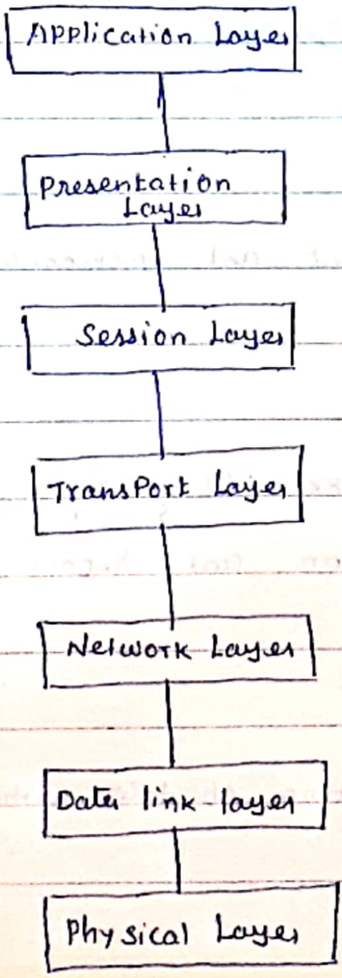
* What is the function of N/w Layer?

The Primary function of the network layer is to enable different networks to be interconnected. It does this by forwarding Packets to network routers, which rely on algorithms to determine the best Paths for the data to travel.

* OSI Model

  - OSI Reference Model - internationally Standardised network architecture.
  - OSI (Open System Interconnection) - deals with open systems
  - Specified in ISO 7498.
  - Model has 7 layers.



Note

* Layers 1-4 relate to communi-cations technology.
* Layers 5-7 relate to user applications.

Layer-7 :- Application Layer :-

- Application access network services.
- Represents services that directly support software applications for file transfers, database access and electronic mail etc..

Layer-6 :- Presentation Layer:-

- Related to representation of transmitted data
  * Translates different data representations from the application layer into uniform standard
- Providing services for secure transmission
  * data encryption and data compression

Layer-5 :- Session Layer:-

- Establishes dialog control
- Performs token management and synchronization.

Layer:- 4 :- Transport Layer:-

- Manages transmission packets (when necessary small packets)
- Handles error recognition and recovery.

Layer :- 03 Network Layer:-

- Manages addressing / routing of data within the subnet

* Addresses messages and translates logical addresses and names into Physical addresses.
* Determines the route
* Manages traffic Problems.

- Routing can be:
  - Based on Static tables
  - Determined at Start of each Session

Layer-2 :- Data Link Layer

* Packages raw bits from the physical Layer into frames (Logical, Structured Packets for data)
* Provides reliable transmission of frames

Layer:-1 Physical Layer

* Regulates the transmission of a stream of bits over a Physical Medium.
* Cable is attached to the network adapter

Link - State Routing Protocol

Overview

Features of Link State routing Protocols.

Link - State Routing algorithm.

Dijkstra's algorithm.

OSPF

IS - IS

Advantages and DisAdvantages of LS routing Protocols.

Overview

- One of two main classes of interior gateway routing Protocols
  - * OSPF
  - * IS-IS
- Performed by every switching node in the Network

Basic Concept:-

- every node creates a map of the connectivity to the network
  - The graph shows which nodes are connected to which other nodes.
  - Each node calculates the next best logical path to the destination.
  - Collection of best paths form the routing table of the node.

Features of Link-State routing Protocols.

* Link State advertisement (LSA) or Link-State-Packet (LSP)
  - Small packet of routing information that is sent b/w routers.
* Topological database (or) Link-State Database.
  - A collection of information gathered from LSAs
* SPF Algorithm:-
  - A calculation performed on the database that results in the SPF tree
* Routing table:-
  - A list of the known paths and interfaces.

Link State routing algorithm:-

Each node responsible for meeting its neighbors and learning

↓

Each router constructs a LSP / LSA

↓

LSP / LSA is transmitted to all others router.

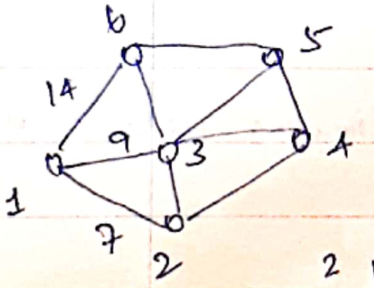
↓

Each router uses complete information on the Network topology.

↓

Compute the shortest path route.

Dijkstra's algorithm.



	2	3	4	5	6
1	7	9	-	-	14

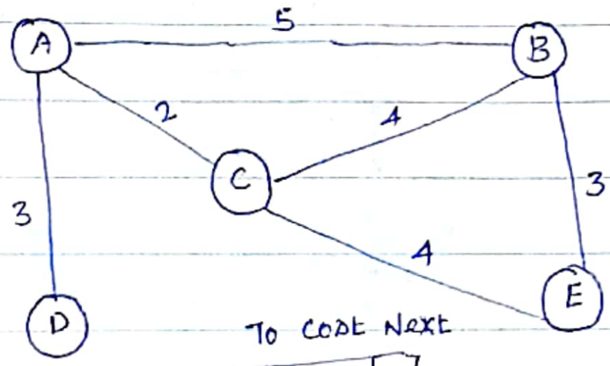
Distance Vector Routing

* The least-cost route b/w any two nodes is the route with minimum distance.

* Each node maintains a vector (table) of minimum distance to every node.

* The table at each node also guides the packets to the desired node by showing the next hop routing.

Final Distance Vector routing tables



A's table

To	cost	Next
A	0	–
B	5	–
C	2	–
D	3	–
E	6	C

B's table

To	cost	Next
A	5	–
B	0	–
C	4	–
D	8	A
E	3	–

D's table

To	cost	Next
A	3	–
B	8	A
C	5	A
D	0	–
E	9	A

C's table

To	cost	Next
A	2	–
B	4	–
C	0	–
D	5	A
E	4	–

E's table

To	cost	Next
A	6	C
B	3	–
C	4	–
D	9	C
E	0	–

Initialization

a) The table in figure are stable

b) Each node known how to reach any other node and their cost.

c) At the beginning, each node know the cost of itself and its immediate neighbor

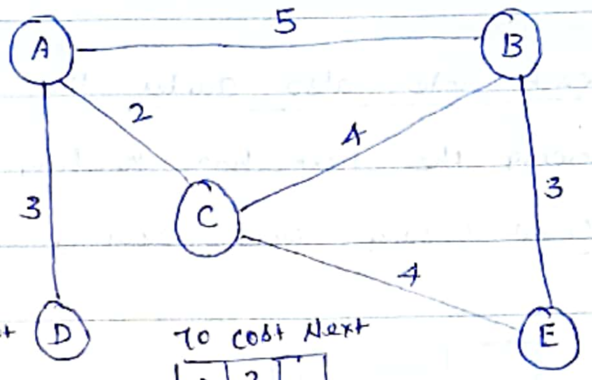
d) Assume that each node send a message to the immediate neighbors and find the distance b/w itself and these neighbors.

e) The distance of any entry that is not a neighbor is marked as infinite

Initialization of table in distance Vector Routing (DVR)

To	Cost	Next
A	0	–
B	5	–
C	2	–
D	3	–
E	∞	

A's table



To	Cost	Next
A	5	–
B	0	–
C	4	–
D	∞	
E	3	–

B's table.

To	Cost	Next
A	3	–
B	∞	
C	∞	
D	0	–
E	∞	

D's table

To	Cost	Next
A	2	–
B	4	–
C	0	–
D	∞	
E	4	–

C's table

To	Cost	Next
A	∞	
B	3	B
C	4	C
D	∞	
E	0	D

E's table

Sharing

a) Idea is to share the information b/w neighbors.

b) The node A does not know the distance about E, but node 'C' does.

c) If node C share it routing table with A, node 'A' can also know how to reach node E.

d) On the other hand, node C does not know how to reach node D, but node A does.

e) If node A share its routing table with C, then node 'C' can also know how to reach node D.

f) Node A and C are immediate neighbors, can improve their routing tables if they help each other.

When to Share :-

a) Periodic update :- A node sends its table, normally every 30sec, in a periodic update, it depends on the protocol that is using DVR

b) Triggered update :-

A node sends its two-column routing table to its neighbors any time there is a change in its routing table.

c) This is called triggered update the change can result from the following.

✓ A node receives a table from a neighbor, resulting in changes in its own table after updating.

✓ A node detects some failure in the neighboring links which results in a distance change to infinity.

3-keys to understand how this algorithm works,

* Sharing knowledge about the entire AS
* Sharing only with immediate neighbours.
* Sharing at regular intervals.

Problems :-

Tedious comparing / updating process, slow response to infinite loop problem, huge list to be maintained.

Introduction

- Routing protocols used in wired networks cannot be directly applied to ad hoc wireless networks
  - Highly dynamic topology
  - No infrastructure for centralized administration
  - Bandwidth constrained
  - Energy constrained
- For the above reasons, we need to design new routing protocols for ad hoc networks

Issues in Designing a Routing Protocol

- Mobility:
  - Ad hoc is highly dynamic due to the movement of nodes
  - Node movement causes frequent path breaks
  - The path repair in wired network has slow convergence
- Bandwidth Constraint:
  - Wireless has less bandwidth due to the limited radio band: Less data rate and difficult to maintain topology information
  - Frequent change of topology causes more overhead of topology maintenance
  - Target: Bandwidth optimization and design topology update mechanism with less overhead

Issues in Designing a Routing Protocol

- Error-prone shared broadcast radio channel:
  - Wireless links have time varying characteristics in terms of link capacity and link-error probability
  - Target: Interact with MAC layer to find better-quality link
  - Hidden terminal problem causes packet collision
  - Target: Find routes through better quality links and find path with less congestion
- Hidden and exposed terminal problems
  - RTS-CTS control packet cannot ensure collision free, see Fig. 7.2
- Resource Constraints:
  - Limited battery life and limited processing power
  - Target: optimally manage these resources

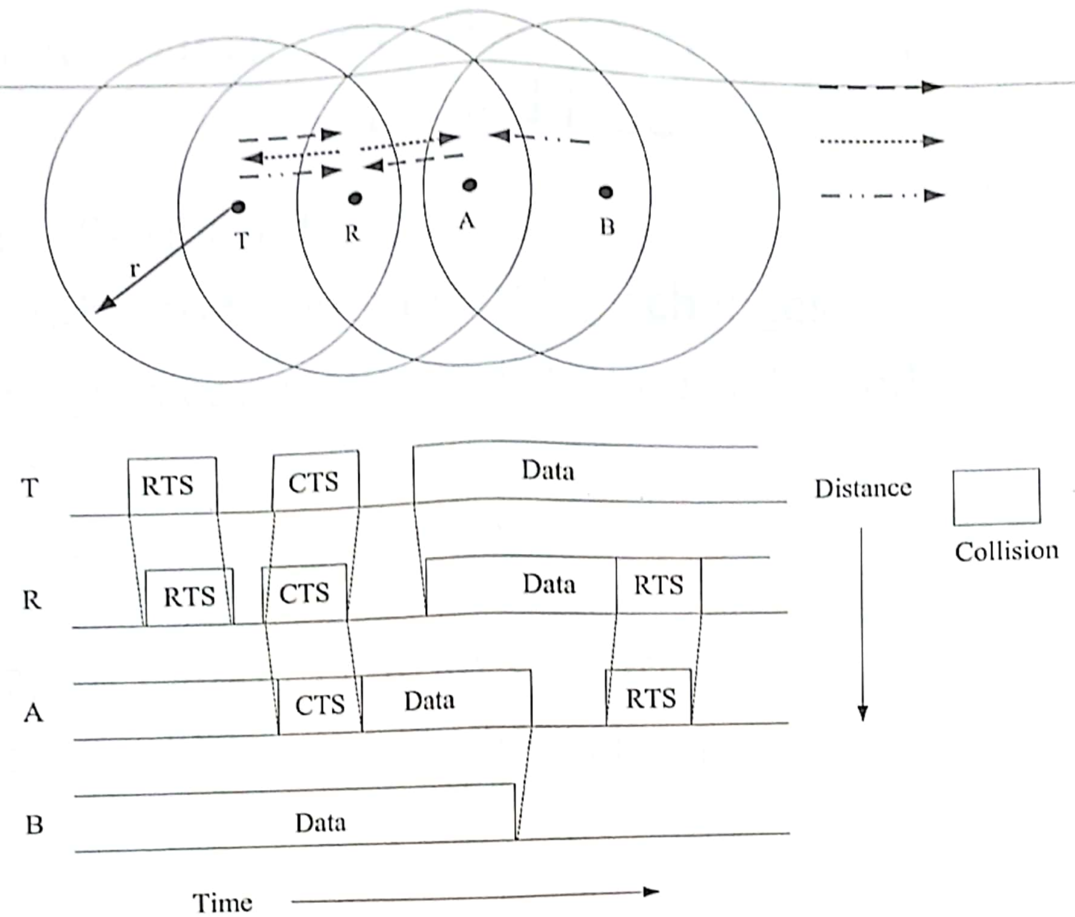


Figure 7.2. Hidden terminal problem with RTS-CTS-Data-ACK scheme.

Characteristics of an Ideal Routing Protocol for Ad Hoc

- Fully distributed
- Adaptive to frequent topology changes
- Minimum connection setup time is desired
- Localized
  - global maintenance involves a huge state propagation control overhead
- Loop free and free from stale routes
- Packet collision must seldom happen

Characteristics of an Ideal Routing Protocol for Ad Hoc (cont.)

- Converge to optimal route quickly
- Optimally use scarce resource
  - Bandwidth, computing power, memory, and battery
- Remote parts of the network must not cause updates in the topology information maintained by this node
- Provide quality of service and support for time-sensitive traffic

Classifications of Routing Protocols

- Routing protocol can be broadly classified into four categories :
  - Routing information update mechanism
    - Pro-active - (table driven)
    - Re-active - (on-demand)
    - Hybrid - (with in zone - table driven, without zone - Re-active)
  - Use of temporal information for routing - Past status of the link (after taking decision)
    - Past status
    - Future status of the link
  - Routing topology
    - Flat topology
    - Hierarical topology
  - Utilization of specific resource
    - Power-aware Routing.
    - Geographical Routing.
- These classification is not mutually exclusive

Based on the Routing Information Update Mechanism

- Proactive or table-driven routing protocols
  - Maintain routing information in the routing table
  - Routing information is flooded in the whole network
  - Runs path-finding algorithm with the routing table
- Reactive or on-demand routing protocols
  - Obtain the necessary path while required
- Hybrid routing protocols
  - In the zone of given node : use table-driven
  - Out of the zone of given node : use on-demand

Based on the Use of Temporal Information for Routing

- Using past temporal information
  - Past status of the links or
  - the status of links at the time of routing to make routing decision
- Using future temporal information
  - Expected future status of the links to make decision
  - Node lifetime is also included
    - Ex: remaining battery charge, prediction of location, and link availability

Based on the Routing Topology

- Flat topology routing protocols
  - Flat addressing scheme similar to IEEE 802.3 LANs
  - Globally unique addressing mechanism for nodes
- Hierarchical topology routing protocols
  - Logical hierarchy
  - Associated addressing scheme
  - May based on geographical information or hop distance

Figure 7.4. Classifications of routi

Based on the Utilization of Specific Resource

- Power-aware routing
  - Minimize consumption of resource
    - Ex: Battery power
- Geographical information assisted routing
  - Improve the routing performance
  - Reduce control overhead

Figure 7.4: Classifications of routi

Classifications of Routing Protocol:

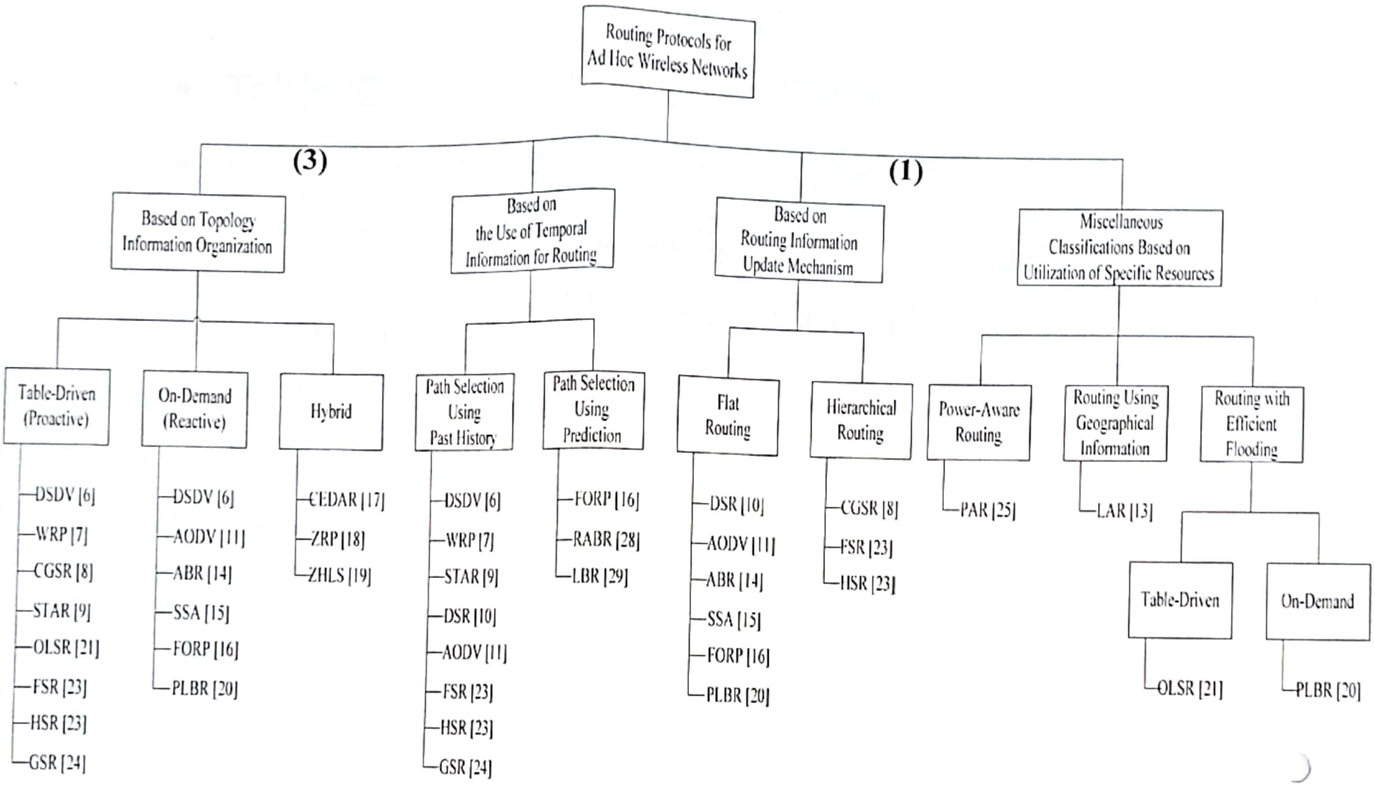


Figure 7.4. Classifications of routir

Scanned with CamScanner

- Table-Driven Routing Protocols
- On-Demand Routing Protocols
- Hybrid Routing Protocols
- Routing Protocol With Efficient Flooding Mechanisms
- Hierarchical Routing Protocols
- Power-Aware Routing Protocols

Table-Driven Routing Protocols

- We introduce these routing protocols:
  - Destination Sequenced Distance-Vector Routing Protocol (DSDV)
  - Wireless Routing Protocol (WRP)
  - Cluster-Head Gateway Switch Routing Protocol (CGSR)
  - Source-Tree Adaptive Routing Protocol (STAR)

Destination Sequenced Distance-Vector Routing Protocol (DSDV)

- Enhanced from distributed Bellman-Ford algorithm
- Obtain a table that contains shortest path from this node to every node
- Incorporate table updates with increasing sequence number tags
  - Prevent loops
  - Counter the count-to-infinity problem
  - Faster convergence

* Proactive Routing Protocol
↓
Example :- (DSDV)
↓
In this each node keeps record of route information in the form of routing table.

* Table consists of
  - Desistnation ID
  - Next Node
  - Distance (No. of hops)
  - Sequence No.

* Route broadcast message:
  - Destination node
  - next hop
  - Recent seq. No

Each node exchanges its updated routing table with each other.

updates
- Full Dump: Entire Routing table is sent to neighbor
  - Takes Multi Network Data Packet unit (NDPUS)
- Incremental update: Only entries that are changed are exchanged.
  - Single Network Data Packet Unit (NDPU)

DSDV (Cont.)

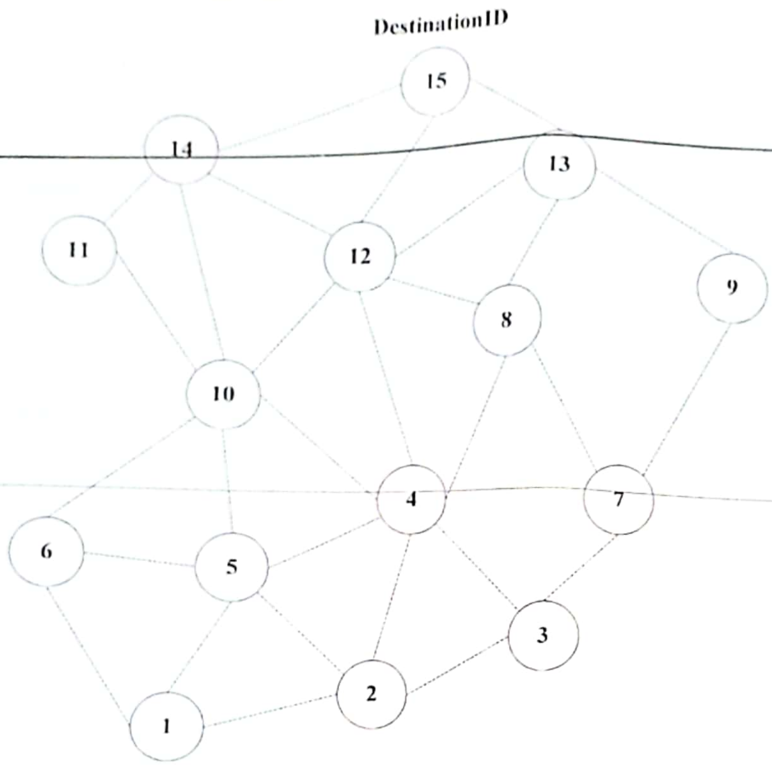
- Exchange table between neighbors at regular time interval
- Two types of table updates
  - Incremental update
    - Takes a single network data packet unit (NDPU)
      - When no significant change in the local topology
  - Full dumps update
    - Takes multiple NDPUs:
      - When local topology changes significantly
      - Or incremental updates require more than a NDPU

DSDV (Cont.)

- Table updates are initiated by the destination with the new sequence number which is always greater than the previous one
- Single link break cause propagation of table update information to the whole network
  - With odd sequence
- The changed node informs neighbors about new shortest path while receiving the table update message
  - With even sequence

Table Maintenance in DSDV

1) Each node receives the route info with most recent Seq. No from other nodes and updates its table
2) Node looks at its routing table in order to determine shortest path to reach all the destination.
3) Each node constructs another routing table based on shortest path info.
4) New Routing table will be broadcast to its neighbors
5) Neighbor nodes updates its routing table.

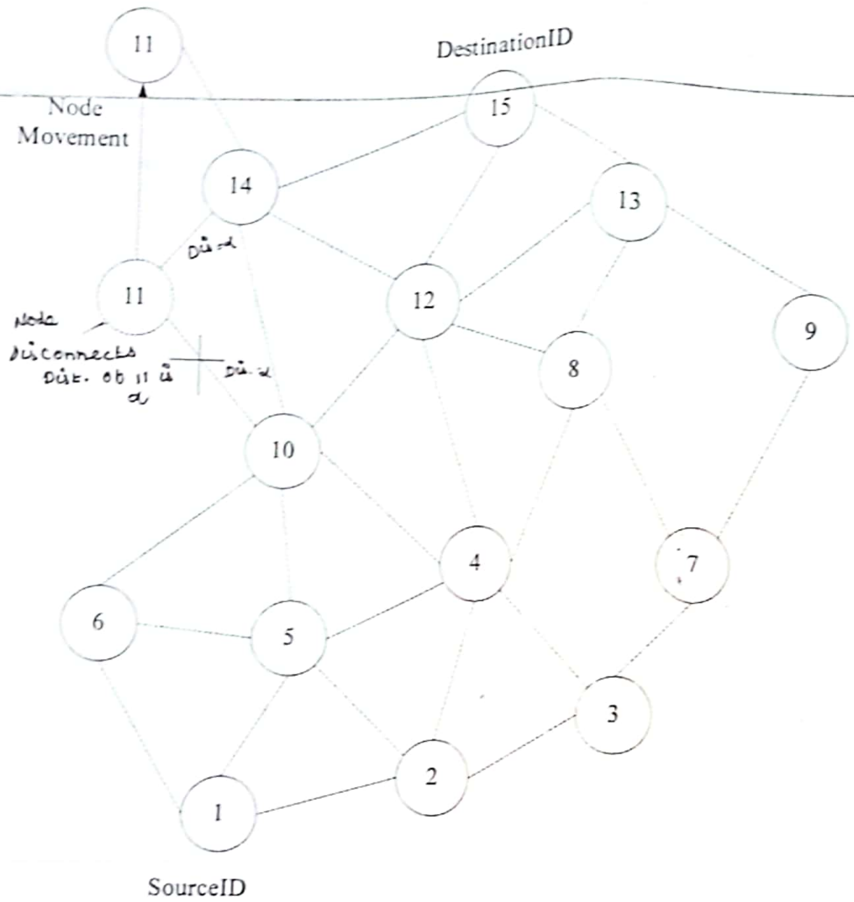


(a) Topology graph of the network

Dest	NextNode	Dist	SeqNo
2	2	1	22
3	2	2	26
4	5	2	32
5	5	1	134
6	6	1	144
7	2	3	162
8	5	3	170
9	2	4	186
10	6	2	142
11	6	3	176
12	5	3	190
13	5	4	198
14	6	3	214
15	5	4	256

(b) Routing table for Node 1

Figure 7.5. Route establishment in DSDV



Dest	NextNode	Dist	SeqNo
2	2	1	22
3	2	2	26
4	5	2	32
5	5	1	134
6	6	1	144
7	2	3	162
8	5	3	170
9	2	4	186
10	6	2	142
11	5	4	180
12	5	3	190
13	5	4	198
14	6	3	214
15	5	4	256
11	5	4	194

Table updates.

Figure 7.6. Route maintenance in DSDV

DSDV (Cont.)

- Advantages:
  - Route setup process is very fast
  - Make the existing wired network protocol apply to ad hoc network with fewer modifications
- Disadvantages:
  - Excessive control overhead during high mobility
  - Node must wait for a table update message initiated by the destination node
    - Cause stale routing information at nodes

On-demand Routing Protocol

- Unlike the table-driven routing protocols, on-demand routing protocols execute the path-finding process and exchange routing information only when a path is required by a node to communicate with a destination.

On-demand Routing Protocol

- Dynamic Source Routing Protocol (DSR)
- Ad Hoc On-demand Distance-Vector Routing Protocol (AODV)
- Temporally Ordered Algorithm (TORA)
- Location-Aided Routing (LAR)
- Associativity-Based Routing(ABR)
- Signal Stability-Based Adaptive Routing Protocol (SSA)
- Flow-Oriented Routing Protocol (FORP)

Dynamic Source Routing Protocol (DSR)

- Beacon-less: no *hello* packet
- Routing cache
- DSR contains two phases
  - Route Discovery (find a path)
    - Flooding RouteRequest with TTL from source
    - Response RouteReply by destination
  - If an forwarding node has a route to the destination in its route cache, it sends a RouteREply to the source
  - Route Maintenance (maintain a path)
    - RouteError

Routing Discovery

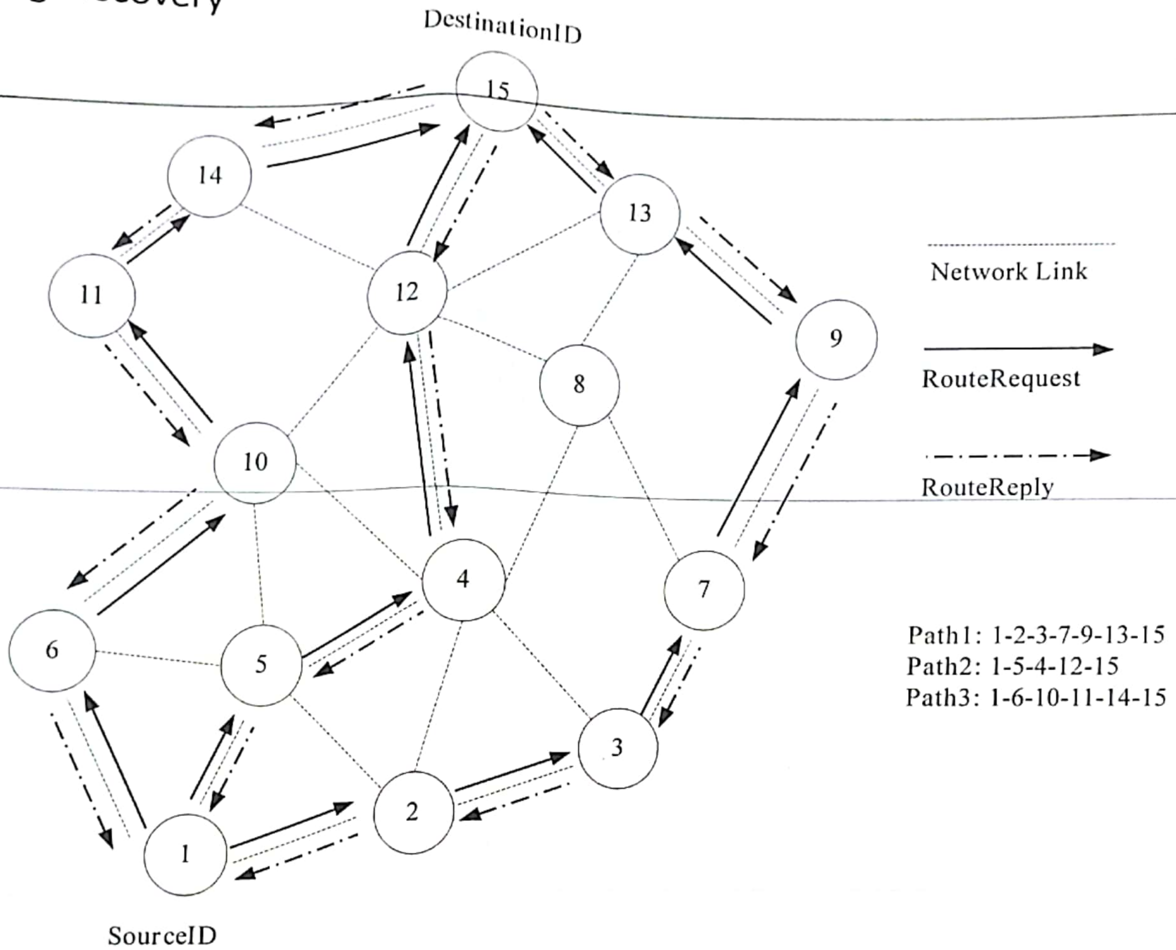


Figure 7.10. Route establishment in DSR.

Routing Maintain

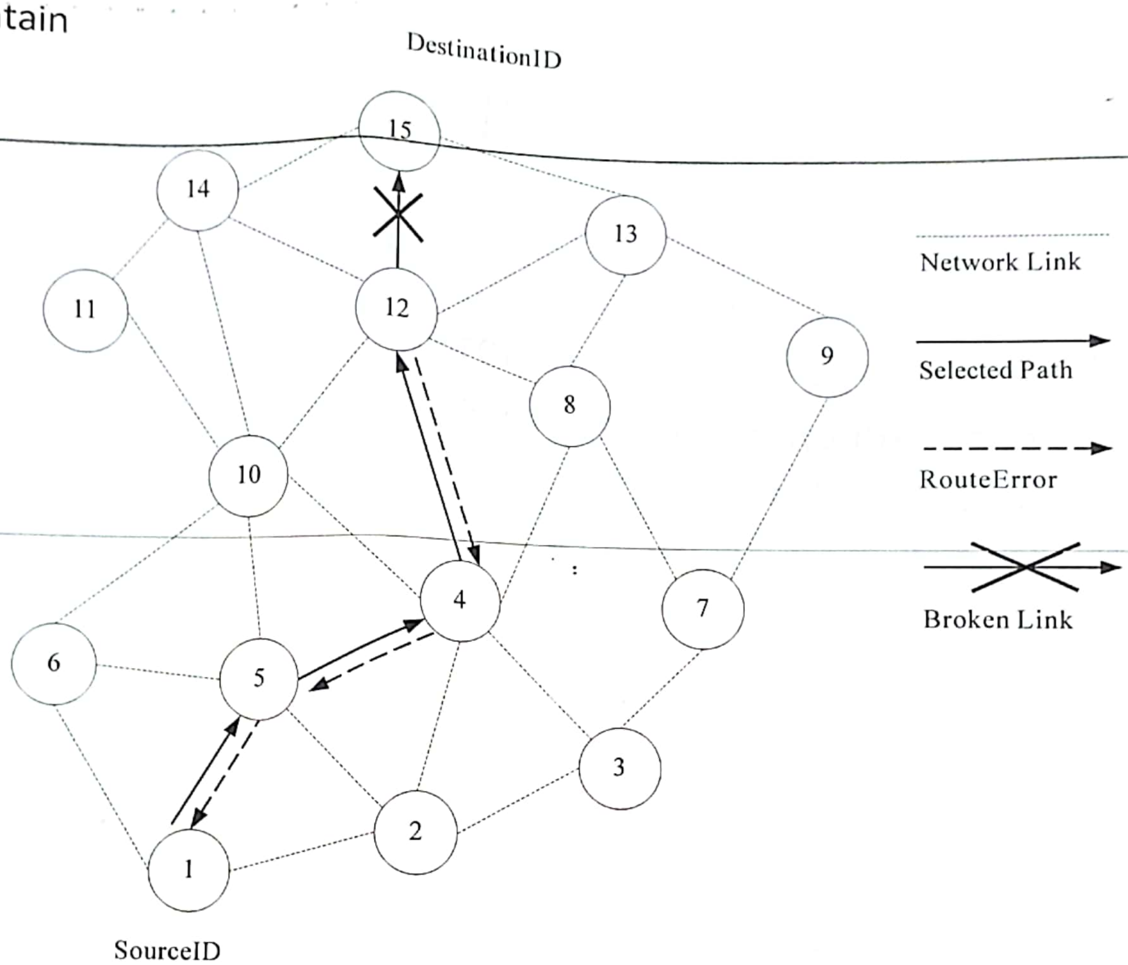


Figure 7.11. Route maintenance in DSR.

Dynamic Source Routing Protocol

- Advantage
  - No need to updating the routing tables
  - Intermediate nodes are able to utilize the Route Cache information efficiently to reduce the control overhead
  - There are no "hello" messages needed (beacon-less)
- Disadvantage
  - The Route Maintenance protocol does not locally repair a broken link
  - There is always a small time delay at the begin of a new connection

Ad Hoc On-demand Distance-Vector Routing Protocol (AODV)

- Every node has a routing table. When a node knows a route to the destination, it sends a route reply to the source node
- The major difference between DSR and AODV
  - DSR uses source routing in which a data packet carries the complete path to traversed.
  - AODV stores the next-hop information corresponding to each flow for data packet transmission.
- Message types
  - Route Requests (RREQs)
  - Route Replies (RREPs)
  - Route Errors (RERRs).

AODV

- RouteRequest packet carries:
  - SrcID, DestID, DestSeqNum, BcastID, and TTL
  - DestSeqNum indicates the freshness of the route is accepted
  - An intermediate node receives a RouteRequest packet. It either forwards it or prepares a RouteReply if it has a valid route to the destination
- RouteReply packet:
  - A node receives RouteReply packet will record the information as the next hop toward the destination
- AODV does not repair a broken path locally

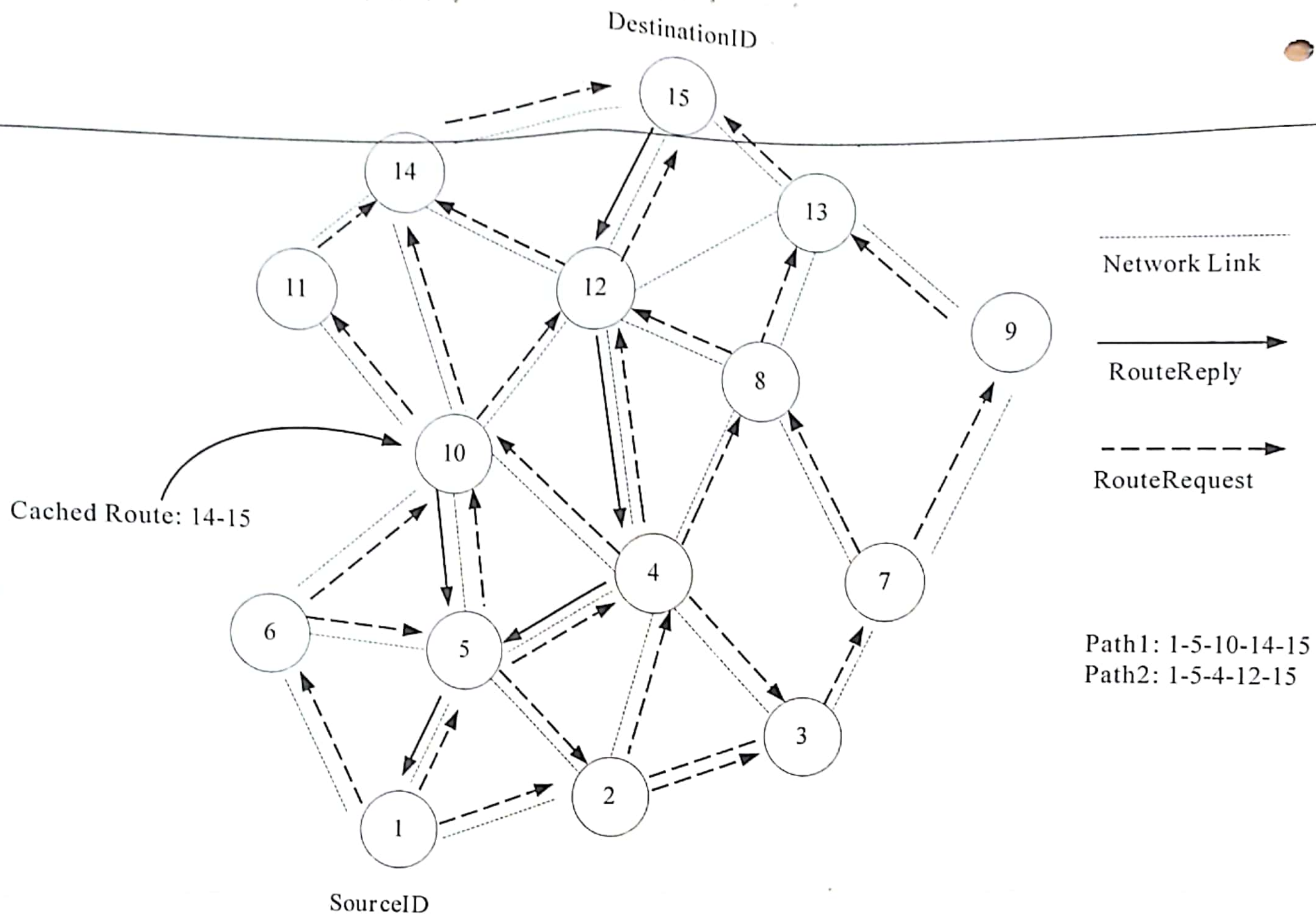


Figure 7.12. Route establishment in AODV.

Route Maintenance

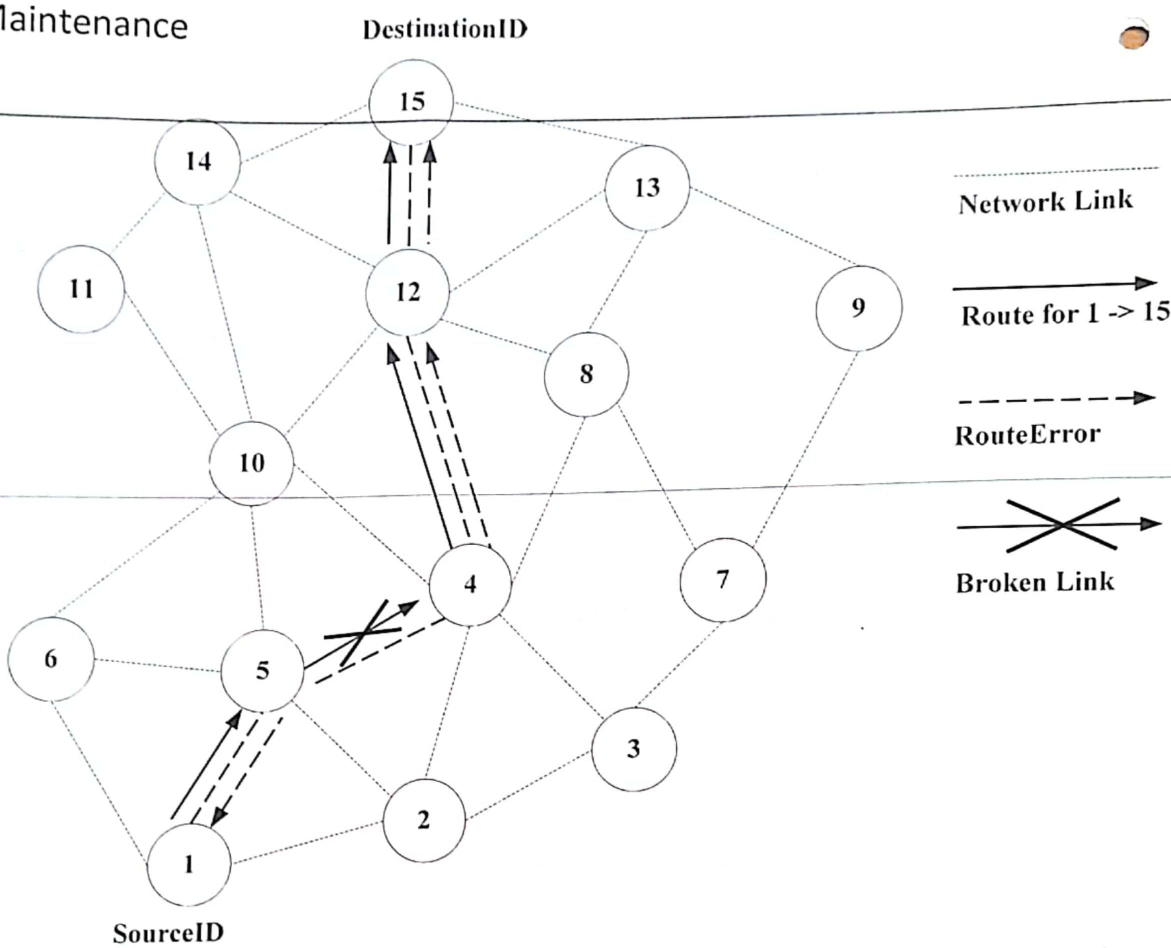


Figure 7.13. Route maintenance in AODV.

AODV

- Advantage
  - Establish on demand
  - Destination sequences are used to find the latest path to destination
  - The connection setup delay is less
- Disadvantage
  - Intermediate node can lead to inconsistent route
  - Beacon-base
  - Heavy control overhead