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OSPF Topology-Transparent Zone
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Abstract

This document presents a topology-transparent zone in an OSPF area. A topology-transparent zone comprises a group of routers and a number of links connecting these routers. Any router outside of the zone is not aware of the zone. The information about the links and routers such as a link down inside the zone is not advertised to any router outside of the zone.

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1. Introduction

Networks expand as business grows and traffic increases. For scalability and manageability, a hierarchical network architecture is usually deployed in OSPF networks by re-grouping routers into areas, which is often challenging and causes service interruptions.

At first, reorganizing a network from one area into multiple areas or from a number of existing areas into even more areas is a very challenging and time consuming task since it involves significant network architecture changes. Considering the one area case, originally the network has only one area, which is the backbone. This original backbone area will be reorganized into a new backbone and a number of non-backbone areas. In general, each of the non-backbone areas is connected to the new backbone area through the Area Border Routers (ABRs) between the non-backbone and the backbone area (refer to [RFC 2328 section 3](#)). It demands careful re-designing of network topology in advance to guarantee backbone area continuity and non-backbone area reachability, and requires significant modifications of configurations on many routers to ensure consistent routing.

Secondly, the services carried by the network may be interrupted while the network is being reorganized from one area into multiple areas or from a number of existing areas into even more areas since every OSPF interface with an area change is going down with its old area and then up with a new area.

This document presents a topology-transparent zone (TTZ) in an OSPF area and describes extensions to OSPF for supporting the topology-transparent zone, which is scalable and resolves the issues above.

2. Terminology

TTZ link or TTZ internal link: A link whose ends are within a single TTZ.

TTZ internal router: A router whose links are TTZ internal links inside a single TTZ.

TTZ external router: A router outside of a TTZ that has no TTZ internal links.

TTZ external link: A link not configured to be within a TTZ.

TTZ edge router: A router is called TTZ edge router if some, but not all, of its links are within a single TTZ.

TTZ router: A TTZ internal router or a TTZ edge router.

3. 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](#).

4. Requirements

A Topology-Transparent Zone may be deployed to resolve some critical issues in existing networks and future networks. The requirements for a TTZ are listed as follows:

- o Routers outside a TTZ MUST NOT require any changes to operate with the TTZ.
- o A TTZ MUST be enclosed in a single area.
- o A TTZ MUST hide the topology of the TTZ from any router outside of the TTZ.

5. Topology-Transparent Zone

5.1. Overview of Topology-Transparent Zone

A Topology-Transparent Zone is identified by a TTZ identifier (ID), and it consists of a group of routers and a number of links connecting the routers. A TTZ MUST be contained within an OSPF area.

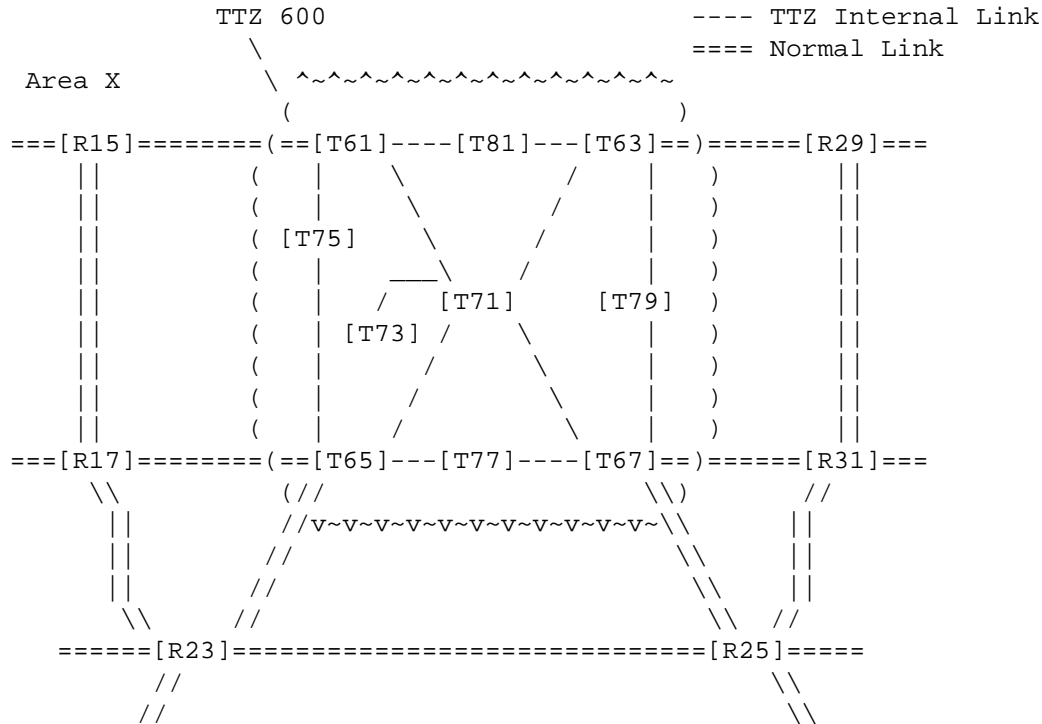
A TTZ ID is a 32-bit number that is unique for identifying a TTZ. The TTZ ID SHOULD NOT be 0.

In addition to having similar functions of an OSPF area, an OSPF TTZ makes some improvements on an OSPF area, which include:

- o An OSPF TTZ represents a set of TTZ edge routers, connected by a full mesh of virtual connections between them.
- o Non-TTZ link state information is handled as normal. TTZ Routers receive the link state information about the topology outside of the TTZ, store the information, and flood the information through the TTZ to the routers outside of the TTZ.

5.2. TTZ Example

The figure below shows an area containing a TTZ: TTZ 600.



All the routers in the figure are in area X. Routers with T (i.e., T61, T63, T65, T67, T71, T73, T75, T77, T79 and T81) are also in TTZ 600, which contains the TTZ internal links connecting them. To create a TTZ, we need configure it (refer to [section 11](#)).

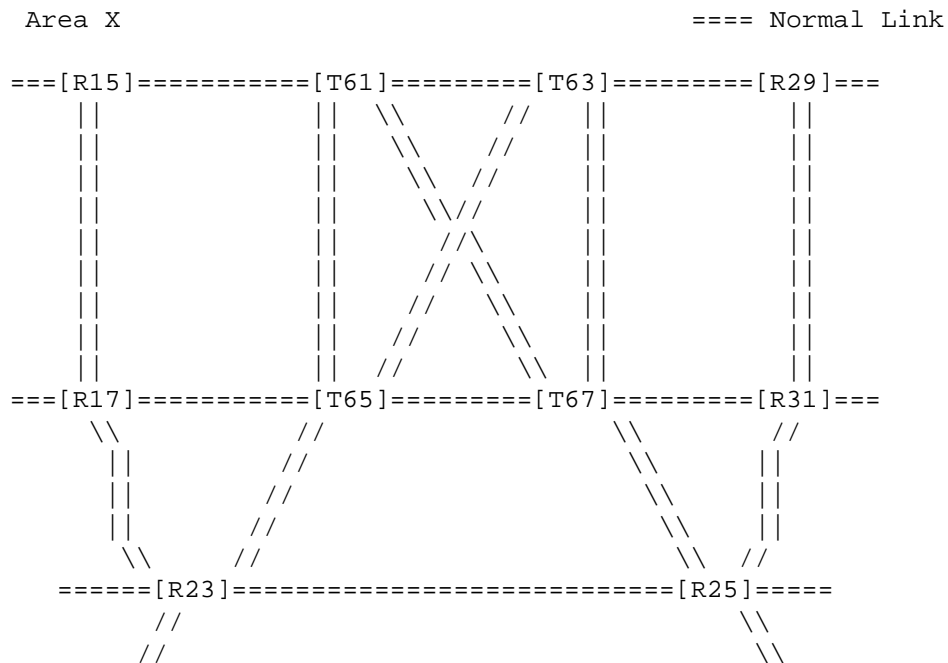
There are two types of routers in a TTZ: TTZ internal and TTZ edge routers. TTZ 600 has four TTZ edge routers T61, T63, T65 and T67. Each of them has at least one adjacent router in TTZ 600 and one adjacent router outside of TTZ 600. For instance, router T61 is a TTZ edge router since it has an adjacent router R15 outside of TTZ 600 and three adjacent routers T75, T71 and T81 in TTZ 600.

In addition, TTZ 600 comprises six TTZ internal routers T71, T73, T75, T77, T79 and T81. Each of them has all its adjacent routers in TTZ 600. For instance, router T71 is a TTZ internal router since its adjacent routers T61, T63, T65, T67 and T73 are all in TTZ 600. It should be noted that by definition, a TTZ internal router cannot also be an ABR.

A TTZ hides the internal topology of the TTZ from the outside. It does not directly advertise any internal information about the TTZ to a router outside of the TTZ.

For instance, TTZ 600 does not send the information about TTZ internal router T71 to any router outside of TTZ 600; it does not send the information about the link between TTZ router T61 and T71 to any router outside of TTZ 600.

The figure below illustrates area X from the point of view on a router outside of TTZ 600 after TTZ 600 is created.



From a router outside of the TTZ, a TTZ is seen as the TTZ edge routers connected each other. For instance, router R15 sees that T61, T63, T65 and T67 are connected each other.

In addition, a router outside of the TTZ sees TTZ edge routers having normal connections to the routers outside of the TTZ. For example, router R15 sees that T61, T63, T65 and T67 have the normal connections to R15, R29, R17 and R23, R25 and R31 respectively.

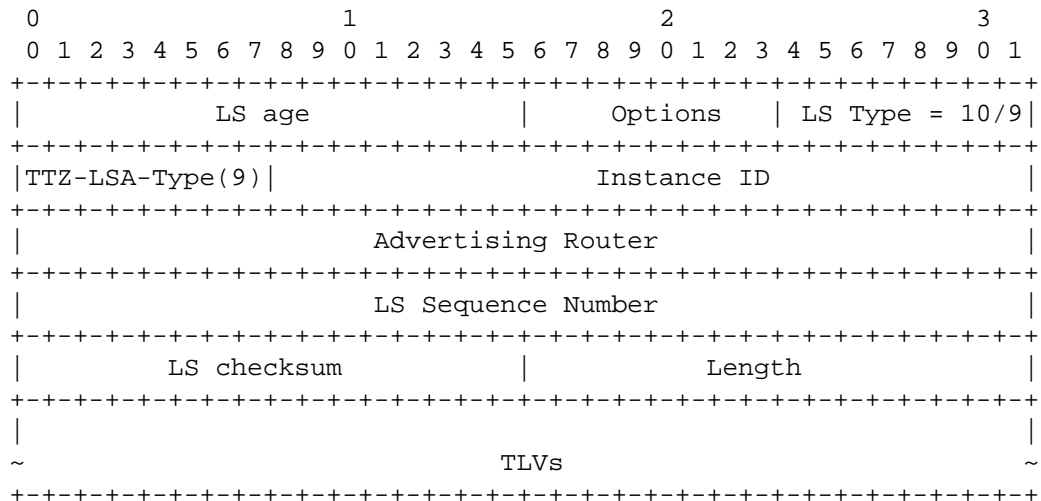
6. Extensions to OSPF Protocols

The link state information about a TTZ includes router LSAs, which

can be contained and advertised in opaque LSAs [RFC5250] within the TTZ. Some control information regarding a TTZ can also be contained and advertised in opaque LSAs within the TTZ. These opaque LSAs are called TTZ opaque LSAs or TTZ LSAs for short.

6.1. General Format of TTZ LSA

The following is the general format of a TTZ LSA. It has an LS Type = 10/9 and TTZ-LSA-Type, and contains a number of TLVs.



Where TTZ-LSA-Type is 9, the exact number is to be assigned by IANA.

There are three TTZ LSAs of LS Type 10 defined:

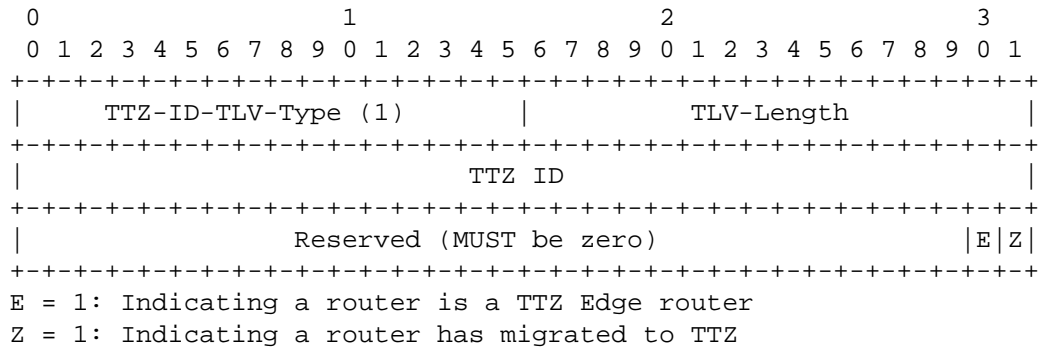
- o TTZ Router LSA: a TTZ LSA containing a TTZ ID TLV and a TTZ Router TLV.
- o TTZ Control LSA: a TTZ LSA containing a TTZ ID TLV and a TTZ Options TLV.
- o TTZ Indication LSA: a TTZ LSA containing a TTZ ID TLV with E = 0, which indicates that the router originating this LSA is a TTZ internal router.

There is one TTZ LSA of LS Type 9:

- o TTZ Discovery LSA: a TTZ LSA containing a TTZ ID TLV and a optional TTZ Options TLV.

6.2. TTZ ID TLV

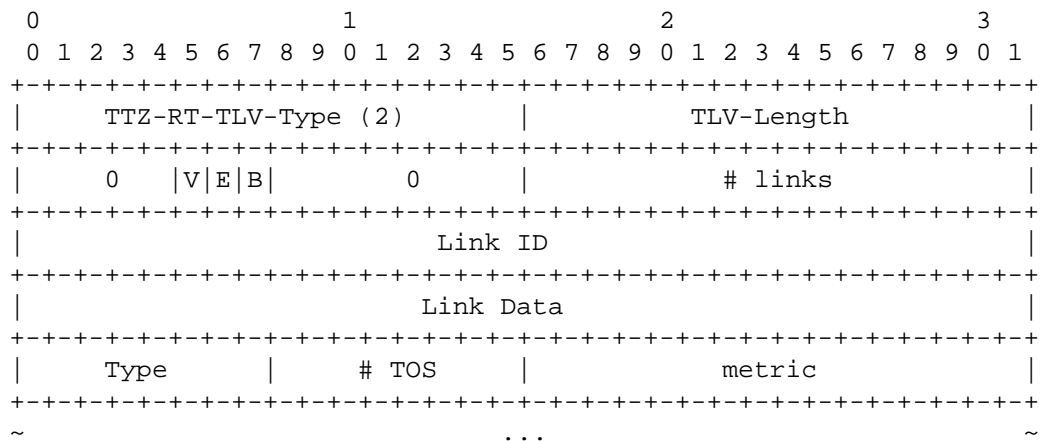
A TTZ ID TLV has the following format. It contains a TTZ ID and some flags.



When a TTZ router originates a TTZ LSA containing a TTZ ID TLV, it sets flag E to 1 in the TTZ ID TLV if it is a TTZ edge router, and to 0 if it is a TTZ internal router. It sets flag Z to 1 after it has migrated to TTZ.

6.3. TTZ Router TLV

The format of a TTZ Router TLV is as follows. It has the same content as a standard OSPF Router LSA ([RFC 2328](#)) with the following modifications.



For a router link, the existing eight bit Type field for a router link is split into two fields as follows:

```

      0   1   2   3   4   5   6   7
+-----+-----+-----+-----+
| I |           Type-1           |
+-----+-----+-----+-----+

```

I bit flag:

1: Router link is a TTZ internal link.

0: Router link is a TTZ external link.

Type-1: The kind of the link. The values for Type-1 are the same as those for Type defined in [RFC 2328 section 12.4.1](#).

6.4. TTZ Options TLV

The format of a TTZ Options TLV is as follows.

```

      0               1               2               3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-----+-----+-----+-----+-----+-----+-----+-----+
|           TTZ-OP-TLV-Type (3)           |           TLV-Length           |
+-----+-----+-----+-----+-----+-----+-----+-----+
| OP |           Reserved (MUST be zero)           |
+-----+-----+-----+-----+-----+-----+-----+-----+
OP Value      Meaning (Operation)
0x001 (T):    Advertising TTZ Topology Information for Migration
0x010 (M):    Migrating to TTZ
0x011 (N):    Advertising Normal Topology Information for Rollback
0x100 (R):    Rolling back from TTZ

```

A OP field of three bits is defined. It may have a value of 0x001 for T, 0x010 for M, 0x011 for N, or 0x100 for R, which indicates one of the four operations above. When any of the other values is received, it is ignored.

Advertising TTZ Topology Information for Migration (T): After a user configures a TTZ router to advertise TTZ topology information, advertising TTZ topology information for migration is triggered. The TTZ router originates a TTZ Control LSA having a TTZ Options TLV with OP for T. It also originates its other TTZ LSA such as a TTZ router LSA or TTZ indication LSA. When another TTZ router receives the LSA with OP for T, it originates its TTZ LSA as described below.

Migrating to TTZ (M): After a user configures a TTZ router to migrate to TTZ, migrating to TTZ is triggered. The TTZ router originates a TTZ Control LSA having a TTZ Options TLV with OP for M and migrates to TTZ. When another TTZ router receives the LSA with OP for M, it also migrates to TTZ. When a router migrates to TTZ, it computes routes using the TTZ topology and the topology outside of the TTZ.

For a TTZ internal router, it also updates its TTZ indication LSA with $Z = 1$. For a TTZ edge router, it updates its TTZ router LSA with $Z = 1$ and its router LSA for virtualizing the TTZ.

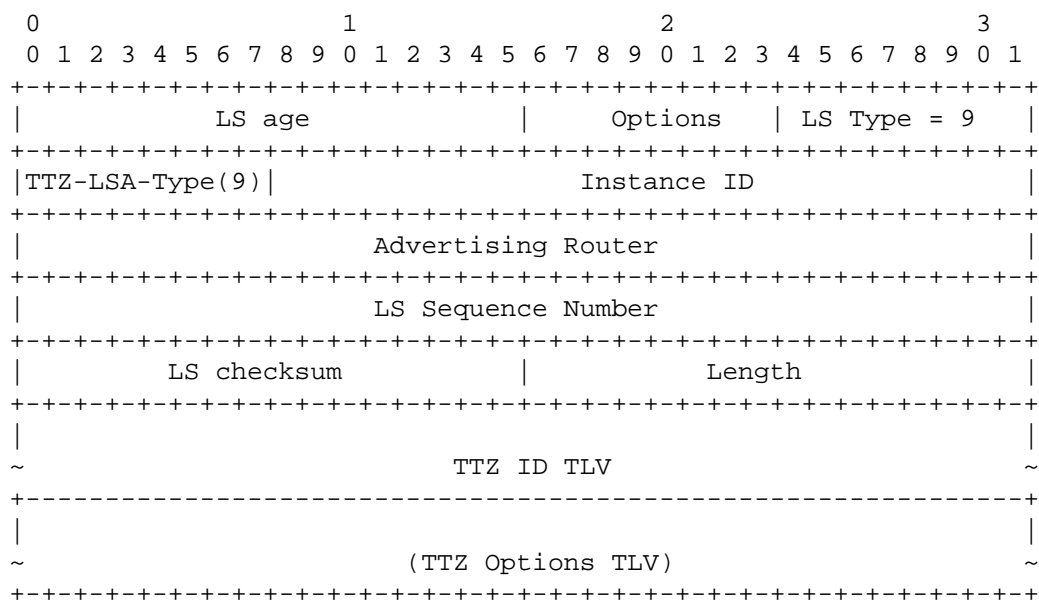
Advertising Normal Topology Information for Rollback (N): After a user configures a TTZ router to advertise normal topology information, advertising Normal topology information for rollback is triggered. The TTZ router originates a TTZ Control LSA having a TTZ Options TLV with OP for N. It also advertises its normal LSAs such as its normal router LSA and stops advertising its other TTZ LSAs. When another TTZ router receives the LSA with OP for N, it advertises its normal LSAs and stops advertising its TTZ LSAs.

Rolling back from TTZ (R): After a user configures a TTZ router to roll back from TTZ, rolling back from TTZ is triggered. The TTZ router originates a TTZ Control LSA having a TTZ Options TLV with OP for R and rolls back from TTZ. When another TTZ router receives the LSA with OP for R, it also rolls back from TTZ.

After a TTZ router originates a TTZ control LSA in response to a configuration described above to control TTZ, it flushes the TTZ control LSA if OP in the LSA is set for the configuration and the configuration is removed.

6.5. Link Scope TTZ LSA

A TTZ LSA of LS Type 9 has the following format.



It contains a mandatory TTZ ID TLV, which may be followed by a optional TTZ Options TLV. It is used to discover a TTZ neighbor.

7. Constructing LSAs for TTZ

For a TTZ, its topology is represented by the LSAs generated by its TTZ routers for the link states in the TTZ, which include TTZ router LSAs, TTZ indication LSAs, normal router LSAs and network LSAs. The TTZ router LSAs and TTZ indication LSAs are generated after advertising TTZ topology information for migration is triggered.

A TTZ router LSA generated by a TTZ edge router has a TTZ ID TLV and a TTZ Router TLV. The former includes the ID of the TTZ to which the router belongs and flag E set to 1, which indicates the originator of the LSA is a TTZ Edge router. For a TTZ edge router, its normal Router LSA content is copied into a TTZ Router TLV with the modifications described in [section 6](#), and a TTZ router LSA containing this TLV is constructed and advertised.

A TTZ indication LSA generated by a TTZ internal router has a TTZ ID TLV containing the ID of the TTZ to which the router belongs and flag E set to 0, which indicates the originator of the LSA is a TTZ internal router. For a TTZ internal router, its regular Router LSA is still generated. If a TTZ router is a DR, it originates its regular network LSA.

After receiving a trigger to migrate to TTZ such as a TTZ control LSA with OP for M, a TTZ edge router originates its normal router LSA for virtualizing a TTZ, which comprises three groups of links in general.

The first group are the router links connecting the TTZ external routers. These router links are normal router links. There is a router link for every adjacency between this TTZ edge router and a TTZ external router.

The second group are the "virtual" router links connecting to the other TTZ edge routers. For each of the other TTZ edge routers, there is a corresponding point-to-point router link to it from this TTZ edge router. The cost of the link is the cost of the shortest path from this TTZ edge router to the other TTZ edge router within the TTZ.

In addition, the LSA may contain a third group of links, which are the stub links for the loopback addresses inside the TTZ to be accessed by nodes outside of the TTZ.

7.1. TTZ Migration Process

After migration to TTZ is triggered, a TTZ router computes routes using its TTZ topology (refer to [section 10](#)) and a TTZ edge router originates its normal router LSA for virtualizing the TTZ in two steps:

Step 1: The router updates its router LSA by adding a point-to-point link to each of the other known edge routers in the TTZ, and also by adding the stub links for the loopback addresses in the TTZ to be accessed outside of the TTZ.

Step 2: After MaxLSAGenAdvTime (0.3 s) or sr-time + MaxLSAAdvTime (0.1 s), it removes the TTZ links from its router LSA, where sr-time is the time from updating its router LSA to receiving the ack for its router LSA and receiving the updated router LSAs originated by the other TTZ edge routers. In other words, it removes the TTZ links from its router LSA after sending its updated router LSA and receiving the updated router LSAs originated by the other TTZ edge routers for MaxLSAAdvTime or after sending its updated router LSA for MaxLSAGenAdvTime (refer to [Appendix A](#)).

This is to avoid a possible short route down or change in a TTZ external router while the TTZ is being virtualized. If each TTZ edge router originates its router LSA by adding its point-to-point links to the other TTZ edge routers and removing its TTZ links in one step, a route taking a path through the TTZ in the TTZ external router may be down or changed before all the router LSAs generated by the TTZ edge routers reach the TTZ external router. When the TTZ external router computes routes with some router LSAs originated by the TTZ edge routers, bi-directional check for some of the point-to-point links will fail. Thus the route taking the path through the shortest path for the point-to-point link failing the bi-directional check will be down or changed.

To roll back from a TTZ smoothly after receiving a trigger to roll back from TTZ, a TTZ edge router originates its normal router LSA in the above two steps in a reverse way.

Step 1: Initially, it updates its normal router LSA by adding the normal links for the links configured as TTZ links into the LSA.

Step 2: It then removes the point-to-point links to the other edge routers of the TTZ for virtualizing the TTZ and the stub links for the loopback addresses from its updated router LSA after sending its updated router LSA and receiving the updated router LSAs originated by the other TTZ edge routers for MaxLSAAdvTime or

after sending its updated router LSA for MaxLSAGenAdvTime.

8. Establishing Adjacencies

This section describes the TTZ adjacencies.

8.1. Discovery of TTZ Neighbors

For two routers A and B connected by a P2P link and having a normal adjacency, they TTZ discover each other through a TTZ LSA of LS Type 9 with a TTZ ID TLV. We call this LSA D-LSA for short.

If two ends of the link have different TTZ IDs or only one end is configured with TTZ ID, no TTZ adjacency over the link will be "formed".

If two ends of the link have the same TTZ ID and Z flag value, A and B are TTZ neighbors. The following is a sequence of events related to TTZ for this case.

A		B
Configure TTZ		Configure TTZ
	D-LSA (TTZ-ID=100)	
	----->	Same TTZ ID and Z
		A is B's TTZ Neighbor
	D-LSA (TTZ-ID=100)	
Same TTZ ID and Z <-----		
B is A's TTZ Neighbor		

A sends B a D-LSA with TTZ-ID after the TTZ is configured on it. B sends A a D-LSA with TTZ-ID after the TTZ is configured on it.

When A receives the D-LSA from B and determines they have the same TTZ ID and Z flag value, B is A's TTZ neighbor. A also sends B all the TTZ LSAs it has and originates its TTZ LSA when one of the following conditions is met.

- o Z = 0 and there is a TTZ LSA with OP for T.
- o Z = 1.

B is symmetric to A and acts similarly to A.

If two ends of the link have the same TTZ ID but Z flags are different, a TTZ adjacency over the link is "formed" in the following steps. Suppose that A has migrated to TTZ and B has not (i.e., flag

Z in A's D-LSA is 1 and flag Z in B's D-LSA is 0).

```

      A                                     B
  Configure TTZ                           Configure TTZ

      D-LSA(TTZ-ID=100,Z=1)
      -----> Same TTZ ID, but
                  different Z
                  A is B's TTZ Neighbor

      D-LSA(TTZ-ID=100,Z=0)
  Same TTZ ID, but <-----
  different Z
  B is A's TTZ Neighbor

      TTZ LSAs
      ----->
      TTZ LSAs
  <-----

```

When A receives the D-LSA from B and determines they have the same TTZ ID but its Z = 1 and B's Z = 0, A sends B all the TTZ LSAs it has and triggers B to migrate to TTZ. A updates and sends B its D-LSA by adding an TTZ Options TLV with OP for M after sending B all the TTZ LSAs.

```

      D-LSA(TTZ-ID=100,OP=M)
  Add TTZ Options -----> Migrate to TTZ
  TLV with OP for M

      D-LSA(TTZ-ID=100,Z=1) Migrated to TTZ
  <----- Set Z=1

      D-LSA(TTZ-ID=100,Z=1)
  Remove ----->
  TTZ Options TLV

```

When B receives the D-LSA from A and determines they have the same TTZ ID but its Z = 0 and A's Z = 1, B sends A all the TTZ LSAs it has.

When B receives the D-LSA from A with OP for M, it starts to migrate to TTZ. B updates and advertises its LSAs as needed.

After receiving B's D-LSA with Z = 1, A updates and sends B its D-LSA by removing the TTZ Options TLV. It also updates and advertises its LSAs as needed.

For a number of routers connected through a broadcast link and having normal adjacencies among them, they also TTZ discover each other

through D-LSAs. The DR for the link "forms" TTZ adjacencies with the other routers if all the routers attached to the link have the same TTZ ID configured on the connections to the link. Otherwise, the DR does not "form" any TTZ adjacency with any router attached to the link.

For a number of routers connected through a broadcast link and having TTZ adjacencies among them, if a mis-configured router is introduced on the broadcast link, the DR for the link will not "form" any TTZ adjacency with this mis-configured router.

For routers connected via a link without any adjacency among them, they TTZ discover each other through D-LSAs in the same way as described above after they form a normal adjacency.

A TTZ adjacency over a link is removed when one of the following events happens.

- o TTZ ID on one end of the link is changed to a different one.
- o TTZ ID on one end of the link is removed.
- o D-LSA is not received for sometime such as 60 minutes or is flushed.
- o Normal adjacency over the link is down.

When the TTZ ID on one end of the link is removed, the corresponding D-LSA is flushed.

8.2. Adjacency between TTZ Edge and TTZ External Router

A TTZ edge router forms an adjacency with any TTZ external router to which it is connected.

When the TTZ edge router synchronizes its link state database with the TTZ external router, it sends the TTZ external router the information about all the LSAs except for the LSAs belonging to the TTZ that are hidden from any router outside of the TTZ.

At the end of the link state database synchronization, the TTZ edge router originates its own router LSA for virtualizing the TTZ and sends this LSA to its adjacent routers including the TTZ external router.

9. Advertisement of LSAs

LSAs can be divided into a couple of classes according to their Advertisements. The first class of LSAs is advertised within a TTZ. The second is advertised through a TTZ.

9.1. Advertisement of LSAs within TTZ

Any LSA about a link state in a TTZ is advertised only within the TTZ. It is not advertised to any router outside of the TTZ. For example, a router LSA generated for a TTZ internal router is advertised only within the TTZ.

Any network LSA generated for a broadcast or NBMA network in a TTZ is advertised only within the TTZ. It is not advertised outside of the TTZ.

Any opaque LSA generated for a TTZ internal TE link is advertised only within the TTZ.

After migrating to TTZ, every edge router of a TTZ MUST NOT advertise any LSA about a link state in the TTZ to any router outside of the TTZ.

For any TTZ LSA originated by a router within the TTZ, every edge router of the TTZ MUST NOT advertise it to any router outside of the TTZ.

9.2. Advertisement of LSAs through TTZ

Any LSA about a link state outside of a TTZ received by an edge router of the TTZ is advertised using the TTZ as transit. For example, when an edge router of a TTZ receives an LSA from a router outside of the TTZ, it floods it to its neighboring routers both inside the TTZ and outside of the TTZ. This LSA may be any LSA such as a router LSA that is advertised within an OSPF area.

The routers in the TTZ continue to flood the LSA. When another edge router of the TTZ receives the LSA, it floods the LSA to its neighboring routers both outside of the TTZ and inside the TTZ.

10. Computation of Routing Table

After a router migrates to TTZ, the computation of the routing table on the router is the same as that described in [RFC 2328 section 16](#) with one exception. The router in a TTZ ignores the router LSAs generated by the TTZ edge routers for virtualizing the TTZ. This can

be achieved by adding a flag into every link stored in LSDB and setting this flag to 1 in every link in these router LSAs, which indicates that the link is unusable. It computes routes using the TTZ topology (i.e., using LSAs for representing the TTZ) and the topology outside of the TTZ, excluding any unusable links. The LSAs for representing a TTZ are described in [Section 7](#).

11. Operations

11.1. Configuring TTZ

This section proposes some options for configuring a TTZ.

1. Configuring TTZ on Every Link in TTZ

If every link in a TTZ is configured with a same TTZ ID as a TTZ link, the TTZ is determined. A router with some TTZ links and some normal links is a TTZ edge router. A router with only TTZ links is a TTZ internal router.

2. Configuring TTZ on Every Router in TTZ

A same TTZ ID is configured on every router in a TTZ, and on every TTZ edge router's links connecting to the routers in the TTZ.

A router configured with the TTZ ID on some of its links is a TTZ edge router. A router configured with the TTZ ID only is a TTZ internal router. All the links on a TTZ internal router are TTZ links. This option is simpler than option 1 above.

11.2. Migration to TTZ

For a group of routers and a number of links connecting the routers in an area, making them transfer to work as a TTZ without any service interruption takes a few of steps or stages.

At first, a user configures the TTZ feature on every router in the TTZ. In this stage, a router does not originate or advertise its TTZ topology information. It will discover its TTZ neighbors.

Secondly, after configuring the TTZ, a user issues a CLI command on one router in the TTZ, which triggers every router in the TTZ to generate and advertise TTZ information among the routers in the TTZ. When the router receives the command, it originates a TTZ control LSA with OP for T (indicating TTZ information generation and advertisement for migration). It also originates its TTZ LSA such as TTZ router LSA or TTZ indication LSA, and advertises the LSA to its

TTZ neighbors. When another router in the TTZ receives the LSA with OP for T, it originates its TTZ LSA. In this stage, every router in the TTZ has dual roles. One is to function as a normal router. The other is to generate and advertise TTZ information.

Thirdly, a user checks whether a router in the TTZ is ready for migration to TTZ. A router in the TTZ is ready after it has received all the necessary information from all the routers in the TTZ. This information may be displayed on a router through a CLI command.

And then a user activates the TTZ through using a CLI command such as migrate to TTZ on one router in the TTZ. The router migrates to TTZ, generates and advertises a TTZ control LSA with OP for M (indicating Migrating to TTZ) after it receives the command. After another router in the TTZ receives the TTZ control LSA with OP for M, it also migrates to TTZ. Thus, activating the TTZ on one TTZ router propagates to every router in the TTZ, which migrates to TTZ.

For an edge router of the TTZ, migrating to work as a TTZ router comprises generating a router LSA to virtualize the TTZ and flooding this LSA to all its neighboring routers in two steps as described in [section 7](#).

In normal operations for migration to TTZ and rollback from TTZ, a user issues a series of commands according to certain procedures. In an abnormal case, for example two conflicting commands are issued on two TTZ routers in a TTZ at the same time, a TTZ router issues an error and logs the error when it detects a conflict.

A conflicting command may be detected on a router on which the command is issued. Thus some abnormal cases may be prevented. When a command for migration/rollback is issued on a router, the router checks whether it is in a correct sequence of commands for migration/rollback through using the information it has. For migrating a part of an area to a TTZ, the correct sequence of commands is as follows in general:

- 1) configure TTZ on every router in the part of the area to be migrated to TTZ;
- 2) configure on one router in the TTZ to trigger every router in the TTZ to generate and advertise TTZ information for migration; and
- 3) configure on one router in the TTZ to trigger every router in the TTZ to migrate to TTZ.

For rolling back from TTZ, it is similar.

After receiving a command on a router to migrate to TTZ, which is for 3), the router checks whether 2) is performed through checking if it has received/originated TTZ LSAs. If it has not, it issues an error to an operator (generation and advertisement of TTZ information for migration to TTZ is not done yet) and rejects the command at this time.

After a router receives a TTZ LSA with OP for M for 3) from another router, it checks whether 2) is performed through checking if it has received/originated TTZ LSAs. If it has not, it issues an error and logs the error. The operation for migration will continue.

After receiving a command on a router to generate and advertise TTZ information, which is for 2), the router checks whether 1) is performed through checking if TTZ is configured on it. If it is not, it issues an error to an operator (TTZ is not configured on it yet) and rejects the command at this time.

11.3. Adding a Router into TTZ

When a non TTZ router (say R1) is connected via a P2P link to a migrated TTZ router (say T1), and there is a normal adjacency between them over the link, a user can configure TTZ on both ends of the link to add R1 into the TTZ to which T1 belongs. They TTZ discover each other as described in [section 8](#).

When a number of non TTZ routers are connected via a broadcast or NBMA link to a migrated TTZ router (say T1), and there are normal adjacencies among them, a user configures TTZ on the connection to the link on every router to add the non TTZ routers into the TTZ to which T1 belongs. The DR for the link "forms" TTZ adjacencies with the other routers connected to the link if they all have the same TTZ ID configured for the link. This is determined through the TTZ discovery process described in [section 8](#).

12. Manageability Considerations

[Section 11](#) (Operations) outlines the configuration process and deployment scenarios for a TTZ. The configurable item is enabling a TTZ on a router and/or an interface on a router. The TTZ function may be controlled by a policy module and assigned a suitable user privilege level to enable. A suitable model may be required to verify the TTZ status on routers participating in the TTZ, including their role as internal or edge TTZ router. The mechanisms defined in this document do not imply any new liveness detection and monitoring requirements in addition to those indicated in [\[RFC2328\]](#).

13. Prototype Implementation

13.1. What are Implemented and Tested

1. CLI Commands for TTZ

The CLIs implemented and tested include:

- o the CLIs of the simpler option for configuring TTZ, and
- o the CLIs for controlling migration to TTZ.

2. Extensions to OSPF Protocols for TTZ

All the extensions defined in section "Extensions to OSPF Protocols" are implemented and tested except for rolling back from TTZ. The testing results illustrate:

- o A TTZ is virtualized to outside as its edge routers connected each other. Any router outside of the TTZ sees the edge routers (as normal routers) connecting each other and to some other routers.
- o The link state information about the routers and links inside the TTZ is contained within the TTZ. It is not advertised to any router outside of the TTZ.
- o TTZ is transparent. From a router inside a TTZ, it sees the topology (link state) outside of the TTZ. From a router outside of the TTZ, it sees the topology beyond the TTZ. The link state information outside of the TTZ is advertised through the TTZ.
- o TTZ is backward compatible. Any router outside of a TTZ does not need to support or know TTZ.

3. Smooth Migration to TTZ

The procedures and related protocol extensions for smooth migration to TTZ are implemented and tested. The testing results show:

- o A part of an OSPF area is smoothly migrated to a TTZ without any routing disruptions. The routes on every router are stable while the part of the area is being migrated to the TTZ.
- o Migration to TTZ is very easy to operate.

4. Add a Router to TTZ

Adding a router into TTZ is implemented and tested. The testing

results illustrate:

- o A router can be easily added into a TTZ and becomes a TTZ router.
- o The router added into the TTZ is not seen on any router outside of the TTZ, but it is a part of the TTZ.

5. Leak TTZ Loopbacks Outside

Leaking loopback addresses in a TTZ to routers outside of the TTZ is implemented and tested. The testing results illustrate:

- o The loopback addresses inside the TTZ are advertised to the routers outside of the TTZ.
- o The loopback addresses are accessible from a router outside of the TTZ.

13.2. Implementation Experience

The implementation of TTZ is relatively easy compared to other features of OSPF. Re-using the existing OSPF code along with additional simple logic does the work. A couple of engineers started to work on implementing the TTZ from the middle of June, 2014 and finished coding it just before the end of July, 2014. After some testing and bug fixes, it works as expected.

In our implementation, the link state information in a TTZ opaque LSA is stored in the same link state database as the link state information in a normal LSA. For each TTZ link in the TTZ opaque LSA, there is an additional flag, which is used to differentiate between a TTZ link and a Normal link.

Before migration to TTZ, every router in the TTZ computes its routing table using the normal links. After migration to TTZ, every router in the TTZ computes its routing table using the TTZ links and normal links. In the case where both the TTZ link and the normal link exist, the TTZ link is used.

14. Security Considerations

The mechanism described in this document does not raise any new security issues for the OSPF protocols since a TTZ is enclosed in a single area. TTZ relies on the OSPF security mechanisms in place and has the same security threat surface.

15. IANA Considerations

Under Registry Name: Opaque Link-State Advertisements (LSA) Option Types [[RFC5250](#)], IANA is requested to assign a new Opaque type registry value for Topology-Transparent Zone (TTZ) LSA as follows:

Registry Value	Opaque Type	reference
IANA TBD (9 Suggested)	TTZ LSA	This document

IANA is requested to assign Types for new TLVs in the new TTZ LSA as follows:

Type	Name	Allowed in
1	TTZ ID TLV	TTZ LSA of LS Type 10 and 9
2	TTZ Router TLV	TTZ LSA of LS Type 10
3	TTZ Options TLV	TTZ LSA of LS Type 10 and 9

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Appendix A. Constants for LSA Advertisement

MaxLSAAdvTime: The maximum time for an LSA to be advertised to all the routers in an area. The value of MaxLSAAdvTime is set to 0.1 second.

MaxLSAGenAdvTime: The maximum time for all TTZ router LSAs to be generated by all TTZ edge routers and advertised to all the routers in an area after a first TTZ router LSA is generated. The value of MaxLSAGenAdvTime is set to 0.3 second.

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