Supernetting and CIDR

Internetworking

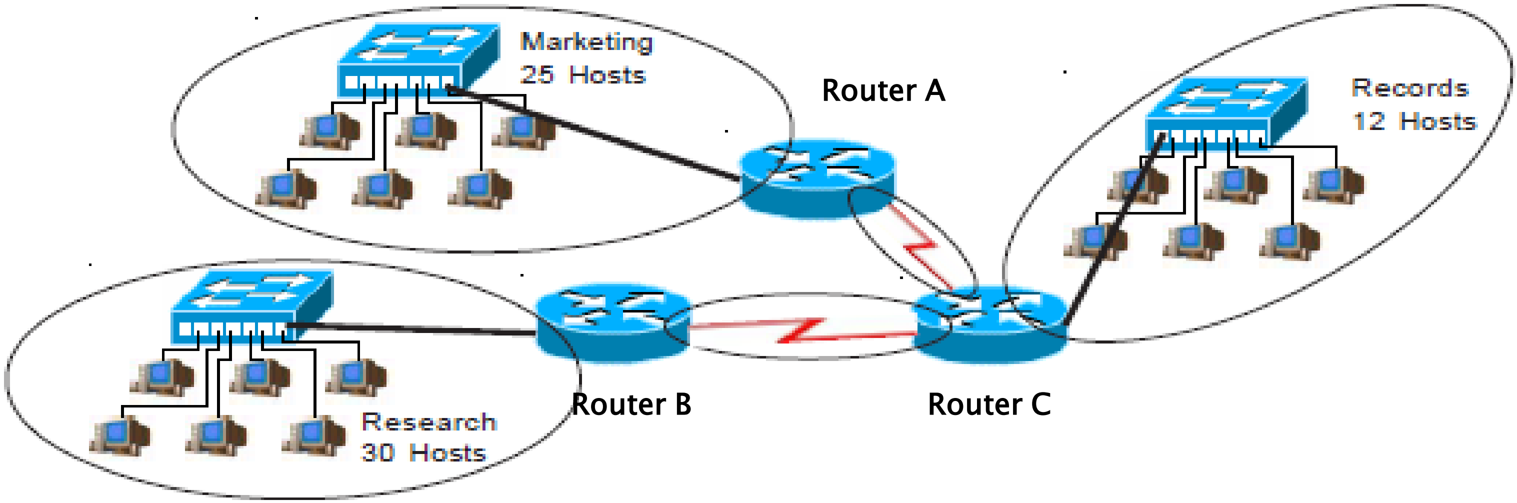
Lecture 5

IP Addresses & Subnets

- Comparison of:
  - Classless Subnetting
  - VLSM (Classless)
- Variable Length Subnet Mask – VLSM
- Classless Inter-Domain Routing – CIDR
- Supernetting

Let’s start with a task..

IP Address: 192.168.1.0



The above network requires the creation of 5 subnets:

- Marketing: 25 usable host addresses (total 27)
- Research: 30 usable host addresses (total 32)
- Records: 12 usable host addresses (total 14)
- WAN link A – C: 2 usable host addresses (total 4)
- WAN link B – C: 2 usable host addresses (total 4)

Classful vs Classless (VLSM)

Research:
192.168.1.0 -192.168.1.31 /27
Marketing:
192.168.1.32 – 192.168.1.63 /27
Records:
192.168.1.64 – 192.168.1.95 /27
Link A-C:
192.168.1.96 – 192.168.1.127 /27
Link B-C:
192.168.1.128 – 192.168.1.159 /27

- 192.168.1.160 – 192.168.1.191 /27
- 192.168.1.192 – 192.168.1.223 /27
- 192.168.1.224 – 192.168.1.255 /27

Classful – 8 equally sized subnets

Research:
192.168.1.0 – 192.168.1.31 /27
Marketing:
192.168.1.32 – 192.168.1.63 /27
Records:
192.168.1.64 – 192.168.1.79 /28
Link A-C:
192.168.1.80 – 192.168.1.83 /30
Link B-C:
192.168.1.84 – 192.168.1.87 /30

- 192.168.1.88 – 192.168.1.95 /29
- 192.168.1.96 – 192.168.1.127 /27
- 192.168.1.128 – 192.168.1.255 /25

VLSM – 8 variable sized subnets

Utilisation of addressing space

Classful approach

Research:
32/32 → 100%
Marketing:
27/32 → 84%
Records:
14/32 → 44%
Link A–C:
4/32 → 13%
Link B–C:
4/32 → 13%

Total addresses reserved:
160/256 → 62.5%

Classless approach

Research:
32/32 → 100%
Marketing:
27/32 → 84%
Records:
14/16 → 88%
Link A–C:
4/4 → 100%
Link B–C:
4/4 → 100%

Total addresses reserved:
88/256 → 34.4%

Variable Length Subnet Mask

- Allows more than one subnet mask in the same network
  - Efficient use of an organisation's IP address space
    - Create subnets significantly different in size
    - Consider a 4 host network with mask 255.255.255.0 → it wastes 250 IP addresses
  - Allows route aggregation → less routing information
- VLSM needs to be supported by the routing protocol (RIPv2, OSPF, EIGRP, BGP)

Requirements for VLSM

- Routing table → need to specify the extended network prefix information (subnet mask) for every entry.
- Routing protocol → must carry extended network prefix information with each route advertisement
  - 131.175.192.0 = 10000011.10101111.11000000.00000000
  - Prefix /27 →
  - 255.255.250.224 = 11111111.11111111.11111111.11100000
- VLSM is usually compatible with more complex routing protocols such as OSPF even for small networks

Requirements for VLSM

- "Longest Match" forwarding algorithm
  - When you have two or more matching entries in your routing table for a specific destination → select the longest match!

→ "Longest Match" Forwarding Algorithm

IP packet
Destination: 11.1.2.5

Routing table		
11.0.0.0	/8	Route 1
11.1.0.0	/16	Route 2
11.1.2.0	/24	Route 3

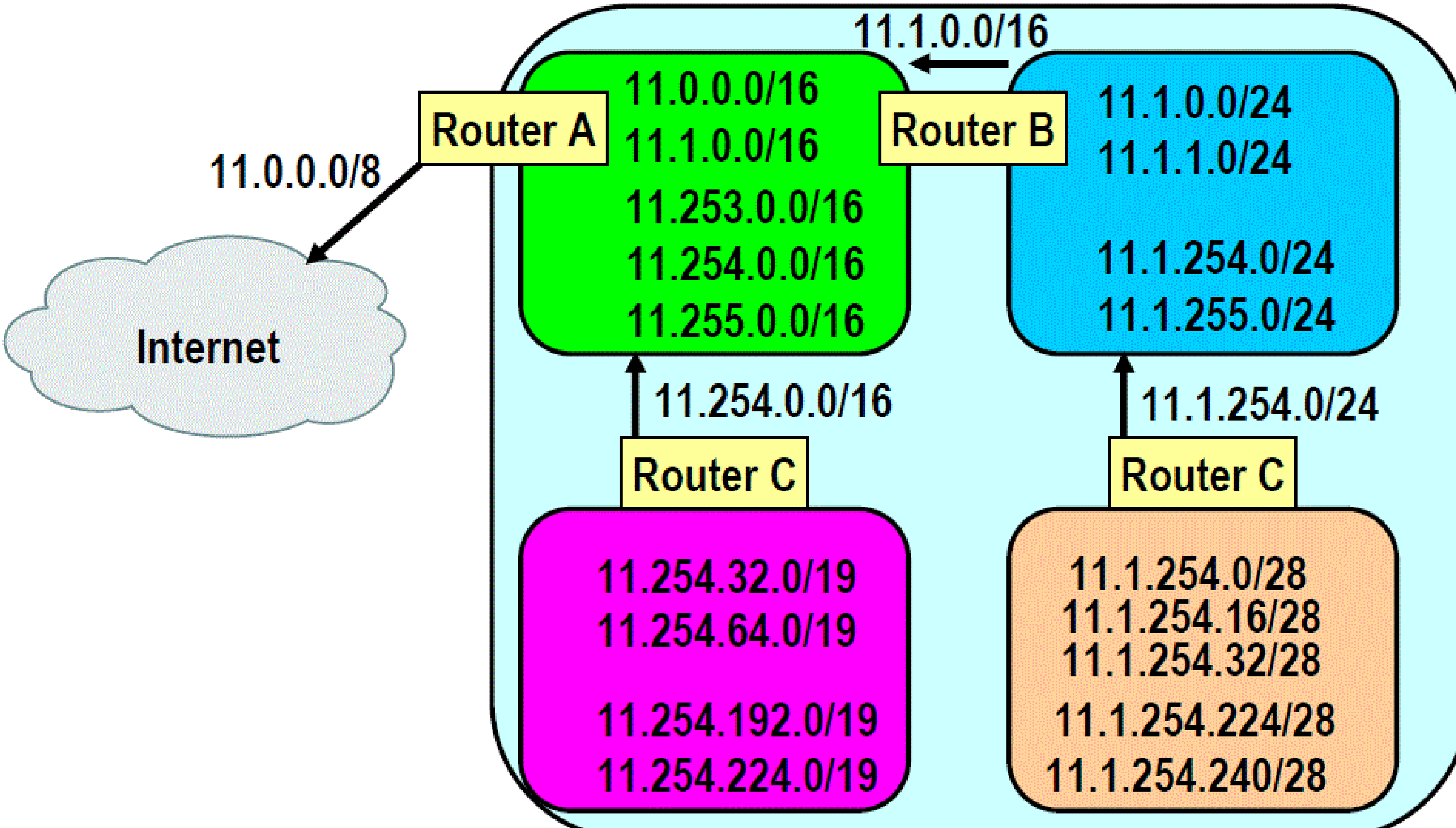
Three matches

Best (longest) match

Longest match = smaller network

Route aggregation – VLSM

- VLSM allows to hide the detailed structure of routing information for one subnet group from other routers
  - Reduces the size of the routing table!

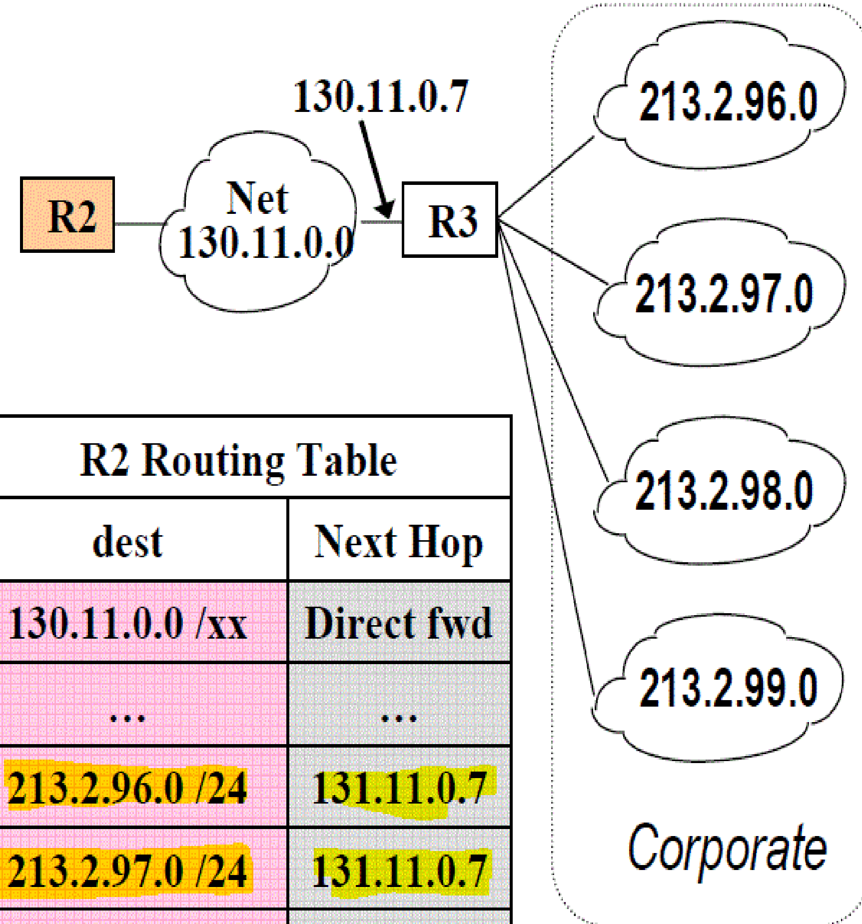


Classless Inter-Domain Routing

- CIDR was officially developed in September 1993
- CIDR is also called Supernetting
- It was considered a fundamental solution for the routing table problem
- It was a temporary solution to Internet address space depletion.
  - IPv4 = 32 bits → quickly proved to be inadequate
    - Internet grew exponentially
    - Billions interconnected devices
  - Inefficient address assignment in early days
  - Ultimate solution was soon implemented
    - IPv6 !

Routing table problem – CIDR

- Introduced to replace the classful IP addressing method.
- Class C addresses
  - Not enough hosts?
- Class B addresses
  - Too many hosts?
- N*class C
  - Not wise, exponential growth of routing tables
- Class B addresses → the only feasible option → quickly exhausted!



R2 Routing Table	
dest	Next Hop
130.11.0.0 /xx	Direct fwd
...	...
213.2.96.0 /24	131.11.0.7
213.2.97.0 /24	131.11.0.7
213.2.98.0 /24	131.11.0.7
213.2.99.0 /24	131.11.0.7

Classless Inter-Domain Routing

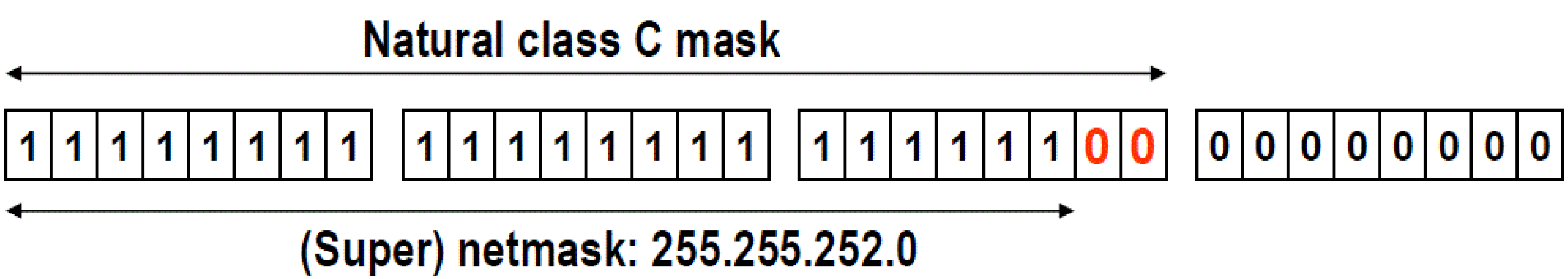
- Follows a classless approach
  - The classful concept completely abandoned
- Requires to specify the network prefix
  - Routers do not identify IP classes.
  - Network prefix is needed to identify the division point between the net_id and host_id
  - Prefix needs to be supported by the routing protocol
- CIDR is similar to VLSM but applies to the whole Internet.

Classless addresses (CIDR)

- 10.23.64.0/25 = 00001010.00010111.01000000.00000000
- 130.5.10.0/25 = 10000010.00000101.00000110.00000000
- 200.7.128.0/25 = 11001000.00000111.10000000.00000000
- What is the difference between these network addresses?
  - None! They are similar as they all have 126 usable hosts available.

CIDR – Supernetting

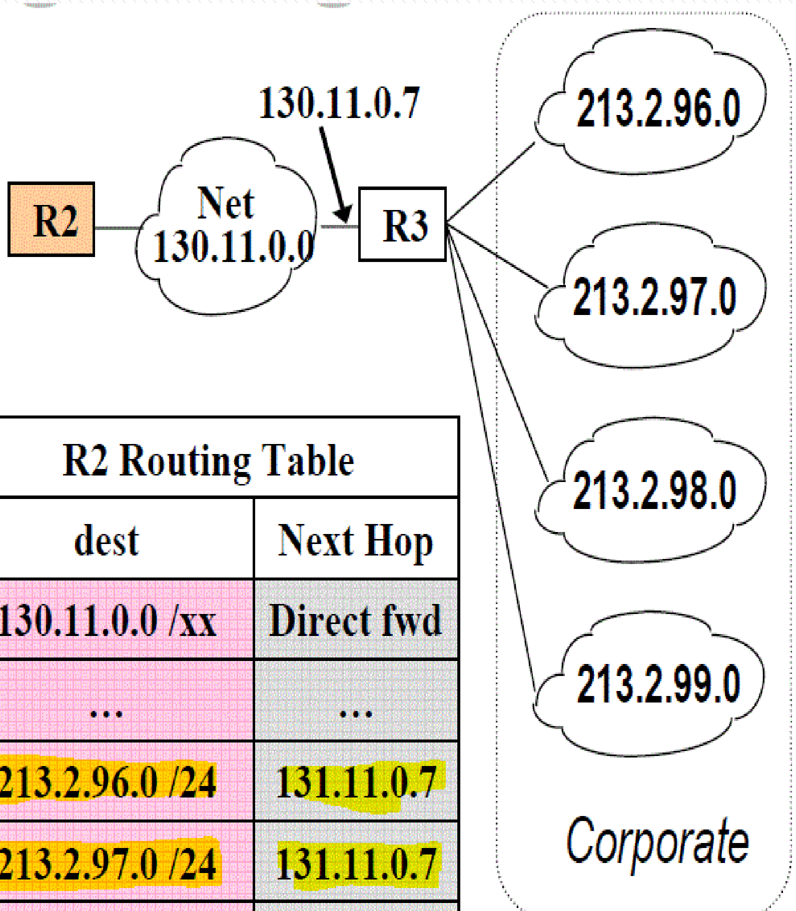
- Supernetting is combining several small (class C) networks into a big one to create a large range of addresses.
  - Example: An organisation is assigned a range of 2^n class C addresses
    - The range is contiguous
    - Addressing: Reserve network bits for use by host_id
      - The opposite of subnetting!



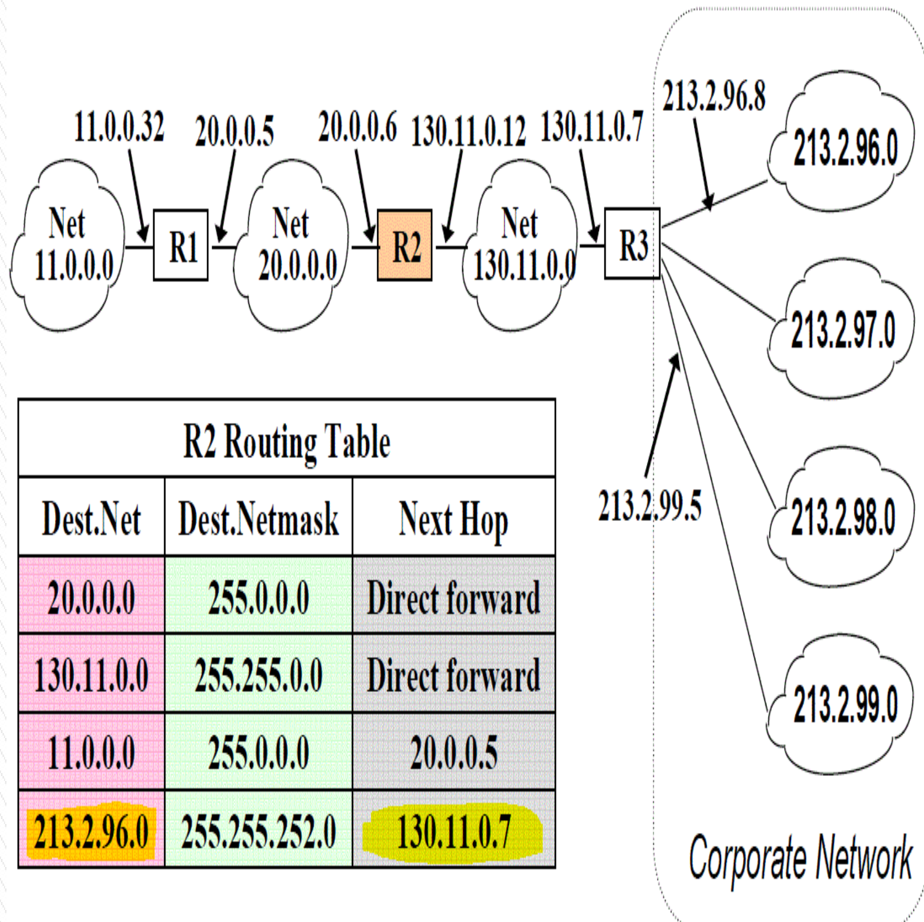
Supernetting – Addressing

- You have been assigned 4 contiguous network addresses:
  - 213.2.96.0 → 11010101.00000010.01100000.00000000
  - 213.2.97.0 → 11010101.00000010.01100001.00000000
  - 213.2.98.0 → 11010101.00000010.01100010.00000000
  - 213.2.99.0 → 11010101.00000010.01100011.00000000
  - Two bits reserved → 2^2 class C networks included into the new supernet
- Supernet mask:
  - 255.255.252.0
- Supernet address:
  - 213.2.96.0/22
  - **11010101.00000010.011000 00.00000000**

Routing table problem – solved



R2 Routing Table	
dest	Next Hop
130.11.0.0 /xx	Direct fwd
…	…
213.2.96.0 /24	131.11.0.7
213.2.97.0 /24	131.11.0.7
213.2.98.0 /24	131.11.0.7
213.2.99.0 /24	131.11.0.7



R2 Routing Table		
Dest.Net	Dest.Netmask	Next Hop
20.0.0.0	255.0.0.0	Direct forward
130.11.0.0	255.255.0.0	Direct forward
11.0.0.0	255.0.0.0	20.0.0.5
213.2.96.0	255.255.252.0	130.11.0.7

Corporate Supernet address: 213.2.96.0/22

11010101 . 00000010 . 011000 00 . 00000000

CIDR – Example

- An ISP has been allocated the network address 192.10.64.0/19.
- What is the network mask
- What are the first and last host addresses in the range?
- How many (usable) host addresses can the ISP allocate?

CIDR – Example

- Network mask
  - Can be calculated by setting the network ID to all 1s

- Network address:
  - Class C address: 192.10.64.0/19
  - Default mask = 24 bits
    - 11111111.11111111.11111111.00000000
  - New mask = 19 bits
    - 11111111.11111111.111|00000.00000000
    - 255.255.224.0

  - The **BLUE** bits are the bits we borrowed from the default net_ID
  - 11000000.00001010.010|00000.00000000
    - 192.10.64.0/19

CIDR – Example

- The network address is:
  - 192.10.64.0/19→ 11000000.00001010.010|00000.00000000

- The first network host address is:
  - 192.10.64.1→ 11000000.00001010.010|00000.00000001
- The broadcast address for the network is:
  - 192.10.95.255→ 11000000.00001010.010|11111.11111111
- The last host address for the network is:
  - 192.10.95.254→ 11000000.00001010.010|11111.11111110
- Number of addresses the ISP allocate:
  - There are 13 host_id bits available → $2^{13} = 8192$
  - $8192-2 = 8190$ usable IP addresses

CIDR & large networks

- Organisation assigned 2^n class C addresses

- May arbitrarily deploy subnetworks with more than 254 hosts
  - Previously impossible with classful IP assignment
    - Default netmask = /24 (bits)
- ALL subnet hosts need to accept netmasks larger than the default ones – software permitted
  - Software might not allow to use netmask 255.255.252.0 for host address 193.28.33.52

CIDR – Requirements

- The same as VLSM
  - But on a worldwide scale
- Routing protocol must carry network prefix information for every advertised route
- Routers must implement a consistent forwarding algorithm based on the “longest match”
- Route aggregation can happen only if topologically significant addresses are assigned (see next slide)

CIDR allocation

- Topological allocation of ex class C addresses

Multi regional	192.0.0.0 - 193.255.255.255
Europe	194.0.0.0 - 195.255.255.255
Others	196.0.0.0 - 197.255.255.255
North America	198.0.0.0 - 199.255.255.255
Central-South America	200.0.0.0 - 201.255.255.255
Pacific Rim	202.0.0.0 - 203.255.255.255
Others	204.0.0.0 - 205.255.255.255
Others	206.0.0.0 - 207.255.255.255
IANA reserved	208.0.0.0 - 223.255.255.255

All are class C blocks, since class B blocks are no more allocated…

- Next Week
  - Dynamic Routing
    - Distance Vector
    - Link State
    - Metrics used
    - Autonomous systems