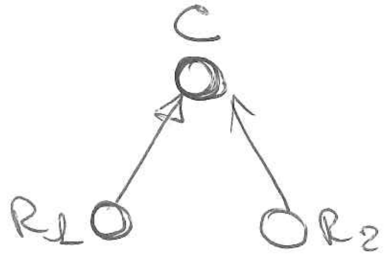
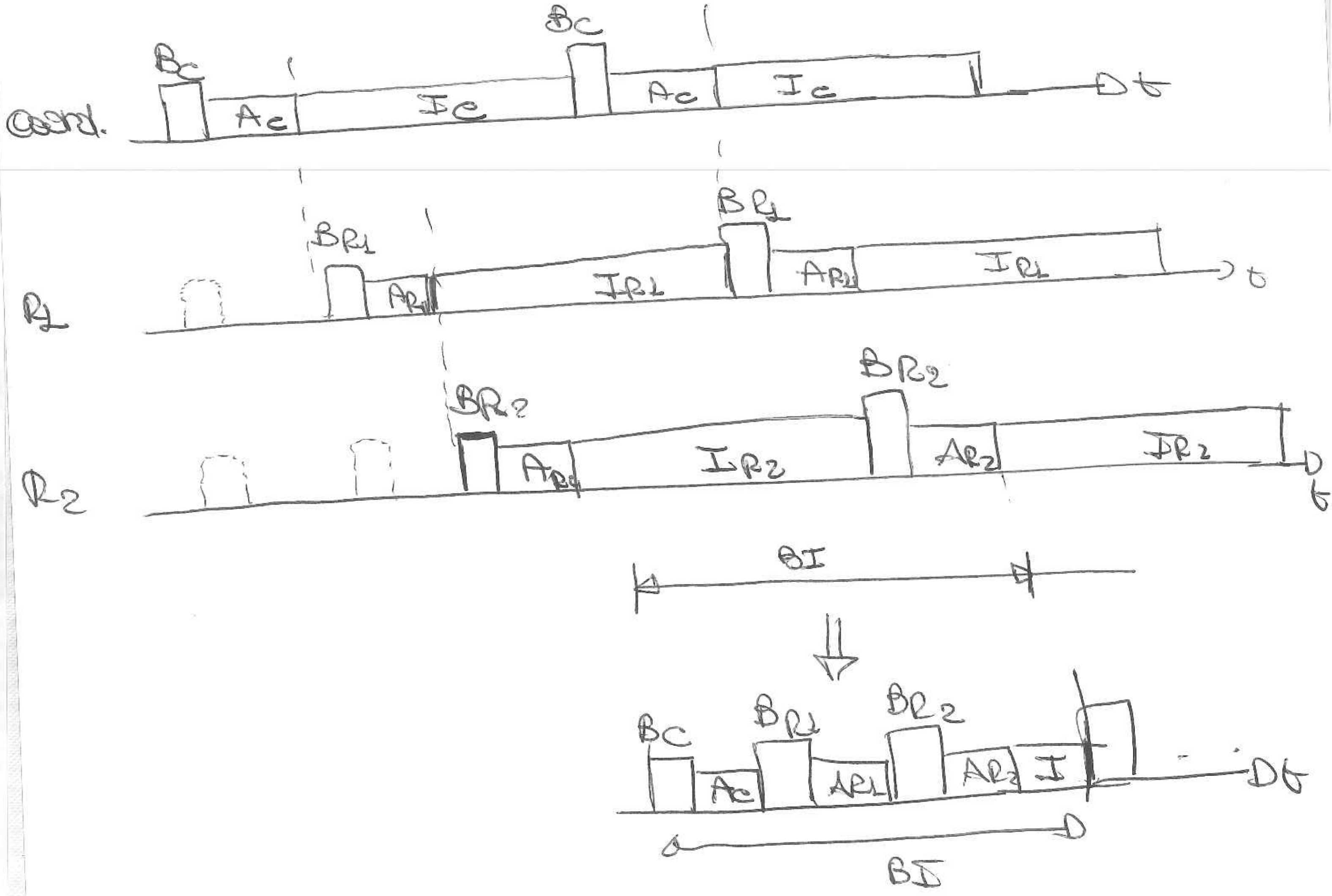
Beacon Tracking - Tree Formation

A ⇒ Active Part
I ⇒ Inactive Part

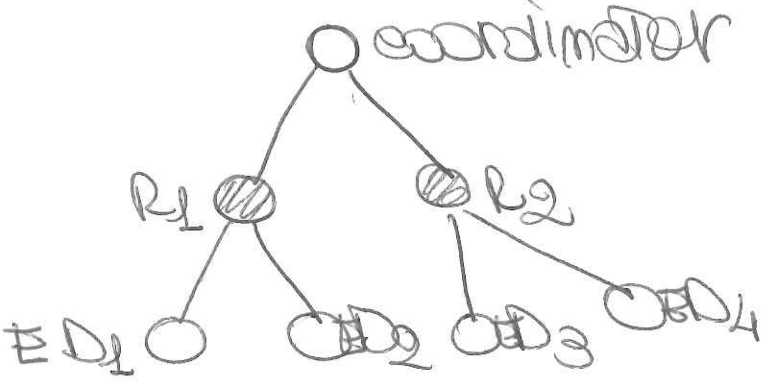




TREE TOPOLOGY

L-level tree

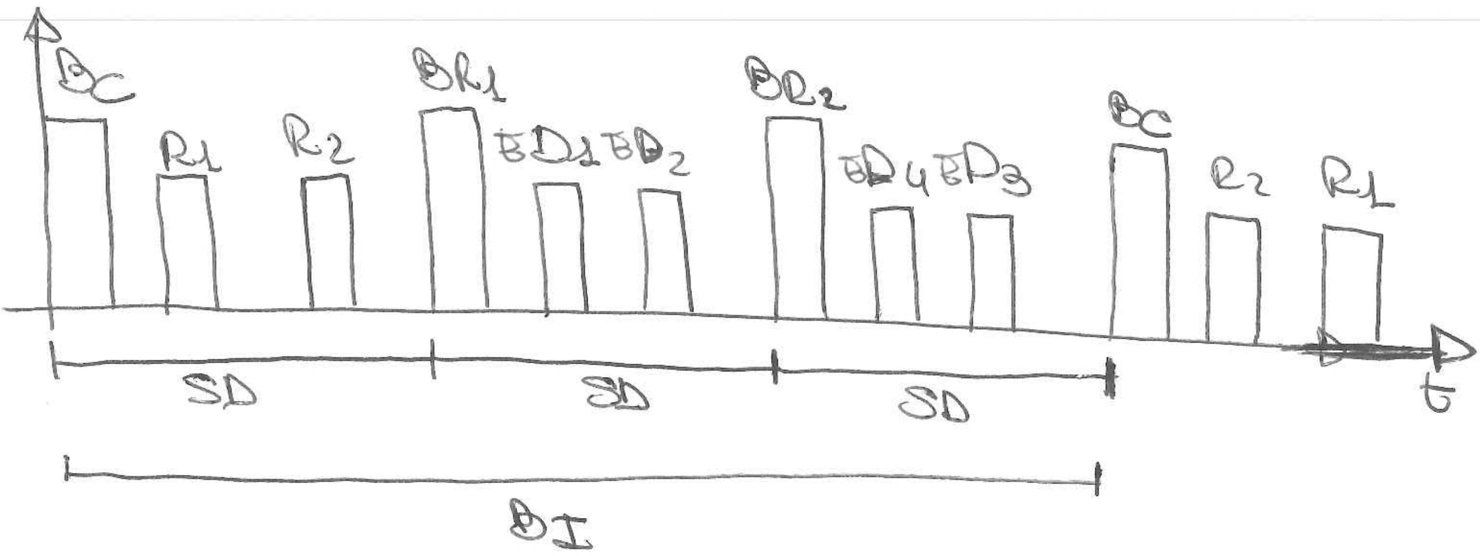
L=3



N1 nodes

N2 nodes

$N = N_1 + N_2 \qquad N_R = 2$



Star Topology: Frame success probability

$$P_S^{FRAME} = P_{con}(P_R) \cdot P_{mac}(N_{star}, D, r, SO)$$

$$P_{con} = 1 \longrightarrow$$

$$P_S^{FRAME} = P_{mac}(N_{star}, D, r, SO)$$

TREE-BASED TOPOLOGY : PACKET SUCCESS PROBABILITY

$$P_S^{packet} = \sum_{k=1}^{L-1} P_k \cdot P_{S_k}^{packet}$$

Average packet success probability, averaged among the different nodes

$L \Rightarrow$ number of levels of the tree topology

$P_k \Rightarrow$ probab. of being at level k

$P_{S_k}^{packet} \Rightarrow$ " of success for a packet generated by a node that is at level k

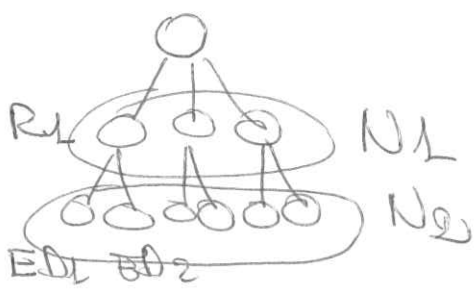
L=3 - THREE-LEVEL TREE

Level Ø

" 1

" 2

$N = N_1 + N_2$



CASE 1 : DATA AGGREGATION AT ROUTERS

e.g. Packet transmitted by R1 contains payload of: R1, ED1, ED2

$\rightarrow$ data compression without loss of information

$$P_S^{packet} = P_1 \cdot P_S^{frame}(N_1, D, SD) +$$
$$+ P_S^{frame}(N_1, D, SD) \cdot P_{SD} \cdot$$
$$\cdot \sum_{i=1}^{N_R} P_{2|i} \cdot P_S^{frame}(N_{2|i}, D, SD)$$

where:

- $P_1 = \frac{N_1}{N}$ → Probab of being at level 1

- $P_S^{frame} = P_{coll} \cdot P_{mac} \underset{P_{coll}=1}{=} P_{mac}$

- $P_{SD} = \begin{cases} 1 & \text{if } 2^{BO-SO} - 1 \geq N_R \\ \frac{2^{BO-SO} - 1}{N_R} & \text{otherwise} \end{cases}$

P_{SD} → probab that a Router has a portion of BI (i.e., one SD) available for receiving data from children.

N_R → Number of Routers at level 1

$N_R = N_1$ ⇒ All nodes at level 1 are routers

- $P_{2|i} \stackrel{\Delta}{\Rightarrow}$ probability of being at level 2 and connected to router i

$$\underbrace{P_{2|i} = \frac{N_{2|i}}{N}}$$

where : $N_{2|i} \stackrel{\Delta}{=}$ number of nodes at level 2 and connected to router i.

- If nodes at level 2 are equally distributed among routers at level 1 (equally balanced clusters)

$$P_S^{packet} = P_1 \cdot P_{mac}(N_1, D, SO) +$$

$$+ P_{mac}(N_1, D, SO) \cdot P_{SD} \cdot$$

$$\cdot P_2 \cdot P_{mac}\left(\frac{N_2}{N_R}, D, SO\right)$$

CASE 2: NO DATA AGGREGATION

Assumptions:

- clusters equally balanced
- $N_1 = N_R$ → All nodes at level 1 are routers

$$P_S^{packet} = P_1 \cdot P_S^{frame}(N_1, D(1+N_S), S_0) +$$

$$+ P_{SD} \cdot P_2 \cdot P_S^{frame}(N_1, D(1+N_S), S_0) \cdot$$

$$\cdot P_S^{frame}\left(\frac{N_2}{\underbrace{N_R}_{=N_1}}, D, S_0\right)$$

where N_S = Average number of packets received by whatever a Router at level 1.

$$N_S = \underbrace{\frac{N_2}{N_R}}_{\substack{\text{number}\\ \text{of nodes}\\ \text{connected}\\ \text{to our Router}}} \cdot P_S^{frame}\left(\frac{N_2}{N_R}, D, S_0\right)$$

TREE-BASED TOPOLOGY: throughput

$$S = \frac{N \cdot p_s^{packet} \cdot D \cdot 8\ [bit]}{BI\ [s]}$$

TREE-BASED TOPOLOGY: Average Delay

$$D_{mean_{tree}} = \sum_{k=1}^{L-1} p_k \cdot D_{mean_k}$$

- $L = 3$ (tree-based topology)
- equally balanced clusters
- Data aggregation

$$D_{mean_{tree}} = p_1 \cdot D_{mean}^{(star)}(N_1, D, S_0) + $$
$$+ p_2 \cdot \left(BI + D_{mean}^{(star)}(N_1, D, S_0)\right)$$