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                    Point-to-point operation over LAN
                     in link-state routing protocols

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Abstract

   The two predominant circuit types used by link state routing
   protocols are point-to-point and broadcast. It is important to
   identify the correct circuit type when forming adjacencies,
   flooding link state database packets, and representing the circuit
   topologically. This document describes a simple mechanism to treat
   the broadcast network as a point-to-point connection from the
   standpoint of IP routing.

[1](#). Introduction

   Point-to-point and broadcast are the two predominant circuit
   types used by link state routing protocols such as IS-IS [[ref1](#)]
   [[ref2](#)] and OSPF [[ref3](#)]. They are treated differently with respect
   to establishing neighbor adjacencies, flooding of link-state
   information, representation of the topology, SPF calculation and
   protocol packets. The most important differences are that broadcast
   circuits utilize the concept of a designated router and are
   represented topologically as virtual nodes in the network topology
   graph.

   Compared with broadcast circuits, point-to-point circuits
   afford more straightforward IGP operation. There is no designated
   router involved and there is no representation of the pseudo-node
   or network LSA in the link state database. For ISIS, there also is
   no periodic database synchronization. Conversely, if there are more
   than two routers on the LAN media, the traditional view of the
   broadcast circuit will reduce the routing information in the network.

   When there are only two routers on the LAN, it makes more sense to
   treat the connection between the two routers as a point-to-point
   circuit. This document describes the mechanism to allow link state
   routing protocols to operate using point-to-point connections over
   a LAN under this condition. Some implications related to forwarding
   IP packets on this type of circuit are also discussed. We will refer
   to this as a p2p-over-lan circuit in this document.

[2](#). Motivation

   Even though a broadcast circuit is meant to handle more than two
   devices, there are cases where only two routers are connected
   over either the physical or logical LAN segment:

      1. The media itself is being used for point-to-point
          operation between two routers. This is mainly for
          long-haul operation.
      2. There are only two routers on the physical LAN.
      3. There are only two routers on a virtual LAN (vLAN).

   In any of the above cases, the link state routing protocols will
   normally still treat the media as a broadcast circuit. Hence, they
   will have the overhead involved with protocol LAN operation without
   the benefits of reducing routing information and optimized flooding.

   Being able to treat a LAN as a point-to-point circuit provides the
   benefit of reduction in the amount of information routing
   protocols must carry and manage. DR/DIS election can be omitted.

Flooding can be done as in p2p links without the need of using
   "LSA reflection" by the DR in OSPF or periodic CSNPs in ISIS.

Also, if a broadcast segment wired as a point-to-point link
can be treated as a point-to-point link, only the connection between
the two routers would need to be advertised as a topological entity.

Even when there are multiple routers on the LAN an ISP may want
to sub-group the routers into multiple vLANs since this allows
them to assign different costs to IGP neighbors. When there are
only two routers in some of the vLANs, this LAN can be viewed by
the IGP as a mesh of point-to-point connections.

As a side benefit, unnumbered interface can also be applied over
p2p-over-lan circuits. The advantages of unnumbered point-to-point
links are obvious in the current IP addressing environment where
addresses are a scarce resource. Separating the concept of network
type from media type will allow LANs, e.g. ethernet, to be
unnumbered and realize the IP address space savings. Another
advantage is in simpler network management and configuration.

[3]. IP multi-access subnets

When an IP network includes multi-access segments, each segment is
usually assigned a separate subnet and each router connected to it is
assigned a distinct IP address within that subnet. The role of the
IP address assigned to a multi-access interface can be outlined as
follows:

   1. Source IP address - The interface address can be used by
      the router as the source IP address in locally originated
      IP packets destined for that subnet or having a best path
      next hop on that subnet.

   2. Destination IP address - The interface address can be used by
      other devices in the network as a destination address for
      packets to router applications (examples include telnet, SMTP,
      TFTP, OSPF, BGP, etc).

   3. Next-hop identifier - If other routers connected to the same
      segment need to forward traffic through the router, the
      corresponding routes in their routing tables will include the
      router's interface IP address. This address will be used to
      find the router's MAC address using the ARP protocol.
      Effectively, the interface IP addresses help other routers
      find the data-link layer details that are required to specify
      the destination of the encapsulating data-link frame when it
      is sent on the segment.

The IP addressing scheme includes an option that allows the
administrators to not assign any subnets to point-to-point links

(links connecting only two devices and using protocols like PPP, SLIP
or HDLC for IP encapsulation). This is possible, because the routers

do not need next-hop identifiers on point-to-point links (there is
only one destination for any transmission), and an interface
independent IP address can be used as the source and destination.
Using the unnumbered option for a point-to-point link essentially
makes it a purely topological entity used only to reach other
destinations.

[4](#). **Point-to-point connection over LAN media**

The idea is very simple: provide a configuration mechanism to
inform the IGP that the circuit is type point-to-point
irrespective of the physical media type. For the IGP, this implies
that it will send protocol packets with the appropriate
point-to-point information and expects to receive protocol packets
as they would be received on a point-to-point circuit. Over LAN
media, the MAC header must contain the correct multicast MAC address
to be received by the other side of the connection. For vLAN
environments, the MAC header must also contain the proper vLAN ID.

In order to allow LAN links used to connect only two routers to be
treated as unnumbered point-to-point interfaces, the MAC address
resolution and nexthop IP address issues need to be addressed.

[4.1](#) **Operation of IS-IS**

This p2p-over-lan circuit extension for IS-IS is only concerned
in pure IP routing and forwarding operation.

Since the physically circuit is a broadcast one, the IS-IS protocol
packets need to have MAC addresses for this p2p-over-lan circuit.
From link layer point of view, those packets are IS-IS LAN packets.
The Multi-destination address including AllISs, AllL1ISs and AllL2ISs
defined in [[ref1](#)] can be used for link layer encapsulation, the
use of AllISs is recommended.

The circuit needs to have IP address(es) and the p2p IIH over this
circuit MUST include the IP interface address(es) as defined in
[[ref2](#)]. The IP address(es) can be numbered or unnumbered.

[4.2](#) **Operation of OSPF**

OSPF routers supporting the capabilities described herein should
support an additional interface configuration parameter specifying
the interface topology type. For a LAN (i.e., broadcast capable)
interface, the interface may be viewed as a point-to-point interface.
Both routers on the LAN will simply join the AllSPFRouters

(224.0.0.5) multicast group and send all OSPF packets to 224.0.0.5.
This is identical to operation over a physical point-to-point link
as described in sections 8.1 and 8.2 of [ref3].

4.3 **IP forwarding and ARP**

   Unlike normal point-to-point IGP circuit, the IP nexthop for the
   routes using this p2p-over-lan circuit as an outbound interface is
   not optional. The IP nexthop address has to be a valid interface
   or internal address on the adjacent router. This address is used by
   local router to obtain the MAC address for IP packet forwarding.
   Proxy ARP has to be enabled if the address is not the adjacent
   interface IP address.

   In the case where unnumbered IP addresses are used for p2p-over-lan
   circuit, the source IP address of ARP request and the target
   interface IP address are usually on different subnets. The ARP
   should reply only if this is a p2p-over-lan circuit and the source
   IP address of the ARP request is the same as the neighbor's
   interface IP address at the other end. The neighbor's address is
   learned from IGP hello exchanges over this circuit.

4.4 **Other MAC address resolution mechanisms**

   In more general cases while p2p-over-lan circuit is used as an
   unnumbered link, other MAC address resolution mechanisms are needed
   for IP packet forwarding. For example, if link-state IGP is not
   configured over this p2p-over-lan link, or Proxy ARP is not enabled
   on the circuit. The following techniques can be used to acquire the
   MAC address and/or the next-hop IP address of the remote device on
   an unnumbered point-to-point LAN link.

       1. Static configuration. A router can be statically configured
          with the MAC address that should be used as the destination
          MAC address when sending data out of the interface.

       2. MAC address gleaning. If a dynamic routing protocol is running
          between the routers connected to the link, the MAC address of
          the remote device can be taken from a data-link frame carrying
          a packet of the corresponding routing protocol.

       3. ARP for reference IP address. When a point-to-point link is
          configured as unnumbered, the router usually associates with
          it a "reference IP address", that is used as the source IP
          address in the packets originated for the unnumbered
          interface. When such an address is known to a router, the
          router may announce its MAC address by sending a gratuitous
          ARP message. This solution will also help in the situations
          where routers calculate the next-hop addresses for the routes
          through point-to-point interfaces. Since the source IP address
          in the received routing protocol packet is used as the next-
          hop address in the route, forwarding an IP packet along such

a route will lead to an ARP request submission on the LAN
link that will be answered by the remote device.

4. Broadcast/multicast/proprietary.

[4.5](#) **Detection of mis-configuration**

   With this p2p-over-lan extension, the difference between a LAN and
   a point-to-point circuit can be made purely by configuration. It is
   important to implement the mechanisms for early detection of
   mis-configuration.

   If the circuit is configured as point-to-point type and receives
   LAN hello packets, the router MUST discard the incoming packets; If
   the circuit is a LAN type and receive point-to-point hello packets,
   it MUST discard the incoming packets. If the system ID or the
   router ID of incoming hello packet does not match the system ID or
   the router ID of already established adjacency over this p2p-over-lan
   circuit, it MUST discard the packet. The implementation should offer
   logging and debugging information of the above events.

[5](#). **Compatibility considerations**

   Both routers on a LAN must support the p2p-over-lan extension
   and both must have the LAN segment configured as a p2p-over-lan
   circuit for successful operation. Both routers MAY also support
   one of the above listed methods for mapping ip addresses on the
   link to MAC address, and MUST support proxy ARP on the link. If
   a proprietary method of IP address to MAC address resolution is
   used by one router, both routers must be capable of using the
   same method. Otherwise, the link should be configured as a
   standard LAN link, with traditional IGP LAN models used.

[6](#). **Scalability and deployment considerations**

   There is obvious advantage to use this extension on the LANs
   that are connected back-to-back or only contain two routers.
   However, there are tradeoffs when modeling a LAN as multiple vLANs
   and using this extension since one does sacrifice the inherent
   scalability benefits of multi-access networks. In general,
   it will increase the link-state database size, the amount of
   packets flooded and the route calculation overhead. Network design
   engineers should carefully balance between the associated
   overhead. The scalability impact is less of a concern if all the
   vLANs are within a single OSPF area or ISIS level.

   Deployment of the described technique brings noticeable benefits from
   the perspective of IP address usage, the network management and the
   router configuration. Note, however, that use of the IP unnumbered

option for point-to-point LAN links inherits the same problems as
those present for serial links, i.e., not being able to ping or
monitor a specific interface between routers.

[7](). Security Issues

This document does not introduce any new security issues to ISIS or
OSPF. For ARP to support unnumbered IP interface addresses, it needs
to verify the p2p-over-lan circuit type described in this document
and to verify the ARP packet source interface address to match the
IGP adjacency interface IP address. This is due to normal ARP sanity
check for common subnet can not be applied in this case.

[8](). Acknowledgments

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[9](). References

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