21ES614 – Internet of Things

Sivraj P, Asst. Professor,
Dept. of EEE, Amrita School of Engineering
Amrita Vishwa Vidyapeetham

Syllabus

Unit 1

Introduction to IoT - Definitions, frameworks and key technologies. Functional blocks of IoT systems: hardware and software elements- devices, communications, services, management, security, and application. Challenges to solve in IoT

Unit 2

Basics of Networking & Sensor Networks - Applications, challenges - ISO/OSI Model, TCP/IP Model, Sensor network architecture and design principles, IoT technology stack, Communication models. Communication Protocols - Overview of protocols in each layer, Application protocols for the transfer of sensor data, Infrastructure for IoT: LoRa-Wan, 6LoWPAN, 5G and Sigfox.

Unit 3

Introduction to Cloud, Fog and Edge Computing. Modern trends in IoT – Industrial IoT, Wearable. Applications of IoT - Smart Homes/Buildings, Smart Cities, Smart Industry, and Smart Medical care, Smart Automation etc.

Network Layer - Revisiting

- Routing
- Logical Addressing
- Connectionless delivery
- Connection services are provided including network layer flow control, network layer error control and packet sequence control
- Network layer devices – Routers and Gateways

Ref: https://networkhope.in/iso-osi-basic-reference-model/
http://cs.uok.edu.in/Files/79755f07-9550-4aeb-bd6f-5d802d56b46d/Custom/ADC%20unit%202.pdf
https://www.studytonight.com/computer-networks/complete-osi-model
https://www.geeksforgeeks.org/layers-of-osi-model/

Network Layer – Flow Control

- Routing metric - Congestion
- Congestion free links
- Networks of different character – data rate

Ref: https://www.studytonight.com/computer-networks/network-layer-in-computer-networks

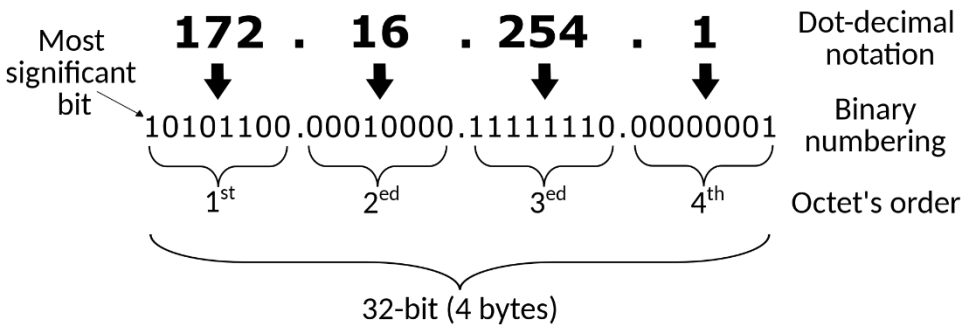
Network Layer – Error Control

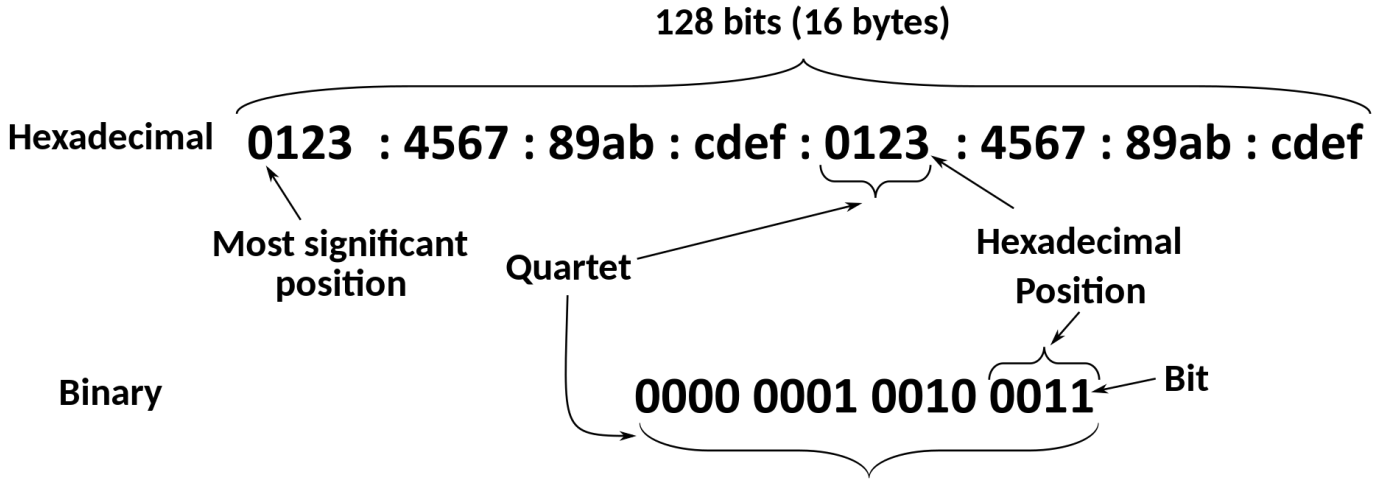
- Error in header addressed
- Header - IP Addresses and control bits
- Checksum - Trailer

Ref: https://www.studytonight.com/computer-networks/network-layer-in-computer-networks

Network Layer - IP Address

- Identifier that allows information to be sent between devices on a network
- Contain location information and make devices accessible for communication





Ref: https://www.kaspersky.com/resource-center/definitions/what-is-an-ip-address
https://en.wikipedia.org/wiki/IPv4 ; https://en.wikipedia.org/wiki/IPv6
https://medium.com/@sadatnazrul/basics-of-ip-addresses-in-computer-networking-f1a4661ea85c

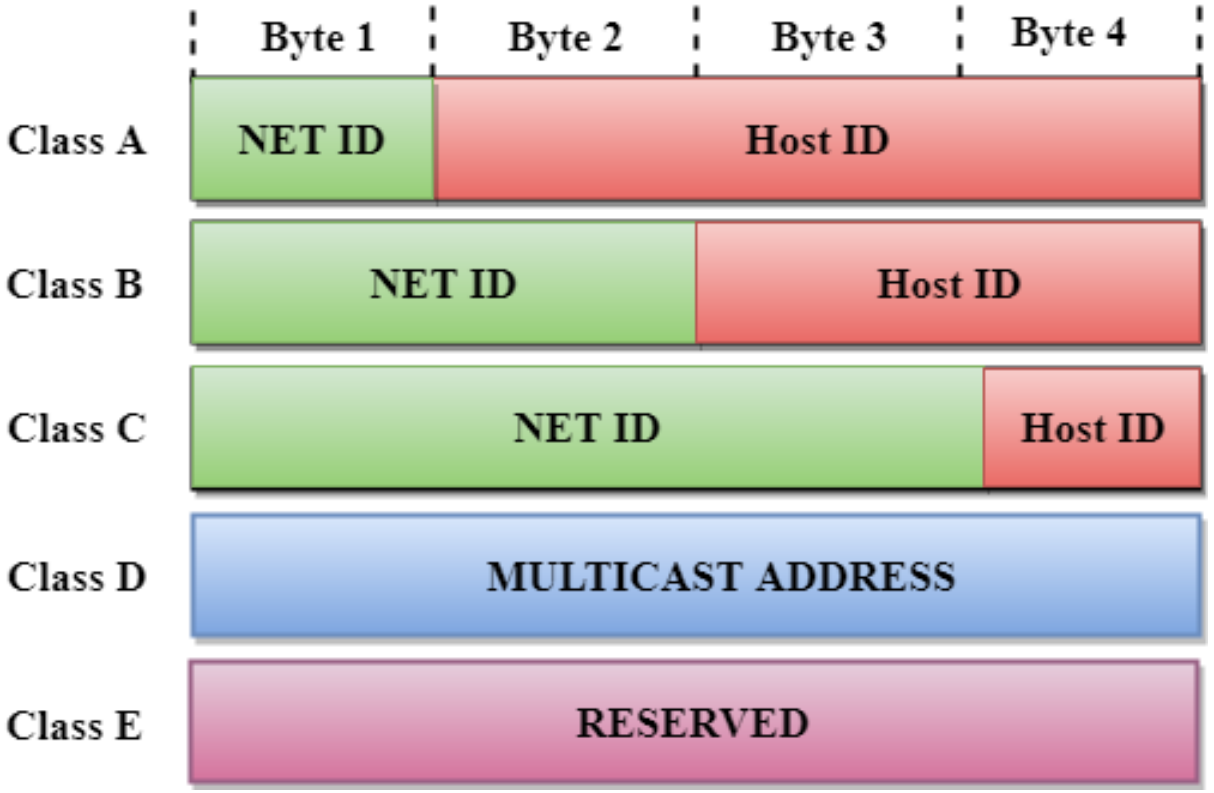
Network Layer - IP Address - Types

- Public IP Address
- Private IP Address
- Static IP Address
- Dynamic IP Address
- Shared IP Address
- Dedicated IP Address
- Unicast/Broadcast/Multicast/Anycast

Ref: https://www.kaspersky.com/resource-center/definitions/what-is-an-ip-address
https://www.javatpoint.com/ip-address
https://www.guru99.com/types-of-ip-addresses.html

Network Layer – IPv4- Classes

- Network ID
- Host ID
- Subnet ID
- Subnet Mask



Ref: https://www.javatpoint.com/network-addressing
https://medium.com/@sadatnazrul/basics-of-ip-addresses-in-computer-networking-f1a4661ea85c
https://docs.microsoft.com/en-us/troubleshoot/windows-client/networking/tcpip-addressing-and-subnetting

Network Layer – IPv4- Classes

- **0.0.0.0** - Default network address.
- **255.255.255.255** - Network broadcast
- **127.0.0.1** - Loopback address
- **169.254.0.1** to **169.254.255.254** - Automatic Private IP Addressing (APIPA) range of addresses assigned automatically when a computer is unsuccessful in getting an address from a DHCP server.

Class	Higher bits	NET ID bits	HOST ID bits	No.of networks	No.of hosts per network	Range
A	0	8	24	2^7	2^{24}	0.0.0.0 to 127.255.255.255
B	10	16	16	2^{14}	2^{16}	128.0.0.0 to 191.255.255.255
C	110	24	8	2^{21}	2^8	192.0.0.0 to 223.255.255.255
D	1110	Not Defined	Not Defined	Not Defined	Not Defined	224.0.0.0 to 239.255.255.255
E	1111	Not Defined	Not Defined	Not Defined	Not Defined	240.0.0.0 to 255.255.255.255

Ref: https://www.javatpoint.com/network-addressing
https://medium.com/@sadatnazrul/basics-of-ip-addresses-in-computer-networking-f1a4661ea85c
https://docs.microsoft.com/en-us/troubleshoot/windows-client/networking/tcpip-addressing-and-subnetting

Network Layer – IPv4- Classless Addressing

- CIDR - Classless Inter Domain Routing
- When a user asks for specific number of IP Addresses,
  - CIDR dynamically assigns a block of IP Addresses based on certain rules.
  - This block contains the required number of IP Addresses as demanded by the user.
  - This block of IP Addresses is called as a **CIDR block**
- CIDR Notation - a.b.c.d / n 182.0.1.2 / 28

Ref: https://www.tutorialspoint.com/classful-vs-classless-addressing
https://binaryterms.com/classless-addressing-in-ipv4.html
https://www.gatevidyalay.com/classless-addressing-cidr/

Network Layer – IPv4- Classless Addressing

- Rules For Creating CIDR Block
  - All the IP Addresses in the CIDR block must be contiguous
  - The size of the block must be presentable as power of 2
  - First IP Address of the block must be divisible by the size of the block

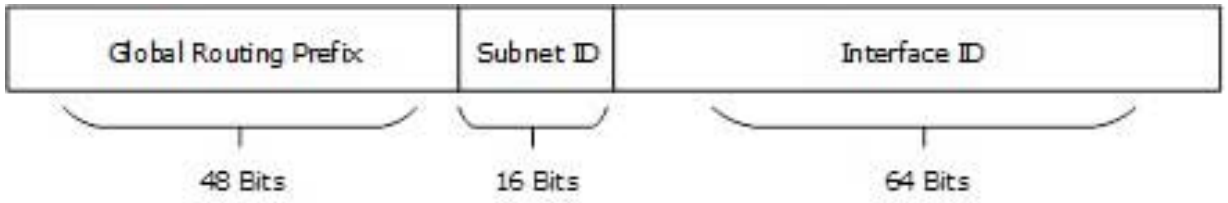
Ref: https://www.tutorialspoint.com/classful-vs-classless-addressing
https://binaryterms.com/classless-addressing-in-ipv4.html
https://www.gatevidyalay.com/classless-addressing-cidr/

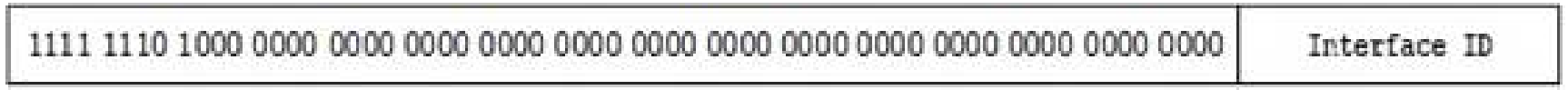
Network Layer – IPv6-Types

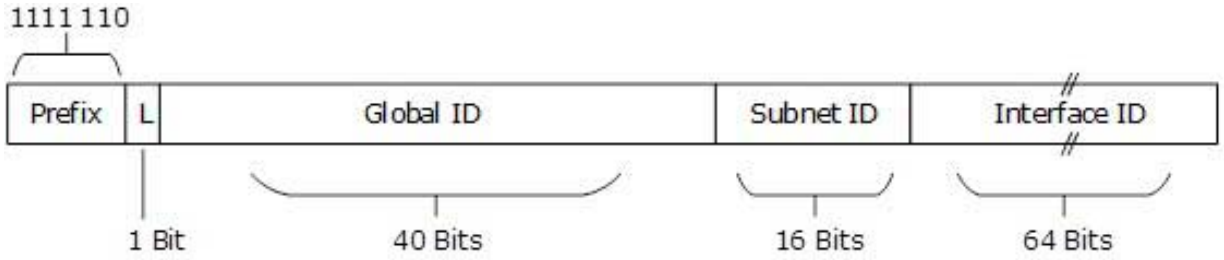
- Global unicast - Starts with "2001:" as the prefix group. Global unicast addresses are the equivalent of IPv4 public addresses.
- Anycast address - Used to identify a group of interfaces on different nodes.
- Multicast address - An address used to define multicast.
- Link local addresses - One of the two internal address types that are not routed on the internet. Link local addresses are used inside an internal network, are self-assigned and start with "fe80:" as the prefix group.
- Unique local addresses. This is the other type of internal address that is not routed on the internet. Unique local addresses are equivalent to the IPv4 addresses 10.0.0.0/8, 172.16.0.0/12 and 192.168.0.0/16.

Ref: https://internetofthingsagenda.techtarget.com/definition/IPv6-address
https://www.tutorialspoint.com/ipv6/ipv6_address_types.htm
http://www.steves-internet-guide.com/ipv6-guide/

Network Layer – IPv6-Types





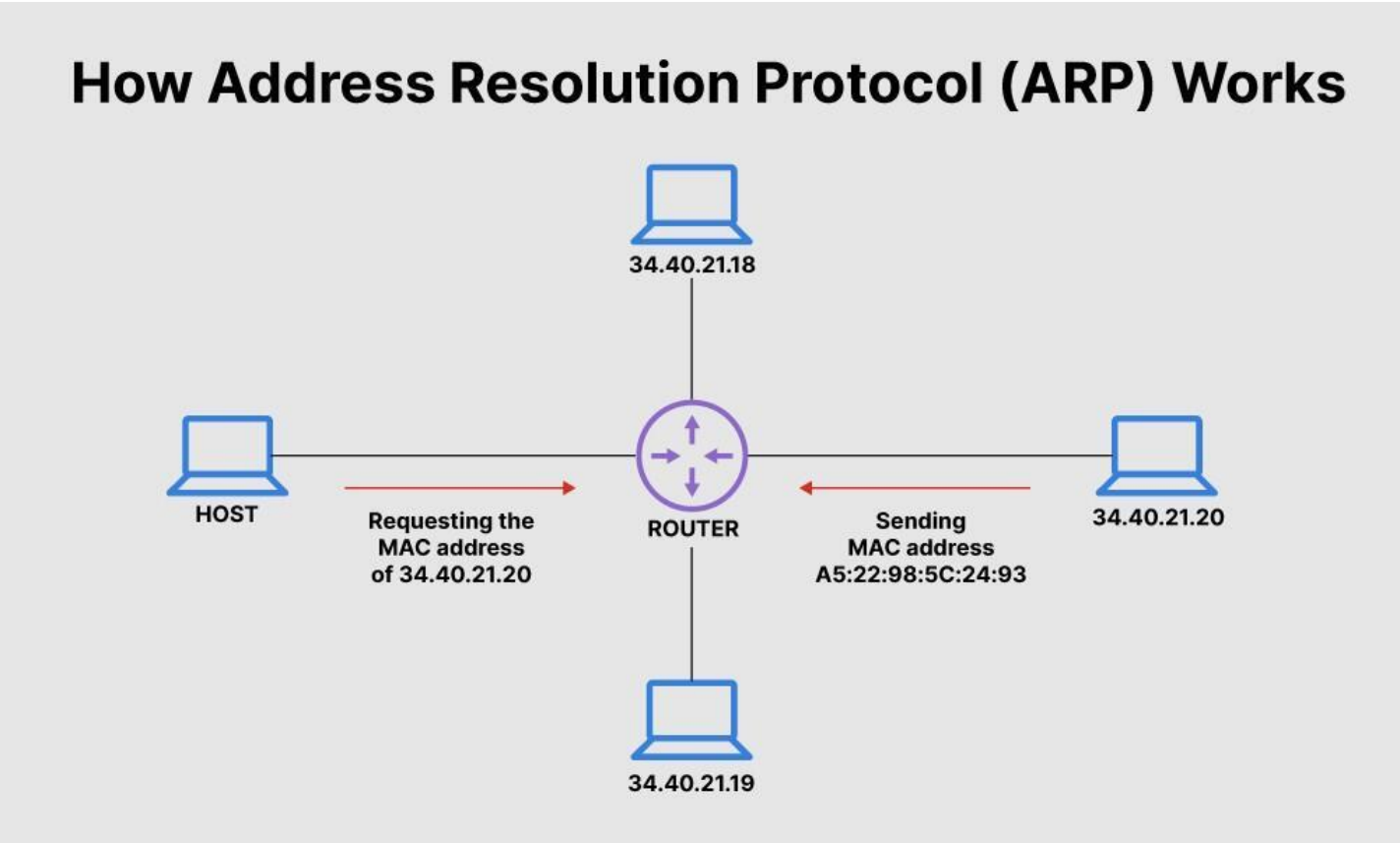


Ref: https://internetofthingsagenda.techtarget.com/definition/IPv6-address
https://www.tutorialspoint.com/ipv6/ipv6_address_types.htm
http://www.steves-internet-guide.com/ipv6-guide/

Network Layer – Binding

- ARP – Link Layer Protocol

- Table lookup
- Dynamic
- Closed-form computation



Ref: https://www.fortinet.com/resources/cyberglossary/what-is-arp
https://www.javatpoint.com/address-resolution-protocol-and-its-types
https://www.guru99.com/address-resolution-protocol.html

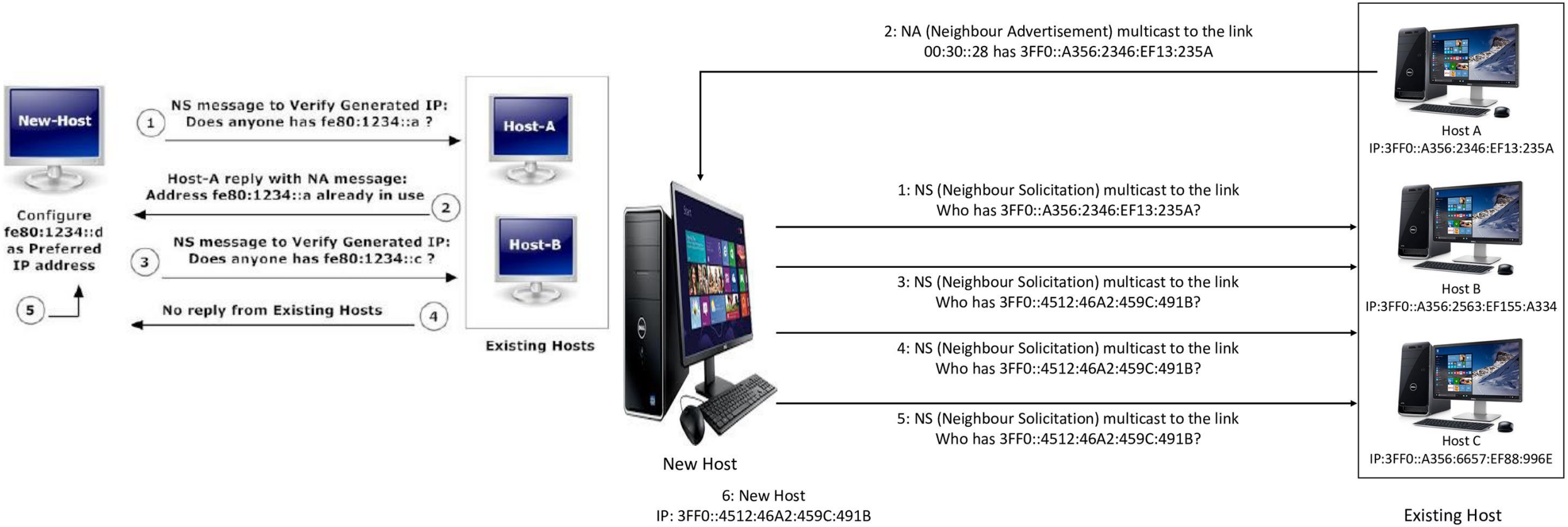
ARP - Types

- Proxy ARP
- Gratuitous ARP
- Reverse ARP
- Inverse ARP

Ref: https://www.fortinet.com/resources/cyberglossary/what-is-arp
https://www.javatpoint.com/address-resolution-protocol-and-its-types
https://www.guru99.com/address-resolution-protocol.html

Network Layer – DAD

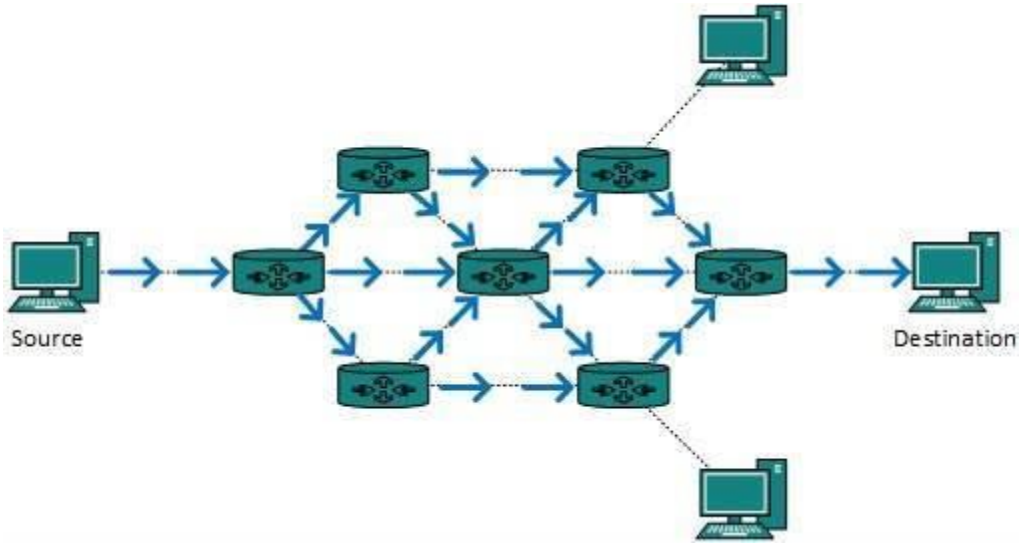
- Duplicate Address Detection



Ref: http://dx.doi.org/10.14257/ijsia.2015.9.11.08
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0214518

Network Layer – Routing - Types

- Default Routing
- Static Routing (Non-adaptive)
- Dynamic Routing (Adaptive)

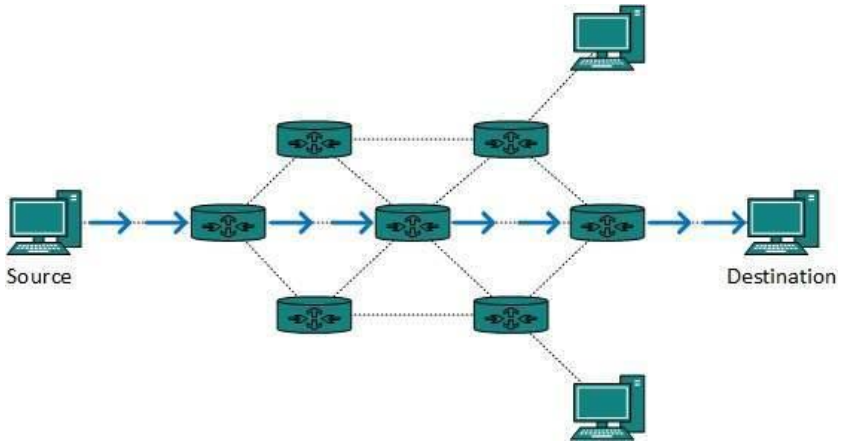


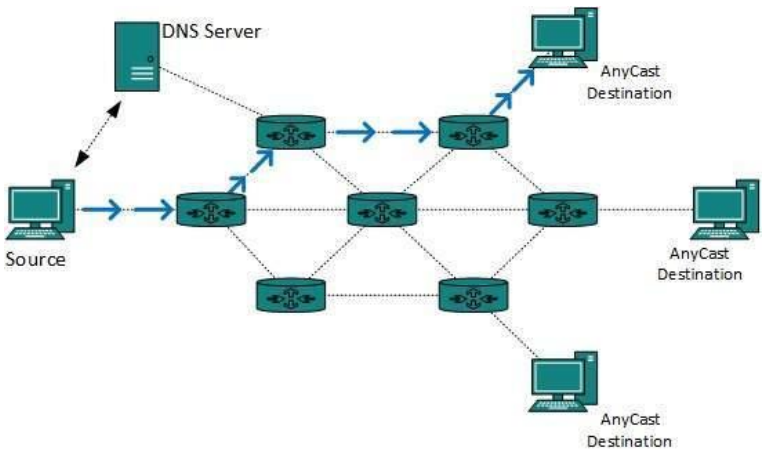
- Isolated
- Centralized
- Distributed

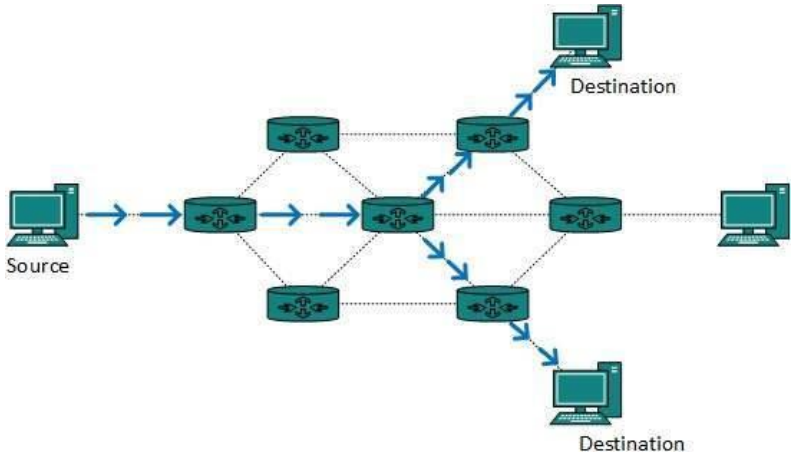
Ref: https://www.javatpoint.com/computer-network-routing
https://www.tutorialspoint.com/data_communication_computer_network/network_layer_routing.htm
https://www.javatpoint.com/computer-network-routing-algorithm

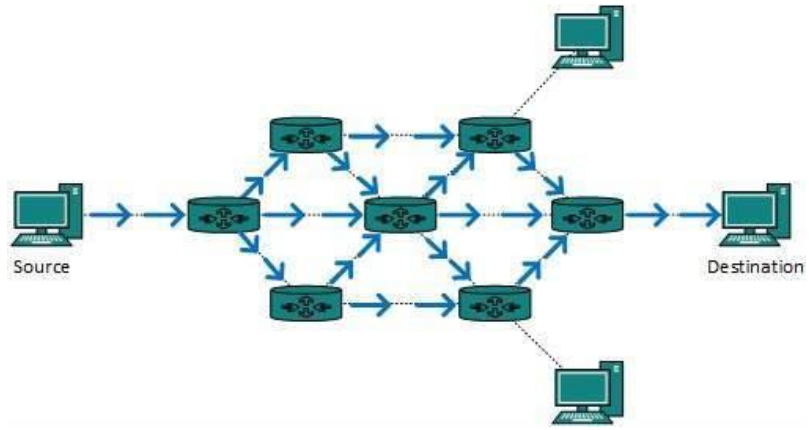
Network Layer – Routing - Types

- Unicast Routing
- Broadcast Routing
- Multicast Routing
- Anycast Routing









Ref: https://www.javatpoint.com/computer-network-routing
https://www.tutorialspoint.com/data_communication_computer_network/network_layer_routing.htm

Network Layer – Routing - Metrics

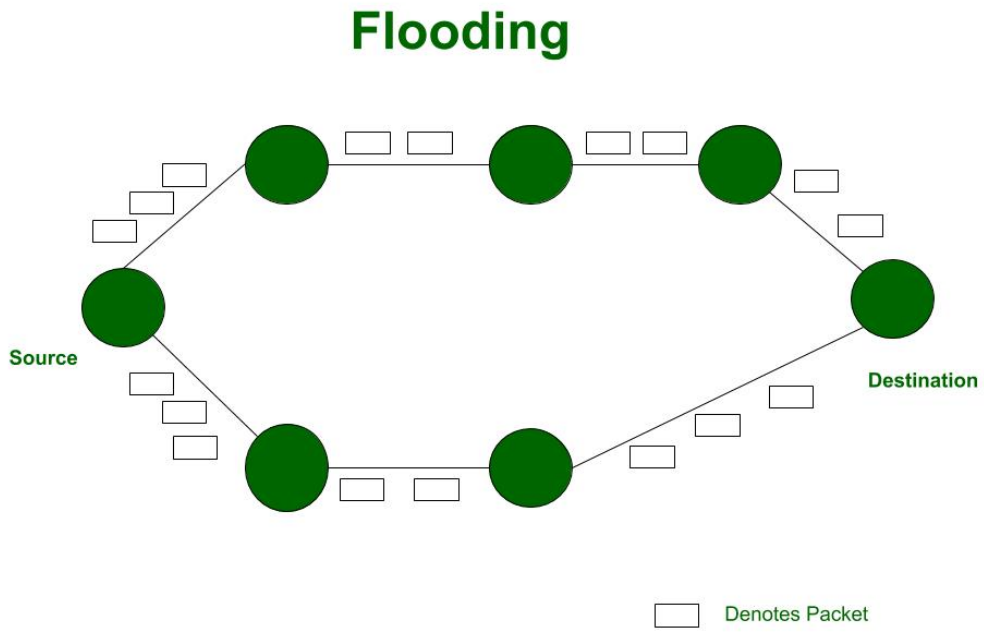
- Hop Count
- Energy
- Distance
- Traffic
- Delay
- Noise (Quality)
- Many more…

Ref: https://www.javatpoint.com/computer-network-routing
https://www.tutorialspoint.com/data_communication_computer_network/network_layer_routing.htm

Network Layer – Routing - Flooding

- Uncontrolled Flooding
- Controlled Flooding (Gossiping)
- Selective Flooding (Rumour Routing)

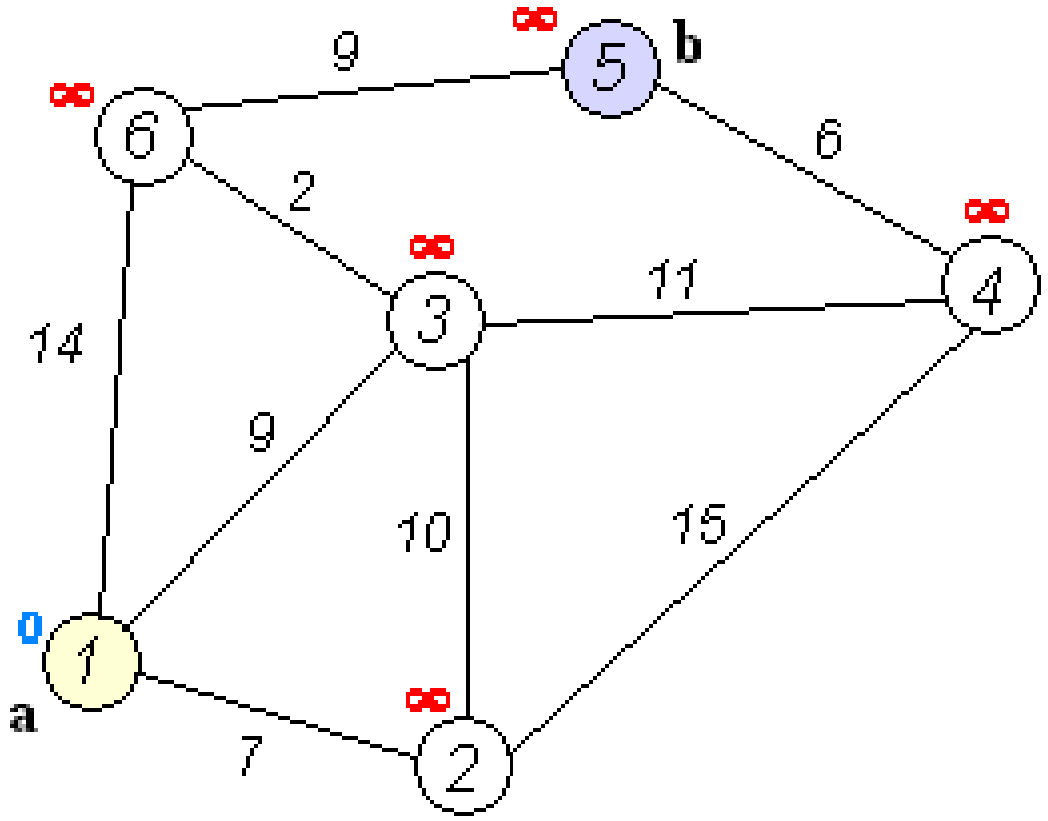
- Random Walks



Ref: https://geeksgod.com/routing-vs-flooding-a-creative-comparison/
https://www.javatpoint.com/computer-network-routing-algorithm
https://www.tutorialspoint.com/flooding-in-computer-network

Network Layer – Routing – Shortest Path

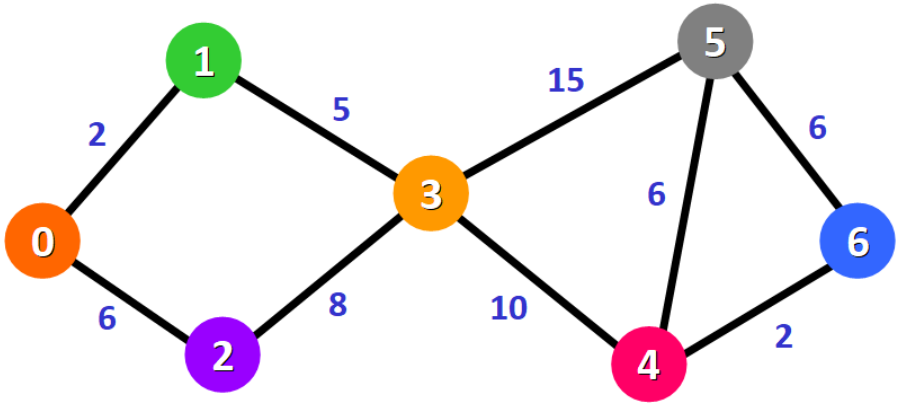
- Dijkstra's shortest path algorithm
- Set of unvisited nodes
- Set of visited nodes
- Source node
- Distance to all nodes (0, ∞)
- Visit all nodes & update distance



Ref: https://en.wikipedia.org/wiki/Dijkstra%27s_algorithm
https://www.geeksforgeeks.org/dijkstras-shortest-path-algorithm-greedy-algo-7/

Network Layer – Routing – Shortest Path

- Dijkstra's shortest path algorithm



Unvisited Nodes: {0, 1, 2, 3, 4, 5, 6}

Distance:

0: 0
1: ∞
2: ∞
3: ∞
4: ∞
5: ∞
6: ∞

Unvisited Nodes: {~~0~~, 1, 2, 3, 4, 5, 6}

Distance:

0: 0
1: ~~∞~~ 2
2: ~~∞~~ 6
3: ∞
4: ∞
5: ∞
6: ∞

Distance

0: 0
1: ~~∞~~ 2 ■
2: ~~∞~~ 6
3: ∞
4: ∞
5: ∞
6: ∞

Unvisited Nodes: {~~0~~, ~~1~~, 2, 3, 4, 5, 6}

Distance:

0: 0
1: ~~∞~~ 2 ■
2: ~~∞~~ 6
3: ~~∞~~ 7
4: ∞
5: ∞
6: ∞

Distance:

0: 0
1: ~~∞~~ 2 ■
2: ~~∞~~ 6 ■
3: ~~∞~~ 7
4: ∞
5: ∞
6: ∞

Unvisited Nodes: {~~0~~, ~~1~~, ~~2~~, 3, 4, 5, 6}

Distance:

0: 0
1: ~~∞~~ 2 ■
2: ~~∞~~ 6 ■
3: ~~∞~~ 7 from (5 + 2) vs. 14 from (6 + 8)
4: ∞
5: ∞
6: ∞

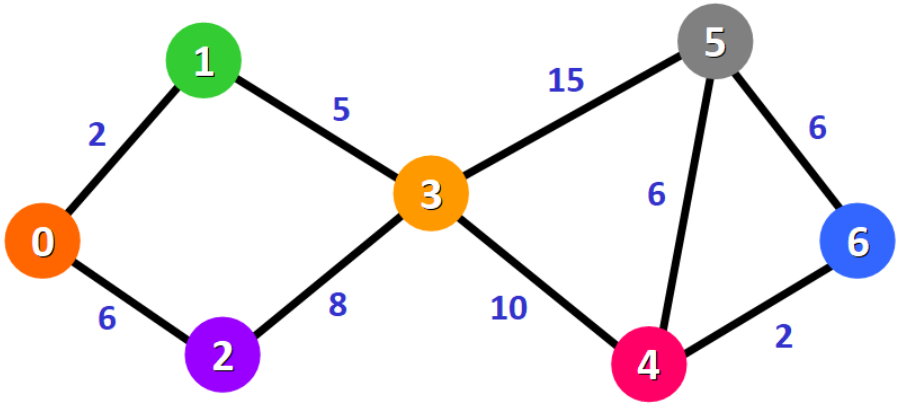
Distance:

0: 0
1: ~~∞~~ 2 ■
2: ~~∞~~ 6 ■
3: ~~∞~~ 7 ■
4: ∞
5: ∞
6: ∞

Ref: https://en.wikipedia.org/wiki/Dijkstra%27s_algorithm
https://www.freecodecamp.org/news/dijkstras-shortest-path-algorithm-visual-introduction/

Network Layer – Routing – Shortest Path

- Dijkstra's shortest path algorithm



Unvisited Nodes: {0, 1, 2, 3, 4, 5, 6}

Distance:

0: 0
1: ∞ 2
2: ∞ 6
3: ∞ 7
4: ∞ 17 from (2 + 5 + 10)
5: ∞ 22 from (2 + 5 + 15)
6: ∞

Distance:

0: 0
1: ∞ 2
2: ∞ 6
3: ∞ 7
4: ∞ 17
5: ∞ 22
6: ∞

Unvisited Nodes: {0, 1, 2, 3, 4, 5, 6}

Distance:

0: 0
1: ∞ 2
2: ∞ 6
3: ∞ 7
4: ∞ 17
5: ∞ 22 vs. 23 (2 + 5 + 10 + 6)
6: ∞ 19 from (2 + 5 + 10 + 2)

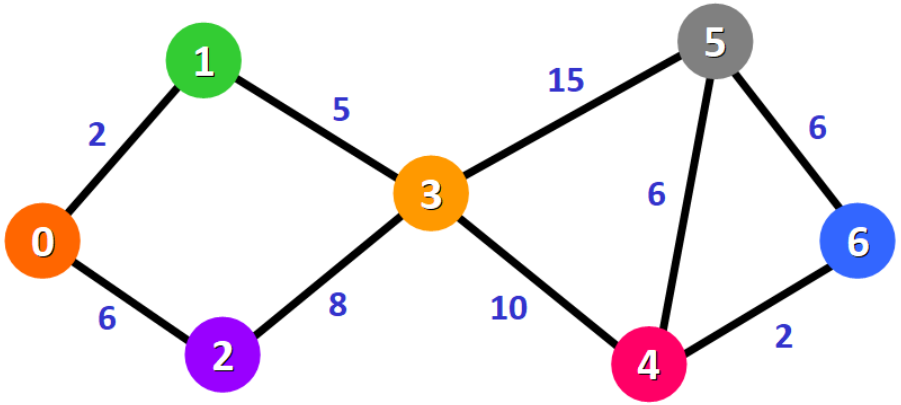
Distance:

0: 0
1: ∞ 2
2: ∞ 6
3: ∞ 7
4: ∞ 17
5: ∞ 22
6: ∞ 19

Ref: https://en.wikipedia.org/wiki/Dijkstra%27s_algorithm
https://www.freecodecamp.org/news/dijkstras-shortest-path-algorithm-visual-introduction/

Network Layer – Routing – Shortest Path

- Dijkstra's shortest path algorithm



Unvisited Nodes: {0, 1, 2, 3, 4, 5, 6}

Distance:

0: 0
1: ∞ 2
2: ∞ 6
3: ∞ 7
4: ∞ 17
5: ∞ 22 from (2 + 5 + 15) vs. 23 from (2 + 5 + 10 + 6) vs. 25 from (2 + 5 + 10 + 2 + 6)
6: ∞ 19

Unvisited Nodes: {0, 1, 2, 3, 4, 5, 6}

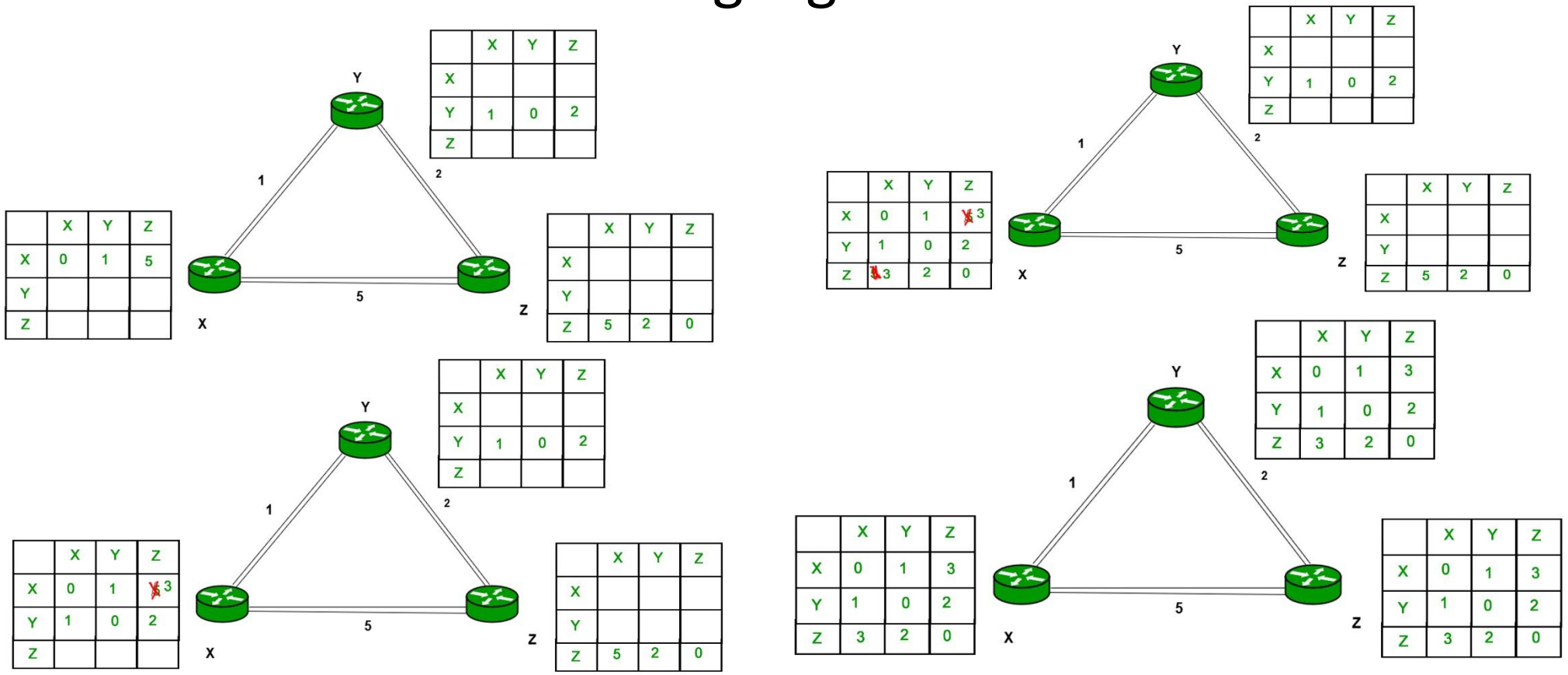
Distance:

0: 0
1: ∞ 2
2: ∞ 6
3: ∞ 7
4: ∞ 17
5: ∞ 22
6: ∞ 19

Ref: https://en.wikipedia.org/wiki/Dijkstra%27s_algorithm
https://www.freecodecamp.org/news/dijkstras-shortest-path-algorithm-visual-introduction/

Network Layer – Routing – DVR

- Distance Vector Routing algorithm



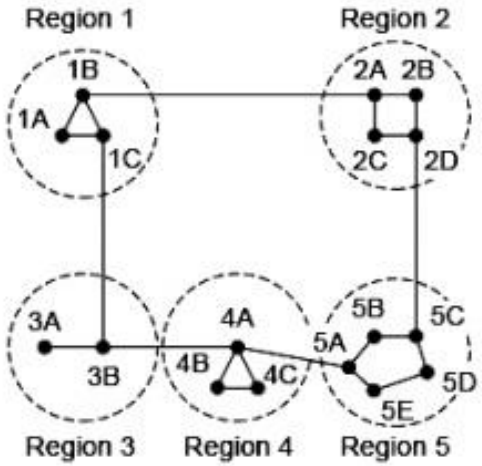
Ref: https://www.geeksforgeeks.org/distance-vector-routing-dvr-protocol/

Network Layer – Routing – Link State

- **Knowledge about the neighbourhood:** Instead of sending its routing table, a router sends the information about its neighbourhood only. A router broadcast its identities and cost of the directly attached links to other routers.
- **Flooding:** Each router sends the information to every other router on the internetwork except its neighbours. This process is known as Flooding. Every router that receives the packet sends the copies to all its neighbours. Finally, each and every router receives a copy of the same information.
- **Information sharing:** A router sends the information to every other router only when the change occurs in the information.

Ref: https://www.tutorialspoint.com/what-is-link-state-routing-in-computer-network
https://www.javatpoint.com/link-state-routing-algorithm

Network Layer – Routing – Hierarchical



Full Table for 1A

Dest.	Line	Hops
1A	-	-
1B	1B	1
1C	1C	1
2A	1B	2
2B	1B	3
2C	1B	3
2D	1B	4
3A	1C	3
3B	1C	2
4A	1C	3
4B	1C	4
4C	1C	4
5A	1C	4
5B	1C	5
5C	1B	5
5D	1C	6
5E	1C	5

Hierarchical Table for 1A

Dest.	Line	Hops
1A	-	-
1B	1B	1
1C	1C	1
2	1B	2
3	1C	2
4	1C	3
5	1C	4

Ref: https://www.tutorialspoint.com/what-is-hierarchical-routing

Thank You…