The OSPF NSSA Option

Status of this Memo

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1.0 Abstract

This memo documents of an optional type of OSPF area which is
somewhat humorously referred to as a "not-so-stubby" area (or NSSA).
NSSAs are similar to the existing OSPF stub area configuration option
but have the additional capability of importing AS external routes in
a limited fashion.

The OSPF NSSA Option was originally defined in RFC 1587. The functional
differences between this memo and RFC 1587 are explained in Appendix D.
All differences, while expanding capability, are backward-compatible in
nature. Implementations of this memo and of RFC 1587 will interoperate.

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[2.0](#) Overview

[2.1](#) Motivation - transit networks

   Wide-area transit networks (such as the NSFNET regionals) often have
   connections to moderately-complex "leaf" sites. A leaf site may have
   multiple IP network numbers assigned to it.

   Typically, one of the leaf site's networks is directly connected to a
   router provided and administered by the transit network while the
   others are distributed throughout and administered by the site. From
   the transit network's perspective, all of the network numbers
   associated with the site make up a single "stub" entity. For example,
   BBN Planet has one site composed of a class-B network, 130.57.0.0,
   and a class-C network, 192.31.114.0. From BBN Planet's perspective,
   this configuration looks something like this:

```
                192.31.114
                    |
                  (cloud)
               -------------- 130.57.4
                    |
                    |
               ------ 131.119.13 ------
               |BR18|------------|BR10|
               ------            ------
                                    |
                                    V
                          to BBN Planet "core" OSPF system
```
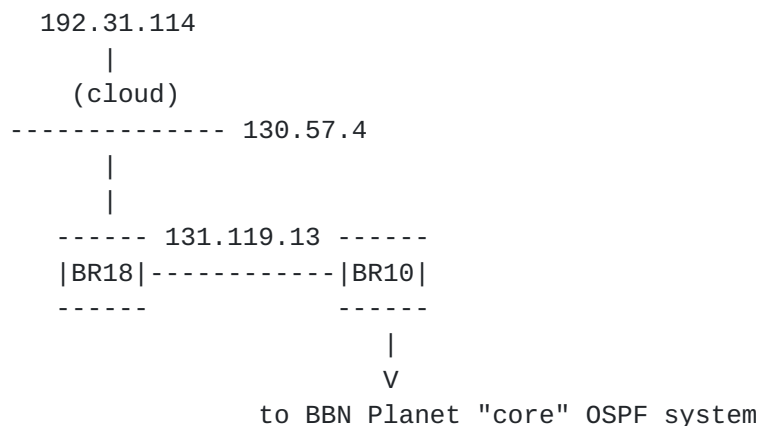

   where the "cloud" consists of the subnets of 130.57 and network
   192.31.114, all of which are learned by RIP on router BR18.
   Topologically, this cloud looks very much like an OSPF stub area. The
   advantages of running the cloud as an OSPF stub area are:

           1. Type-5 routes (OSPF external link-state advertisements
              (LSAs)) are not advertised beyond the router labeled
              "BR10". This is advantageous because the link between
              BR10 and BR18 may be a low-speed link or the router BR18
              may have limited resources.

           2. The transit network is abstracted to the "leaf" router
              BR18 by advertising only a default route across the link
              between BR10 and BR18.

           3. The cloud becomes a single, manageable "leaf" with
              respect to the transit network.

> 4. The cloud can become, logically, a part of the transit
>   network's OSPF routing system.

> 5. Translated type-5 LSAs that are sent into the backbone
>   from the cloud (which is a separate stub area) may be
>   considered "leaf" nodes when performing the Dijkstra
>   calculation.

However, the current definition of the OSPF protocol [1] imposes
topological limitations which restrict simple cloud topologies from
becoming OSPF stub areas. In particular, it is illegal for a stub
area to import routes external to OSPF; it is not possible for
routers BR18 and BR10 to both be members of the stub area and to
import the routes learned from RIP or other IP routing protocols as
type-5 (OSPF external LSAs) into the OSPF system. In order to run
OSPF out to BR18, BR18 must be a member of a non-stub area or the
OSPF backbone before it can import routes other than its
directly-connected network(s). Since it is not acceptable for BR18 to
maintain all of BBN Planet's external (type-5) routes, BBN Planet
is forced by OSPF's topological limitations to only run OSPF out to
BR10 and to run RIP between BR18 and BR10.

2.2 Motivation - corporate networks

In a corporate network which supports a large corporate infrastructure it
is not uncommon for OSPF area 0 to have a large area infrastructure
injecting large routing tables into area 0. Organizations within the
corporate infrastructure may routinely multi-home their non-0 OSPF areas
to strategically located backbone area 0 routers, either to provide
backbone redundancy or increase backbone connectivity or both. Because
of these large routing tables, OSPF aggregation via summarization is
routinely used and recommended. Stub areas are also recommended to keep
the size of the non-zero routing tables small. Organizations within the
corporation are administratively autonomous and compete for corporate
backbone resources. They also want isolation from each other in order
protect their own network resources within the organization.

Consider a typical backbone connection, as shown on the next page, where
routers An, Bn are connected to their respective area n's and routers A0
and B0 are border routers to both area 1 and area 2. Serial lines are
displayed, but several ethernets, not displayed, may also connect from
the connected areas at each router depicted internal to Areas 1 and 2.
Assume the 192.243.192/20 and 192.243.208/22 clouds are subnetted with a
protocol foreign to the corporate OSPF process. These processes could be
RIP, IGRP, or second and third OSPF processes separate from the corporate
OSPF backbone process.

```
          /---A0-----Area 0(cloud)------B0---\
          |   |                         |    |
    56kbs|   |T1            19.2 dialup|    |T1
          |   |                         |    |
          |   A1-----Area 1(cloud)------B1   |
          |   |    T1                T1 |    |
          | T1|                         |T1 |
          |   \---192.243.192/20 cloud---/   |
          |                             |
          \---A2-----Area 2(cloud)------B2---/
              |   T1                T1  |
              |                         |
              \---192.243.208/22 cloud---/
```
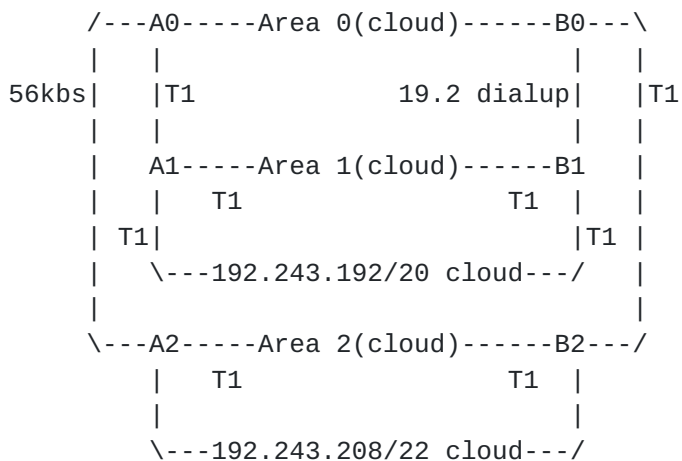
As a matter of policy, the corporate network administrators want
192.243.192/20 and 192.243.208/22 aggregated to the backbone. This
policy conflicts with both Area 1 and Area 2's desire to see the
aggregate's subnetted infrastructures learned from Area 1's internal
routers A1 and B1 and Area 2's internal routers A2 and B2 from which it
can make efficient routing decisions. The current standard OSPF stub
area has no mechanism to support the redistribution of routes for
192.243.192/20 and 192.243.208/22 subnets within their respective areas.
If one assumes that both the Area 1 and Area 2 clouds are extremely large
with internally very large routing tables originating from a complex OSPF
link state topology and subnetting scheme, neither Area 1 or Area 2 wants
to be at the mercy of either the other area's summary links
advertisements or external links advertisements. Thus standard OSPF
areas are not an option either.

Any solution to this dilemma must honor Area 1's path of choice through
A0 with redundancy through B0 while at the same time honoring Area 2's
path of choice through B0 with redundancy through A0. Furthermore, such
a solution must support the aggregation of the externally learned
subnetted routing subdomain.

2.3 Proposed Solution

This document describes a new optional type of OSPF area, somewhat
humorously referred to as a "not-so-stubby" area (or NSSA), which has the
capability of importing external routes in a limited fashion.

The OSPF specification defines two general classes of area configuration.
The first allows type-5 LSAs to be flooded throughout the area. In this
configuration, type-5 LSAs may be originated by routers internal to the
area or flooded into the area by area border routers. These areas,
referred to herein as type-5 capable areas (or just plain areas in the
OSPF specification), are distinguished by the fact that they can carry
transit traffic. The backbone is always a type-5 capable area. The

second type of area configuration, called stub, allows no type-5 LSAs to

be propagated into/throughout the area and instead depends on default
routing to external destinations.

NSSAs are defined in much the same manner as existing stub areas. To
support NSSAs, a new option bit (the "N" bit) and a new type of LSA
(type-7) are defined. The "N" bit ensures that routers belonging to a
NSSA agree on its configuration. Similar to the stub area's use of the
"E" bit, both NSSA neighbors must agree on the setting of the "N" bit or
the OSPF neighbor adjacency will not form.

Type-7 LSAs provide for carrying external route information within a
NSSA. Type-7 AS External LSAs have virtually the same syntax as the
Type-5 AS External LSAs with the obvious exception of the link-state type
(see section 3.2 for more details). There are two major semantic
differences between type-5 and type-7 LSAs.

> o Type-7 LSAs may be originated by and advertised throughout
>   a NSSA; as with stub areas, type-5 LSAs are not flooded
>   into NSSAs and do not originate there, except on NSSA border
>   routers.
>
> o Type-7 LSAs are advertised only within a single NSSA; they
>   are not flooded into the backbone area or any other area by
>   border routers, though the information which they contain
>   can be propagated into the backbone area (see section 3.6).

In order to allow limited exchange of external information across a NSSA
border, NSSA border routers will translate selected type-7 LSAs received
from the NSSA into type-5 LSAs. These type-5 LSAs will be flooded to all
type-5 capable areas. NSSA border routers may be configured with address
ranges so that several type-7 LSAs may be represented by a single type-5
LSA. The NSSA border routers which perform translation are configurable
thus creating efficient forwarding to type-5 LSA originating from
aggregated type-7s.

In addition, a NSSA border router may originate a default type-7 LSA (IP
address of 0.0.0.0) into the NSSA, and must if no NSSA internal type-7
default route exists. Default routes are necessary because NSSAs do not
receive full routing information and must have a default route to route
to AS-external destinations. Like stub areas, NSSAs may be connected to
the backbone at more than one area border router, but may not be used as
a transit area. Note that the default route originated by a NSSA border
router is never translated into a type-5 LSA, however, a default route
originated by a NSSA internal AS boundary router (one that is not also an
area border router) may be translated into a type-5 LSA.

Like stub areas, the importing of OSPF summary routes (type-3 LSAs) into
NSSAs is a configuration option. However particular care should be taken

to ensure that OSPF internal routes are always chosen over OSPF external
(type-7) routes. This may happen when other IGPs, like RIP and ISIS,

   leak routing information between an OSPF NSSA and another OSPF area. In
   these cases, all OSPF summary routes should be imported into the effected
   NSSAs. The recommended default behavior is to import OSPF summary routes
   into NSSAs. Note that if a type-7 default originates from an internal
   NSSA router, all summary routes must automatically be imported into the
   NSSA. This insures that OSPF internal routes are preferred over an
   internal type-7 LSA default path which may cause inter-AS traffic to exit
   the AS.

   In our transit example topologies the subnets of 130.57 and network
   192.31.114 will still be learned by RIP on router BR18 but now both
   BR10 and BR18 can be in a NSSA and all of BBN Planet's external routes
   are hidden from BR18; BR10 becomes a NSSA border router and BR18 becomes
   an AS boundary router internal to the NSSA. BR18 will import the subnets
   of 130.57 and network 192.31.114 as type-7 LSAs into the NSSA. BR10 then
   translates these routes into type-5 LSAs and floods them into BBN
   Planet's backbone.

   In our corporate example, the subnets of 192.243.192/20 and
   192.243.208/22 are learned via their respective routing process,
   redistributed throughout NSSAreas 1 and 2, and then aggregated during the
   translation process into a single Type-5 LSA which is flooded into Area
   0. Area 1 may configure A0 to perform translation with B0 standing by as
   a backup translator, while Area 2 configures B0 as its translator with A0
   its backup.

3.0 Implementation Details

3.1 The N-bit

   The N-bit ensures that all members of a NSSA agree on the area's
   configuration. Together, the N-bit and E-bit reflect an interface's
   (and consequently the interface's associated area) external LSA
   flooding capability. As explained in section 10.5 of the OSPF
   specification, if type-5 LSAs are not flooded into/throughout the
   area, the E-bit must be clear in the option field of the received
   Hello packets. Interfaces associated with a NSSA will not send or
   receive type-5 LSAs on that interface but may send and receive type-7
   LSAs. Therefore, if the N-bit is set in the options field, the E-bit
   must be cleared.

   To support the NSSA option an additional check must be made in the
   function that handles the receiving of the Hello packet to verify that
   both the N-bit and the E-bit found in the Hello packet's option field
   match the value of the options that have been configured in the receiving
   interface. A mismatch in the options causes processing of the received
   Hello packet to stop and the packet to be dropped.

3.2 **Type-7 Address Ranges**

   NSSA border routers may be configured with type-7 address ranges.

   Each address range is defined as an [address,mask] pair. Many
   separate type-7 networks may then be represented by a single address
   range, just as a subnetted network is composed of many separate
   subnets. NSSA border routers may then summarize type-7 routes by
   advertising a single type-5 route for each type-7 address range. The
   type-5 route, resulting from a type-7 address range match will be
   distributed to all type-5 capable areas. Section 4.1 gives the
   details of generating type-5 routes from type-7 address ranges.

   A type-7 address range includes the following configurable items.

                 o An [address,mask] pair.

                 o A status indication of either Advertise or
                   DoNotAdvertise.

                 o An external route tag.

3.3 **Type-7 LSAs: NSSA External Link-State Advertisements**

   External routes are imported into NSSAs as type-7 LSAs by NSSA AS
   boundary routers. A NSSA AS boundary routers (ASBR) is a router
   which has an interface associated with the NSSA and is exchanging
   routing information with routers belonging to another AS. Like ASBRs,
   a NSSA router indicates it is a NSSA ASBR by setting the E-bit in its
   router links advertisement. As with type-5 LSAs a separate type-7 LSA
   is originated for each destination network. To support NSSAs, the
   link-state database must therefore be expanded to contain a type-7
   LSA.

   Type 7-LSAs are identical to type-5 LSAs except for the following
   (see section 12.4.4 "AS external links" in the OSPF specification).

      1. The type field in the LSA header is 7.

      2. Type-7 LSAs are only flooded within the originating NSSA. The
         flooding of type-7 LSAs follows the same rules as the flooding
         of type 1-2 LSAs.

      3. Type-7 LSAs, which are kept within the NSSA's LSDB, are area
         specific. Type-5 LSAs, which are flooded to all type-5 capable
         areas, have global scope and are kept in the router's LSDB.

      4. At the NSSA border router, selected type-7 LSAs are translated
         into type 5-LSAs and flooded into the backbone.

5. Type 7 LSAs have a propagate (P) bit which is used to flag the
   NSSA border router to translate the type-7 LSA into a type-5
   LSA. Examples of how the P-bit is used for loop avoidance are
   in the following sections.

6. Those type-7 LSAs that are to be translated into type-5 LSAs
   must have their forwarding address set. Type-5 LSAs that have
   been translated from type-7 LSAs for the most part must contain
   a forwarding address. The exception to this is if the
   translation to a type-5 LSA is the result of an address range
   match, in which case the type-5 LSA will not contain a
   forwarding address (see section 4.1 for details). The
   forwarding address contained in type-5 LSAs will result in more
   efficient routing to the AS external networks when there are
   multiple NSSA border routers. Having the forwarding address in
   the type-7 LSAs will ease the translation of type-7 into type-5
   LSAs as the NSSA border router will not be required to compute
   the forwarding address.

   If the network between the NSSA AS boundary router and the
   adjacent AS is advertised into OSPF as an internal OSPF route,
   the forwarding address should be the next hop address as is
   currently done in type-5 LSAs, but unlike type-5 LSAs if the
   intervening network is not advertised into OSPF as an internal
   OSPF route, the forwarding address should be any one of the
   router's active OSPF interface addresses.

Type-5 and type-7 metrics and path types are directly comparable.

3.4 Originating Type-7 LSAs

NSSA AS boundary routers may originate type-7 LSAs. All NSSA border
routers must also be AS boundary routers since they all must have the
capability of translating type-7 LSAs into type-5 LSAs (see section
4.1 for the translation algorithm). NSSA border routers must
set the E-bit (external bit) as well as the B-bit (border bit) in
their router (type-1) LSAs (both in the backbone and in the NSSA).

   When a NSSA internal AS boundary router originates a type-7 LSA that
   it wants to be translated into a type-5 LSA by NSSA border routers
   (and subsequently flooded into the backbone), it must set the P-bit
   in the LSA header's option field and add a valid forwarding address in
   the type-7 LSA.

   If a router is attached to another AS and is also a NSSA border
   router, it may originate both a type-5 and a type-7 LSA for the same
   network. The type-5 LSA will be flooded to the backbone (and all
   attached type-5 capable areas). The type-7 LSA will be flooded into

the NSSA. If this is the case, the P-bit must be reset in the type-7

NSSA so the type-7 LSA isn't again translated into a type-5 LSA by
another NSSA border router. If the border router only originates a
type-7 LSA, it may set the P-bit, thus allowing the network to be
aggregated/propagated during the type-7 translation.

A type-7 default route (network 0.0.0.0) may be originated into the NSSA
by a NSSA border router or by a NSSA ASBR which is internal to the NSSA.
The type-7 default route originated by the NSSA border router must have
the P-bit reset so that the default route originated by the NSSA border
router will not find its way out of the NSSA into the rest of the AS
system via another NSSA border router.

The type-7 default route originated by a NSSA ASBR which is not a NSSA
border router may have the P-bit set. Type-7 routes which are originated
by a NSSA border router will not get added to the routing tables of other
NSSA border routers. If no NSSA internal router originates a type-7
default route in the NSSA, then, like stub areas, a type-7 LSA with
default destination must be originated by all the NSSA's border routers
in order to support inter-area AS routing and inter-AS routing.

Note that a NSSA area border router which originates a type-7
default route would have to originate a type-5 default route before
other NSSA area border routers would see that default route. An
internal type-7 default route whose P-bit is not set may only be
installed on a NSSA border router when it is the only non-backbone
OSPF area connected to it. This restriction protects the default
routing of other areas attached to the NSSA border router as well any
ISP agreements of the NSSArea.

In order for backbone summary internal routes to be preferred over
external Type 7 routes, all implementations must support the optional
import of summary LSAs from the backbone into a NSSA, with the
exception of a (type-3) summary LSA for the default route. The
import of summary LSAs is automatically activated when an type-7
default route is detected as originating from an internal NSSA ASBR,
regardless of the no-summary setting. This protects the NSSA from
routing intra-AS traffic out the AS via a type-7 default route.

Unlike the stub area case, a default route must not be injected into
the NSSA as a summary (type-3) LSA. The reason for this is that the
summary default route would be chosen over all more preferred type-7
default routes.

3.5 Calculating Type-7 AS External Routes

This calculation must be run when type-7 LSAs are processed during the AS
external route calculation. This calculation will also process type-5
LSAs and may replace section 16.4 when processing type-5 LSAs. If

section 16.4 is still used to process type-5 LSAs, NSSA ASBR routing
table entries are not to be used for the ASBR address calculation of
type-5 LSAs.

A NSSA border router should examine both type-5 LSAs and type-7 LSAs
if either type-5 or type-7 routes need to be updated or recalculated.
This is done as part of the AS external route calculation. A NSSA
internal router should examine type-7 LSAs when type-7 routes need to
be recalculated. When OSPF Section 16.4.1 path preference is applied
in step (6.c), NSSA and non-NSSA intra-AS paths have equal
preference.

What follows is only a modest modification of the OSPF Version 2
Specification Section 16.4. Original text is suffixed with <Moy>. NSSA
specific text is suffixed with <NSSA>.

AS external routes are calculated by examining AS-external-LSAs, be they
type-5 or type-7. Each of the AS-external-LSAs is considered in turn.
Most AS-external-LSAs describe routes to specific IP destinations. An
AS-external-LSA can also describe a default route for the Autonomous
System (Destination ID = DefaultDestination, network/subnet mask =
0x00000000). For each AS-external-LSA <Moy with "or type-7">:

 (1) If the metric specified by the LSA is LSInfinity, or if the age
      of the LSA equals MaxAge, then examine the next LSA. <Moy>

 (2) If the LSA was originated by the calculating router itself,
      examine the next LSA. <Moy>

 (3) Call the destination described by the LSA N. N's address is
      obtained by masking the LSA's Link State ID with the
      network/subnet mask contained in the body of the LSA. Look up
      the routing table entries (potentially one per attached area)
      for the AS boundary router (ASBR) that originated the LSA. If
      no entries exist for router ASBR (i.e., ASBR is unreachable), do
      nothing with this LSA and consider the next in the list. <Moy>

      Else if the destination is a type-7 default route (destination =
      DefaultDestination) and one of the following is true, then do
      nothing with this LSA and consider the next in the list:

         o The originator of the type-7 LSA and the calculating
            router are both NSSA border routers.

         o The calculating router is a border router, the LSA has its
            P-bit clear, and at least two non-backbone OSPF areas
            connect to the calculating router. <NSSA>

      Else, this LSA describes an AS external path to destination N.
      Examine the forwarding address specified in the AS-external-LSA.

      This indicates the IP address to which packets for the
      destination should be forwarded. <Moy>

If the forwarding address is set to 0.0.0.0, packets should be
sent to the ASBR itself. <Moy>

If the current LSA is type-5, among the multiple non-NSSA ASBR
routing table entries for the ASBR (both NSSA and non-NSSA ASBR
entries might exists on an NSSA border router), select the
preferred entry as follows <NSSA>:

If RFC1583Compatibility is set to "disabled", prune the set
of routing table entries for the ASBR as described in OSPF
Section 16.4.1. In any case, among the remaining routing
table entries, select the routing table entry with the least
cost; when there are multiple least cost routing table
entries the entry whose associated area has the largest OSPF
Area ID (when considered as an unsigned 32-bit integer) is
chosen. <Moy>

If the forwarding address is non-zero, look up the forwarding
address in the routing table. The matching routing table entry
must specify an intra-area or inter-area path; if no such path
exists, do nothing with the LSA and consider the next in the
list. <Moy>

(4) Let X be the cost specified by the preferred routing table entry
for the ASBR/forwarding address, and Y the cost specified in the
LSA. X is in terms of the link state metric, and Y is a type 1
or 2 external metric. <Moy>

(5) Now, look up the routing table entry for the destination N. If
no entry exists for N, install the AS external path to N, with
the next hop equal to the list of next hops to the
ASBR/forwarding address, and advertising router equal to ASBR.
If the external metric type is 1, then the path-type is set to
Type-1 external and the cost is equal to X + Y. If the external
metric type is 2, the path-type is set to Type-2 external, the
link-state component of the route's cost is X, and the Type-2
cost is Y. <Moy>

(6) Otherwise compare the AS external path described by the LSA with
the existing paths in N's routing table entry, as follows. If
the new path is preferred, it replaces the present paths in N's
routing table entry. If the new path is of equal preference, it
is added to N's routing table entry's list of paths. <Moy>

Preference is defined as follows:

(a) Intra-area and inter-area paths are always preferred over AS
external paths. <Moy>

(b) Type 1 external paths are always preferred over type 2

external paths. When all paths are type 2 external paths,
the paths with the smallest advertised type 2 metric are
always preferred. <Moy>

(c) If the new AS external path is still indistinguishable from
the current paths in N's routing table entry, and
RFC1583Compatibility is set to "disabled", select the
preferred paths based on the intra-AS paths to the
ASBR/forwarding addresses, as specified in Section
16.4.1. <Moy>

(d) If the new AS external path is still indistinguishable from
the current paths in N's routing table entry, select the
preferred path based on a least cost comparison. Type 1
external paths are compared by looking at the sum of the
distance to the forwarding address and the advertised type 1
metric (X+Y). Type 2 external paths advertising equal type
2 metrics are compared by looking at the distance to the
forwarding addresses. <Moy>

(e) If the new paths are still indistinguishable the following
priorities apply (listed from highest to lowest) for
breaking the tie.

a. Any type-5 LSA.

b. A type-7 LSA with the P-bit set and the forwarding
address non-zero.

c. Any other type-7 LSA. <NSSA>

3.6 Incremental Updates

Incremental updates for type-7 LSAs should be treated the same as
incremental updates for type-5 LSAs (see section 16.6 of the OSPF
specification). That is, if a new instance of a type-7 LSA is
received it is not necessary to recalculate the entire routing table.
If there is already an OSPF internal route to the destination
represented by the type-7 LSA, no recalculation is necessary.
Otherwise, the procedure in the proceeding section will have to be
performed but only for the external routes (type-5 and type-7) whose
networks describe the same networks as the newly received LSA.

[4.0](#) Originating Type-5 LSAs

[4.1](#) Translating Type-7 LSAs Into Type-5 LSAs

   This step is performed as part of the NSSA's Dijkstra calculation after
   type-5 and type-7 routes have been calculated. If the calculating router
   is not a NSSA border router this translation algorithm should be skipped.
   It is not recommended that multiple NSSA border routers perform the
   translation unless the efficient routing of packets through area 0 to a
   NSSA partitioned by aggregation requires it. It is normally sufficient
   to have only one NSSA border router perform the translation. Excessive
   numbers of type-7 translators unnecessarily increase the size of the OSPF
   link state data base.

   A new bit called bit Nt is added to the router links advertisement. All
   NSSA area border routers which are performing the translation set bit Nt in
   their router links advertisement into the NSSA.

   A new parameter called the NSSATranslateState is added to the OSPF area
   data structure. If a NSSA border router has

        NSSATranslateState = enabled

   then this router always translates Type-7 LSAs into Type-5 LSAs for the
   NSSA.

   If a NSSA border router has

        NSSATranslateState = disabled

   and no NSSA border router for the NSSA has bit Nt set in its router links
   advertisement and this router has the highest router ID among the NSSA
   border router set, then this router performs the translation of type-7
   LSAs into type-5 LSAs for the NSSA and NSSATranslateState should be set
   to elected.

   Otherwise the translation algorithm should not be performed and
   NSSATranslateState should remain set to disabled.

   Note that during the translation of type-7 LSAs into aggregated type-5
   LSAs, the highest router ID is not necessarily the best choice for an
   advertising router as all packets which are forwarded by a type-5 LSA
   routing table entry originating from an aggregated type-7 LSA translation
   are sent to the translator (As described below, the forwarding address is
   not set in type-5 LSAs which originate from aggregated type-7 LSAs). The
   NSSATranslateState allows the network designer to configure the most cost
   effective route to the NSSA's type-5 LSAs which originate from the
   aggregation of type-7 LSAs. Is cases of aggregate partitioning of the
   NSSA, multiple translators may be required to effect efficient routing.

Indeed, all NSSA border routers could be set to perform translation, if required.

All installed type-7 LSA's should be examined including those type-7s originated by the router itself (a set which may differ between NSSA border routers of the same NSSArea). This allows NSSA border routers to propagate and/or aggregate locally originated type-7s during the translation. Locally originated type-7s are skipped during the external route calculation. Their installation status is external to OSPF.

If the type-7 LSA (associated with the route being examined) has the P-bit set and a non-zero forwarding address, the following steps should be taken.

The translation procedure must first check for a configured type-7 address range. Recall that a type-7 address range consists of an [address,mask] pair and a status indication of either Advertise or DoNotAdvertise. At most a single type-5 LSA is made for each range. If the route being examined falls within the type-7 address range, (i.e., the [address,mask] pair of the route is equal to or a more specific instance of the [address,mask] pair of the type-7 address range), one of following three actions may take place.

1. When the range's status indicates Advertise and the route's address and mask are equal to the address and mask of the type-7 range, a type-5 LSA should be originated if

   o there currently is no type-5 LSA originated from this router corresponding to the type-7 LSA, or there is and

   o the path type or the metric in the corresponding type-5 LSA is different from the type-7 LSA or

   o the forwarding address in the corresponding type-5 LSA is different from the type-7 LSA.

   The newly originated type-5 LSA will describe the same network and have the same network mask, metrics, forwarding address, external route tag and path type as the type-7 LSA, however, the advertising router field will be the router ID of this area border router.

2. When the range's status indicates Advertise and the route's address or mask indicates a more specific route (i.e., the route's address is subsumed by the range or the route has a longer mask), a type-5 LSA is generated with link-state ID

equal to the range's address (if necessary, the link-state
ID can also have one or more of the range's "host" bits set;
see Appendix F of the OSPF specification for details), the
network mask, external route tag and path type will be set
to the configured type-7 range values. The advertising
router field will be the router ID of this area border
router. The forwarding address will not be set. The path
type should always be set to the highest path type that is
subsumed by the net range. The metric for the type-5 LSA
will be set as follows:

o if the path type is external type 2, the type-5 metric
  should be set to the largest type-7 metric subsumed by
  this net range + 1.

o if the path type is external type 1, the type-5 metric
  should be set to the largest metric.

For example, given a net range of [10.0.0.0, 255.0.0.0] for
an area that has type-7 routes of:

        10.1.0.0 path type 1, metric 10
        10.2.0.0 path type 1, metric 11
        10.3.0.0 path type 2, metric 5

a type-5 LSA will be generated with a path type of 2 and a
metric of 6.

As another example, given a net range of [10.0.0.0,
255.0.0.0] for an area that has type-7 routes of:

        10.1.0.0 path type 1, metric 10
        10.2.0.0 path type 1, metric 11
        10.3.0.0 path type 1, metric 5

a type-5 LSA will be generated with a path type of 1 and a
metric of 11.

These metric and path type rules will avoid routing loops in
the event that path type 1 and 2 are both used within the
area.

3. When the range's status indicates DoNotAdvertise, the type-5
   LSA is suppressed and the component networks remain hidden
   from the rest of the AS.

By default (given that the P-bit is set and the LSA has a non-zero
forwarding address) if a network is not contained in any

explicitly configured address range, a type-7 to type-5 LSA
translation will occur.

A new instance of a type-5 LSA should be originated and flooded to
all attached type-5 capable areas if

> o there currently is no type-5 LSA originated from this
>   router corresponding to the type-7 LSA, or there is and
>
> o the path type or the metric in the corresponding type-5
>   LSA is different from the type-7 LSA or
>
> o the forwarding address in the corresponding type-5 LSA is
>   different from the type-7 LSA.

The newly originated type-5 LSAs will describe the same network
and have the same network mask, metrics, forwarding address,
external route tag and path type as the type-7 LSA. The
advertising router field will be the router ID of this area border
router.

As with all newly originated type-5 LSAs, a type-5 LSA that is the
result of a type-7 to type-5 translation (type-7 range or default
case) is flooded to all attached type-5 capable areas.

4.2 Flushing Translated Type-7 LSAs

If a NSSA border router has translated a type-7 LSA to a type-5 LSA that
should no longer be translated, the type-5 LSA should be flushed (set to
MaxAge and flooded). The translated type-5 LSA should be flushed
whenever the routing table entry that caused the translation changes so
that either the routing table entry is unreachable or the entry's
associated LSA is not a type-7 with the P-bit set and a non-zero
forwarding address.

If a NSSA border router is translating type-7 LSA's into type-5 LSA's and

> NSSATranslateState = elected

and a new router links advertisement arrives in the NSSA with bit Nt set,
then it should flush any of its type-5 LSAs originating from translated
type-7 LSAs and readvertise its router links advertisement into the NSSA
with bit Nt clear.

This flushing keeps the number of type-7 translators at the minimum
number configured, either explicitly or by default. Since the default
translator election process only occurs in the absence of a translator,
should a router with a higher router ID join the NSSA border router set
it will not necessarily assume translator duties. Indeed, a previously
default elected translator should continue to perform translation duties
until supplanted by an NSSA border router whose Nt bit is set to true.

Such an event might happen due to by setting the NSSATranslateState to

enabled or a topological rejoining of a partitioned NSSA. This behavior
reduces the flushing of translated type-7 LSA's in the AS.

Any change in the membership of the NSSA border router set or the setting
of their Nt bits resulting from updated router links advertisements
should force a NSSA border router whose NSSATranslateState is not set to
recheck and possibly elect or disable its type-7 translation status.

5.0 Acknowledgments

This document was produced by the OSPF Working Group, chaired by John
Moy.

In addition, the comments of the following individuals are also
acknowledged:

```
          Phani Jajjarvarpu  cisco
          Dino Farinacci     cisco
          Jeff Honig         Cornell University
          John Moy           Proteon, Inc.
          Doug Williams      IBM
```

6.0 References

[1] Moy, J., "OSPF Version 2", RFC 1583, Proteon, Inc., March 1994.

[2] Moy, J., "Multicast Extensions to OSPF", RFC 1584, Proteon, Inc.,
    Proteon, Inc., March 1994.

7.0 Security Considerations

Security issues are not discussed in this memo.

8.0 Authors' Addresses

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in support of the new features suggested by Pat Murphy.

Appendix A: Type-7 Packet Format

```
         0                               32
         -----------------------------------
         |                   | OPTS  |  7   |
         |                   -----------------
         |        Link-State Header        |
         |                                 |
         -----------------------------------
         | Network Mask                    |
         -----------------------------------   _____
         |E| Tos  |         metric         |  .
         -----------------------------------  .  repeated for each TOS
         | Forwarding Address              |  .
         -----------------------------------  .
         | External Route Tag              |  _____
         -----------------------------------
```
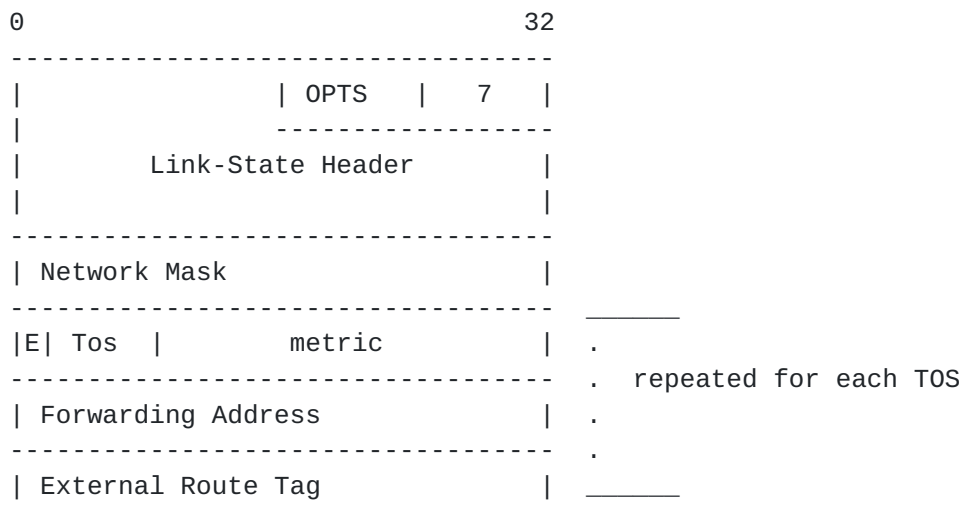
The definitions of the link-state ID, network mask, metrics and
external route tag are the same as the definitions for the type-5
LSAs (see A.4.5 in the OSPF specification) except for:

        The Forwarding Address

If the network between the NSSA AS boundary router and the adjacent
AS is advertised into OSPF as an internal OSPF route, the forwarding
address should be the next hop address but if the intervening network
is not advertised into OSPF as an internal OSPF route, the forwarding
address should be any one of the router's active OSPF interface
addresses.

Appendix B: The Options Field

   The OSPF options field is present in OSPF Hello packets, Database
   Description packets and all link-state advertisements. See appendix
   A.2 in the OSPF specification for a description of option field. Six
   bits are assigned but only two (the E-bit and the N/P bit) are
   described completely in this section.

                     | * | * | DC | EA | N/P | MC | E | T |

                        The Type-7 LSA options field

             E-bit: Type-5 AS external link advertisements are not
                     flooded into/through OSPF stub areas and NSSAs.
                     The E-bit ensures that all members of a stub area
                     agree on that area configuration. The E-bit is
                     meaningful only in OSPF Hello packets. When the
                     E-bit is reset in the Hello packet sent out a
                     particular interface, it means that the router
                     will neither send nor receive type-5 AS external
                     link state advertisements on that interface (in
                     other words, the interface connects to a stub
                     area or NSSArea). Two routers will not become
                     neighbors unless they agree on the state of the
                     E-bit.

             N-bit: The N-bit describes the router's NSSArea
                     capability. The N-bit is used only in Hello
                     packets and ensures that all members of a NSSArea
                     agree on that area's configuration. When the
                     N-bit is set in the Hello packet and sent out a
                     particular interface, it means that the router
                     will send and receive type-7 LSAs on that
                     interface. Two routers will not form an adjacency
                     unless they agree on the state of the N-bit. If
                     the N-bit is set in the options field, the E-bit
                     must be reset.

             P-bit: The P-bit is used only in the type-7 LSA header.
                     It flags the NSSA border router to translate
                     the type-7 LSA into a type-5 LSA.

Appendix C: Router-LSAs

   Router-LSAs are the Type 1 LSAs. Each router in an area originates a
   router-LSA. The LSA describes the state and cost of the router's links
   (i.e., interfaces) to the area. All of the router's links to the area
   must be described in a single router-LSA. For details concerning the
   construction of router-LSAs, see the OSPF Specification, Section 12.4.1.

       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
      +-+
      | LS age | Options | 1 |
      +-+
      | Link State ID |
      +-+
      | Advertising Router |
      +-+
      | LS sequence number |
      +-+
      | LS checksum | length |
      +-+
      | 0 Nt|W|V|E|B| 0 | # links |
      +-+
      | Link ID |
      +-+
      | Link Data |
      +-+
      | Type | # TOS | TOS 0 metric |
      +-+
      | TOS | 0 | metric |
      +-+
      | ... |
      +-+
      | TOS | 0 | metric |
      +-+
      | Link ID |
      +-+
      | Link Data |
      +-+
      | ... |

   In router-LSAs, the Link State ID field is set to the router's OSPF
   Router ID. The T-bit is set in the LSA's Option field if and only
   if the router is able to calculate a separate set of routes for each
   IP TOS. Router-LSAs are flooded throughout a single area only.

   bit V
       When set, the router is an endpoint of one or more fully
       adjacent virtual links having the described area as Transit area
       (V is for virtual link endpoint).

   bit E
       When set, the router is an AS boundary router (E is for
       external).

   bit B
       When set, the router is an area border router (B is for border).

   bit W
       When set, the router is a wild-card multicast receiver (W is for
       for wild).

   bit Nt
       When set, the router is a NSSA border router which translates type-7
       LSAs into type-5 LSAs (Nt is for NSSA translation).

   The remainder of the router links specification is as defined in the OSPF
   Specification, Section A.4.2

Appendix D: Configuration Parameters

   Appendix C.2 in the OSPF specification lists the area parameters. The
   area ID, list of address ranges for type-3 summary routes and
   authentication type remain unchanged. Section 3.2 of this document lists
   the configuration parameters for type-7 address ranges. The following
   parameter is added to the NSSArea data structure:

   NSSATranslateState
        This parameter indicates whether or not an NSSA Border router is
        performing NSSA translation of type-7 LSAs into type-5 LSAs and
        flooding the translated type-5 LSAs into the AS. If the parameter is
        set to "enabled", translation is always performed. If the parameter
        is set to "elected", it means translation is being performed because
        the router was chosen during the default election process. If the
        parameter is set to "disabled" the NSSA border router is not
        currently performing type-7 translation. "disabled" is the default
        setting. (See Section 4.1.)

   For NSSAs the external capabilities of the area must be set to accept
   type-7 external routes. Additionally there must be a way of
   configuring the NSSA border router to send a default route into the
   NSSArea using a specific metric (type 1 or type 2 and the actual cost).

Appendix E: Differences from RFC 1587

   This section documents the differences between this memo and RFC
   1587. All differences are backward-compatible. Implementations of
   this memo and of RFC 1587 will interoperate.

   E.1 Enhancements to OSPF summary LSAs.   .

      The flooding of backbone summary LSAs (type-3 LSAs) into the NSSA
      is now optional. In RFC 1587 the flooding of backbone summary
      LSAs was mandated in order to guarantee inter-area routes are
      preferred over external routes. The current recommended default
      behavior is to flood summary LSAs.

      See sections 2.2 and 3.4 for details.

   E.2 Changes to the type-7 AS external routing calculation.

      The type-7 external route calculation has been revised. Most
      notably:

        o The path preference defined in OSPF Section 16.4.1 has been
          included.

        o A type-7 default route with the P-bit clear will not be installed
          on a NSSA border router which connects multiple non-backbone
          areas. This protects the default routing of other OSPF Areas as
          well as any ISP agreements of the originating NSSArea.

        o The type-7 AS external route calculation may now compute
          type-5 external paths.

      See Section 3.5 for details.

   E.3 Changes to translating type-7 LSAs into type-5 LSAs

      NSSA border routers which perform the translation are now optionally
      configurable, with more than one allowed. This allows the network
      designer to choose the most cost effective intra-AS route for NSSA
      type-7 aggregates propagated into the AS. Furthermore, since
      different NSSA border routers may install different sets of type-7
      LSA routes, the cost effectiveness of non-aggregated type-7
      propagation may also be maximized.

      All installed type-7 LSA's including those originated by the NSSA
      border router are processed for translation. This allows the
      NSSA border router to propagate and/or aggregate locally
      originated type-7s utilizing the type-5 translation process.
      NSSA RFC 1587 required locally originated type-7 LSAs be paired

with locally originated type-5 LSAs for the external path to be
seen by the AS (Note that locally originated type-7s are skipped
during the external route calculation).

The default translator election process occurs only in the absence of
a translator amongst the NSSA border router set.

See Section 4.1 for details.

E.4 Changes to flushing translated type-7 LSAs

A NSSA border router which was elected by the default selection
process of RFC 1587, terminates its translation duties and flushes
its translated type-7 LSAs from the AS when another translator
presents itself in the NSSA. This keeps the number of translators at
a minimum.

See Section 4.2 for details.