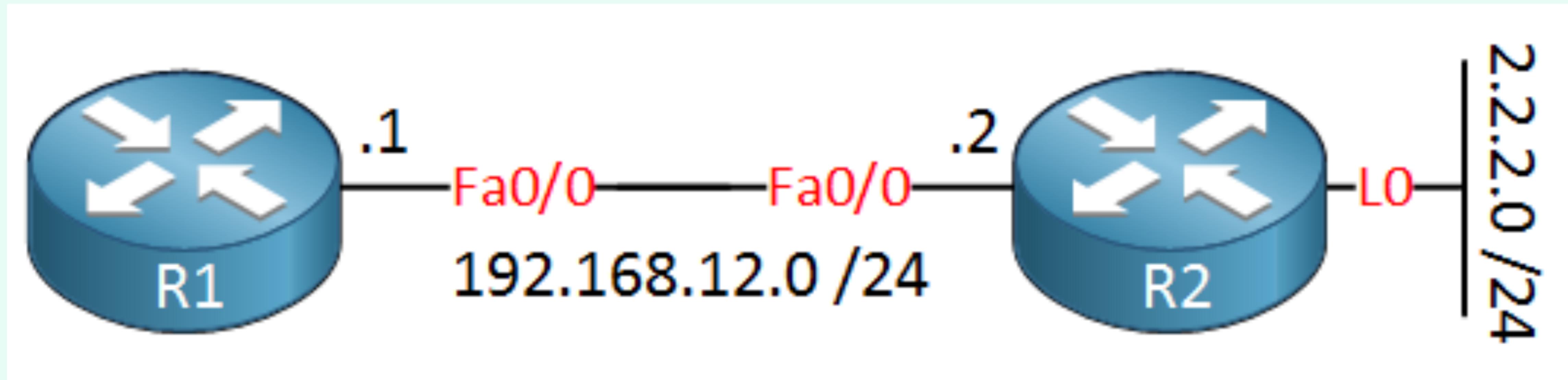


# Working of OSPF with pcap

## Brief About the Topology



## Topology Overview

### Network Setup:

- The topology consists of two routers, R1 and R2, connected via an Ethernet link on their FastEthernet0/0 interfaces.

### IP Addressing:

- R1: FastEthernet0/0 IP: 192.168.12.1/24, Loopback 0: 1.1.1.1.
- R2: FastEthernet0/0 IP: 192.168.12.2/24, Loopback 0: 2.2.2.2.

### OSPF Configuration:

- Both routers operate in OSPF Area 0 (backbone area).
- The Ethernet link is treated as a broadcast network, leading to the election of a Designated Router (DR) and Backup Designated Router (BDR).
- Router IDs are derived from loopback interfaces: R1 (1.1.1.1), R2 (2.2.2.2).

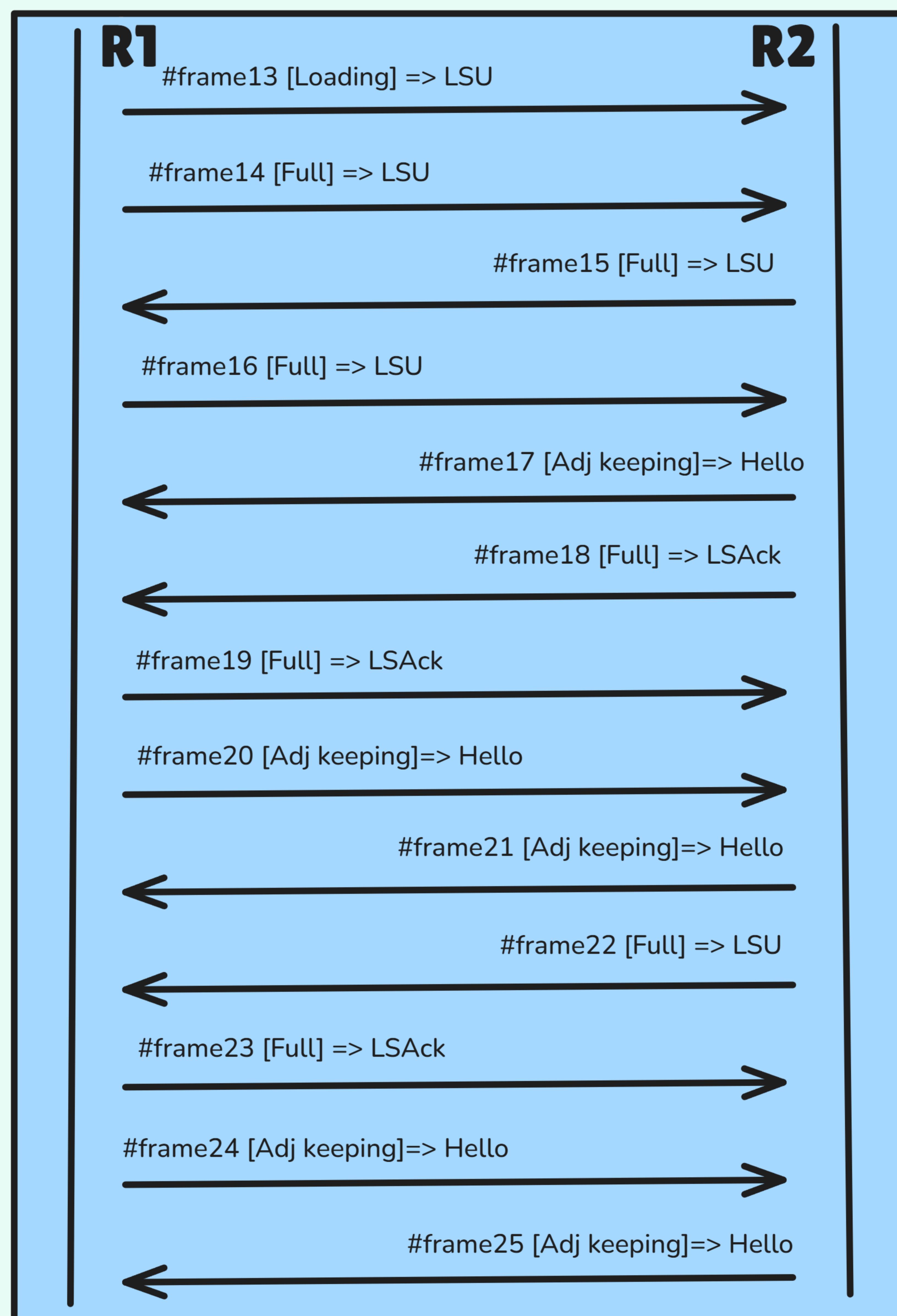
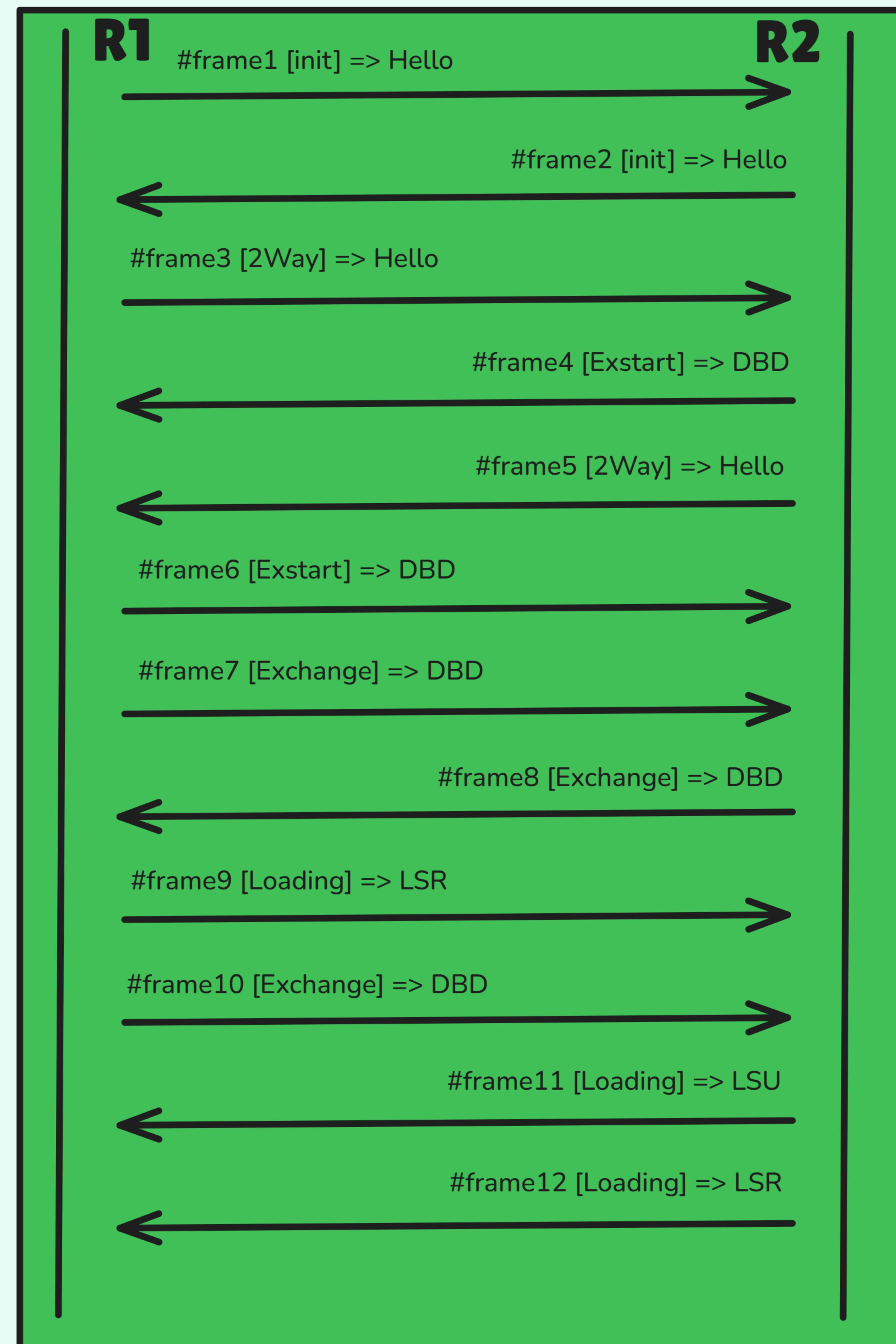
### Purpose:

- This setup is used to capture and analyze OSPF adjacency formation, including DR/BDR election, database synchronization, and packet exchange.

# Summary of the capture

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.12.1	224.0.0.5	OSPF	110	Hello Packet
2	0.602114461	192.168.12.2	224.0.0.5	OSPF	110	Hello Packet
3	9.702465905	192.168.12.1	224.0.0.5	OSPF	114	Hello Packet
4	9.703130205	192.168.12.2	192.168.12.1	OSPF	78	DB Description
5	9.703140752	192.168.12.2	192.168.12.1	OSPF	114	Hello Packet
6	9.703509047	192.168.12.1	192.168.12.2	OSPF	78	DB Description
7	9.703587554	192.168.12.1	192.168.12.2	OSPF	98	DB Description
8	9.703952636	192.168.12.2	192.168.12.1	OSPF	98	DB Description
9	9.704269665	192.168.12.1	192.168.12.2	OSPF	70	LS Request
10	9.704277627	192.168.12.1	192.168.12.2	OSPF	78	DB Description
11	9.704604504	192.168.12.2	192.168.12.1	OSPF	98	LS Update
12	9.704626506	192.168.12.2	192.168.12.1	OSPF	70	LS Request
13	9.705043483	192.168.12.1	192.168.12.2	OSPF	98	LS Update
14	9.707433527	192.168.12.1	224.0.0.5	OSPF	94	LS Update
15	9.755863845	192.168.12.2	224.0.0.5	OSPF	98	LS Update
16	9.756298773	192.168.12.1	224.0.0.5	OSPF	98	LS Update
17	10.4674803...	192.168.12.2	224.0.0.5	OSPF	114	Hello Packet
18	12.2060773...	192.168.12.2	224.0.0.5	OSPF	118	LS Acknowledge
19	12.2062127...	192.168.12.1	224.0.0.5	OSPF	98	LS Acknowledge
20	19.5213901...	192.168.12.1	224.0.0.5	OSPF	114	Hello Packet
21	19.5736393...	192.168.12.2	224.0.0.5	OSPF	114	Hello Packet
22	19.5753413...	192.168.12.2	224.0.0.5	OSPF	98	LS Update
23	22.0774404...	192.168.12.1	224.0.0.5	OSPF	78	LS Acknowledge
24	28.8269421...	192.168.12.1	224.0.0.5	OSPF	114	Hello Packet
25	28.8474231...	192.168.12.2	224.0.0.5	OSPF	114	Hello Packet

# Overall summary flow diagram



# Frequently Asked Questions

## FAQ 1: Why is the network type broadcast and not point-to-point?

### Answer:

- ◆ The network is treated as a broadcast type because the link is an Ethernet interface, which OSPF considers a multi-access network by default. Ethernet supports multiple devices on the same segment, requiring a Designated Router (DR) to manage LSA flooding. Unless explicitly configured with the OSPF command `ip ospf network point-to-point`, the interface retains the broadcast network type, as seen in the multicast Hello packets (224.0.0.5) in the capture.

## FAQ 2: Why is Router 1.1.1.1 the DR instead of Router 2.2.2.2?

### Answer:

- ◆ Router 1.1.1.1 is elected as the Designated Router (DR) because it was the first router to activate OSPF on the network segment, sending Hello packets and declaring itself DR when no other routers were present (Frame 1). Both routers have equal priority (1), but OSPF's sticky DR behavior ensures an existing DR retains its role unless it fails or the OSPF process is reset. Despite Router 2.2.2.2 having a higher Router ID ( $2.2.2.2 > 1.1.1.1$ ), it does not preempt the existing DR, as OSPF does not support DR preemption.

## FAQ 3: Why is the Down state not visible in the packet capture?

### Answer:

- ◆ The Down state is not visible in the packet capture because it represents the initial state before OSPF packet exchange begins, where no Hello packets have been sent or received. The capture starts with Frame 1 (Hello packet), indicating the routers are already in the Init state. The Down state is transient and internal to the OSPF process, not represented by any packets, making it irrelevant to the captured traffic.

# Frequently Asked Questions

## FAQ 4: Why are there many LSU packets but fewer LSR and LSAck packets?

### Answer:

- ◆ Multiple Link-State Update (LSU) packets (Frames 11, 13, 14, 15, 16, 22) are sent during initial database synchronization to exchange Router-LSAs (Type 1) and the Network-LSA (Type 2), and for periodic LSA refreshes. Only two Link-State Request (LSR) packets (Frames 9, 12) are needed, as each router requests only the other's Router-LSA during the Loading state. Link-State Acknowledgment (LSAck) packets (Frames 18, 19, 23) are fewer because OSPF uses delayed acknowledgments, consolidating multiple LSA acknowledgments into a single packet to reduce overhead and prevent flooding of acknowledgment packets.

## FAQ 5: Are Master/Slave and DR/BDR roles the same?

### Answer:

- ◆ No, Master/Slave and DR/BDR roles are distinct. The Master/Slave relationship is established during the ExStart and Exchange states (Frames 4, 6-8, 10) to control the Database Description (DBD) packet exchange, with the router having the higher Router ID (2.2.2.2) acting as Master. The DR/BDR roles are elected on multi-access networks (Frames 3, 5) to minimize LSA flooding overhead, with the DR (Router 1.1.1.1) and BDR (Router 2.2.2.2) managing LSA distribution. Master/Slave is temporary for database synchronization, while DR/BDR roles persist for network operation.

# Frequently Asked Questions

## FAQ 6: Why is the link type “stub” in LSU packets? Is it a real OSPF stub?

### Answer:

- ◆ The “stub” link type in LSU packets (e.g., Frames 11, 13) refers to a stub network in the OSPF Router-LSA (Type 1), indicating a network (192.168.12.0/24) with no other OSPF routers or areas connected to it. This is not an OSPF stub area, which is a specific area type that restricts external routes. Instead, the stub link represents a local network attached to the router, with no further OSPF topology beyond it, as seen in the Router-LSAs describing the 192.168.12.0/24 subnet.

## FAQ 7: In the Exchange state, DBD packets send LSA Type 1 headers, so why are the same LSAs requested again via LSR?

### Answer:

- ◆ In the Exchange state (Frames 7-8, 10), Database Description (DBD) packets contain only LSA headers (e.g., Router-LSA Type 1) to summarize the link-state database, identifying the LSAs each router possesses. These headers include the Link State ID, Advertising Router, and Sequence Number but lack detailed link information (e.g., link type, metric). The Link-State Request (LSR) packets (Frames 9, 12) are sent in the Loading state to request the full LSA content, including link details (e.g., stub or transit links, metrics), to ensure complete database synchronization.

# Frame#1 - Init state R1 to R2

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.12.1	224.0.0.5	OSPF	110	Hello Packet

```
> Frame 1: 110 bytes on wire (880 bits), 110 bytes captured (880 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 224.0.0.5
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
      Message Type: Hello Packet (1)
      Packet Length: 44
      Source OSPF Router: 1.1.1.1
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0xea9c [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  ▼ OSPF Hello Packet
    Network Mask: 255.255.255.0
    Hello Interval [sec]: 10
    Options: 0x12, (L) LLS Data block, (E) External Routing
    Router Priority: 1
    Router Dead Interval [sec]: 40
    Designated Router: 0.0.0.0
    Backup Designated Router: 0.0.0.0
  > OSPF LLS Data Block
```

## Role in Adjacency

- 📌 Initial Hello packet sent by Router 1.1.1.1 to discover neighbors on the 192.168.12.0/24 network.
- 📌 router is in the Down or Init state, broadcasting its presence to the OSPF multicast address (224.0.0.5).
- 📌 No DR or BDR is elected yet, and no neighbors are known.

# Frame#2 - Init state R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
2	0.602114461	192.168.12.2	224.0.0.5	OSPF	110	Hello Packet

```
> Frame 2: 110 bytes on wire (880 bits), 110 bytes captured (880 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
> Internet Protocol Version 4, Src: 192.168.12.2, Dst: 224.0.0.5
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
      Message Type: Hello Packet (1)
      Packet Length: 44
      Source OSPF Router: 2.2.2.2
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0xe89a [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  ▼ OSPF Hello Packet
    Network Mask: 255.255.255.0
    Hello Interval [sec]: 10
    Options: 0x12, (L) LLS Data block, (E) External Routing
    Router Priority: 1
    Router Dead Interval [sec]: 40
    Designated Router: 0.0.0.0
    Backup Designated Router: 0.0.0.0
  > OSPF LLS Data Block
```

## Role in Adjacency

- Router 2.2.2.2 sends its initial Hello packet, also in the Down or Init state.
- Router 1.1.1.1 receives this packet (since it's sent to 224.0.0.5) and learns about Router 2.2.2.2.
- Router 2.2.2.2 likely received Frame 1's Hello and will include Router 1.1.1.1 in its next Hello packet, transitioning to the 2-Way state.

# Frame#3 - 2Way state R1 to R2

No.	Time	Source	Destination	Protocol	Length	Info
3	9.702465905	192.168.12.1	224.0.0.5	OSPF	114	Hello Packet

> Frame 3: 114 bytes on wire (912 bits), 114 bytes captured (912 bits) on interface 0  
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: IPv4mcast\_05 (01:00:5e:00:00:05)  
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 224.0.0.5  
▼ Open Shortest Path First  
  ▼ OSPF Header  
    Version: 2  
    Message Type: Hello Packet (1)  
    Packet Length: 48  
    Source OSPF Router: 1.1.1.1  
    Area ID: 0.0.0.0 (Backbone)  
    Checksum: 0x19eb [correct]  
    Auth Type: Null (0)  
    Auth Data (none): 0000000000000000  
  ▼ OSPF Hello Packet  
    Network Mask: 255.255.255.0  
    Hello Interval [sec]: 10  
    Options: 0x12, (L) LLS Data block, (E) External Routing  
    Router Priority: 1  
    Router Dead Interval [sec]: 40  
    Designated Router: 192.168.12.1  
    Backup Designated Router: 0.0.0.0  
    Active Neighbor: 2.2.2.2  
  > OSPF LLS Data Block

## Role in Adjacency

- ❖ By Frame 3, Router 1.1.1.1 has received Router 2.2.2.2's Hello (Frame 2) and lists 2.2.2.2 as an active neighbor, confirming the 2-Way state.
- ❖ Router 1.1.1.1 is DR because it was the first router to send Hellos and declare itself DR, before Router 2.2.2.2 was active. OSPF's sticky DR behavior ensures Router 1.1.1.1 retains the DR role, even though Router 2.2.2.2 has a higher Router ID (2.2.2.2 > 1.1.1.1).

.

# Frame#4 - Exstart state R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
4	9.703130205	192.168.12.2	192.168.12.1	OSPF	78	DB Description

> Frame 4: 78 bytes on wire (624 bits), 78 bytes captured (624 bits) on interface 0  
 > Ethernet II, Src: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10), Dst: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10)  
 > Internet Protocol Version 4, Src: 192.168.12.2, Dst: 192.168.12.1  
 ▼ Open Shortest Path First  
   ▼ OSPF Header  
     Version: 2  
     Message Type: DB Description (2)  
     Packet Length: 32  
     Source OSPF Router: 2.2.2.2  
     Area ID: 0.0.0.0 (Backbone)  
     Checksum: 0x980a [correct]  
     Auth Type: Null (0)  
     Auth Data (none): 0000000000000000  
   ▼ OSPF DB Description  
     Interface MTU: 1500  
     > Options: 0x52, 0, (L) LLS Data block, (E) External Routing  
     ▼ DB Description: 0x07, (I) Init, (M) More, (MS) Master  
       .... 0... = (R) OOBResync: Not set  
       .... .1.. = (I) Init: Set  
       .... ..1. = (M) More: Set  
       .... ...1 = (MS) Master: Yes  
     DD Sequence: 2540  
   > OSPF LLS Data Block

## Role in Adjacency

- 📌 Router 2.2.2.2 initiates the ExStart state by sending a DBD packet to Router 1.1.1.1.
- 📌 The I (Init) flag indicates this is the first DBD packet in the exchange.
- 📌 The M (More) flag indicates more DBD packets will follow.
- 📌 The MS (Master) flag shows Router 2.2.2.2 claims to be the master.
- 📌 **Master-Slave Election:** Both routers initially claim to be the master (MS bit set). The router with the higher Router ID (2.2.2.2 > 1.1.1.1) will become the master, but this is resolved in subsequent packets.

# Frame#5 - 2Way state R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
5	9.703140752	192.168.12.2	192.168.12.1	OSPF	114	Hello Packet

```
> Frame 5: 114 bytes on wire (912 bits), 114 bytes captured (912 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10), Dst: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10)
> Internet Protocol Version 4, Src: 192.168.12.2, Dst: 192.168.12.1
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
    Message Type: Hello Packet (1)
    Packet Length: 48
    Source OSPF Router: 2.2.2.2
    Area ID: 0.0.0.0 (Backbone)
    Checksum: 0x4d40 [correct]
    Auth Type: Null (0)
    Auth Data (none): 0000000000000000
  ▼ OSPF Hello Packet
    Network Mask: 255.255.255.0
    Hello Interval [sec]: 10
    Options: 0x12, (L) LLS Data block, (E) External Routing
    Router Priority: 1
    Router Dead Interval [sec]: 40
    Designated Router: 192.168.12.1
    Backup Designated Router: 192.168.12.2
    Active Neighbor: 1.1.1.1
  > OSPF LLS Data Block
```

## Role in Adjacency

- Router 2.2.2.2 acknowledges Router 1.1.1.1 as the DR and declares itself the BDR (since it has the next highest Router ID).
- This unicast Hello confirms the 2-Way state and agreement on DR/BDR roles, allowing the adjacency to proceed to the ExStart state.
- The unicast nature suggests it's part of the adjacency process, reinforcing neighbor discovery.

# Frame#6 - Exstart state R1 to R2

No.	Time	Source	Destination	Protocol	Length	Info
6	9.703509047	192.168.12.1	192.168.12.2	OSPF	78	DB Description

```
> Frame 6: 78 bytes on wire (624 bits), 78 bytes captured (624 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10)
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 192.168.12.2
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
      Message Type: DB Description (2)
      Packet Length: 32
      Source OSPF Router: 1.1.1.1
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0x8931 [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  ▼ OSPF DB Description
    Interface MTU: 1500
    > Options: 0x52, 0, (L) LLS Data block, (E) External Routing
    ▼ DB Description: 0x07, (I) Init, (M) More, (MS) Master
      .... 0... = (R) OOBResync: Not set
      .... .1.. = (I) Init: Set
      .... ..1. = (M) More: Set
      .... ...1 = (MS) Master: Yes
    DD Sequence: 6855
  > OSPF LLS Data Block
```

## Role in Adjacency

- ❖ Router 1.1.1.1 responds with its own DBD packet, also claiming to be the master (MS bit set).
- ❖ The ExStart state continues as both routers negotiate the master-slave relationship.
- ❖ The different DD Sequence number (6855 vs. 2540) indicates that the routers are not yet synchronized. The router with the higher Router ID (2.2.2.2) will win the master role.

# Frame#7 - Exchange state R1 to R2

No.	Time	Source	Destination	Protocol	Length	Info
7	9.703587554	192.168.12.1	192.168.12.2	OSPF	98	DB Description

> Frame 7: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0  
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10)  
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 192.168.12.2  
▼ Open Shortest Path First  
  ▼ OSPF Header  
    Version: 2  
    Message Type: DB Description (2)  
    Packet Length: 52  
    Source OSPF Router: 1.1.1.1  
    Area ID: 0.0.0.0 (Backbone)  
    Checksum: 0xb75b [correct]  
    Auth Type: Null (0)  
    Auth Data (none): 0000000000000000  
  ▼ OSPF DB Description  
    Interface MTU: 1500  
    Options: 0x52, 0, (L) LLS Data block, (E) External Routing  
    ▼ DB Description: 0x02, (M) More  
      .... 0... = (R) OOBResync: Not set  
      .... .0.. = (I) Init: Not set  
      .... ..1. = (M) More: Set  
      .... ...0 = (MS) Master: No  
    DD Sequence: 2540  
    > LSA-type 1 (Router-LSA), len 36  
    > OSPF LLS Data Block

## Role in Adjacency

- 📌 Router 1.1.1.1 accepts Router 2.2.2.2 as the master (MS bit not set) and adopts the master's DD Sequence number (2540).
- 📌 The Exchange state begins as Router 1.1.1.1 sends its database summary, including a Router-LSA describing its links.
- 📌 The M (More) flag indicates additional DBD packets will follow.
- 📌 Master-Slave Election Complete: Router 2.2.2.2 (higher Router ID) is the master, controlling the DBD exchange sequence.

# Frame#8 - Exchange state R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
8	9.703952636	192.168.12.2	192.168.12.1	OSPF	98	DB Description

> Frame 8: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0  
> Ethernet II, Src: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10), Dst: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10)  
> Internet Protocol Version 4, Src: 192.168.12.2, Dst: 192.168.12.1  
▼ Open Shortest Path First  
  ▼ OSPF Header  
    Version: 2  
    Message Type: DB Description (2)  
    Packet Length: 52  
    Source OSPF Router: 2.2.2.2  
    Area ID: 0.0.0.0 (Backbone)  
    Checksum: 0xfe0f [correct]  
    Auth Type: Null (0)  
    Auth Data (none): 0000000000000000  
  ▼ OSPF DB Description  
    Interface MTU: 1500  
    Options: 0x52, 0, (L) LLS Data block, (E) External Routing  
    ▼ DB Description: 0x01, (MS) Master  
      .... 0... = (R) OOBResync: Not set  
      .... .0.. = (I) Init: Not set  
      .... ..0. = (M) More: Not set  
      .... ...1 = (MS) Master: Yes  
    DD Sequence: 2541  
    > LSA-type 1 (Router-LSA), len 36  
    > OSPF LLS Data Block

## Role in Adjacency

- ❖ Router 2.2.2.2, as the master, responds with its database summary, including its Router-LSA.
- ❖ The absence of the M (More) flag indicates this is the final DBD packet from Router 2.2.2.2.
- ❖ The Exchange state continues, with both routers now aware of each other's LSAs.

# Frame#9 - Loading state R1 to R2

No.	Time	Source	Destination	Protocol	Length	Info
9	9.704269665	192.168.12.1	192.168.12.2	OSPF	70	LS Request

```
> Frame 9: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10)
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 192.168.12.2
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
    Message Type: LS Request (3)
    Packet Length: 36
    Source OSPF Router: 1.1.1.1
    Area ID: 0.0.0.0 (Backbone)
    Checksum: 0xf3cd [correct]
    Auth Type: Null (0)
    Auth Data (none): 0000000000000000
  ▼ Link State Request
    LS Type: Router-LSA (1)
    Link State ID: 2.2.2.2
    Advertising Router: 2.2.2.2
```

## Role in Adjacency

- Router 1.1.1.1 enters the Loading state and requests the full Router-LSA from Router 2.2.2.2, as identified in Frame 8's DBD.
- This LSR is sent because Router 1.1.1.1 needs the complete LSA to synchronize its link-state database.

# Frame#10 - Exchange state R1 to R2

No.	Time	Source	Destination	Protocol	Length	Info
10	9.704277627	192.168.12.1	192.168.12.2	OSPF	78	DB Description

> Frame 10: 78 bytes on wire (624 bits), 78 bytes captured (624 bits) on interface 0  
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10)  
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 192.168.12.2  
▼ Open Shortest Path First  
  ▼ OSPF Header  
    Version: 2  
    Message Type: DB Description (2)  
    Packet Length: 32  
    Source OSPF Router: 1.1.1.1  
    Area ID: 0.0.0.0 (Backbone)  
    Checksum: 0x9a12 [correct]  
    Auth Type: Null (0)  
    Auth Data (none): 0000000000000000  
  ▼ OSPF DB Description  
    Interface MTU: 1500  
    Options: 0x52, 0, (L) LLS Data block, (E) External Routing  
    ▼ DB Description: 0x00  
      .... 0... = (R) OOBResync: Not set  
      .... .0.. = (I) Init: Not set  
      .... ..0. = (M) More: Not set  
      .... ...0 = (MS) Master: No  
    DD Sequence: 2541  
  > OSPF LLS Data Block

## Role in Adjacency

- Router 1.1.1.1, as the slave, sends its final DBD packet, acknowledging the master's sequence (2541).
- The absence of the M (More) flag indicates Router 1.1.1.1 has completed sending its database summary.
- The Exchange state is nearing completion.

# Frame#11 - Loading state R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
11	9.704604504	192.168.12.2	192.168.12.1	OSPF	98	LS Update

```
> Frame 11: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10), Dst: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10)
> Internet Protocol Version 4, Src: 192.168.12.2, Dst: 192.168.12.1
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
    Message Type: LS Update (4)
    Packet Length: 64
    Source OSPF Router: 2.2.2.2
    Area ID: 0.0.0.0 (Backbone)
    Checksum: 0x9115 [correct]
    Auth Type: Null (0)
    Auth Data (none): 0000000000000000
  ▼ LS Update Packet
    Number of LSAs: 1
    ▼ LSA-type 1 (Router-LSA), len 36
      .000 0000 0000 1010 = LS Age (seconds): 10
      0.... .... .... = Do Not Age Flag: 0
    > Options: 0x22, (DC) Demand Circuits, (E) External Routing
    LS Type: Router-LSA (1)
    Link State ID: 2.2.2.2
    Advertising Router: 2.2.2.2
    Sequence Number: 0x80000007
    Checksum: 0xefad
    Length: 36
    > Flags: 0x00
    Number of Links: 1
    > Type: Stub     ID: 192.168.12.0     Data: 255.255.255.0     Metric: 10
```

## Role in Adjacency

- Router 2.2.2.2 responds to Frame 9's LSR by sending the requested Router-LSA in an LSU.
- The LSA describes Router 2.2.2.2's stub link to the 192.168.12.0/24 network.
- Router 1.1.1.1 will update its link-state database with this information.

# Frame#12 - Loading state R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
12	9.704626506	192.168.12.2	192.168.12.1	OSPF	70	LS Request

> Frame 12: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface 0  
> Ethernet II, Src: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10), Dst: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10)  
> Internet Protocol Version 4, Src: 192.168.12.2, Dst: 192.168.12.1  
▼ Open Shortest Path First  
  ▼ OSPF Header  
    Version: 2  
    Message Type: LS Request (3)  
    Packet Length: 36  
    Source OSPF Router: 2.2.2.2  
    Area ID: 0.0.0.0 (Backbone)  
    Checksum: 0xf5cf [correct]  
    Auth Type: Null (0)  
    Auth Data (none): 0000000000000000  
  ▼ Link State Request  
    LS Type: Router-LSA (1)  
    Link State ID: 1.1.1.1  
    Advertising Router: 1.1.1.1

## Role in Adjacency

- Router 2.2.2.2, in the Loading state, requests the full Router-LSA from Router 1.1.1.1, as identified in Frame 7's DBD.
- This ensures Router 2.2.2.2's database is synchronized.

# Frame#13 - Loading state R1 to R2

No.	Time	Source	Destination	Protocol	Length	Info
13	9.705043483	192.168.12.1	192.168.12.2	OSPF	98	LS Update

```
> Frame 13: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10)
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 192.168.12.2
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
    Message Type: LS Update (4)
    Packet Length: 64
    Source OSPF Router: 1.1.1.1
    Area ID: 0.0.0.0 (Backbone)
    Checksum: 0x4a61 [correct]
    Auth Type: Null (0)
    Auth Data (none): 0000000000000000
  ▼ LS Update Packet
    Number of LSAs: 1
    ▼ LSA-type 1 (Router-LSA), len 36
      .000 0000 0000 1001 = LS Age (seconds): 9
      0... .... .... .... = Do Not Age Flag: 0
      > Options: 0x22, (DC) Demand Circuits, (E) External Routing
      LS Type: Router-LSA (1)
      Link State ID: 1.1.1.1
      Advertising Router: 1.1.1.1
      Sequence Number: 0x80000007
      Checksum: 0x3c69
      Length: 36
      > Flags: 0x00
      Number of Links: 1
      > Type: Stub     ID: 192.168.12.0     Data: 255.255.255.0     Metric: 10
```

## Role in Adjacency

- 📌 Router 1.1.1.1 responds to Frame 12's LSR by sending the requested Router-LSA.
- 📌 The LSA describes Router 1.1.1.1's stub link to the 192.168.12.0/24 network.
- 📌 Router 2.2.2.2 will update its link-state database.

# Frame#14 - Full state R1 to R2

No.	Time	Source	Destination	Protocol	Length	Info
14	9.707433527	192.168.12.1	224.0.0.5	OSPF	94	LS Update

> Frame 14: 94 bytes on wire (752 bits), 94 bytes captured (752 bits) on interface 0  
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: IPv4mcast\_05 (01:00:5e:00:00:05)  
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 224.0.0.5  
▼ Open Shortest Path First  
  ▼ OSPF Header  
    Version: 2  
    Message Type: LS Update (4)  
    Packet Length: 60  
    Source OSPF Router: 1.1.1.1  
    Area ID: 0.0.0.0 (Backbone)  
    Checksum: 0xbdf9 [correct]  
    Auth Type: Null (0)  
    Auth Data (none): 0000000000000000  
  ▼ LS Update Packet  
    Number of LSAs: 1  
    ▼ LSA-type 2 (Network-LSA), len 32  
      .000 0000 0000 0001 = LS Age (seconds): 1  
      0... .... .... .... = Do Not Age Flag: 0  
      > Options: 0x22, (DC) Demand Circuits, (E) External Routing  
      LS Type: Network-LSA (2)  
      Link State ID: 192.168.12.1  
      Advertising Router: 1.1.1.1  
      Sequence Number: 0x80000001  
      Checksum: 0xc7eb  
      Length: 32  
      Netmask: 255.255.255.0  
      Attached Router: 1.1.1.1  
      Attached Router: 2.2.2.2

## Role in Adjacency

- 📌 As the DR, Router 1.1.1.1 sends a Network-LSA to describe the transit network (192.168.12.0/24).
- 📌 This LSA lists both routers (1.1.1.1 and 2.2.2.2) as attached to the network, confirming the adjacency.
- 📌 The multicast destination indicates this is sent to all OSPF routers on the segment.

# Frame#15 - Full state R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
15	9.755863845	192.168.12.2	224.0.0.5	OSPF	98	LS Update

```
> Frame 15: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
> Internet Protocol Version 4, Src: 192.168.12.2, Dst: 224.0.0.5
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
    Message Type: LS Update (4)
    Packet Length: 64
    Source OSPF Router: 2.2.2.2
    Area ID: 0.0.0.0 (Backbone)
    Checksum: 0xe2cc [correct]
    Auth Type: Null (0)
    Auth Data (none): 0000000000000000
  ▼ LS Update Packet
    Number of LSAs: 1
    ▼ LSA-type 1 (Router-LSA), len 36
      .000 0000 0000 0001 = LS Age (seconds): 1
      0.... .... .... = Do Not Age Flag: 0
      > Options: 0x22, (DC) Demand Circuits, (E) External Routing
      LS Type: Router-LSA (1)
      Link State ID: 2.2.2.2
      Advertising Router: 2.2.2.2
      Sequence Number: 0x80000008
      Checksum: 0xd153
      Length: 36
      > Flags: 0x00
      Number of Links: 1
      ▼ Type: Transit ID: 192.168.12.1 Data: 192.168.12.2 Metric: 10
        Link ID: 192.168.12.1 - IP address of Designated Router
        Link Data: 192.168.12.2
        Link Type: 2 - Connection to a transit network
        Number of Metrics: 0 - TOS
        0 Metric: 10
```

## Role in Adjacency

- Router 2.2.2.2 sends an updated Router-LSA, describing its connection to the transit network (via the DR, 192.168.12.1).
- The sequence number (0x80000008) indicates this is a new LSA, likely updated to reflect the adjacency.
- The multicast destination ensures the DR (Router 1.1.1.1) receives and processes this LSA.

# Frame#16 - Full state R1 to R2

No.	Time	Source	Destination	Protocol	Length	Info
16	9.756298773	192.168.12.1	224.0.0.5	OSPF	98	LS Update

```
> Frame 16: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 224.0.0.5
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
    Message Type: LS Update (4)
    Packet Length: 64
    Source OSPF Router: 1.1.1.1
    Area ID: 0.0.0.0 (Backbone)
    Checksum: 0xaa09 [correct]
    Auth Type: Null (0)
    Auth Data (none): 0000000000000000
  ▼ LS Update Packet
    Number of LSAs: 1
    ▼ LSA-type 1 (Router-LSA), len 36
      .000 0000 0000 0001 = LS Age (seconds): 1
      0... .... .... .... = Do Not Age Flag: 0
      > Options: 0x22, (DC) Demand Circuits, (E) External Routing
      LS Type: Router-LSA (1)
      Link State ID: 1.1.1.1
      Advertising Router: 1.1.1.1
      Sequence Number: 0x80000008
      Checksum: 0x101e
      Length: 36
      > Flags: 0x00
      Number of Links: 1
      ▼ Type: Transit ID: 192.168.12.1 Data: 192.168.12.1 Metric: 10
        Link ID: 192.168.12.1 - IP address of Designated Router
        Link Data: 192.168.12.1
        Link Type: 2 - Connection to a transit network
        Number of Metrics: 0 - TOS
        0 Metric: 10
```

## Role in Adjacency

- Router 1.1.1.1, as the DR, sends an updated Router-LSA, describing its connection to the transit network.
- The sequence number (0x80000008) indicates a new LSA, reflecting the established adjacency.
- This completes the database synchronization, moving both routers to the Full state.

# Frame#17 - Hello message R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
17	10.4674803...	192.168.12.2	224.0.0.5	OSPF	114	Hello Packet

```
> Frame 17: 114 bytes on wire (912 bits), 114 bytes captured (912 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
> Internet Protocol Version 4, Src: 192.168.12.2, Dst: 224.0.0.5
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
    Message Type: Hello Packet (1)
    Packet Length: 48
    Source OSPF Router: 2.2.2.2
    Area ID: 0.0.0.0 (Backbone)
    Checksum: 0x4d40 [correct]
    Auth Type: Null (0)
    Auth Data (none): 0000000000000000
  ▼ OSPF Hello Packet
    Network Mask: 255.255.255.0
    Hello Interval [sec]: 10
    Options: 0x12, (L) LLS Data block, (E) External Routing
    Router Priority: 1
    Router Dead Interval [sec]: 40
    Designated Router: 192.168.12.1
    Backup Designated Router: 192.168.12.2
    Active Neighbor: 1.1.1.1
  > OSPF LLS Data Block
```

## Role in Adjacency

- Router 2.2.2.2 sends a periodic Hello to maintain the adjacency.
- The presence of Router 1.1.1.1 as an active neighbor and agreement on DR/BDR roles confirm the Full state.
- This packet ensures the adjacency remains active.

# Frame#18 - Full state R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
18	12.2060773..	192.168.12.2	224.0.0.5	OSPF	118	LS Acknowledge

> Internet Protocol Version 4, Src: 192.168.12.2, Dst: 224.0.0.5  
  ↳ Open Shortest Path First  
    ↳ OSPF Header  
      Version: 2  
      Message Type: LS Acknowledge (5)  
      Packet Length: 84  
      Source OSPF Router: 2.2.2.2  
      Area ID: 0.0.0.0 (Backbone)  
      Checksum: 0x27f3 [correct]  
      Auth Type: Null (0)  
      Auth Data (none): 0000000000000000  
    ↳ LSA-type 1 (Router-LSA), len 36  
      .000 0000 0000 1001 = LS Age (seconds): 9  
      0... .... .... .... = Do Not Age Flag: 0  
    > Options: 0x22, (DC) Demand Circuits, (E) External Routing  
      LS Type: Router-LSA (1)  
      Link State ID: 1.1.1.1  
      Advertising Router: 1.1.1.1  
      Sequence Number: 0x80000007  
      Checksum: 0x3c69  
      Length: 36  
    ↳ LSA-type 2 (Network-LSA), len 32  
      .000 0000 0000 0001 = LS Age (seconds): 1  
      0... .... .... .... = Do Not Age Flag: 0  
    > Options: 0x22, (DC) Demand Circuits, (E) External Routing  
      LS Type: Network-LSA (2)  
      Link State ID: 192.168.12.1  
      Advertising Router: 1.1.1.1  
      Sequence Number: 0x80000001  
      Checksum: 0xc7eb  
      Length: 32  
    ↳ LSA-type 1 (Router-LSA), len 36  
      .000 0000 0000 0001 = LS Age (seconds): 1  
      0... .... .... .... = Do Not Age Flag: 0  
    > Options: 0x22, (DC) Demand Circuits, (E) External Routing  
      LS Type: Router-LSA (1)  
      Link State ID: 1.1.1.1  
      Advertising Router: 1.1.1.1  
      Sequence Number: 0x80000008  
      Checksum: 0x101e  
      Length: 36

## Role in Adjacency

- ❖ Router 2.2.2.2 acknowledges receipt of LSAs from Frames 13(0x800007), 14(0x800001), and 16 (0x800008). This ensures reliable LSA transmission, confirming that Router 2.2.2.2 has processed these LSAs.
- ❖ The multicast destination targets the DR (Router 1.1.1.1).

# Frame#19 - Full state R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
19	12.2062127...	192.168.12.1	224.0.0.5	OSPF	98	LS Acknowledge

```
> Frame 19: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 224.0.0.5
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
    Message Type: LS Acknowledge (5)
    Packet Length: 64
    Source OSPF Router: 1.1.1.1
    Area ID: 0.0.0.0 (Backbone)
    Checksum: 0xe641 [correct]
    Auth Type: Null (0)
    Auth Data (none): 0000000000000000
  ▼ LSA-type 1 (Router-LSA), len 36
    .000 0000 0000 1010 = LS Age (seconds): 10
    0... .... .... .... = Do Not Age Flag: 0
    > Options: 0x22, (DC) Demand Circuits, (E) External Routing
    LS Type: Router-LSA (1)
    Link State ID: 2.2.2.2
    Advertising Router: 2.2.2.2
    Sequence Number: 0x80000007
    Checksum: 0xefad
    Length: 36
  ▼ LSA-type 1 (Router-LSA), len 36
    .000 0000 0000 0001 = LS Age (seconds): 1
    0... .... .... .... = Do Not Age Flag: 0
    > Options: 0x22, (DC) Demand Circuits, (E) External Routing
    LS Type: Router-LSA (1)
    Link State ID: 2.2.2.2
    Advertising Router: 2.2.2.2
    Sequence Number: 0x80000008
    Checksum: 0xd153
    Length: 36
```

## Role in Adjacency

- ❖ Router 1.1.1.1 acknowledges receipt of LSAs from Frames 11 (0x800007) and 15 (0x800008).
- ❖ This confirms that Router 1.1.1.1 has processed Router 2.2.2.2's LSAs, ensuring database synchronization.

# Frame#20 - Hello message R1 to R2

No.	Time	Source	Destination	Protocol	Length	Info
20	19.5213901...	192.168.12.1	224.0.0.5	OSPF	114	Hello Packet

```
> Frame 20: 114 bytes on wire (912 bits), 114 bytes captured (912 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 224.0.0.5
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
      Message Type: Hello Packet (1)
      Packet Length: 48
      Source OSPF Router: 1.1.1.1
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0x4d40 [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  ▼ OSPF Hello Packet
    Network Mask: 255.255.255.0
    Hello Interval [sec]: 10
    Options: 0x12, (L) LLS Data block, (E) External Routing
    Router Priority: 1
    Router Dead Interval [sec]: 40
      Designated Router: 192.168.12.1
      Backup Designated Router: 192.168.12.2
      Active Neighbor: 2.2.2.2
  ▶ OSPF LLS Data Block
```

## Role in Adjacency

- Router 1.1.1.1 sends a periodic Hello to maintain the adjacency.
- The Full state is confirmed by the active neighbor and DR/BDR agreement.

# Frame#21 - Hello message R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
21	19.5736393...	192.168.12.2	224.0.0.5	OSPF	114	Hello Packet

> Frame 21: 114 bytes on wire (912 bits), 114 bytes captured (912 bits) on interface 0  
> Ethernet II, Src: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10), Dst: IPv4mcast\_05 (01:00:5e:00:00:05)  
> Internet Protocol Version 4, Src: 192.168.12.2, Dst: 224.0.0.5  
▼ Open Shortest Path First  
  ▼ OSPF Header  
    Version: 2  
    Message Type: Hello Packet (1)  
    Packet Length: 48  
    Source OSPF Router: 2.2.2.2  
    Area ID: 0.0.0.0 (Backbone)  
    Checksum: 0x4d40 [correct]  
    Auth Type: Null (0)  
    Auth Data (none): 0000000000000000  
  ▼ OSPF Hello Packet  
    Network Mask: 255.255.255.0  
    Hello Interval [sec]: 10  
    Options: 0x12, (L) LLS Data block, (E) External Routing  
    Router Priority: 1  
    Router Dead Interval [sec]: 40  
    Designated Router: 192.168.12.1  
    Backup Designated Router: 192.168.12.2  
    Active Neighbor: 1.1.1.1  
  > OSPF LLS Data Block

## Role in Adjacency

- Router 2.2.2.2 continues to send periodic Hellos, maintaining the Full state.
- The adjacency is stable, with both routers agreeing on DR/BDR roles.

# Frame#22 - Full state R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
22	19.5753413...	192.168.12.2	224.0.0.5	OSPF	98	LS Update

```
> Frame 22: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
> Ethernet II, Src: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
> Internet Protocol Version 4, Src: 192.168.12.2, Dst: 224.0.0.5
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
    Message Type: LS Update (4)
    Packet Length: 64
    Source OSPF Router: 2.2.2.2
    Area ID: 0.0.0.0 (Backbone)
    Checksum: 0xe4ca [correct]
    Auth Type: Null (0)
    Auth Data (none): 0000000000000000
  ▼ LS Update Packet
    Number of LSAs: 1
    ▼ LSA-type 1 (Router-LSA), len 36
      .000 0000 0001 = LS Age (seconds): 1
      0... .... .... = Do Not Age Flag: 0
      > Options: 0x22, (DC) Demand Circuits, (E) External Routing
      LS Type: Router-LSA (1)
      Link State ID: 2.2.2.2
      Advertising Router: 2.2.2.2
      Sequence Number: 0x80000009
      Checksum: 0xcf54
      Length: 36
      > Flags: 0x00
      Number of Links: 1
      ▼ Type: Transit ID: 192.168.12.1 Data: 192.168.12.2 Metric: 10
        Link ID: 192.168.12.1 - IP address of Designated Router
        Link Data: 192.168.12.2
        Link Type: 2 - Connection to a transit network
        Number of Metrics: 0 - TOS
        0 Metric: 10
```

## Role in Adjacency

- Router 2.2.2.2 sends an updated Router-LSA with a new sequence number (0x80000009), possibly due to a topology change or periodic refresh.
- The multicast destination ensures the DR (Router 1.1.1.1) processes this update.

# Frame#23 - Full state R1 to R2

No.	Time	Source	Destination	Protocol	Length	Info
23	22.0774404...	192.168.12.1	224.0.0.5	OSPF	78	LS Acknowledge

> Frame 23: 78 bytes on wire (624 bits), 78 bytes captured (624 bits) on interface 0  
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: IPv4mcast\_05 (01:00:5e:00:00:05)  
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 224.0.0.5  
▼ Open Shortest Path First  
  ▼ OSPF Header  
    Version: 2  
    Message Type: LS Acknowledge (5)  
    Packet Length: 44  
    Source OSPF Router: 1.1.1.1  
    Area ID: 0.0.0.0 (Backbone)  
    Checksum: 0x8240 [correct]  
    Auth Type: Null (0)  
    Auth Data (none): 0000000000000000  
  ▼ LSA-type 1 (Router-LSA), len 36  
    .000 0000 0000 0001 = LS Age (seconds): 1  
    0... .... .... .... = Do Not Age Flag: 0  
  > Options: 0x22, (DC) Demand Circuits, (E) External Routing  
  LS Type: Router-LSA (1)  
  Link State ID: 2.2.2.2  
  Advertising Router: 2.2.2.2  
  Sequence Number: 0x80000009  
  Checksum: 0xcf54  
  Length: 36

## Role in Adjacency

- ❖ Router 1.1.1.1 acknowledges the LSA from Frame 22, confirming receipt and processing.
- ❖ This maintains the reliability of LSA flooding.

# Frame#24 - Hello message R1 to R2

No.	Time	Source	Destination	Protocol	Length	Info
24	28.8269421..	192.168.12.1	224.0.0.5	OSPF	114	Hello Packet

> Frame 24: 114 bytes on wire (912 bits), 114 bytes captured (912 bits) on interface 0  
> Ethernet II, Src: aa:bb:cc:00:01:10 (aa:bb:cc:00:01:10), Dst: IPv4mcast\_05 (01:00:5e:00:00:05)  
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 224.0.0.5  
▼ Open Shortest Path First  
  ▼ OSPF Header  
    Version: 2  
    Message Type: Hello Packet (1)  
    Packet Length: 48  
    Source OSPF Router: 1.1.1.1  
    Area ID: 0.0.0.0 (Backbone)  
    Checksum: 0x4d40 [correct]  
    Auth Type: Null (0)  
    Auth Data (none): 0000000000000000  
  ▼ OSPF Hello Packet  
    Network Mask: 255.255.255.0  
    Hello Interval [sec]: 10  
    Options: 0x12, (L) LLS Data block, (E) External Routing  
    Router Priority: 1  
    Router Dead Interval [sec]: 40  
    Designated Router: 192.168.12.1  
    Backup Designated Router: 192.168.12.2  
    Active Neighbor: 2.2.2.2  
  > OSPF LLS Data Block

## Role in Adjacency

- ❖ Another periodic Hello from Router 1.1.1.1, maintaining the Full state.

# Frame#25 - Hello message R2 to R1

No.	Time	Source	Destination	Protocol	Length	Info
25	28.8474231...	192.168.12.2	224.0.0.5	OSPF	114	Hello Packet

> Frame 25: 114 bytes on wire (912 bits), 114 bytes captured (912 bits) on interface 0  
> Ethernet II, Src: aa:bb:cc:00:02:10 (aa:bb:cc:00:02:10), Dst: IPv4mcast\_05 (01:00:5e:00:00:05)  
> Internet Protocol Version 4, Src: 192.168.12.2, Dst: 224.0.0.5  
▼ Open Shortest Path First  
  ▼ OSPF Header  
    Version: 2  
    Message Type: Hello Packet (1)  
    Packet Length: 48  
    Source OSPF Router: 2.2.2.2  
    Area ID: 0.0.0.0 (Backbone)  
    Checksum: 0x4d40 [correct]  
    Auth Type: Null (0)  
    Auth Data (none): 0000000000000000  
  ▼ OSPF Hello Packet  
    Network Mask: 255.255.255.0  
    Hello Interval [sec]: 10  
    Options: 0x12, (L) LLS Data block, (E) External Routing  
    Router Priority: 1  
    Router Dead Interval [sec]: 40  
    Designated Router: 192.168.12.1  
    Backup Designated Router: 192.168.12.2  
    Active Neighbor: 1.1.1.1  
  > OSPF LLS Data Block

## Role in Adjacency

- Router 2.2.2.2 sends another periodic Hello, ensuring the adjacency remains in the Full state.

# Why Too Many LS Update Packets and Only 2 LSR and 3 LSAck?

## LS Update Packets (Frames 11, 13, 14, 15, 16, 22):

⇒ **Total:** 6 LS Update packets

⇒ **Reason**

### Initial Synchronization (Frames 11, 13):

- ◆ These unicast LSUs respond to LSRs (Frames 9, 12), delivering the requested Router-LSAs to synchronize the link-state databases.

### Network-LSA by DR (Frame 14):

- ◆ The DR (Router 1.1.1.1) sends a Network-LSA to describe the transit network, listing attached routers (1.1.1.1, 2.2.2.2).

### Updated Router-LSAs (Frames 15, 16):

- ◆ Both routers send updated Router-LSAs (sequence numbers incremented to 0x80000008) to reflect their connections to the transit network, finalizing the adjacency.

### Periodic Update (Frame 22):

Router 2.2.2.2 sends another Router-LSA (sequence 0x80000009), likely due to a refresh or minor change, maintaining database consistency.

## ★ Why So Many?

- LSUs are used for both initial synchronization and ongoing updates.
- The DR's Network-LSA and updated Router-LSAs are necessary to fully describe the network topology.
- Periodic LSUs (e.g., Frame 22) ensure LSAs remain fresh (OSPF refreshes LSAs every 30 minutes by default, but this capture shows an early refresh).

# Why Too Many LS Update Packets and Only 2 LSR and 3 LSAck? (continue...)

## LS Request Packets (Frames 9, 12):

» **Total:** 2 LSR packets.

» **Reason**

**Frame 18:** Router 2.2.2.2 acknowledges LSAs from Frames 13, 14, and 16, ensuring reliable delivery.

**Frame 19:** Router 1.1.1.1 acknowledges LSAs from Frames 11 and 15.

**Frame 23:** Router 1.1.1.1 acknowledges the updated LSA from Frame 22.

### ★ Why Only Three?

- OSPF uses delayed acknowledgments to reduce overhead. Multiple LSAs can be acknowledged in a single LSAck packet (e.g., Frame 18 acknowledges three LSAs).
- Only the DR and BDR exchange LSACKs in this capture, as they are the only routers on the segment.
- The small number of LSACKs reflects the efficient acknowledgment process and the simple topology.

## LS Acknowledgment Packets (Frames 18, 19, 23):

» **Total:** 3 LSACK packets.

» **Reason**

- ◆ Each router sends one LSR to request the other's Router-LSA after the DBD exchange (Frames 7, 8).
- ◆ Router 1.1.1.1 requests Router 2.2.2.2's LSA (Frame 9), and Router 2.2.2.2 requests Router 1.1.1.1's LSA (Frame 12).
- ◆ Only two LSRs are needed because each router has only one Router-LSA to request during the Loading state.

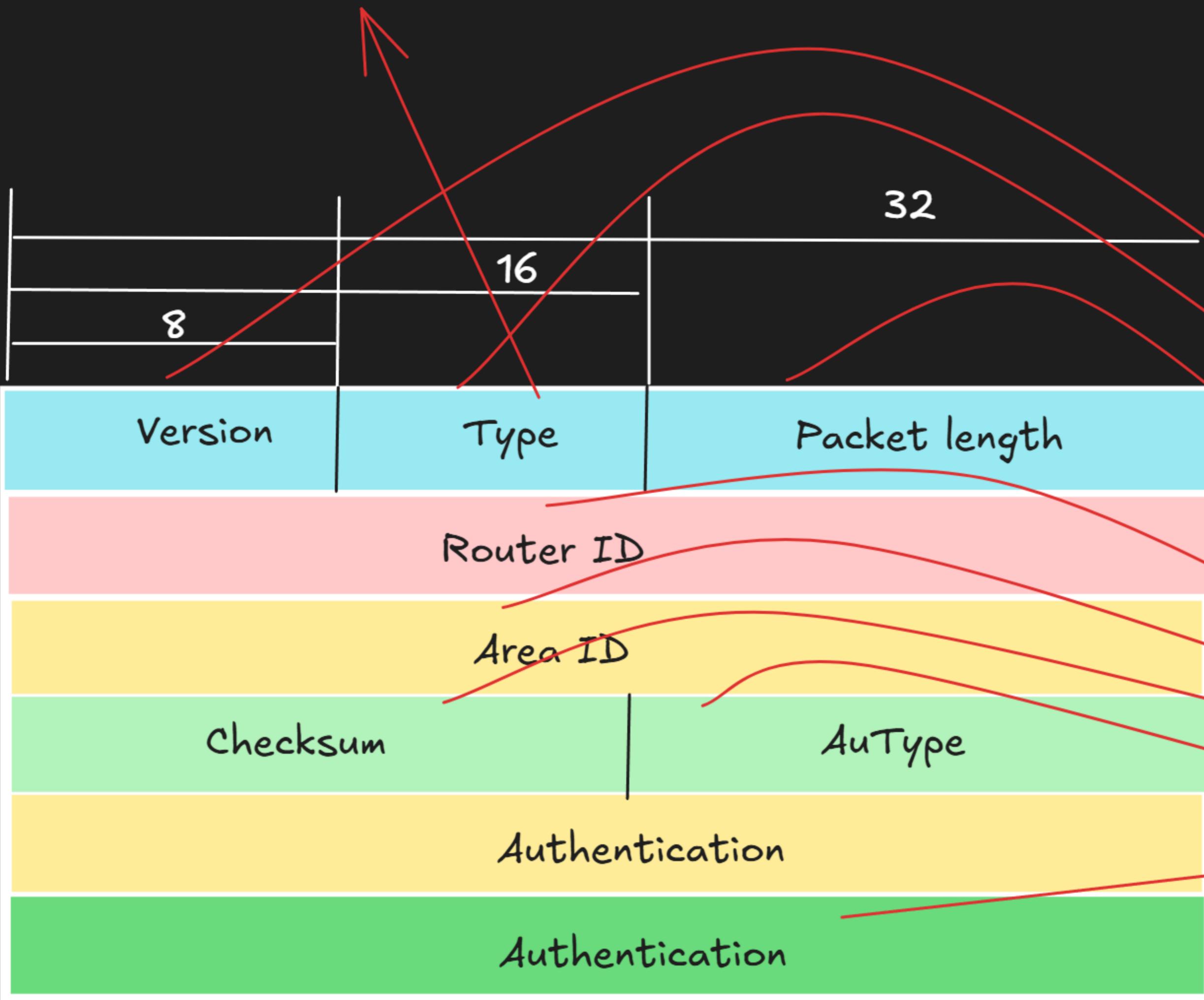
### ★ Why Only Two?

- The DBD exchange identifies exactly which LSAs are missing, and in this simple topology (two routers, one network), each router needs only one LSA from the other.
- No additional LSRs are needed after the initial synchronization.

Created by: Sherif (shareefmv1007@gmail.com)

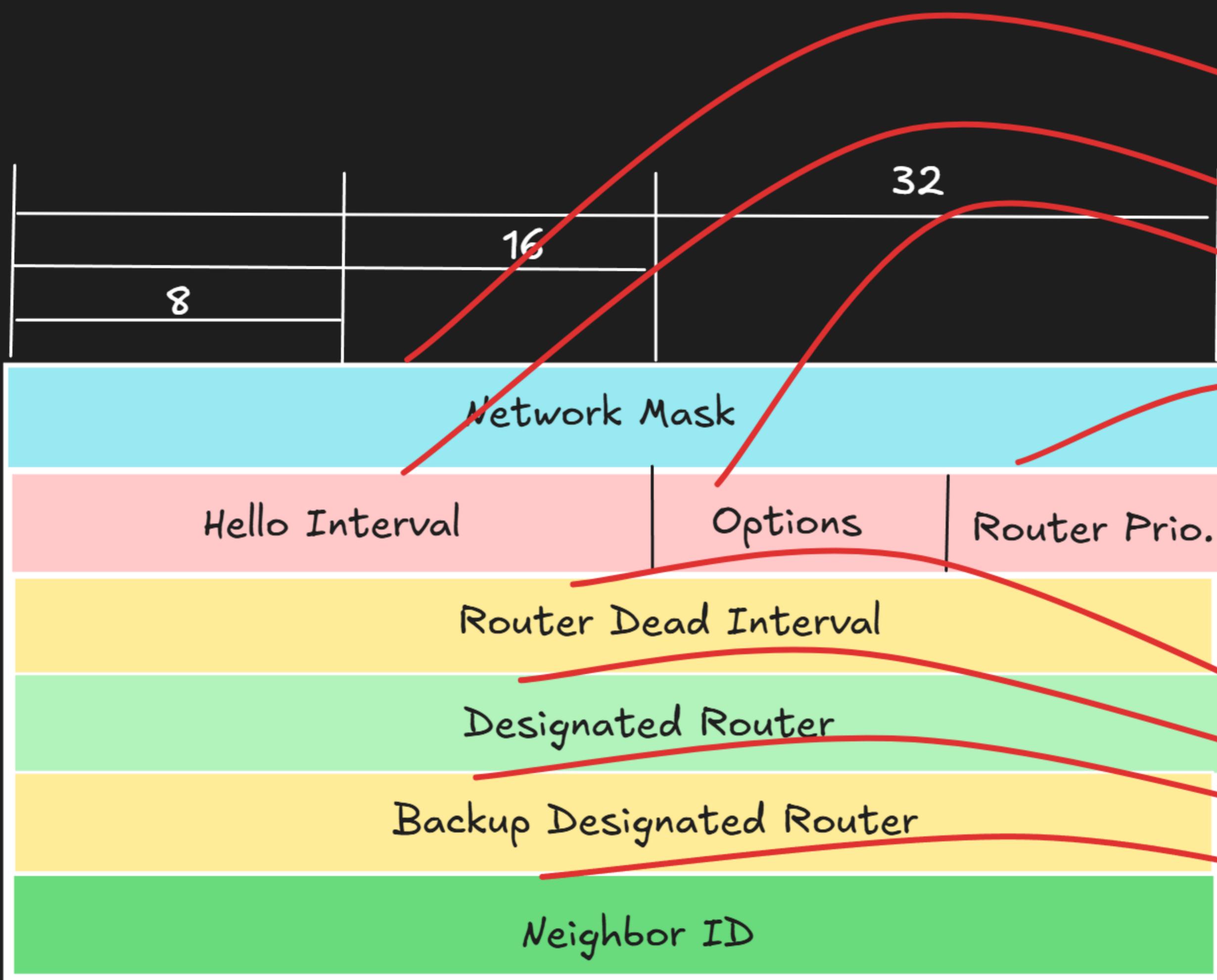
# OSPF Packet Header

- 1.Hello
- 2.DBD
- 3.LSR
- 4.LSU
- 5.LSAck



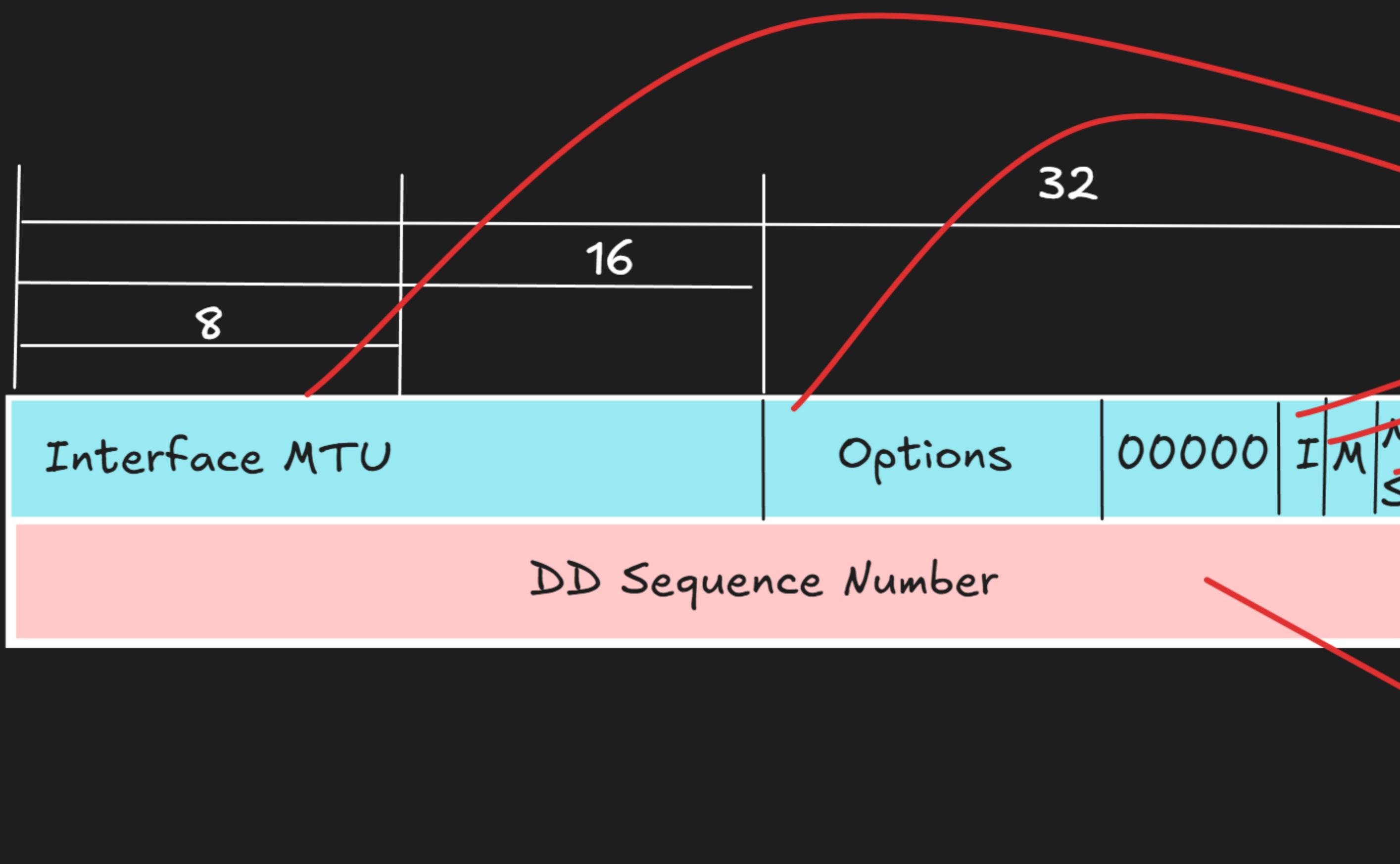
No.	Time	Source	Source Port	Destination	Destination I	Protocol	Length	Info
1	0.000000	10.0.20.2		224.0.0.5		OSPF	90	Hello Packet
> Frame 1: 90 bytes on wire (720 bits), 90 bytes captured (720 bits) on interface 0								
> Ethernet II, Src: c2:00:56:ab:00:00 (c2:00:56:ab:00:00), Dst: IPv4mcast_05 (01:00:5e:00:00:05)								
> Internet Protocol Version 4, Src: 10.0.20.2, Dst: 224.0.0.5								
Open Shortest Path First								
OSPF Header								
Version: 2								
Message Type: Hello Packet (1)								
Packet Length: 44								
Source OSPF Router: 5.5.5.5								
Area ID: 0.0.0.20								
Checksum: 0xe184 [correct]								
Auth Type: Null (0)								
Auth Data (none): 0000000000000000								
> OSPF Hello Packet								
> OSPF LLS Data Block								

# OSPF Hello Packet



30	62.918273	10.0.20.1	224.0.0.5	OSPF	94 Hello Packet
> Ethernet II, Src: c2:03:56:cc:00:01 (c2:03:56:cc:00:01), Dst: IPv4mcast_05 (01:00:5e:00:00:05)					
> Internet Protocol Version 4, Src: 10.0.20.1, Dst: 224.0.0.5					
Open Shortest Path First					
> OSPF Header					
> OSPF Hello Packet					
Network Mask: 255.255.255.252					
Hello Interval [sec]: 10					
Options: 0x12, (L) LLS Data block, (E) External Routing					
0... .... = DN: Not set					
.0... .... = O: Not set					
..0. .... = (DC) Demand Circuits: Not supported					
...1 .... = (L) LLS Data block: Present					
.... 0... = (N) NSSA: Not supported					
.... .0.. = (MC) Multicast: Not capable					
.... ..1. = (E) External Routing: Capable					
.... ..0 = (MT) Multi-Topology Routing: No					
Router Priority: 1					
Router Dead Interval [sec]: 40					
Designated Router: 10.0.20.2					
Backup Designated Router: 10.0.20.1					
Active Neighbor: 5.5.5.5					
> OSPF LLS Data Block					

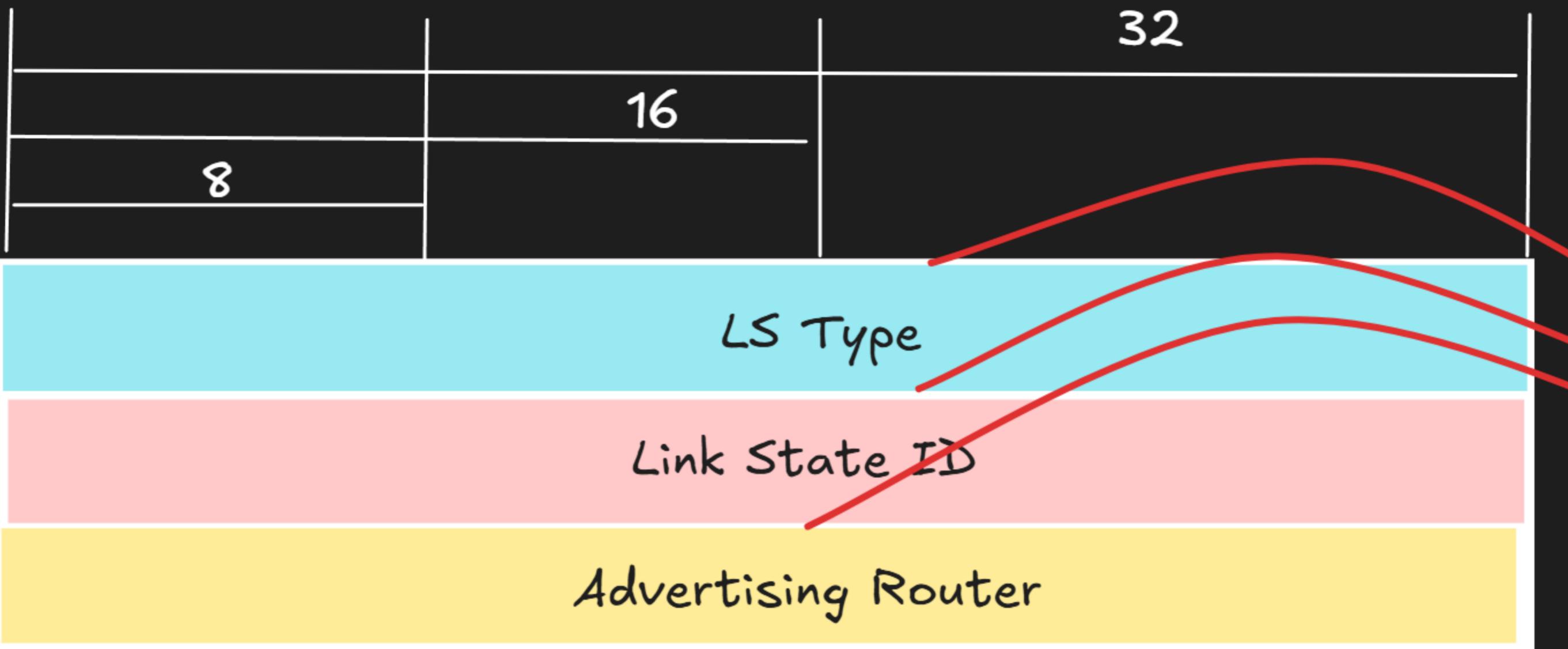
# OSPF Database Description Packet



No.	Time	Source	Source Port	Destination	Destination I	Protocol	Length	Info
7	32.934033	10.0.20.2		10.0.20.1		OSPF	78	DB Description

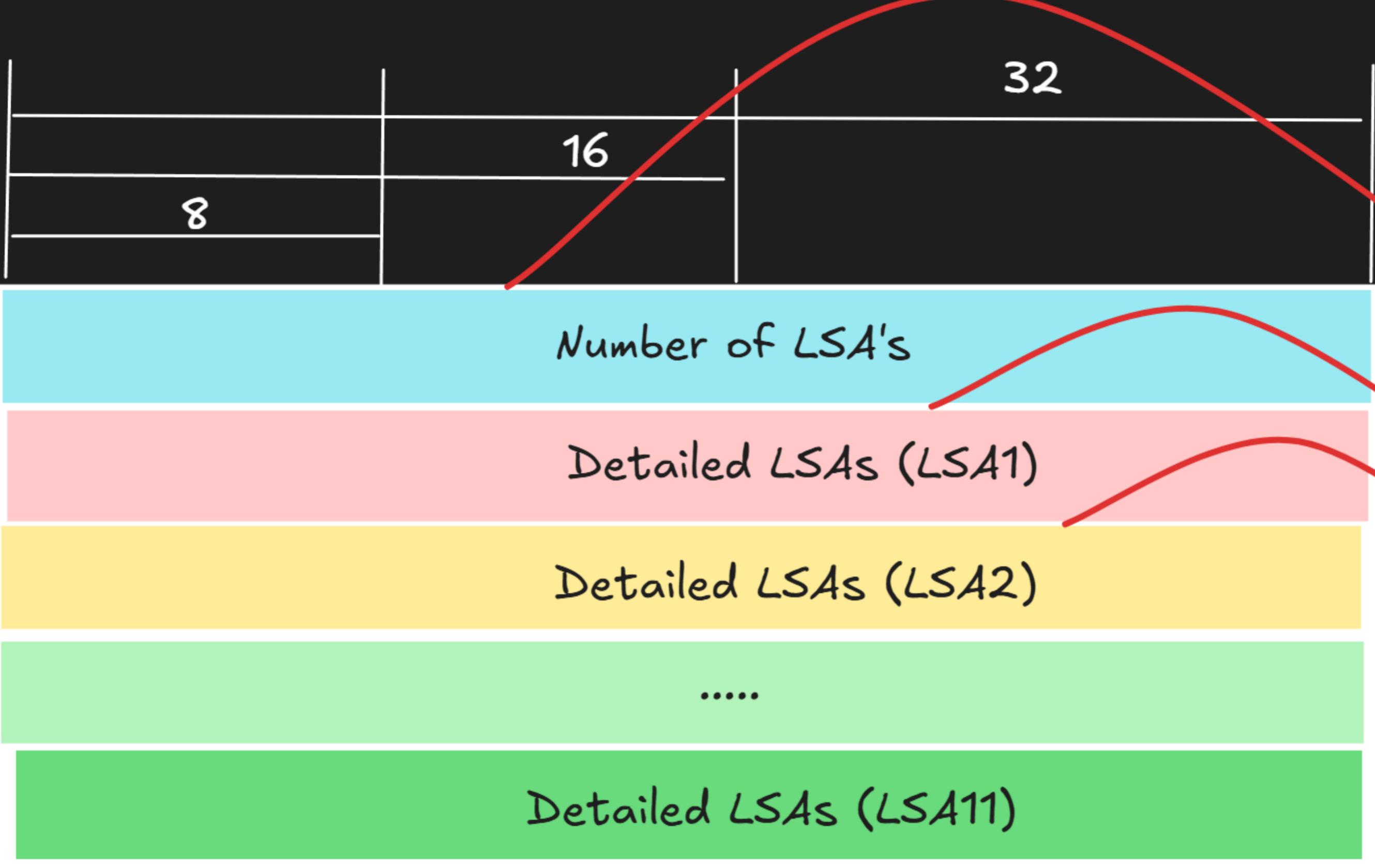
Frame 7: 78 bytes on wire (624 bits), 78 bytes captured (624 bits) on interface 0  
Ethernet II, Src: c2:00:56:ab:00:00 (c2:00:56:ab:00:00), Dst: c2:03:56:cc:00:01 (c2:03:56:cc:00:01)  
Internet Protocol Version 4, Src: 10.0.20.2, Dst: 10.0.20.1  
Open Shortest Path First  
  > OSPF Header  
    > OSPF DB Description  
      Interface MTU: 1500  
      Options: 0x52, 0, (L) LLS Data block, (E) External Routing  
        0... .... = DN: Not set  
        .1... .... = 0: Set  
        ..0. .... = (DC) Demand Circuits: Not supported  
        ...1 .... = (L) LLS Data block: Present  
        .... 0... = (N) NSSA: Not supported  
        .... .0... = (MC) Multicast: Not capable  
        .....1. = (E) External Routing: Capable  
        .....0. = (MT) Multi-Topology Routing: No  
      DB Description: 0x07, (I) Init, (M) More, (MS) Master  
        .... 0... = (R) OOBResync: Not set  
        .... .1... = (I) Init: Set  
        .... ..1. = (M) More: Set  
        .... ...1 = (MS) Master: Yes  
      DD Sequence: 5266  
    > OSPF LLS Data Block

# Link State Request Packet



No.	Time	Source	Source Port	Destination	Destination I	Protocol	Length	Info
11	32.950034	10.0.20.2		10.0.20.1		OSPF	190	LS Request
> Frame 11: 190 bytes on wire (1520 bits), 190 bytes captured (1520 bits) on interface 0								
> Ethernet II, Src: c2:00:56:ab:00:00 (c2:00:56:ab:00:00), Dst: c2:03:56:cc:00:01 (c2:03:56:cc:00:01)								
> Internet Protocol Version 4, Src: 10.0.20.2, Dst: 10.0.20.1								
▼ Open Shortest Path First								
▼ OSPF Header								
Version: 2								
Message Type: LS Request (3)								
Packet Length: 156								
Source OSPF Router: 5.5.5.5								
Area ID: 0.0.0.20								
Checksum: 0xd3cd [correct]								
Auth Type: Null (0)								
Auth Data (none): 0000000000000000								
Link State Request								
LS Type: Router-LSA (1)								
Link State ID: 5.5.5.5								
Advertising Router: 5.5.5.5								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								
Link State Request								

# Link State Update Packet

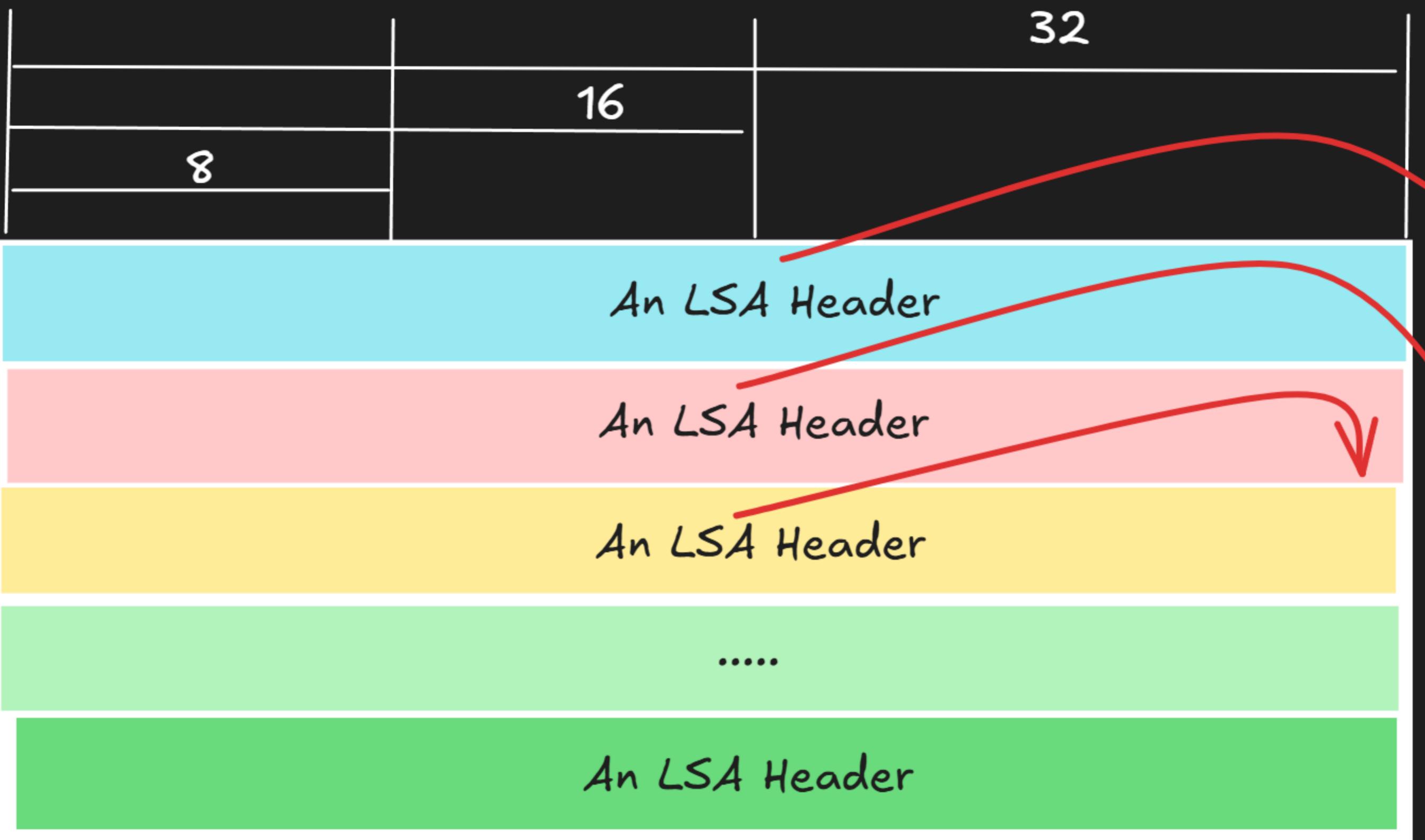


No.	Time	Source	Source Port	Destination	Destination I	Protocol	Length	Info
12	32.954068	10.0.20.1		10.0.20.2		OSPF	434	LS Update

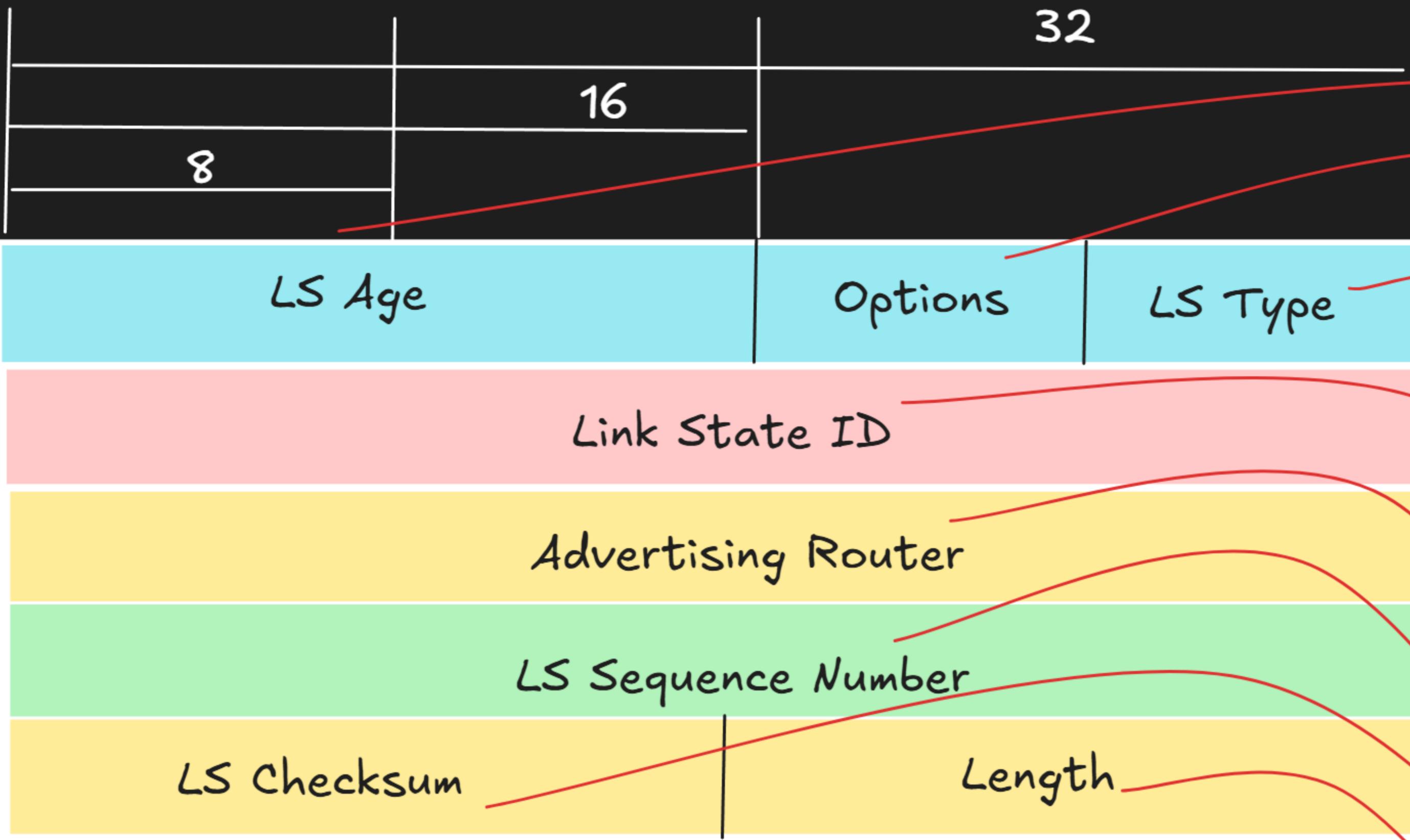
```
> Frame 12: 434 bytes on wire (3472 bits), 434 bytes captured (3472 bits) on interface 0
> Ethernet II, Src: c2:03:56:cc:00:01 (c2:03:56:cc:00:01), Dst: c2:00:56:ab:00:00 (c2:00:56:ab:00:00)
> Internet Protocol Version 4, Src: 10.0.20.1, Dst: 10.0.20.2
▼ Open Shortest Path First
  ▼ OSPF Header
    Version: 2
    Message Type: LS Update (4)
    Packet Length: 400
    Source OSPF Router: 4.4.4.4
    Area ID: 0.0.0.20
    Checksum: 0xd794 [correct]
    Auth Type: Null (0)
    Auth Data (none): 0000000000000000
  ▼ LS Update Packet
    Number of LSAs: 11
    > LSA-type 1 (Router-LSA), len 48
    > LSA-type 1 (Router-LSA), len 36
    > LSA-type 2 (Network-LSA), len 32
    > LSA-type 3 (Summary-LSA (IP network)), len 28
    > LSA-type 3 (Summary-LSA (IP network)), len 28
    > LSA-type 3 (Summary-LSA (IP network)), len 28
    > LSA-type 4 (Summary-LSA (ASBR)), len 28
    > LSA-type 5 (AS-External-LSA (ASBR)), len 36
    > LSA-type 5 (AS-External-LSA (ASBR)), len 36
```

# Link State Acknowledgment Packet



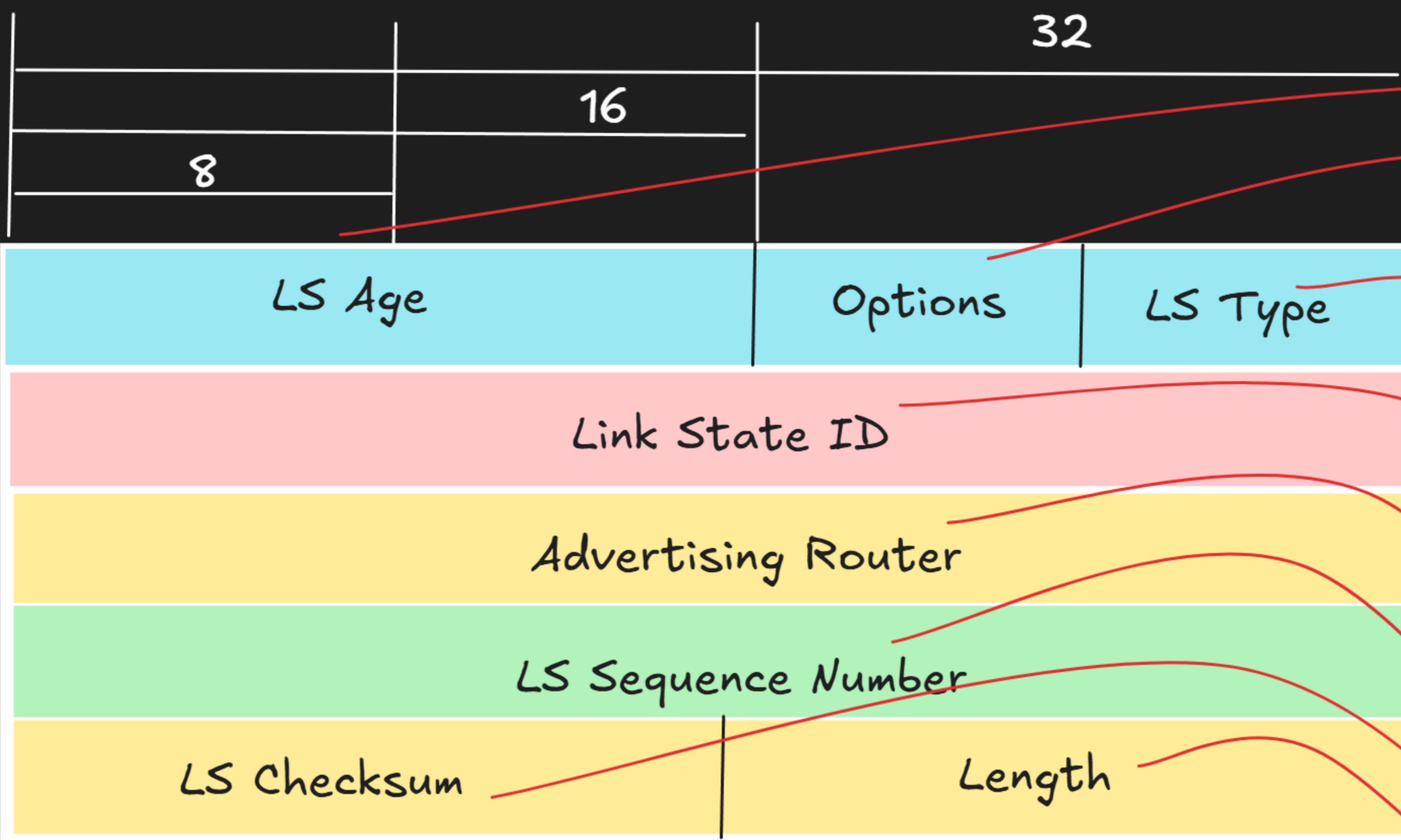
ospf.msg == 5							
No.	Time	Source	Source Port	Destination	Destination I	Protocol	Length Info
18	35.462172	10.0.20.2		224.0.0.5		OSPF	278 LS Acknowledge
> Frame 18: 278 bytes on wire (2224 bits), 278 bytes captured (2224 bits) on interface 0							
> Ethernet II, Src: c2:00:56:ab:00:00 (c2:00:56:ab:00:00), Dst: IPv4mcast_05 (01:00:5e:00:00:05)							
> Internet Protocol Version 4, Src: 10.0.20.2, Dst: 224.0.0.5							
Open Shortest Path First							
OSPF Header							
Version: 2							
Message Type: LS Acknowledge (5)							
Packet Length: 244							
Source OSPF Router: 5.5.5.5							
Area ID: 0.0.0.20							
Checksum: 0x1cf1 [correct]							
Auth Type: Null (0)							
Auth Data (none): 0000000000000000							
> LSA-type 1 (Router-LSA), len 48							
> LSA-type 1 (Router-LSA), len 36							
> LSA-type 2 (Network-LSA), len 32							
> LSA-type 3 (Summary-LSA (IP network)), len 28							
> LSA-type 3 (Summary-LSA (IP network)), len 28							
> LSA-type 3 (Summary-LSA (IP network)), len 28							
> LSA-type 4 (Summary-LSA (ASBR)), len 28							
> LSA-type 5 (AS-External-LSA (ASBR)), len 36							
> LSA-type 5 (AS-External-LSA (ASBR)), len 36							
> LSA-type 5 (AS-External-LSA (ASBR)), len 36							
> LSA-type 5 (AS-External-LSA (ASBR)), len 36							

# OSPF LSA1 (Router LSA)

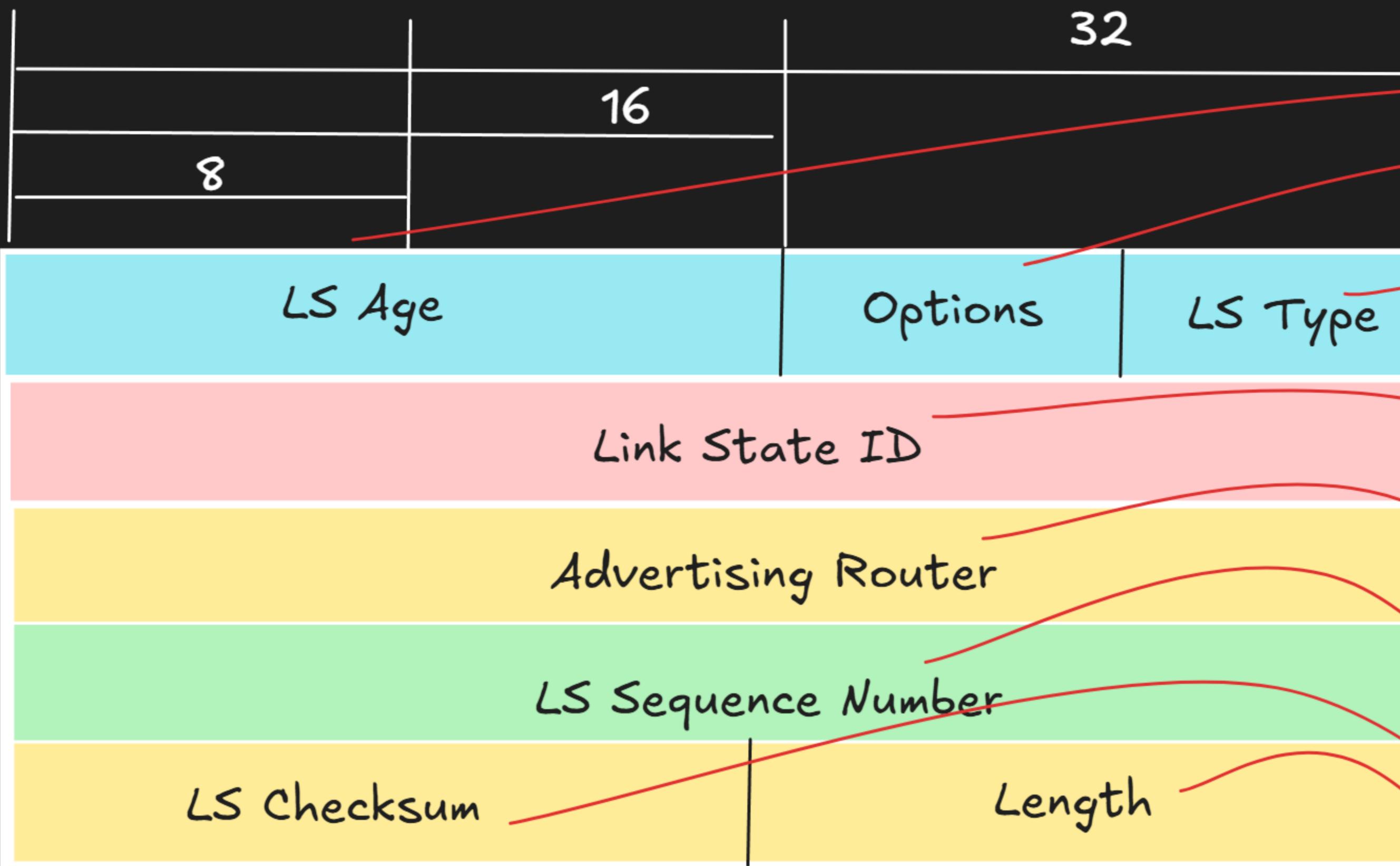


ospf.lsa == 1								
No.	Time	Source	Source Port	Destination	Destination I	Protocol	Length	Info
8	32.938125	10.0.20.1		10.0.20.2		OSPF	298	DB Description
> Frame 8: 298 bytes on wire (2384 bits), 298 bytes captured (2384 bits) on interface 0								
> Ethernet II, Src: c2:03:56:cc:00:01 (c2:03:56:cc:00:01), Dst: c2:00:56:ab:00:00 (c2:00:56:ab:00:00)								
> Internet Protocol Version 4, Src: 10.0.20.1, Dst: 10.0.20.2								
Open Shortest Path First								
OSPF Header								
Version: 2								
Message Type: DB Description (2)								
Packet Length: 252								
Source OSPF Router: 4.4.4.4								
Area ID: 0.0.0.20								
Checksum: 0xb288 [correct]								
Auth Type: Null (0)								
Auth Data (none): 0000000000000000								
> OSPF DB Description								
< LSA-type 1 (Router-LSA), len 36								
.000 0000 0000 1001 = LS Age (seconds): 9								
0..... .... .... = Do Not Age Flag: 0								
Options: 0x22, (DC) Demand Circuits, (E) External Routing								
0... .... = DN: Not set								
.0... .... = O: Not set								
..1. .... = (DC) Demand Circuits: Supported								
..0.... = (L) LLS Data block: Not Present								
.... 0... = (N) NSSA: Not supported								
.... .0.. = (MC) Multicast: Not capable								
.... ..1. = (E) External Routing: Capable								
.... ..0 = (MT) Multi-Topology Routing: No								
LS Type: Router-LSA (1)								
Link State ID: 4.4.4.4								
Advertising Router: 4.4.4.4								
Sequence Number: 0x80000006								
Checksum: 0x36b1								
Length: 36								

# OSPF LSA2 (Network LSA)

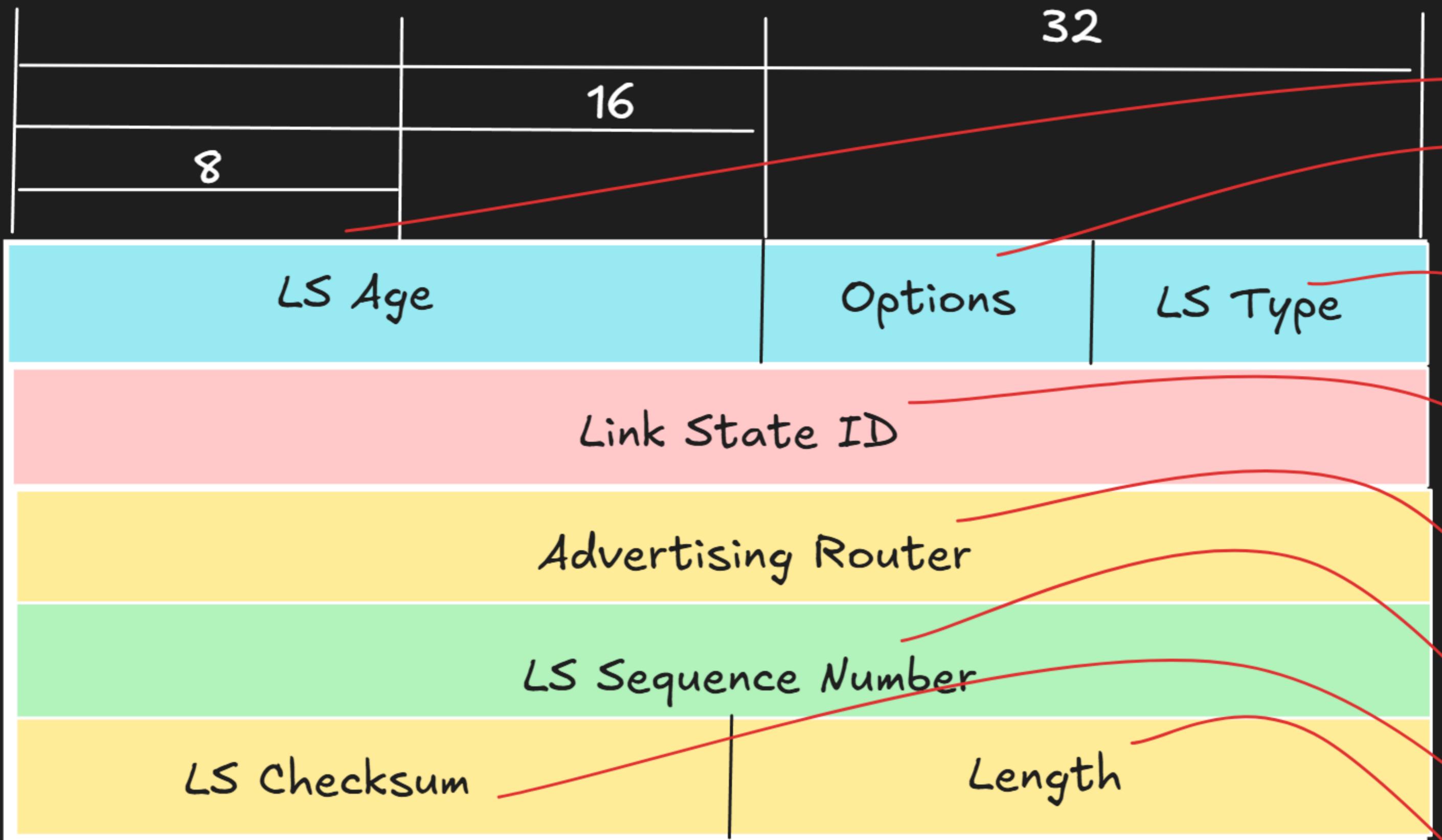


# OSPF LSA3 (Summary LSA)



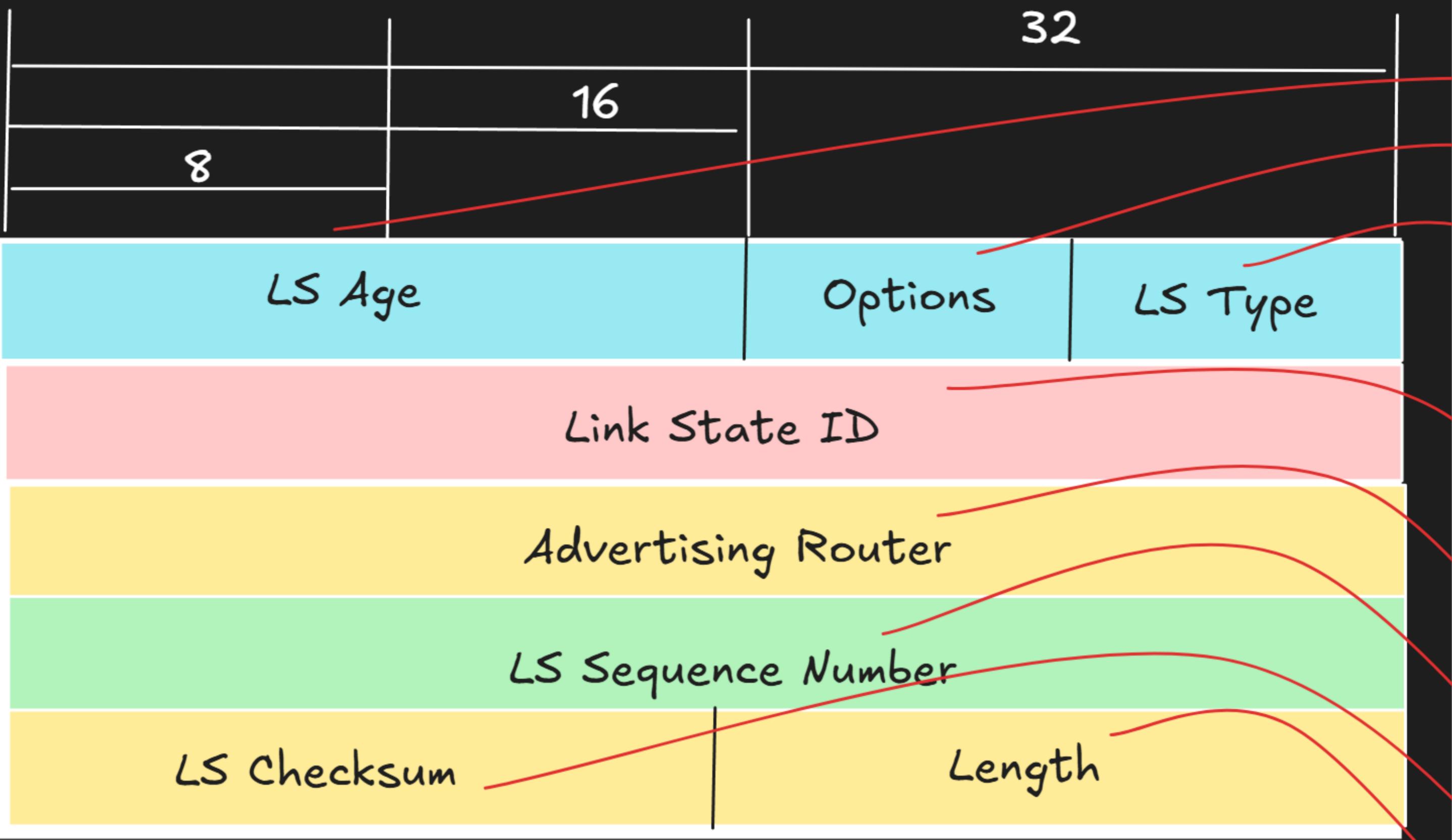
ospf.lsa == 3							
No.	Time	Source	Source Port	Destination	Destination I	Protocol	Length Info
8	32.938125	10.0.20.1		10.0.20.2		OSPF	298 DB Description
<b>Open Shortest Path First</b>							
<b>OSPF Header</b>							
Version: 2							
Message Type: DB Description (2)							
Packet Length: 252							
Source OSPF Router: 4.4.4.4							
Area ID: 0.0.0.20							
Checksum: 0xb288 [correct]							
Auth Type: Null (0)							
Auth Data (none): 0000000000000000							
<b>&gt; OSPF DB Description</b>							
<b>&gt; LSA-type 1 (Router-LSA), len 36</b>							
<b>&gt; LSA-type 1 (Router-LSA), len 48</b>							
<b>&gt; LSA-type 2 (Network-LSA), len 32</b>							
<b>&lt; LSA-type 3 (Summary-LSA (IP network)), len 28</b>							
.000 0000 0000 1010 = LS Age (seconds): 10							
0..... .... .... = Do Not Age Flag: 0							
<b>Options: 0x22, (DC) Demand Circuits, (E) External Routing</b>							
0..... .... = DN: Not set							
.0... .... = O: Not set							
..1. .... = (DC) Demand Circuits: Supported							
...0 ..... = (L) LLS Data block: Not Present							
.... 0... = (N) NSSA: Not supported							
.... 0.. = (MC) Multicast: Not capable							
.... .1. = (E) External Routing: Capable							
.... ..0 = (MT) Multi-Topology Routing: No							
<b>LS Type: Summary-LSA (IP network) (3)</b>							
<b>Link State ID: 10.0.0.0</b>							
<b>Advertising Router: 4.4.4.4</b>							
<b>Sequence Number: 0x80000001</b>							
<b>Checksum: 0xe03b</b>							
<b>Length: 28</b>							

# OSPF LSA4 (Summary LSA - ASBR)



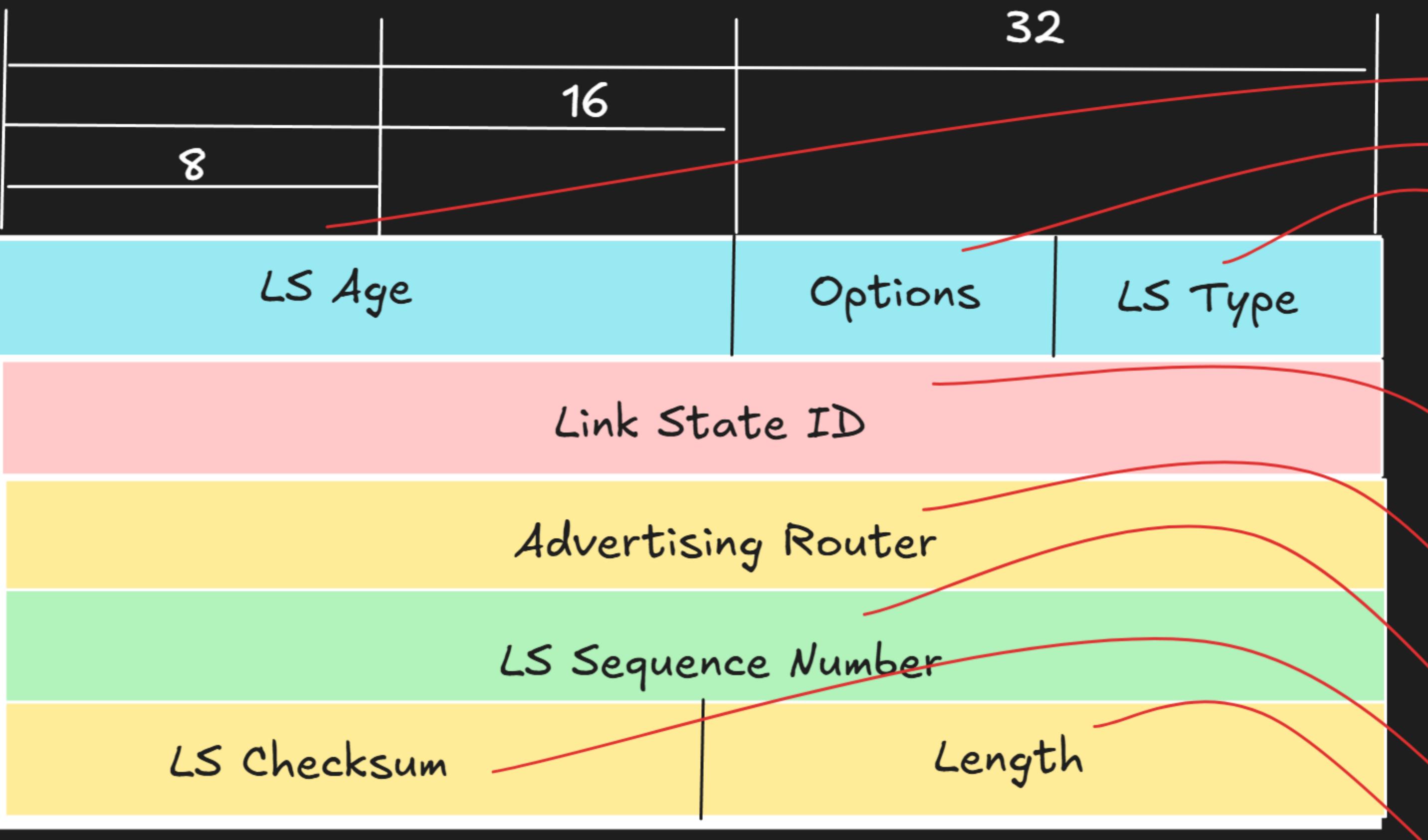
ospf.lsa == 4							
No.	Time	Source	Source Port	Destination	Destination I	Protocol	Length Info
8	32.938125	10.0.20.1		10.0.20.2		OSPF	298 DB Description
<b>Open Shortest Path First</b>							
> OSPF Header Version: 2 Message Type: DB Description (2) Packet Length: 252 Source OSPF Router: 4.4.4.4 Area ID: 0.0.0.20 Checksum: 0xb288 [correct] Auth Type: Null (0) Auth Data (none): 0000000000000000							
> OSPF DB Description > LSA-type 1 (Router-LSA), len 36 <b>&gt; LSA-type 1 (Router-LSA), len 48</b> > LSA-type 2 (Network-LSA), len 32 > LSA-type 3 (Summary-LSA (IP network)), len 28 > LSA-type 3 (Summary-LSA (IP network)), len 28 > LSA-type 3 (Summary-LSA (IP network)), len 28 > LSA-type 4 (Summary-LSA (ASBR)), len 28 .000 0000 0000 1010 = LS Age (seconds): 10 0.... .... .... = Do Not Age Flag: 0							
> Options: 0x22, (DC) Demand Circuits, (E) External Routing 0.... .... = DN: Not set .0.... .... = O: Not set ..1.... .... = (DC) Demand Circuits: Supported ...8.... .... = (L) LLS Data block: Not Present ....0.... .... = (N) NSSA: Not supported ....0... = (MC) Multicast: Not capable ....1... = (E) External Routing: Capable ....0... = (MT) Multi-Topology Routing: No							
LS Type: Summary-LSA (ASBR) (4) Link State ID: 2.2.2.2 Advertising Router: 4.4.4.4 Sequence Number: 0x80000001 Checksum: 0x6fa0 Length: 28							

# OSPF LSA5 (AS External LSA - ASBR)



ospf.lsa == 5							
No.	Time	Source	Source Port	Destination	Destination I	Protocol	Length Info
8	32.938125	10.0.20.1		10.0.20.2		OSPF	298 DB Description
<b>Open Shortest Path First</b>							
<b>OSPF Header</b>							
Version: 2							
Message Type: DB Description (2)							
Packet Length: 252							
Source OSPF Router: 4.4.4.4							
Area ID: 0.0.0.20							
Checksum: 0xb288 [correct]							
Auth Type: Null (0)							
Auth Data (none): 0000000000000000							
<b>OSPF DB Description</b>							
<b>LSA-type 1 (Router-LSA)</b> , len 36							
<b>LSA-type 1 (Router-LSA)</b> , len 48							
<b>LSA-type 2 (Network-LSA)</b> , len 32							
<b>LSA-type 3 (Summary-LSA (IP network))</b> , len 28							
<b>LSA-type 3 (Summary-LSA (IP network))</b> , len 28							
<b>LSA-type 3 (Summary-LSA (IP network))</b> , len 28							
<b>LSA-type 4 (Summary-LSA (ASBR))</b> , len 28							
<b>LSA-type 5 (AS-External-LSA (ASBR))</b> , len 36							
.000 0000 1100 0100 = LS Age (seconds): 196							
0... .... .... ... = Do Not Age Flag: 0							
<b>Options: 0x20, (DC) Demand Circuits</b>							
0... .... = DN: Not set							
.0... .... = O: Not set							
..1. .... = (DC) Demand Circuits: Supported							
...0. .... = (L) LLS Data block: Not Present							
.... 0... = (N) NSSA: Not supported							
.... 0... = (MC) Multicast: Not capable							
.... 0. = (E) External Routing: Not capable							
.... 0. = (MT) Multi-Topology Routing: No							
<b>LS Type: AS-External-LSA (ASBR) (5)</b>							
<b>Link State ID: 172.16.0.0</b>							
<b>Advertising Router: 2.2.2.2</b>							
<b>Sequence Number: 0x80000001</b>							
<b>Checksum: 0x3757</b>							
<b>Length: 36</b>							

# OSPF LSA7 (NSSA AS External LSA)



ospf.lsa == 7							
No.	Time	Source	Source Port	Destination	Destination Port	Protocol	Length Info
51	251.672388	192.168.23.3		192.168.23.2		OSPF	138 DB Description
> Frame 51: 138 bytes on wire (1104 bits), 138 bytes captured (1104 bits) on interface 0							
> Ethernet II, Src: c2:01:0f:cb:00:01 (c2:01:0f:cb:00:01), Dst: c2:02:0f:72:00:01 (c2:02:0f:72:00:01)							
> Internet Protocol Version 4, Src: 192.168.23.3, Dst: 192.168.23.2							
Open Shortest Path First							
OSPF Header							
Version: 2							
Message Type: DB Description (2)							
Packet Length: 92							
Source OSPF Router: 192.168.127.134							
Area ID: 0.0.0.1							
Checksum: 0xa6c [correct]							
Auth Type: Null (0)							
Auth Data (none): 0000000000000000							
> OSPF DB Description							
> LSA-type 1 (Router-LSA), len 36							
> LSA-type 7 (NSSA AS-External-LSA), len 36							
> LSA-type 7 (NSSA AS-External-LSA), len 36							
.000 0000 0001 0111 = LS Age (seconds): 23							
0.... .... .... = Do Not Age Flag: 0							
Options: 0x20, (DC) Demand Circuits							
0.... .... = DN: Not set							
.0.... .... = O: Not set							
..1.... .... = (DC) Demand Circuits: Supported							
...0.... .... = (L) LLS Data block: Not Present							
....0.... .... = (P) Propagate: Not set							
.....0.... = (MC) Multicast: Not capable							
.....0.... = (E) External Routing: Not capable							
.....0.... = (MT) Multi-Topology Routing: No							
LS Type: NSSA AS-External-LSA (7)							
Link State ID: 192.168.127.0							
Advertising Router: 192.168.127.134							
Sequence Number: 0x80000001							
Checksum: 0xef56							
Length: 36							

# References

## Topology Diagram:

- NetworkLessons. (n.d.). OSPF Packets and Neighbor Discovery. Retrieved from <https://networklessons.com/ospf/ospf-packets-and-neighbor-discovery>

## Packet Capture Reference:

- NetworkLessons GitHub. (n.d.). ospf-neighbor-adjacency-broadcast-two-routers.pcapng. Retrieved from <https://github.com/networklessons/labs/raw/refs/heads/main/packet-captures/ospf-neighbor-adjacency-broadcast-two-routers.pcapng>

## Lab Environment:

- EVE-NG. (n.d.). EVE-NG Network Emulator. Available at <https://www.eve-ng.net/>

## OSPF Protocol Standards:

- Moy, J. (1998). OSPF Version 2. RFC 2328, Internet Engineering Task Force (IETF). Retrieved from <https://datatracker.ietf.org/doc/html/rfc2328>

## Wireshark Documentation:

- Wireshark. (n.d.). Wireshark User's Guide. Retrieved from [https://www.wireshark.org/docs/wsug\\_html\\_chunked/](https://www.wireshark.org/docs/wsug_html_chunked/)

## OSPF Operations and Configuration:

- Cisco. (n.d.). Understanding OSPF Operations. Retrieved from <https://www.cisco.com/c/en/us/support/docs/ip/open-shortest-path-first-ospf/7039-1.html>
- Cisco. (n.d.). Configuring OSPF. Retrieved from [https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/iproute\\_ospf/configuration/15-mt/iro-15-mt-book/iro-cfg.html](https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/iproute_ospf/configuration/15-mt/iro-15-mt-book/iro-cfg.html)

*Thank  
You!*

