224.0.0.6 224.0.0.5

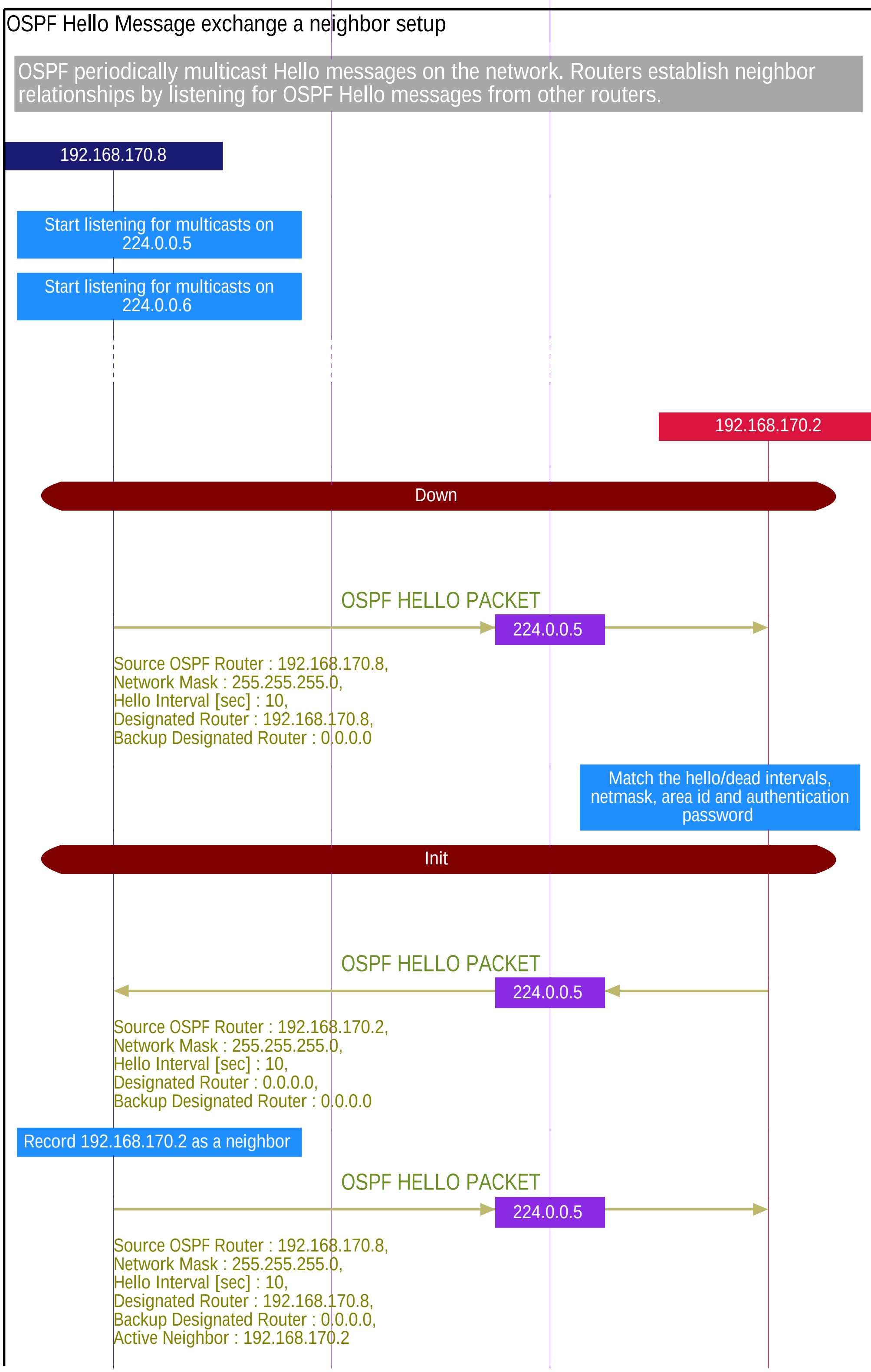
OSPF Router Startup and Link State Update

OSPF (Open Shortest Path First) is a routing protocol that is used as an interior gateway protocol in large enterprises.

This flow shows the message exchange that takes place when a new OSPF router comes online. You can click on any message in the flow to see full message contents.

Covered sequence: (1)OSPF hello message exchange (2) Master-slave resolution (3) Router database synchronization (4) Link state update

This sequence diagram was generated from a PCAP file with VisualEther (http://www.EventHelix.com/VisualEther/) and then modified with EventStudio ((http://www.EventHelix.com/EventStudio/) to add further design details.



Router 192.168.170.8 starts up.

Router 192.168.170.2 starts up.

This is the first OSPF neighbor state. It means that no hello packets have been received from this neighbor, but hello packets can still be sent to the neighbor in this state.

Router 192.168.170.8 is the only router on the network. It assumes that is it the designated router. The router multicasts an OSPF Hello message on the 224.0.0.5 multicast address.

The received hello is processed only if all parameters match.

This state specifies that the router has received a hello packet from its neighbor, but the receiving router's ID was not included in the hello packet.

The router starts up and sends out an OSPF Hello. The router is yet to learn about the designated router.

The DR sends out a periodic multicast, listing 192.168.170.2 as a neighbor.

192.168.170.8	224.0.0.6	224.0.0.5	192.168.170.2

Record 192.168.170.8 as a neighbor

2-Way

This state is entered when bi-directional communication has been established between two routers. Bi-directional means that each router has seen the other's hello packet (i.e. the hello packet received from another router lists this router's ID as an active neighbor.

OSPF HELLO PACKET

224.0.0.5

Source OSPF Router : 192.168.170.3,
Network Mask : 255.255.255.0,
Hello Interval [sec] : 10,
Designated Router : 0.0.0.0,
Backup Designated Router : 0.0.0.0,
Active Neighbor : 192.168.170.8

192.168.170.2 also reports that 192.168.170.8 is a neighbor.

Database synchronization

After the link establishment, the neighboring routers exchange their link status database.

Exstart

At this point the Designated Router (DR) has been finalized and the routing information exchange can begin.

Master-Slave resolution for DB synchronization

The routers first establish a master-slave relationship. This is followed by the exchange of database information. Note that only link state headers will be exchanged during this phase.

OSPF DB DESCRIPTION

Source OSPF Router : 192.168.170.8,
DB Description : 0x07 (I, M, MS),
DD Sequence : 1098361214

Router asserts that is the master by setting the MS option bit. The message also sets the I bit signifying that this is the initial message of the Database synchronization handshake. The more bit (M) signals that more data is going to follow.

OSPF DB DESCRIPTION

Source OSPF Router : 192.168.170.3,
DB Description : 0x07 (I, M, MS),
DD Sequence : 1098361214

Router asserts that is the master by setting the MS option bit. The message also sets the I bit signifying that this is the initial message of the Database synchronization handshake. The more bit (M) signals that more data is going to follow.

Master-slave resolution: 'I am slave'

192.168.0.2 is less than 192.168.170.8 so this router assumes that it is a slave.

OSPF DB DESCRIPTION

Source OSPF Router : 192.168.170.3,
DB Description : 0x02 (M),
DD Sequence : 1098361214,
LS Type : Router-LSA,
Link State ID : 192.168.170.3,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 80.212.16.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 148.121.171.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.130.120.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.0.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.1.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.172.0,
Advertising Router : 192.168.170.2

Router removes the master assertion by resetting the MS bit. The router also starts sending its database. The more bit(M)signals that their are more database update need to be exchanged.

192.168.170.8	224.0.0.6	224.0.0.5	192.168.170.2

Master-slave resolution: 'I am master'

OSPF DB DESCRIPTION (192.168.170.8 → 192.168.170.2)

Source OSPF Router : 192.168.170.8,
DB Description : 0x03 (M, MS),
DD Sequence : 1098361215,
LS Type : Router-LSA,
Link State ID : 192.168.170.8,
Advertising Router : 192.168.170.8

192.168.170.8 is greater than 192.168.170.2, so the router asserts that it is the master.

The router asserts that it is the master by setting the MS bit. The master also increments the DD sequence.

Exchange

Master-slave is now settled. The routers initiate the exchange of database information.

OSPF DB DESCRIPTION (192.168.170.2 → 192.168.170.8)

Source OSPF Router : 192.168.170.3,
DB Description : 0x00,
DD Sequence : 1098361215

The slave acknowledges the DD sequence.

OSPF DB DESCRIPTION (192.168.170.8 → 192.168.170.2)

Source OSPF Router : 192.168.170.8,
DB Description : 0x01 (MS),
DD Sequence : 1098361216

The master again updates the DD sequence.

OSPF DB DESCRIPTION (192.168.170.2 → 192.168.170.8)

Source OSPF Router : 192.168.170.3,
DB Description : 0x00,
DD Sequence : 1098361216

The slave acknowledges the changed DD sequence.

Full link state update

The database update has synchronized the link state headers between the routers. Routers now scan the synchronized link state headers to determine if they are missing any link state updates. This is followed by requesting the link state updates to completely sychronize the link states.

Loading

OSPF LINK STATE REQUEST (192.168.170.2 → 192.168.170.8)

Source OSPF Router : 192.168.170.3,
LS Type : Router-LSA,
Link State ID : 192.168.170.8,
Advertising Router : 192.168.170.8

After exchanging Database Description packets with a neighboring router, "192.168.170.2" router finds that parts of its topological database are out of date. The Link State Request packet is used to request the pieces of the neighbor's database that are more up to date.

OSPF LINK STATE REQUEST (192.168.170.8 → 192.168.170.2)

Source OSPF Router : 192.168.170.8,
LS Type : Router-LSA,
Link State ID : 192.168.170.3,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 80.212.16.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 148.121.171.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.130.120.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.0.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.1.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.172.0,
Advertising Router : 192.168.170.2

"192.168.170.8" also requests update for its out of date database.

192.168.170.8	224.0.0.6	224.0.0.5	192.168.170.2

The routers then send out their link state updates as a multicast flood. The Link State Update packets contain a collection of link state advertisements that are one hop away from the sender.

OSPF LINK STATE UPDATE (192.168.170.8 → 224.0.0.5)

Source OSPF Router : 192.168.170.8,
LS Type : Router-LSA,
Link State ID : 192.168.170.8,
Advertising Router : 192.168.170.8,
Link ID : 192.168.170.0 - IP network /subnet number,
Link Type : 3 - Connection to a stub network,
0 Metric : 10

OSPF LINK STATE UPDATE (192.168.170.2 → 224.0.0.6)

Source OSPF Router : 192.168.170.3,
LS Type : Router-LSA,
Link State ID : 192.168.170.3,
Advertising Router : 192.168.170.3,
Link ID : 192.168.170.0 - IP network /subnet number,
Link Type : 3 - Connection to a stub network,
0 Metric : 10,
Link ID : 192.168.170.0 - IP network /subnet number,
Link Type : 3 - Connection to a stub network,
0 Metric : 10,
LS Type : AS-External-LSA (ASBR),
Link State ID : 80.212.16.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 148.121.171.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.130.120.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.0.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.1.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.172.0 (192.168.172.0),
Advertising Router : 192.168.170.2

OSPF LINK STATE UPDATE (192.168.170.2 → 224.0.0.6)

Source OSPF Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 148.121.171.0,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.130.120.0,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.0.0,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.1.0,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.172.0,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 80.212.16.0,
Advertising Router : 192.168.170.3

OSPF LINK STATE UPDATE (192.168.170.8 → 224.0.0.5)

Source OSPF Router : 192.168.170.8,
LS Type : Network-LSA,
Link State ID : 192.168.170.8,
Advertising Router : 192.168.170.8

OSPF LINK STATE UPDATE (192.168.170.8 → 224.0.0.5)

Source OSPF Router : 192.168.170.8,
LS Type : Router-LSA,
Link State ID : 192.168.170.8,
Advertising Router : 192.168.170.8,
Sequence Number : 0x80000dc4,
Link ID : 192.168.170.8 - IP address of Designated Router,
Link Type : 2 - Connection to a transit network,
0 Metric : 10

192.168.170.8 | 224.0.0.6 | 224.0.0.5 | 192.168.170.2

All routers acknowledge the link state updates. The acknowledgements contain link state headers to identify the link state updates that are being acknowledged.

OSPF LINK STATE ACKNOWLEDGE

224.0.0.5

Source OSPF Router : 192.168.170.8,
LS Type : Router-LSA,
Link State ID : 192.168.170.3,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 80.212.16.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 148.121.171.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.130.120.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.0.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.1.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.172.0,
Advertising Router : 192.168.170.2,
LS Type : AS-External-LSA (ASBR),
Link State ID : 148.121.171.0,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.130.120.0,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.0.0,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.1.0,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 192.168.172.0,
Advertising Router : 192.168.170.3,
LS Type : AS-External-LSA (ASBR),
Link State ID : 80.212.16.0,
Advertising Router : 192.168.170.3

OSPF LINK STATE UPDATE

224.0.0.6

Source OSPF Router : 192.168.170.3,
LS Type : Router-LSA,
Link State ID : 192.168.170.3,
Advertising Router : 192.168.170.3,
Sequence Number : 0x80000002,
Link ID : 192.168.170.0 - IP network /subnet number,
Link Type : 3 - Connection to a stub network,
0 Metric : 10,
Link ID : 192.168.170.0 - IP network /subnet number,
Link Type : 3 - Connection to a stub network,
0 Metric : 10

OSPF LINK STATE ACKNOWLEDGE

224.0.0.5

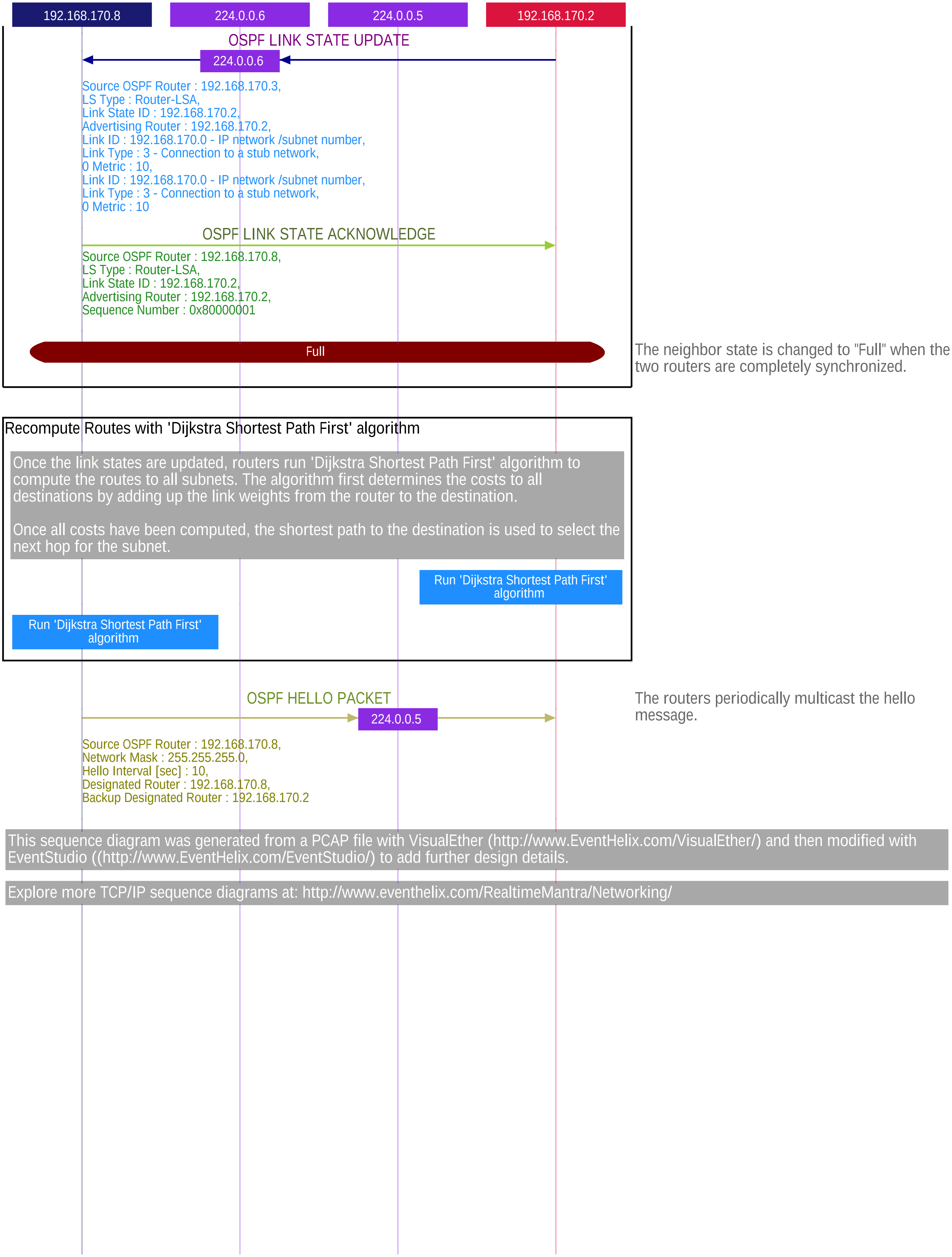
Source OSPF Router : 192.168.170.8,
LS Type : Router-LSA,
Link State ID : 192.168.170.3,
Advertising Router : 192.168.170.3

OSPF LINK STATE UPDATE

Source OSPF Router : 192.168.170.3,
LS Type : Router-LSA,
Link State ID : 192.168.170.2,
Advertising Router : 192.168.170.2,
Link ID : 192.168.170.0 - IP network /subnet number,
Link Type : 3 - Connection to a stub network,
0 Metric : 10,
Link ID : 192.168.170.0 - IP network /subnet number,
Link Type : 3 - Connection to a stub network,
0 Metric : 10

OSPF LINK STATE ACKNOWLEDGE

Source OSPF Router : 192.168.170.8,
LS Type : Router-LSA,
Link State ID : 192.168.170.2,
Advertising Router : 192.168.170.2,
Sequence Number : 0x80000001


192.168.170.8
224.0.0.6
224.0.0.5
192.168.170.2
OSPF LINK STATE UPDATE
224.0.0.6
Source OSPF Router : 192.168.170.3,
LS Type : Router-LSA,
Link State ID : 192.168.170.2,
Advertising Router : 192.168.170.2,
Link ID : 192.168.170.0 - IP network /subnet number,
Link Type : 3 - Connection to a stub network,
0 Metric : 10,
Link ID : 192.168.170.0 - IP network /subnet number,
Link Type : 3 - Connection to a stub network,
0 Metric : 10
OSPF LINK STATE ACKNOWLEDGE
Source OSPF Router : 192.168.170.8,
LS Type : Router-LSA,
Link State ID : 192.168.170.2,
Advertising Router : 192.168.170.2,
Sequence Number : 0x80000001
Full
The neighbor state is changed to "Full" when the two routers are completely synchronized.
Recompute Routes with 'Dijkstra Shortest Path First' algorithm
Once the link states are updated, routers run 'Dijkstra Shortest Path First' algorithm to compute the routes to all subnets. The algorithm first determines the costs to all destinations by adding up the link weights from the router to the destination.
Once all costs have been computed, the shortest path to the destination is used to select the next hop for the subnet.
Run 'Dijkstra Shortest Path First' algorithm
Run 'Dijkstra Shortest Path First' algorithm
OSPF HELLO PACKET
224.0.0.5
The routers periodically multicast the hello message.
Source OSPF Router : 192.168.170.8,
Network Mask : 255.255.255.0,
Hello Interval [sec] : 10,
Designated Router : 192.168.170.8,
Backup Designated Router : 192.168.170.2
This sequence diagram was generated from a PCAP file with VisualEther (http://www.EventHelix.com/VisualEther/) and then modified with EventStudio ((http://www.EventHelix.com/EventStudio/) to add further design details.
Explore more TCP/IP sequence diagrams at: http://www.eventhelix.com/RealtimeMantra/Networking/