CS344

Build an Internet Router

PWOSPF

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Pee-Wee OSPF Protocol Details

Protocol Overview:

  PWOSPF is a greatly simplified link state routing protocol based on O
  (rfc 1247).  Like OSPFv2, routers participating in a PWOSPF topology
  periodically broadcast HELLO packets to discover and maintain a list
  neighbors.  Whenever a change in a link status is detected (for examp
  addition or deletion of a router to the topology) or a timeout occurs
  router floods its view of the network throughout the topology so that
  router has a complete database of the network connectivity.  Djikstra
  algorithm is used by each router independently to determine the next
  hop in the forwarding table to all advertised routes.

Data Structures:

PWOSPF Router:

  Like OSPF, PWOSPF operates within an "area" of routers, defined by a
  value.  A router can only participate in one area at a time.  Each ro
  an area must have a unique 32 bit router ID.  By convention, the IP a
  of the 0th interface is used as the router ID.  0 and 0xffffffff are
  router IDs and can be used internally to mark uninitialized router ID

  Each router must therefore define the following values:

  32 bit router ID
  32 bit area ID
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  16 bit lsuint    - interval in seconds between link state update broa
  List of router interfaces

PWOSPF Interface:

  The interface is a key abstraction in PWOSPF for logically decomposin
  topology.  Interfaces between neighboring routers are connected by li
  must have an associated subnet and mask.  All links are assumed to be
  bi-directional.  Note you must support multiple routers connected to
  single interface, ie. via a hub or switch.

  An interface within a pwospf router is defined by the following value

  32 bit ip address  - IP address of associated interface
  32 bit mask mask   - subnet mask of associated interface
  16 bit helloint    - interval in seconds between HELLO broadcasts
  list [
    32 bit neighbor id - ID of neighboring router.
    32 bit neighbor ip - IP address of neighboring router's interface t
                         interface is directly connected to.
  ]

PWOSPF Hello Protocol:

  To discover and maintain the state of available links, a router parti
  in a PWOSPF topology periodically listens for and broadcasts HELLO pa
  HELLO packets are broadcasted every helloint seconds with a destinati
  address of ALLSPFRouters that is defined as "224.0.0.5" (0xe0000005).
  implies that all participating routers must be configured to receive
  process packets sent to ALLSPFRouters.  On receipt of a HELLO packet
  may do one of three things.  If the packet is invalid or corrupt the
  will drop and ignore the packet and optionally log the error.  If the
  is from a yet to be identified neighbor and no other neighbors have b
  discovered off of the incoming interface, the router will add the nei
  the interface.  If the packet is from a known neighbor, the router wi
  the time the packet was received to track the uptime of its neighbor.
  set of links of routers to neighbors provides the basic connectivity
  information for the full topology.

  PWOSPF routers use HELLO packets to monitor the status of a neighbori
  router.  If a neighboring router does not emit a HELLO packet within
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  NEIGHBOR_TIMEOUT seconds (three times the neighbor's HelloInt) of the
  the router is assumed down, removed from the interface and a link sta
  update flood is initiated.  Note that ONLY HELLO packets are used to
  determine link status.  Even in the case where the router is actively
  packets and generating link state update packets, if no HELLO packets
  generated it will be considered disconnected from the topology.

PWOSPF Link State Updates:

  Global network connectivity is obtained by each router through link s
  updates in which local link connectivity information is flooded throu
  the area by each router. Link state updates are sent periodically eve
  LSUINT seconds (default value of 30) and whenever a change in link st
  detected.  If a link state change initiates a links state update, the
  counter is reset to wait another LSUINT seconds before triggering ano
  flood.

  The link state advertisements generated by each router lists the subn
  each of the router's interfaces and all neighboring routers.  Link st
  updates operate via a simple sequenced, unacknowledged flooding schem
  which received packets are flooded to all neighbors except the neighb
  whom the packet was received.  Generated packets are flooded to all
  neighbors (they should be addressed directly to each neighbor - i.e.,
  send them to the special ALLSPFRouters address). LSU packets are used
and maintain the network topology database at each router.  If the LSU
advertise a change in the state of the topology as is already reflected
discarded and the sequence number is updated.  Otherwise, the informati
the database and the router's forwarding tables are recalculated using

  A gateway router may advertise an additional default subnet for an in
  that is connected to a separate network.  In the typical case, this i
  will be the networks link to the Internet and will advertise a defaul
  of 0.0.0.0.  All traffic not destined to a subnet on the PWOSPF netwo
  be routed to this as a gateway to the Internet.

The Topology Database

  Every router in a PWOSPF area maintains a full representation of the
  network topology.  This topology database is used to calculate the ne
  for each destination in the network.  A typical implementation of the
  topology database will contain an adjacency list of all the routers i
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  network as well as the subnets associated with each link.  Djikstra's
  algorithm is used on the adjacency list to determine the  best, next
  each router.  The forwarding table is then built using the advertised
  from each router and the next hop to those routers as determined by
  Djikstra.

  If there are discrepancies in advertisements from two different hosts
  the same link, the link is assumed invalid and not added to the datab
  This may happen in the following cases:

  - Host A advertises that it is connected to subnet with mask 255.255.
    and neighbor B.  Host B does not advertise that A is a neighbor.

  - Host A advertises that it is connected to subnet with mask 255.255.
    and neighbor B.  Host B advertises it is connected to a subnet with
    255.255.255.240 with neighbor A.

 In both of these cases the link should not be added to the advertised
 database.

 Each entry in the database is time-stamped with the last time an LSU f
 the associated router was received.  If an LSU is not received from th
 host within LSU_TIMEOUT seconds (three times LSUINT) from the last, th
 is invalidated and removed from the database.

Handling Incoming PWOSPF Packets

 Each host participating in a PWOSPF topology must check the following
 on incoming pwospf packets:

 o The version number field must specify protocol version 2.
 o The 16-bit checksum on the PWOSPF packet's contents must be
   verified. (the 64-bit authentication field must be excluded
   from the checksum calculation)
 o The area ID found in the PWOSPF header must match the Area ID
   of the receiving router.
 o The Authentication type specified must match the authentication type
   of the receiving router.

 PWOSPF does not support authentication, however it is our plan to prog
 towards OSPFv2 compatibility.  For this reason, we are using the full
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 header format which contains both an Authtication type and data field.
 fields should be set to 0 for all valid PWOSPF packets.

Handling Incoming HELLO Packets

   This section explains the detailed processing of a received Hello pa
   The generic input processing of PWOSPF packets will have checked the
   validity of the IP header and the PWOSPF packet header.  Next, the v
   the Network Mask and HelloInt fields in the received Hello packet mu
   checked against the values configured for the receiving interface.
   mismatch causes processing to stop and the packet to be dropped.  In
   words, the above fields are really describing the attached network's
   configuration.

   At this point, an attempt is made to match the source of the Hello P
   one of the receiving interface's neighbors.  If the receiving interf
   a multi-access network (either broadcast or non-broadcast) the sourc
   identified by the IP source address found in the Hello's IP header.
   interface's current neighbor(s) are contained in the interface's dat
   structure.  If the interface does not have a neighbor, a neighbor is
   If the interface already has neighbor(s) but none  match the IP of t
   incoming packet, a new neighbor is added. Finally, if the HELLO pack
   a current neighbor, the neighbor's "last hello packet received" time
   updated.

Handling Incoming LSU Packets

  Each received LSU packet must go through the following handling proce
  If the LSU was originally generated by the incoming router, the packe
  dropped.  If the sequence number matches that of the last packet rece
  from the sending host, the packet is dropped.  If the packet contents
  equivalent to the contents of the packet last received from the sendi
  the host's database entry is updated and the packet is ignored.  If t
  is from a host not currently in the database, the packets contents ar
  to update the database and Djikstra's algorithm is used to recompute
  forwarding table.  Finally, if the LSU data is for a host currently i
  database but the information has changed, the LSU is used to update t
  database, and Djikstra's algorithm is run to recompute the forwarding

  All received packets with new sequence numbers are flooded to all nei
  but the incoming neighbor of the packet.  The TTL header is only chec
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  in the forwarding stage and should not be considered when handling th
  locally.  The TTL field of all flooded packets must be decremented be
  exiting the router.  If the field after decrement is zero or less, th
  must not be flooded.

PWOSPF IP Packets

  PWOSPF are expected to be encapsulated IPv4 packets with IP protocol
  89 (the same as OSPFv2). OSPF HELLO packets are sent to destination I
  address ALLSPFRouters which is defined as "224.0.0.5" (0xe0000005).
  packets are sent point to point using the IP address of the neighbori
  interface as the destination.

PWOSPF Packet Header Format

  All PWOSPF packets are encapsulated in a common header that is identi
  the OSPFv2 header.   Using the OSPFv2 header will allow PWOSPF to con
  OSPF compliance in the future and is recognized by protocol analyzers
  as ethereal which can greatly aid in debugging.  The PWOSPF header is
  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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Version #   |     Type      |         Packet length         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          Router ID                            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                           Area ID                             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           Checksum            |             Autype            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       Authentication                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       Authentication                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Version #
    The PWOSPF/OSPF version number.  This specification documents versi
    the protocol.
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Type
    The OSPF packet types are as follows.  The format of each of these
    packet types is described in a succeeding section.

                      Type   Description
                      ________________________________
                      1      Hello
                      4      Link State Update

Packet length
    The length of the protocol packet in bytes.  This length includes
    the standard OSPF header.

Router ID
    The Router ID of the packet's source.  In OSPF, the source and
    destination of a routing protocol packet are the two ends of an
    (potential) adjacency.

Area ID
    A 32 bit number identifying the area that this packet belongs to.
    All OSPF packets are associated with a single area.  Most travel a
    single hop only.

Checksum
    The standard IP checksum of the entire contents of the packet,
    excluding the 64-bit authentication field.  This checksum is
    calculated as the 16-bit one's complement of the one's complement
    sum of all the 16-bit words in the packet, excepting the
    authentication field.  If the packet's length is not an integral
    number of 16-bit words, the packet is padded with a byte of zero
    before checksumming.

AuType
   Set to zero in PWOSPF

Authentication
   Set to zero in PWOSPF

HELLO Packet Format

  Hello packets are PWOSPF packet type 1.  These packets are sent perio
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  on all interfaces in order to establish and maintain neighbor relatio
  In addition, Hellos broadcast enabling dynamic discovery of neighbori
  routers.

  All routers connected to a common network must agree on certain param
  (network mask and helloint).  These parameters are included in Hello
  so that differences can inhibit the forming of neighbor relationships
  full HELLO packet with PWOSPF header 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
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |   Version #   |       1       |         Packet length         |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                          Router ID                            |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                           Area ID                             |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |           Checksum            |             Autype            |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                       Authentication                          |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                       Authentication                          |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                        Network Mask                           |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |         HelloInt              |           padding             |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

  Network mask
      The network mask associated with this interface.  For example, if
      the interface is to a class B network whose third byte is used fo
      subnetting, the network mask is 0xffffff00.

  HelloInt
      The number of seconds between this router's Hello packets.

LSU Packet Format

  LSU packets implement the flooding of link states and  are used to bu
  maintain the network topology database at each router.  Each link sta
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update packet carries a collection of link state advertisements on ho
further from its origin. Several link state advertisements may be in
in a single packet. A link state packet with full PWOSF header looks
follows:

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  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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |   Version #   |       4       |         Packet length         |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                          Router ID                            |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                           Area ID                             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |           Checksum            |             Autype            |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                       Authentication                          |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                       Authentication                          |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |     Sequence                 |           TTL                  |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                      # advertisements                         |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                                                               |
 +-                                                            +-+
 |                   Link state advertisements                  |
 +-                                                            +-+
 |                              ...                              |
```

Sequence
   Unique sequence number associated with each Link State Updated.
   Incremented by the LSU source for each subsequence updated. Dupli
   LSU packets are dropped by the receiver.

TTL
   Hop limited value decremented each time the packet is forwarded.
   TTL value is only considered during packet forwarding and not duri
   packet reception.
# of advertisements
   Total number of link state advertisements contained in the packet

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 Link state advertisements

  Each link state update packet should contain 1 or more link state
  advertisements.  The advertisements are the reachable routes directl
  connected to the advertising router.  Routes are in the form of the
  mask and router neighor for the attached link. Link state advertisem
  look specifically as follows:

  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                           Subnet                              |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                           Mask                                |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                         Router ID                             |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

  subnet
     Subnet number of the advertised route.  Note that default routes
     will have a subnet value of 0.0.0.0.

  Mask
     Subnet mask of the advertised route

  Router ID
     ID of the neighboring router on the advertised link.  If there is
     connected router to the link the RID should be set to 0.

  Example:

    In the below topology with subnet 192.168.128 using IP addresses
    allocated as showing (xxx is intended to be 192.168.128).

             xxx.1      xxx.2     xxx.4      xxx.5   xxx.8  xxx.9
[Internet]-[FW]---------------- A ------------------ B ------- <endhos

  Assuming FW is not participating in the PWOSPF area.

  A could advertise the following routes

  1. (subnet between A and the firewall)
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      Subnet 192.168.128.0
      Mask   255.255.255.252
      RID    0

   2. (default route to the Internet)
      Subnet 0.0.0.0
      Mask   0.0.0.0
      RID    0.0.0.0

   3. (link shared with B
      Subnet 192.168.128.4
      Mask   255.255.255.254
      RID    192.168.128.5  (B's router ID)

  B could advertise the following routes

  1. (link shared with A)
      Subnet 192.168.128.4
      Mask   255.255.255.254
      RID    192.168.128.4  (A's router ID)

 2. (Link to end host)
      Subnet 192.168.128.8
      Mask   255.255.255.254
      RID    0.0.0.0 (no attached PWOSPF router)
```