

# OSPF

## 11.1 OSPF

Link state Interior Gateway Protocol OSPF 1988 IETF OSPF  
workgroup . OSPF 가 RFC 2383 version 2  
Chapter OSPF Version 2 . OSPF IGP AS  
1 가 .

### 11.1.1 Convergence Traffic

Distance Vector Link state  
OSPF 가  
(Flooding) 가  
OSPF  
RIP

### 11.1.2 CIDR, VLSM

OSPF 가 RIP version 1  
CIDR, VLSM IP

### 11.1.3

가 Hops 가 15 RIP OSPF  
OSPF

### 11.1.4 Routing Table

Simple Password<sup>2</sup> RIP OSPF  
. OSPF Simple Password Password  
Rogue Router

### 11.1.5

OSPF 224.0.0.5 224.0.0.6  
RIP  
30

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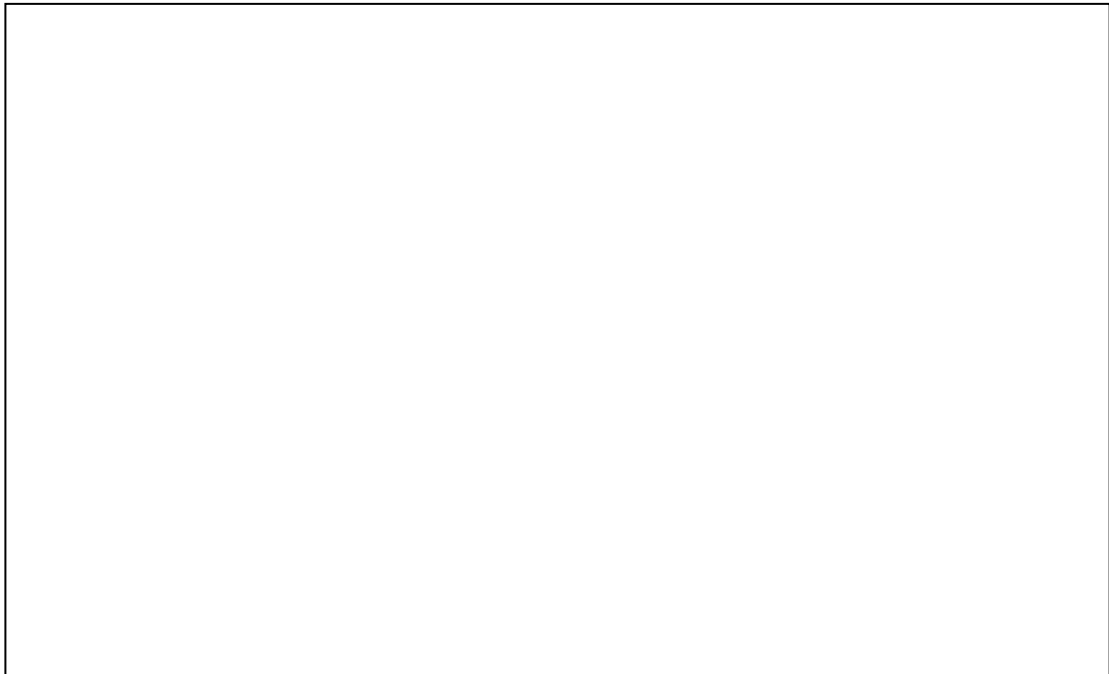
<sup>1</sup> OSPF AS Area  
Area

<sup>2</sup> Password

WAN

### 11.1.6

Hops 3  
가 RIP IP  
가 가 OSPF  
( ) 가 Cost  
1 Hops  
가



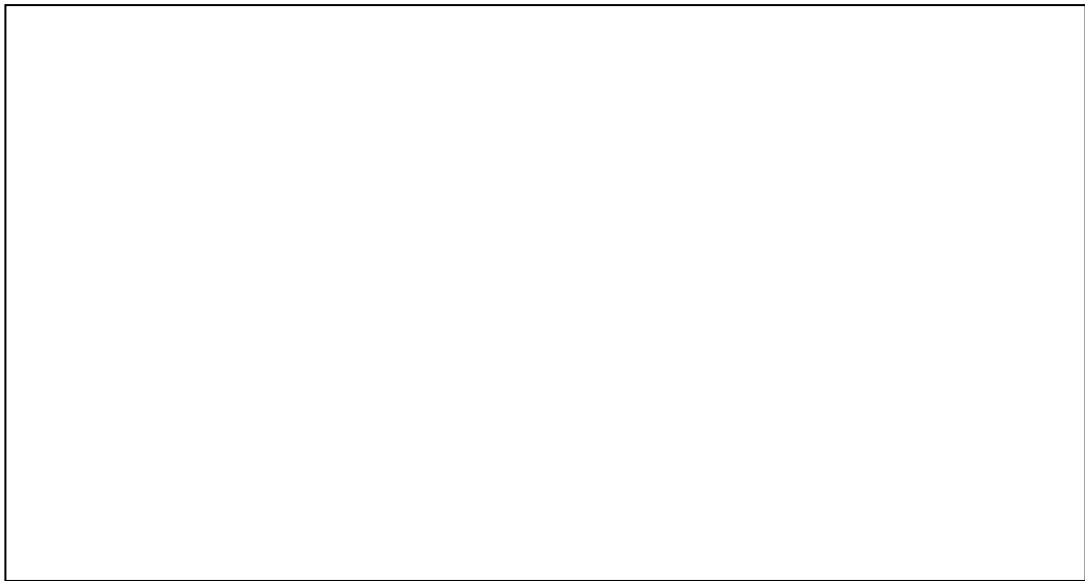
1 Cost

### 11.2 OSPF

Link State OSPF  
2 (Area)  
Link state Link state database Root Shortest Path Tree

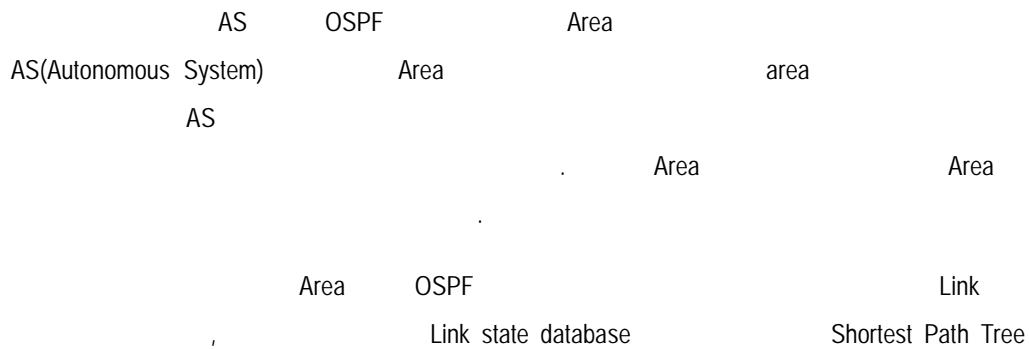
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<sup>3</sup> RIP 가 Chapter 9 가 RIP Next Hop  
가 가 가



2

Shortest Path Tree



### 11.2.1

4

OSPF , OSPF  
OSPF

#### A. Autonomous System(AS)

#### B. Interface(link):

가

(Low level)

가

Unnumbered Connection<sup>5</sup> 가 IP 가

### C.Link State

LSA(Link State Advertisements) Hello (

### D.Router ID

OSPF 32bits AS

### E. Hello

### F. Network

IP Network/ subnet/ supernet. Network ID Point to Point

### G.Area

AS Area ID 가 Area OSPF Link State

### H.Cost

Link (Metric). Cost Outbound

### I. Neighborhood Database

가

### J. Link-state Database(Topology database)

Link-state LSA 가 Area Link-state database 가

### K.Routing Table

Link state database Shortest Path First(SPF, Dijkstra<sup>6</sup>) Forwarding database. OSPF

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<sup>5</sup> Point to Point Serial IP Ethernet

<sup>6</sup> Link State

**L. Broadcast Networks**

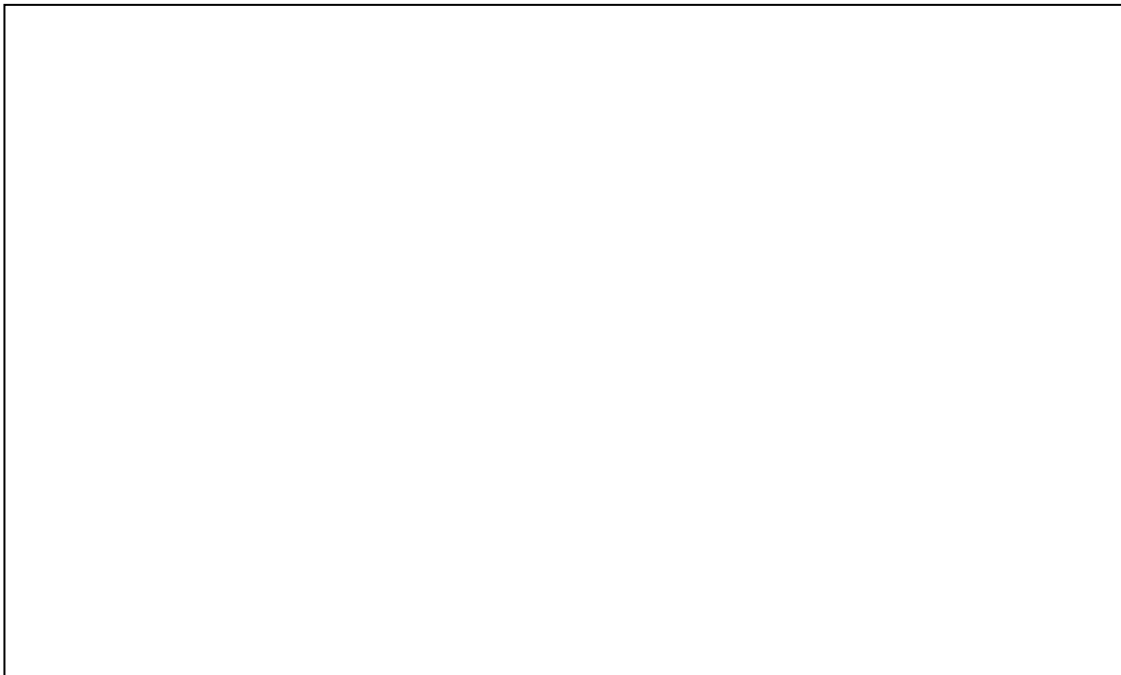
가 가

**M. Point to Point Networks**

T1 가

**N. Non Broadcast Multiple Access(NBMA) networks**

Relay, X. 25 Broadcast . Frame



3 OSPF

Link Topology

**O. Neighboring Router**

Hello . OSPF

**P. Adjacency**

**Q. Flooding**

OSPF Link-state database OSPF  
RIP LSA

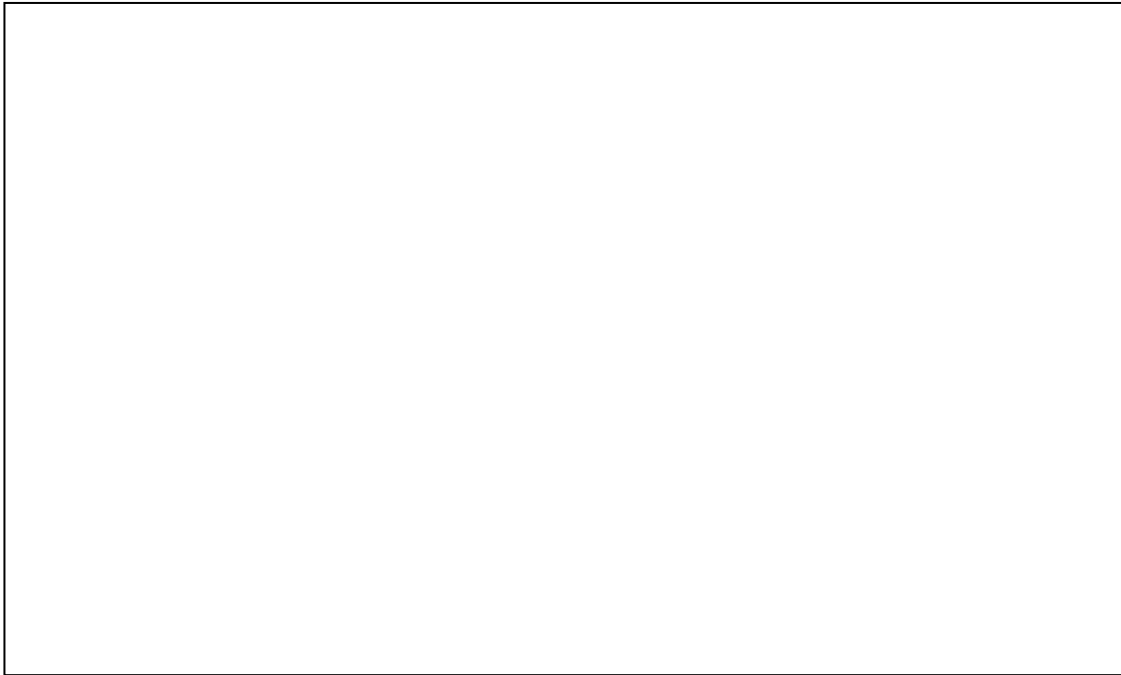
Flooding

### R. Designated Router

가 Broadcast NBMA  
Designate Router Hello Broadcast  
OSPF 가 가  
가 (adjacency)  
6 가 가  
15 Adjacency가 LSA  
Multiple Access  
Designate Router Designated  
Router Link state Database

### S. Lower-Level Protocols

IP OSPF Network Access  
Frame Relay



4 OSPF

Chapter가

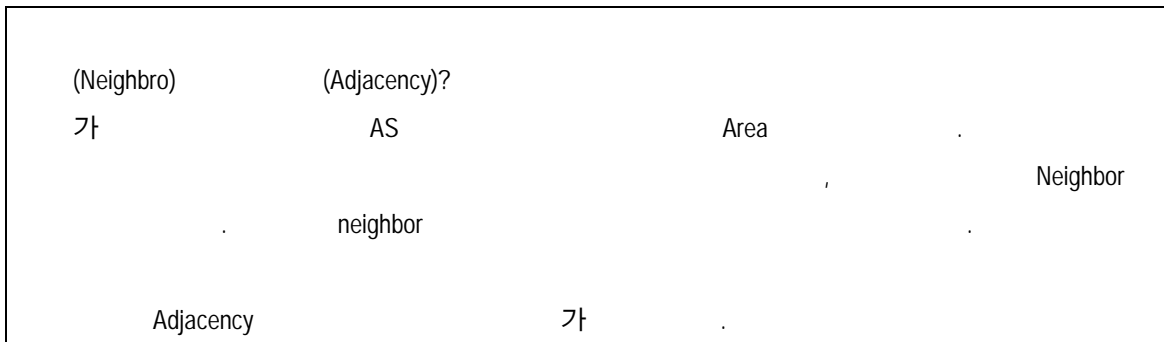
가

Area OSPF

OSPF Link state

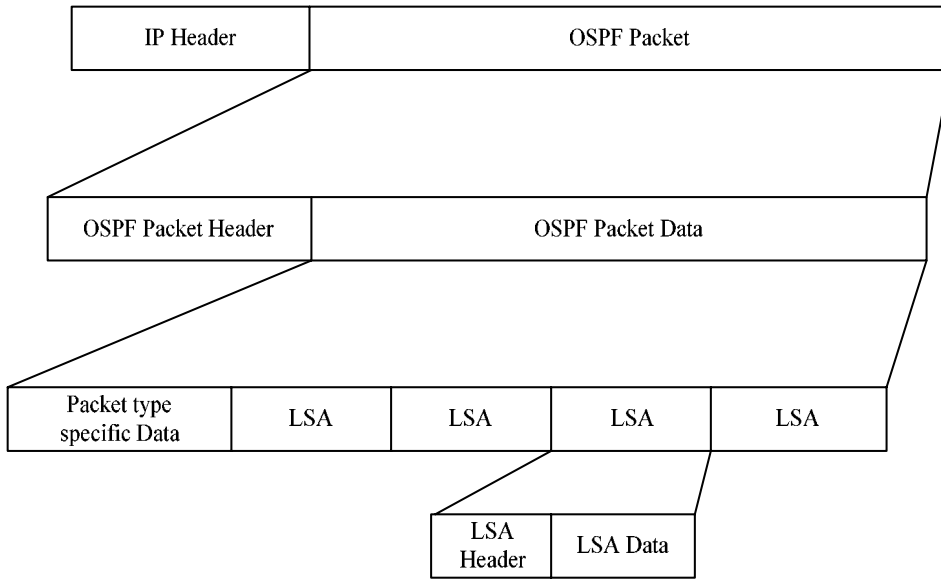
Distance Vector 가 ( 가 )  
 OSPF Area 가 OSPF 가

1. OSPF Link Hello
2. LSA Hello Link state OSPF  
 Link State LSA
3. LSA Link State Database OSPF Link State  
 Area LSA Shortest Path Tree  
 Database



### 11.2.2 OSPF

7



### 5 OSPF

OSPF . 5  
 IP OSPF 5 ( 1 )  
 가 가 OSPF

OSPF .



### 6 OSPF Packet Header



- Version No.: OSPF

- Type: OSPF

가

| Type | Description               |
|------|---------------------------|
| 1    | Hello                     |
| 2    | Database Description      |
| 3    | Link State Request        |
| 4    | Link State Update         |
| 5    | Link State Acknowledgment |

### 1 OSPF Type Value

- Packet Length: OSPF . byte. OSPF

- Router ID: ID

- Area ID: 32bits Area .

- Authentication type: OSPF

| Authentication Type Value | Description                         |
|---------------------------|-------------------------------------|
| 0                         | (Null Authentication)               |
| 1                         | Password(Simple Password)           |
| 2                         | (Cryptographic MD 5 Authentication) |
| All Others                | .                                   |

### 2 Authentication Type

```

IP: ID = 0xF3CC: Proto = OSPF IGP: Len: 64
IP: Version = 4 (0x4)
IP: Header Length = 20 (0x14)
IP: Precedence = Routine
IP: Type of Service = Normal Service
IP: Total Length = 64 (0x40)
IP: Identification = 62412 (0xF3CC)
+ IP: Flags Summary = 0 (0x0)
IP: Fragment Offset = 0 (0x0) bytes
IP: Time to Live = 1 (0x1)
IP: Protocol = Open Shortest Path First IGP
IP: Checksum = 0xAFB8
IP: Source Address = 192,168,117,50
IP: Destination Address = 224,0,0,5
IP: Data: Number of data bytes remaining = 44 (0x002C)
- OSPF: Message = Hello
  OSPF: Version = 2 (0x2)
  OSPF: OSPF Packet Type = Hello
  OSPF: Packet Length = 44 (0x2C)
  OSPF: Source Router ID = 61,107,21,26
  OSPF: Area ID = 0,0,0,0
  OSPF: Checksum = 0xAA18
  OSPF: Authentication Type = Simple Password
  OSPF: Authentication = 0x3837363534333231
  OSPF: Netmask = 255,255,255,0
  OSPF: Hello Interval = 10 (0xA) seconds
+ OSPF: Hello Options = 2
  OSPF: Router Priority = 1 (0x1)
  OSPF: Dead Interval = 40 (0x28) seconds
  OSPF: Designated Router = 0,0,0,0
  OSPF: Backup Designated Router = 0,0,0,0

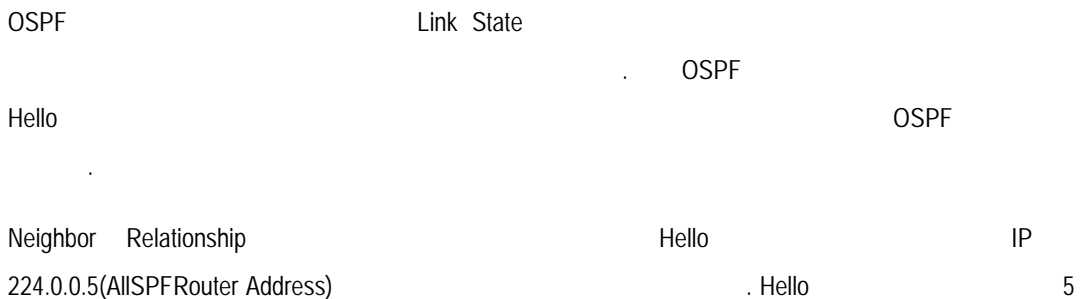
```

7 IP Header and OSPF Header Format

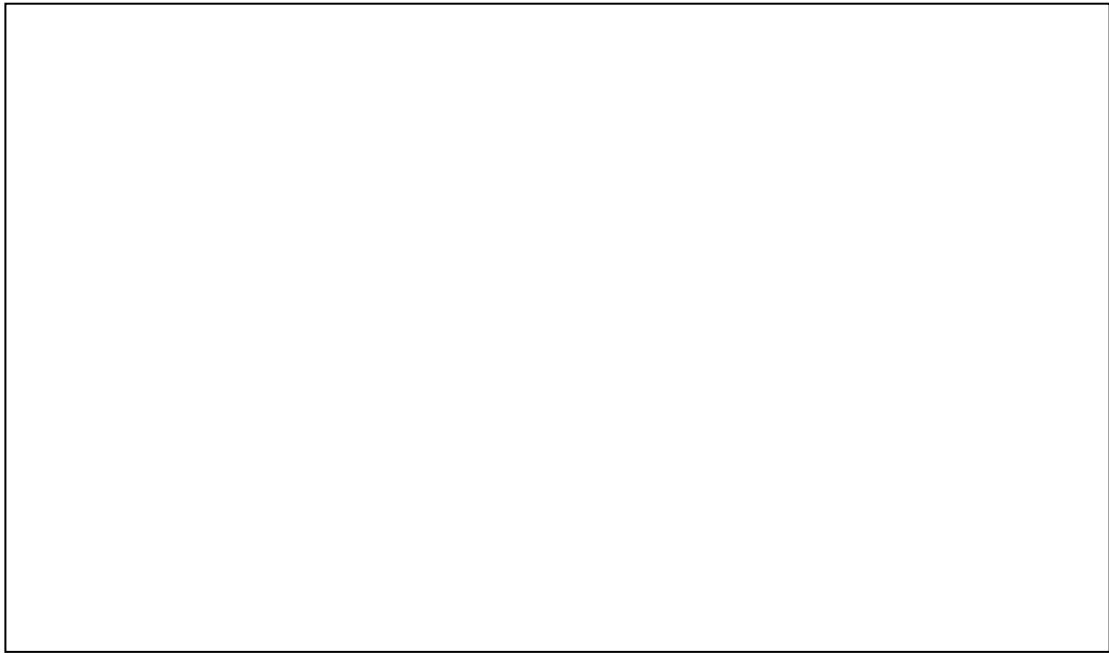


11.3 OSPF Operation

11.3.1 OSPF



A. Hello Protocol



### 8 Hello Packet Format

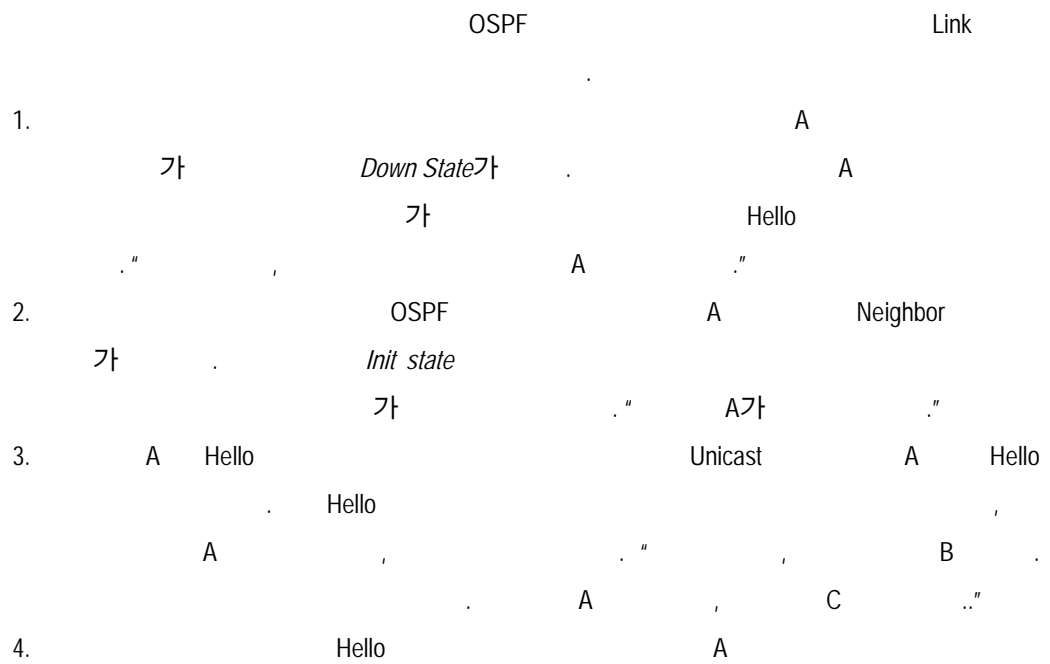
- Router ID:** 32bits 가 Router ID AS  
 IP 가 IP 가 Router id가  
 2 가 OSPF IP 가  
 192.168.1.1 192.168.12.1 192.168.12.1 Router ID가
- HelloInterval:** OSPF 가 Hello (Multi access Network  
 10 )
- Router Priority:** 8 bits 가 OSPF Designated  
 Router( DR) Backup Designated Router( BDR)  
 가 DR BDR  
 OSPF  
 DR BDR
- Router Dead Interval:** OSPF Hello  
 가  
 Dead Interval Dead Interval Hello interval 4
- Neighbors:**  
 Hello

- DR and BDR IP address: DR BDR IP
- Authentication Password: OSPF Password

**B.**



**9 OSPF Exchange Process**



Neighbor Database

Two way state

OSPF

가 (Broadcast Network)  
가

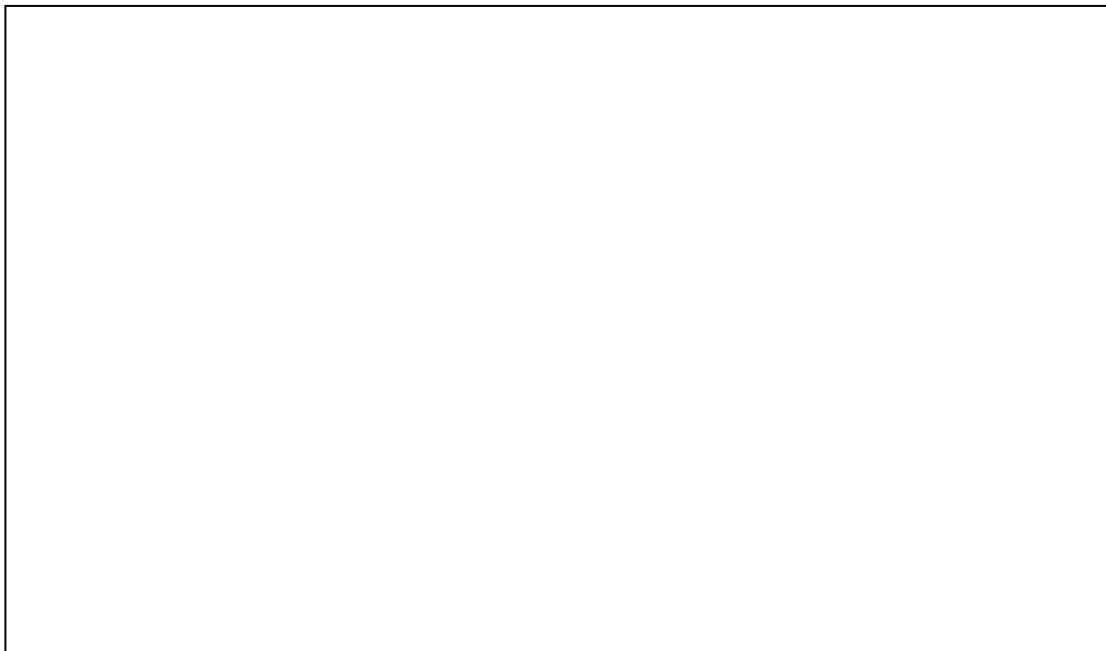
가  
Point to Point

..^^) NBMA ( Point to Point

가? 가 ..^^)

가

### C.Designated Router and Backup Designated Router



10 DR BDR

OSPF

(Adjacency)

LSA

OSPF

Point to Point

가

가

Multiple Access( ) 가

8

가 . 가

OSPF Convergence 가

OSPF

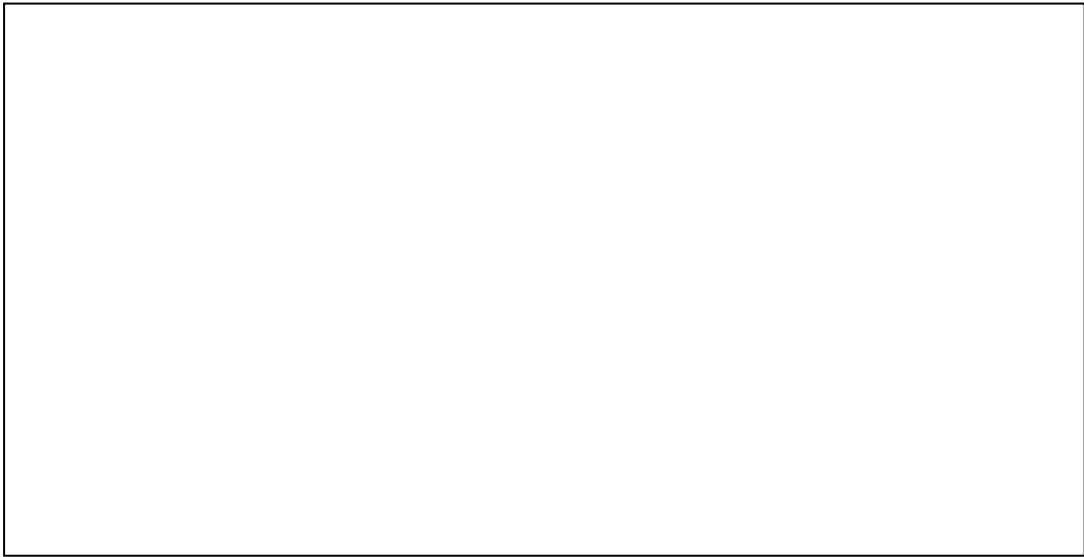
Link state Designated , Designated Router

Designated Router가 가 Backup

Designated Router . BDR Link State

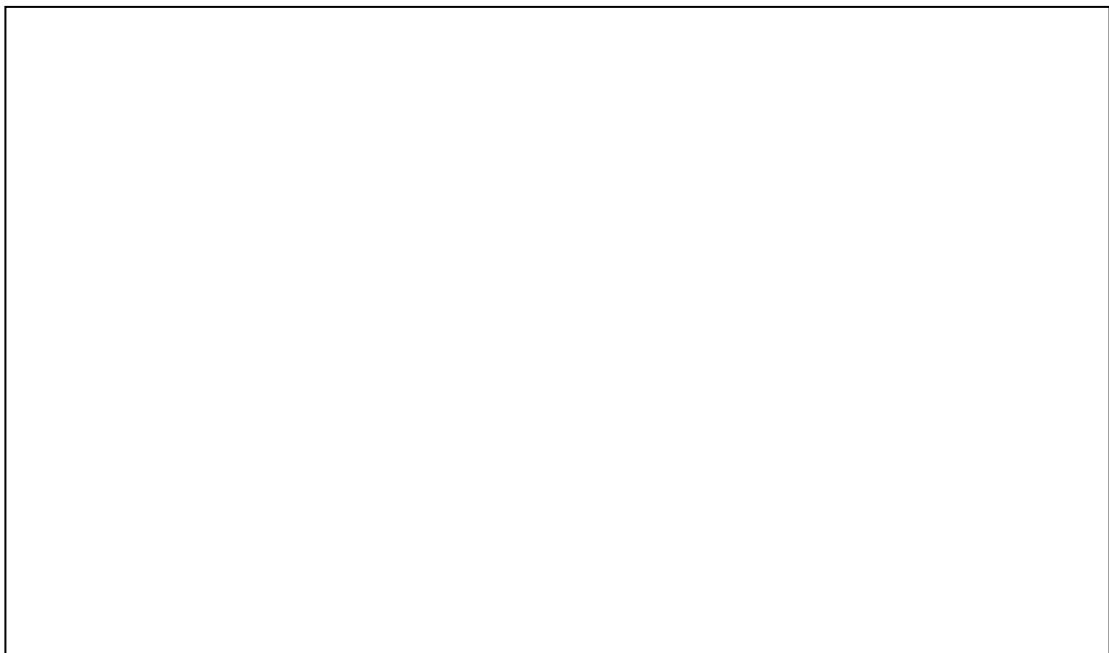
DR . DR BDR

- 9 DR BDR OSPF 8
- 가
- 가
- Link-state DR BDR Link state 가
- DR BDR Router Priority
- Priority가 가 DR BDR
- Priority가 ID가 가 DR
- OSPF 1 ID
- 가 가 DR
- "0" DR BDR
- (DR BDR "Drother" .)
- 가 가 가 DR
- DR BDR , DR BDR
- BDR DR 가 DR
- LSA가 BDR DR
- Multiple Access OSPF , DR BDR
- DR, BDR DR



11 Broadcast

DR/BDR



12 NBMA

DR

**D.**

<sup>8</sup>

DR BDR

OSPF

exstart state가

. Exstart state

DR

---

<sup>8</sup> Point to Point

Point to point

DR/BDR

BDR (Master) ID (Slave) ( ID가  
가 가 ) . Exstart state  
Sequence No.  
Database Description (DBD)  
exchange state가 11 DBD Link state  
LSA 가 (LSA Header)  
Link-state , LSA Sequence Number  
. LSA Sequence 가 가  
DD Sequence

Database Description

|                    |                     |               |
|--------------------|---------------------|---------------|
| Version No.        | Type=2              | Packet Length |
| Router ID          |                     |               |
| Area ID            |                     |               |
| Checksum           | Authentication Type |               |
| Authentication     |                     |               |
| Authentication     |                     |               |
| Interface MTU      | Option              |               |
| DD Sequence Number |                     |               |
| LSA Header         |                     |               |

13 Database Description Packet Format

- Interface MTU: MTU 가 Database Description



Virtual Link

0

● Options:

I-bit:

1

Database

Description 가

M-bit: More bit.

1

가

Database Description

MS-bit: Master/Slave bit. 1

가

● DD Sequence Number: Database Description

Database Description

가

DBD

DBD Sequence

LSA

Acknowledgement

DBD

LSA

Link State Request

(Loading state).

Link State Request

OSPF

Link State Update

Link State Update

Link state database

Shortest Path Tree

가

Full state

Full state가

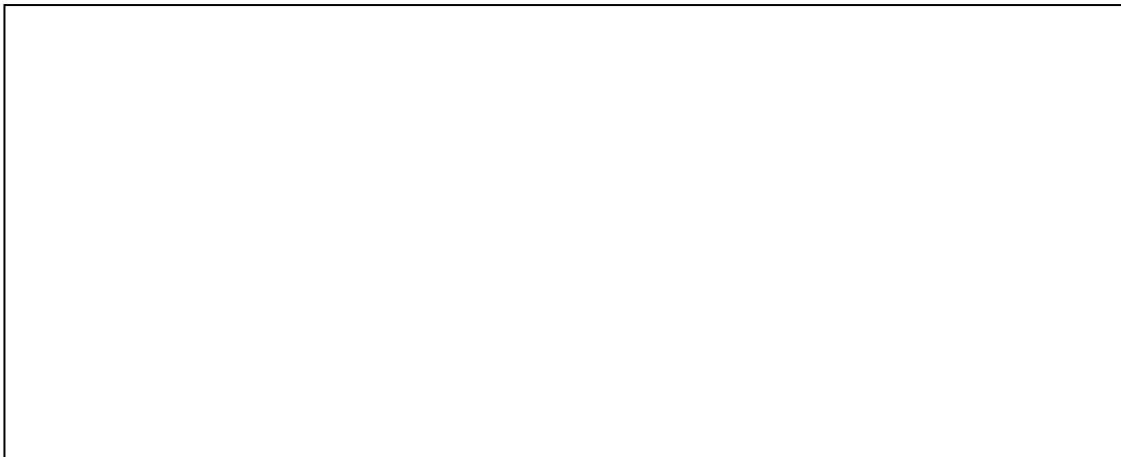
가

Hello

가

30

LSA



E. Dijkstra

Shortest Path First Tree

LSA  
Dijkstra

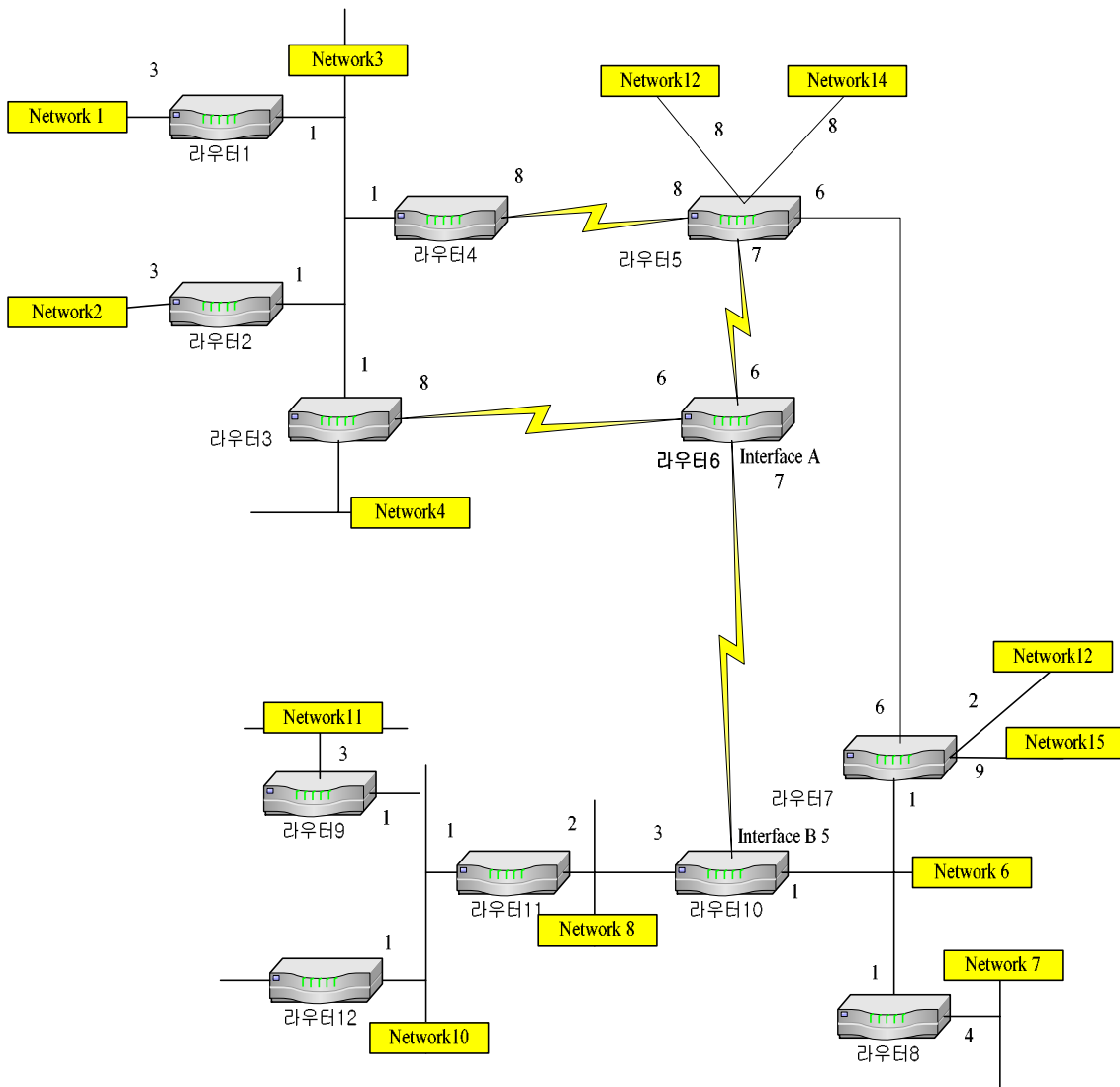
Link State Database

OSPF  
SPF Tree(Shortest Path

First Tree)

SPF Tree

가



15 Sample AS Diagram

<sup>9</sup> Dijkstra

AS

Full state가

가

. Dijkstra

Cost가

SPF Tree

Graph

3

가

|     |      | FROM |     |     |     |     |     |     |     |     |      |      |      |    |    |    |    |
|-----|------|------|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|----|----|----|----|
|     |      | Rt1  | Rt2 | Rt3 | Rt4 | Rt5 | Rt6 | Rt7 | Rt8 | Rt9 | Rt10 | Rt11 | Rt12 | N3 | N6 | N8 | N9 |
| TO  | Rt1  |      |     |     |     |     |     |     |     |     |      |      |      | 0  |    |    |    |
|     | Rt2  |      |     |     |     |     |     |     |     |     |      |      |      | 0  |    |    |    |
|     | Rt3  |      |     |     |     |     | 6   |     |     |     |      |      |      | 0  |    |    |    |
|     | Rt4  |      |     |     |     | 8   |     |     |     |     |      |      |      | 0  |    |    |    |
|     | Rt5  |      |     |     | 8   |     | 6   | 6   |     |     |      |      |      |    |    |    |    |
|     | Rt6  |      |     |     |     | 7   |     |     |     |     | 5    |      |      |    |    |    |    |
|     | Rt7  |      |     |     |     | 6   |     |     |     |     |      |      |      |    | 0  |    |    |
|     | Rt8  |      |     |     |     |     |     |     |     |     |      |      |      |    | 0  |    |    |
|     | Rt9  |      |     |     |     |     |     |     |     |     |      |      |      |    |    |    | 0  |
|     | Rt10 |      |     |     |     |     | 7   |     |     |     |      |      |      |    | 0  | 0  |    |
|     | Rt11 |      |     |     |     |     |     |     |     |     |      |      |      |    |    | 0  | 0  |
|     | Rt12 |      |     |     |     |     |     |     |     |     |      |      |      |    |    |    | 0  |
|     | N1   | 3    |     |     |     |     |     |     |     |     |      |      |      |    |    |    |    |
|     | N2   |      | 3   |     |     |     |     |     |     |     |      |      |      |    |    |    |    |
|     | N3   | 1    | 1   | 1   | 1   |     |     |     |     |     |      |      |      |    |    |    |    |
|     | N4   |      |     | 2   |     |     |     |     |     |     |      |      |      |    |    |    |    |
|     | N6   |      |     |     |     |     |     |     |     | 1   |      | 1    |      |    |    |    |    |
|     | N7   |      |     |     |     |     |     |     |     | 4   |      |      |      |    |    |    |    |
|     | N8   |      |     |     |     |     |     |     |     |     |      | 3    | 2    |    |    |    |    |
|     | N9   |      |     |     |     |     |     |     |     |     | 1    |      | 1    | 1  |    |    |    |
| N10 |      |      |     |     |     |     |     |     |     |     |      |      | 2    |    |    |    |    |
| N11 |      |      |     |     |     |     |     |     |     | 3   |      |      |      |    |    |    |    |
| N12 |      |      |     |     | 8   |     |     |     |     |     |      |      |      |    |    |    |    |
| N14 |      |      |     |     | 8   |     |     |     |     |     |      |      |      |    |    |    |    |
| N15 |      |      |     |     |     |     |     | 9   |     |     |      |      |      |    |    |    |    |

3 Directed Graph (Rt: Router, N: Network)

3

AS

(FROM)

Cost

12가

LSA<sup>10</sup>

| To | From |      |    |     |
|----|------|------|----|-----|
|    |      | RT12 | N9 | N10 |
|    | RT12 |      |    |     |
|    | N9   | 1    |    |     |
|    | N10  | 2    |    |     |

4 12 LSA

가 4 LSA OSPF

3

15

SPF Tree

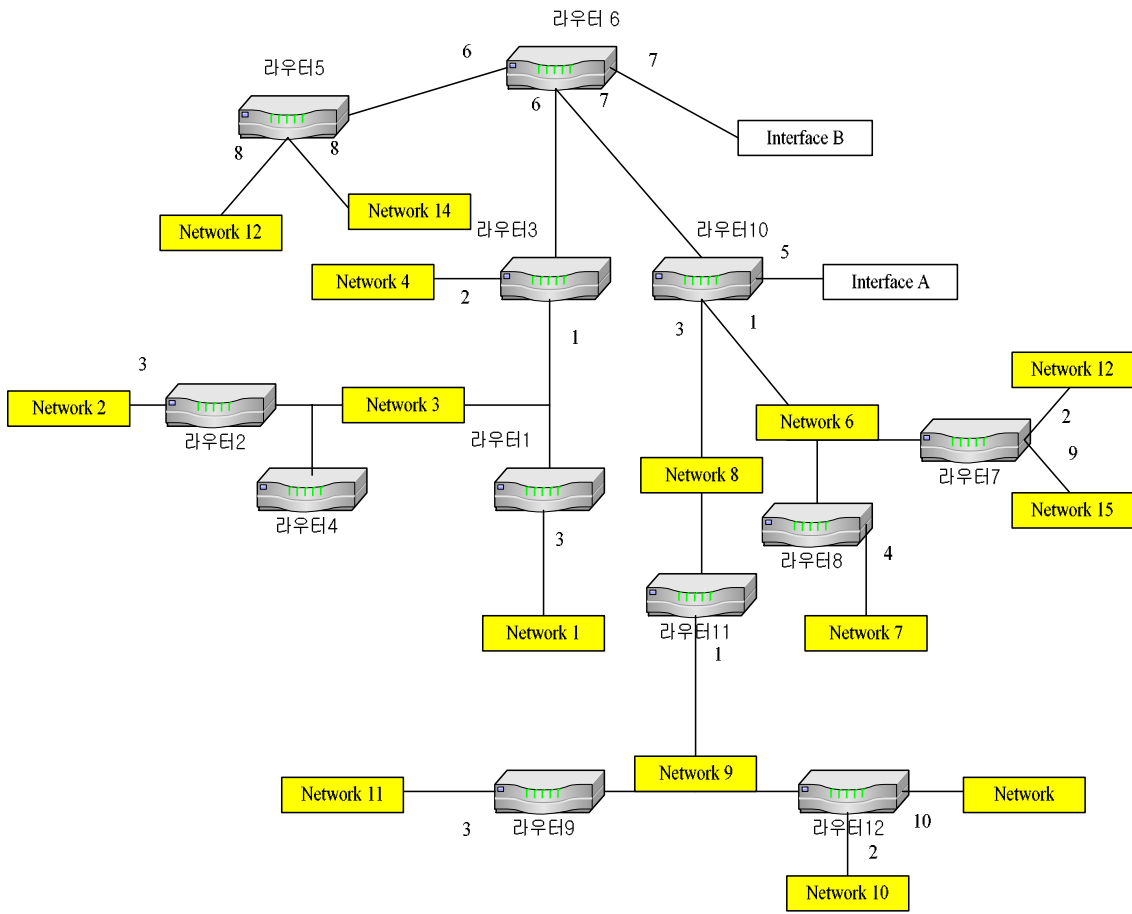
6 SPF Tree

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<sup>10</sup> LSA  
LSA

LSA  
11.5 LSA

LSA



16 6 SPF Tree

가 , 가  
 가 Cost  
 SPF Tree OSPF

**F. SRF Tree**

**Routing Table**

AS Area OSPF  
 Routing Table(Forward Table) LSU  
 Link State database OSPF ( 5  
 ) PSTN  
 가  
 OSPF LSU

OSPF 가 가 가

ospf SPF Tree 가

가

가

( Forwarding Table)

OSPF

Cost가

Load balancing

가

가

Cost<sup>11</sup>

가

, OSPF

가

IP

가

<sup>12</sup>

15

6가

| Destination | Next Hop | Cost |
|-------------|----------|------|
| N1          | RT3      | 10   |
| N2          | RT3      | 10   |
| N3          | RT3      | 7    |
| N4          | RT3      | 8    |
| Interface A | RT10     | 12   |
| Interface B |          | 7    |
| N6          | RT10     | 8    |
| N7          | RT10     | 12   |
| N8          | RT10     | 10   |
| N9          | RT10     | 11   |
| N10         | RT10     | 13   |
| N11         | RT10     | 14   |
| RT5         | RT5      | 6    |
| RT7         | RT10     | 8    |

5

6

12

5, 7, 12가

AS

가

6

<sup>11</sup>

RFC 2328

Cost

Cisco

Cost

$10^8 /$

100M

Cost=1

<sup>12</sup>

4

Load Balancing

6

가

5 13.

OSPF Network Router  
5 가 Nxx Network entry RTx  
Router Entry

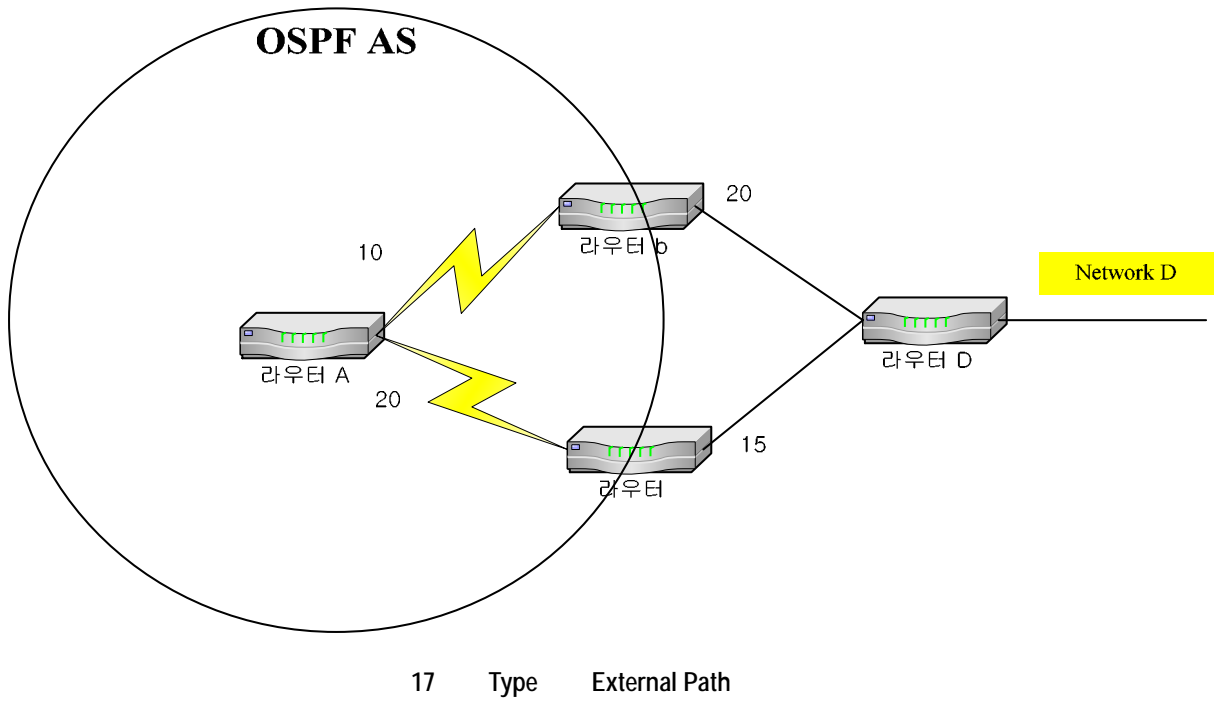
Network Entry 가  
, Router Entry Area Border Router(ABR) AS Border Router(ASBR)  
. OSPF 가 Area AS  
, ABR ASBR  
가

**Path Type**

OSPF 가 Intra Area, Inter Area, Type 1 External, Type 2  
External 4 11.6 Area

- Intra Area: 가 OSPF 가 Area
- Inter Area: 가 OSPF 가 AS Area
- Type1 External: 가 AS Type 1  
OSPF ASBR Cost ASBR 가  
( 17 )
- Type2 External: 가 AS Type  
OSPF ASBR Cost가 Metric , ASBR  
가 ASBR Cost

17 ASBR D  
Type 1 B가 ASBR Type2 가 C가  
ASBR



Routing Table

OSPF

- IP 가  
IP 가 192.168.10.100  
가 192.168.10.0 /24, 192.168.10.64/26  
OSPF 192.168.10.64/26
- 가 Path  
1. Intra Area Path, 2. Inter Area Path, 3. E1 External Path, 4. E2 External path
- 가

G.Routing

14

OSPF

Area

가

가 Link state

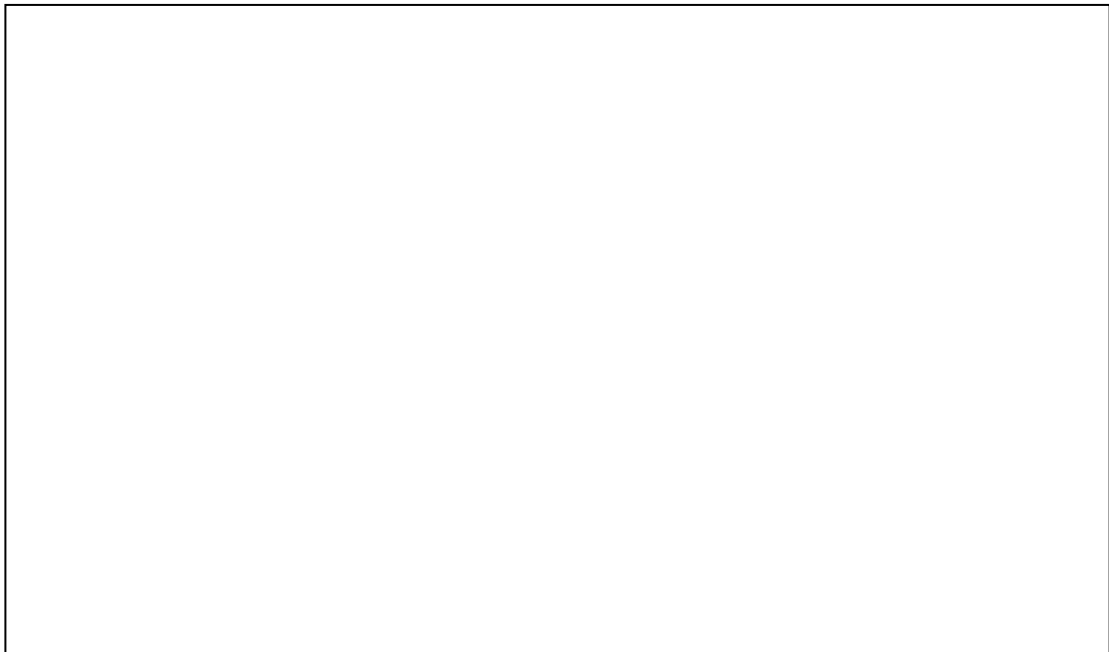
link state update

14 LSA LSU

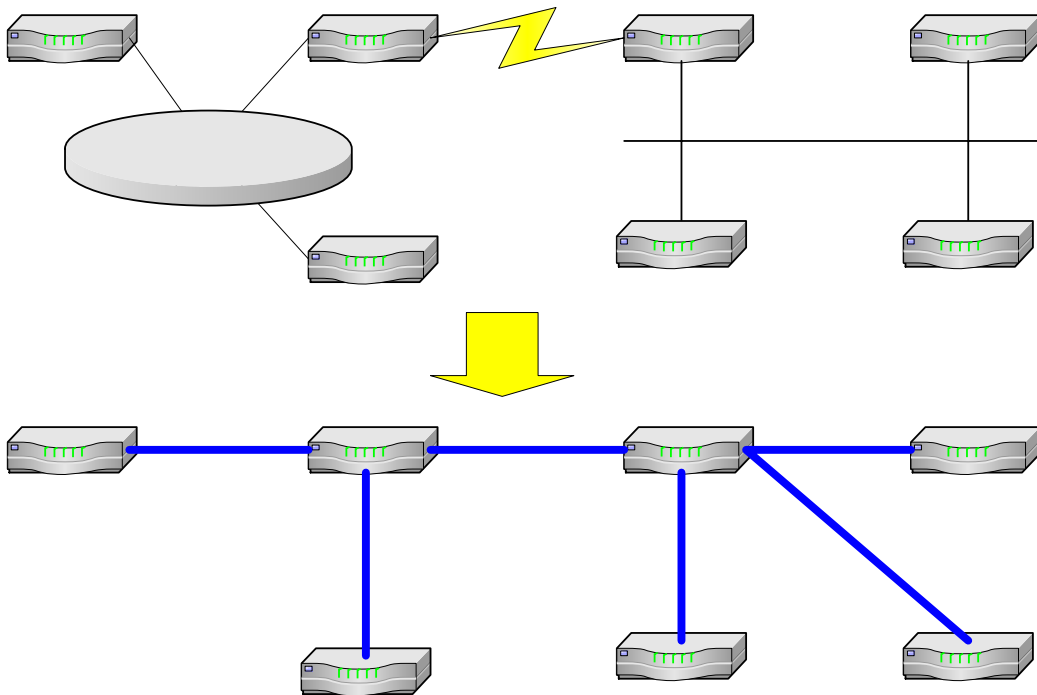
11.5 LSA



- Area Flooding Flooding Process  
DR BDR) Link state Update LSA 224.0.0.6(
- DR LSA ACK Flooding (224.0.0.5)  
가 Flooding LSU ( LSAACK DR
- 가 LSU Flooding ( 가 Multiple Access  
DR Point to Point Flooding )
- LSA LSU Link state database



**H. Flooding**



19 Adjacencies

OSPF

19

가

가

OSPF

Link State

LSU

가

가

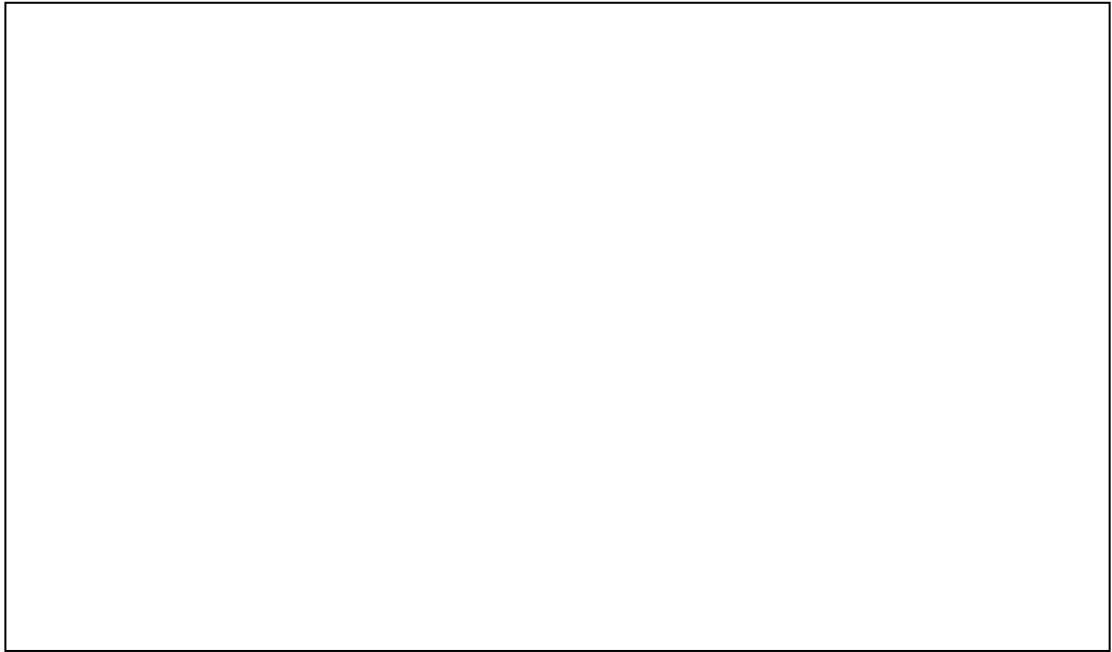
LSA

LSU

OSPF

LSAck

( 20 )



20 OSPF Link state Update LSAck

OSPF LSU

Flooding OSPF 가 LSU

AS(Area가 ) Link state Area

Link state database OSPF Flooding

OSPF Flooding 가

**Acknowledgments**

Link state Update LSA OSPF

가 가 가

LSA LSA

OSPF LSU LSA Ack

Ack 가 LSA , Ack

가

## Sequencing, Checksum, and Aging

LSA가 Sequence No. Checksum, age  
가 . Sequence No. LSA가 가  
. , LSA 가 ,  
Checksum LSA 가 Checksum  
LSA 가 (Age Flooding  
) 가 Link state Database 5  
Link state database가  
Age LSA가 가 가  
3600 , 1 0 . LSA Age LSA가 Flooding  
가 . LSA age , 1  
OSPF LSA

OSPF OSPF Topology  
OSPF

### 11.3.2

### OSPF Operation

#### A. Point to Point

Point to Point OSPF Broadcast  
DR/BDR . Point to Point OSPF  
224.0.0.5 Hello , DR  
Point to Point IP Unnumbered Interface  
Point to Point  
OSPF  
가 Point to Point  
가

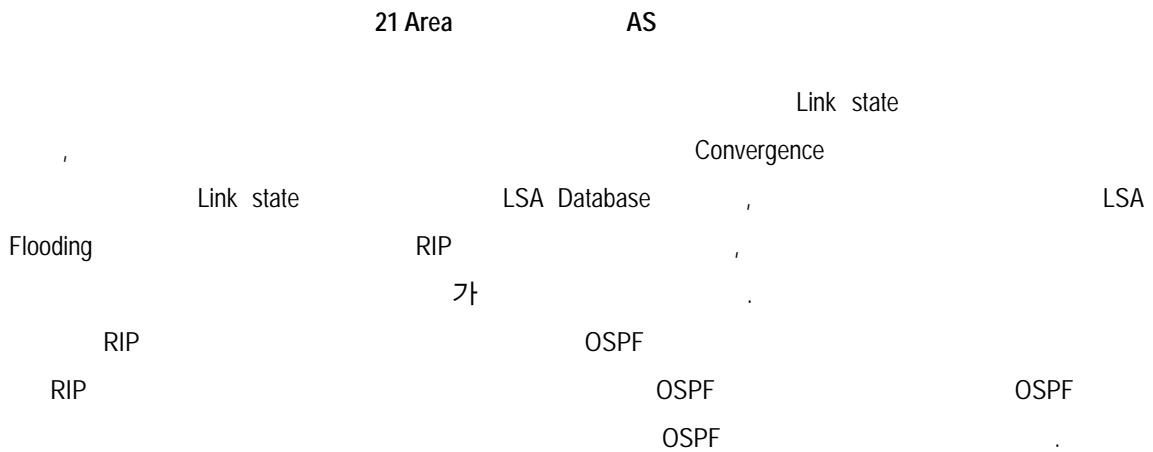
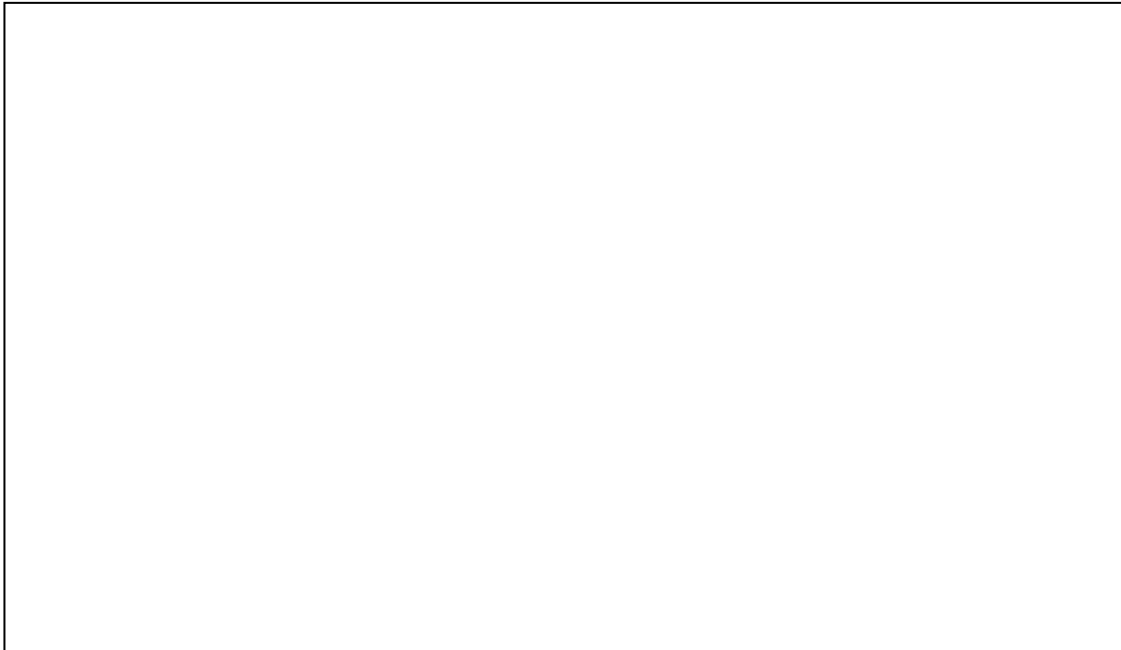
#### B. Non Broadcast Multiple Access

Broadcast 가 Multiple Access 가  
Frame Relay, OSPF  
VC

- OSPF Unicast
- OSPF 가
- OSPF Broadcast
- A. Nonbroadcast Multiple Access(NBMA)- DR/BDR
- B. Point to Multipoint – VC Point to Point 가
- DR/BDR

C.  
**11.4 Area**

**11.4.1 Area**



Area

AS

AS Area 가

Area Area 가

Area OSPF

C. 가 가

가

D. Link State Database 가 LSA 가

CPU

E. Link State Database 가 Area LSA Flooding

### 11.4.2 area ID

AS Area 32 bits Area id IP

4 Octec Area ID Area 0.0.1.20 IP

ID Area 0.0.1.20 Area 276

Area 0.0.0.0 AS Area ID

OSPF Area Area

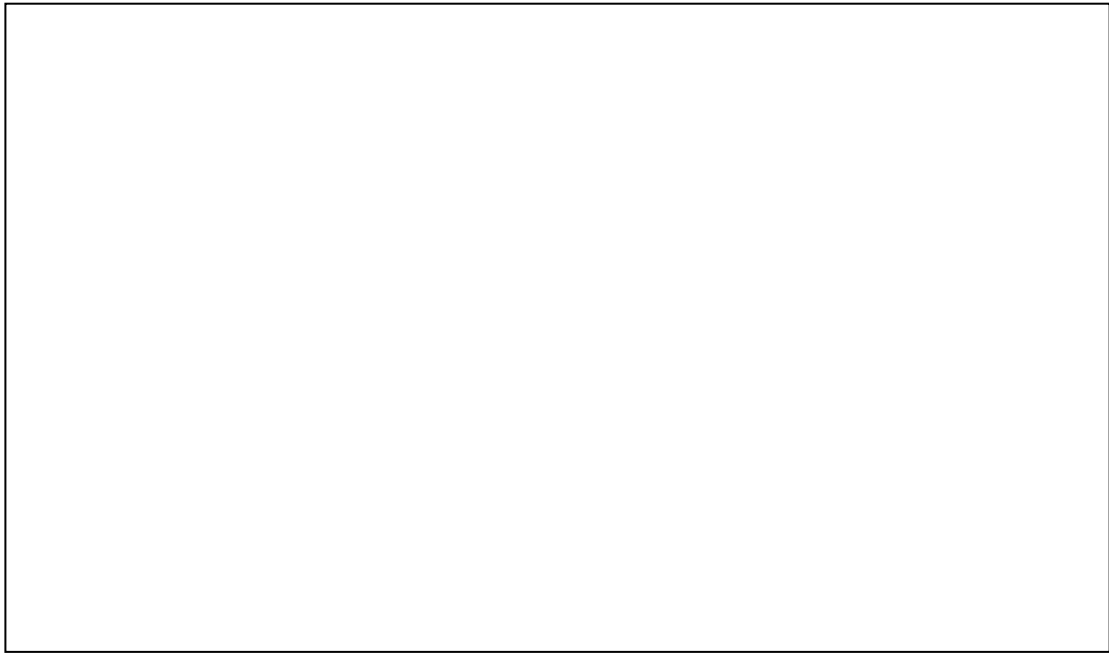
Area AS Area Area Area

가 OSPF AS Area Area Area

Area가 OSPF AS

Intra Area Traffic, Inter Area Traffic, External Traffic

### 11.4.3 Router Type



22 OSPF Router types

OSPF AS

**A. Internal Router**

Area Link state database  
가

**B. Area Border Router(ABR)**

Area ABR Area Inter Area  
가  
Area Link state Database ABR  
Area

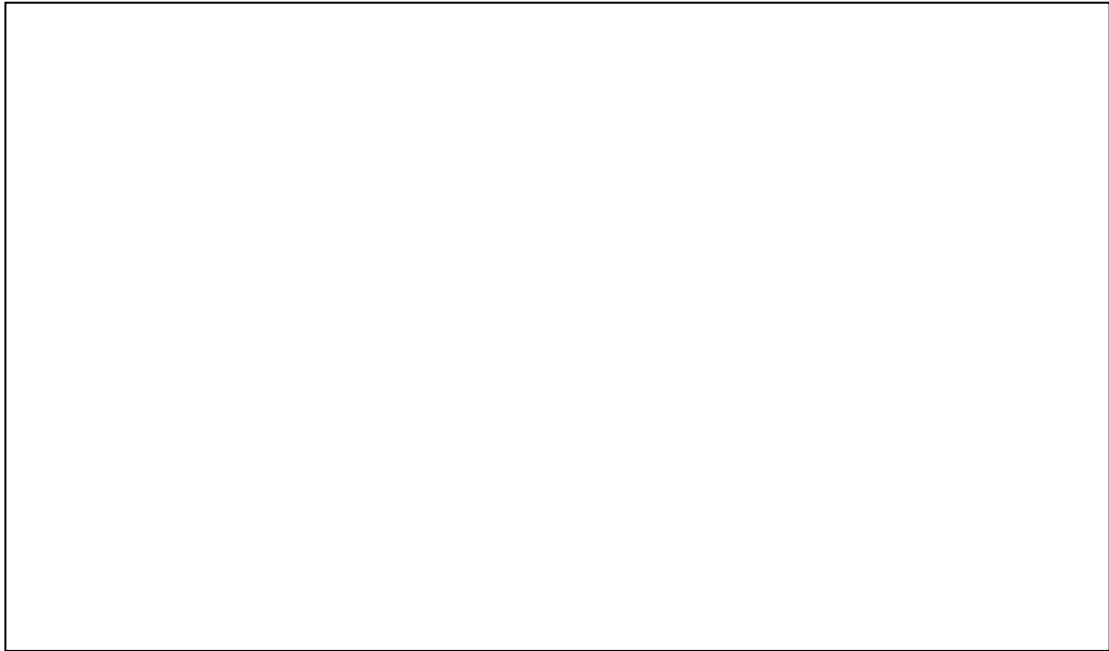
**C. Backbone Router**

가 Area Area 0.0.0.0  
가 Backbone Router ABR Backbone 가

**D. Autonomous system Boudary Router(ASBR)**

External ( BGP)  
가  
ASBR OSPF AS Area

## 11.4.4 Virtual Link



### 23 Virtual Link

Virtual Link Area Area Non  
 Backbone Area 23 Area 4가  
 가 Area , Area 3 가

Virtual Link Non backbone Area 가  
 Area Non Backbone Area(Transit Area)  
 ABR Virtual Link AS

가 , Hello Interval, Dead Interval

## 11.5 Link state Database

LSA OSPF  
 LSA Link State Database Link State  
 Database LSA

### 11.5.1 LSA Type

OSPF AS LSA  
 Area ABR



Area LSA 가 Area LSA  
 LSA . OSPF LSA  
 11가 .

| Type Code | Description                  |
|-----------|------------------------------|
| 1         | Router LSA                   |
| 2         | Network LSA                  |
| 3         | Network Summary LSA          |
| 4         | ASBR Summary LSA             |
| 5         | AS External LSA              |
| 6         | Group Membership LSA         |
| 7         | NSSA External LSA            |
| 8         | External Attribute LSA       |
| 9         | Opaque LSA(Link-local scope) |
| 10        | Opaque LSA(Area-local scop)  |
| 11        | Opaque LSA(AS Scope)         |

**6 LSA Type**

**A.Router LSA(type 1)**

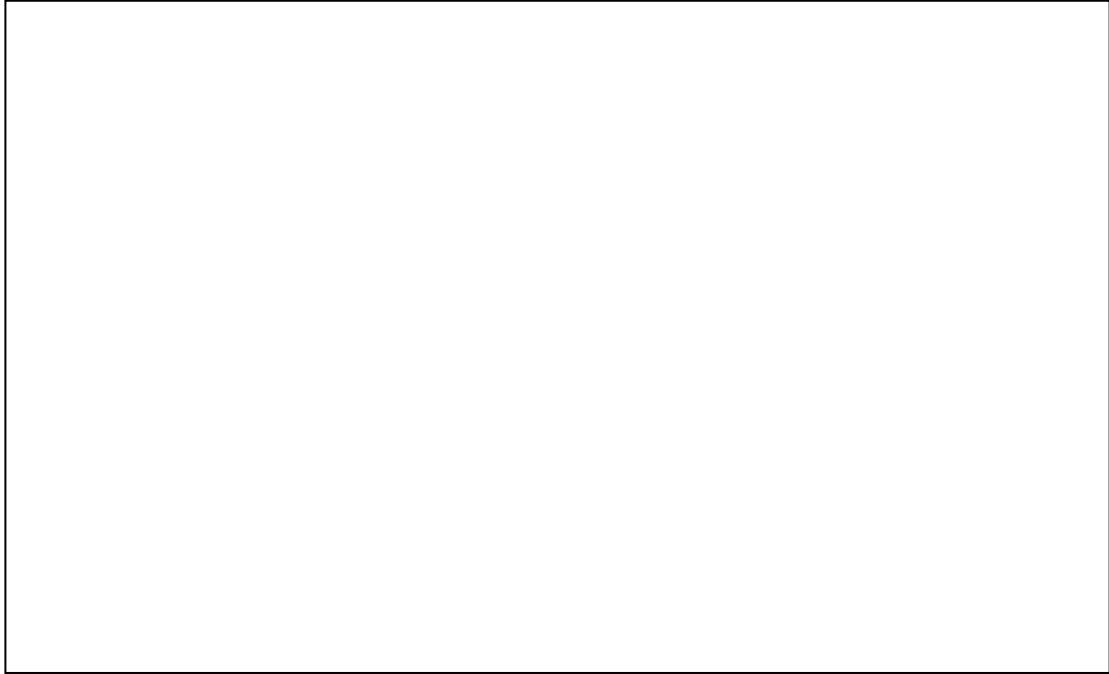


**24 Router LSA**

Router LSA OSPF LSA . OSPF  
 LSA 가 ID, , Cost

. Router LSA      LSA      Area      Flooding .

**B. Network LSA(type 2)**



**25 Network LSA**

Network LSA    Multiple Access                      DR                      LSA  
25              DR    가(DR              )  
                    DR    DR  
                    LSA              Router LSA              가              DR              Area              Flooding

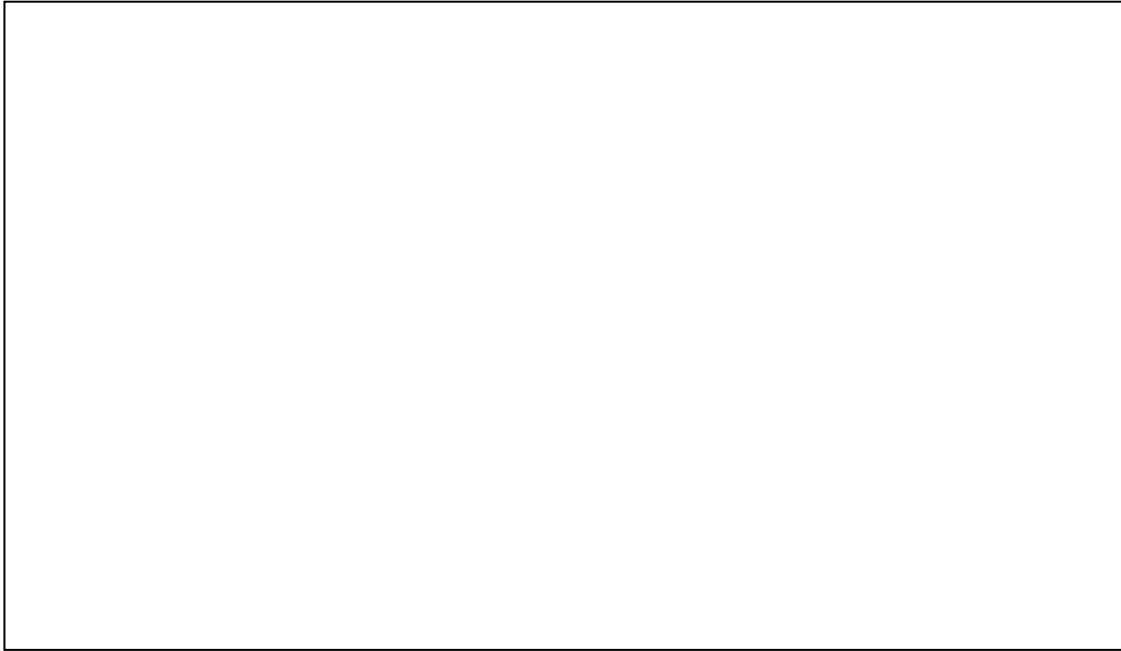
**C. Network Summary LSA(type 3)**



### 26 Network Summary LSA

Network Summary LSA ABR ABR Area  
 Network summary LSA Area ABR Area  
 Network Summary LSA Area ABR ABR Area  
 ABR Network Summary LSA 26  
 Cost  
 가 가 LSA 가  
 Cost가 LSA ABR  
 Area 가 Cost가  
 Area Area Area  
 ABR network Summary LSA SPF Tree  
 Cost ABR 가 Cost LSA  
 가

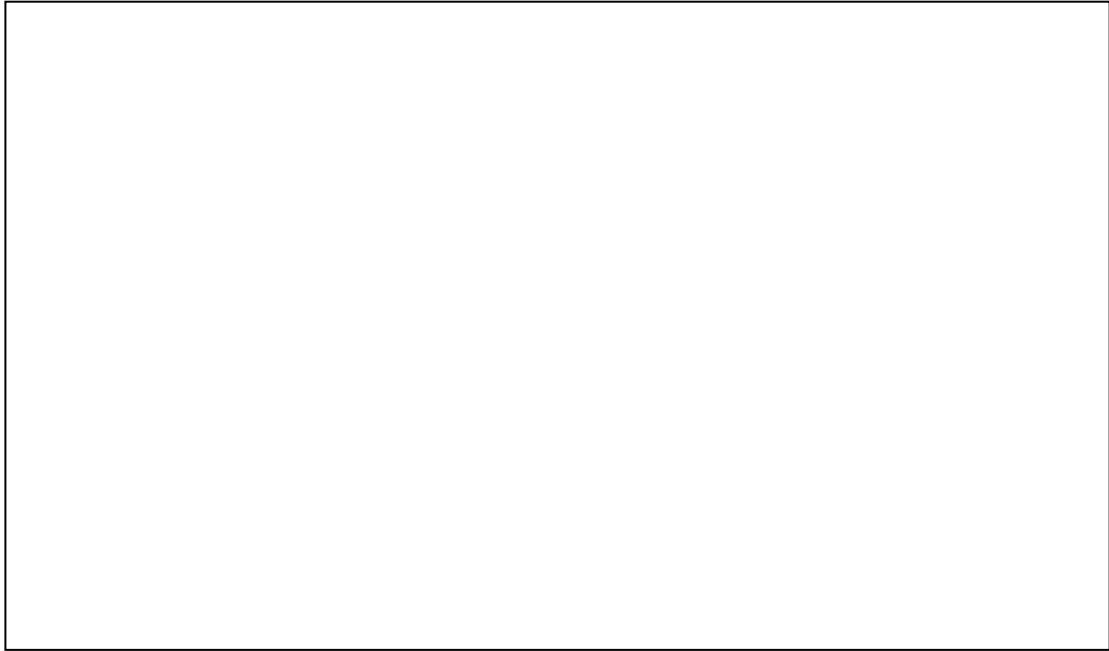
### D.ASBR Summary LSA(type 4)



### 27 ASBR Summary LSA

ASBR Summary LSA      ABR      LSA      ASBR      가  
                27      ASBR Summary LSA  
      ID가      ID      가      가  
ASBR,      가

### **E. Autonomous System External LSA(type 5)**



### 28 AS External LSA

External LSA Network Summary LSA AS Network Summary LSA  
가 AS Area External LSA AS  
, AS Default Route LSA ASBR

### F. Group Membership LSA(type 6)

Group Membership LSA <sup>15</sup>

### 11.5.2 Stub Area<sup>16</sup>

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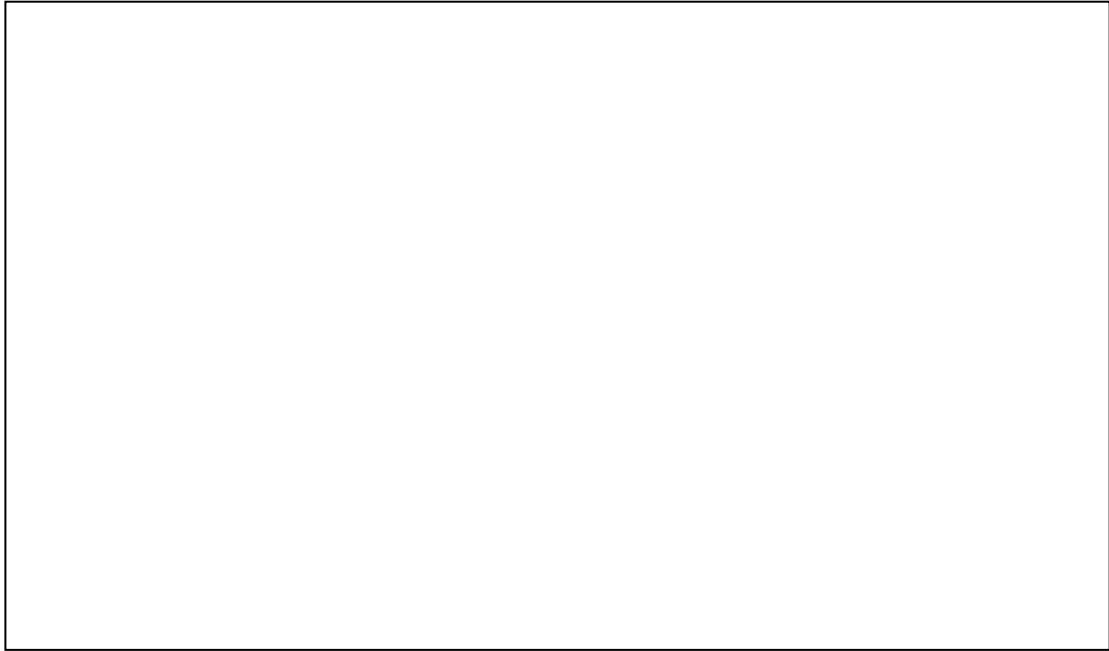
<sup>15</sup>

<sup>16</sup> Stub Area

Area  
AS

Chapter 15 IGMP  
External LSA

Link State Database



### 29 Stub Area

ASBR AS 가 AS External LSA AS

AS External LSA AS External Link state 가 AS

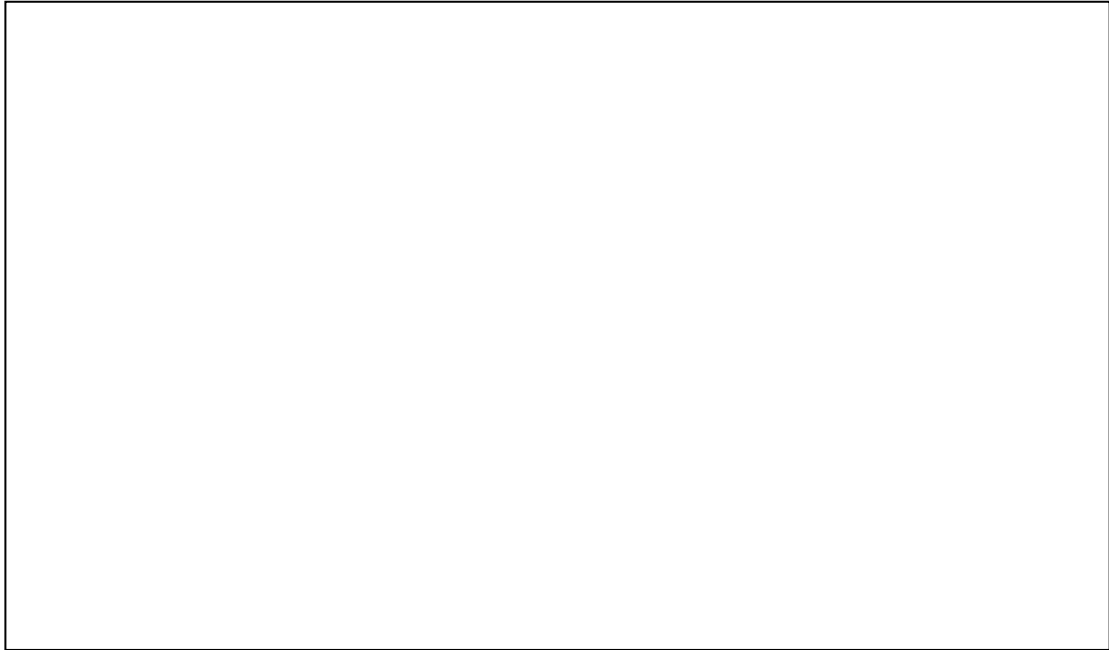
29 Area 4 가 가 Area 4 Area ABR External LSA가 가

Area Stub Area Stub Area ABR Network Summary LSA External LSA Default Route Stub Area Internal Router AS 가

- Stub Area Link state Database Stub Hello Packet Flag E-bit 0 stub router

- Virtual Link가

- Stub Area ASBR
- Stub Area ABR Defult Route  
ABR ASBR 가 가



30 Stub Area LSU Flooding

## 11.6

Link State OSPF  
Distance Vector 가  
OSPF AS Area  
OSPF RIP  
AS Area  
OSPF ( ) 가  
가 가  
가 Link State ?  
가