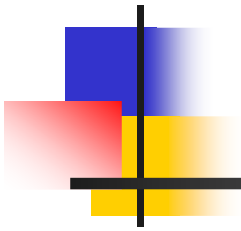

Hybrid Routing Protocols

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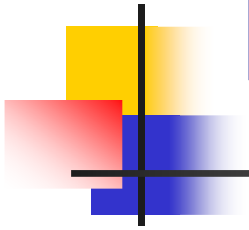
Special Course In Mobility Management

Hybrid Routing Protocols

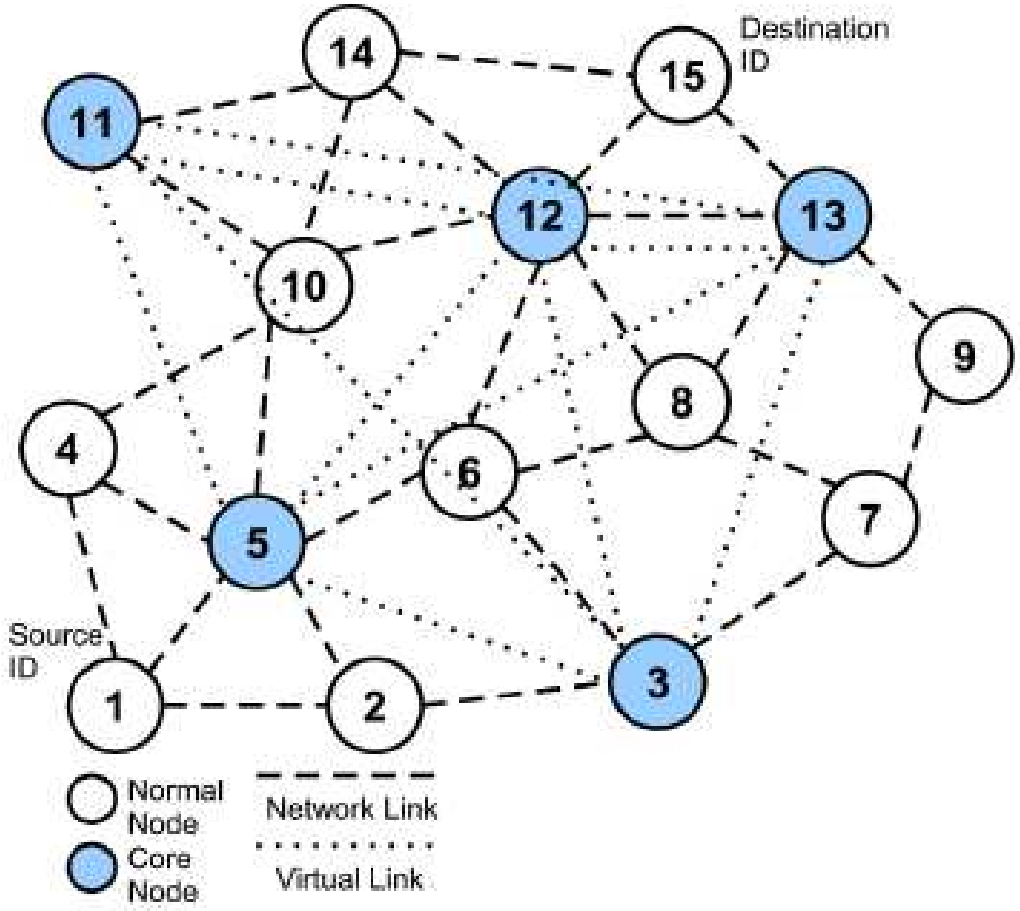


- Core Extraction Distributed Ad Hoc Routing(CEDAR) protocol
- Zone Routing Protocol (ZRP)
- Zone-based Hierarchical Link State (ZHLS) Routing Protocol
- Routing Protocols with Efficient Flooding Mechanisms
  - Preferred link–based rooting(PLBR) protocols
    - Neighbor Degree-based Preferred Link Algorithm
    - Weight-based Preferred Link algorithm
  - Optimized link state routing(OSLR) protocol

Core Extraction Distributed Ad Hoc Routing(CEDAR) protocol

- Route establishment uses reactive routing scheme and is performed by core nodes
- Basic concept: core extraction
  - there is at least on core node every three hops
  - every node picks up a node within a distance not greater than one hop from it, as its dominator
  - the core consists of the *dominators* and *tunnels*
  - tunnels consist of at most two intermediate non-core nodes
  - core nodes advertise their presence in the three-hop neighborhood

Core Extraction Distributed Ad Hoc Routing(CEDAR) protocol



Phase1:

- Finding core nodes
- Establishing virtual links

Phase2:

- Check local topology
- Initiate a RouteRequest
- Core broadcast
- RouteReply
- Core path

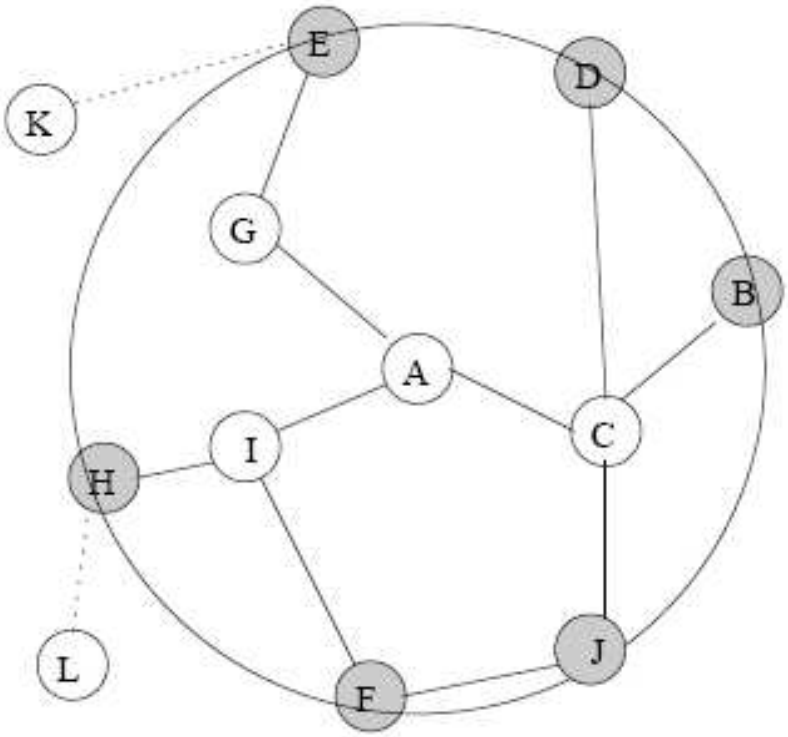
Core Extraction Distributed Ad Hoc Routing(CEDAR) protocol

- Link break:
  - The node after which the break occurred
    - sends a notification of failure
    - begins to find a new path from it to the destination.
    - rejects every received packet till the moment it finds a new path to the destination.
  - Meanwhile, as the source receives the notification message
    - it stops to transmit
    - tries to find a new route to the destination.
  - If the new route is found by either of these two nodes, a new path from the source to the destination is established!
- Advantage:
    - utilization of core nodes → reduces the traffic overhead
- Disadvantage:
    - the route establishment and computation is relied on core nodes
    - core nodes' movement affects the performance of the protocol

Zone Routing Protocol (ZRP)

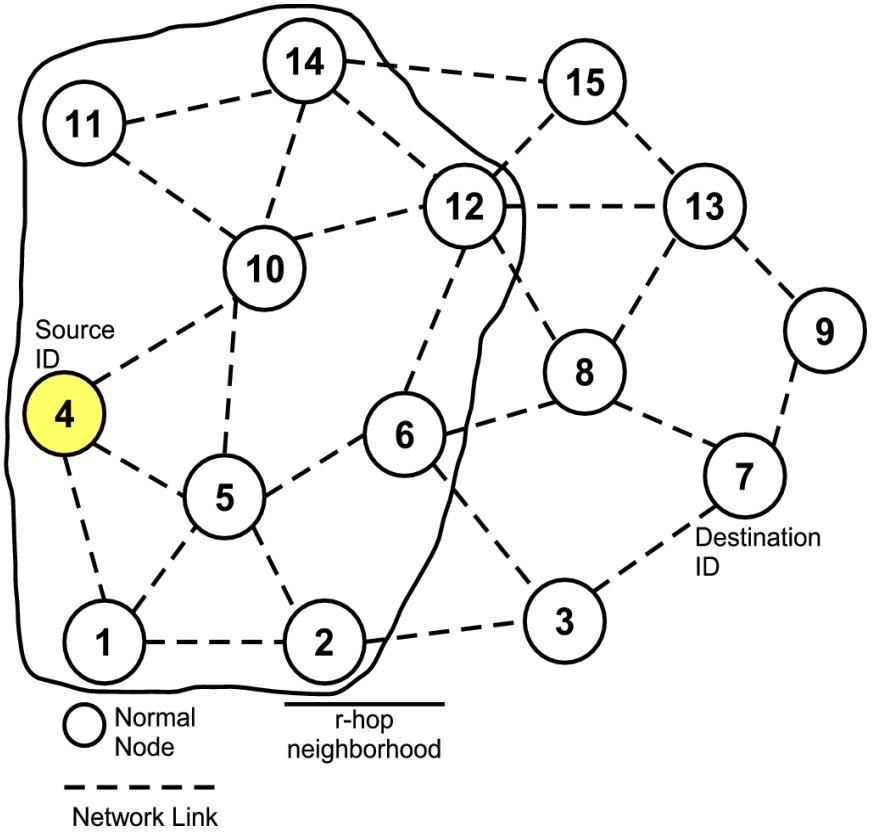
- Typical hybrid protocol:
  - combines proactive and reactive routing schemes.
- Divides the network to local "neighborhoods" – zones
- Intra-zone routing protocol (IARP) is used in the zone – proactive routing scheme
- Inter-zone routing protocol (IERP) is used for communication between the zones – reactive routing scheme

Zone Routing Protocol (ZRP)



- Each node may be in more then one zones
- Zones may be of a different size
- Zone radius r=2
- A's zone={B, C, D, E, F, G, H, I, J }
- Interior nodes={C, G, I }
- Peripheral nodes={B, D, E, F, H, J }
- Each node maintains the information about the routes to its zone nodes

Zone Routing Protocol (ZRP)

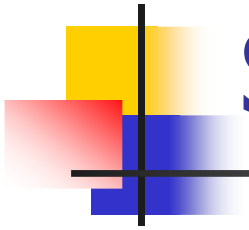


- Route establishment:
  - Check if the destination is within the zone
  - Bordercast RouteRequest
  - Check if the destination is within the zone
  - RouteReply
  - Source node chooses the best path

Zone Routing Protocol (ZRP)

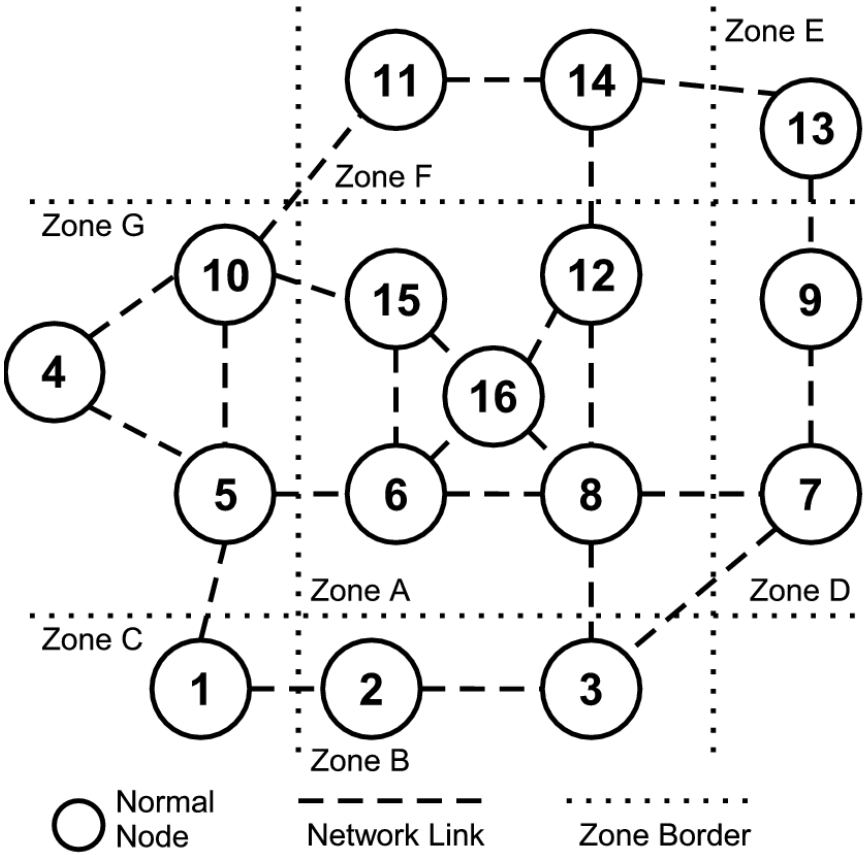
- Link break:
  - The intermediate node that detects a broken link in the path
    - chooses another alternative path to bypass the broken link - local path reconfiguration!
    - path update message is sent to the sender to inform it about the link failure.
- Advantage:
  - it reduces the control traffic produced by periodic flooding of routing information packets(proactive scheme)
  - it reduces the wastage of bandwidth and control overhead compared to reactive schemes
- Disadvantage:
  - the large overlapping of routing zones

Zone-based Hierarchical Link State (ZHLS) Routing Protocol



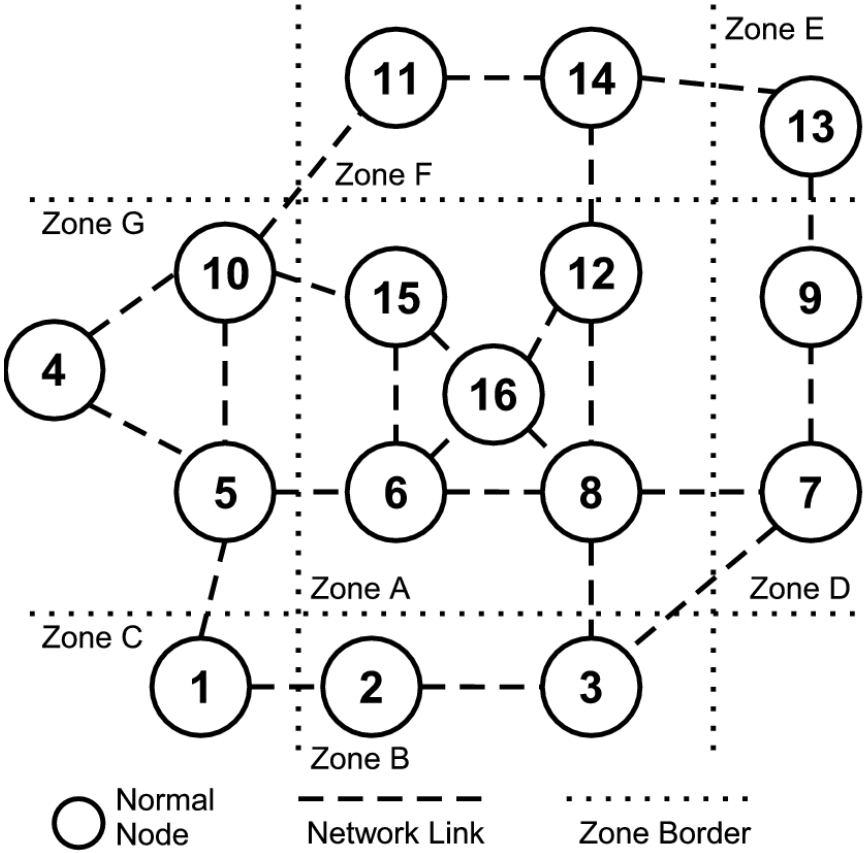
- Hybrid protocol based on node ID and zone ID approach
- Each node knows only the node connectivity within its zone and the zone connectivity of the whole network
- No cluster heads are defined in this protocol
- Routing is established based on zone ID and node ID of the destination
- No path containing the nodes between the source and the destination is required.
- Therefore, no link break could cause any problem to the delivery of the information.

Zone-based Hierarchical Link State (ZHLS) Routing Protocol



- Each node knows its physical location(node ID)
- Each node can determine its zone ID
- Each node maintains two link state packets(LSP)
  - node LSP: list of connected neighbors
  - zone LSP: list of connected zones

Zone-based Hierarchical Link State (ZHLS) Routing Protocol

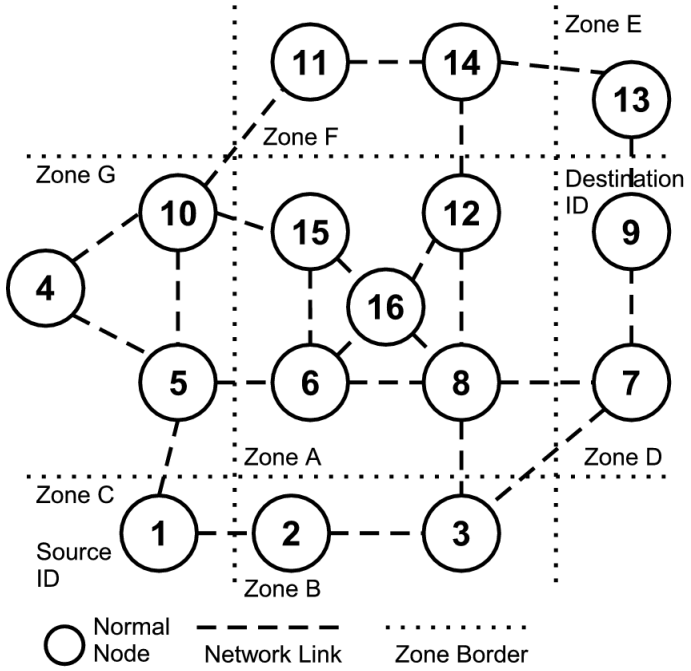


Source	Node LSP
6	8,15,16,G
8	6,12,16,B,D
12	8,16,F
15	6,16,G
16	6,8,12,15

Source	Zone LSP
A	B,D,F,G
B	A,C
C	B,G
D	A,B,E
E	D,F
F	A,E,G
G	A,C,F

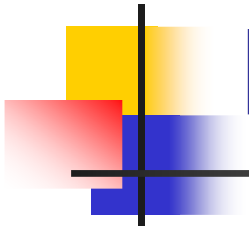
Zone-based Hierarchical Link State (ZHLS) Routing Protocol

- Route establishment:
  - Check if destination is within zone
  - Location request packet
  - Location response packet



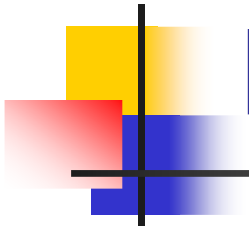
- Advantage:
  - No overlapping zones
  - The zone-level topology information is distributed to all nodes → reduces the traffic and avoids single point of failure
- Disadvantage:
  - Additional traffic produced by the creation and maintaining of the zone-level topology.

Routing Protocols with Efficient Flooding Mechanisms



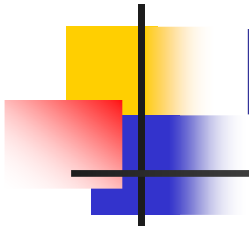
- Many protocols flood the network with RouteRequest packets in order to obtain a path to the destination
- Flooding of control packets results in:
  - Wastage of bandwidth
  - Increase in number of collisions
- Efficient flooding mechanism:
  - Preferred link–based rooting(PLBR) protocols
  - Optimized link state routing(OSLR) protocol

Preferred Link-based Routing(PLBR) protocols



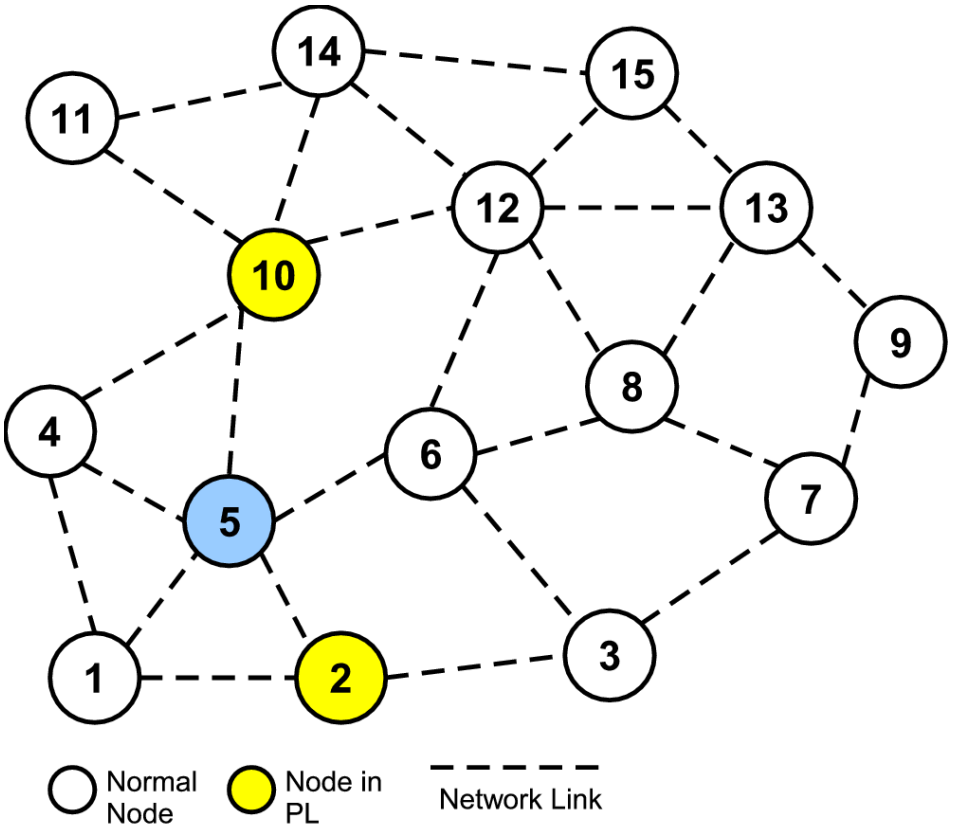
- Reactive rooting protocols
- Basic concept:
  - Each node maintains two tables: NT and NNT
  - Each node selects a subset called Preferred List(PL)
  - K: the size of the PL
  - Preferred List construction:
    - Neighbor Degree-based Preferred Link Algorithm
      - based on neighbor nodes' degree
      - divides its neighbor nodes to reachable and unreachable
    - Weight-based Preferred Link algorithm
      - based on the weight given to a node
      - its weight is based on its neighbors' temporal and spatial stability

Preferred Link-based Routing(PLBR) protocols



- RouteRequest packet:
  - Source node's address
  - Destination node's address
  - Unique sequence number
  - Traversed Path
  - Preferred List
  - Time to Live field
- RouteRequest packet is always broadcasted to all node's neighbors
- Only the ones in PL can forward it!

Preferred Link-based Routing(PLBR) protocols



- Route establishment
  - Preferred List
  - Broadcast
  - Only nodes in PL forward the broadcast
- Path selection
  - shortest path
  - least delay path
  - most stable path

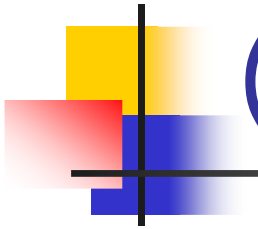
Preferred Link-based Routing(PLBR) protocols

- Link break:
  - PLBR uses a quick route repair mechanism to bypass the broken link using information about the next two hops from NNT.
- Advantage:
  - The efficient flooding mechanism → reduces the routing control overhead and provides better solutions than the other reactive protocols
  - A flooding efficient protocol has higher scalability and decreases the network collisions.
- Disadvantage:
  - Both PLBR and WBPL are much more computationally complex than the other reactive protocols.

Optimized Link State Routing (OLSR) protocol

- Proactive(table-driven) routing protocol: periodic information exchange
- Basic concept: the use of multipoint relaying(MPR) technique
- MPR is a subset of node's neighbors
  - Minimum one-hop nodes→ access to all of the two-hop nodes
  - Only MPRs retransmit the packets!!!
- Since MPRset is selected → two-hop neighborhood is known
- The MPRset is re-calculated when a change is detected in the neighborhood:
  - bidirectional link break or
  - bidirectional link appearance.

Optimized Link State Routing (OLSR) protocol



- MPRs are selected among the one-hop neighbors with a bidirectional link
- Periodic broadcast of HELLO messages
  - Hello message is received by all the one-hop neighbors
  - Hello message contains:
    - a list of neighbors with which the node has bidirectional link
    - a list of neighbors from which the node has received HELLO message but their link is not yet confirmed as bidirectional
- Advantage: Reduced number of broadcasts
- Disadvantage: Overlapping MPRsets
- Generally: OLSR is more suitable for large and dence networks