# IPv6, Routing: RIP & OSPF

28 December 2025
Lecture 9

Some Slides Credits: Steve Zdancewic (UPenn)

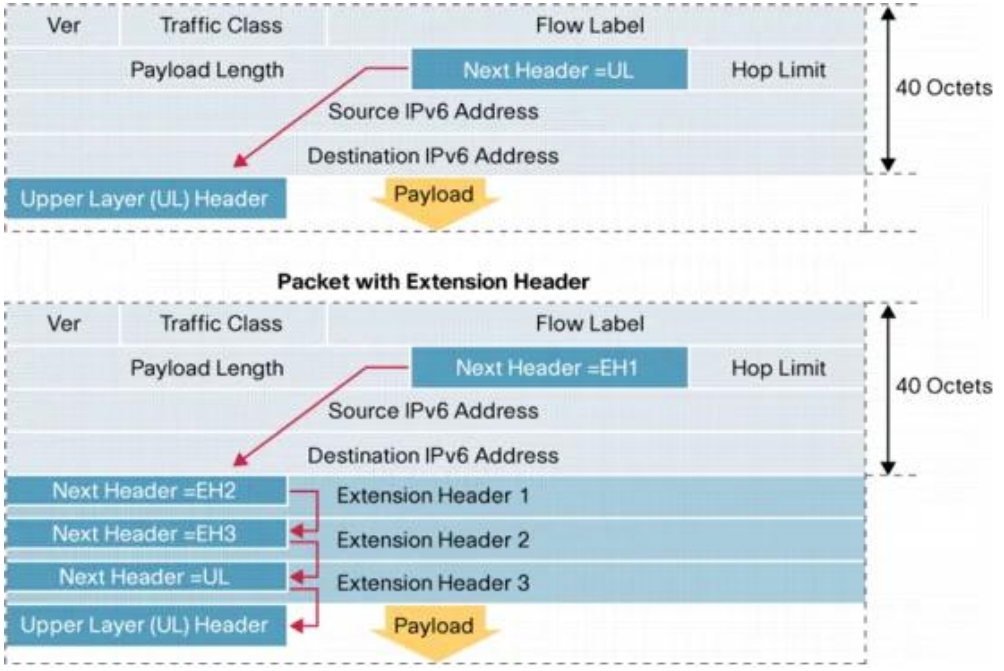
# Topics for Today

- IPv6 Headers
- Routing
  - Introduction and Goals
  - RIP
  - OSPF

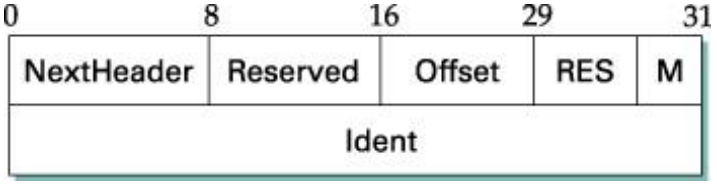
- Sources in PD:
  - RIP: 3.4.2
  - OSPF: 3.4.3

# IPv6 Next Header

- Additional options and extensions are in headers after the initial 40B
  - Fixed order, multiple of 8 bytes
- If there are extensions → Next Header has the next extension header type
  - 44 for fragmentation
  - 43 mobile routing
  - 51 authentication
  - 50 encrypted data
- If no extensions → it's the inner protocol number
  - 59 if there is nothing inside





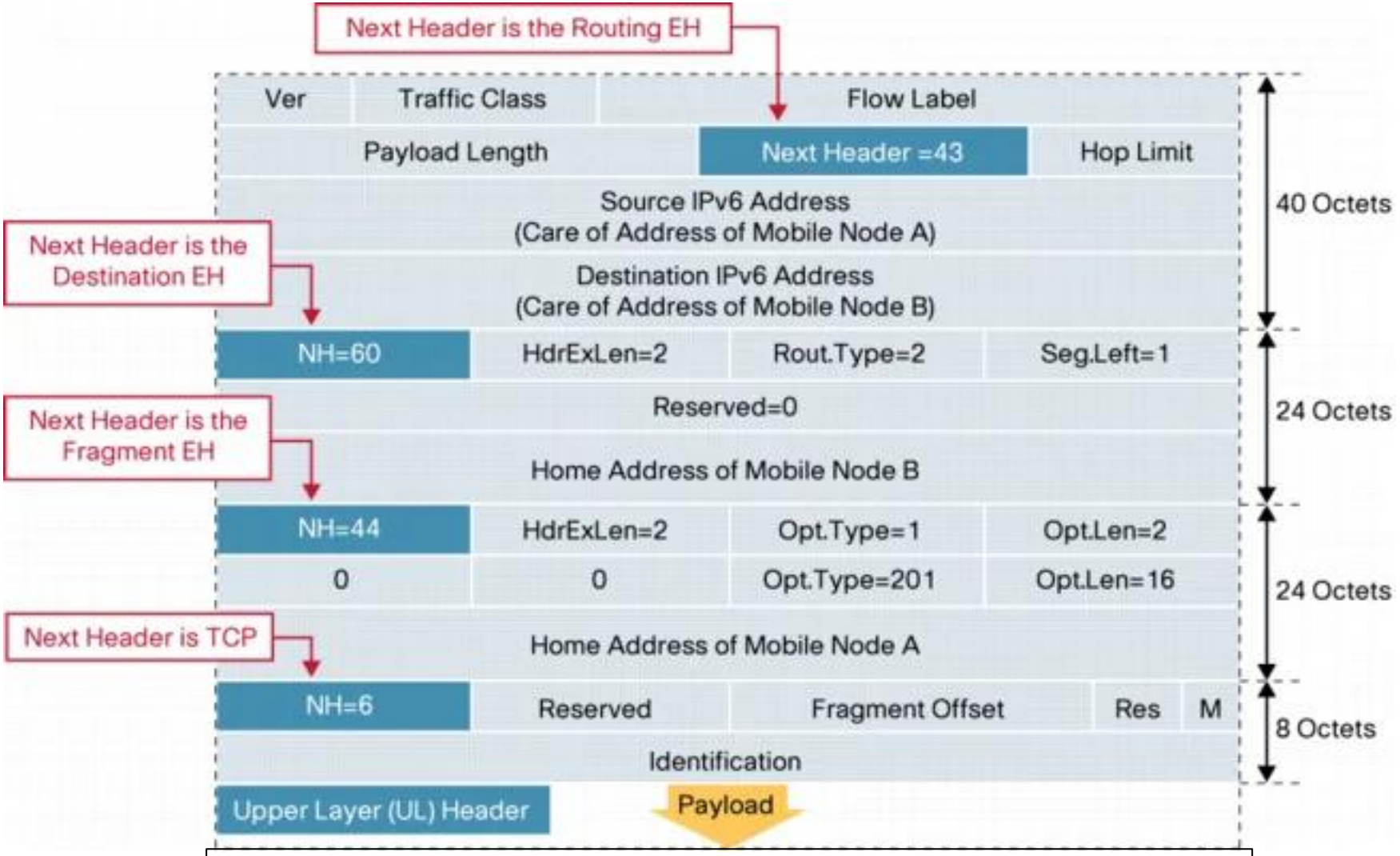




44 fragmentation header

# IPv6 Extension Headers List (RFC 2460)

| Order | Header Type | Next Header Code |
|---|---|---|
| 1 | **Basic IPv6 Header** | - |
| 2 | **Hop-by-Hop Options** | 0 |
| 3 | **Destination Options (with Routing Options)** | 60 |
| 4 | **Routing Header** | 43 |
| 5 | **Fragment Header** | 44 |
| 6 | **Authentication Header** | 51 |
| 7 | **Encapsulation Security Payload Header** | 50 |
| 8 | **Destination Options** | 60 |
| 9 | **Mobility Header** | 135 |
| | **No next header** | 59 |
| Upper Layer | TCP | 6 |
| Upper Layer | UDP | 17 |
| Upper Layer | ICMPv6 | 58 |

# How Extension Chaining Looks



# Header details: Hop-by-Hop Options

Type, Value pairs that each router on the path should examine

Only options defined now are:

- Padding
- For jumbograms (>64KB)

Use is discouraged since it may slow down the internet

# Header details: Destination Options

Type, Value pairs that the destination should examine

Only options defined now are:

- Padding
- Limit nesting of tunnels
- Mobile IPv6
- Routing protocol for low power and lossy networks (RPL)

# Header details: Routing Header

## Original version

- A type of source routing
- List of routers $\langle R_1, R_2, \ldots, R_n, D \rangle$ to go through on the way to D
- Pointer to where up to on the list – next hop put in the IPv6 Destination field

## Deprecated due to security problem

- What if you write $\langle R_1, R_2, R_1, R_2, R_1, \ldots, D \rangle$ ?

## More limited header defined later

- Original one still use for the RPL low power setting

# Header details: Fragmentation Header

## Only the sender can fragment

- Routers and middle nodes can't fragment or reassemble
- Avoid if possible

## Fragmentation fields

- 32 bit Unique ID
- 13 bit Offset

Each fragment must have a copy of the IPv6 header and critical extension headers

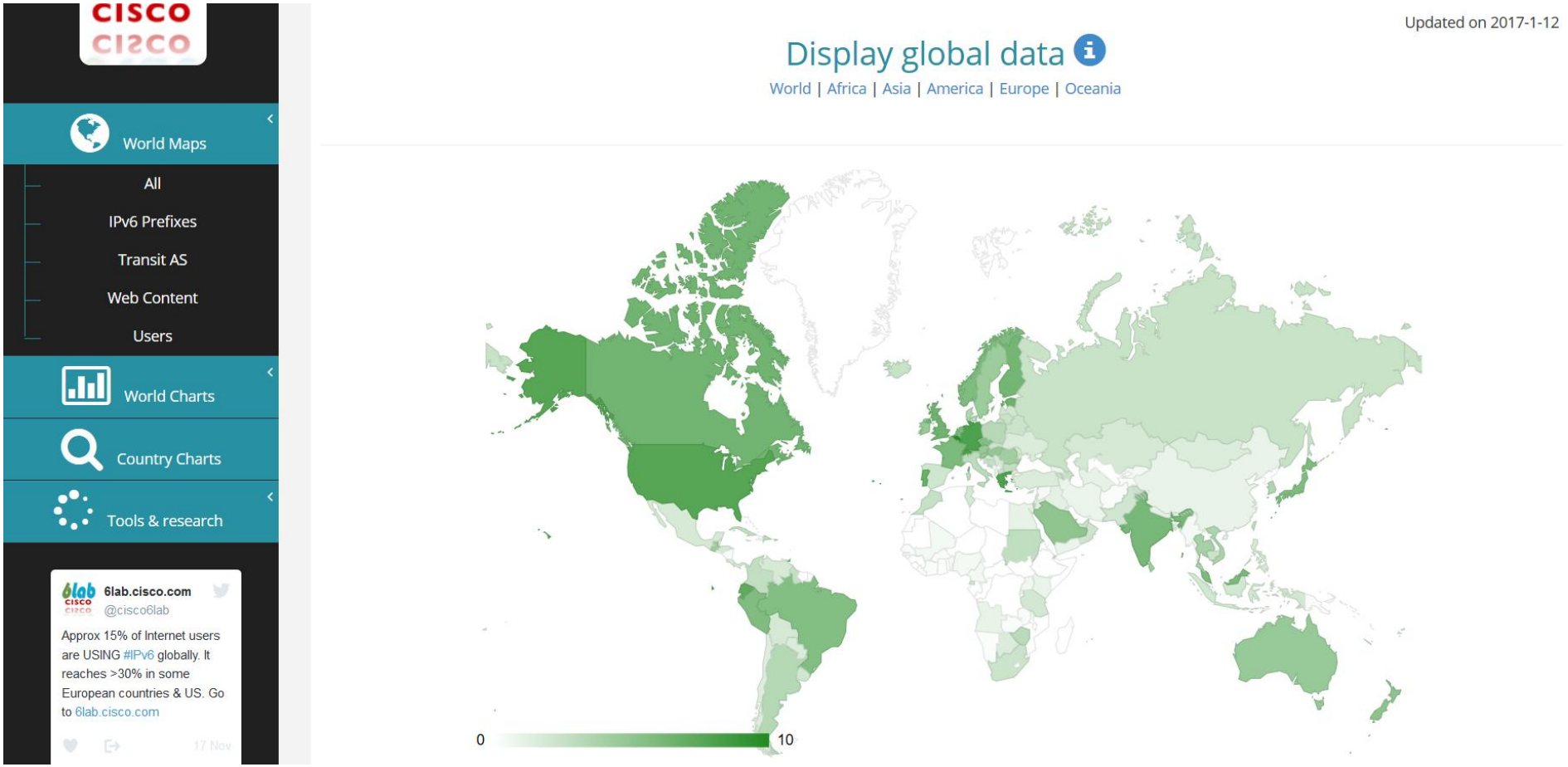
## IPv6 requires path MTU of 1280 bytes after link layer headers

- If smaller, link layer must fragment and reassemble on its own

# IPv6 Deployment Map

http://6lab.cisco.com/stats/

http://6lab.cisco.com/stats/cible.php?country=IL&option=all

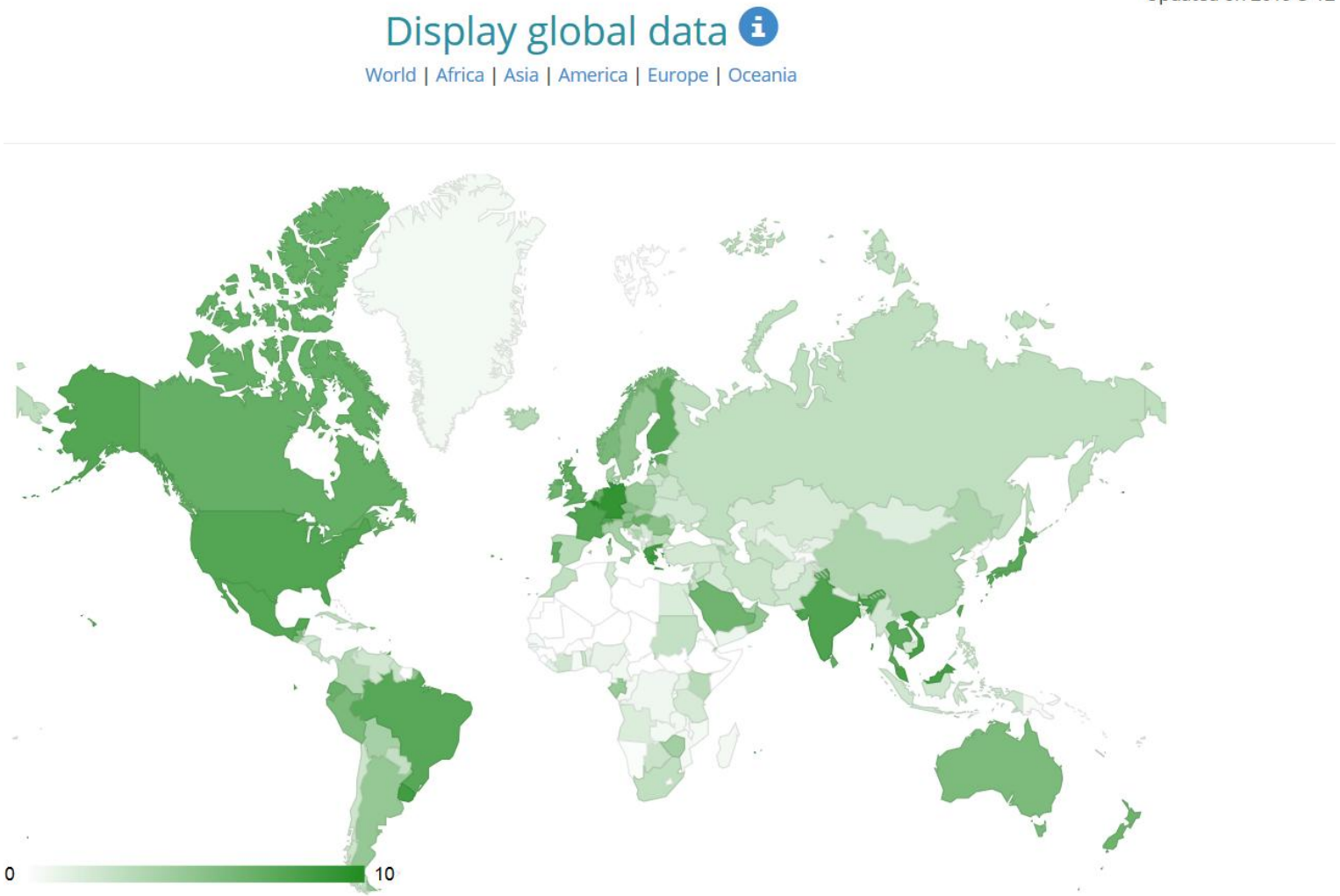


# IPv6 Deployment Map

http://6lab.cisco.com/stats/

https://6lab.cisco.com/stats/index.php?option=all

Updated on 2019-5-12



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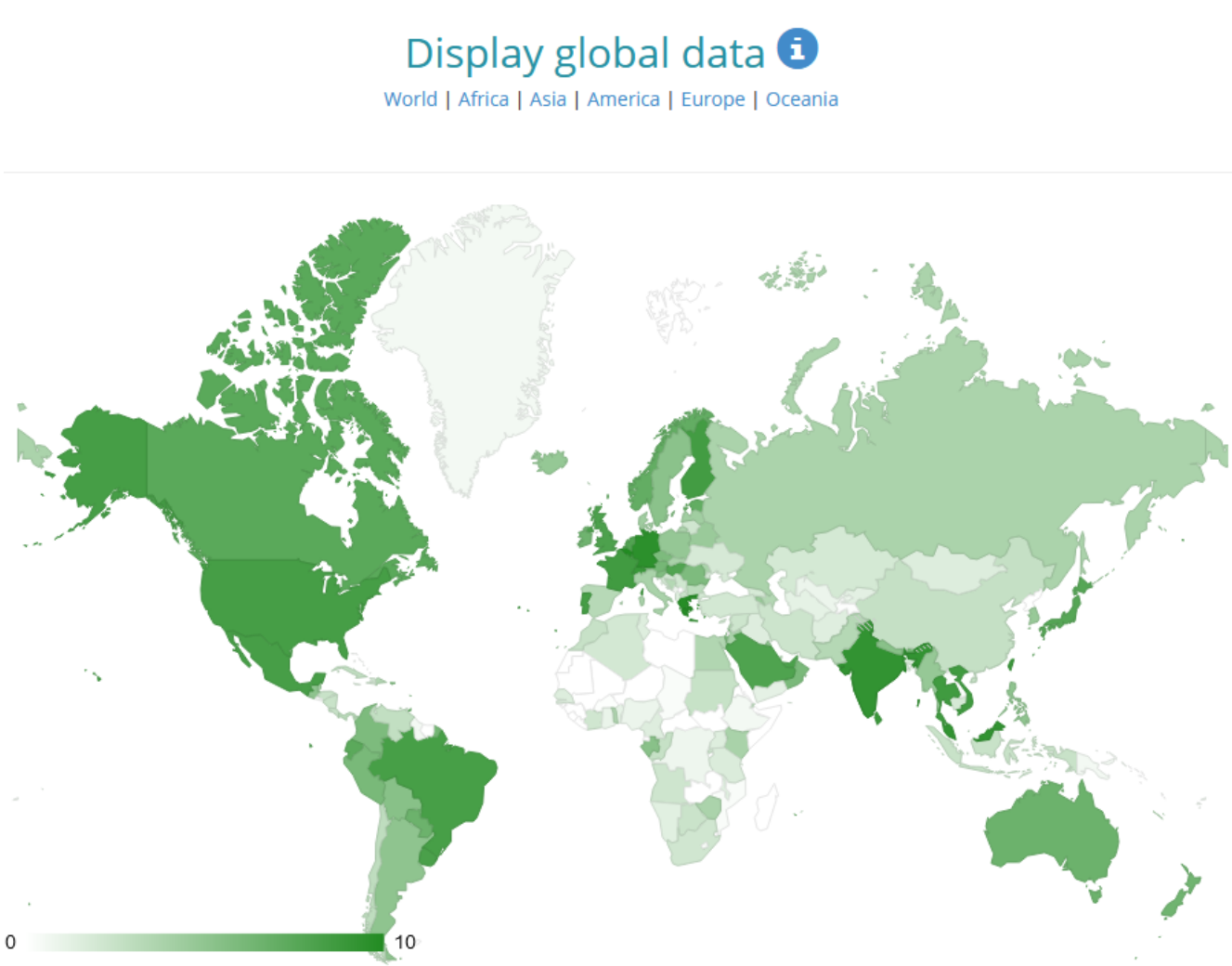
Updated on 2020-12-23

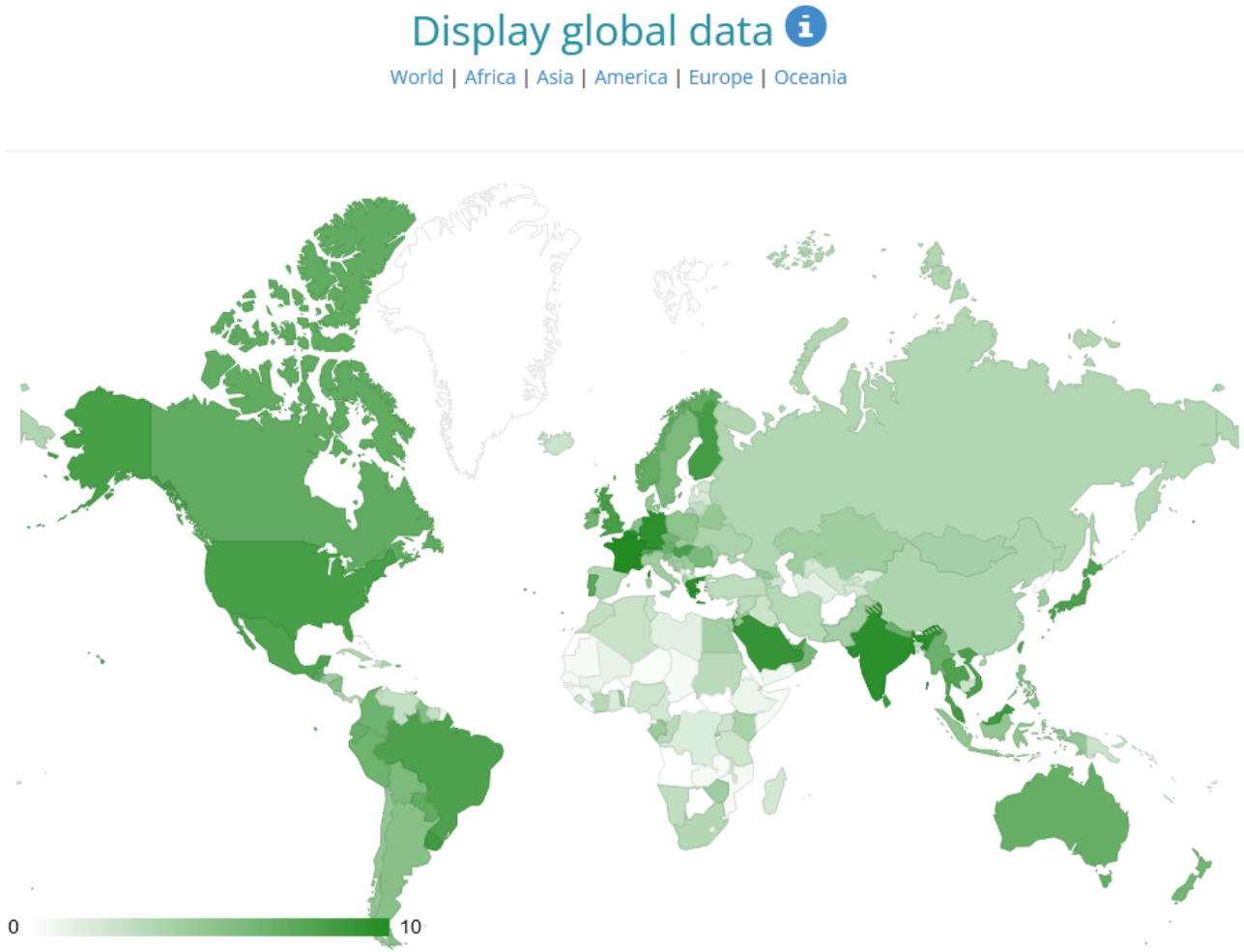


# IPv6 Deployment Map

http://6lab.cisco.com/stats/

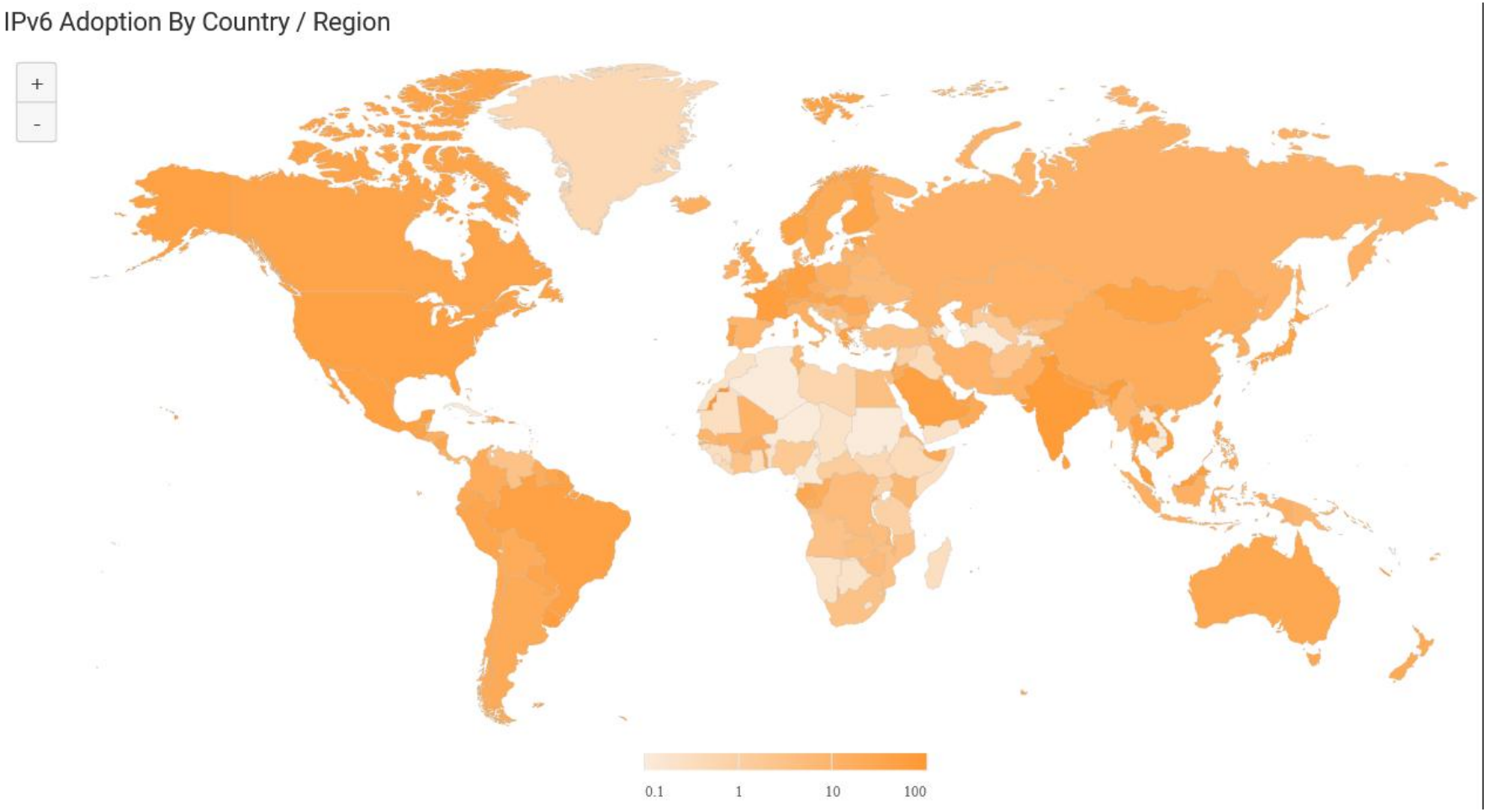
https://6lab.cisco.com/stats/index.php?option=all

Updated on 2022-12-15

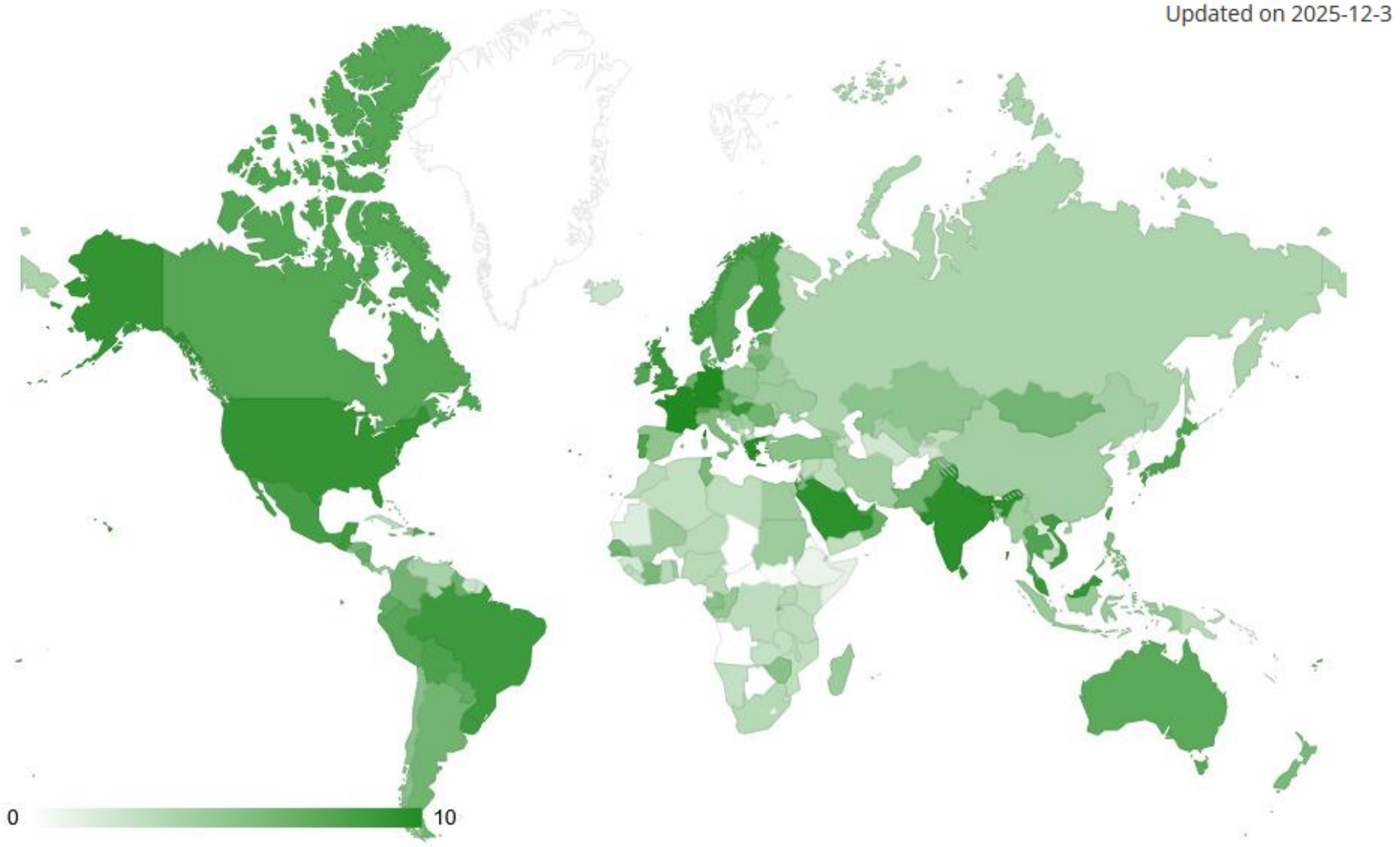


# IPv6 Deployment Map

Updated June 2024



# IPv6 Deployment Map



# Top 10 Countries

https://www.akamai.com/visualizations/state-of-the-internet-report/ipv6-adoption-visualization

*Country data ranked by % of IPv6 connections from that country.

Search:

| RANK | IPV6% | COUNTRY / REGION |
|---|---|---|
| 1 | 100% | Heard Island and McDonald Islands |
| 2 | 100% | French Southern Territories |
| 3 | 98.6% | USA Minor Outlying Islands |
| 4 | 97.5% | Western Sahara |
| 5 | 96.3% | Saint Helena |
| 6 | 96.3% | Christmas Island |
| 7 | 94% | South Georgia/South Sandwich Isl. |
| 8 | 90.6% | Pitcairn |
| 9 | 86.1% | Bouvet Island |
| 10 | 69% | India |

# Top 10 Countries

https://www.akamai.com/visualizations/state-of-the-internet-report/ipv6-adoption-visualization

| RANK | IPV6% | COUNTRY / REGION |
|---|---|---|
| 24 | 51.9% | Israel |

Search: Israel

# So Far

- IPv6 Headers
- Routing
  - Introduction and Goals
  - RIP
  - OSPF

# Routing



Images: https://www.aaroads.com/blog/south-carolinas-new-highway-signs/#post/0
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# Routing protocols on the internet

## Routing information protocol (RIP)

- Distance vector routing
- Uses Bellman-Ford algorithm
- Outdated, suffers from count-to-infinity problem

## Open shortest path first (OSPF)

- Link state routing
- Runs over Layer 3 (over IP)
- Uses Dijkstra algorithm to determine shortest paths

## Intermediate System to Intermediate System IS-IS

- Link state routing – similar to OSPF
- Runs over Layer 2 (under IP)
- Uses Dijkstra's algorithm

## Border gateway protocol (BGP)

- Between networks (administrative domains, Autonomous Systems)
- Path-vector routing
- Consideration of business agreements

# Routing criteria

## Correctness

Every packet is delivered to its destination

## Efficiency

Choose paths with small delay and high throughput (network wide)

## Complexity

Setting up routing tables

Making routing decisions

## Robustness

Cope with topology changes

No network reboot

## Adaptiveness

Load balancing and traffic control

## Fairness

All users get the same degree of service

# Path costs, Routing metrics

## Minimum hop

Number of channels traversed

## Shortest path

Channels have statically assigned weights

Cost of a path is the sum of costs of the edges

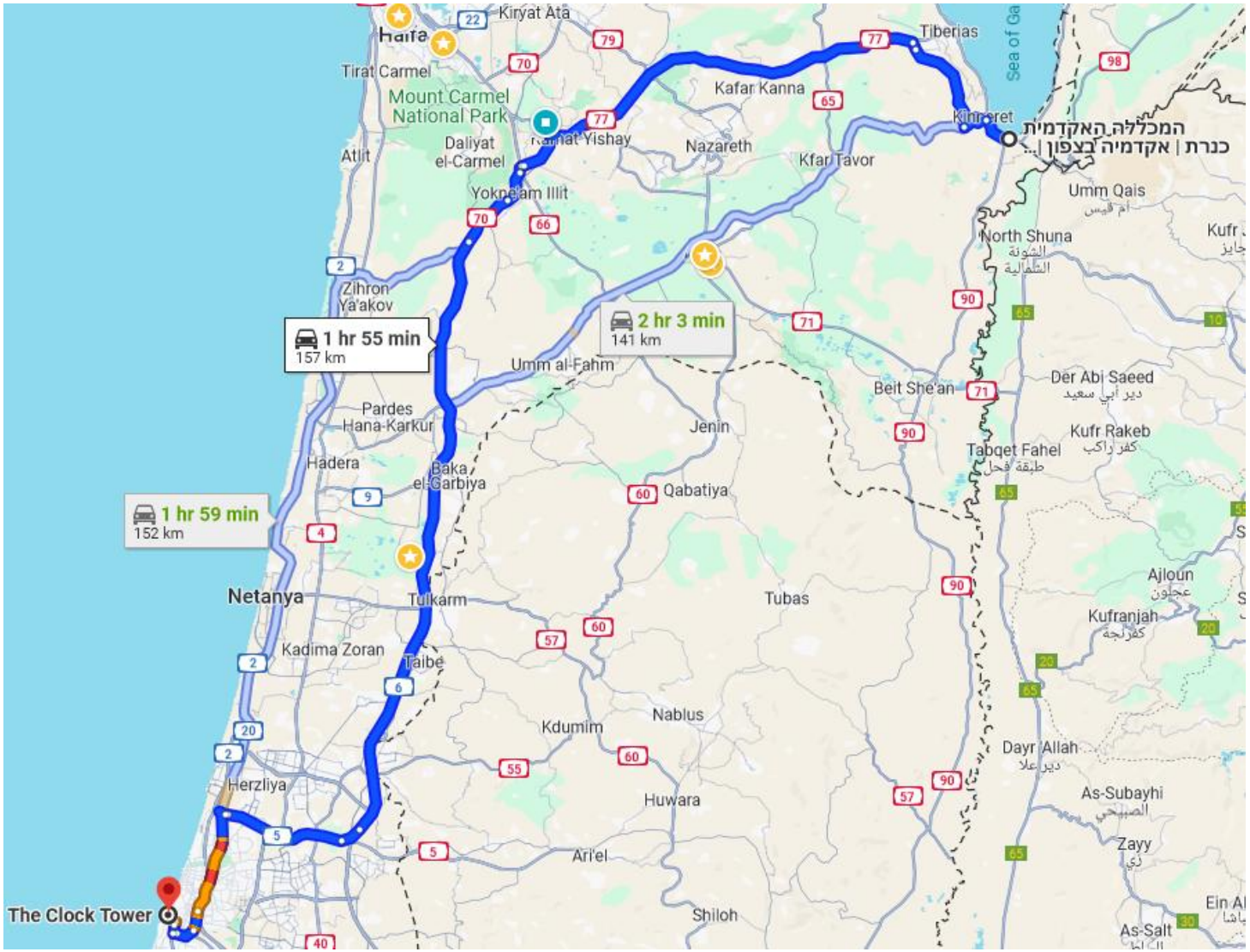
Presumes no negative-cost cycles

## Minimum delay

Channels have dynamically assigned weights based on the traffic on the channel

Routing tables are repeatedly revised such that paths with close to minimal delays are chosen

# Shortest vs Fastest



# So Far

- IPv6 Headers
- Routing
  - Introduction and Goals
  - RIP
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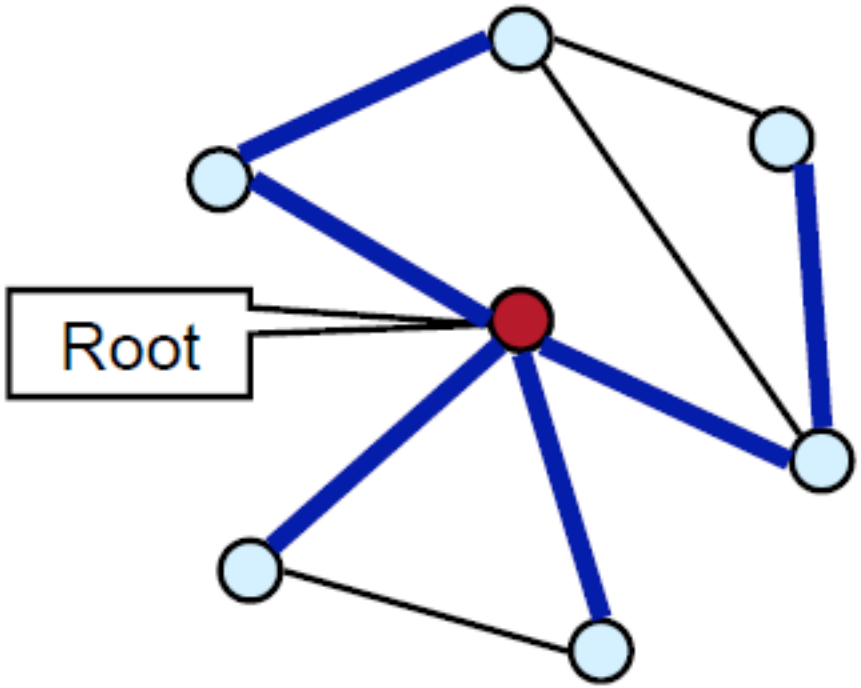
# Spanning Tree Algorithm (Abstractly)

- Pick a root node
  - Compute shortest paths to root
  - Need to break ties

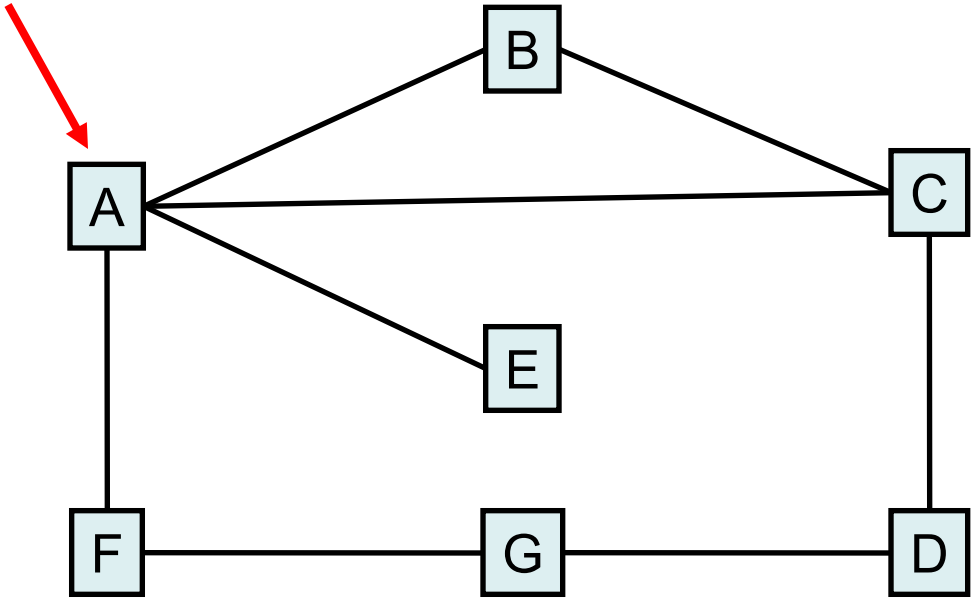


# Distance Vector Algorithm (RIP)

- Similar to the Spanning Tree Algorithm
  - Except that information about distance to ALL nodes is forwarded (not just info. about root.)
  - Sometimes called Bellman-Ford algorithm

- Each node constructs a *Distance Vector*
  - Contains distances (costs) to reach all other node
  - Initially:
    - Distance to neighbors (a simplification for now) = 1
    - Distance to others = ∞
  - Routing table reflects node's beliefs

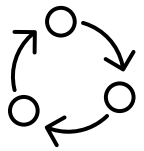
# Example Network Graph




A's initial information:

| Dest | Cost | NextHop |
|---|---|---|
| B | 1 | B |
| C | 1 | C |
| D | ∞ | - |
| E | 1 | E |
| F | 1 | F |
| G | ∞ | - |

# Iteration Steps



Each host sends its DV (cost) to its neighbors

Neighbors update distance vectors and routing information accordingly.

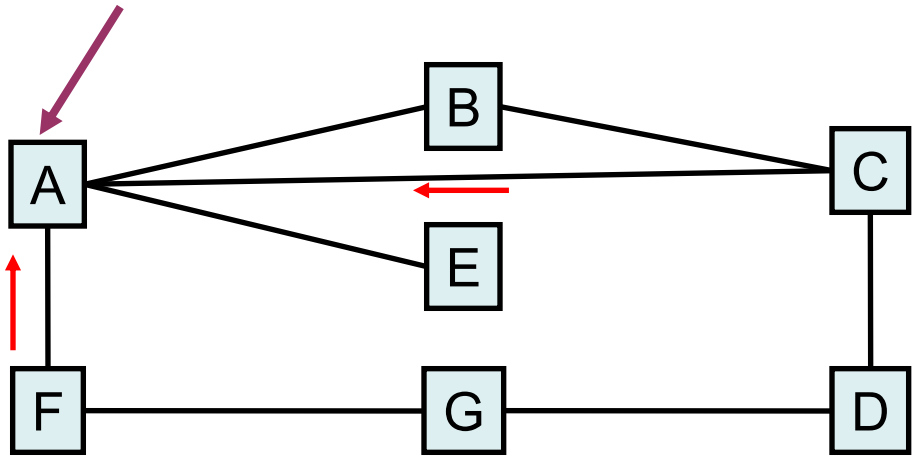
- Ignore worse information
- Update any better routes

If host changed its tables, send new DV to neighbors

After a few iterations, routing information *converges*

# Example Iteration Steps

| | |
|---|---|
| A | 1 |
| B | ∞ |
| C | ∞ |
| D | ∞ |
| E | ∞ |
| F | 0 |
| G | 1 |




| | |
|---|---|
| A | 1 |
| B | 1 |
| C | 0 |
| D | 1 |
| E | ∞ |
| F | ∞ |
| G | ∞ |

F sends A its DV

- A discovers that G can be reached in to two hops via F

C send A its DV

- A discovers that D can be reached in two hops via C

| Dest | Cost | NextHop |
|---|---|---|
| B | 1 | B |
| C | 1 | C |
| D | ∞ | - |
| E | 1 | E |
| F | 1 | F |
| G | ∞ | - |

| Dest | Cost | NextHop |
|---|---|---|
| B | 1 | B |
| C | 1 | C |
| D | ∞ | - |
| E | 1 | E |
| F | 1 | F |
| G | 2 | F |

| Dest | Cost | NextHop |
|---|---|---|
| B | 1 | B |
| C | 1 | C |
| D | 2 | C |
| E | 1 | E |
| F | 1 | F |
| G | 2 | F |

# Details

- Note: No single host has all routing information.
- When to send update vectors?
  - When your routing table changes (triggered)
  - Periodically (“I’m alive!”)

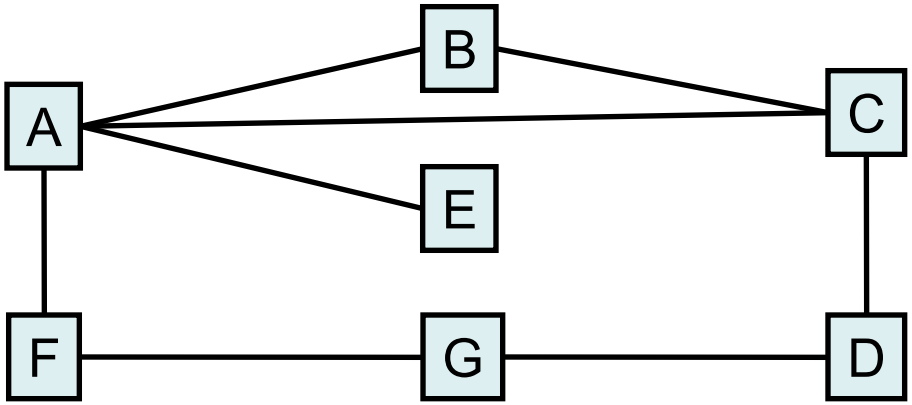
- Detecting link/node failure
  - (1) Periodically exchange “I’m alive!” messages.
  - (2) Timeout mechanism

- In a static network, if all weights are 1, once A discovers a path to B (cost < $\infty$), no subsequent round will ever discover a better path to B
  - All weights are 1 is called “Hop Count” (Default RIP action)

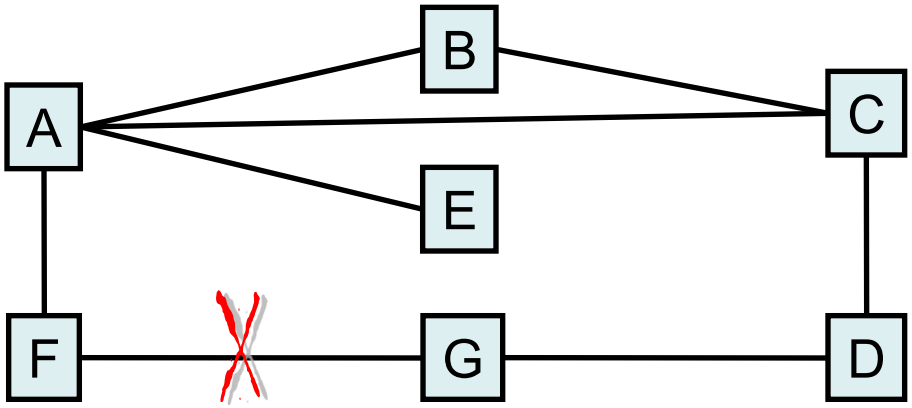
# Dynamic Networks

What about a dynamic network?

- A nodes enters
  - The new neighbors will eventually inform everyone else (easy)

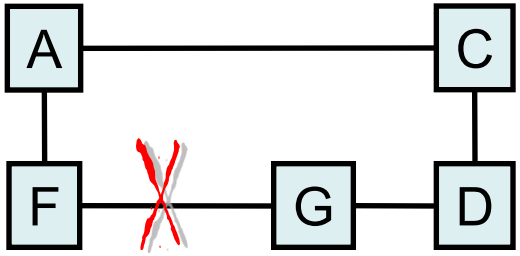



- A node/link fails
  - Is the network partitioned?
  - How do nodes discover that a node/link is gone?



# Link Failure Example 1

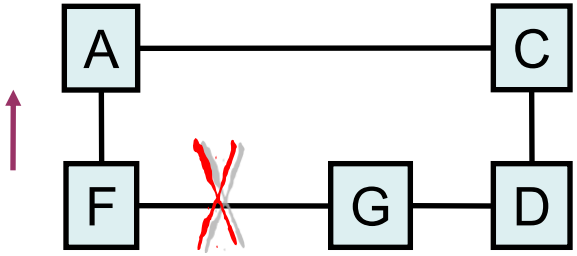
| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 2 | F | G | 2 | D | G | 1 | G | G | 1 | G |




| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 2 | F | G | 2 | D | G | 1 | G | G | ∞ | - |

# Link Failure Example 1

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 2 | F | G | 2 | D | G | 1 | G | G | ∞ | - |



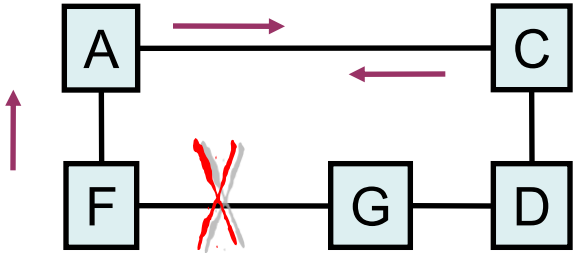

Case 1:

1. F sends to A

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | ∞ | - | G | 2 | D | G | 1 | G | G | ∞ | - |

# Link Failure Example 1

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | ∞ | - | G | 2 | D | G | 1 | G | G | ∞ | - |



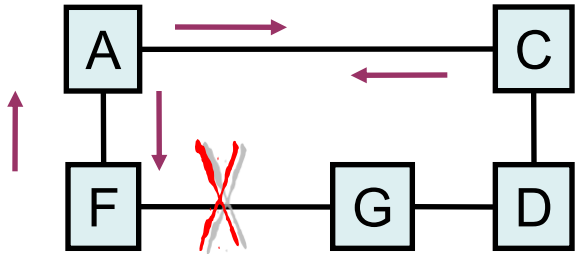

Case 1:

1. F sends to A
2. A sends to C
   - (nothing)
3. C sends to A

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 3 | C | G | 2 | D | G | 1 | G | G | ∞ | - |

# Link Failure Example 1

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 3 | C | G | 2 | D | G | 1 | G | G | ∞ | - |



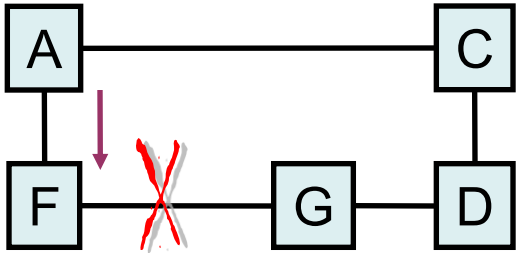

Case 1:

1. F sends to A
2. A sends to C
   - (nothing)
3. C sends to A
4. A sends to F

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 3 | C | G | 2 | D | G | 1 | G | G | 4 | A |

# Link Failure Example 2

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 2 | F | G | 2 | D | G | 1 | G | G | ∞ | - |



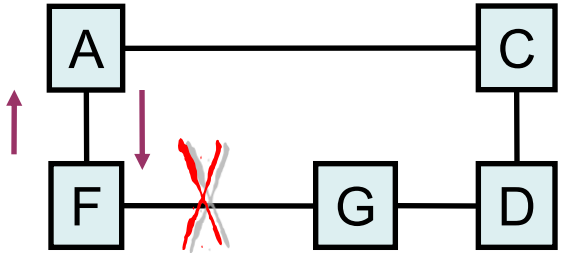

Case 2:

1. A sends to F

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 2 | F | G | 2 | D | G | 1 | G | G | 3 | A |

# Link Failure Example 2

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 2 | F | G | 2 | D | G | 1 | G | G | 3 | A |



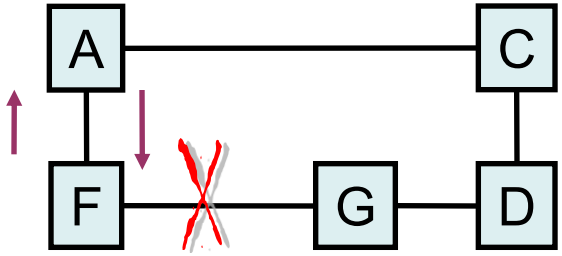

Case 2:

1. A sends to F
2. F sends to A

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 4 | F | G | 2 | D | G | 1 | G | G | 3 | A |

# Link Failure Example 2

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 4 | F | G | 2 | D | G | 1 | G | G | 3 | A |




Case 2:

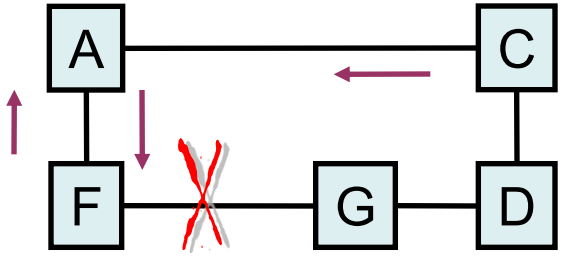
1. A sends to F
2. F sends to A
3. A sends to F

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 4 | F | G | 2 | D | G | 1 | G | G | 5 | A |

# Link Failure Example 2

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 4 | F | G | 2 | D | G | 1 | G | G | 5 | A |

| A | | | C | | | D | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop | Dest | C | Next hop |
| A | - | - | A | 1 | A | A | 2 | C | A | 1 | A |
| C | 1 | C | C | - | - | C | 1 | C | C | 2 | A |
| D | 2 | C | D | 1 | D | D | - | - | D | 2 | G |
| F | 1 | F | F | 2 | A | F | 2 | G | F | - | - |
| G | 3 | C | G | 2 | D | G | 1 | G | G | 4 | A |




Case 2:

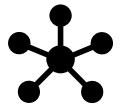
1. A sends to F
2. F sends to A
3. A sends to F
4. …
5. C sends to A
6. A sends to F

# Network Partition

- The loop between A and F is broken only by C's update
  - C has **real information** about another path to G
- What if C's update never comes? What if C's information is false?
  - The network is partitioned –OR–
  - G is completely offline
- The other nodes will continue counting until infinity (or the distance field reaches its max)

# Three RIP Solutions

## Option 1: Infinity is small



- Don't let the distance fields go above a predefined maximum
  - Say 15, 20, etc. (15 is the actual value)
  - The max must be greater than the diameter of the network

---

## Option 2: Don't send routes to the one who sent it to you

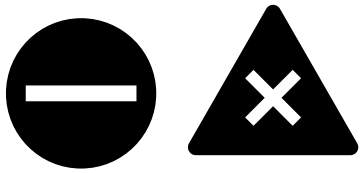
Example: F receives an update from A about a path to G.

- In the example before, F didn't know that's A's "path" went via F
- A doesn't send F an advertisement to get to G since it goes via F
- Called "split horizon"
- "Split horizon with poison reverse"- A sends route for G to F, but with infinite distance

# Three RIP Solutions

## Option 3: Route Poisoning and Holddowns

- Instead of just stopping to announce a lost destination, a router sends a poison message for the destination
  - E.g. the router announces distance 16 (≡ ∞) for the destination
- For a fixed period of time (say 3 minutes) any new offers for the destination via the sender will be rejected
  - E.g. Wait until everyone has heard the poison and then accept new offers
- Gives a chance for the route to be deleted by everyone.
- Cisco specific



# RIP v1 (1986) Details

## Classful routing only

- No subnet masks
- Assumes everyone has same mask

## Supports multiple address families

## Commands

- Request: Ask for someone to send their info
- Response: Respond with routing table

## Updates sent

- Timer about 30 seconds between updates
- Due to changes

## Split Horizon, Poison Reverse, Small Infinity

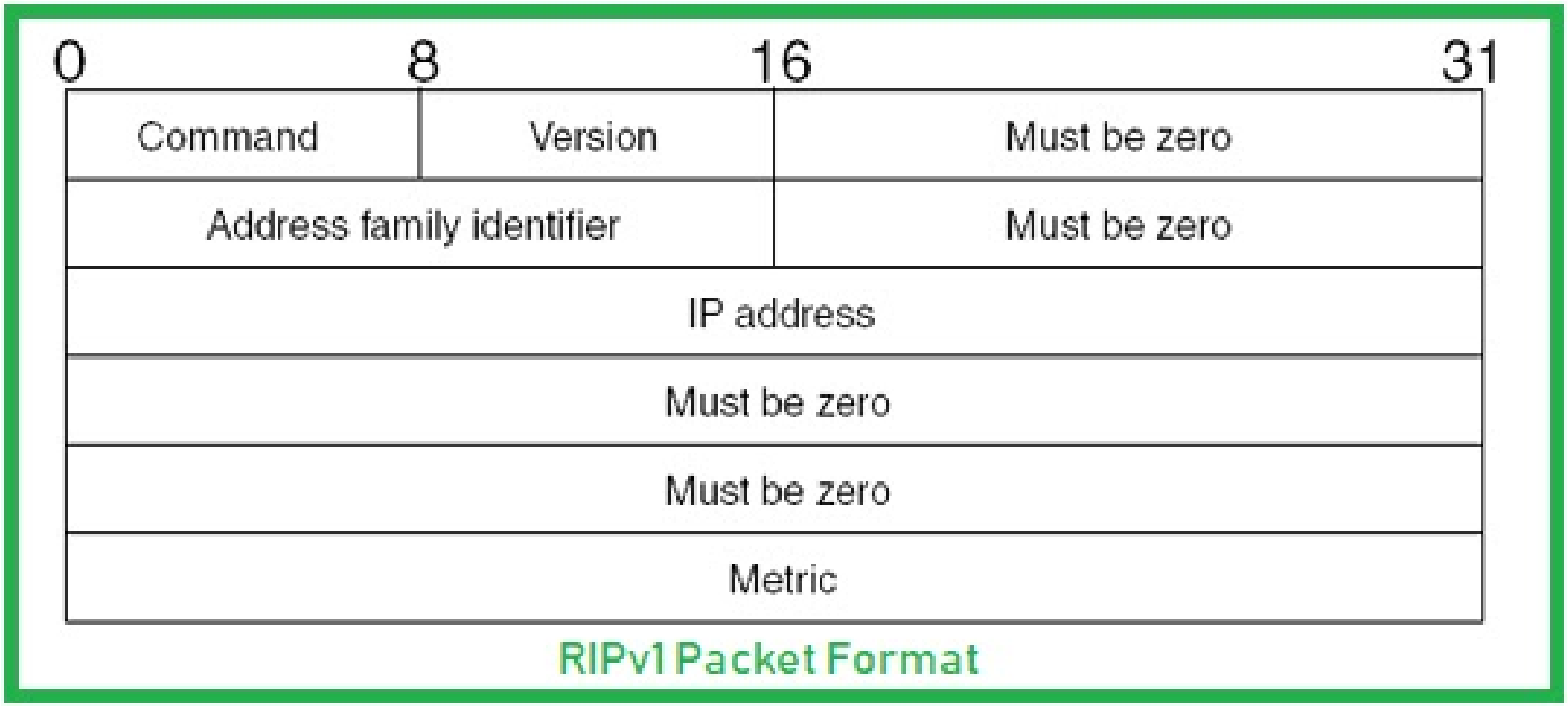
## Takes shortest path

- If two are shortest, splits traffic on them equally

## Route deletion

- If no update in 180 seconds or reaches infinity
- Marked as deleted
- Lives 120 seconds longer to send to others

# RIP v1 (1986) Details



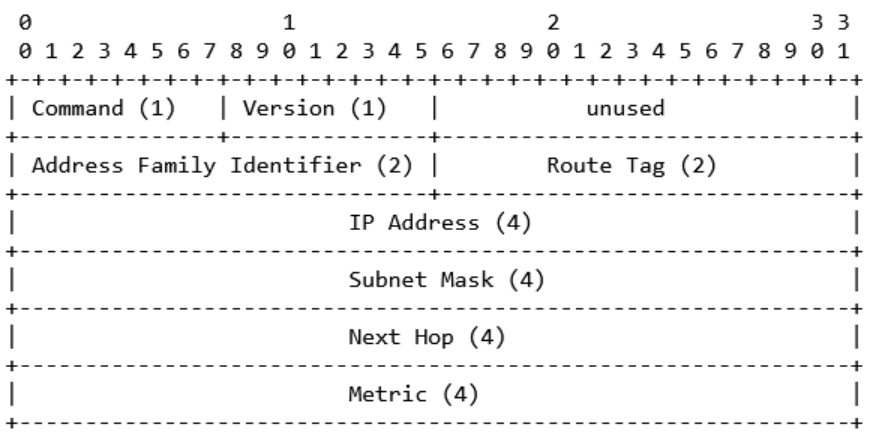

https://www.networkurge.com/2020/05/ripv1.html

# RIP v2 (1998) Details

## Added authentication

- Simple password
- Address family ID 0xFFFF

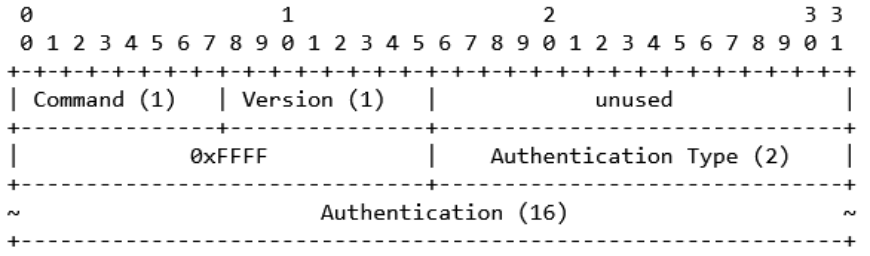
Route tag for exterior routing




## Next hop

- 0.0.0.0 for the sender
- Another address must be on the subnet, allows just some routers to run RIP

Message sent via Multicast 224.0.0.9



# So Far

- IPv6 Headers
- Routing
  - Introduction and Goals
  - RIP
  - OSPF

# Open Shortest Path First (OSPF)

## OSPFv2 (1998)

- RFC 2328
- IPv4 ✓
- In protocol authentication of routers and completeness of messages
- Atoms are networks and subnets
- Routers identified by Router ID and/or IP address

## OSPFv3 (2008)

- RFC 5340
- IPv4 + IPv6 ✓
- Authentication at IP layer (IPSec)
- Completeness at IP layer
- Atoms are links (may have multiple subnets)
- Router IDs and IP addresses are disjoint

# Open Shortest Path First (OSPF)

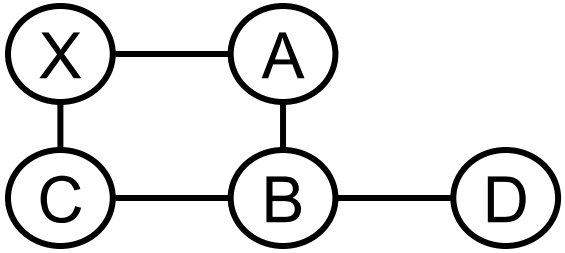
- Each node sends a *reliable flood* of information to all other nodes
  - In v3, can limit the flooding scope
- Link-State Packets (LSPs) contain

| | | |
|---|---|---|
| ID of the node that created the packet | List of (neighbor, cost) pairs associated with the source node | Sequence Number (64bits—no wrapping) |
| Time To Live (ensure old info is eventually removed) | Authentication (v2) – password or message authenticity code (MAC) | |

# OSPF Steps

**Reliable Flooding**

- Adjacent routers reliably send updates (ACKs)
- Source sends to all neighbors
- Recipients
  - Send to all neighbors except the one it got the message from
  - Ignores duplicates




**Local Calculations**

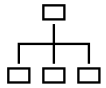
1. Once all of the link-state info has been flooded each node has complete network topology
2. Compute routing information using Dijkstra's shortest-path algorithm
3. Periodic updates and failure detection are like RIP.

# OSPF Features

## Authentication of routing messages (v2)

- Misconfigured or malicious host could advertise bad route info (i.e. reach anywhere in 0 hops)
- Prevent routers from accidentally joining a network
- Prevent malicious or accidental changes to route information
- (Eventually added to RIP too.)

## Additional Hierarchy



- Partitions domains into *areas*
- Reduces transmission & storage overhead

## Load Balancing

- Multiple routes with same cost
- Traffic evenly distributed

# Dijkstra's Algorithm

Node has two lists – Confirmed and Tentative - pairs of (Destination, Cost, Next-Hop)

## Algorithm:

1. Initialize Confirmed with an entry for self with cost 0.

2. For the node just added to Confirmed in the previous step, ($Next$), examine its Link State Packet (LPS).

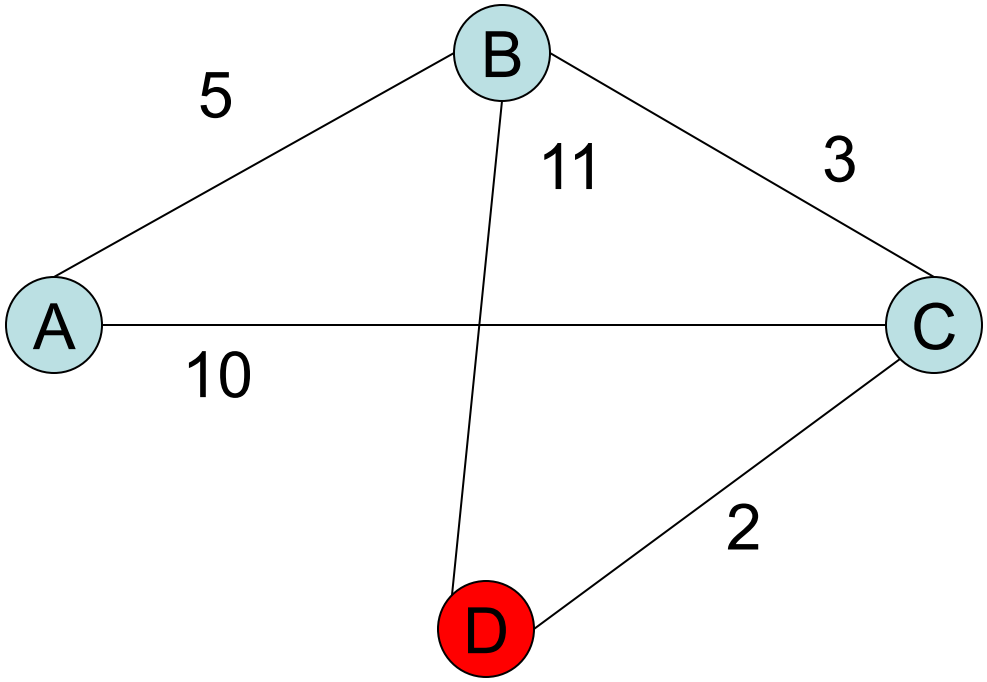
3. For each $Neigh$ of $Next$, calculate the distance to $Neigh$ via $Next$
   $cost = (self \rightarrow Next) + (Next \rightarrow Neigh)$
   a) If $Neigh$ isn't on Confirmed or Tentative, add $(Neigh, cost, NH)$ to Tentative, where $NH$ is the way to reach $Next$ in Confirmed.

   a) If $Neigh$ is on Tentative and $cost$ is better than the old cost, replace it with $(Neigh, cost, NH)$, where $NH$ is the way to reach $Next$ in Confirmed.

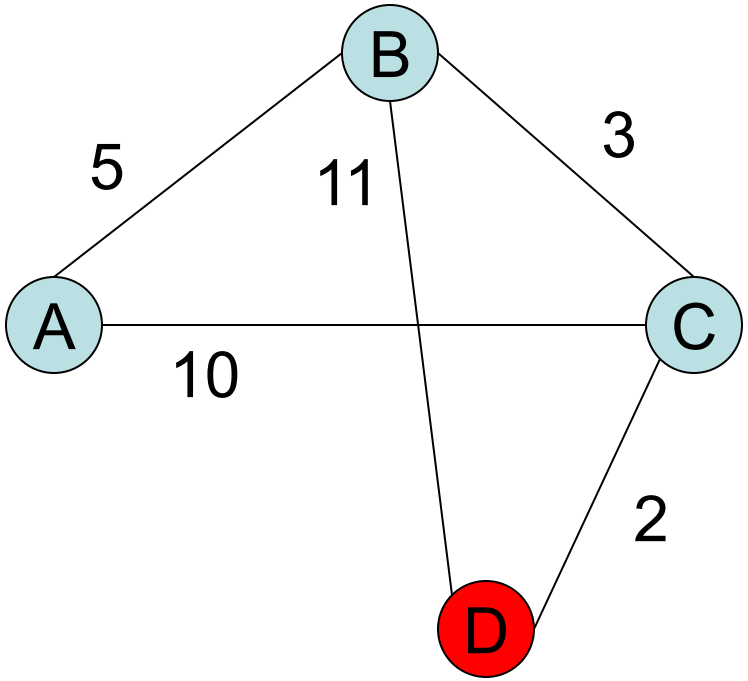
4. If Tentative is empty, **stop**.

5. Choose the node on Tentative with the lowest cost, move it to Confirmed, and go to step 2.

# Dijkstra Example

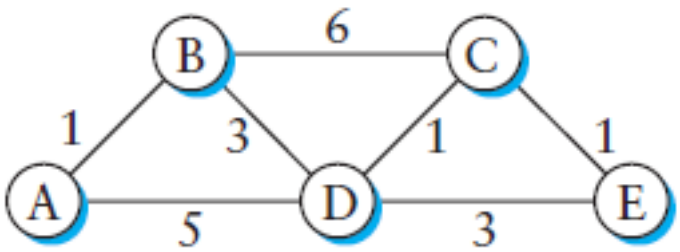


# Dijkstra Example




| Step | Confirmed | Tentative | Comments |
|---|---|---|---|
| 1 | (D,0,-) | | Since D is the only new member of the confirmed list, look at its LSP. |
| 2 | (D,0,-) | (B,11,B)<br>(C,2,C) | D's LSP says we can reach B through B at cost 11, which is better than anything else on either list, so put it on Tentative list; same for C. |
| 3 | (D,0,-)<br>(C,2,C) | (B,11,B) | Put lowest-cost member of Tentative (C) onto Confirmed list. Next, examine LSP of newly confirmed member (C). |
| 4 | (D,0,-)<br>(C,2,C) | (B,5,C)<br>(A,12,C) | Cost to reach B through C is 5, so replace (B,11,B). C's LSP tells us that we can reach A at cost 12. |
| 5 | (D,0,-)<br>(C,2,C)<br>(B,5,C) | (A,12,C) | Move lowest-cost member of Tentative (B) to Confirmed, then look at its LSP. |
| 6 | (D,0,-)<br>(C,2,C)<br>(B,5,C) | (A,10,C) | Since we can reach A at cost 5 through B, replace the Tentative entry. |
| 7 | (D,0,-)<br>(C,2,C)<br>(B,5,C)<br>(A,10,C) | | Move lowest-cost member of Tentative (A) to Confirmed, and we are all done. |

# Dijkstra Example 2




| Step | Confirmed | Tentative |
|---|---|---|
| 1 | (A,0,-) | |
| 2 | (A,0,-) | (B,1,B) (D,5,D) |
| 3 | (A,0,-) (B,1,B) | (D,4,B) (C,7,B) |
| 4 | (A,0,-) (B,1,B) (D,4,B) | (C,5,B) (E,7,B) |
| 5 | (A,0,-) (B,1,B) (D,4,B) (C,5,B) | (E,6,B) |
| 6 | (A,0,-) (B,1,B) (D,4,B) (C,5,B) (E,6,B) | |

# Conclusion

- IPv6 Headers
- Routing
  - Introduction and Goals
  - RIP
  - OSPF