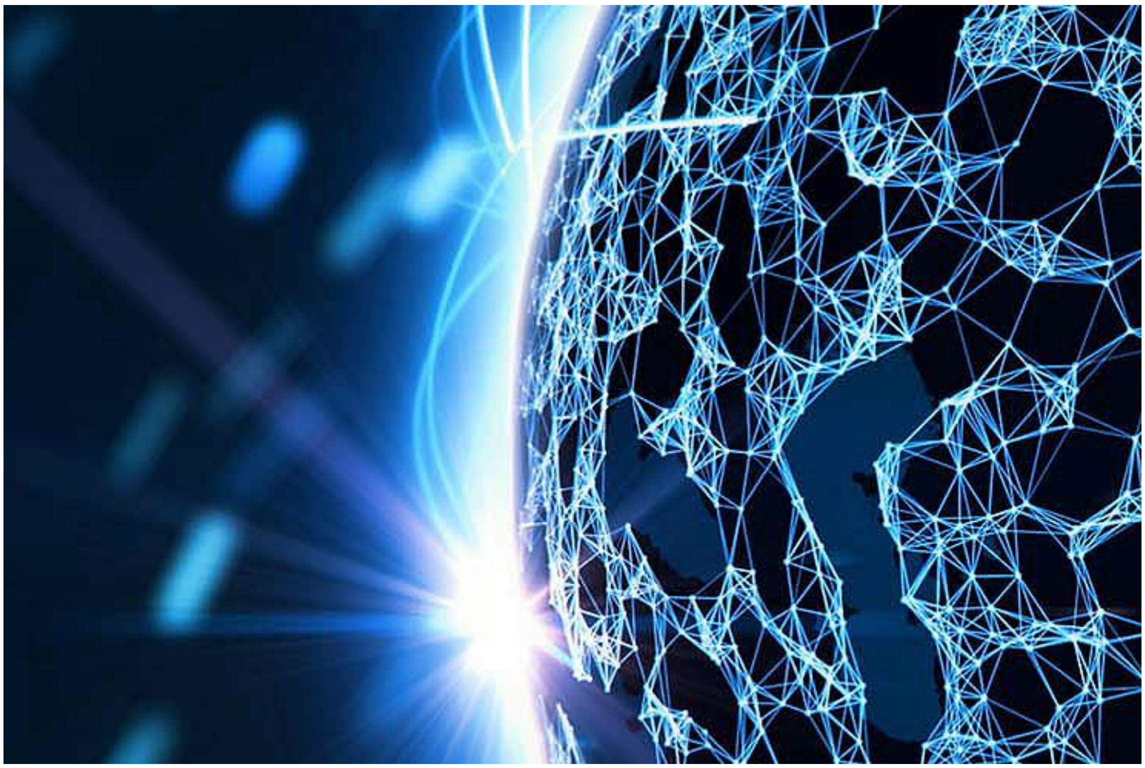
Project

Phase II WAN Design



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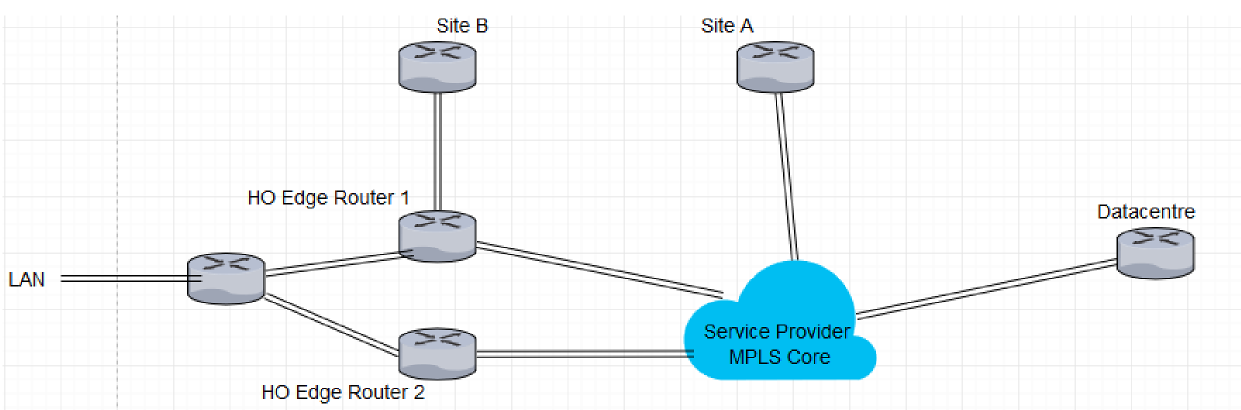
High Level Design

Introduction to WAN

In contrast to a LAN, a **Wide Area Network** or **WAN** is a computer network that is spread across regions, countries or even the world. WANs allows different Local Area Networks to interact with each other and with the internet as it is used for transmitting data over long distances. There are two types of WAN connections – wired and wireless. Wired WAN services generally operates **MPLS,** T1s, Carrier Ethernet etc. whereas wireless WAN utilize 4G LTE as well as public Wi-Fi or satellite networks. Since, wireless WAN is yet to establish itself, wired network connection remain the preferred medium for most enterprises. ("Wide area network", n.d.)

WAN infrastructure could be either privately owned or leased as a service from a third-party service provider. Some enterprises may have a private dedicated connection often backed up by a service-level agreement or a shared public medium such as the internet. Organizations may also use third-party service providers such as telecommunication carriers or an ISP. In addition, there is a third type of WAN architecture known as **Hybrid WAN,** which employ both public and private network services. ("What is WAN (wide area network)? - Definition from WhatIs.com", n.d.)

Tyrell Corp WAN Architecture



<u>Overview of WAN architecture</u>

Tyrell Corp uses an Internet Service Provider network connection for the WAN. The Enterprise WAN allow users to share access to applications, services and other centrally located resources. This eliminates the need to install the same application server, firewall or other resource in multiple locations, for example. The enterprise WAN consists of connections to the company's new head office site which is connected to the company LAN, two sites A and B and a datacenter, all linked together through a ISP MPLS Core.

For connecting the LAN to the WAN, two edge routers are used. One of these edge routers act as a primary link and the other one is the backup link. All of the LAN routes will move through the primary link and the backup link will remain idle, but will contain very small traffic such as the OSPF neighbor association maintenance. In case, the primary link fails for some reason, all of the LAN route traffic will be redirected through the backup link and hence, the customers wouldn't have to deal with a disruption in service. Similarly, only one of the edge routers would be the primary link between the Head Office and the Service Provider carrying the LAN traffic and the other edge router would act as the backup service. WAN links to the provider is 100Mb Ethernet which is a CAT5 cable. It provides a pretty decent speed at a low cost. The Ethernet link is used in contrast to the Wi-Fi because unlike the wireless speed, Ethernet speeds are pretty consistent and reliable.

Site B is located within the same city as that of the Head Office and routes its traffic via the head office to the service provider. Site B is directly connected to one of the edge routers via a direct 100Mb Ethernet fibre link. This link also acts as a **backdoor** point to point link between the Head Office site and Site B. The backdoor link is very useful as it provides a legitimate point of access for the administrator (Management VLANs) to enter the system remotely for troubleshooting and doing maintenance for software/system upkeep. The Site has been assigned the network range 10.8.0.0/16 for its LAN. (Zetter et al., n.d.)

Q: The customer needs to know why the Site B link is directly connected to one of the existing HO edge routers?

Since, Site B and the Head Office are located within the same city and given the short distance, it is very convenient to establish a communication between the two sites. If we use an additional router, it will be redundant, since it would perform the same functions as that of the existing edge router. However, if we connect Site B directly to a distribution switch, there would be a large amount of overhead since the switch would be handling large amount of traffic from the Site B LAN.

Service Provider is a MPLS service which connects the Head Office and Site B to two other sites – Site A and the Datacenter. The MPLS core provides very high-speed reliable service to the end customers. The benefits of MPLS are scalability, performance, better bandwidth utilization, and reduced network congestion. MPLS itself does not provide encryption, but it is a virtual private network and therefore, MPLS is considered a secure transport mode. And it is not vulnerable to denial of service attacks, which might impact pure-IP-based networks. In this scenario, the service provider is only configured as a single router and is assumed to be a collection of many routers forming a transit AS. The service provider and the edge routers are connected via two point to point links – 172.16.17.0/30 and 172.16.17.4/30. Only one of these links

(172.16.17.0/30) is configured to be the primary one and all the traffic flows through it in either direction. The second link acts as a backup and remains idle unless the primary link fails.

Site A has been allocated a range of 10.6.0.0/16 for its operation. The **datacenter** uses 10.1.0.0/16. The service provider ensures end to end connectivity between the customers and the different sites.

The Head Office consists of a LAN Core router apart from the edge routers. The Core Router is connected to the LAN and it advertises all the VLAN routes for Admin, HR, Marketing etc. Point to point network 10.7.100.28/30 is used between the Core and the first edge router and similarly, 10.7.100.32/30 between Core and the other edge router. 10.7.100.36/30 is used between the two edge routers. The Edge routers provides for scalability as any other new branches which might open can be very easily connected to it. Since, there are primary and backup paths, it provides a great deal of reliability and availability.

The most important functionality in the WAN is routing which is achieved using two different routing protocols – OSPF and BGP. Different areas in the WAN are divided into Autonomous Systems or AS to separate the functionality of these areas from each other. These areas are assigned via IANA. The Head Office comes under AS 65007, service provider under AS 4700, Site A under AS 65006 and the datacenter under AS 65001. There are two kind of routing requirements which arises – one for routing traffic within the AS handled by an Interior Gateway Protocol – OSPF in our corporation, and the second one is to handle traffic between different Autonomous Systems done by BGP which is an Exterior Gateway Protocol.

Technologies Implemented

- **Open Shortest Path First** or **OSPF,** is a link state protocol which is used to route traffic within an Autonomous System. However, there can be more than one OSPF area within a single AS. Since, routers communicate with other routers in an OSPF area by establishing a neighbor relationship, if there are many routers within an area, all communicating with each other, the routing table becomes very large and hence results in a large link database. To avoid this, routers are divided across areas. Area 0 or the backbone area connects all the OSPF areas and is a necessary requirement in any network. OSPF implements Dijkstra algorithm to calculate the shortest path and determine the best route to the destination. The edge routers and the Core are in the backbone area. Site B is present in Area 1 which is a totally stubby area, a special type of OSPF area. A totally stubby area is a Cisco proprietary area type that does not accept external autonomous system routes or summary routes from other areas internal to the autonomous system. If a router needs to send a packet to a network external to the area, it sends the packet using a default route. Totally stubby areas cannot contain ASBRs (except that the ABRs may also be ASBRs). Since, Site B is required to be configured such that to minimize the flooding of OSPF LSA, it is configured as a totally stubby area with Edge router 1 as the ABR. An ABR or Autonomous Border Router forms a link between two OSPF areas and the ABR must be present in both of the OSPF areas which it is responsible to connect. Similarly, an Autonomous System Border Router connects an OSPF area to a different external AS or the internet. Both of the edge routers acts as an ASBR. The Head Office advertises the VLANs and Site B's network into the OSPF and is hence, learned by every router connected to the Core. As there are two edge routers and for reaching them, there are two paths – only one of which is the primary and the other one is the backup. One of the path is made primary by utilizing OSPF cost metric attribute, assigning a lower cost to Edge router 1 makes it more desirable for the LAN traffic and hence, it is the primary link.

***Why is OSPF used and how does it helps our customers*?**

It improves scalability as it is designed to work with larger networks. OSPF uses small hello packets to verify link operation without transferring large tables. OSPF can route packets by different criterion based on their type of service field. Routes can be tagged with arbitrary values, easing interoperation. The main advantage of link state routing (OSPF) is that complete knowledge of topology allows routers to calculate routes that satisfy the incoming request hence satisfying the customer requests with ease. OSPF is useful for traffic engineering purposes where routes can be manipulated to meet different service requirements. ("The Pros and Cons of OSPF and EIGRP", 2009)

Other Option – EIGRP

EIGRP allows you to summarize at any interface and it reduces the amount of update traffic, it reduces the length of routing tables, and sets boundaries for queries. EIGRP is known for its fast convergence and has more versatility and adaptability than its OSPF rival. But, in contrast to EIGRP which is a CISCO-proprietary, OSPF will run on any device as it's based on open standard. ("The Pros and Cons of OSPF and EIGRP", 2009)

Other Option – BGP

Even BGP can be used to route internal AS traffic. The Edge routers are connected using iBGP also known as Internal BGP. However, BGP is not advised to be used as an IGRP. Within an AS, OSPF is preferred over iBGP since it has a lower administrative distance than iBGP.

- **Border Gateway Protocol** or **BGP** is an exterior gateway protocol which provides loop-free routing between different Autonomous Systems. BGP forms peers or neighbors by establishing a TCP connection which other BGP operating Routers. Unlike an IGP, BGP makes routing decisions based on path attributes and not a metric which gives a network administrator more control. There are two types of BGP – External BGP or eBGP when between routers in different AS and the other one is Internal BGP or iBGP, running between routers in the same AS. eBGP routers are directly connected whereas

iBGP routers can be connected even if they are not in direct contact with each other. Service Provider acts as a transit AS between AS 65007, AS 65006 and AS 65001.
In network failure conditions, Site A can use the Head Office as a transit AS to reach Datacenter and vice versa. To prevent this, AS path prefix list is used. The ^$ regular expression which is used in the prefix list ensures that we will only advertise locally originated prefixes.
There are many attributes that BGP uses – out of which Local Preference and MED is used to configure Edge router 1 as the primary link, making router 2 as the backup. Since, Edge router 1 should be the primary link for both incoming and outgoing traffic, Local Preference and MED are used for this purpose.
Local Preference is used to determine the best path to leave the AS. It is only used between iBGP peers. A higher value of Local Preference is preferred and hence, for all the routes through Edge router 1, it is given a higher Local Preference making it more desirable than the second Edge router.
MED is used to determine the path to enter an AS when multiple paths exists. Since MED is a metric, lower MED value is preferred. A lower MED is set for Edge router 1 making it more desirable for the ISP to choose it over the second Edge router.
BGP aggregation is used to summarize the individual routes into a single summary. In any closed network, this aggregate information propagates through BGP and back to one of the ASs that the **as-set** lists. This propagation creates the possibility of a loop. The loop detection behavior of BGP notes its own AS number in the **as-set** of the aggregate update and drops the aggregate. This action prevents a loop. The **as-set** information becomes important in the avoidance of routing loops because the information records where the route has been.

***Why is BGP used and how does it helps our customers*?**

BGP has the reputation of being the hardest routing protocol to design, configure and maintain. But while this notion has some validity, there are situations where BGP is the *only* tool available to get the job done, or where deploying BGP throughout your network can increase its security or stability. It has many ISP advantages and hence BGP is deployed to increase the stability of their network, provide end-to-end quality-of-service or penetrate enterprise markets. Enterprise-focused ISPs have to run BGP from the start to support their multi-homed customers. With the separation of core and edge routing into two routing protocols, your network core becomes more stable, as the edge problems cannot disrupt the core. This design has been used very successfully in large enterprise networks with haphazard addressing schemes that defied attempts at route summarization. It should also be used in almost all service provider environments. You should never carry your customers' routes in your core routing protocol, as customer's internal problems could quickly affect the stability of your own network. You can also use BGP to implement network-wide sinkholes and remote blackholes to quickly stop worms and denial-of-service attacks on your network. ("5 essential reasons for BGP in your IP network", n.d.)

Other Option – EGP

EGP is an old protocol which had many scalability issues and was also very slow in detecting issues and as a result was replaced by BGP

Other Option – ECESSA

Ecessa devices aggregate WAN links from any number of separate ISPs and let you use all of the working connections, all of the time. This requires no special arrangements with service providers, no extra hassle.

Ecessa Internet appliances accomplish multihoming without BGP by using Network Address Translation (NAT) and Dynamic Domain Names Service (DNS) to direct each new TCP session. Ecessa WAN link controllers not only provide automatic failover in the event an ISP link fails, they load balance outbound traffic and inbound traffic for optimal application performance. This method is far less expensive, less complicated to deploy and it works much better than BGP. (Tina Plant, n.d.)

Security Considerations

1) All routers have privilege exec mode password

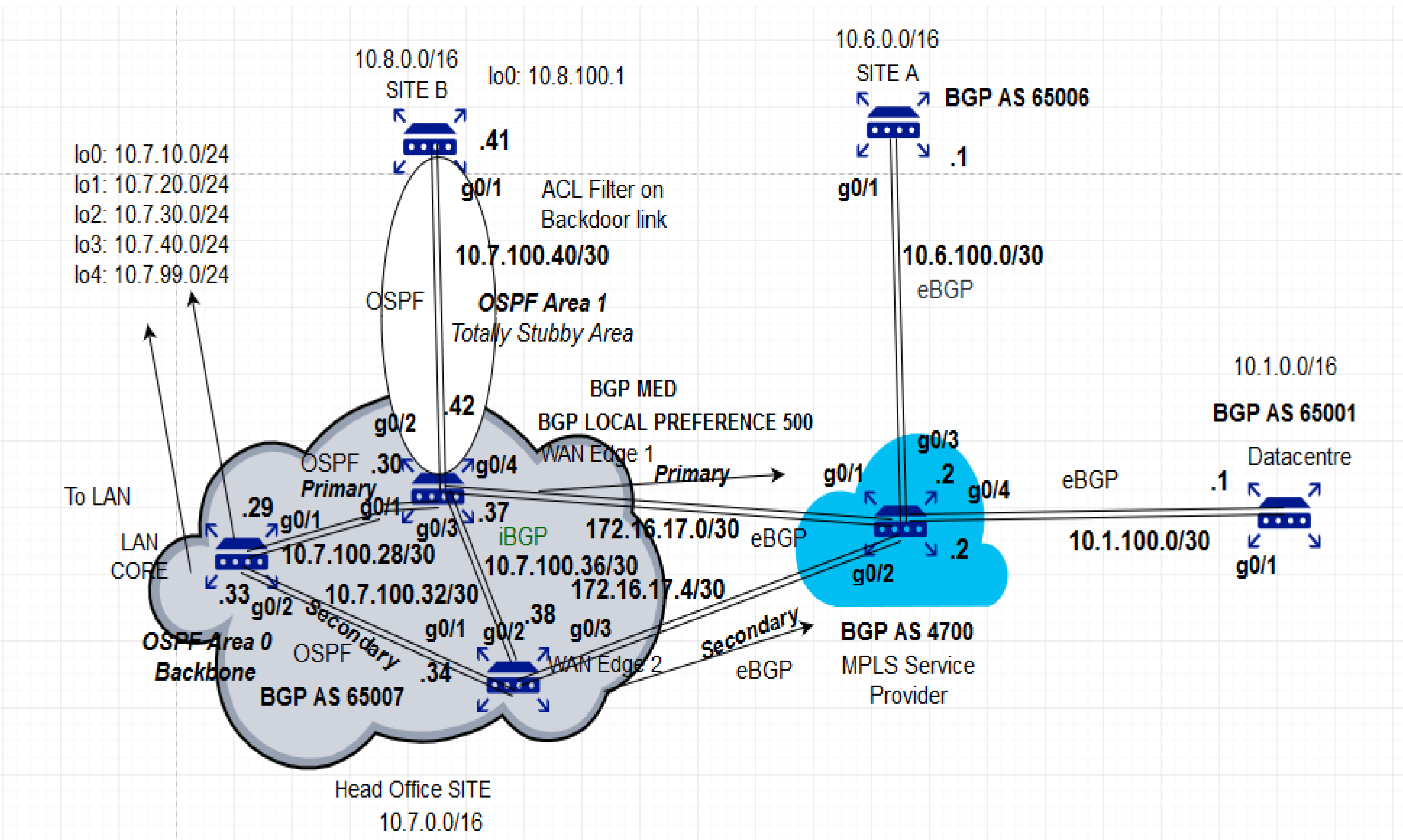
2) Since the link between Edge router 1 and Site B is a backdoor link, it could have security implications and hence access list is implemented to prevent unauthorized access. The access-list only allows users from the Site B LAN and the Head Office Management VLAN to access the backdoor link. To negate the implicit deny, the access-list is configured to allow OSPF, BGP and ping. (Support, Services & TechNotes, n.d.)

3) MD5 authentication is implemented on both OSPF interfaces as well as the BGP interfaces on routers.

4) Unicast RPF is implemented on the Edge routers to prevent malicious activities as it verify the reachability of the source address in packets being forwarded. This capability can limit the appearance of spoofed addresses on a network. If the source IP address is not valid, the packet is discarded. In our enterprise, it is allowed in loose mode so that it doesn't drop legitimate traffic.

To ensure end to end connectivity between Head Office VLANs and Site A, Site B and the datacenter, OSPF routes are redistributed to BGP and vice-versa. OSPF is simply redistributed into BGP but for the other way around, a static default route is defined followed by default-information originate. (Support, Routing & TechNotes, n.d.)

WAN Topology Diagram



Working Configuration

```
Router#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is 10.7.100.30 to network 0.0.0.0

O*E2  0.0.0.0/0 [110/100] via 10.7.100.30, 01:07:35, GigabitEthernet0/1
      10.0.0.0/8 is variably subnetted, 16 subnets, 3 masks
C        10.7.10.0/24 is directly connected, Loopback0
L        10.7.10.1/32 is directly connected, Loopback0
C        10.7.20.0/24 is directly connected, Loopback1
L        10.7.20.1/32 is directly connected, Loopback1
C        10.7.30.0/24 is directly connected, Loopback2
L        10.7.30.1/32 is directly connected, Loopback2
C        10.7.40.0/24 is directly connected, Loopback3
L        10.7.40.1/32 is directly connected, Loopback3
C        10.7.99.0/24 is directly connected, Loopback4
L        10.7.99.1/32 is directly connected, Loopback4
C        10.7.100.28/30 is directly connected, GigabitEthernet0/1
L        10.7.100.29/32 is directly connected, GigabitEthernet0/1
C        10.7.100.32/30 is directly connected, GigabitEthernet0/2
L        10.7.100.33/32 is directly connected, GigabitEthernet0/2
O IA     10.7.100.40/30 [110/2] via 10.7.100.30, 01:19:21, GigabitEthernet0/1
O IA     10.8.100.1/32 [110/3] via 10.7.100.30, 00:05:11, GigabitEthernet0/1
Router#
```

```
Router#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
172.16.17.5       1   FULL/DR         00:00:32    10.7.100.34     GigabitEthernet0/2
172.16.17.1       1   FULL/DR         00:00:38    10.7.100.30     GigabitEthernet0/1
Router#
```

```
Router#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is 172.16.17.2 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 172.16.17.2
      10.0.0.0/8 is variably subnetted, 15 subnets, 3 masks
B        10.1.0.0/16 [20/0] via 172.16.17.2, 00:22:55
B        10.6.0.0/16 [20/0] via 172.16.17.2, 00:22:55
O        10.7.10.1/32 [110/2] via 10.7.100.29, 00:15:13, GigabitEthernet0/1
O        10.7.20.1/32 [110/2] via 10.7.100.29, 00:15:13, GigabitEthernet0/1
O        10.7.30.1/32 [110/2] via 10.7.100.29, 00:15:13, GigabitEthernet0/1
O        10.7.40.1/32 [110/2] via 10.7.100.29, 00:15:13, GigabitEthernet0/1
O        10.7.99.1/32 [110/2] via 10.7.100.29, 00:15:13, GigabitEthernet0/1
C        10.7.100.28/30 is directly connected, GigabitEthernet0/1
L        10.7.100.30/32 is directly connected, GigabitEthernet0/1
O        10.7.100.32/30
           [110/201] via 10.7.100.29, 00:15:13, GigabitEthernet0/1
C        10.7.100.36/30 is directly connected, GigabitEthernet0/3
L        10.7.100.37/32 is directly connected, GigabitEthernet0/3
C        10.7.100.40/30 is directly connected, GigabitEthernet0/2
L        10.7.100.42/32 is directly connected, GigabitEthernet0/2
O        10.8.100.1/32 [110/2] via 10.7.100.41, 00:10:22, GigabitEthernet0/2
      172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
C        172.16.17.0/30 is directly connected, GigabitEthernet0/4
L        172.16.17.1/32 is directly connected, GigabitEthernet0/4
B        172.16.17.4/30 [20/0] via 172.16.17.2, 00:22:55
```

```
Router#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.7.99.1         1   FULL/BDR        00:00:38    10.7.100.29     GigabitEthernet0/1
10.8.100.1        1   FULL/BDR        00:00:39    10.7.100.41     GigabitEthernet0/2
```

```
Router#show ip bgp
BGP table version is 28, local router ID is 172.16.17.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 * i 10.1.0.0/16      172.16.17.6              0    100      0 4700 i
 *>                   172.16.17.2              0             0 4700 i
 * i 10.6.0.0/16      172.16.17.6              0    100      0 4700 i
 *>                   172.16.17.2              0             0 4700 i
 *>  10.7.10.1/32     10.7.100.29              2         32768 ?
 * i                  10.7.100.33              2    100      0 ?
 *>  10.7.20.1/32     10.7.100.29              2         32768 ?
 * i                  10.7.100.33              2    100      0 ?
 *>  10.7.30.1/32     10.7.100.29              2         32768 ?
 * i                  10.7.100.33              2    100      0 ?
 *>  10.7.40.1/32     10.7.100.29              2         32768 ?
 * i                  10.7.100.33              2    100      0 ?
 *>  10.7.99.1/32     10.7.100.29              2         32768 ?
 * i                  10.7.100.33              2    100      0 ?
 *>  10.7.100.28/30   0.0.0.0                  0         32768 i
 * i                  10.7.100.33              2    100      0 ?
 *>  10.7.100.32/30   10.7.100.29            201         32768 ?
 * i                  10.7.100.38              0    100      0 i
 *>  10.7.100.36/30   0.0.0.0                  0         32768 i
 * i                  10.7.100.38              0    100      0 i
 *>  10.7.100.40/30   0.0.0.0                  0         32768 i
 * i                  10.7.100.33              3    100      0 ?
 * i 10.8.100.1/32    10.7.100.33              4    100      0 ?
 *>                   10.7.100.41              2         32768 ?
 r>  172.16.17.0/30   172.16.17.2              0    500      0 4700 i
 * i 172.16.17.4/30   172.16.17.6              0    100      0 4700 i
 *>                   172.16.17.2              0    500      0 4700 i
```

```
Router#show cef interface GigabitEthernet 0/4
GigabitEthernet0/4 is up (if_number 6)
  Corresponding hwidb fast_if_number 6
  Corresponding hwidb firstsw->if_number 6
  Internet address is 172.16.17.1/30
  ICMP redirects are never sent
  Per packet load-sharing is disabled
  IP unicast RPF check is enabled
  Input features: uRPF
  IP policy routing is disabled
  BGP based policy accounting on input is disabled
  BGP based policy accounting on output is disabled
  Hardware idb is GigabitEthernet0/4
  Fast switching type 1, interface type 27
  IP CEF switching enabled
  IP CEF switching turbo vector
  IP prefix lookup IPv4 mtrie 8-8-8-8 optimized
  Input fast flags 0x4000, Output fast flags 0x0
  ifindex 6(6)
  Slot  Slot unit 4 VC -1
  IP MTU 1500
```

```
Router#show access-lists
Standard IP access list 65
    10 permit 172.16.17.0, wildcard bits 0.0.0.3 (16 matches)
    20 permit 172.16.17.4, wildcard bits 0.0.0.3 (15 matches)
    30 permit 10.6.100.0, wildcard bits 0.0.0.3
    40 permit 10.1.100.0, wildcard bits 0.0.0.3
Standard IP access list 99
    10 permit 10.7.10.0, wildcard bits 0.0.0.255 (7 matches)
    20 permit 10.7.20.0, wildcard bits 0.0.0.255 (7 matches)
    30 permit 10.7.30.0, wildcard bits 0.0.0.255 (7 matches)
    40 permit 10.7.40.0, wildcard bits 0.0.0.255 (7 matches)
    50 permit 10.7.99.0, wildcard bits 0.0.0.255 (7 matches)
    60 permit 10.7.100.28, wildcard bits 0.0.0.3 (7 matches)
    70 permit 10.7.100.32, wildcard bits 0.0.0.3 (7 matches)
    80 permit 10.7.100.36, wildcard bits 0.0.0.3 (7 matches)
    90 permit 10.7.100.40, wildcard bits 0.0.0.3 (7 matches)
```

```
Router#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is 172.16.17.6 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 172.16.17.6
      10.0.0.0/8 is variably subnetted, 14 subnets, 3 masks
B        10.1.0.0/16 [20/0] via 172.16.17.6, 00:30:44
B        10.6.0.0/16 [20/0] via 172.16.17.6, 00:30:44
O        10.7.10.1/32 [110/2] via 10.7.100.33, 04:20:06, GigabitEthernet0/1
O        10.7.20.1/32 [110/2] via 10.7.100.33, 04:20:06, GigabitEthernet0/1
O        10.7.30.1/32 [110/2] via 10.7.100.33, 04:20:06, GigabitEthernet0/1
O        10.7.40.1/32 [110/2] via 10.7.100.33, 04:20:06, GigabitEthernet0/1
O        10.7.99.1/32 [110/2] via 10.7.100.33, 04:20:06, GigabitEthernet0/1
O        10.7.100.28/30 [110/2] via 10.7.100.33, 04:20:06, GigabitEthernet0/1
C        10.7.100.32/30 is directly connected, GigabitEthernet0/1
L        10.7.100.34/32 is directly connected, GigabitEthernet0/1
C        10.7.100.36/30 is directly connected, GigabitEthernet0/2
L        10.7.100.38/32 is directly connected, GigabitEthernet0/2
O IA     10.7.100.40/30 [110/3] via 10.7.100.33, 04:20:06, GigabitEthernet0/1
O IA     10.8.100.1/32 [110/4] via 10.7.100.33, 00:17:40, GigabitEthernet0/1
      172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
B        172.16.17.0/30 [200/0] via 172.16.17.2, 00:30:07
C        172.16.17.4/30 is directly connected, GigabitEthernet0/3
L        172.16.17.5/32 is directly connected, GigabitEthernet0/3
```

```
Router#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.7.99.1         1   FULL/BDR        00:00:31    10.7.100.33     GigabitEthernet0/1
```

```
Router#show ip bgp
BGP table version is 26, local router ID is 172.16.17.5
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 * i 10.1.0.0/16      172.16.17.2              0    100      0 4700 i
 *>                   172.16.17.6              0             0 4700 i
 * i 10.6.0.0/16      172.16.17.2              0    100      0 4700 i
 *>                   172.16.17.6              0             0 4700 i
 * i 10.7.10.1/32     10.7.100.29              2    100      0 ?
 *>                   10.7.100.33              2         32768 ?
 * i 10.7.20.1/32     10.7.100.29              2    100      0 ?
 *>                   10.7.100.33              2         32768 ?
 * i 10.7.30.1/32     10.7.100.29              2    100      0 ?
 *>                   10.7.100.33              2         32768 ?
 * i 10.7.40.1/32     10.7.100.29              2    100      0 ?
 *>                   10.7.100.33              2         32768 ?
 * i 10.7.99.1/32     10.7.100.29              2    100      0 ?
 *>                   10.7.100.33              2         32768 ?
 * i 10.7.100.28/30   10.7.100.37              0    100      0 i
 *>                   10.7.100.33              2         32768 ?
 * i 10.7.100.32/30   10.7.100.29            201    100      0 ?
 *>                   0.0.0.0                  0         32768 i
 * i 10.7.100.36/30   10.7.100.37              0    100      0 i
 *>                   0.0.0.0                  0         32768 i
 * i 10.7.100.40/30   10.7.100.37              0    100      0 i
 *>                   10.7.100.33              3         32768 ?
 *>  10.8.100.1/32    10.7.100.33              4         32768 ?
 * i                  10.7.100.41              2    100      0 ?
 *>i 172.16.17.0/30   172.16.17.2              0    500      0 4700 i
 *                    172.16.17.6              0             0 4700 i
 r i 172.16.17.4/30   172.16.17.2              0    500      0 4700 i
 r>                   172.16.17.6              0             0 4700 i
```

```
Router#show cef interface g0/3
GigabitEthernet0/3 is up (if_number 5)
  Corresponding hwidb fast_if_number 5
  Corresponding hwidb firstsw->if_number 5
  Internet address is 172.16.17.5/30
  ICMP redirects are never sent
  Per packet load-sharing is disabled
  IP unicast RPF check is enabled
  Input features: uRPF
  IP policy routing is disabled
  BGP based policy accounting on input is disabled
  BGP based policy accounting on output is disabled
  Hardware idb is GigabitEthernet0/3
  Fast switching type 1, interface type 27
  IP CEF switching enabled
  IP CEF switching turbo vector
  IP prefix lookup IPv4 mtrie 8-8-8-8 optimized
  Input fast flags 0x4000, Output fast flags 0x0
  ifindex 5(5)
  Slot  Slot unit 3 VC -1
  IP MTU 1500
```

```
Router#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is 10.7.100.42 to network 0.0.0.0

O*IA  0.0.0.0/0 [110/2] via 10.7.100.42, 00:22:01, GigabitEthernet0/1
      10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
C        10.7.100.40/30 is directly connected, GigabitEthernet0/1
L        10.7.100.41/32 is directly connected, GigabitEthernet0/1
C        10.8.100.0/30 is directly connected, Loopback0
L        10.8.100.1/32 is directly connected, Loopback0
```

```
Router#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
172.16.17.1       1   FULL/DR         00:00:36    10.7.100.42     GigabitEthernet0/1
```

```
Router#show ip ospf database

            OSPF Router with ID (10.8.100.1) (Process ID 4)

                Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum Link count
10.8.100.1      10.8.100.1      1520        0x8000000D 0x00A1D1 2
172.16.17.1     172.16.17.1     1521        0x8000000C 0x0071DA 1

                Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum
10.7.100.42     172.16.17.1     1516        0x8000000A 0x008FF1

                Summary Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum
0.0.0.0         172.16.17.1     1806        0x80000001 0x00A1CD
```

```
Router#show ip bgp
BGP table version is 222, local router ID is 172.16.17.6
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>  10.1.0.0/16      0.0.0.0                       100  32768 i
 s>  10.1.100.0/30    0.0.0.0                  0         32768 i
 s                    10.1.100.1               0             0 65001 i
 *>  10.6.0.0/16      0.0.0.0                       100  32768 i
 s   10.6.100.0/30    10.6.100.1               0             0 65006 i
 s>                   0.0.0.0                  0         32768 i
 *   10.7.10.1/32     172.16.17.1            100             0 65007 ?
 *>                   172.16.17.5              2             0 65007 ?
 *   10.7.20.1/32     172.16.17.1            100             0 65007 ?
 *>                   172.16.17.5              2             0 65007 ?
 *   10.7.30.1/32     172.16.17.1            100             0 65007 ?
 *>                   172.16.17.5              2             0 65007 ?
 *   10.7.40.1/32     172.16.17.1            100             0 65007 ?
 *>                   172.16.17.5              2             0 65007 ?
 *   10.7.99.1/32     172.16.17.1            100             0 65007 ?
 *>                   172.16.17.5              2             0 65007 ?
 *>  10.7.100.28/30   172.16.17.1            100             0 65007 i
 *                    172.16.17.5              2             0 65007 ?
 *   10.7.100.32/30   172.16.17.1            100             0 65007 ?
 *>                   172.16.17.5              0             0 65007 i
 *   10.7.100.36/30   172.16.17.1            100             0 65007 i
 *>                   172.16.17.5              0             0 65007 i
 *>  10.7.100.40/30   172.16.17.1            100             0 65007 i
 *                    172.16.17.5              3             0 65007 ?
 *>  10.8.100.1/32    172.16.17.5              4             0 65007 ?
 *                    172.16.17.1            200             0 65007 ?
 *>  172.16.17.0/30   0.0.0.0                  0         32768 i
 *>  172.16.17.4/30   0.0.0.0                  0         32768 i
```

```
Router#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 14 subnets, 3 masks
B        10.1.0.0/16 [20/0] via 10.6.100.2, 00:39:21
B        10.6.0.0/16 [20/0] via 10.6.100.2, 00:39:21
C        10.6.100.0/30 is directly connected, GigabitEthernet0/1
L        10.6.100.1/32 is directly connected, GigabitEthernet0/1
B        10.7.10.1/32 [20/0] via 10.6.100.2, 00:39:21
B        10.7.20.1/32 [20/0] via 10.6.100.2, 00:39:21
B        10.7.30.1/32 [20/0] via 10.6.100.2, 00:39:21
B        10.7.40.1/32 [20/0] via 10.6.100.2, 00:39:21
B        10.7.99.1/32 [20/0] via 10.6.100.2, 00:39:21
B        10.7.100.28/30 [20/0] via 10.6.100.2, 00:39:21
B        10.7.100.32/30 [20/0] via 10.6.100.2, 00:39:21
B        10.7.100.36/30 [20/0] via 10.6.100.2, 00:39:21
B        10.7.100.40/30 [20/0] via 10.6.100.2, 00:39:21
B        10.8.100.1/32 [20/0] via 10.6.100.2, 00:29:29
      172.16.0.0/30 is subnetted, 2 subnets
B        172.16.17.0 [20/0] via 10.6.100.2, 00:39:21
B        172.16.17.4 [20/0] via 10.6.100.2, 00:39:21
```

```
Router#show ip bgp
BGP table version is 18, local router ID is 10.6.100.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>  10.1.0.0/16      10.6.100.2               0             0 4700 i
 *>  10.6.0.0/16      10.6.100.2               0             0 4700 i
 *>  10.6.100.0/30    0.0.0.0                  0         32768 i
 *>  10.7.10.1/32     10.6.100.2                             0 4700 65007 ?
 *>  10.7.20.1/32     10.6.100.2                             0 4700 65007 ?
 *>  10.7.30.1/32     10.6.100.2                             0 4700 65007 ?
 *>  10.7.40.1/32     10.6.100.2                             0 4700 65007 ?
 *>  10.7.99.1/32     10.6.100.2                             0 4700 65007 ?
 *>  10.7.100.28/30   10.6.100.2                             0 4700 65007 i
 *>  10.7.100.32/30   10.6.100.2                             0 4700 65007 i
 *>  10.7.100.36/30   10.6.100.2                             0 4700 65007 i
 *>  10.7.100.40/30   10.6.100.2                             0 4700 65007 i
 *>  10.8.100.1/32    10.6.100.2                             0 4700 65007 ?
 *>  172.16.17.0/30   10.6.100.2               0             0 4700 i
 *>  172.16.17.4/30   10.6.100.2               0             0 4700 i
```

```
Router#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 14 subnets, 3 masks
B        10.1.0.0/16 [20/0] via 10.1.100.2, 03:54:05
C        10.1.100.0/30 is directly connected, GigabitEthernet0/1
L        10.1.100.1/32 is directly connected, GigabitEthernet0/1
B        10.6.0.0/16 [20/0] via 10.1.100.2, 03:54:05
B        10.7.10.1/32 [20/0] via 10.1.100.2, 02:30:45
B        10.7.20.1/32 [20/0] via 10.1.100.2, 02:30:45
B        10.7.30.1/32 [20/0] via 10.1.100.2, 02:30:45
B        10.7.40.1/32 [20/0] via 10.1.100.2, 02:30:45
B        10.7.99.1/32 [20/0] via 10.1.100.2, 02:30:45
B        10.7.100.28/30 [20/0] via 10.1.100.2, 00:43:32
B        10.7.100.32/30 [20/0] via 10.1.100.2, 00:44:35
B        10.7.100.36/30 [20/0] via 10.1.100.2, 03:54:36
B        10.7.100.40/30 [20/0] via 10.1.100.2, 00:43:32
B        10.8.100.1/32 [20/0] via 10.1.100.2, 00:31:26
      172.16.0.0/30 is subnetted, 2 subnets
B        172.16.17.0 [20/0] via 10.1.100.2, 03:54:05
B        172.16.17.4 [20/0] via 10.1.100.2, 03:54:05
```

```
Router#show ip bgp
BGP table version is 95, local router ID is 10.1.100.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>  10.1.0.0/16      10.1.100.2               0             0 4700 i
 *>  10.1.100.0/30    0.0.0.0                  0         32768 i
 *>  10.6.0.0/16      10.1.100.2               0             0 4700 i
 *>  10.7.10.1/32     10.1.100.2                             0 4700 65007 ?
 *>  10.7.20.1/32     10.1.100.2                             0 4700 65007 ?
 *>  10.7.30.1/32     10.1.100.2                             0 4700 65007 ?
 *>  10.7.40.1/32     10.1.100.2                             0 4700 65007 ?
 *>  10.7.99.1/32     10.1.100.2                             0 4700 65007 ?
 *>  10.7.100.28/30   10.1.100.2                             0 4700 65007 i
 *>  10.7.100.32/30   10.1.100.2                             0 4700 65007 i
 *>  10.7.100.36/30   10.1.100.2                             0 4700 65007 i
 *>  10.7.100.40/30   10.1.100.2                             0 4700 65007 i
 *>  10.8.100.1/32    10.1.100.2                             0 4700 65007 ?
 *>  172.16.17.0/30   10.1.100.2               0             0 4700 i
 *>  172.16.17.4/30   10.1.100.2               0             0 4700 i
```

Time Sheet

Activity	Date	Time Spent	Description
Understanding the Enterprise WAN Design	**30/5/2018**	**60-80 minutes**	**Cisco Best Practices for WAN design**
OSPF and BGP Revision	**2/6/2018**	**200 minutes**	**I forgot most of the stuff so I went through the slides.**
Configured OSPF	**4/6/2018**	**80 minutes**	**OSPF configuration**
Configured some of the BGP features	**6/6/2018**	**180 minutes**	**Configured basic BGP and redistributed OSPF into it.**

Fixing BGP	**7/6/2018**	**180 minutes**	**Many of the BGP features are not working.**
Fixed BGP and added some security features	**8/6/2018**	**360 minutes**	**Had to do everything again and also added some new features.**
Documenting Everything	**8/6/2018-9/6/2018**	**240 minutes**	**Added everything to the Word document.**

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