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Detection Performance in Balanced Binary Relay Trees with Node and Link Failures

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We study the distributed detection problem in the context of a balanced binary relay tree, where the leaves of the tree correspond to N identical and independent sensors generating binary messages. The root of the tree is a fusion center making an overall decision. Every other node is a relay node that aggregates the messages received from its child nodes into a new message and sends it up toward the fusion center. We derive upper and lower bounds for the total error probability P_N as explicit functions of N in the case where nodes and links fail with certain probabilities. These characterize the asymptotic decay rate of the total error probability as N goes to infinity. Naturally, this decay rate is not larger than that in the non-failure case, which is $\sqrt N$. However, we derive an explicit necessary and sufficient condition on the decay rate of the local failure probabilities p_k (combination of node and link failure probabilities at each level) such that the decay rate of the total error probability in the failure case is the same as that of the non-failure case. More precisely, we show that $\log P_N^{-1}=\Theta(\sqrt N)$ if and only if $\log p_k^{-1}=\Omega(2^{k/2})$.

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