OSPF

Open Shortest Path First

CCDP

Agenda

- OSPF Theory
- OSPF Fast Convergence
- Convergence and Micro-loop
- OSPF Scalability, Multi Area OSPF Design
- Fast Reroute with OSPF
- Overlay Technologies and OSPF (GRE, mGRE,IPSEC, DMVPN, LISP)
- OSPF in the Datacenter Networks
- OSPF in the Service Provider Networks

Agenda

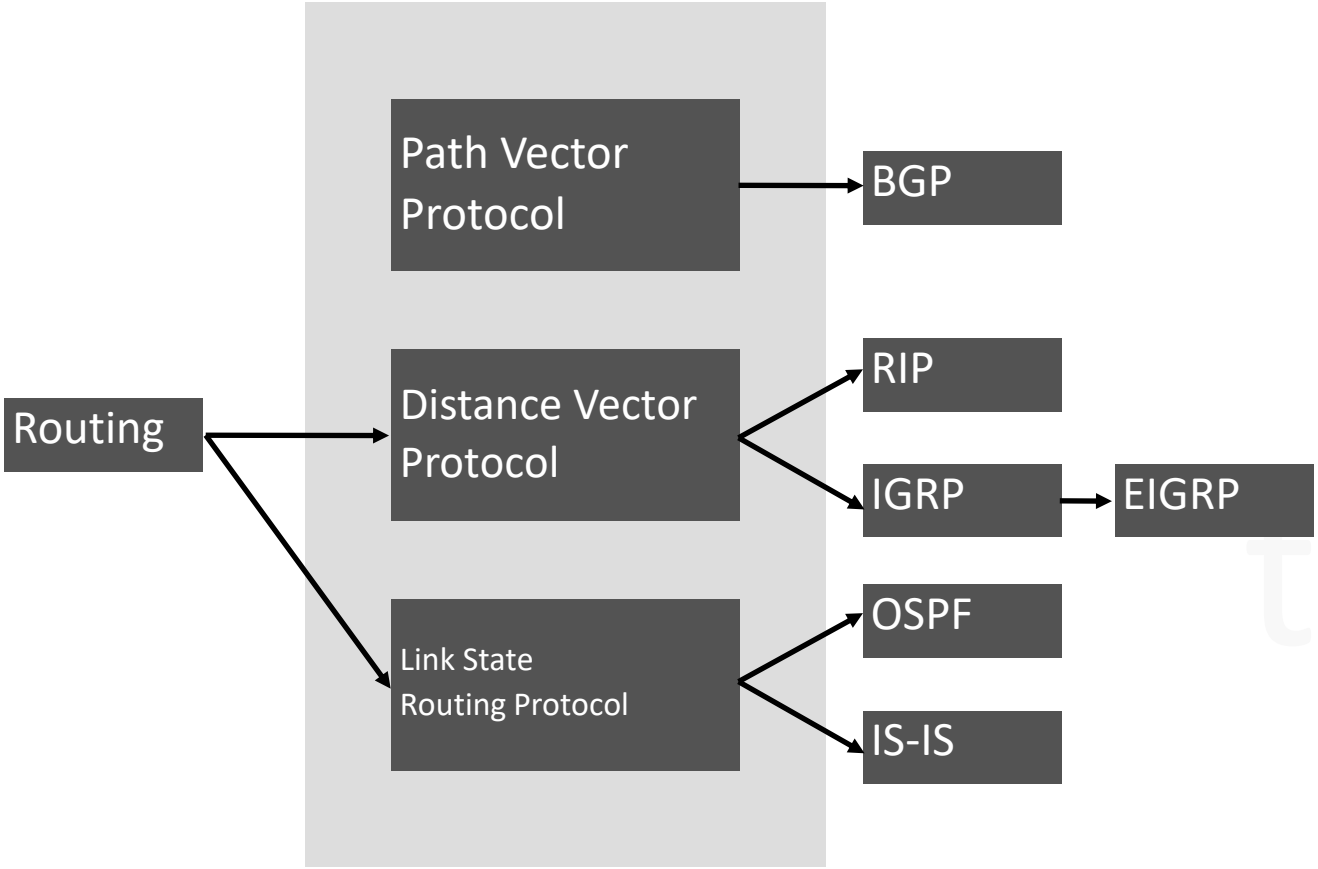
- OSPF Design Best Practices
- OSPF Advantages and Disadvantages
- OSPF Frequently Asked Questions – How many Routers in an OSPF Area, How many ABR per Area ?
- Case Studies
- OSPF in the CCDE Exam
- Summary
- Bonus Materials

Theory

- If the requirements is to have MPLS Traffic Engineering, Standard based and Enterprise level protocol then only choice is OSPF.

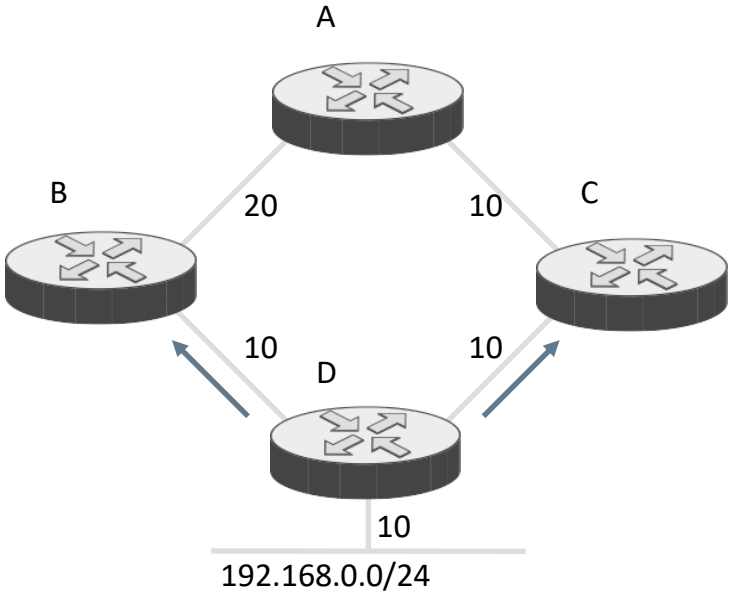
- OSPF as a link state protocol has many similarities with IS-IS but if the requirements is to run IPsec, since IS-IS doesn't work on top of IP, it is not well suited for Enterprise environment.

3 Types of Routing Protocols



LSA Flooding

- In a link state protocols, each router advertises the state of its links to every other router in the Network

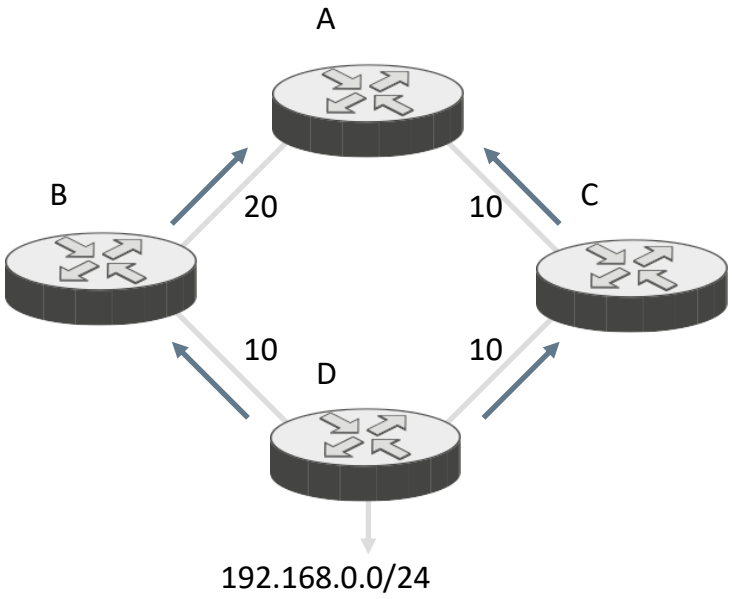


- D determines that it is connected to 192.168.0.0/24 with metric 10
- Connected to B with metric 10
- Connected to B with metric 10

- D advertises this information describing all of its links to its neighbors B and C

lsa

LSA Flooding

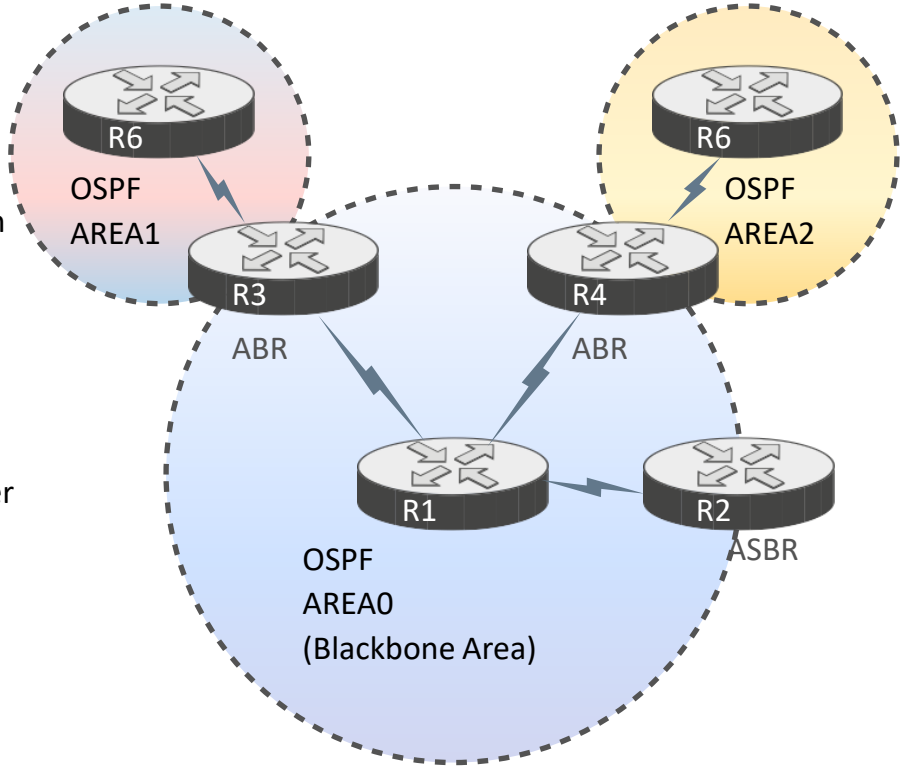


- This process of recording and re-transmitting is called flooding.
- Since information is flooded within a link State network, every router should have the same information about the network (How it looks like).

lsa

ABR (Area Border Router) and ASBR (Autonomous System Border Router)

- When scaling become an issue network is broken into separate flooding domains, which we call it areas.
- The router connecting the two area is called an Area Border Router (ABR).
- The router connecting the network to the other networks is called ASBR.



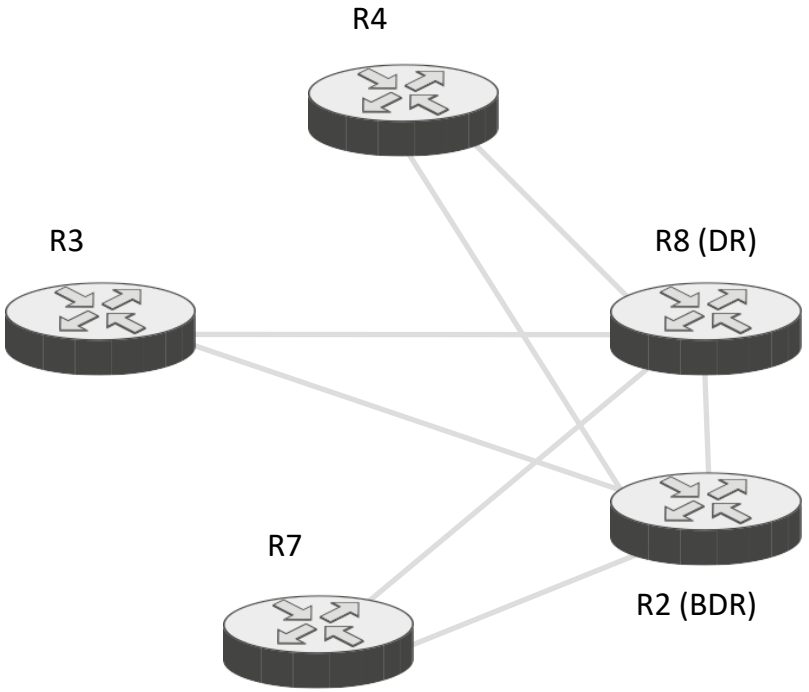
- In a particular area every routers have identical topology map. Every router knows which network behind which router and their metrics.

  - OSPF, unlike EIGRP and IS-IS works differently on different media. On broadcast network DR (Designated Router) creates a pseudo node to avoid unnecessary flooding.

OSPF DR & BDR

- DR creates type 2 LSA (Network LSA) to inform the connected routers on the broadcast network.

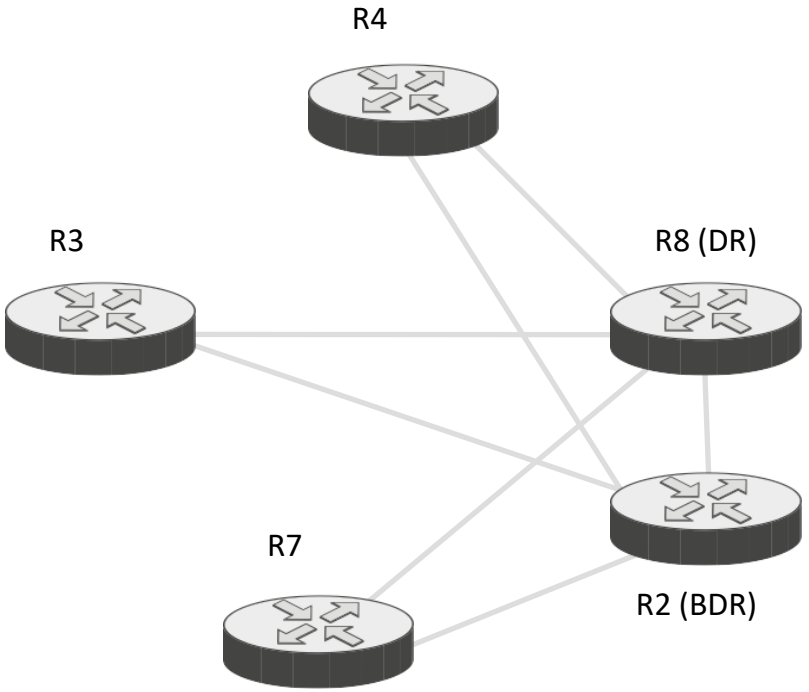
- Highest priority OSPF router on the broadcast segment wins the Designated Router (DR) election. If priorities are the same then highest router ID wins the DR election. On every broadcast segment there can be only 1 DR.



OSPF DR & BDR

- Each router in multi access segment creates a OSPF neighbourship with DR and BDR only

- Unlike IS-IS, there is Backup Designated Router (BDR) in OSPF.



DR & BDR Question

- Is there a DR and BDR in the below topology?

Direct back to back connection

- We can only have scalable, resilient, fast-converged OSPF design when we understand OSPF LSAs and Area types and their restrictions

- There are 11 types of LSAs and 5 of them are important for the OSPF routing protocol design.

5 Critical LSAs for OSPF Design

	Description
1.Router	• Router information • Connections to other routers • Connections to links (link states)
2.Pseudonode	• Pseudonode information • Connections to routers • Connections to broadcast link
3.Summary	• Destinations reachable within an area (flooding domain)
4.Border Router	• Cost to reach a router advertising external routing information (an ASBR) • Generated by the ABR
5.External Destination	• Cost to reach a destination which is external to the OSPF flooding domain (outside the local autonomous system)

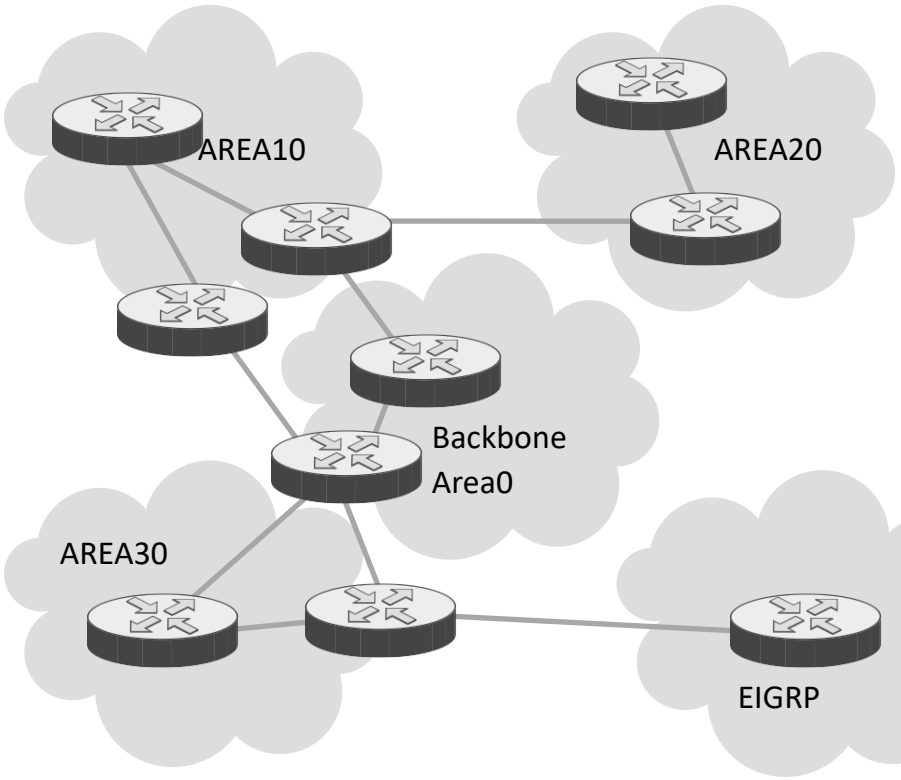
OSPFv2 all LSA Types

LSA Type	Description
1	Router LSA
2	Network LSA
3 and 4	Summary LSAs
5	AS external LSA
6	Multicast OSPF LSA
7	Defined for NSSAs
8	External attribute LSA for Border Gateway Protocol (BGP)
9, 10, 11	Opaque LSAs

OSPF Area Types

Area	Restriction
Normal	None
Stub	No type 5 LSA/No External LSAs allowed
Totally Stubby	No type 3, 4 or 5 LSA allowed except the default summary route
NSSA	No type 5 ASYExternal LSAs allowed, but type 7 LSAs that convert to type 5 at the NSSA ABR can traverse
NSSA Totally Stubby	No type 3, 4 or 5 LSAs allowed except the default summary route, but type 7 LSAs that convert to type 5 at the NSSA ABR are allowed

All routers in an area must have same LSDB (Link State Database)



- OSPF uses two level hierarchical model.
- Areas are use for scalability.
- Regular, Stub, Totally Stub, NNSA and Totally NSSA Areas.
- Router keeps separate link state database for each area which it belongs.
- LSA flooding is bounded by area, outside of an area Type 1 and Type 2 LSA is not sent.
- SPF calculation is performed independently for each area.
- All routers belonging the same area should have identical link state database.

OSPF Fast Convergence

- Network convergence is the between the failure event and the recovery.
    - Through the path all the routers process the event and update their routing and forwarding table.
- Thus; there are 4 steps for convergence in general:

1. Failure Detection
2. Failure Propagation
3. Processing the new information
4. Routing and Forwarding table update

OSPF Fast Convergence

- Convergence is a control plane events and for IGPs it can take seconds; BGP routers which have full internet routing table, control plane convergence can take minutes.

- Protection is a data plane recovery mechanism. As soon as failure is detected and propagated to the nodes, data plane can react and a backup path can be used. A backup path should be calculated and installed in routing and forwarding table before the failure event.

Convergence Tools

- DETECTION

  Carrier Delays
  Debounce Timers
  Bidirectional Forwarding Detection-BFD
  Protocol Hello/Dead Timers

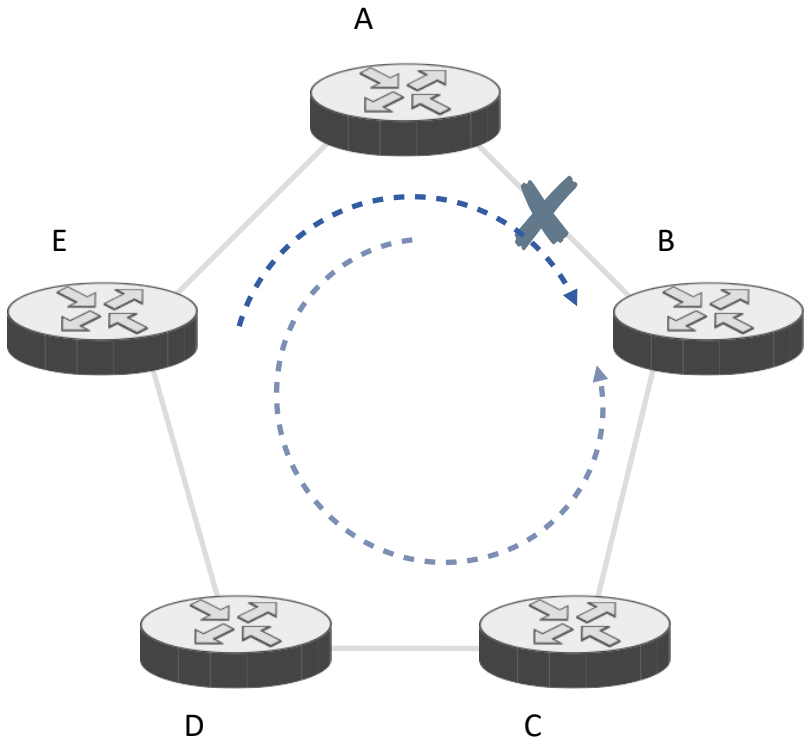
- PROPAGATION

  Interface event dampening
  LSA Pacing

- PROCESSING

  Full, Partial and Incremental SPF
  MinLSA Arrival Interval
  LSA and SPF Throttling timers

Convergence & Micro-loop



OSPF Scalability and Multi Area Design

- To reduce the impact of flooding and provide scalability Multi Area OSPF Design can be used.
  - With the today hardware 100s of OSPF routers can be placed in an OSPF area.
- OSPF Multi-Area design is not the only tool to provide scalability.

OSPF Scalability and Multi Area Design

- OSPF prefix-suppression feature provides scalability through removing point-to-point links from the Type 1 LSA, thus LSDB and routing table size is reduced.

- Also OSPF Database-filter (similar to IS-IS mesh group) reduces the flooding between the routers in a full-mesh topology, thus provides scalability

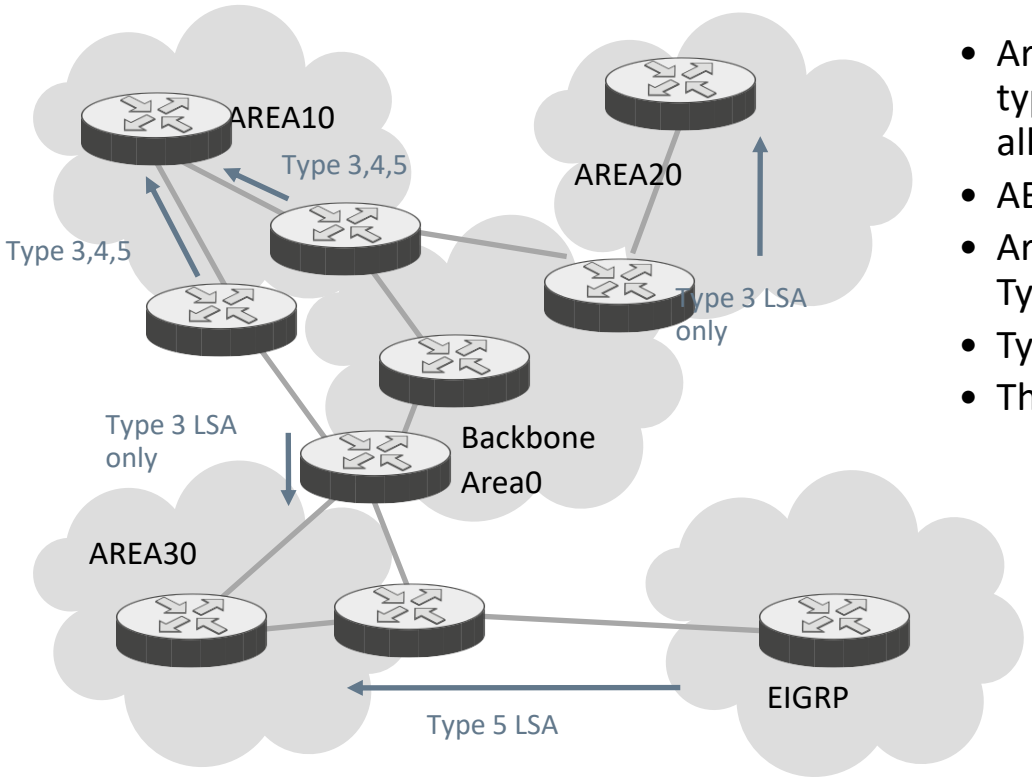
OSPF Scalability and Multi Area Design

- Number of routers in an OSPF domain may impact scalability.
    - Problem with the number of routers in OSPF domain is the Router LSA size.
- Each additional link and subnet makes Router LSA bigger and when it exceed the interface MTU, packet is fragmented. You should always avoid fragmentation.

Multi Area OSPF – Fault Isolation

- Special areas such as Stub and NSSA in OSPF provides fault isolation.
  - When fault is isolated, adding a link or node or changing the metric in one area doesn't cause Full SPF calculation in other OSPF areas.
- This is important for scaling.

What is the problem with the below area design?



- Area 10 is regular area thus all the LSA types including type 3 and 5 are allowed.
- ABRs create Type 4 LSA into an Area 10.
- Area 20 is Stub Area. That's why only Type 3 LSA is allowed.
- Type 5 LSA is not allowed in Stub Area
- Thus type 4 is not generated as well.

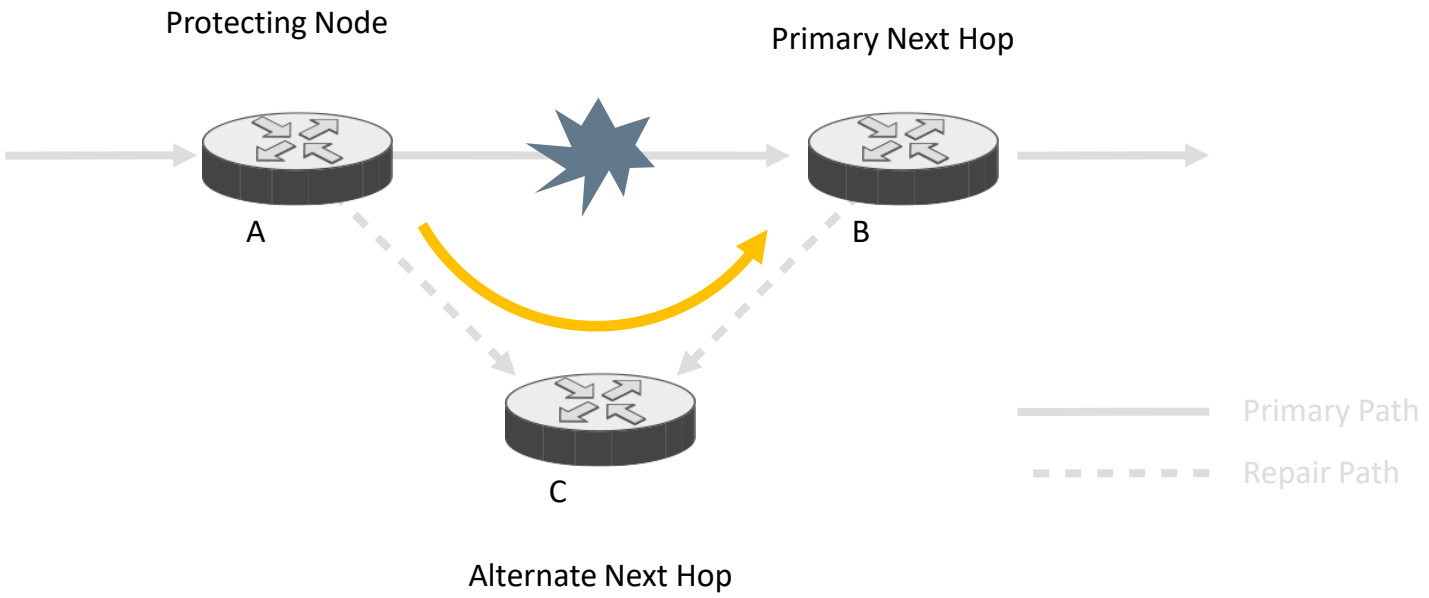
- ABR has to have a connection to more than one area, and at least one area should be in Area 0 (Backbone Area) but even creating a loopback interface and placing it into a Area 0 makes that router an ABR.

Area	LSAs Allowed
Backbone	1, 2, 3, 4, 5
Regular	1, 2, 3, 4, 5
Stub	1, 2, 3
Totally Stubby	1, 2, Default 3
Not So Stubby	1, 2, 3, 4, 7

Fast reroute with OSPF

- Fast reroute is done by placing the alternate route in RIB and FIB
  - Alternate/backup route is not used while primary link is up and running.
- OSPF FRR can be done with LFA, Remote LFA, Segment Routing FRR, RSVP-TE FRR.

Convergence & Micro-loop



- OSPF Fast reroute can provide 50ms convergence time which cannot be done by tuning SPF parameters, link failure detection tuning with BFD etc.

- Fast reroute is proactive recovery, fast convergence is reactive recovery technique.

  - Proactive recovery mean, calculating and installing the backup path into the RIB and FIB before the failure event.

Overlay Technologies and OSPF (GRE, MGRE, DMVPN, GETVPN, LISP)

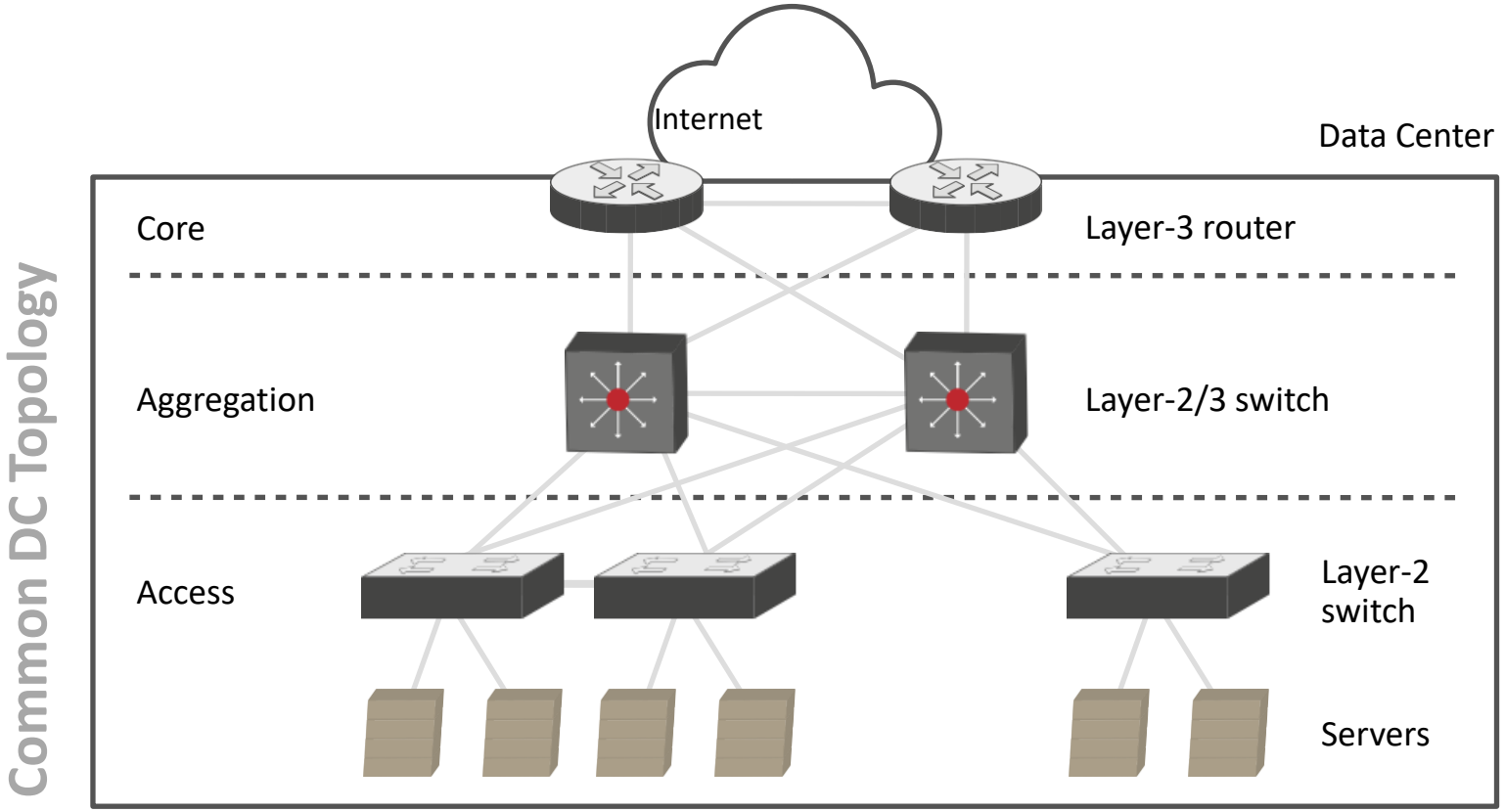
- OSPF can work on top of many overlay technologies.
    - GRE, MGRE, DMVPN, GETVPN and LISP can be used to create overlay/VPN in the networks.
- OSPF can be used for these overlay mechanisms as an underlay infrastructure routing protocol.

Overlay Technologies and OSPF (GRE, MGRE, DMVPN, GETVPN, LISP)

- OSPF works over GRE, MGRE and DMVPN
    - OSPF doesn't work over GETVPN and LISP, because both are tunnelless VPN mechanisms, routing protocols can be an underlay for them but not an overlay
- OSPF with GRE is not scalable for large scale deployment but scaling limitation comes from GRE, it is not the OSPF problem, MGRE provides scalability with OSPF even in large scale deployment.

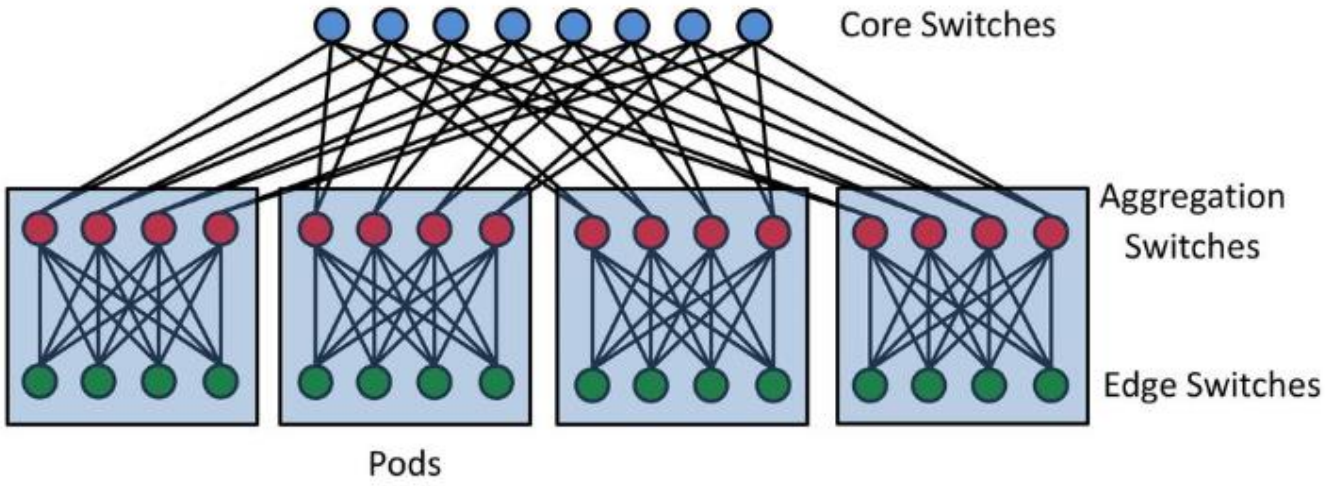
OSPF in the Datacenter

- OSPF can be used at the DC edge to advertise DC prefixes to the WAN and Campus network



- Also OSPF can be used as a Datacenter Fabric Protocol.
  - Datacenters are very densely connected networks, thus OSPF flooding creates scalability problem.
- Large scale Datacenters mainly use CLOS (Leaf and Spine) topology, depends on scale, multi stage CLOS topologies are used.

3 stage CLOS topology



- The Fabric provides basic connectivity, with possibility to carry one or more overlays
- The Fabric MAY provide interconnect facility for other fabrics.
- The Fabric MUST support non equidistant end-points.
- The Fabric MUST support Spine and Leaf [CLOS] + isomorphic topologies within its network.
- The Fabric MAY support non Spine and Leaf topologies

- The Fabric SHOULD support 250k routes @ 5k fabric nodes with convergence time below 250ms.
- The Fabric SHOULD support 500k routes @ 7.5k fabric nodes with convergence time below 500ms.
- The Fabric SHOULD support 1M routes @ 10k fabric nodes with convergence time below 1s.

- The Fabric routing protocol MUST support load balancing using ECMP, wECMP and UCMP.
- The Fabric routing protocol MUST support and provide facility for topology-specific algorithms that enable correct operations in that specific topology.
- The Fabric routing protocol SHOULD support route scale and convergence times of a Fabric mentioned above.
- The Fabric routing protocol SHOULD support ECMP as wide as 256 paths.
- The Fabric routing protocol MUST support various address families that covers IP as well as MPLS forwarding.
- The Fabric routing protocol MUST support Traffic Engineering paths that are host and/or router based paths.

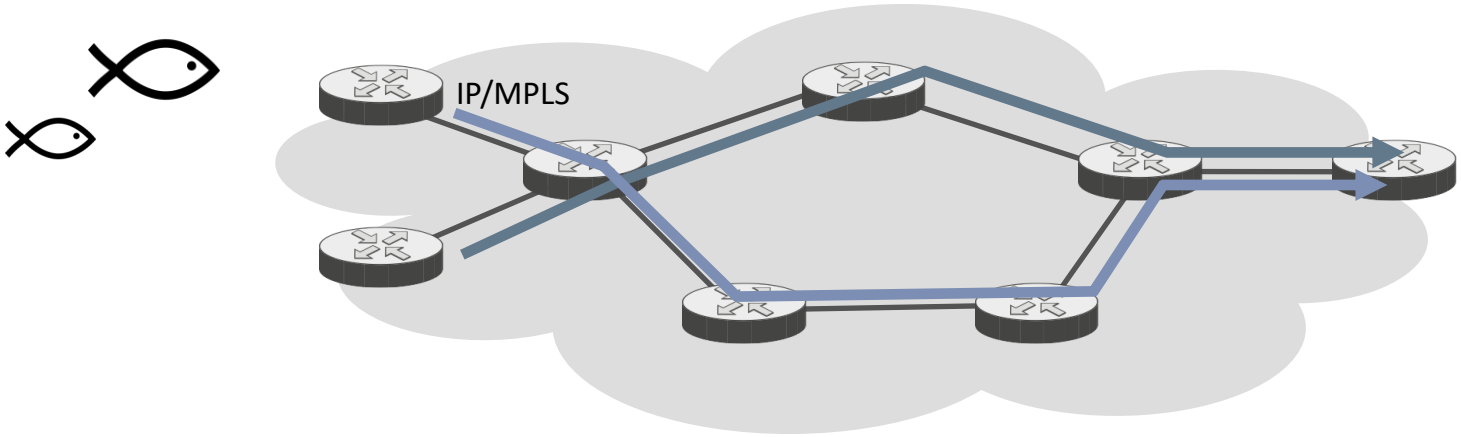
- The Fabric routing protocol MUST support Zero Touch Provisioning (ZTP).
- The Fabric routing protocol MUST support Neighbor Discovery to facilitate ZTP.
- The Fabric routing protocol MUST be able to leverage BFD [RFC5880] for neighbor state.
- The Fabric routing protocol MUST be able to support real time state notifications of routes and its neighbors state to facilitate control plane telemetry.
- The Fabric routing protocol MUST be able handle commission/decommission of a node as well as any node restart with a minimal data plane impact.

OSPF in the Service Provider Networks

- OSPF is very commonly used in the Service Provider networks, especially in the Middle East and Europe, many Service Providers use OSPF in their network, IS-IS is found in U.S Service Provider networks commonly.
    - OSPF is used in Core Networks mostly but some providers extend OSPF to the Aggregation and even to the access domains.
- In Seamless MPLS/Unified MPLS architecture, OSPF in the access network usage will be explained in detail.

OSPF and MPLS Traffic Engineering is used together in many SP networks

- OSPF is used to create shortest path routing but many Service Providers use OSPF with MPLS Traffic Engineering so they don't just use shortest path between their nodes.



Classical Fish Diagram of MPLS Traffic Engineering.
Without MPLS TE, IGP protocols always chooses shortest path.
Source routing is not possible with IGP protocols.

- OSPF is used to carry the Service Provider network device prefixes in the SP networks, not the customer routes.
    - Customer routes are carried within BGP.
- OSPF is used in Service Provider network as a PE-CE routing protocol if SP is providing MPLS L3 VPN , or mobile operators are using MPLS L3 VPN at their 3G UMTS and 4G LTE sites in Unified/MPLS architecture.

OSPF Design Best Practices

- Unless there is a valid reason, don’t deploy Multi Area OSPF, keep the design simple, it provides better convergence, less configuration on the ABR nodes and optimal traffic flow.

- Don’t enable OSPF on the customer facing ports, for MPLS L3 VPN PE-CE protocol, enable prefix limit, authentication and control plane policing

OSPF Design Best Practices

- Use OSPF Prefix-suppression feature to remove infrastructure links from the Type 1 (Router) LSA, it provides scalability if necessary.

- Always start deploying OSPF Area 0 (Backbone Area), it will provide easier migration when multi area OSPF design is necessary.

OSPF Design Best Practices

- Use OSPF network type ‘ point to point ‘, it removes the Types 2 LSA from LSDB, thus better for troubleshooting and high availability also it is good for fast convergence.

- If there is DR in the OSPF domain, make sure you don’t have performance problem with it.

OSPF Design Best Practices

- Summarization removes reachability information and it can be done on either ABR for summary LSA or at ASBR for External Type 5 LSA.
    - Summarization may break the MPLS LSP, since LDP cannot have aggregated FEC unless the RFC 5283 – LDP Extension to Inter Area LSP is in use.

OSPF Design Best Practices

- If PE loopback mask is /24, OSPF advertises it as /32 but LDP assigns a label for /24, since there is a mismatch between two control plane protocols (LDP and OSPF), packet is dropped. Because OSPF advertises loopback interfaces as /32. They should follow each other.
    - Either OSPF network type should be point to point to advertise loopback as /32 so routing table and LDP is same, or use /32 loopback subnet mask.

OSPF Design Best Practices

- Don’t redistribute full Internet routing table to OSPF.
  - OSPF in the large scale datacenter has flooding issue, database filter-out can be used to remove the topology information, towards downstream TOR switches.
- If you need to deploy Multi Area Design , know that it can create suboptimal routing in many topologies.

OSPF Design Best Practices

- Don’t deploy more than two ABRs for redundancy, two is enough.
    - ABRs slow down the convergence.
- Don’t carry customer prefixes with the infrastructure OSPF in Service Provider networks, customer prefixes should be carried in BGP.

OSPF Design Best Practices

- OSPF Fast convergence might bring unstability to network, make sure timers are tuned accordingly for the fast convergence.

- OSPF Fast reroute with LFA may not cover every topology, especially ring will not be protected, you may need to deploy Remote LFA or MPLS TE FRR for that , if topology is partial/full mesh, OSPF and LFA is enough to provide FRR for links or prefixes.

OSPF Design Best Practices

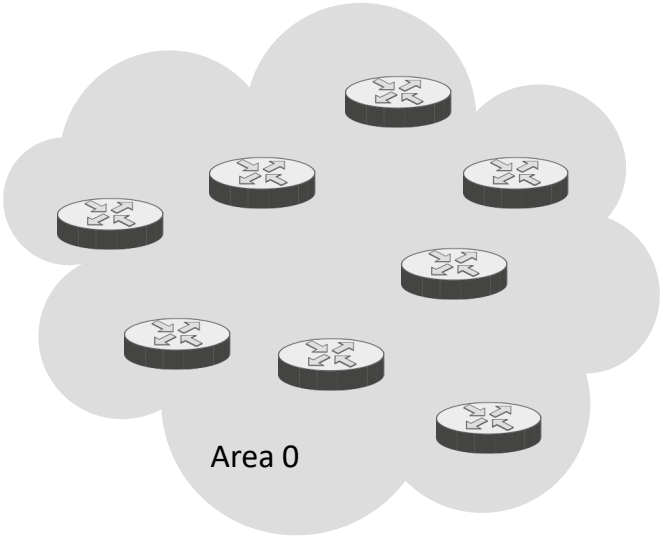
- OSPF doesn't use TLV encoding, it is not extendable, required OSPFv3 for IPv6 for example.
    - OSPF has 11 Type of LSA, compare to 2 Levels of IS-IS it is considered as more complex.
- Each OSPF LSA has a separate header, IS-IS TLVs share common LSP header, thus OSPF is seen as less scalable.

OSPF Design Best Practices

- OSPF needs an IP address for adjacency, IS-IS doesn't require an IP Address for neighborship, remote attack to the IS-IS is hard if not impossible, thus IS-IS is seen more secure compare to OSPF.
    - OSPF provides MPLS TE supports, similar to IS-IS, but distance vector protocols don't.
- OSPF is a good protocols for those who look Enterprise level and standard base protocol.

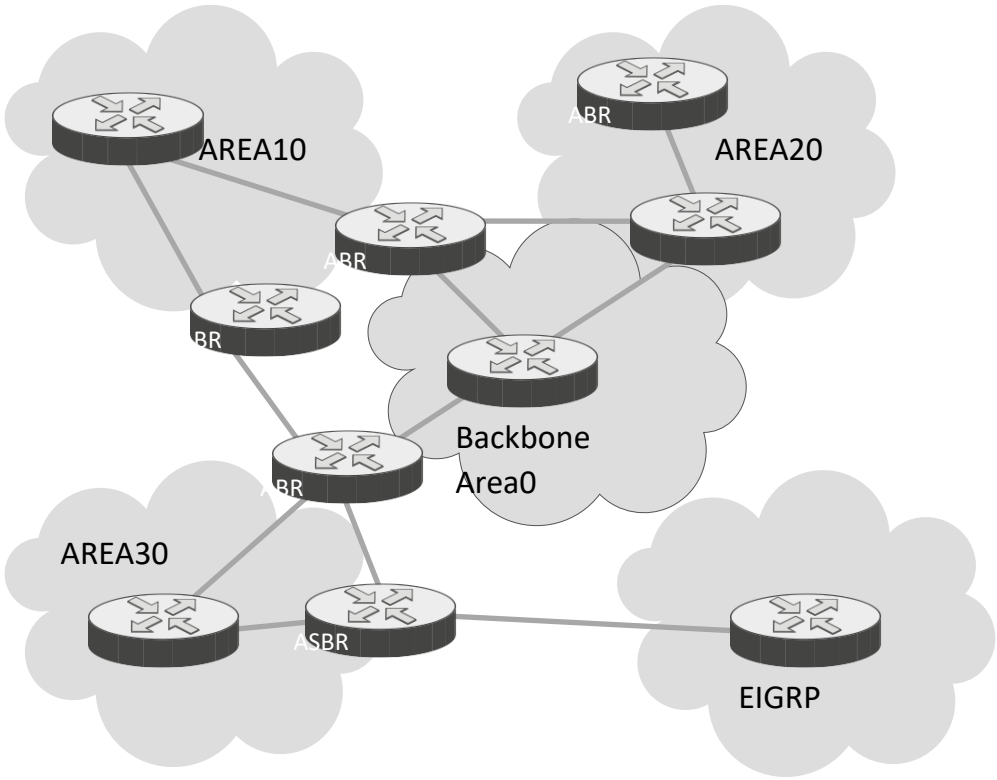
OSPF Frequently Asked Questions

- How many routers should be in one OSPF Area ?



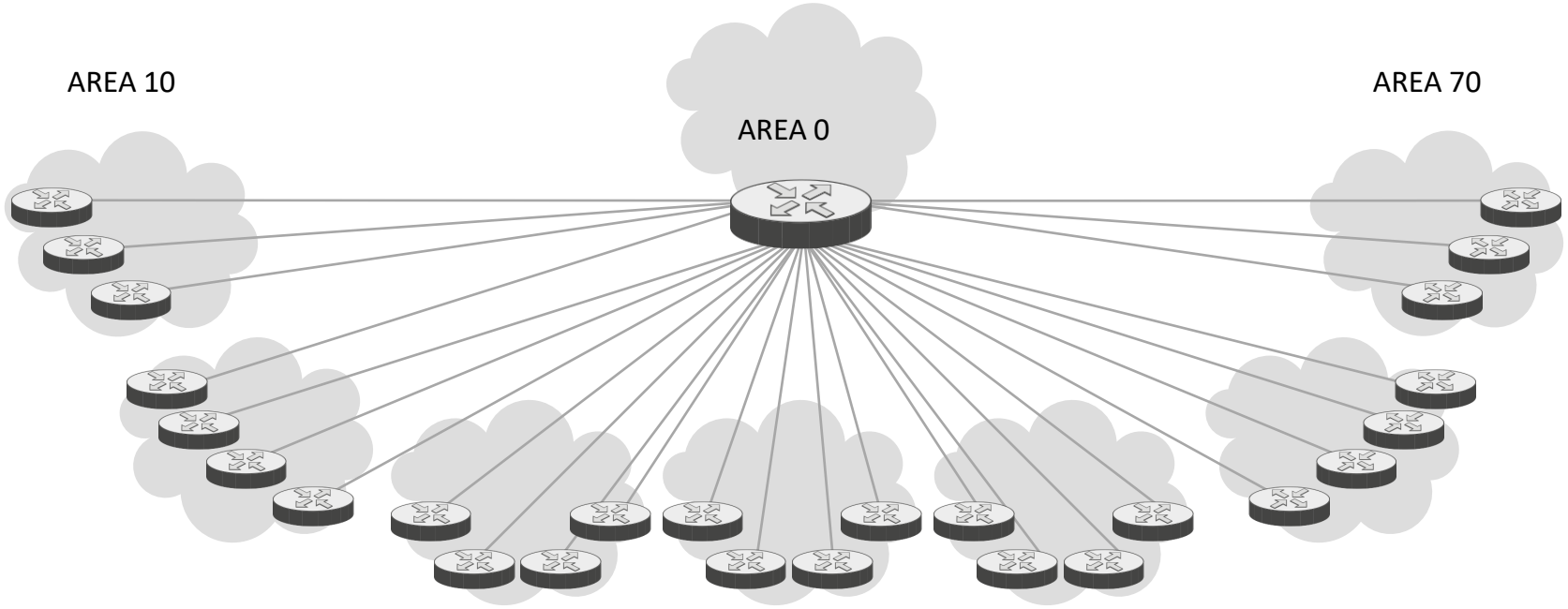
- Number of neighbor is more important question which we should ask.
- Always try to keep router LSA under the MTU size to avoid fragmentation.
- Routers cannot deal with fragmentation and reassembly well.

How many ABR (Area Border Router) per OSPF Area ?



- In the previous diagram, there are 2 ABRs in Area 10. For the redundancy and optimal traffic flow, two is always enough.
    - More ABRs will create more Type 3 LSA replication within the back bone and non-back bone areas.
- In large scale OSPF design, number of ABRs will have an huge impact on number of prefixes.

How many OSPF area is suitable per OSPF ABR?



- More Areas per ABR might create a resource problem on the ABR.
- Much more Type 3 LSA will be generated by the ABR
- Between the Areas there will not be Type 1 or Type 2 LSA, Type 1 and Type 2 LSA stays in the area and the reachability information is sent as Type 3 LSA between the Areas.

OSPF
CASE STUDIES

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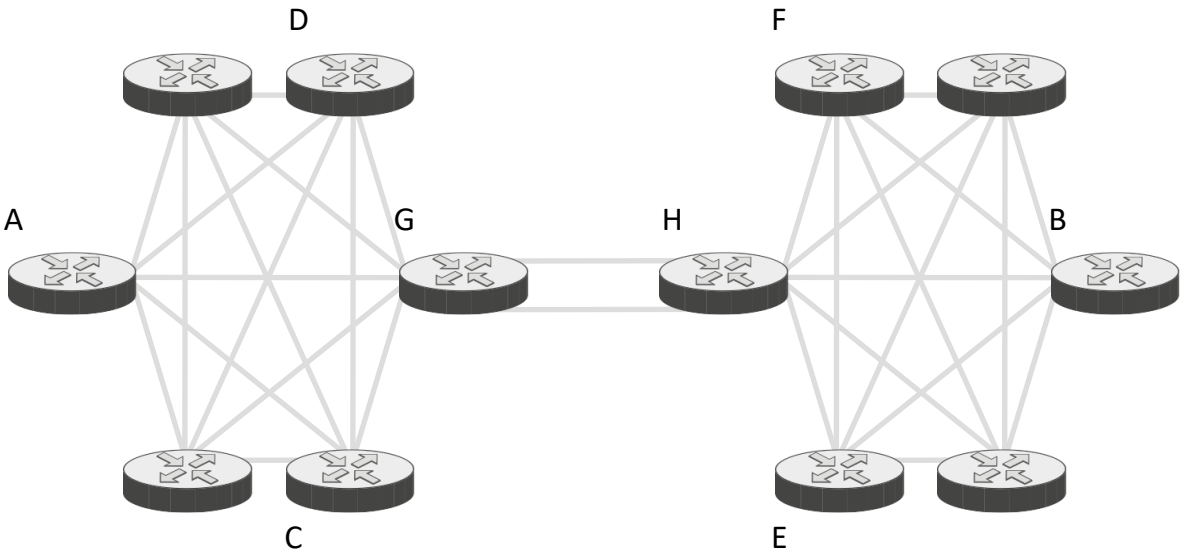
ABR Placement

- Where should we place an ABR in the below topology. Why?



ABR Placement

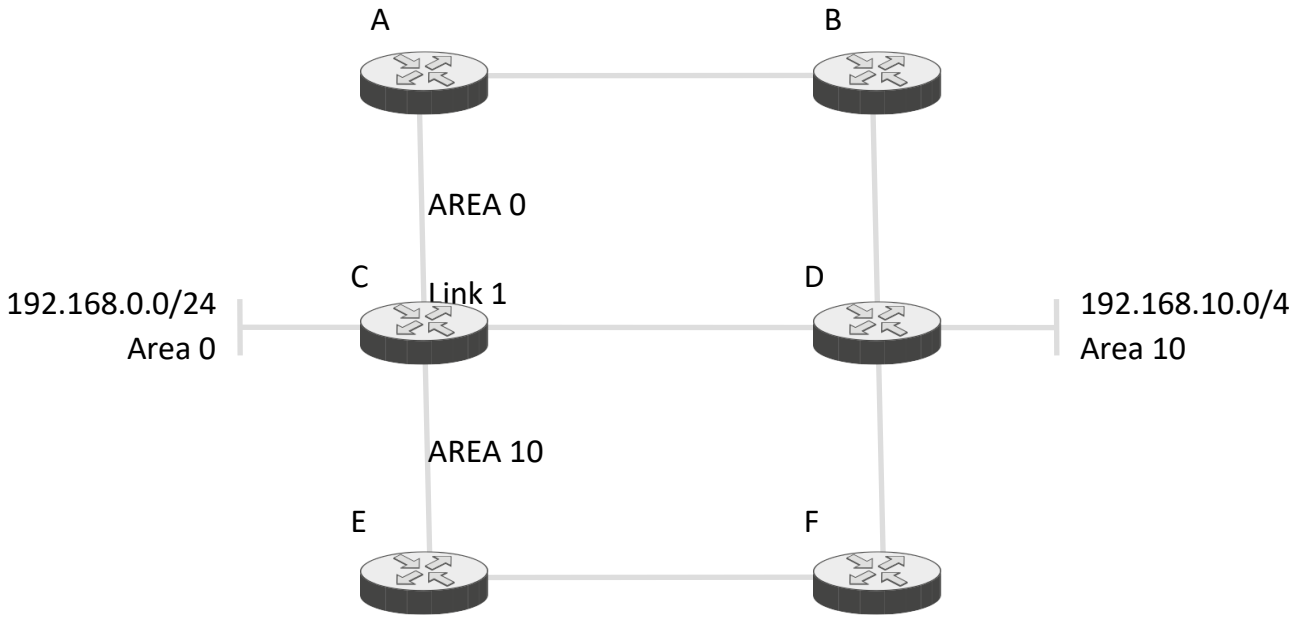
- Between Router A and Router B there are 1800 different paths. (5x6) x 2 (5x6) If we would put all of them in a same area we would have flooding, convergence, resource utilization, troubleshooting problems.

- If we use Router G or Router H as an ABR, we will have only 32 paths max (5x6) +2 between Router A and B, this will greatly reduce the load on the resources, reduces the overall complexity thus makes troubleshooting easier.

- Put ABR always a place where you can separate the complex topologies.

Multi-Area OSPF Adjacency

- What is the path from Router C to 192.168.10.0/24 and path from Router D to 192.168.0.0/24 networks? Is there a problem with the path? Why? What is the possible solution?



Multi-Area OSPF Adjacency

- If Link 1 is in area 0, router C will choose an path through E, F, and D to 192.168.10.0/24 rather than Link1.
  - This is because OSPF always prefers intra-area routes over inter-area routes.
- If Link 1 is put in area 10, router D will choose an path through B, A, and C to 192.168.0.0/24 with the same reason.

Multi-Area OSPF Adjacency

- This is suboptimal. Placing link into Area 1 and creating virtual link was the temporary solution. Also in this solution for each additional non-backbone area new OSPF adjacency is required.
    - Real solution to this: RFC 5185 -OSPF Multi Area Adjacency.

Multi-Area OSPF Adjacency

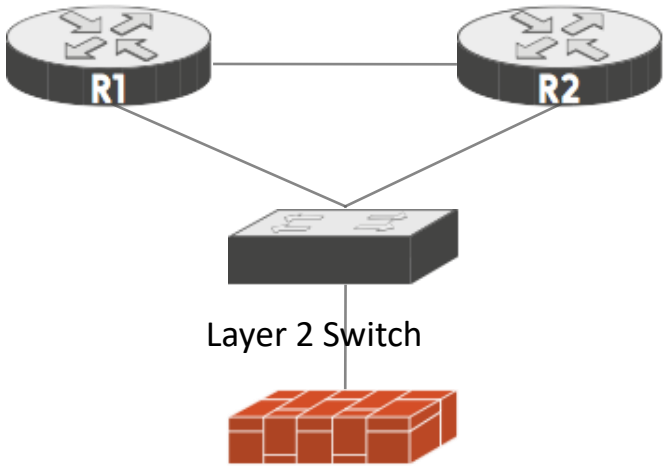
- Over 1 OSPF adjacency multiple area can be allowed with the RFC 5185.

- Below is a sample configuration from the Cisco device which supports RFC 5185.

```
rtr-C(config)# interface Ethernet 0/0
rtr-C(config-if)# ip address 192.168.12.1 255.255.255.0
rtr-C(config-if)# ip ospf 1 area 0
rtr-C(config-if)# ip ospf network point-to-point
rtr-C(config-if)# ip ospf multi-area 2
```

NSSA at the Internet Edge

- Enterprise company wants to run OSPF at the Internet edge between their Internet Gateway routers and the firewalls, which type of OSPF area is most suitable in this design and why?



NSSA at the Internet Edge

- Solution: If OSPF is used at the Internet Edge, IGW(Internet Gateways) don't need to have full OSPF routing table.
  - Using Stub or NSSA areas is most suitable. Firewalls only need a default routes from the Internet Gateways.
- Default route, partial route or even full route can be received from the BGP neighbor but only default route is needed by the firewalls.

NSSA at the Internet Edge

- It is good practice to redistribute default route from BGP to OSPF.
  - If the link fails between the customer and the service provider, BGP goes down and default route is removed from the OSPF as well.
- Only NSSA allows redistribution into an OSPF Stub areas.
  - That’s why, if OSPF will be implemented NSSA would be the most suitable area types on the Internet Edge.

OSPF and BGP Interaction

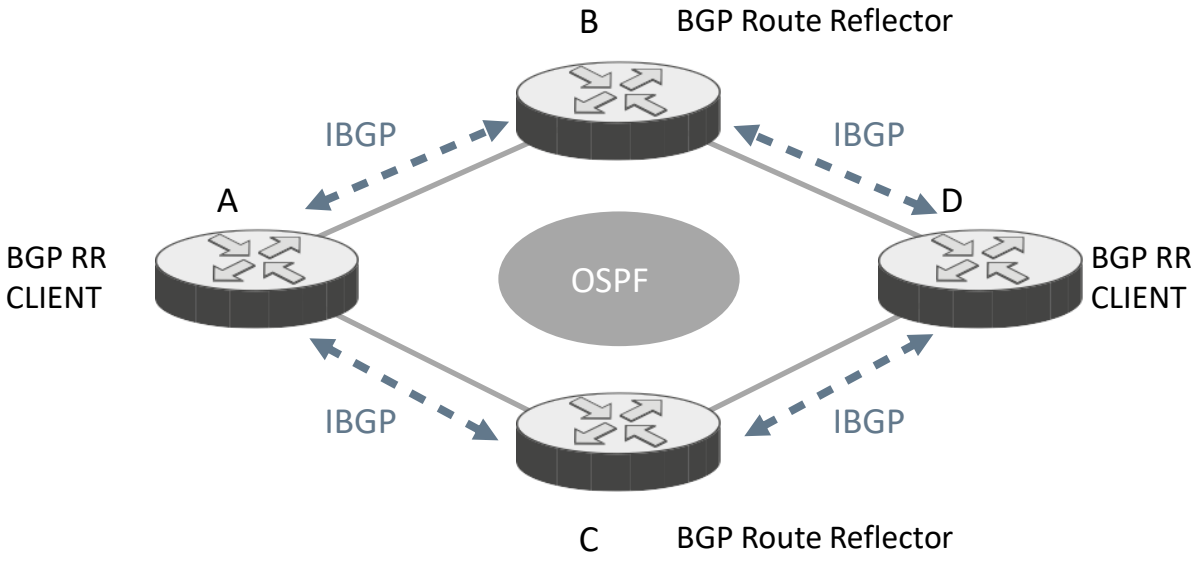
- OSPF is running as an IGP protocol in the below network. Also there is no MPLS in the core and all routers run BGP.

For scaling purpose company decided to use BGP Route Reflector design.

Router B and C are the Route Reflectors and Router A and D are the Route Reflector clients

Company wants to perform maintenance on the Router B but they don't want to have any downtime

What would be your design recommendation ?



OSPF and BGP Interaction

- BGP as an overlay protocol needs next hop reachability. Static routing or the dynamic routing protocol is used to create an underlay network infrastructure for the overlay protocols such as BGP, LDP, PIM and so on.

- In this case study one of the routers which is in the path towards BGP next hop will be reloaded. We might have two problems here.

OSPF and BGP Interaction

- When Router B is reloaded traffic is going to Router B shouldn't be dropped. Router B should signal the other OSPF routers. This signaling is done with OSPF Stub Router advertisement feature.
  - ' max-metric router-lsa ' is used by OSPF for graceful restart
- IGP always converges faster than BGP.
  - Second problem is when the Router B comes back, BGP traffic towards Router B will be black holed, because IGP process of Router B will converge faster than its BGP.

OSPF and BGP Interaction

- IGP should wait to BGP. Router B should take the BGP traffic once BGP prefixes installed in the routing table.
  - This is done with the OSPF Stub router advertisement feature as well.
- ‘ max-metric router-lsa on-startup wait-for-bgp ‘ is used by OSPF, so until BGP process is converged, OSPF doesn’t take traffic.
  - In this case study, with the OSPF Stub router advertisement feature, other OSPF routers are signaled for Graceful restart and also OSPF.

Case Study Key Point

- OSPF interacts with many protocols in the network such as spanning tree, BGP, MPLS and so on. Understanding the impact of such an interaction is the first step for the robust network design.

OSPF in the CCDE Exam

- OSPF Areas and LSA Types should be known very well.
  - ABR placement is an important topic, When there is a DC, Branches, WAN modules, where ABR will be placed?
- OSPF in an MPLS VPN environment , superbackbone, sham-link, route advertisement should be expected.
  - In general OSPF Scaling, Multi Area design needs to be understood very well.

Summary

- Link state protocols behaviors are explained
- OSPF Fast Convergence and Fast Reroute
- OSPF Scalability,Multi Area OSPF Design
- Overlay Technologies and OSPF (GRE, mGRE, DMVPN, LISP)
- OSPF in the Datacenter Networks
- OSPF in the Service Provider Networks
- OSPF Design Best Practices
- OSPF Advantages and Disadvantages
- OSPF Frequently Asked Questions – How many Routers in an OSPF Area, How many ABR per Area?
- OSPF in the CCDE Exam

OSPF

Open Shortest Path First

QUIZ

Question 1

How many routers can be placed in any given OSPF area?

A. 50

B. 100

C. 250

D. Less than 50

E. It depends

Answer 1

F. It depends

As it is explained in the OSPF chapter, you cannot have a numeric answer for this question.

There is no numeric answer of this question. It depends on how many links each router have, stability of the links, hardware resources such as CPU and Memory of the routers and physical topology of the network.

For example in full mesh topology, every router is connected to each other and number of links is too much compare to ring or partial topologies.

Thus, in one OSPF network you may place 50 routers in one OSPF area, but other OSPF network can have 100s of routers in one area.

Question 2

Why many different types of LSAs are used in OSPF? (Chose all that apply)

A. Provides Scalability

B. Allow Multi-Area OSPF design

C. Provides fast convergence

D. Provides High Availability

E. Better Traffic Engineering

Answer 2

A. Provides Scalability

B. Allow Multi-Area OSPF design

Question here is asking the reason of having multiple different types of OSPF LSAs. As you have seen in the OSPF chapter there are 11 different types of OSPF LSAs.

Although there are other reasons to use OSPF LSAs, two important ones are scalability and Multi-Area design. They don't help for fast convergence or high availability LSAs are not related with High Availability or Fast convergence. Although MPLS Traf c engineering can use OSPF Opaque LSAs for the distributed CSPF calculation, CSPF is not mandatory and many networks which have MPLS Traf c engineering uses Of ine Path calculation tool such as Cariden Mate.

Question 3

What does topology information mean in OSPF?

A. IP addresses of the directly connected interface.

B. IP addresses of the loopback interfaces of all the routers.

C. Provides an IP reachability information and the metric of all the physical and logical interfaces.

D. Provides a graph of the OSPF network by advertising connection information such as which router is connected to which one and the metric of the connections.

Answer 3

D. Provides a graph of the OSPF network by advertising connection information such as which router is connected to which one and the metric of the connections

There are two type of information is provided in link state protocols: Topology and reachability information.

Reachability information means IP addresses of the physical or logical interfaces of the routers. Topology information explains, which router is connected to which one, what is the OSPF metric value between them, thus provide a graph of the OSPF network.

Based on this information every router runs SPF algorithm to nd a shortest path to each and every destination in the network.

Question 4

Why more than one Area is used in an OSPF network?

A. They are used for high availability.

B. They are used for easier troubleshooting.

C. They are used to provide scalability by having smaller flooding domains.

D. Since topology information is not shared between OSPF areas, they provide better security.

Answer 4

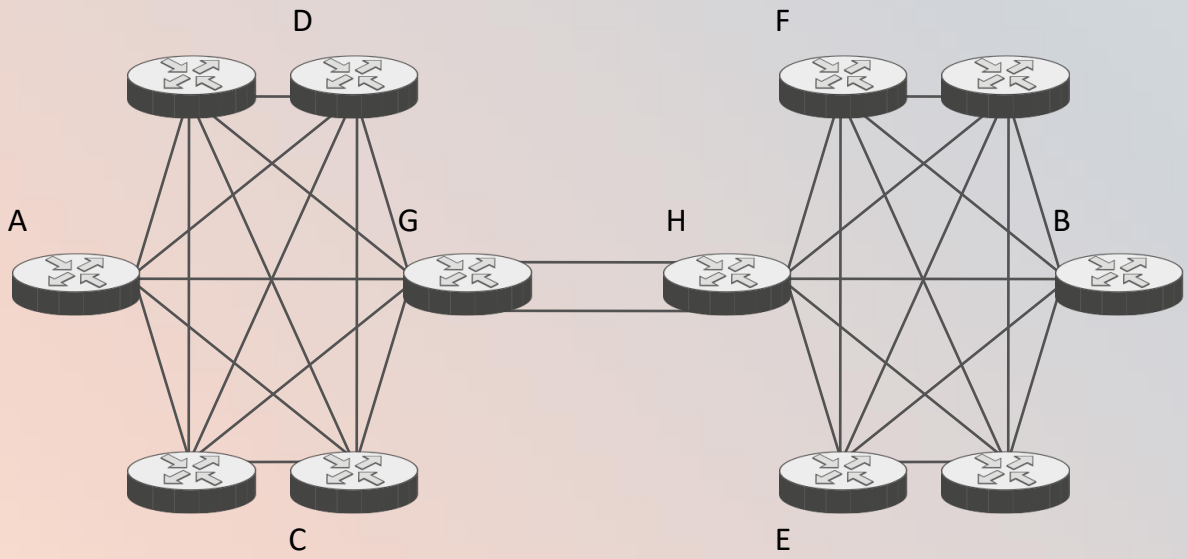
C. They are used to provide scalability by having smaller flooding domains.

OSPF areas are used mainly for scalability. Having smaller domain means, keeping topology information in an area and not sending between the areas. More than one area doesn't provide high availability and doesn't make troubleshooting easier.

Also in OSPF having more than one area doesn't prevent a route to be propagated to other areas by default, it requires manual configuration and even in that case it doesn't bring extra security.

Question 5

Which router in the below topology should be an ABR?



A. G or H B. A or B C. C or D D. E or F E. G

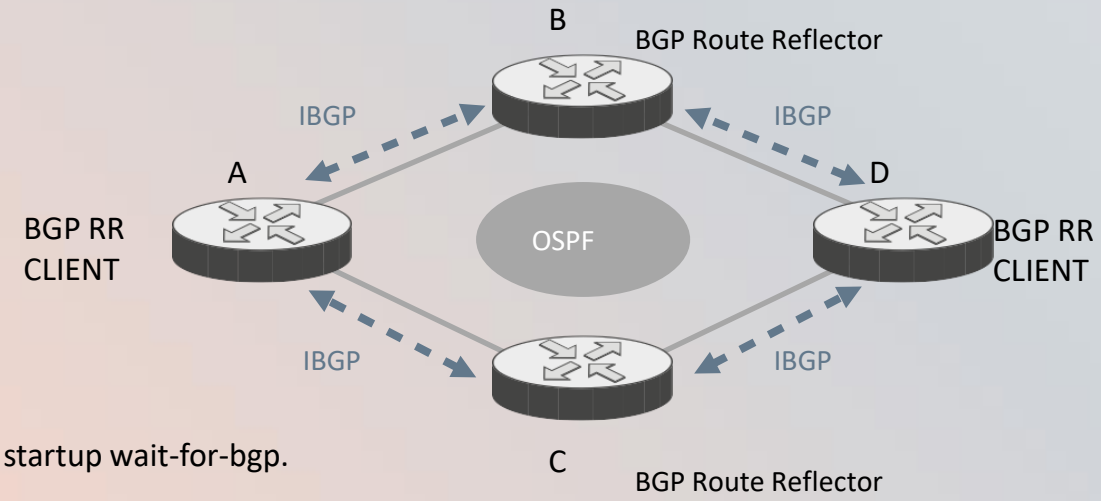
Answer 5

A. G or H

Router G or H should be an ABR to separate two full mesh topology from each other. Otherwise each router in the top full mesh network would run full SPF algorithm for each other router in the below full mesh network in case link failure, metric change or when new link or pre x is added.

Question 6

In the below topology, Router B needs to be reloaded. Network operator doesn't want any traffic loss during and after Router B's maintenance operation. Which feature should be enabled on the Router B?



A. Max-metric router-lsa on startup wait-for-bgp.

B. OSPF prefix-list.

C. Type2-lsa on-startup wait-for-bgp.

D. IGP LDP synchronization.

Answer 6

A. Max-metric router-lsa on startup wait-for-bgp.

BGP as an overlay protocol needs next hop reachability. Static routing or the dynamic routing protocol is used to create an underlay network infrastructure for the overlay protocols such as BGP, LDP, PIM and so on.

One of the routers in the forwarding path towards BGP next hop will be reloaded. We might have two problems here.

When Router B is reloaded, traf c is going to Router B shouldn’t be dropped. Router B should signal the other OSPF routers.

This signaling is done with OSPF Stub Router advertisement feature. ‘ Max-metric router-lsa ‘ is used by OSPF for graceful restart. Second problem is when the Router B comes back; BGP traffic towards Router B will be black holed, because IGP process of Router B will converge faster than its BGP.

IGP should wait to BGP. Router B should take the BGP traf c once BGP pre xes installed in the routing table.

This is done with the OSPF Stub router advertisement feature as well.

Question 7

How many levels in OSPF hierarchy used ?

A. One

B. Two

C. Three

D. As many as possible

Answer 7

B.Two

OSPF supports two level of hierarchy. Hierarchy is common network design term, which is used to identify the logical boundaries. Backbone area and Non-Backbone areas are the only two areas, which are supported by OSPF, thus it supports only two level of hierarchy.

Question 8

Which below options are correct for OSPF ABR?
(Choose all that apply)

A. It slows down the convergence.

B. It generates Type 4 LSA in Multi Area OSPF design.

C. It does translation between Type7 to Type 5 in NSSA area.

D. It does translation between Type 5 to Type 7 in NSSA area.

E. It prevents topology information between OSPF areas.

Answer 8

A. It slows down the convergence.

B. It generates Type 4 LSA in Multi Area OSPF design.

C. It does translation between Type7 to Type 5 in NSSA area.

E. It prevents topology information between OSPF areas.

OSPF ABR slows down the network convergence. Because it needs to calculate for each Type 1 and Type 2 LSAs, corresponding Type 3 LSAs and send its connected OSPF areas.

OSPF ABR generates Type 4 LSAs in Multi Area OSPF Design. When ABR receives the external pre xes in an Area, it translates Type 1 LSAs of the ASBR to Type 4 LSA and sends it to the other areas.

In NSSA Area, ABR translates Type 7 LSA to Type 5 LSA, but there is no Type 5 to Type 7 LSA translation. It is not allowed.

Topology information is not sent between the OSPF Areas, ABR stops topology information.

Thus the answer of this question is A- B – C- E.

Question 9

Why Designated Router is used in OSPF network?

A. It is used to have an ABR in the network

B. It is used to create topology information

C. It is used to centralize the database, instead of keeping distributed OSPF link state database in every node

D. It is used to avoid flooding information between each device in multi access OSPF network

Answer 9

D. It is used to avoid flooding information between each device in multi access OSPF network

Designated Router (DR) is used to avoid flooding information between each OSPF device in Multi-Access networks such as Ethernet or Frame Relay.

Routers only send their update to DR and DR floods this information to the every router in the segment. Multicast Group addresses 2224.0.0.5 and 224.0.0.6 is used for communication in IPv4.

Question 10

Which below feature is used to avoid blackholing when OSPF and LDP are used together?

A. OSPF Fast Reroute.

B. OSPF Multi Area Design.

C. IGP LDP Synchronization.

D. Converging OSPF faster than LDP in case of failure.

Answer 10

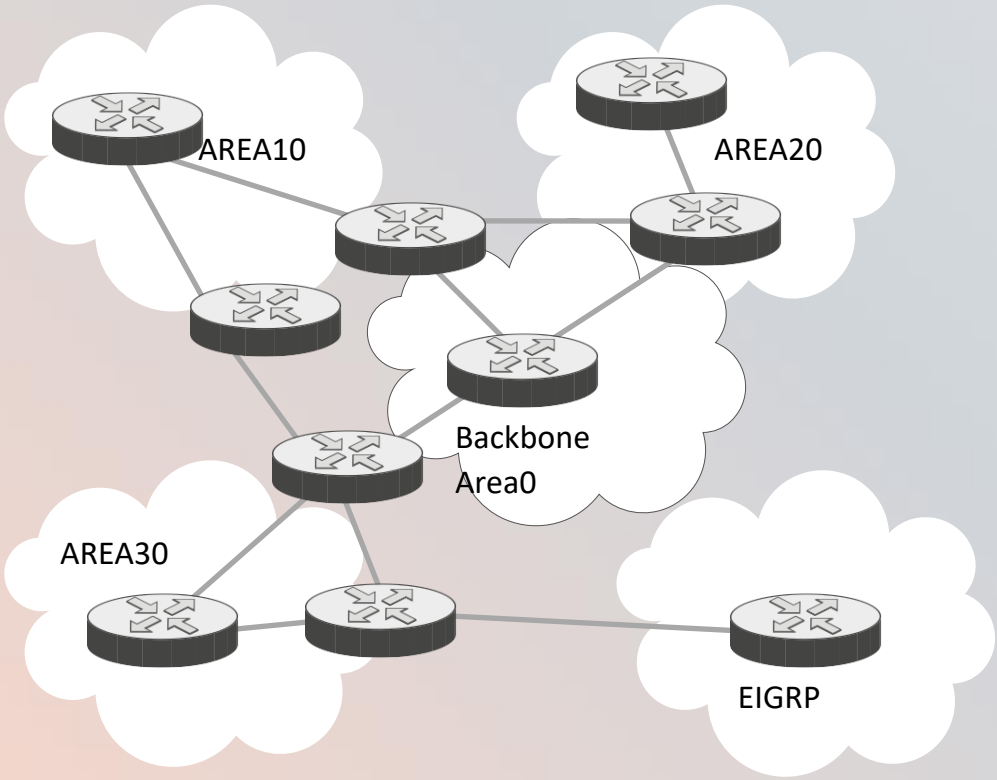
C. IGP LDP Synchronization.

The problem occurs when link or node fails when OSPF and LDP is used together. It also occurs when IS-IS and LDP is together and the IG-LDP synchronization provides a label for the IGP pre xes in the Label database, otherwise since IGP converge rst and then LDP, packets would be blackholed.

Chicken and egg problem is solved and blackholing is avoided.

Question 11

Which below option is correct for the given topology?



A. Area 20 has to be Stub area.

B. Sending default route might create suboptimal routing for internal Area 20 routers.

C. ABR of Area 20 has to be Designated Router.

D. Area 20 doesn't receive Type 1 and Type 2 LSAs from the other areas.

Answer 11

D. Area 20 doesn't receive Type 1 and Type 2 LSAs from the other areas.

Area 20 can be any type of OSPF area since there is no given requirement.

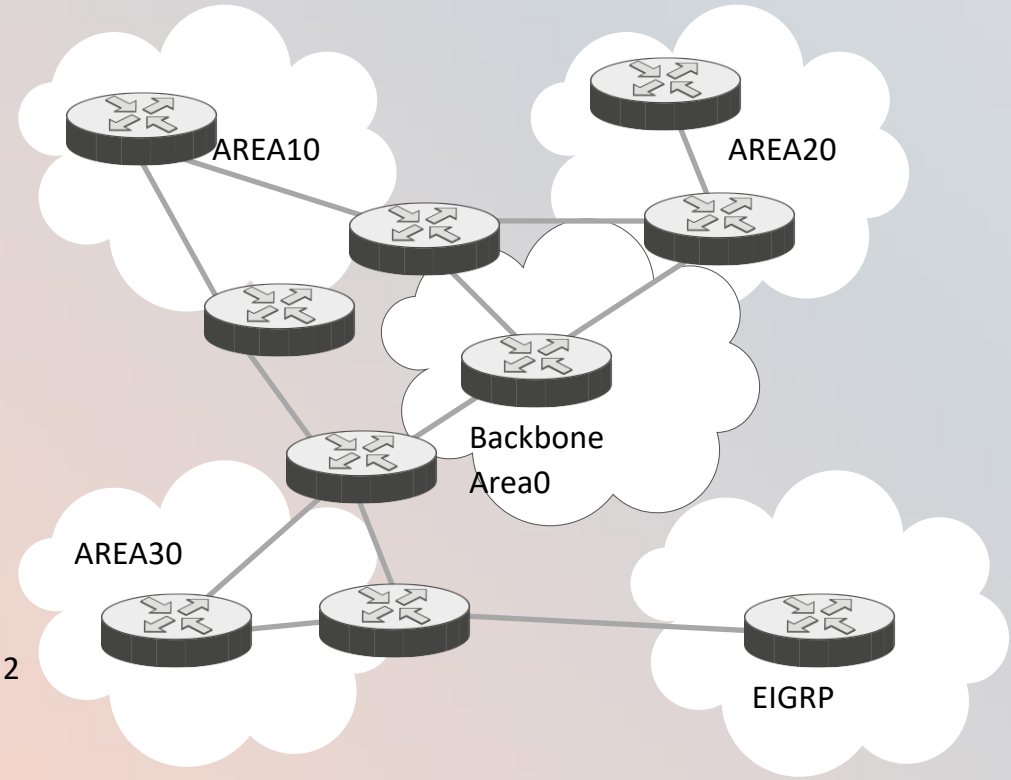
Sending default route cannot create suboptimal routing because there is only one exit point from the Area 20. Sub optimal routing can only be created if there is more than one exit from the Area.

ABR of Area 20 doesn't have to DR. In fact, DR and ABR shouldn't be the same router. Since both operations are resource intensive and separating these two ask is a best practice.

Type 1 and Type 2 LSAs cannot be received from the other Areas because topology information is not allowed between the OSPF areas and in OSPFv2 Type 1 and Type 2 LSAs carry topology information in addition to reachability information.

Question 12

In the below topology Area 30 is an NSSA area. Which below option is true?



A. There will not be any Type 3 LSA in Area 30.

B. ABR of Area 30 will translate Type 7 LSA to Type 5 LSA.

C. There will not be any Type 1 or Type 2 LSA.

D. EIGRP prfixes will not be allowed in Area 30.

Answer 12

B. ABR of Area 30 will translate Type 7 LSA to Type 5 LSA.

Since Area 30 is an NSSA area; there will be Type 3 LSA, that's why Option A is incorrect. There will be Type 1 and Type 2 LSA, but not from the other Areas.

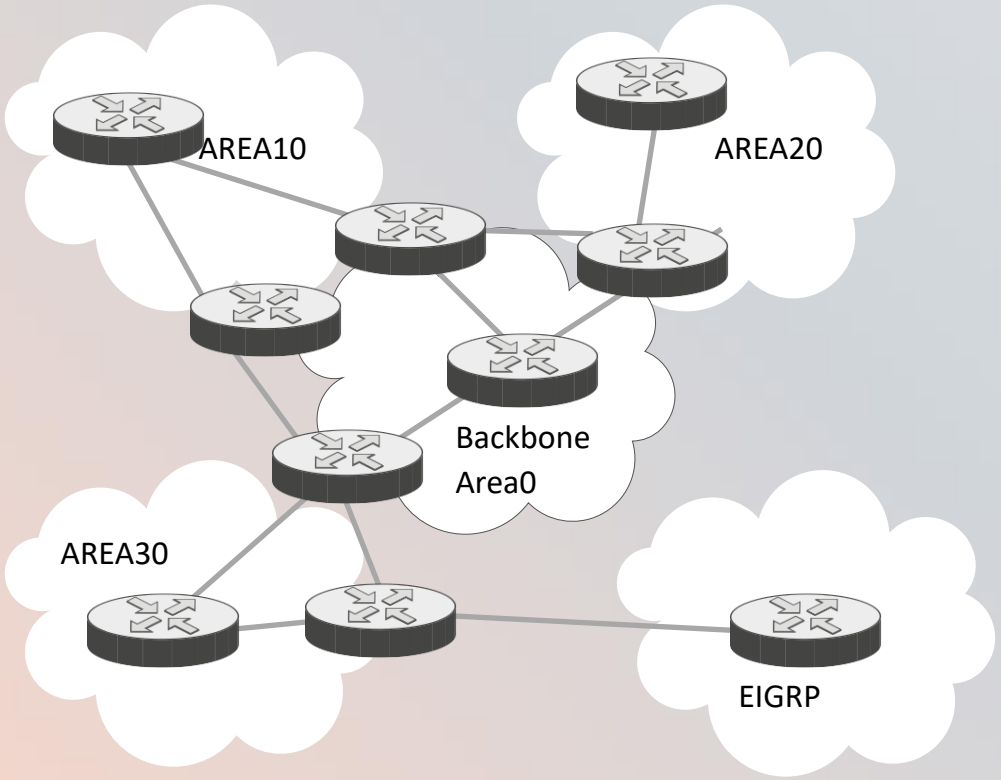
In Are 30, every router generates Type 1 LSAs, and of there is multi- access network, the DR will generate Type 2 LSA as well.

EIGRP preFIxes will be allowed and they will be seen as Type 7 LSA in the Area 30.

Only Option B is correct, because ABR of Area 30 translate Type 7 LSA which is the EIGRP pre xes to Type 5 LSA send them to the network.

Question 13

In the below topology Area 10 is Totally NSSA Area. Which below option is true?



A. Area 10 will not have any Type 1 or Type 2 LSA.

B. Area 10 will not have EIGRP prefixes.

C. Area 10 cannot reach to EIGRP prefixes.

D. Both ABRs of Area 10 will do the Type 7 to Type 5 translation.

Answer 13

B. Area 10 will not have EIGRP prefixes.

Area 10 will be able to reach EIGRP network through default route even if it is Totally NSSA. But Area 10 devices cannot have specific EIGRP prefixes because Type 3, 4, 5 LSAs are not allowed in Totally NSSA Area. Answer of this question is B.

Question 14

Which below topology, OSPF is worse than EIGRP in large-scale implementation?

A. Full Mesh

B. Partial Mesh

C. Hub and Spoke

D. Ring

Answer 14

C. Hub and Spoke

In Full Mesh physical topology, Mesh Group feature allows only two routers to flood LSAs into the area. Mesh Group is supported by both OSPF and IS-IS.

This brings scalability into OSPF.

Ring and Partial mesh topologies are hard for all the routing protocols. Ring and Partial mesh are cheaper to build but convergence, optimal routing and fast reroute is very hard in Ring and Partial mesh.

EIGRP is best in Hub and Spoke topology from the scalability point of view, because it doesn't require so many configurations for its operation. OSPF on the other hand, requires a lot of tuning for its operation in Large scale Hub and spoke topology.

Question 15

Why OSPF is used as an Infrastructure IGP in an MPLS VPN environment?

A. To carry the customer prefixes.

B. Reachability between the MPLS VPN endpoints.

C. OSPF is not used in MPLS VPN environment as an Infrastructure IGP protocol but BGP is used.

D. LDP requires OSPF as an IGP.

Answer 15

B. Reachability between the MPLS VPN endpoints.

LDP requires IGP yes but it is not relevant. It could be EIGRP or IS-IS as well.

And the purpose of OSPF or any other IGP.as an Infrastructure protocol is to carry the loopback interface addresses of the MPLS VPN endpoints.

So the OSPF is used for reachability between the VPN endpoints (PE devices) in SP networks. OSPF is not used to carry the customer prefixes as an Infrastructure IGP.

Knowing the difference between the Infrastructure IGP and the PE-CE IGP protocol in MPLS VPN is important. This will be explained in detail in the MPLS chapter.

Question 16

Which OSPF feature in MPLS VPN PE-CE is used to ensure MPLS service is always chosen as primary link?

A. OSPF max-metric

B. OSPF prefer-primary path

C. OSPF sham-link

D. Passive-interface

E. Virtual link

Answer 16

C OSPF sham-link

Even domain IDs are the same in both site of the MPLS VPN, without sham-link feature only Type 3 LSA can be received from the PE by CE.

Sham-link is used to receive Type 1 LSA and even if there is a backup connection between the CEs, only changing cost on either PE-CE or CE-CE link make MPLS link as primary.

OSPF as a PE-CE protocol will be explained in detail in the MPLS chapter.

Question 17

Which below options are correct for OSPF?
(Choose all that apply)

A. OSPFv2 doesn't support IPv6 so when IPv6 is needed, OSPFv3 is necessary.

B. OSPF virtual link shouldn't be used as permanent solution is OSPF design.

C. OSPF and BGP are the two separate protocols so when OSPF cost changes, it doesn't affect BGP path selection.

D. OSPF can carry the label information in Segment Routing so LDP wouldn't be necessary.

E. OSPF unlike EIGRP, supports MPLS Traffic Engineering with dynamic path calculation.

Answer 17

A.OSPFv2 doesn't support IPv6 so when IPv6 is needed, OSPFv3 is necessary.

B.OSPF virtual link shouldn't be used as permanent solution is OSPF design.

D.OSPF can carry the label information in Segment Routing so LDP wouldn't be necessary.

E.OSPF unlike EIGRP, supports MPLS Traf c Engineering with dynamic path calculation.

Only incorrect option of this question is C. although they are two separate protocols; changing the OSPF metric can affect the best BGP exit point.

Taking IGP cost into consideration to calculate best path for the BGP prefixes is called Hot Potato Routing.

Changing IGP metric can affect BGP best path.

Question 18

What is the reason to place all routers in Area 0/Backbone Area, even at the begiining in OSPF design?

A. You cannot place routers in non-backbone area without backbone area.

B. Type 3 LSAs should be received from the ABR.

C. Future Multi Area design migration can be easier.

D. It is not a best practice to place all the routers in Area 0 in Flat/Single OSPF area design.

Answer 18

C Future Multi Area design migration can be easier.

In OSPF design, all the routers can be placed in any Non-Backbone area. If you have 50 routers in your network, you can place all of them in Area 100 for example.

But having the routers in OSPF Backbone area (Area 0) from the early stage of network design provides easier migration to Multi Area OSPF design.

This is true for the IS-IS as well. In IS-IS you can have all the routers in the network in Level 1 domain. But having them in Level 2 allows easier Multi-Level IS-IS design if it is required in the future. This will be explained in the IS-IS chapter with the case study.

Question 19

In OSPFv2 which LSA types cause Partial SPF run?
(Choose Three)

A. Type 1

B. Type 2

C. Type 3

D. Type 4

E. Type 5

Answer 19

C.Type 3

D.Type 4

E.Type 5

In OSPFv2, Type 3, 4 and 5 causes Partial SPF run. Not full SPF. Partial SPF is less CPU intensive process compare to Full SPF run.

Question 20

Based on which design attributes, number of maximum routers change in OSPF area?

A. It depends on how many area is in the OSPF domain.

B. Maximum number of routers in OSPF area should be around 50.

C. Depends on link stability, physical topology, number of links, hardware resources, rate of change in the network.

D. If there are two or more ABRs, number can be much more

Answer 20

C Depends on link stability, physical topology, number of links, hardware resources, rate of change in the network.

Depends on link stability, physical topology, number of links on the routers, hardware resources and rate of change in the network. If some links flap all the time, this affects the routers resources and the scalability of the network.

Question 21

How many OSPF ABR routers should be in place in OSPF by keeping also redundancy in mind?

A. One

B. Two

C. Three

D. If the number of routers in an area is too much, it can be up to 8 ABRs

Answer 21

B.Two

In large-scale OSPF design, the number of ABRs will have a huge impact on the number of prefixes. Thus having two ABRs is good for redundancy for the critical sites.

For example some of the remote offices or POP locations may not be critical as other locations and having only one ABR in those locations, can be tolerated by the company.

In this case that specific location may have only one ABR as well.

Keep in mind that; two is company, three is crowded in design.

Question 22

What are the most important reasons of route summarization in OSPF? (Choose Two)

A. In order to reduce the routing table size so routers have to store and process less information.

B. In order to increase the availability of the network.

C. Increase the security of the routing domain.

D. In order to reduce the impact of topology changes.

E. In order to provide an optimal routing in the network.

Answer 22

A. In order to reduce the routing table size so routers have to store and process less information.

D. In order to reduce the impact of topology changes.

If there is route summarization, sub optimal routing might occur as it was explained in the OSPF chapter. Thus Option E is incorrect.

Availability and security doesn't increase with route summarization. But topology change affects is de nitely reduced.

Also the routing table size is reduced and this provides better memory and CPU utilization, fast convergence and better troubleshooting.

Extra Study Resources

- Books :
- http://www.amazon.com/OSPF---Choosing-Large-Scale-Networks/dp/0321168798/ref=sr_1_1?ie=UTF8&qid=1436566360&sr=8-1&keywords=ospf+and+is-is
- Videos :
- Ciscolive Session – BRKRST -2337
- Articles :
- http://www.cisco.com/web/about/ac123/ac147/archived_issues/ipj_16-2/162_lsp.html
- http://orhanergun.net/2015/02/ospf-design-challenge/
- https://tools.ietf.org/html/rfc4577