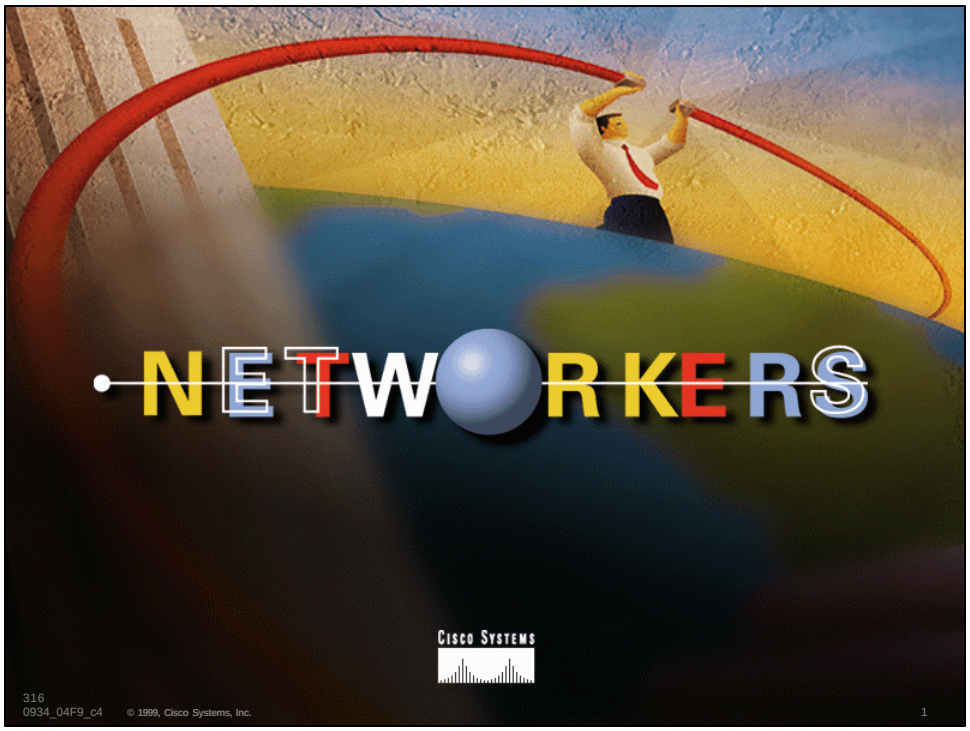




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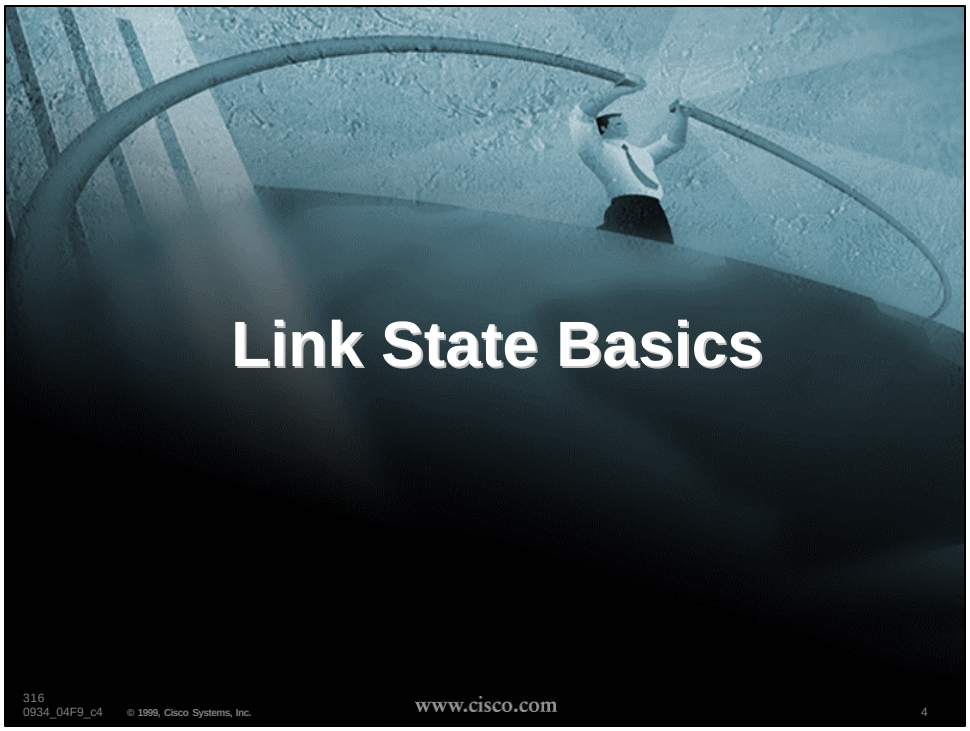
## Topics

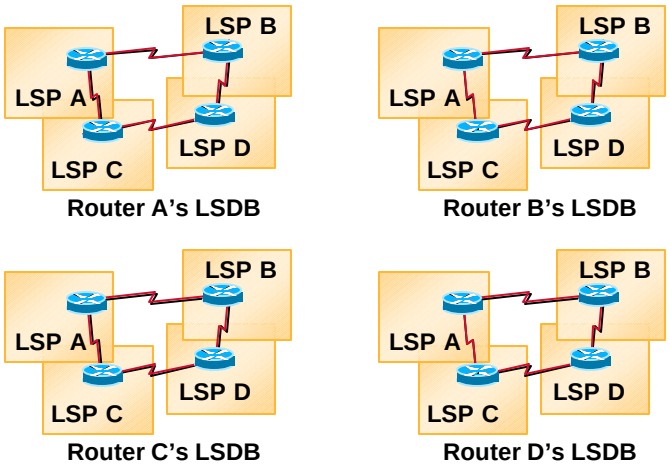
- Review: What Is a Link State Protocol?
- Design Issues
  - Network Cores
  - Advanced Design Techniques
  - Scaling an LS IGP
- Troubleshooting







## Each Router Has the Same LSDB








## Properties of a Link State Protocol

- Neighbor discovery
- Constructing an LSA/LSP
- Distribute LSP/LSA
- Compute routes—SPF algorithm
- On network failure
  - New LSPs flooded
  - All routers recompute routing tables

## Scalability Issues with LS Protocols

- **Limited resources**
  - **CPU**
  - **Memory**
  - **Bandwidth**
- **LSP/LSA flooding**
  - **High CPU—BW**
  - **Fully meshed networks**





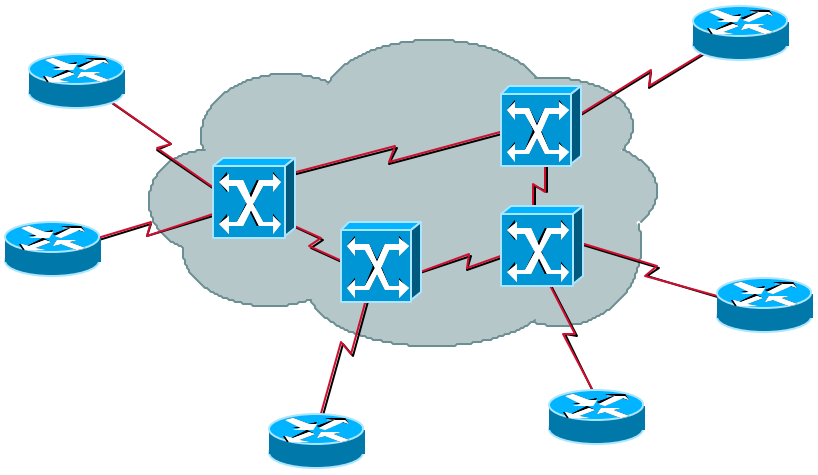
## Non-Broadcast Multi-Access Nets

- Examples: Frame Relay—ATM—X.25
- Some or all routers have many neighbors
- SPF requires more resources
- Many neighbors means lots of duplicate flooding





## NBMA Physical Topology



## Different Logical NBMA Models

- Generic logical models
  - Point-to-point model
  - Broadcast model
- OSPF only logical models
  - Point-to-multipoint model

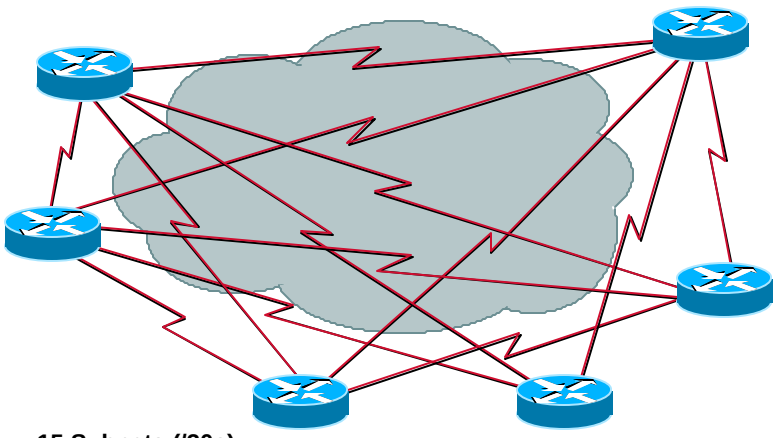




## Point-to-Point Model for NBMA

- Each VC is treated as a regular p2p link
- Full adjacency established with each router
- Each VC needs its own subnet

## Point-to-Point Logical View



15 Subnets (/30s)





## Point-to-Point Model for NBMA

- **Advantages**
  - **SPF has complete view of topology**
  - **Each VC can have its own metric**
- **Disadvantages**
  - **Full LSP flooding done over each VC**
  - **More configuration**

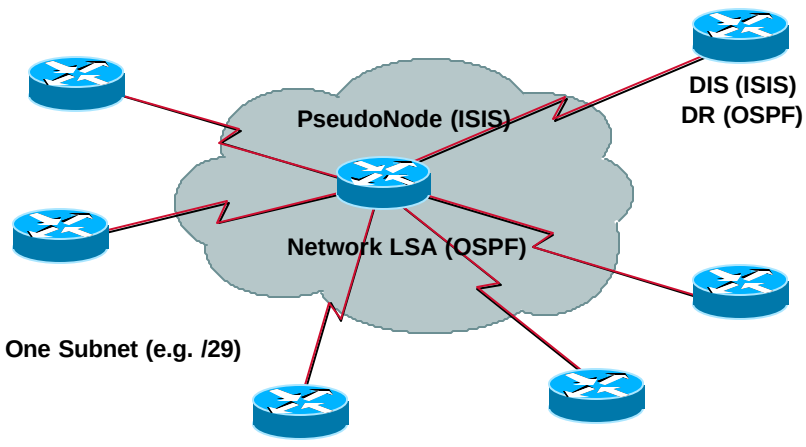
## Broadcast Model for NBMA

- **Oldest logical model on Cisco routers**
  - **Full mesh at all times**
- **NBMA cloud treated as LAN**
  - **DR/DIS election—flooding done via DR/DIS**
  - **PseudoNode LSP/network LSA creation**





## Broadcast Model Logical View



## Broadcast Model for NBMA

- **Advantages**
  - **Easy to configure—one IP prefix for the cloud**
  - **Flooding only done via the DR/DIS**
- **Disadvantages**
  - **Requires full mesh between all routers**
  - **Useful if cloud has rerouting at layer 2**





## Point-to-Multipoint Model

- **OSPF only**
- **All VCs configured on main interface**
- **Each VC is treated as a regular p2p link**
- **One IP prefix for the cloud**

## Point-to-Multipoint Model

- Advantages
  - SPF has complete view of topology
  - Easy configuration
- Disadvantages
  - Full LSP flooding done over each PVC
  - Cannot have different metric for each PVC

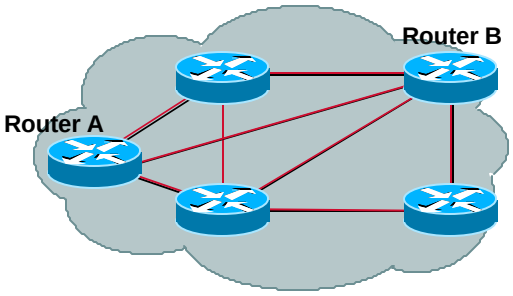




## Which Model to Pick?

- If NBMA has layer 2 routing—broadcast can be used
- If not—use p2p or if using OSPF point to multipoint
- If using ISIS—use mesh groups for scalability

# ISIS Mesh Group




- Router B will receive 4 instances of router A LSP
- Mesh groups will allow to flood only on selected links
- Mesh groups are configured on interfaces

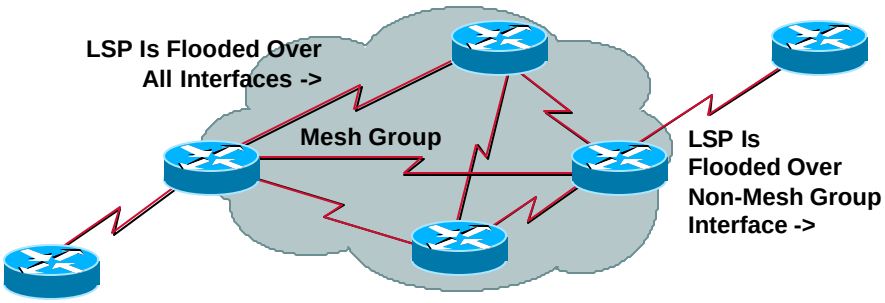




# Mesh Groups

- Mesh groups
  - Normal interface (normal flooding)
  - Blocked (never send LSPs over this interface)
  - Part of a mesh group
    - When LSP is received on non-mesh group interface—flood it out over all interfaces (mesh group or not)
    - If LSP is received on mesh group interface—flood on non-mesh group interfaces—but don't flood on other interfaces in this mesh group

# Flooding over Mesh Groups








# Advanced Design Techniques

## Tuning Timers

- Many LS events are timer—based

  Running SPF, creating LSPs, sending LSPs, resending LSPs, refreshing LSPs

- Most timers are configurable





## Tuning Timers—LSP Creation

- Changes of state trigger creation and sending of a new LSPs
- LSP generation interval

  ISIS/NLSP: lsp-gen-interval 5

  OSPF: not configurable

## SPF Timers

- We receive a changed LSP; how long should we wait before running SPF?
  - ISIS/NLSP: not configurable
  - OSPF: timers spf 5 10





## SPF Timers

- Time between consecutive Dijkstra runs
  - Network instability possible
  - ISIS/NLSP: spf-interval 10
  - OSPF: timers spf 5 10

## Adjacency Timers

- Sensing failures in a cloud
- Default hello timers might be to short

```
isis hello-interval 10 level-1
isis hello-multiplier 30 level-1

ip ospf hello-interval 10
ip ospf dead-interval 40
```





## LSP Refreshes

- Originating router must periodically refresh LSP
- LSP/LSA will be flooded even on a stable network
- Default values:

  OSPF: MaxAge is 60 min., refresh 30 min.

  ISIS: MaxAge is 20 min., refresh 15 min.

## Tuning LSP Refreshes

- ISIS counts down to zero
- OSPF counts up to MaxAge
- OSPF: set Do Not Age bit
- ISIS

  max-lsp-lifetime 65535
  lsp-refresh-interval 65000





## OSPF LSA Pacing

- More efficient packet updates
- 33 ms pacing delay
- show ip ospf flood-list
- New in 12.0(1)T

# Authentication

- Only authenticated routers form adjacency
- ISIS: cleartext passwords
- OSPF: can use MD5 crypto checksums





# Authentication

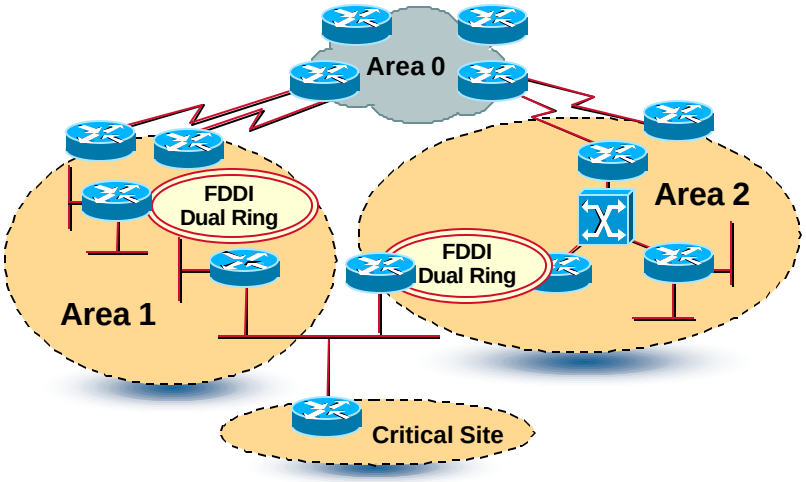
- **OSPF**

```
interface ethernet1
ip address 10.1.1.1 255.255.255.0
ip ospf message-digest-key 100 md5 cisco
!
router ospf 1
network 10.1.1.0 0.0.0.255 area 0
area 0 authentication message-digest
```

- **ISIS**

```
interface ethernet0
ip address 10.1.1.1 255.255.255.0
ip router isis
isis password cisco level-2
```

# Network Design




- Where Do I Make My Area?

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# Good Design Practices

- Where do I define my area?
  - Critical site that is dual attached
- Solution
  - Don't run OSPF on the Ethernet
  - Use static routes at the remote site router
  - Redistribute connected for the Ethernet on both routers

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## Good Design Practices

- OSPF demand circuit
  - Uses a new option of LSAs: Do not age bit
  - Suppresses hellos exchange
  - Suppresses DB synchronization
- All new LSA still have to be transmitted in the area

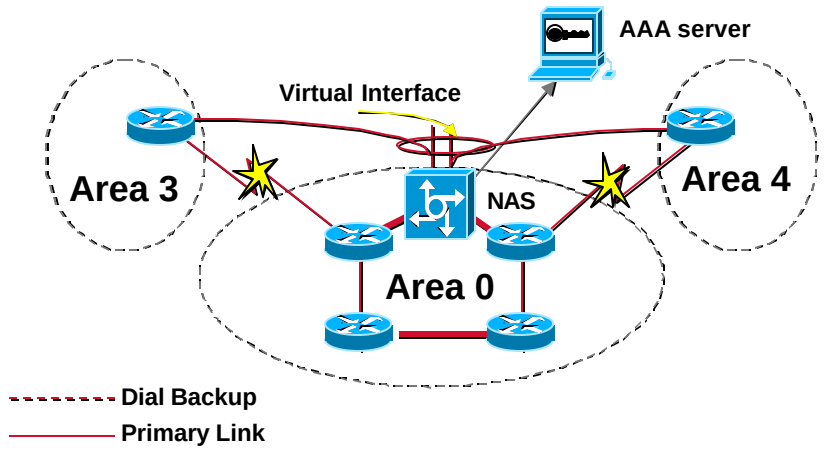


## Good Design Practices

- Dial-on-Demand Techniques:
  - Use virtual profiles
  - Virtual interface gets assigned to the area associated with the calling router
  - Area configuration and IP address for virtual interface are dynamic

# Good Design Practices

## Virtual Profiles

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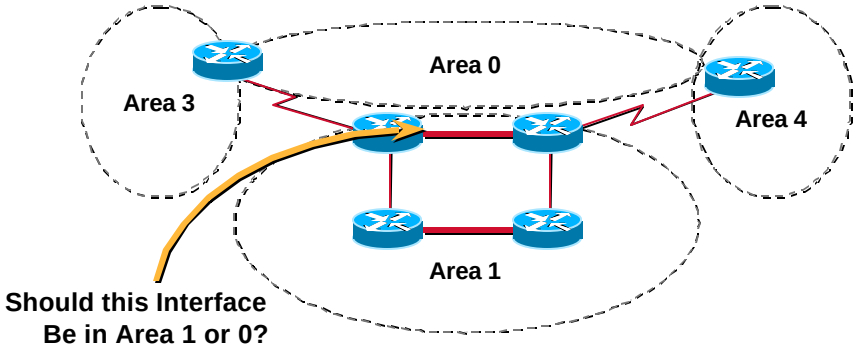
# Good Design Practices




- **Problem**

**Which area do I put my interface in?**

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## Good Design Practices

- Sub-optimal routing if in area 0
- Sub-optimal if in area 1
- Bring the interface in both areas
  - How—create a virtual link between the two ABRs





## Good Design Practices

- For hub and spoke topology
  - Large number of edge routers
  - Need dynamic routing, large number of areas
  - Configure ODR at edge. Allow CDP to carry routing information to hub
  - Redistribute ODR into OSPF
  - Deploy contiguous addressing for summarization


## LS Scaling Issues

- Large meshed network, LSA/LSP flooding
- In OSPF, large area 0
- ABRs with many areas
- Unstable topology

## OSPF Areas

- One SPF per area, flooding done per area
  - Watch out for overloading ABRs
- Different types of areas do different flooding
  - Normal areas
  - Stub areas
  - Totally stubby (stub no-summary)
  - Not so stubby areas (NSSA)





## OSPF Area Types

- Regular area
- Stub area
- Totally stubby area
- Not so stubby area

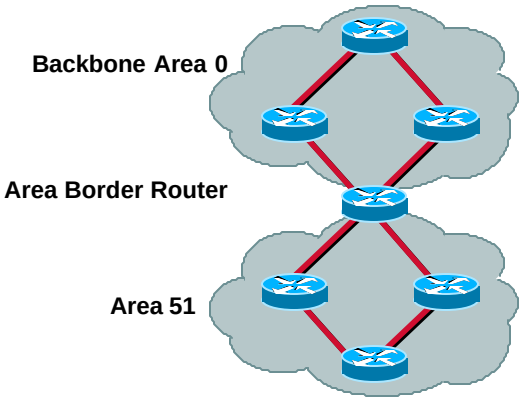
# OSPF Area Types

- **Regular areas**
  - **Summary LSA from other areas injected**
  - **Specific links from other areas injected**
  - **External links injected**





# Regular Area




**An Area Forwards the Following**
- **Summary LSAs**
- **Specific LSAs**
- **Default External 0.0.0.0**
- **Specific External Links**

- **ABRs forward all LSAs from backbone**

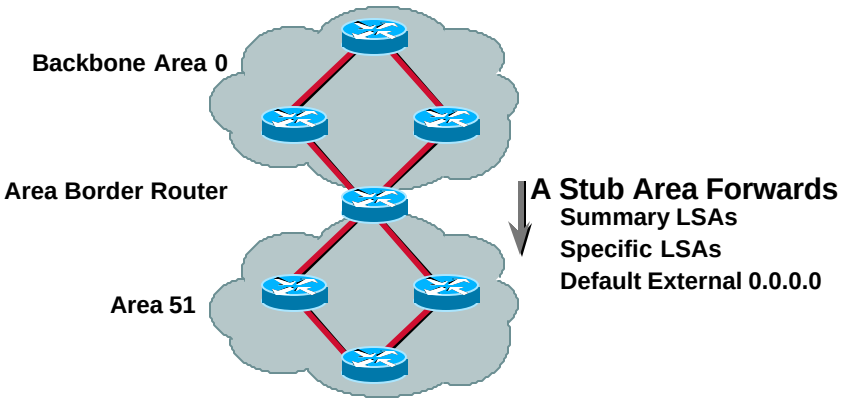
# OSPF Area Types

- **Stub area**
  - **Summary LSAs from other areas injected**
  - **LSA type 5 not injected**
  - **Default LSA injected into area as summary LSA**
  - **Define all routers in area as stub**
  - **External link flaps will not be injected**





# Stub Area




- **Consolidates specific external links—default 0.0.0.0**

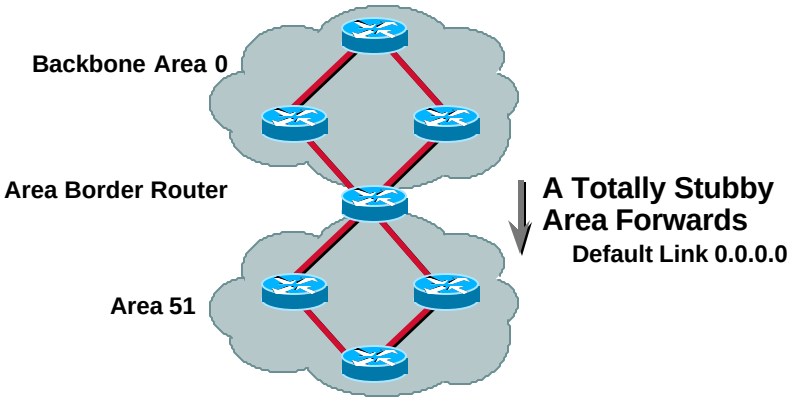
# OSPF Area Types

- **Totally stubby area**
  - **Default LSA injected into area**
  - **Represents all external links**
  - **Represents all summarized internal links**
  - **Represents non-summarized internal links**
  - **Default path to closest area border router**





# Totally Stubby Area




- **Use this for stable—scalable internetworks**

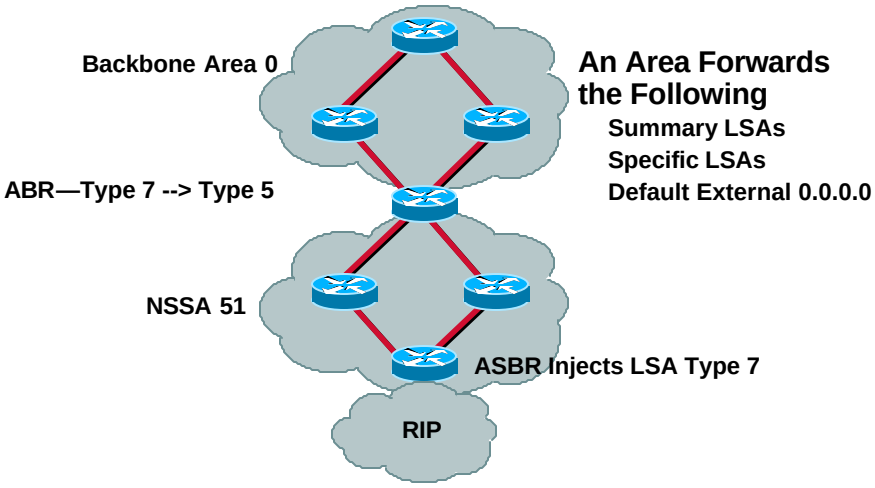
# OSPF Area Types

- **Not so stubby area (rfc 1587)**
  - **Capable of importing external routes in a limited fashion**
  - **Type-7 LSAs carry external information within an NSSA**
  - **NSSA border routers translate selected type-7 LSAs into type-5 LSAs**





# NSSA



## OSPF Using Areas

- One SPF per area
- Summarize IP space
- Different types of areas do different flooding
  - Normal areas
  - Stub areas
  - Totally stubby (stub no-summary)
  - Not so stubby areas (NSSA)





## Summarization

- Advertise summary only
  - Area-range on ABR to summarize type 3 LSAs
  - Summary-address on ASBR to summ. type 5
  - Summary-address in IS-IS
- Reduces LSA database size
- More stable

## Network Design

- Advantages of running BGP in core
  - You could apply policies
  - Fewer routing updates
  - Less CPU utilization
  - Very scalable
  - Logical migration

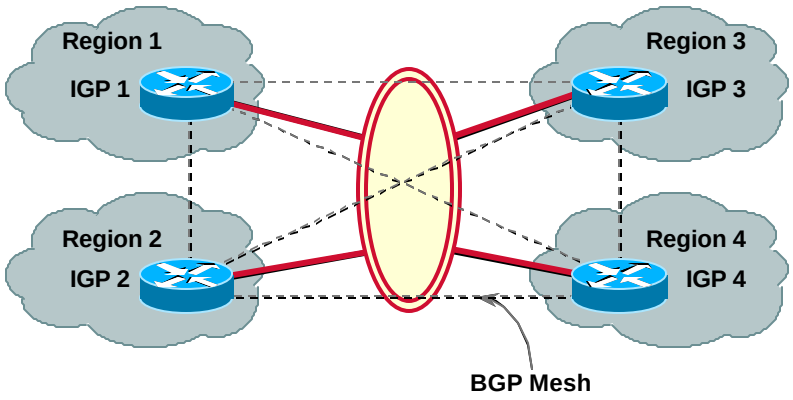




## Scaling Your Network

- Each region could be its own AS depending on policies
- If each region is its own AS—you could use private AS numbers
- Apply policies to accept and reject routes

## Large Core Design




- Connect each region using BGP

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## Core Design

- If no policies required—run iBGP between regions
- Use eBGP if policy implemented
- iBGP peers must be fully meshed
- Run separate instance of IGP just to carry peering and next-hop information

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## Migration Strategy

- Divide the network into multiple regions
- Pick a router from each region to be BGP peer
- iBGP between BGP peers

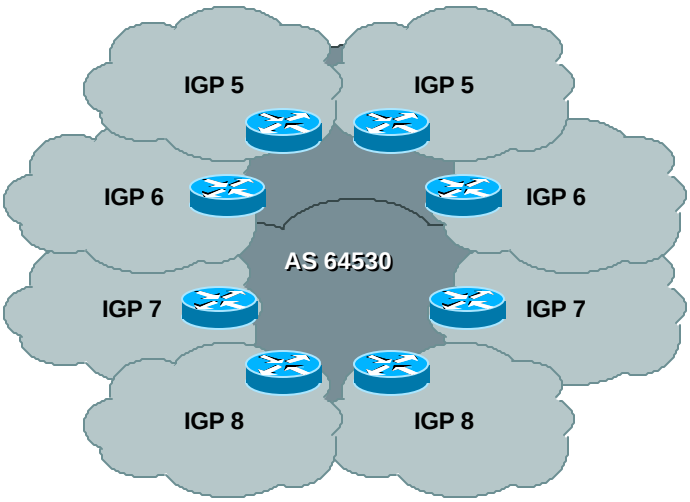




## Migration Strategy

- Redistribute local regional routes into BGP
- Originate default from each iBGP peer into local IGP
- If redundancy is required—each region could have multiple BGP peers

# IBGP Core Architecture

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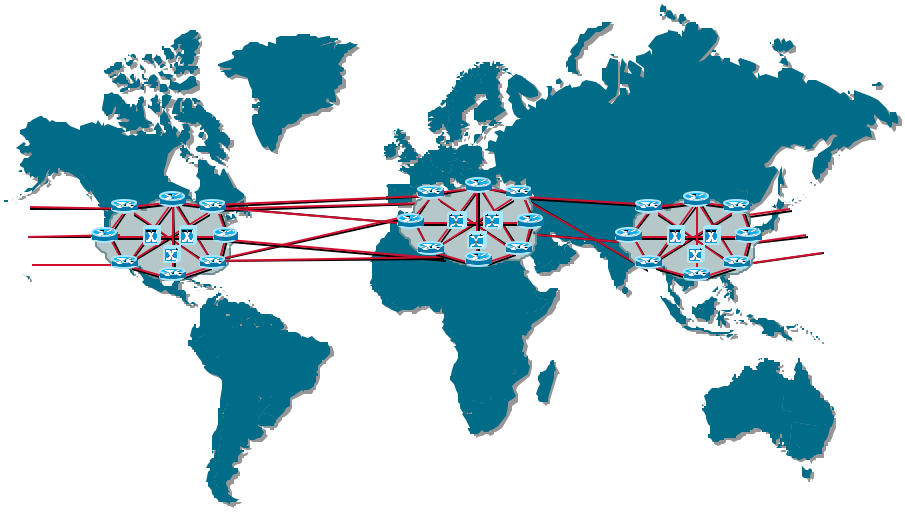
# EBGP Core Architecture



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**0934_04F9_c4.scr**

## Benefits of New Design

- Faster convergence within individual IGP's
- Policy can be applied
- Regions can have local administration
- Isolation of IGP's—greater stability





## Troubleshooting

- Most common issues
  - Adjacency is not coming up
  - Information is in database not in routing table
  - SPF running constantly





## Troubleshooting (Cont.)

- Useful OSPF commands
  - Show ip ospf neighbor
  - Sh ip ospf database
  - Sh ip ospf
  - Debug ip ospf adj

# Troubleshooting (Cont.)

- **OSPF Database**

```
3600-g1#sh ip ospf data

      OSPF Router with ID (30.8.1.1) (Process ID 1)

              Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
30.8.1.1        30.8.1.1        1592        0x800001D0 0xA180   0

              Router Link States (Area 8)
Link ID         ADV Router      Age         Seq#       Checksum Link count
30.8.1.1        30.8.1.1        1592        0x8000023F 0xC782   1
30.8.1.2        30.8.1.2        298         0x800003D1 0x2967   2
30.8.3.2        30.8.3.2        666         0x800002B8 0xE52B   1

              Net Link States (Area 8)
Link ID         ADV Router      Age         Seq#       Checksum
30.8.1.2        30.8.1.2        299         0x80000203 0x4153
30.100.1.2       30.8.3.2       666         0x8000027A 0x10AB
```





# Troubleshooting (Cont.)

- **IP OSPF**

```
3600-g1#sh ip ospf
 Routing Process "ospf 1" with ID 30.8.1.1
 Supports only single TOS(TOS0) routes
 SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
 Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
 Number of external LSA 0. Checksum Sum 0x0
 Number of DCbitless external LSA 0
 Number of DoNotAge external LSA 0
 Number of areas in this router is 2. 1 normal 1 stub 0 nssa
 External flood list length 0
    Area BACKBONE(0) (Inactive)
        Number of interfaces in this area is 2
        Area has no authentication
        SPF algorithm executed 8 times
        Area ranges are
        Number of LSA 1. Checksum Sum 0xA180
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
```

## Troubleshooting (Cont.)

- **IP OSPF**

```
Area 8
    Number of interfaces in this area is 2
    It is a stub area, no summary LSA in this area
     Area has no authentication
     SPF algorithm executed 11 times
     Area ranges are
     Number of LSA 5. Checksum Sum 0x22812
     Number of DCbitless LSA 0
     Number of indication LSA 0
     Number of DoNotAge LSA 0
     Flood list length 0
```





## Troubleshooting (Cont.)

- **Adjacencies not coming up**
  - **Command to look for the neighbor adj**
  - **Sh ip ospf nei**
  - **Mismatched parameters (hello, area, authen key, etc.)**
  - **Database not getting synchronized**

# Troubleshooting (Cont.)

- **Mismatched hello**

**Do a debug ip ospf adjacency**

**r4-4k#debug ip ospf adj**
OSPF adjacency events debugging is on
r4-4k#
***OSPF—mismatched hello parameters from 10.1.2.3***

**r4-4k#show ip ospf neighbor**

| Neighbor ID | Pri | State | Dead Time | Address | Interface |
|---|---|---|---|---|---|
| 10.1.1.1 | 1 | FULL/ - | 00:00:32 | 10.1.1.1 | Serial2 |





# Troubleshooting (Cont.)

- **Mismatched area ID**

**r9-2500#show ip ospf neighbor**
**r9-2500#**
**no neighbors**
**r9-2500#debug ip ospf adj**
**OSPF adjacency events debugging is on**

r9-2500#
%OSPF-4-ERRRCV: Received invalid packet: **mismatch area ID,**
from backbone area must be virtual-link but not found from 10.1.2.1, Serial0.2

## Troubleshooting (Cont.)

- Database not getting synchronized
  - > > > OSPF—send DBD packet to 202.160.101.1 seq 0x7DB
  - > > > OSPF—retransmitting request to neighbor 192.107.145.60
  - > > > OSPF—database request to 192.107.145.60
  - > > > OSPF—sent LS REQ packet to 202.160.101.1—length 48
  - > > > OSPF—retransmitting dbd to nbr 192.107.145.60
  - > > > OSPF—send DBD packet to 202.160.101.1 seq 0x7DB
  - > > > OSPF—receive dbd from 192.107.145.60 seq 0x7DB
- Probable causes
  - Slower link between the two routers
  - Slower router on the other end of the link
- Solution
  - Increase the retransmission timer





## Troubleshooting (Cont.)

- Information in database not in routing table
- Possible causes
  - Route to forward address not OSPF internal
  - Distribute list configured
  - Ospf enabled on secondary address but not on primary

## Troubleshooting (Cont.)

- **Mismatched network types**

**r9-2500#show ip ospf interface s 0.2**
Serial0.2 is up, line protocol is up
  Internet Address 10.1.2.3/24, Area 0
  Process ID 1, Router ID 10.1.2.3, Network Type **BROADCAST**, Cost: 64

**r4-4k#show ip ospf interface s 0.1**
Serial0.1 is up, line protocol is up
  Internet Address 10.1.2.1/24, Area 0.0.0.0
  Process ID 1, Router ID 10.1.2.1, Network Type **POINT_TO_POINT**, Cost: 64





## Troubleshooting (Cont.)

- **SPF is running constantly**
  - **Look at sh ip ospf stat**
  - **Debug ip ospf monitor**

## Troubleshooting (Cont.)

- **Useful is-is commands**
  - **show clns is-neighbors**
  - **show isis database**
  - **show isis spf-log**
  - **Debug isis adj-packets**





## Troubleshooting (Cont.)

- **IS-IS Interface**

```
sh clns int eth0
Ethernet0 is up, line protocol is up
  Checksums enabled, MTU 1497, Encapsulation SAP
  ERPDUs enabled, min. interval 10 msec.
  RDPDUs enabled, min. interval 100 msec., Addr Mask enabled
  Congestion Experienced bit set at 4 packets
  CLNS fast switching enabled
  CLNS SSE switching disabled
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 22 seconds
  Routing Protocol: IS-IS
    Circuit Type: level-1-2
    Interface number 0x1, local circuit ID 0x1
    Level-1 Metric: 10, Priority: 64, Circuit ID: 00E0.1E5D.65D5.01
    Number of active level-1 adjacencies: 1
    Level-2 Metric: 10, Priority: 64, Circuit ID: 00E0.1E5D.65D5.01
    Number of active level-2 adjacencies: 1
    Next IS-IS LAN Level-1 Hello in 1 seconds
    Next IS-IS LAN Level-2 Hello in 1 seconds
```

# Troubleshooting (Cont.)

- IS-IS neighbors—ensure proper level and timers

```
r1#sh clns is-neighbors

System Id      Interface   State  Type Priority  Circuit Id            Format
1921.6800.2004 Se1.2       Up     L1L2 0 /0       00                    Phase V
1921.6800.3003 Et0         Up     L1   64        1921.6800.3003.01     Phase V
r1#
```



# Troubleshooting (Cont.)

- IS-IS database

```
R1# show isis database
IS-IS Level-1 Link State Database
LSPID                 LSP Seq Num  LSP Checksum  LSP Hold time  ATT/P/OL
1921.6800.1001.00-00* 0x00000019   0x2783        1153           1/0/0
1921.6800.1005.00-00  0x0000000C   0x2179        905            0/0/0
1921.6800.1005.01-00  0x00000009   0x40EC        831            0/0/0

IS-IS Level-2 Link State Database
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime   ATT/P/OL
1921.6800.1001.00-00* 0x00000010   0xFC45        1153           0/0/0
1921.6800.1001.01-00* 0x00000001   0x4CB7        1137           0/0/0
1921.6800.2002.00-00  0x00000018   0x86A6        1141           0/0/0
1921.6800.2002.02-00  0x00000004   0x8558        881            0/0/0
```

# Troubleshooting (Cont.)

- IS-IS database in detail

```
R1# show isis database detail
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
00E0.1E5D.65D5.00-00* 0x00002EA0   0x10FC       614           0/0/0
  Area Address: 00.0002
  Area Address: 49
  NLPID:        0xCC
  IP Address:  150.100.1.254
  Metric: 10 IP 172.27.148.0 255.255.255.0
  Metric: 10 IP 150.100.1.0 255.255.255.0
  Metric: 10 IS 00E0.1E5D.65D5.01
  Metric: 0  ES 00E0.1E5D.65D5
IS-IS Level-2 Link State Database
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
0002.0002.0002.00-00  0x000008AD   0x086C       428           0/0/0
  Area Address: 49
  Area Address: 00.0002
  NLPID:        0xCC
  IP Address:  172.27.148.253
  Metric: 10 IS 00E0.1E5D.65D5.01
  Metric: 10 IP 172.27.148.0 255.255.255.0
  Metric: 20 IP 150.100.1.0 255.255.255.0
```





# Troubleshooting (Cont.)

- IS-IS database

  Large variance in seq numbers—possible instabilities

  Hold time consistently large—possible instabilities, look at spf-log

  OL bit set—overload bit

# Troubleshooting (Cont.)

- **ISIS spf-log**

```
R1#sh isis spf-log

  Level 1 SPF log
 When   Duration  Nodes  Count  Triggers

01:41:31      4     3     1  PERIODIC
01:26:30      4     3     1  PERIODIC
01:11:30      4     3     1  PERIODIC
00:56:29      4     3     1  PERIODIC
00:11:27      4     3     1  PERIODIC
  Level 2 SPF log
 When   Duration  Nodes  Count  Triggers
01:58:39      8     3     1  PERIODIC
01:43:38      8     3     1  PERIODIC
01:28:38      8     3     1  PERIODIC
00:28:35      8     3     1  PERIODIC
00:13:34      4     3     1  PERIODIC
```





# Troubleshooting

## debug isis adj-packets

```
Rtr-B# debug isis adj-packets

  ISIS-Adj: Rec L1 IIH from 00e0.1492.2c00 (FastEthernet4/0/0), cir type 1,
            cir id 1921.6800.1005.01
  ISIS-Adj: Sending L1 IIH on FastEthernet4/0/0
  ISIS-Adj: Rec L1 IIH from 00e0.1492.2c00 (FastEthernet4/0/0), cir type 1,
            cir id 1921.6800.1005.01
  ISIS-Adj: Sending serial IIH on POS2/0/0
  ISIS-Adj: Rec serial IIH from *PPP* on POS2/0/0, cir type 3, cir id 00
```