Wireless Sensor Networks

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Credits: 6

To fix the Ideas..

Three-Based Topology

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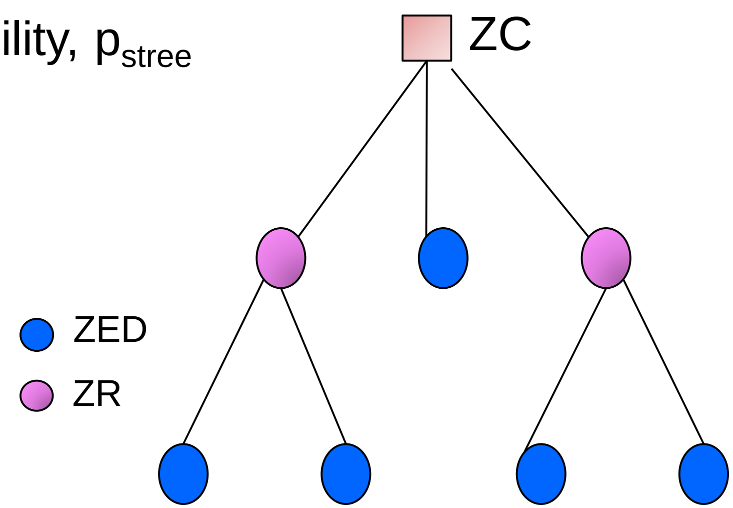
Problem 1

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, 10 bytes of payload);
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 (averaged among nodes) Success Probability, p_{stree} (use the value of BO obtained in point 1)
3. The network throughput



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Problem 2

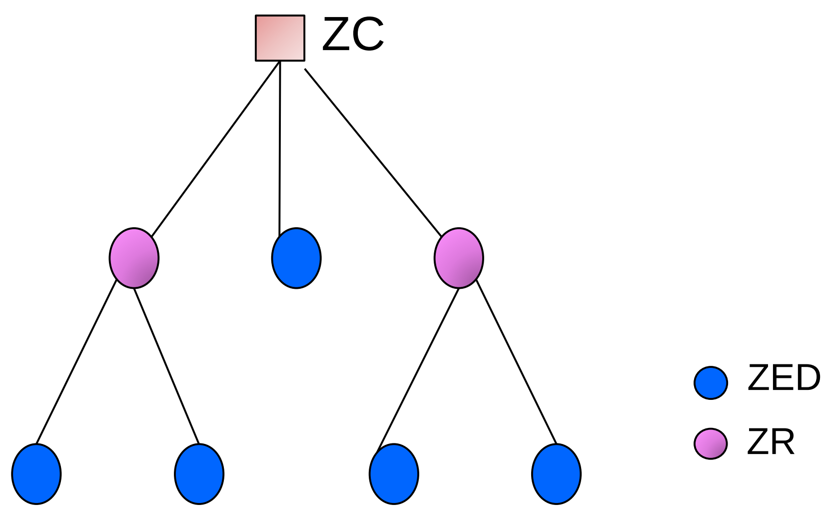
Consider the tree shown in the Figure. Assume that:

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)=5,5 ms; D_{mean}(N=3)=6 ms; D_{mean}(N=4)=6,5 ms;

Question:

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



Problem 2

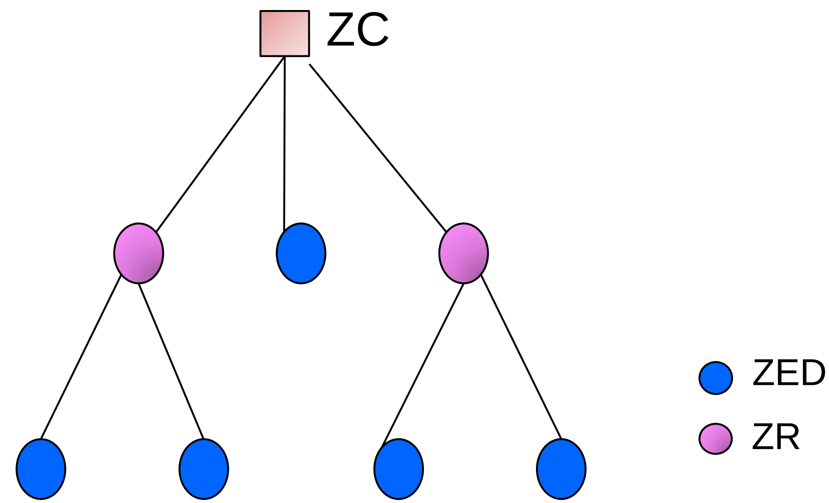
Assume that:

1. Average backoff duration per packet transmitted of 1,12 ms
2. Average sensing duration per packet transmitted of 0,64 ms
3. Nodes use a transmit power of 0 dBm
4. Nodes have a battery charge of 5.000 J
5. The radio consumes:

   $P_{rx}=P_{sens}=79.2$ mW, $P_{tx}=104.4$ mW (at 0 dBm), $P_{backoff}=11.88$ mW, $P_{idle}=0$

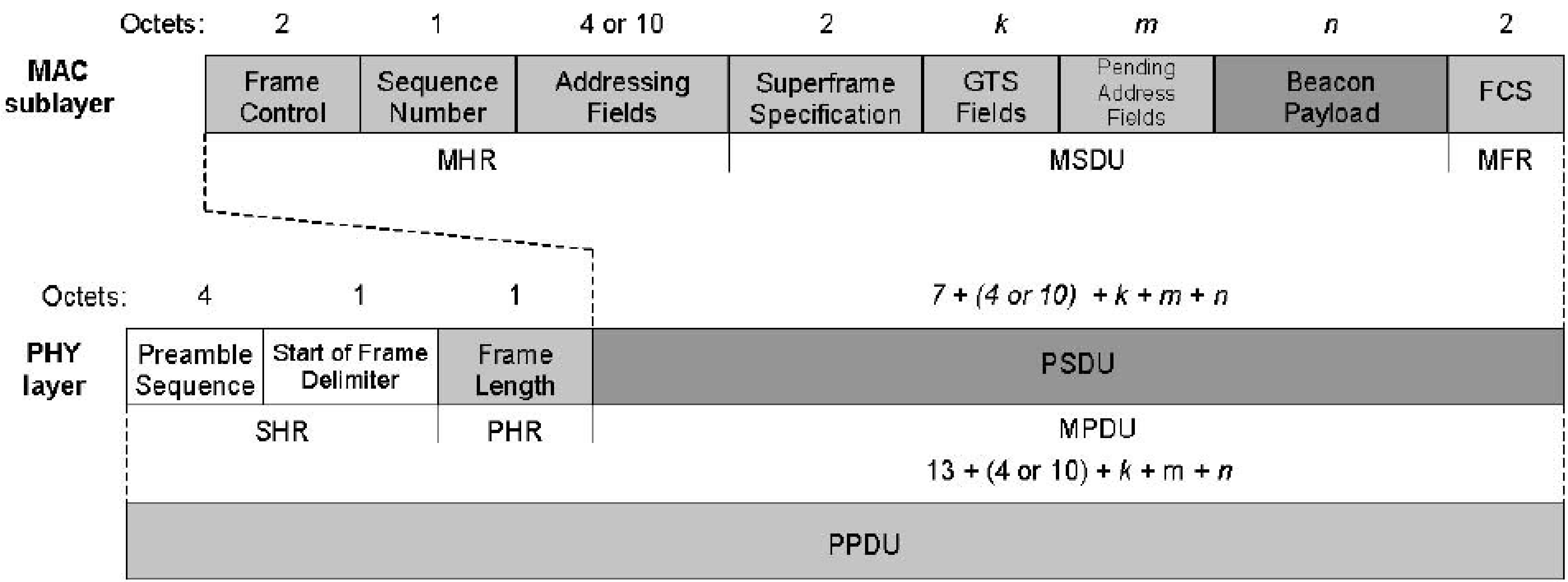
Question:

1. Compute the network lifetime.



Frame Format

- Beacon Frame



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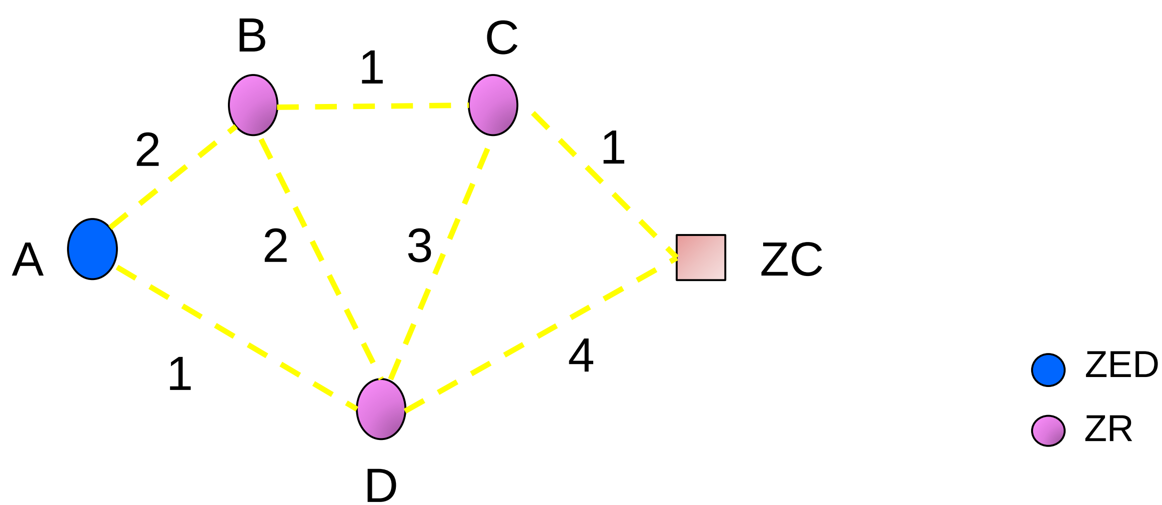
To fix the Ideas..

Mesh Topology

Problem

Consider the set of nodes and 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, using AODV (non beacon-enabled mode) and in case of Zigbee tree-based topology (in beacon-enabled mode).



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)=5,5 ms; D_{mean}(N=3)=6 ms; D_{mean}(N=4)=6,5 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:

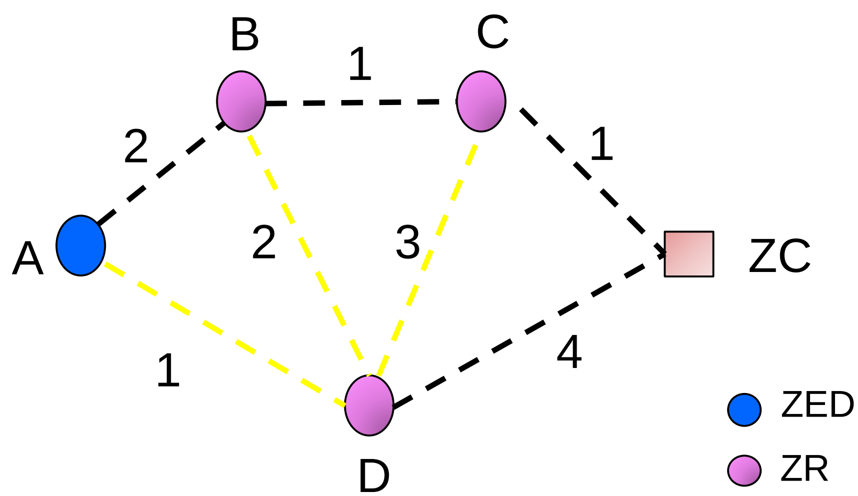
1. $$C(l) = \min\left\{7, \left\lfloor \frac{1}{{p_{CON}}^{4}} \right\rfloor\right\}$$

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}).

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

Mesh – Success Probability



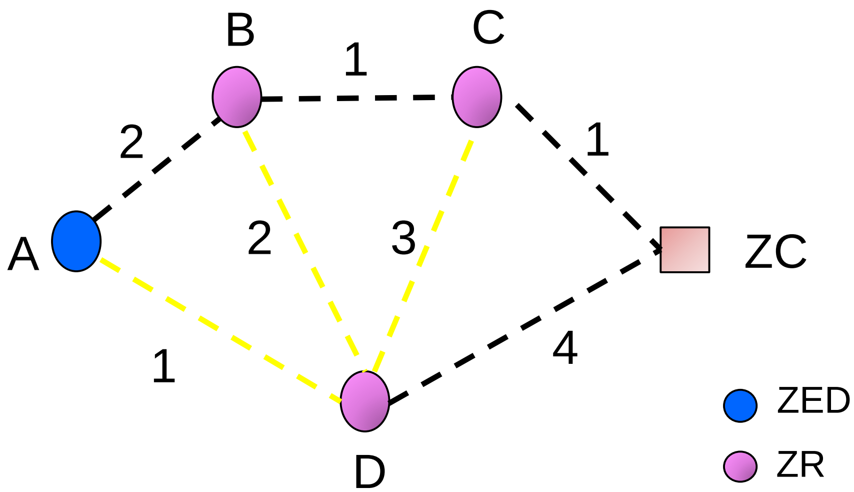
$$p_{CON}(1) = 1$$
$$p_{CON}(2) = 0.84$$
$$p_{CON}(4) = 0.7$$

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

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

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

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

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

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

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

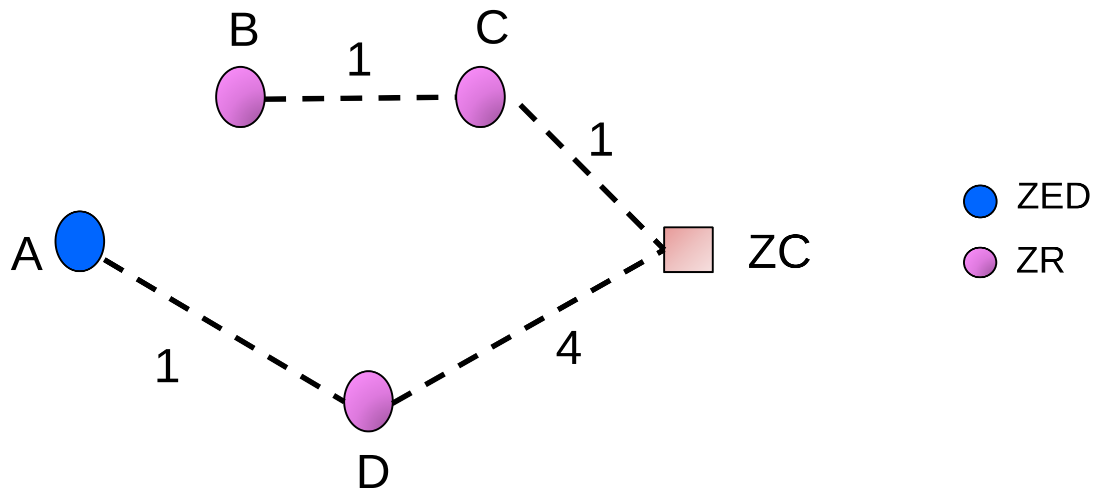
$$p_{s_D} = p_{CON_D} \cdot p_{MAC_D} = 0.49$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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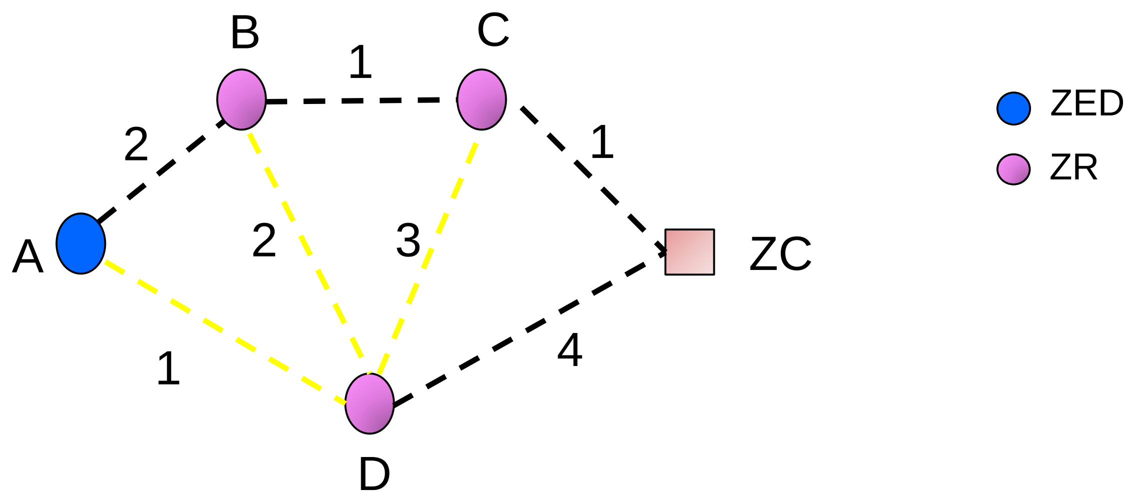
Mesh – Average Delay



$$D_{mean_A} = D_{mean}(4) + D_{mean}(2) + D_{mean}(1) = 17\,ms$$

$$D_{mean_B} = D_{mean}(4) + D_{mean}(2) = 12\,ms$$

$$D_{mean_C} = D_{mean_D} = D_{mean}(4) = 6.5\,ms$$

$$D_{mean} = \frac{1}{4}(D_{mean_A} + D_{mean_B} + D_{mean_C} + D_{mean_C}) = 10.5\,ms$$

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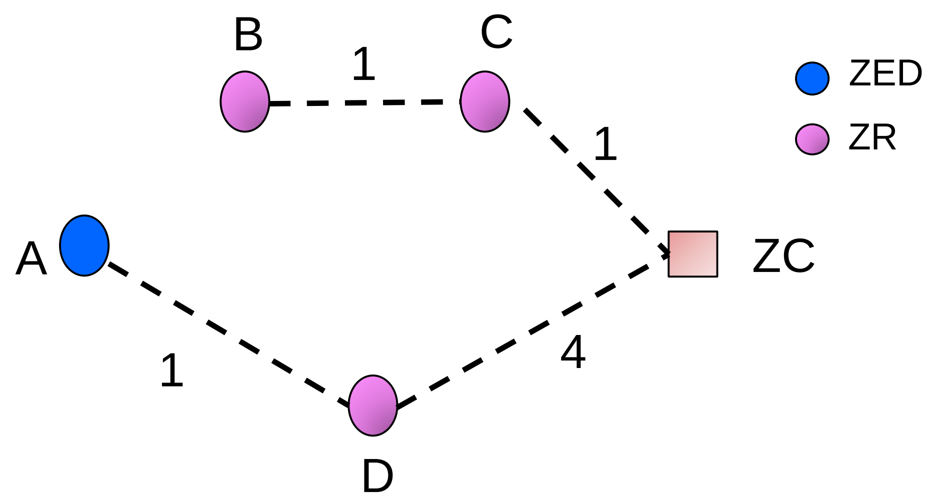
Tree – Average Delay



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

$$D_{mean_A} = D_{mean_B} = D_{mean}(2) + BI = 66.94ms$$

$$D_{mean_C} = D_{mean_D} = D_{mean}(2) = 5.5ms$$

$$D_{mean} = \frac{1}{4}(D_{mean_A} + D_{mean_B} + D_{mean_C} + D_{mean_C}) = 36.22ms$$

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