Chapter 20

course	Computer Networks
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Status	Not started
Resource	☐

Notes

Chapter 20: Unicast Routing

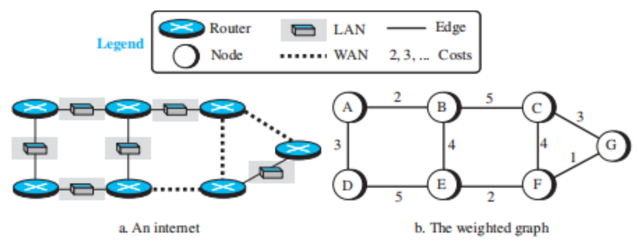
20.1 Introduction

- Unicast routing in the Internet requires hierarchical routing.
- General concept: Packet routed hop by hop using forwarding tables.
- Internet modeled as a weighted graph, with routers as nodes and networks as edges.
- Cost associated with each edge, representing the cost of routing.

20.1.1 General Idea

- Packet routed from source router to destination router.
- Multiple routes possible; determining the best route is crucial.
- Internet modeled as a graph; each router a node, each network an edge.

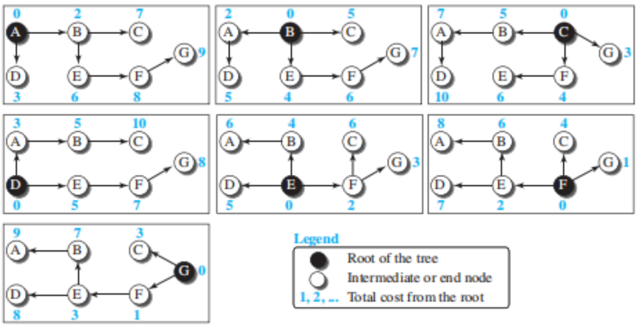
Figure 20.1 *An internet and its graphical representation*



20.1.2 Least-Cost Routing

- Interpret best route as least cost between source and destination router.
- Least-cost trees combine all least-cost paths into a single tree.
- Properties of least-cost trees ensure efficient routing.

Figure 20.2 *Least-cost trees for nodes in the internet of Figure 20.1*



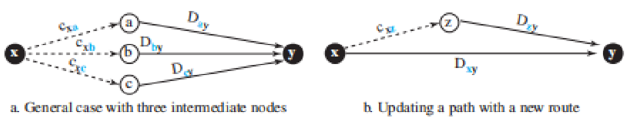
20.2 Routing Algorithms

- Different routing algorithms interpret least cost and create least-cost trees differently.
- Common algorithms discussed, later implemented in Internet routing protocols.

20.2.1 Distance-Vector Routing

- Nodes create least-cost tree with initial information.
- Trees exchanged between neighbors to represent entire Internet.
- Bellman-Ford equation central to distance-vector routing.
- Distance vectors represent least costs; exchanged and updated asynchronously.
- Algorithm run independently by each node, asynchronously.
- Challenges: count to infinity, two-node loop, solutions include split horizon and poison reverse.

Figure 20.3 *Graphical idea behind Bellman-Ford equation*



Conclusion

- Unicast routing crucial for Internet communication.
- Understanding routing algorithms essential for network efficiency and stability.

Figure 20.4 *The distance vector corresponding to a tree*

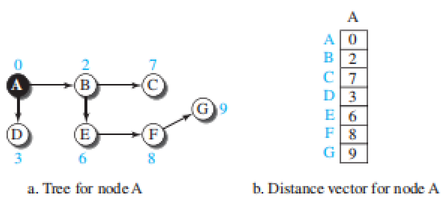


Figure 20.5 *The first distance vector for an internet*

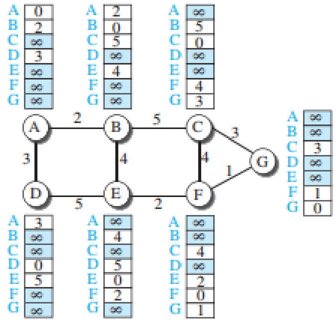
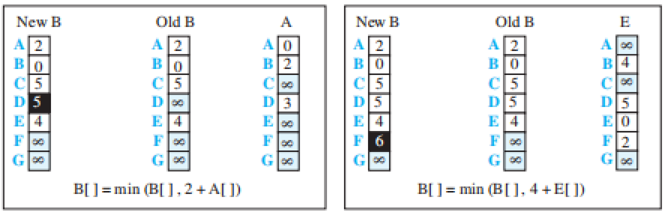


Figure 20.6 *Updating distance vectors*



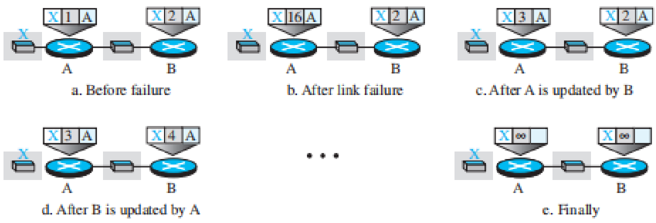
a. First event: B receives a copy of A's vector.

b. Second event: B receives a copy of E's vector.

Problems:

1. Count to infinity problem
2. Two node loop

Figure 20.7 *Two-node instability*

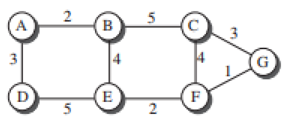


20.2.2 Link-State Routing

- **Definition**: Directly creates least-cost trees and forwarding tables.
- **Link-State Database (LSDB)**:
  - Contains complete network map.
  - Each node maintains a duplicate.
  - Represented as a 2D array.
- **Flooding Process**:
  - Nodes send greeting messages to neighbors to collect LS packets.
  - LS packet: Node identity and link cost.
  - Nodes update LSDB and discard outdated packets.

- **Comparison** with Distance-Vector Routing:
  - Node shares info with neighbors.
  - Focuses on sharing info about neighbors with entire network.

Figure 20.8 *Example of a link-state database*



a. The weighted graph

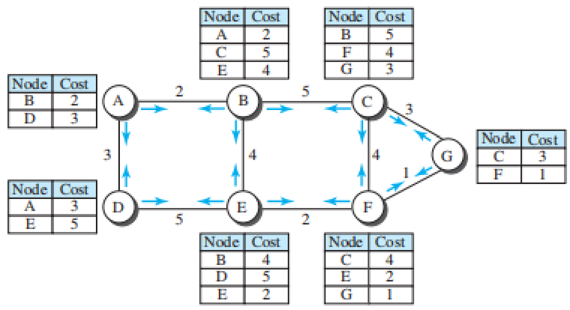
	A	B	C	D	E	F	G
A	0	2	∞	3	∞	∞	∞
B	2	0	5	∞	4	∞	∞
C	∞	5	0	∞	∞	4	3
D	3	∞	∞	0	5	∞	∞
E	∞	4	∞	5	0	2	∞
F	∞	∞	4	∞	2	0	1
G	∞	∞	3	∞	∞	1	0

b. Link state database

Formation of Least-Cost Trees

- **Dijkstra Algorithm**:
  1. Node selects itself as root.
  2. Adds closest node to tree, updates costs.
  3. Repeats until all nodes included.

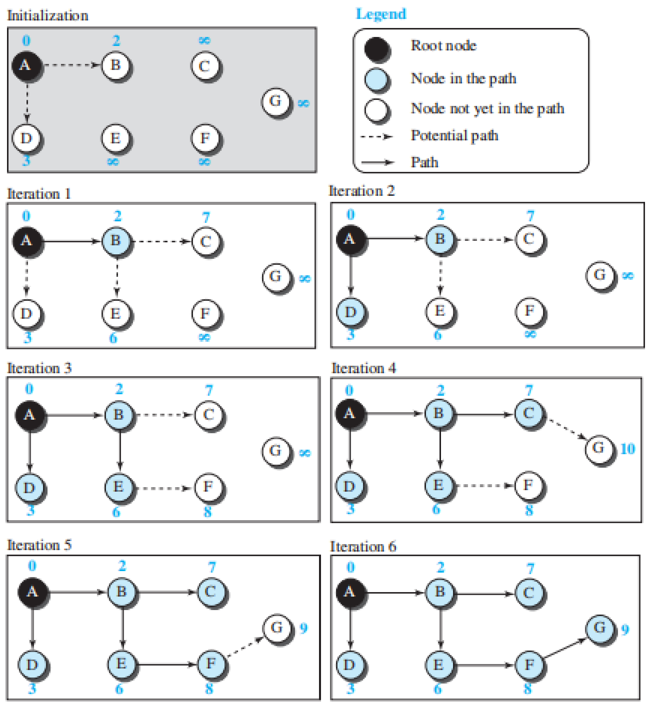
Figure 20.9 *LSPs created and sent out by each node to build LSDB*



20.2.3 Path-Vector Routing

- **Purpose**: Not solely based on least-cost, allows sender control over route.
- **Policy Control**: Source determines route based on policy.
- **Spanning Trees**: Determined by best spanning tree according to policy.
- **Creation**:
  - Asynchronous, each node gradually builds its spanning tree.
  - Initial path vector based on immediate neighbor info.
  - Path vectors updated based on own policy.

Figure 20.10 *Least-cost tree*



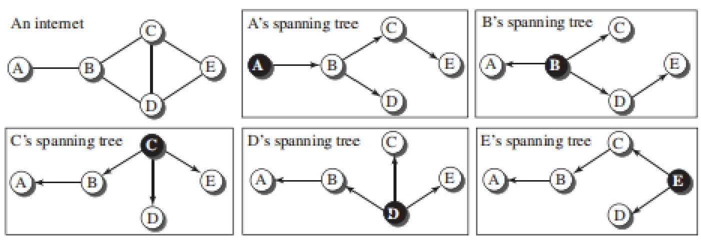
Path-Vector Algorithm

- **Initialization**:
  - Set distances to root, infinity for others.
- **Update Process**:
  - Update vector using received neighbor vectors.
  - Avoid loops in paths.

Conclusion

Unicast routing algorithms like Link-State and Path-Vector offer different approaches to route computation, allowing for flexibility and control over network paths based on various criteria. Understanding their mechanisms is crucial for efficient network management.

Figure 20.11 *Spanning trees in path-vector routing*



Unicast Routing Protocols: A Summary

This document provides a concise overview of unicast routing protocols, focusing on the essential details of RIP, OSPF, and BGP. It highlights the key differences between these protocols and their suitability for various network applications.

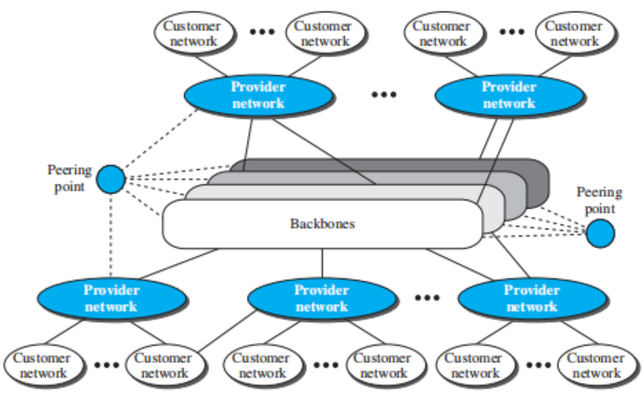
1. Introduction

- Unicast routing protocols are responsible for determining the optimal path for sending packets from a source to a single destination within an internetwork (internet).
- These protocols rely on algorithms to calculate the best route based on specific metrics like hop count, bandwidth, or delay.

2. Internet Structure

- The modern internet has a hierarchical structure consisting of multiple backbones, provider networks, and customer networks.
- Backbones are high-speed connections managed by private corporations and form the core of the internet.
- Provider networks connect to backbones and offer internet services to customers.
- Customer networks are those used by individual users or organizations to access the internet.

Figure 20.14 *Internet structure*



3. Hierarchical Routing

- Due to the internet's vast size and complexity, a single routing protocol cannot manage routing efficiently.
- Hierarchical routing addresses this by dividing the internet into Autonomous Systems (ASes).
- An AS is a group of networks under a single administrative domain that defines its own routing policies.
- Each AS employs an intradomain routing protocol for internal routing, while a global interdomain routing protocol handles communication between ASes.

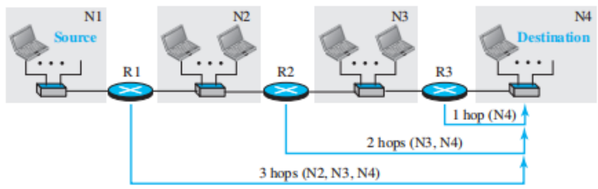
4. Routing Protocols

a. RIP (Routing Information Protocol)

- RIP is a widely used distance-vector routing protocol based on the Bellman-Ford algorithm.
- It uses hop count (number of routers traversed) as the routing metric.
- RIP routers exchange routing information with their neighbors periodically, and updates propagate throughout the network.

- RIP is simple to configure but has limitations:
    - Slow convergence: Updating routing tables after network changes can be slow, especially in large networks.
    - Limited scalability: RIP is not suitable for very large networks due to the volume of routing information exchanged.
    - Loop formation: In certain network configurations, RIP updates can create routing loops.

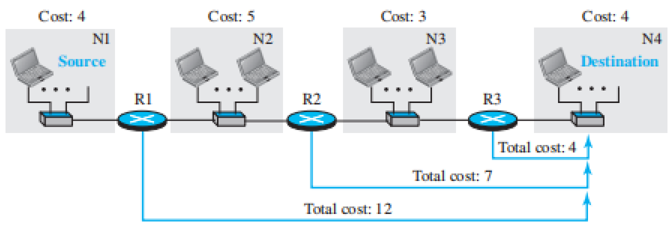
Figure 20.15 *Hop counts in RIP*



b. OSPF (Open Shortest Path First)

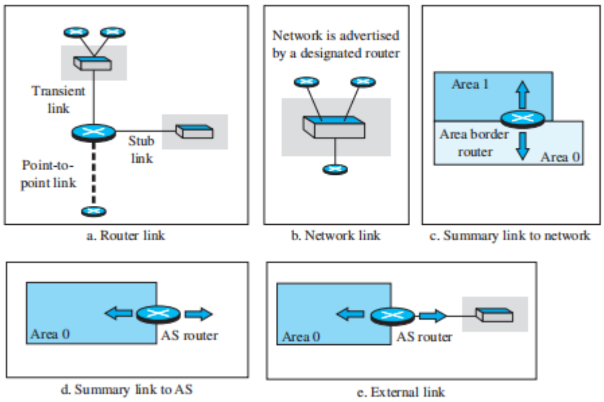
- OSPF is a link-state routing protocol that employs Dijkstra's algorithm to calculate the shortest path to destinations.
- Each OSPF router maintains a Link-State Database (LSDB) containing information about the network topology and link costs.
- Routers advertise their link states to neighbors, enabling them to build their own LSDBs and determine optimal routes.

Figure 20.19 *Metric in OSPF*



- OSPF offers several advantages over RIP:
    - Faster convergence: Routing updates propagate quickly due to the link-state approach.
    - Scalability: OSPF is well-suited for large networks as updates are limited to neighboring routers.
    - Loop prevention: OSPF employs mechanisms to prevent routing loops.
- OSPF is more complex to configure than RIP but provides better performance and scalability for larger networks.

Figure 20.22 *Five different LSPs*



c. BGP (Border Gateway Protocol)

- BGP is the primary interdomain routing protocol used for communication between different ASes.
- It is a path-vector routing protocol that exchanges routing information about reachable networks and their AS paths.
- BGP allows ASes to establish peering relationships and negotiate policies for routing traffic.
- Unlike RIP and OSPF, BGP is not concerned with calculating the shortest path but focuses on reachability and policy-based routing between ASes.

5. Conclusion

The choice of unicast routing protocol depends on the network size, complexity, and administrative requirements. RIP is suitable for small, simple networks, while OSPF offers better performance and scalability for larger internal domains. BGP is essential for interdomain routing and communication between different internet providers.

BGP Routing Protocol Explained

Introduction

The Border Gateway Protocol (BGP) is the internet's core routing protocol. It's responsible for exchanging routing information and network reachability between different autonomous systems (AS) on the internet. Unlike intradomain routing protocols (RIP or OSPF) used within a single network, BGP facilitates communication across networks owned by different administrative entities.

BGP Versions

BGP version 4 (BGP4) is the dominant version used today. It relies on the path-vector routing algorithm, which considers the path a packet takes to reach its destination along with other factors for route selection.

How BGP Works

BGP uses two variations:

- **External BGP (eBGP):** This variation enables border routers from different ASes to establish connections and exchange routing information. Routers create TCP sessions (port 179) and send update messages advertising reachable networks within their AS.
- **Internal BGP (iBGP):** This variation allows routers within the same AS to share routing information learned from eBGP or other iBGP peers. It ensures consistent routing knowledge across the entire AS.

BGP Message Exchange

BGP routers communicate through four message types:

1. **Open Message:** Initiates a BGP session between two routers.
2. **Update Message:** The core message type. It advertises new destinations, withdraws previously advertised ones, or both.
3. **Keepalive Message:** Periodically sent to confirm the BGP session is active.
4. **Notification Message:** Sent when errors occur or a session needs termination.

Path Selection

BGP employs a multi-step process for selecting the best route:

1. **Local Preference:** Routes with higher administrator-defined preference values are prioritized.
2. **AS Path Length:** Shorter AS paths (fewer hops) are generally preferred.
3. **Origin:** Routes learned from more reliable sources (e.g., internal routing protocols) are favored.
4. **Multi-Exit Discriminator (Optional):** If multiple exit points exist within an AS, this attribute can influence selection based on intra-domain routing metrics.

Benefits of BGP

- **Scalability:** BGP can handle the vast internet's size and complexity.
- **Flexibility:** It allows for policy-based routing decisions based on administrative preferences.
- **Loop Prevention:** The AS Path attribute helps avoid routing loops.

Challenges of BGP

- **Complexity:** BGP configuration and troubleshooting can be intricate.
- **Security:** BGP is vulnerable to routing manipulation and hijacking attempts.
- **Convergence Time:** Establishing and updating routing tables across the internet can take time.

Summary

BGP plays a critical role in internet routing. By understanding its core functionalities, message types, and route selection process, you gain valuable knowledge about how internet traffic flows across different networks.