Wireless Sensor Networks

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Credits: 6

To fix the Ideas..

Three-Based Topology

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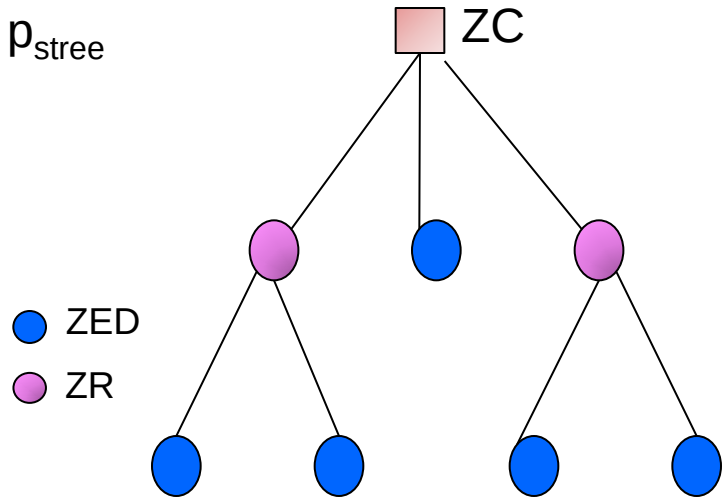
Problem 1

Consider the thee shown in the Figure. Assume that:

1. No connectivity problems are present (p_{CON}=1 in each link);
2. SO=0, D=2 (20 bytes packets);
3. Data aggregation is used at Routers
4. The Success Probability related to MAC, $p_{MAC}(N)$, being N the number of nodes competing for the channel, when SO=0 and D=2, is equal to:
   $p_{MAC}(N=1)=1$; $p_{MAC}(N=2)=0.9$; $p_{MAC}(N=3)=0.8$; $p_{MAC}(N=4)=0.7$;

Evaluate:

1. The value of BO s.t. all routers have a portion of superframe allocated?
2. The average (for whatever a node) Success Probability, p_{stree} (use the value of BO obtained in point 1).



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Problem 2

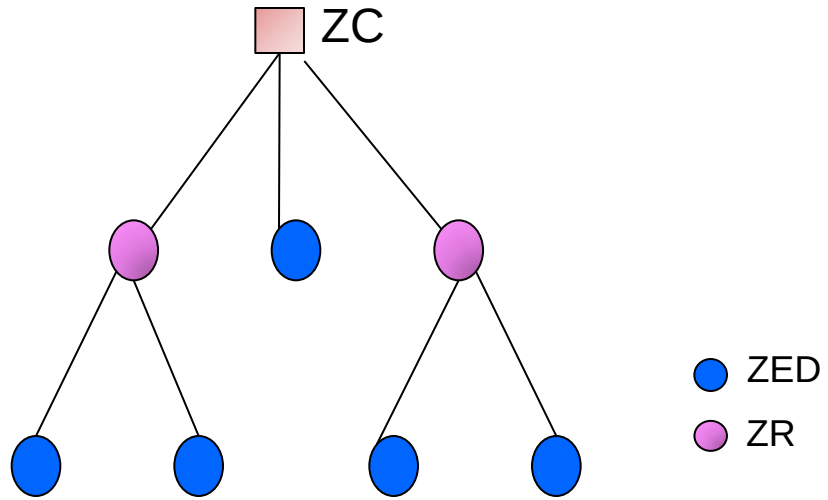
Consider the tree shown in the Figure. Assume that:

1. SO=0, D=2;
2. The Average Delay, $D_{mean}(N)$, for a star topology, when N nodes are competing for the channel and when SO=0 and D=2, is equal to:

$D_{mean}(N=1)=5$ ms; $D_{mean}(N=2)=10$ ms; $D_{mean}(N=3)=15$ ms; $D_{mean}(N=4)=20$ ms;

Question:

1. Compute the Average Delay in the tree, D_{mean_tree}, when BO=2.



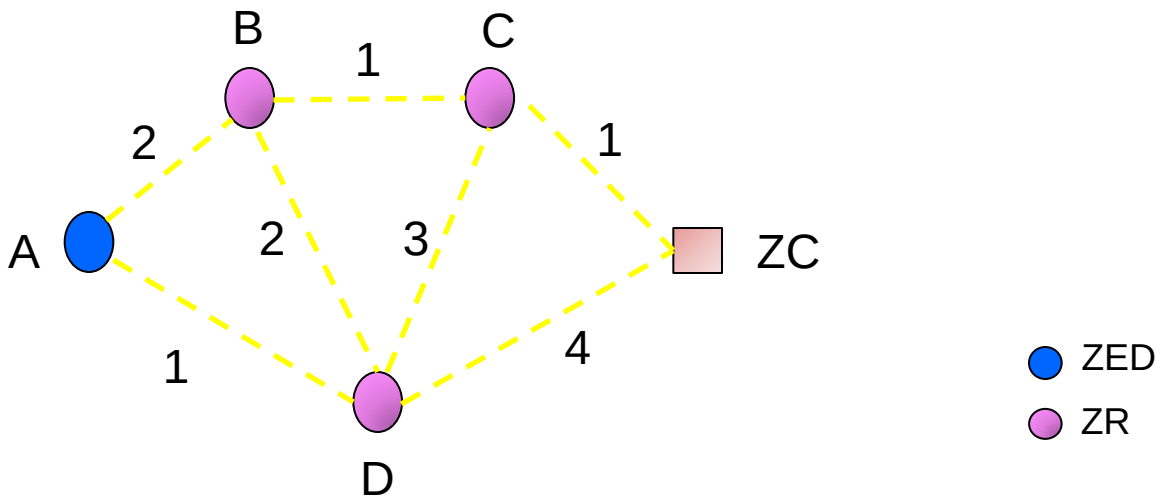
To fix the Ideas..

Mesh Topology

Problem

Consider the set of nodes and virtual links (with the relative costs) shown in the figure.

• Evaluate the set of paths used by all nodes to reach the ZC, in the case of Zigbee mesh routing protocol and in case of Zigbee tree.



Problem

In the case of tree, set SO=0 and BO to the minimum value s.t. p_{frame}=1.

The Success Probability related to MAC, $p_{MAC}(N)$, when N nodes are competing for the channel, in the case of non beacon-enabled (BE) mode and in the case of BE mode (when SO=0), is equal to:

$p_{MAC}(N=1)=1$; $p_{MAC}(N=2)=0.9$; $p_{MAC}(N=3)=0.8$; $p_{MAC}(N=4)=0.7$;

The Average Delay, $D_{mean}(N)$, in a single hop, when N the number of nodes competing for the channel, in the case of non BE mode and in the case of BE mode (when SO=0), is equal to:

$D_{mean}(N=1)=5$ ms; $D_{mean}(N=2)=10$ ms; $D_{mean}(N=3)=15$ ms; $D_{mean}(N=4)=20$ ms;

1) Which is the topology maximising the average Success Probability?
2) Which is the topology minimising the average Delay?

To solve the problem..

Recall that:

1. $C(l) = \min\left\{7, \left\lfloor \frac{1}{p_{CON}{}^4} \right\rfloor\right\}$

Therefore if the cost is lower than 7 → $p_{CON} = \frac{1}{\sqrt[4]{C}}$

2. The total success probability in a given link is the product of the probability of having connectivity on the link (p_{CON}) and the probability to have success in the access to the channel (p_{MAC}).

$$p_s = p_{CON}(C) \cdot p_{MAC}(N)$$

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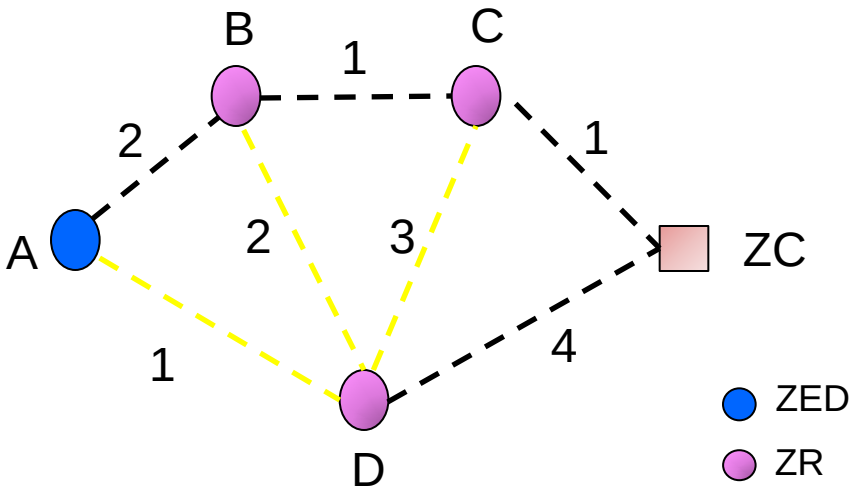
Mesh – Success Probability



$$p_{CON}(1) = 1$$

$$p_{CON}(2) = 0.84$$

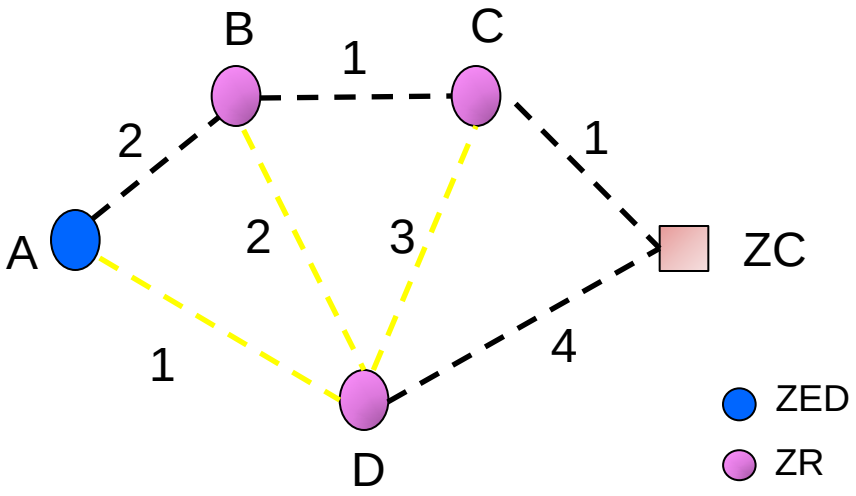
$$p_{CON}(4) = 0.7$$

Step 1: 4 nodes accessing the channel.
A→B, B→C, C→ZC, D→ZC

Step 2: 2 nodes accessing the channel.
B→C (packet of node A)
C →ZC (packet of node B)

Step 3: 1 node accessing the channel.
C→ ZC (packet of node A)

Mesh – Success Probability



$$p_{CON}(1) = 1$$
$$p_{CON}(2) = 0.84$$
$$p_{CON}(4) = 0.7$$

$$p_{s_A} = p_{CON_A} \cdot p_{MAC_A} = 0.52$$
$$p_{CON_A} = p_{CON}(2) \cdot p_{CON}(1) \cdot p_{CON}(1) = 0.84$$
$$p_{MAC_A} = p_{MAC}(4) \cdot p_{MAC}(2) \cdot p_{MAC}(1) = 0.63$$

Mesh – Success Probability

$$p_{s_B} = p_{CON_B} \cdot p_{MAC_B} = 0.63$$

$$p_{CON_B} = p_{CON}(1) \cdot p_{CON}(1) = 1$$

$$p_{MAC_B} = p_{MAC}(4) \cdot p_{MAC}(2) = 0.63$$

$$p_{s_C} = p_{CON_C} \cdot p_{MAC_C} = 0.7$$

$$p_{CON_C} = p_{CON}(1) = 1$$

$$p_{MAC_C} = p_{MAC}(4) = 0.7$$

$$p_{s_D} = p_{CON_D} \cdot p_{MAC_D} = 0.49$$

$$p_{CON_D} = p_{CON}(4) = 0.7$$

$$p_{MAC_D} = p_{MAC}(4) = 0.7$$

$$p_s = \frac{1}{4}(p_{s_A} + p_{s_B} + p_{s_C} + p_{s_D}) = 0.58$$

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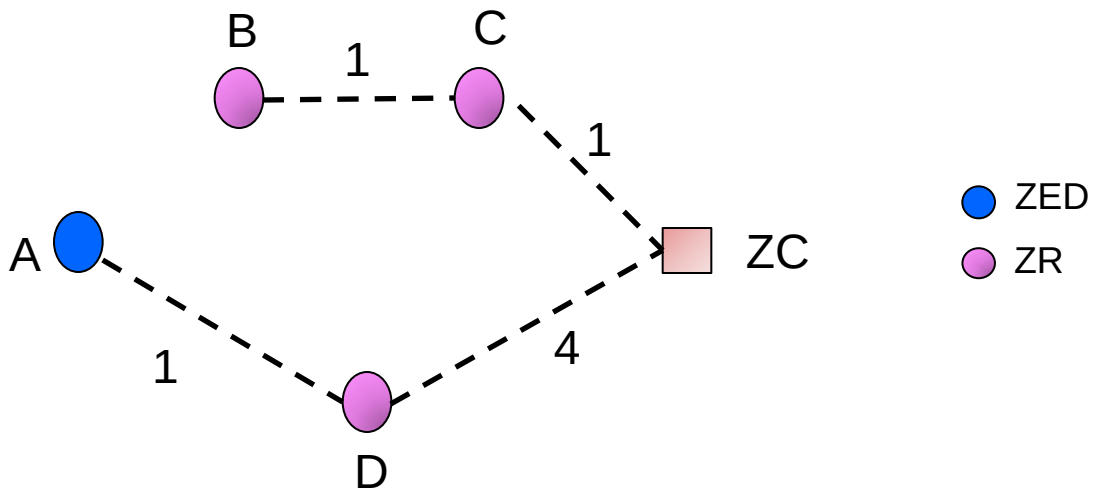
Tree – Success Probability



$$p_{s_A} = p_{CON_A} \cdot p_{MAC_A} = 0.63$$

$$p_{CON_A} = p_{CON}(1) \cdot p_{CON}(4) = 0.7$$

$$p_{MAC_A} = p_{MAC}(1) \cdot p_{MAC}(2) = 0.9$$

Tree – Success Probability

$$p_{s_B} = p_{CON_B} \cdot p_{MAC_B} = 0.9$$

$$p_{CON_B} = p_{CON}(1) \cdot p_{CON}(1) = 1$$

$$p_{MAC_B} = p_{MAC}(1) \cdot p_{MAC}(2) = 0.9$$

$$p_{s_C} = p_{CON_C} \cdot p_{MAC_C} = 0.9$$

$$p_{CON_C} = p_{CON}(1) = 1$$

$$p_{MAC_C} = p_{MAC}(2) = 0.9$$

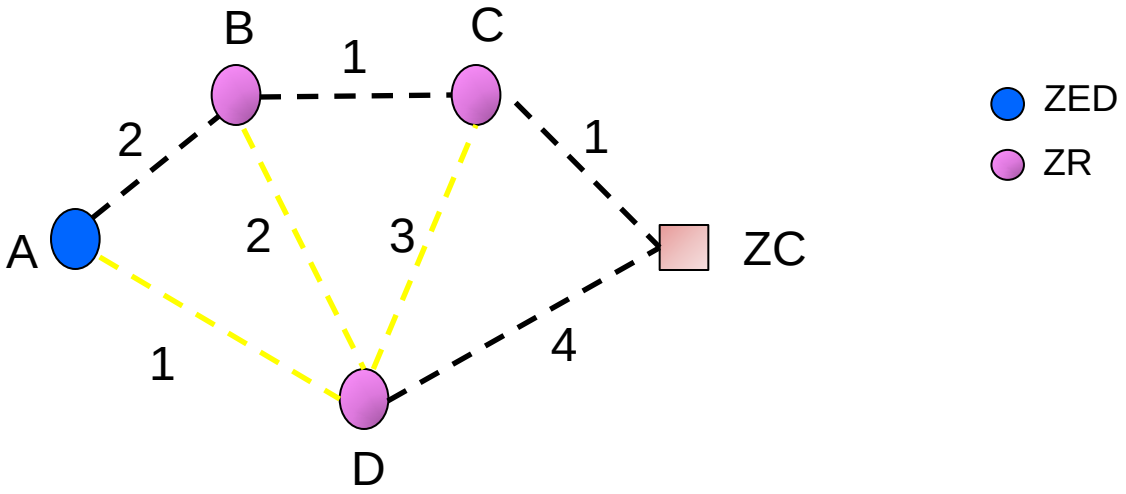
$$p_{s_D} = p_{CON_D} \cdot p_{MAC_D} = 0.63$$

$$p_{CON_D} = p_{CON}(4) = 0.7$$

$$p_{MAC_D} = p_{MAC}(2) = 0.9$$

$$p_s = \frac{1}{4}(p_{s_A} + p_{s_B} + p_{s_C} + p_{s_D}) = 0.76$$

Mesh – Average Delay



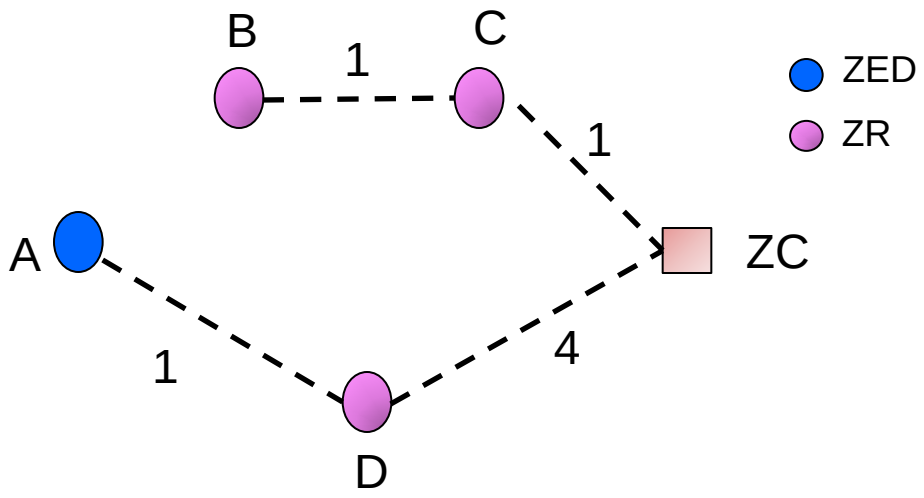
$$D_{mean_A} = D_{mean}(4) + D_{mean}(2) + D_{mean}(1) = 35ms$$

$$D_{mean_B} = D_{mean}(4) + D_{mean}(2) = 30ms$$

$$D_{mean_C} = D_{mean_D} = D_{mean}(4) = 20ms$$

$$D_{mean} = \frac{1}{4}(D_{mean_A} + D_{mean_B} + D_{mean_C} + D_{mean_C}) = 26.25ms$$

Tree – Average Delay



SO=0
BO=2 (s.t. p_{frame}=1)
BI=61.44 ms

$$D_{mean_A} = D_{mean_B} = D_{mean}(2) + BI = 71.44ms$$

$$D_{mean_C} = D_{mean_D} = D_{mean}(2) = 10ms$$

$$D_{mean} = \frac{1}{4}(D_{mean_A} + D_{mean_B} + D_{mean_C} + D_{mean_C}) = 40.72ms$$

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