Ôn tập NT532 - Công nghệ Internet of Things hiện đại

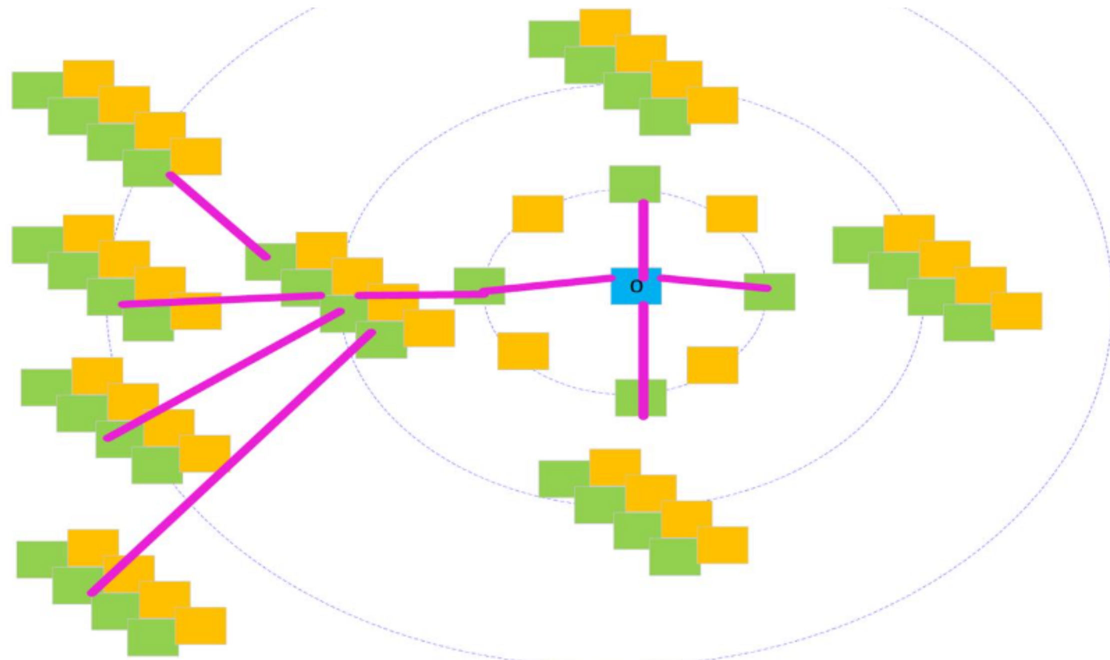
ZigBee - 802.15.4

Theory

> *Note: You can find more documents in Lecture 2*

- Maximum number of routers: R_m
- End devices that each router may have children: D_m
- Maximum deepth of tree: L_m
- Size of the address range: $A(d)$
  - $A(d) = 1 + D_m + R_m, \text{ if } d = L_m - 1$
  - $A(d) = 1 + D_m + R_m \times A(d+1), \text{ if } 0 \leq d < L_m - 1$
- Router at depth d 's address range: $R(x) = [x, x + A(d)]$
- i-th child router's $(1 \leq i \leq R_m)$ address range:
  - $[x + (i-1) \times A(d+1) + 1, x + i + A(d+1)]$
- j-th child end-device's $(1 \leq j \leq D_m)$ address:
  - $x + R_m \times A(d+1) + j$

(Exercise): Assign address for all nodes, with $R_m = 4, D_m = 4, L_m = 3$

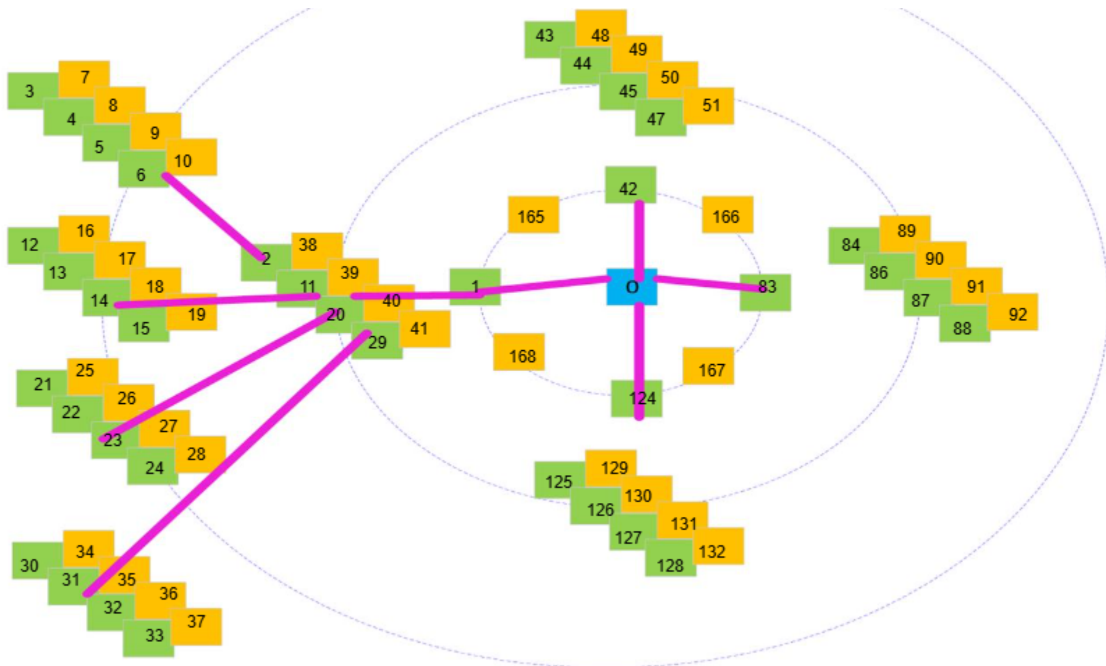


Rm=4, Dm=4, Lm=3

Nốt BLUE: Coordinator/FFD, Nốt GREEN: Router/FFD, Nốt ORANGE: End Device/RFD

- This topology has four depth levels: 0, 1, 2
- Size of address range for each depth level:
  - $A(2) = 1 + 4 + 4 = 9$
  - $A(1) = 1 + 4 + 4 \times A(1) = 41$
  - $A(0) = 1 + 4 + 4 \times A(0) = 169$
- Address range at coordinator: $R(0) = [0, 0 + A[0]] = [0, 169]$
  - 1st child router: $[0 + (1 - 1) \times A(1) + 1, 0 + 1 \times A(1)] = [1, 41]$
  - 2nd child router: $[0 + (2 - 1) \times A(1) + 1, 0 + 2 \times A(1)] = [42, 82]$
  - 3th child router: $[0 + (3 - 1) \times A(1) + 1, 0 + 3 \times A(1)] = [83, 123]$
  - 4th child router: $[0 + (4 - 1) \times A(1) + 1, 0 + 4 \times A(1)] = [124, 164]$
  - 1st child end-device: $0 + 4 \times A(1) + 1 = 165$
  - 2nd child end-device: $0 + 4 \times A(1) + 2 = 166$
  - 3th child end-device: $0 + 4 \times A(1) + 3 = 167$
  - 4th child end-device: $0 + 4 \times A(1) + 3 = 168$
- Address range at router: $R(1) = [1, 41]$
  - 1st child router: $[2, 10]$
  - 2nd child router: $[11, 19]$
  - 3th child router: $[20, 28]$
  - 4th child router: $[29, 37]$
  - 1st child end-device: 38
  - 2nd child end-device: 39

- 3th child end-device: 40
- 4th child end-device: 41
- *Repeat the process until all devices have be assigned*



Rm=4, Dm=4, Lm=3

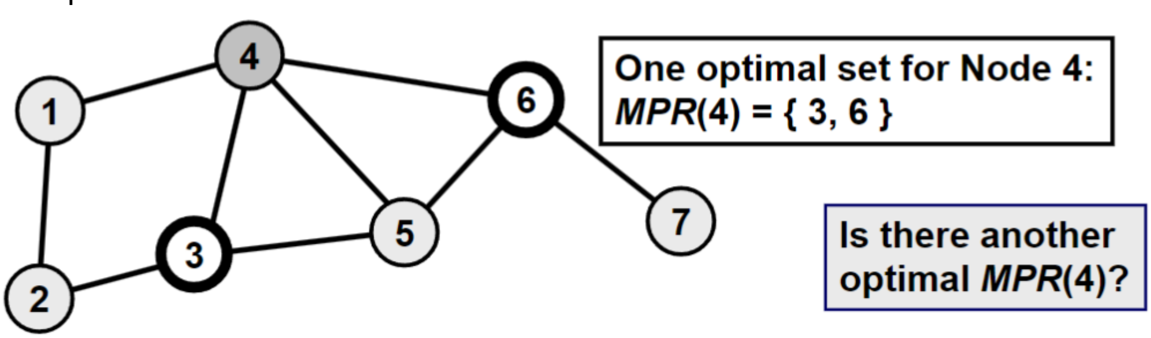
Nốt BLUE: Coordinator/FFD, Nốt GREEN: Router/FFD, Nốt ORANGE: End Device/RFD

Optimized Link State Routing protocol - OLSR

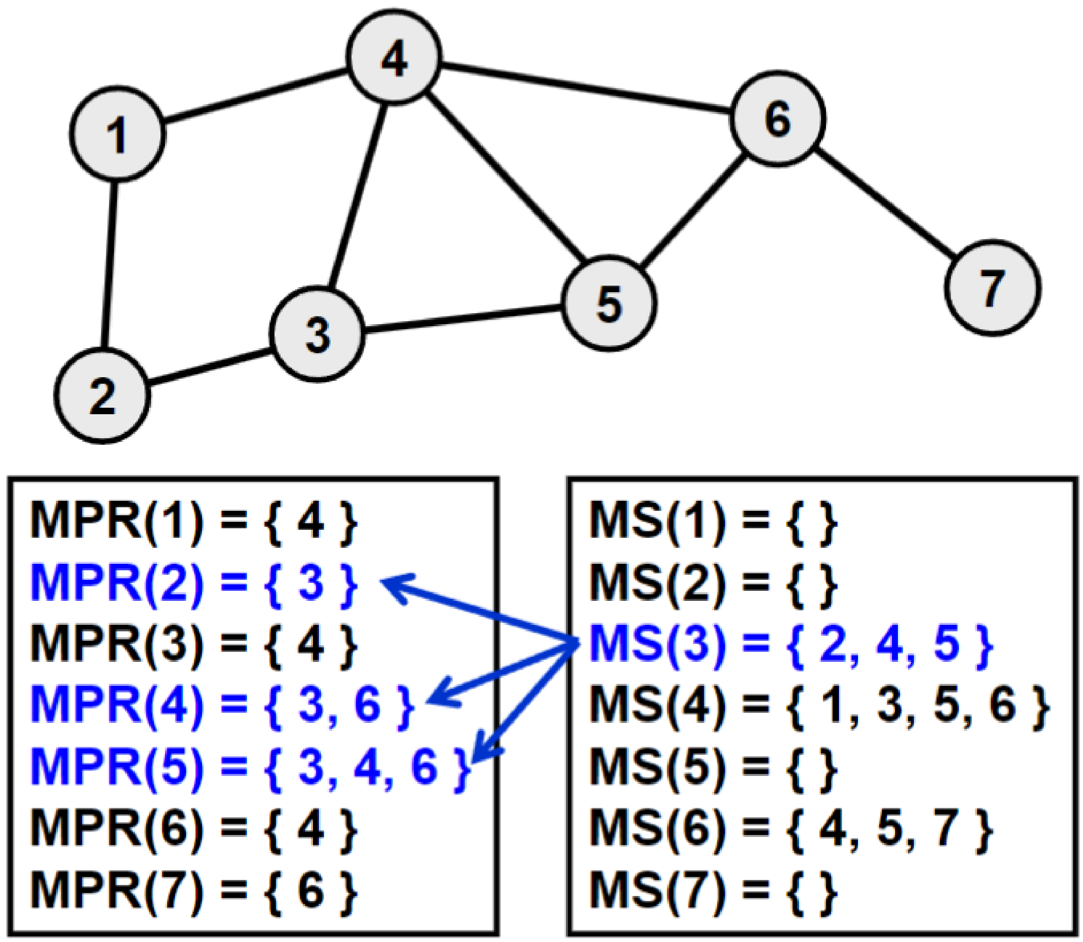
Theory

> *Note: You can find more documents in Lecture 5*

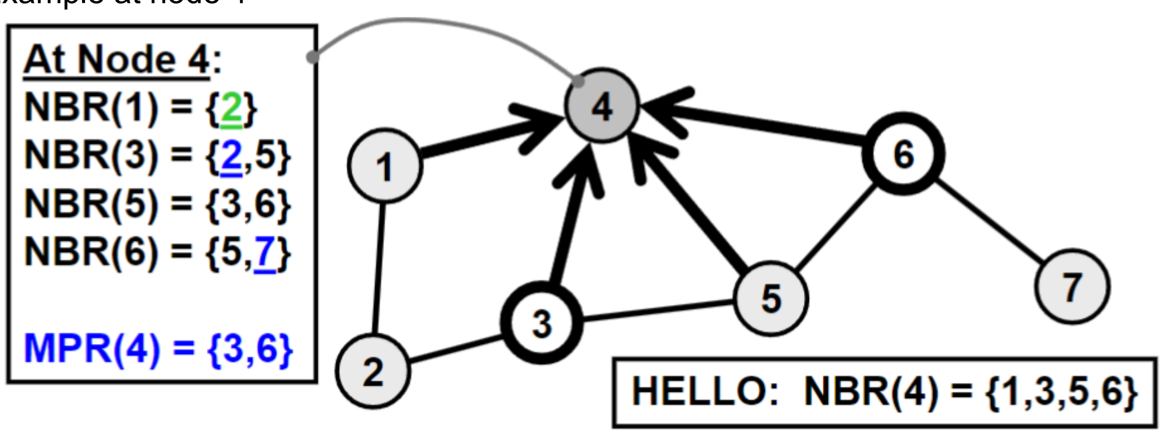
- Multipoint relay set - MPR(N): a set of 1-hop neighbor nodes that can transmit control packet from node N to 2-hop neighbor nodes
  - Example at node 4



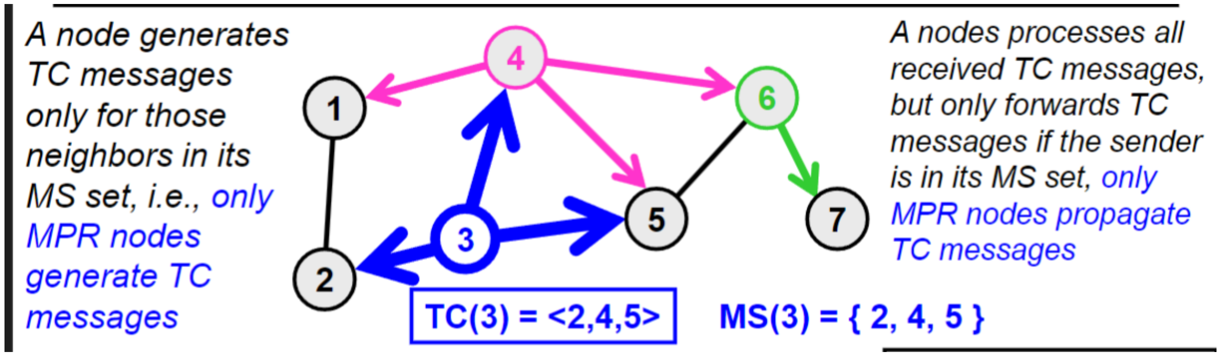
- Multipoint relay selector set - MS(N): a set of SOURCE NODES (in 1-hop neighbor) selected N to forward THEIR broadcasted packets, to cover all 2-hop neighbor nodes
  - Example at node 3



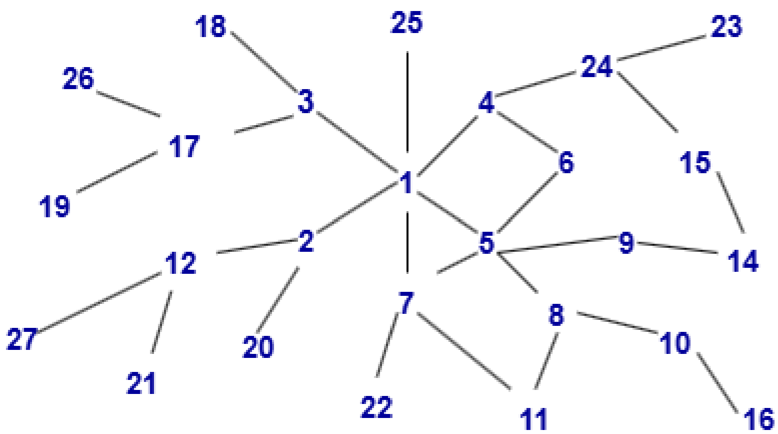
- Neighbor list - NBR(N): a list of nodes that are indicated as node N's neighbors by sending and receiving HELLO message from node N, used to optimize MPR(N) NBR set.
  - Example at node 4



- Topology Control message - TC(N): a list of advertised neighbors (link information) and sequence number (to prevent use of state information). Only MPR nodes generate and probagate TC message
  - Example at node 3



(Exercise) Find: MRP(1), MPR(12), MPR(5), MPR(14), MS(2), MS(9), MS(5), MS(1) following by this topology



- MPR(1) = {2, 3, 4, 5, 7}
- MPR(12) = {2}
- MPR(5) = {1, 6, 7, 8, 9}
- MPR(14) = {9, 15}
- MS(2) = {1, 12, 20}
- MS(9) = {5, 14}
- MS(5) = {1, 6, 7, 8, 9}
- MS(1) = {2, 3, 4, 5, 7, 25}

(Exercise) Given an IoT network including 6 nodes, draw the topology based on the nodes' routing tables and indicate the routing path from Node 6 to Node 1

Route Table of Node 1:

Destination	Next Hop	Hop Count
3	3	1
5	3	2
4	3	2
2	2	1
6	2	3

Route Table of Node 2:

Destination	Next Hop	Hop Count
1	1	1
5	4	2
4	4	1
3	4	2
6	4	2

Route Table of Node 3:

Destination	Next Hop	Hop Count
1	1	1
5	5	1
4	4	1
2	4	2
6	4	2

Route Table of Node 4:

Destination	Next Hop	Hop Count
1	2	2
3	3	1
5	5	1
2	2	1
6	6	1

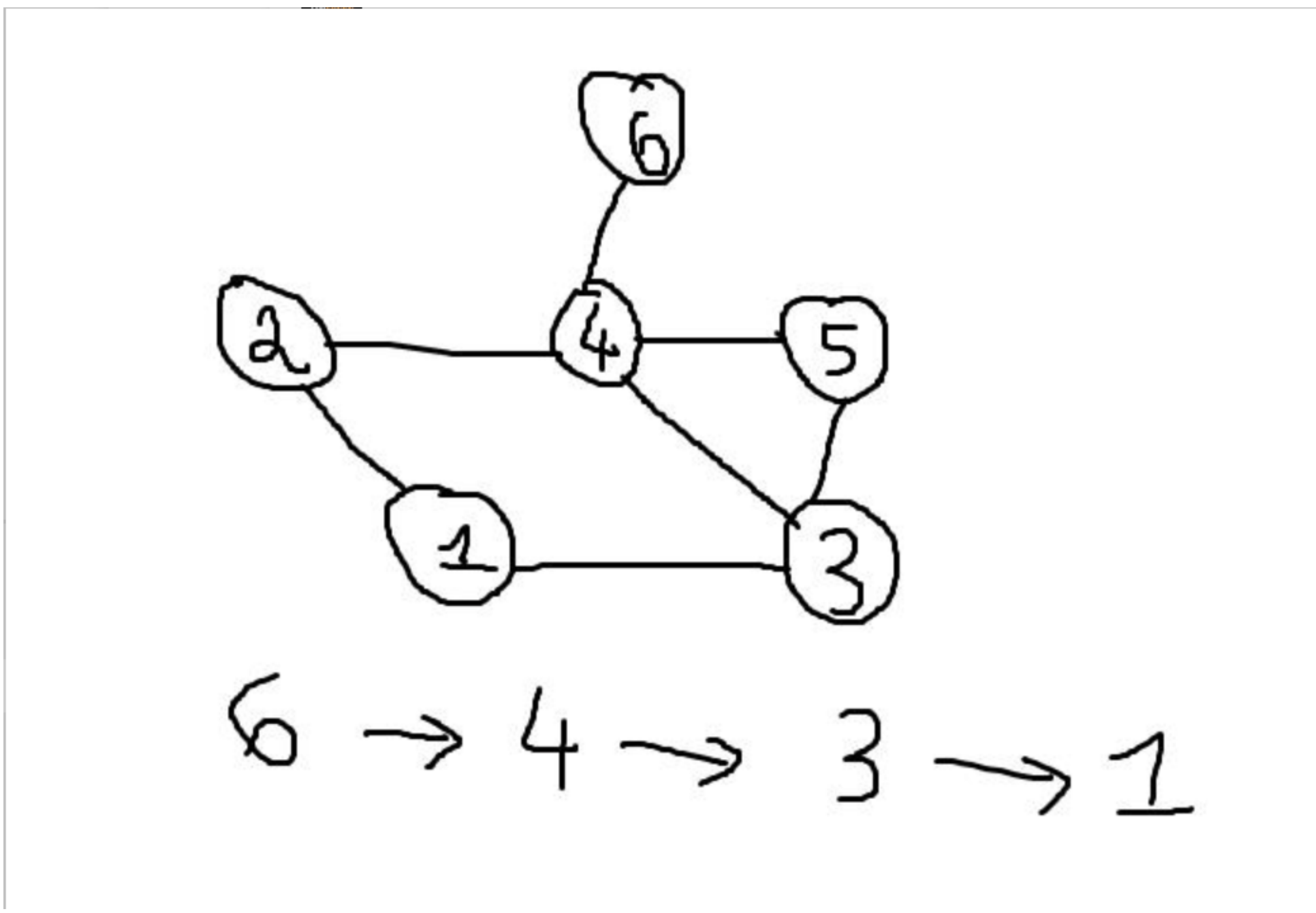
Route Table of Node 5:

Destination	Next Hop	Hop Count
1	3	2
3	3	1
2	4	2
4	4	1
6	4	2

Route Table of Node 6:

Destination	Next Hop	Hop Count
1	4	3
3	4	2
5	4	2
4	4	1
2	4	2

- Answer



Ad hoc On-demand Distance Vector routing protocol - AODV

Theory

> *Note: You can find more documents in Lecture 5*

AODV Route request

- Initiated when a node wants to communicate with another node, but does not have a route to that node
- Source node broadcasts a route request (RREQ) packet to its neighbors
- RREQ packet structure

<table>
<tr><td>type</td><td>flags</td><td>resvd</td><td>hopcnt</td></tr>
<tr><td colspan="4">broadcast_id</td></tr>
<tr><td colspan="4">dest_addr</td></tr>
<tr><td colspan="4">dest_sequence_#</td></tr>
<tr><td colspan="4">source_addr</td></tr>
<tr><td colspan="4">source_sequence_#</td></tr>
</table>

  - Broadcast ID (broadcast_id): is incremented for every RREQ packet sen
  - Source/destination address (source_addr, dest_addr): uniquely identifies the RREQ
  - Source sequence number (source_sequence): indicates “freshness” of reverse route to the source
  - Destination sequence number (dest_squence) indicates freshness of route to the destination
- When a neighbor receives the RREQ, it will return a route reply (RREP) packet, or forward RREQ to its neighbors
- Receivers can identify and discard duplicate RREQ packets

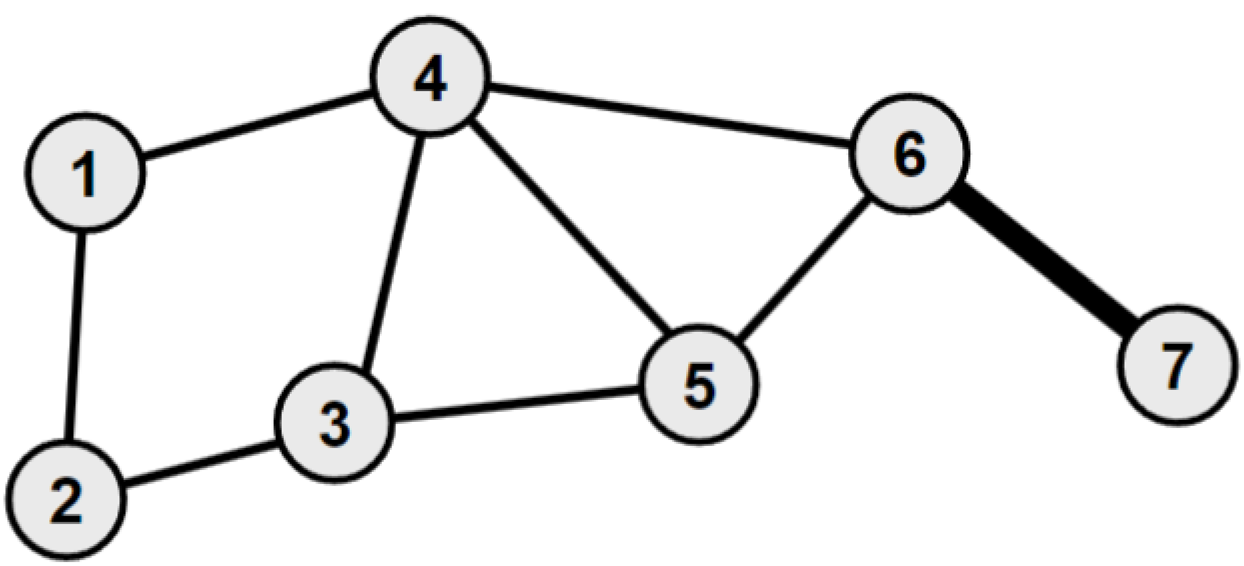
AODV Route Reply

- If a node receives an RREQ packet and it has a current route to the target destination, then it unicasts a route reply packet (RREP) to the neighbor that sent the RREQ packet
- RREP packet structure

type	flags	rsvd	prsz	hopcnt
dest_addr				
dest_sequence_#				
source_addr				
lifetime				

-
    - Source/destination address (source_addr, dest_addr): uniquely identifies the RREP
    - Destination sequence number (dest_squence) indicates freshness of route to the destination
    - (lifetime) or (hop_count): increase in the RREP packet when packet is routed
- Other RREP packets are discarded unless: (dest*sequence#*) number is higher than the previous, or (destination*sequence#*) is the same but (hop_cnt) is smaller

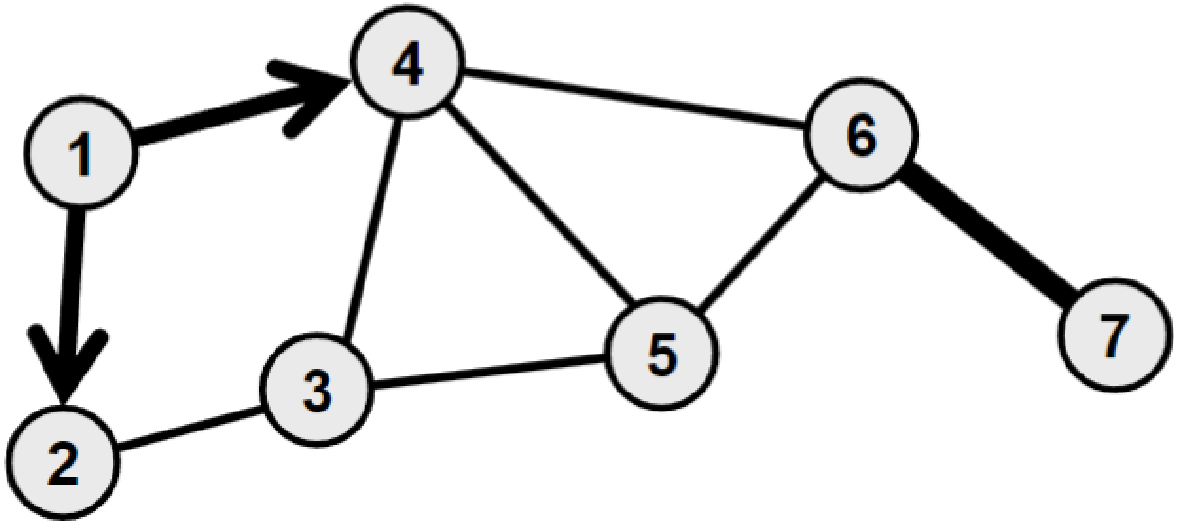
(Example) RREQ and RREP from node 1 to node 7



- Node 1 needs to send a data packet to Node 7
- Assume Node 6 knows a current route to Node 7
- Assume that no other route information exists in the network (related to Node 7)

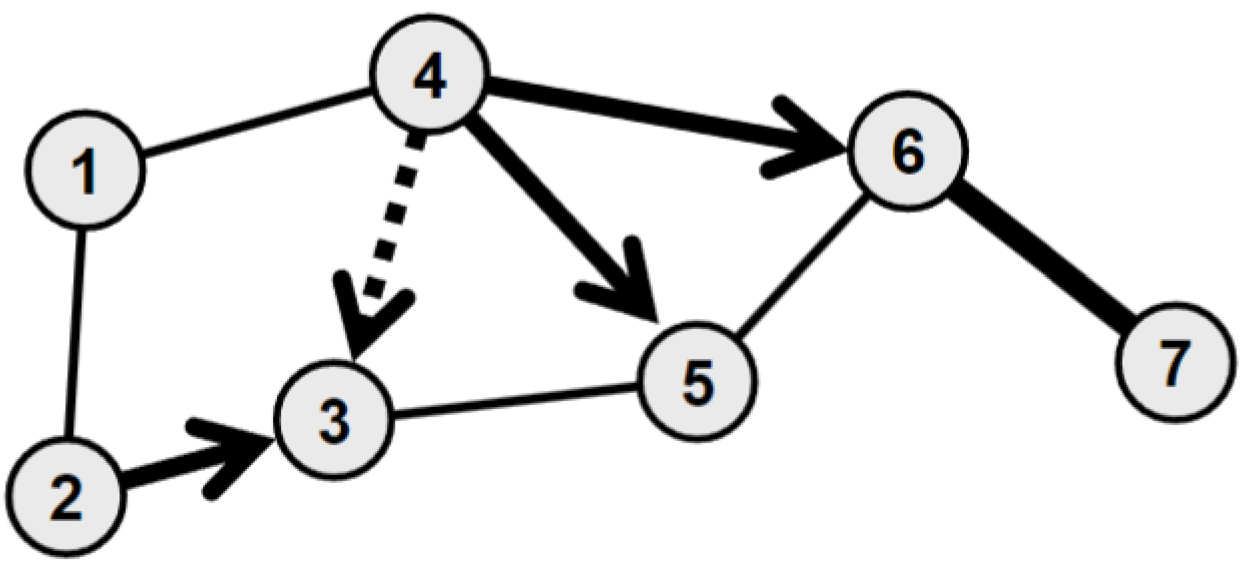
Routing steps

- **STEP 1**



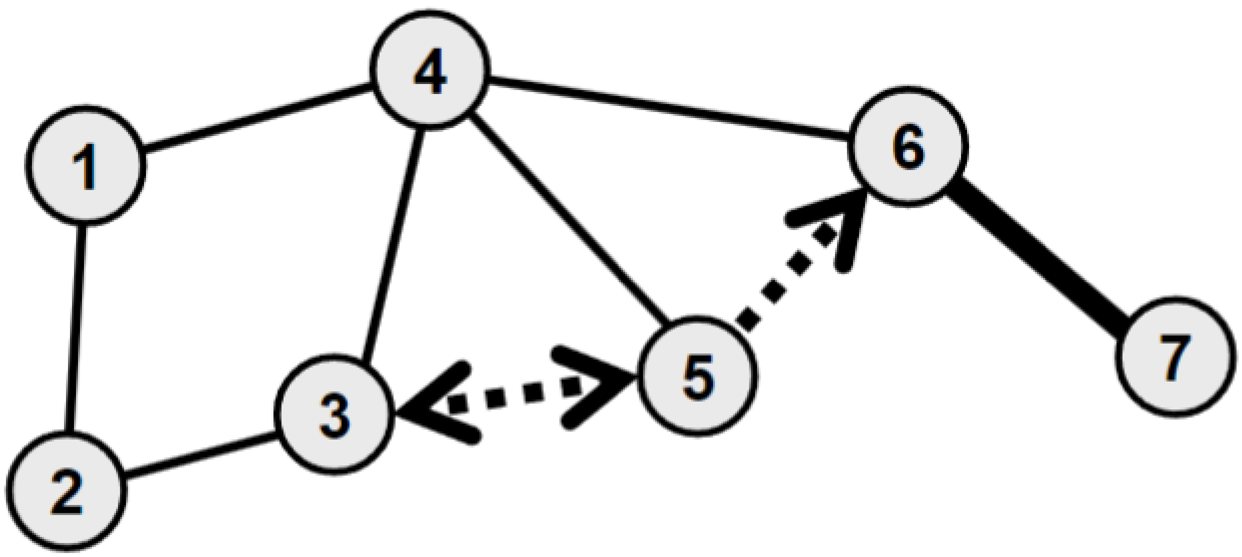
  - Node 1 sends a RREQ packet to its neighbors
    - source_addr = 1
    - dest_addr = 7
    - broadcast_id = broadcast_id + 1
    - source_sequence_# = source_sequence_# + 1
    - dest_sequence_# = last dest_sequence_# for Node 7

- **STEP 2**

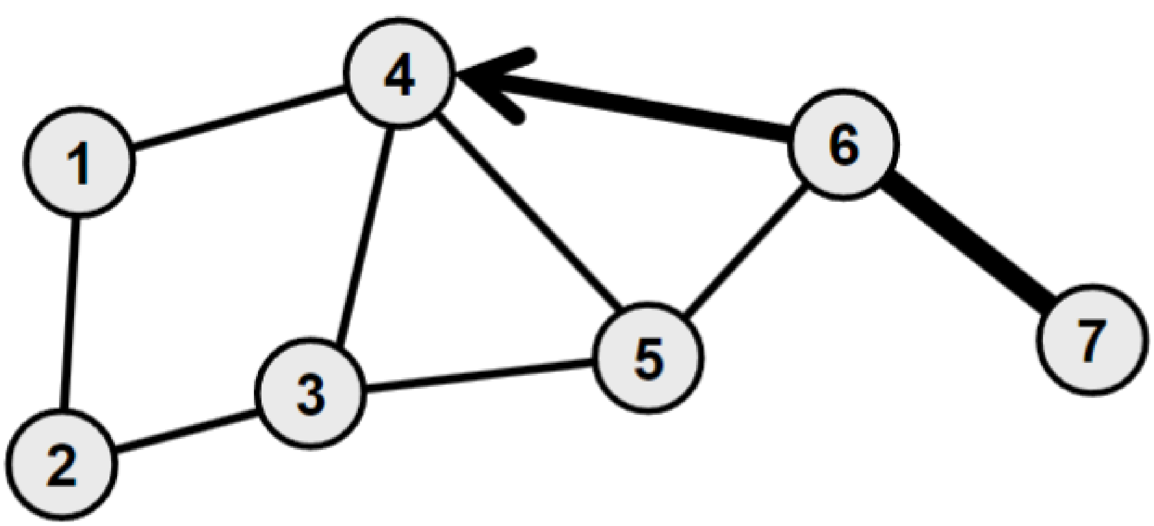


  - Nodes 2 and 4 verify that this is a new RREQ and that the source*sequence#* is not stale with respect to the reverse route to Node 1

    - Nodes 2 and 4 forward the RREQ
        - Update (source*sequence#*) for Node 1
        - Increment (hop_cnt) in the RREQ packet
- **STEP 3**



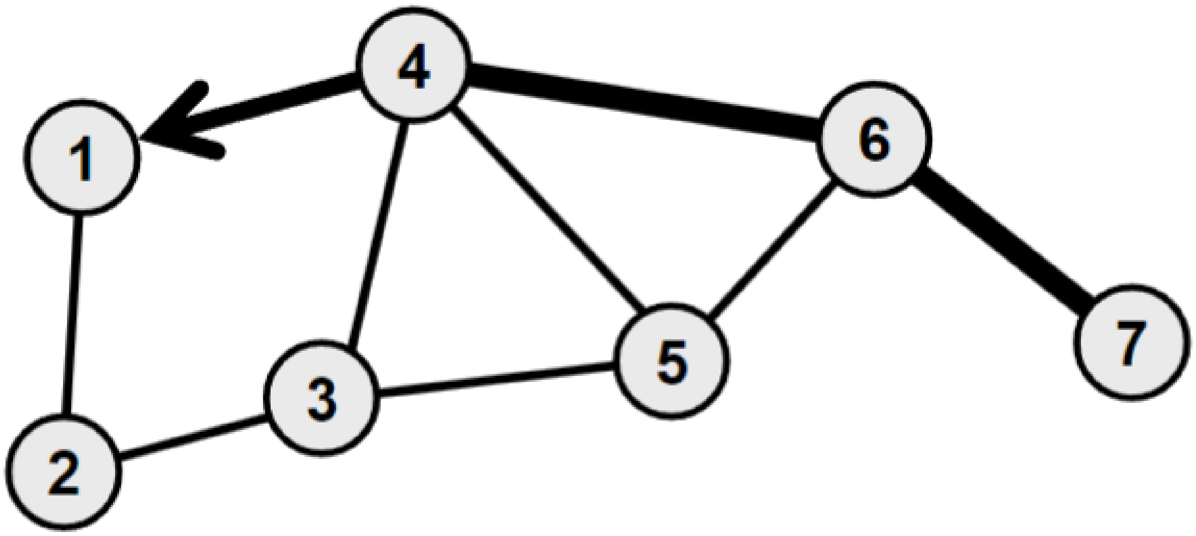
    - RREQ reaches Node 6, which knows a route to 7
    - Node 6 must verify that the destination sequence number is less than or equal to the destination sequence number it has recorded for Node 7
    - Nodes 3 and 5 will forward the RREQ packet, but the receivers recognize the packets as duplicates
- **STEP 4**



    - Node 6 knows a route to Node 7 and sends an RREP to Node 4

- source_addr = 1
- dest_addr = 7
- dest_sequence_# = maximum(own sequence number, dest_sequence_# in RREQ)
- hop_cnt = 1

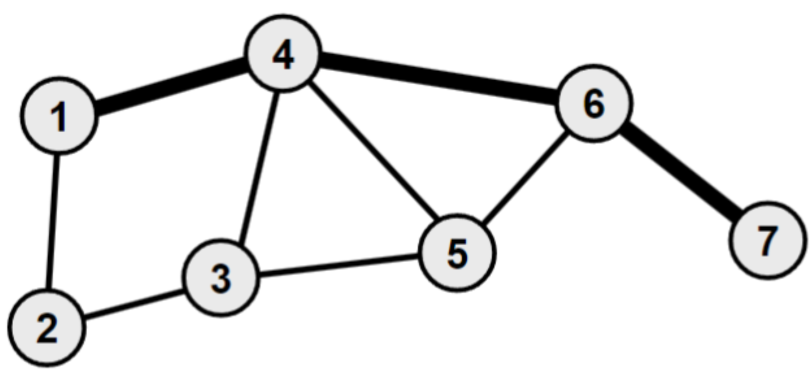
- **STEP 5**



- Node 4 verifies that this is a new route reply (the case here) or one that has a lower hop count
- If so, propagates the RREP packet to Node 1 and increases (hop_cnt) in the RREP packet

- **STEP 6**

Dest	Next	Hops
7	4	3



- Node 1 now has a route to Node 7 in three hops and can use it immediately to send data packets
- Note that the first data packet that prompted path discovery has been delayed until the first RREP was returned

6LoWPAN

> *Note: You can find documents in Lecture 3*

WiFi - 802.11

Note: You can refer to this lecture note [Lecture 17: 802.11 Wireless Networking] - University of California San Diego

IoTs apps {coap/mqtt/...}, solutions, technologies

> *Note: You can refer to this lecture note [Lecture 5 - CoAP & MQTT] - Universitatea Politehnica din București*