE LSPs can be carried onto one or more aggregating LSP(s). One such mechanism, for example is described in [[LSP-HIER](#)].

[7.13. Hard/Soft pre-emption](#)

As defined in [[MPLS-PREEMPT](#)], there are two pre-emption models applicable to MPLS: Soft and Hard Pre-emption

An inter-area MPLS-TE solution SHOULD support the two models.

In case of hard pre-emption, the pre-empted inter-area TE-LSP should be rerouted, following requirements defined in [section 7.10.1](#). In case of soft pre-emption, the pre-empted inter-area TE-LSP should be re-optimized, following requirements defined in [section 7.9](#).

[7.14. Auto-discovery of TE meshes](#)

A TE mesh is a set of LSRs, fully interconnected by a full mesh of TE-LSPs.

Because the number of LSRs participating in some TE mesh might be quite large, it might be desirable to provide some discovery mechanisms allowing an LSR to automatically discover the LSRs members of the TE mesh(es) that it belongs to. The discovery mechanism SHOULD be applicable across multiple IGP areas, and SHOULD not impact the IGP scalability, provided that IGP extensions are used for such a discovery mechanism.

[7.15. Inter-area MPLS TE fault management requirements](#)

The proposed solution SHOULD be able to interoperate with fault detection mechanisms of intra-area MPLS TE.

The solution SHOULD support [LSP-PING] and [[MPLS-TTL](#)].

The solution SHOULD also support for fault detection on backup LSPs, in case [[FAST-REROUTE](#)] is deployed.

[7.16.](#) Inter-area MPLS-TE and routing

In the case of intra-area MPLS TE, there are currently several possibilities to route traffic into an intra-area TE LSP. They are listed in [section 4.2](#).

In case of inter-area MPLS-TE, the solution MUST support static routing into the LSP, and also BGP recursive routing with a static route to the BGP next-hop address.

ABRs propagate IP reachability information (summary LSA in OSPF and IP reachability TLV in ISIS), that MAY be used by the head-end LSR to route traffic to a destination beyond the TE LSP tail-head LSR (e.g. to an ASBR).

The use of IGP shortcuts, MUST be precluded when TE LSP head-end and tail-end LSRs do not reside in the same IGP area. It MAY be used when they reside in the same area.

The advertisement of an inter-area TE LSP as a link into the IGP, to attract traffic to an LSP source MUST be precluded when TE LSP head-end and tail-end LSRs do not reside in the same IGP area. It MAY be used when they reside in the same area.

[8.](#) Evaluation criteria

[8.1.](#) Performances

The solution will be evaluated with respects to the following criteria:

- (1) Optimality of the computed inter-area TE LSP primary and backup paths, in terms of path cost.
- (2) Capability to share bandwidth among inter-area backup LSPs protecting independent facilities.
- (3) Inter-area TE LSP set up time (in msec).
- (4) RSVP-TE and IGP scalability (state impact, number of messages, message size)

[8.2.](#) Complexity and risks

The proposed solution(s) SHOULD not introduce complexity to the current operating network to such a degree that it would affect the stability and diminish the benefits of deploying such

solution over SP networks.

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[8.3.](#) Backward Compatibility

The deployment of inter-area MPLS TE SHOULD not have impact on existing MPLS TE mechanisms to allow for a smooth migration or co-existence. In particular the solution SHOULD allow the setup of an inter-area TE-LSP among transit LSRs that do not support inter-area extensions, provided that these LSRs do not participate in the inter-area TE procedure. For illustration purpose the solution MAY require inter-area extensions only on end-point LSRs, ABRs and potentially on PLRs protecting an ABR.

[9.](#) Security Considerations

This document does not introduce new security issues beyond those inherent in MPLS-TE [[RFC3209](#)] and may use the same mechanisms proposed for this technology. It is, however, specifically important that manipulation of administratively configurable parameters be executed in a secure manner by authorized entities.

[10.](#) Acknowledgements

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[11.](#) Intellectual Property Statement

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11.1. IPR Disclosure Acknowledgement

By submitting this internet-draft, I certify that any applicable patent or other IPR claims of which I am aware have been disclosed, or will be disclosed, and any of which I become aware will be disclosed, in accordance with [RFC 3668](#).

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