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# **BILL5180 -** Digital Communications Homework

You are asked to create ***Modified*** outage probability expressions for Cooperative Decode and Forward Relaying and Selection Decode and Forward networks. Decode and forward relay networks can be visualised as in Figure 1.



Figure 1: A simple relay channel

Where $δ$ stands for the ideally distributed Rayleigh random variable characterising the wireless channel gain.

The outage probability between the Source and Destination nodes is given as

Pr[$I\_{D}<R$] = Pr[log(1+SNR $| δ\_{s,d}|^{2}$) < R] (1)

Where **log (1+SNR**$| δ\_{s,d}|^{2}$**)** is the Shannon capacity of the link between the source and destination and R is the desired bit rate. Since, the channel gain parameter $δ\_{s,d}$ is modelled as an ideally distributed Rayleigh random variable, the outage of the link can easily be shown to be;

Pr[$I\_{D}<R$] = $1-e^{\frac{1-2^{R}}{SNR δ \_{s,d}^{2} }}$ (2)

The details and outage probabilities of the mentioned relaying mechanisms can be found in Nicholas Laneman work in [1]***. Your first task is to find exact outage probability expressions and useful rate regions for these relaying methods with a realistic assumption that the link efficiency between the nodes are given as;***

$$ϑ\_{s,d}=a\_{s,d}\frac{T\_{d(s,d)}}{T\_{b(s,d)}+T\_{i(s,d)}}$$

where$ a\_{s,d}$ is the spectral efficiency of the link and $T\_{d(s,d)}$ is the data transmission period and $T\_{b(s,d)}$ and $T\_{i(s,d)}$ are the busy and idle intervals for the link during transmission of a single packet.

***Your second task is to plot the outage probabilities for different rate regions (e.g. R=1/2 and R=2,5) and analyse your findings in terms of outage of such system within a wireless network setup***.

[1] Laneman, J.N.; Tse, D.N.C.; Wornell, Gregory W., "Cooperative diversity in wireless networks: Efficient protocols and outage behavior," in *Information Theory, IEEE Transactions on* , vol.50, no.12, pp.3062-3080, Dec. 2004 doi: 10.1109/TIT.2004.838089