Spring 2022 – Cooperative Communications and Networks

Assignment 3

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Numerical Questions

Q1) [Selection DF, 40%] Derive the outage probability of Selection Decode-and-Forward (SDF) when the average SNR of the first hop is identical to that of the direct channel, i.e., $\bar{\gamma}_0 = \bar{\gamma}_1$. Show the diversity gain of SDF is equal to two.

Hint: Use the rate expression given in the Appendix of lecture notes.

Simulation

In the lecture, three types of amplify-and-forward (AF) relay operations are introduced. To help you better understand the principle of AF, write a computer program to simulate the variable-gain AF following the steps:

- Generate fading coefficients for the source-relay channel and the relay-destination channel, respectively. Both channels are Rayleigh fading channels with the average channel power of one.
- Generate the complex Gaussian noise.
- Suppose the signal power and the source transmission power are both equal to one. Then determine the noise power for a given signal-to-noise ratio (SNR).
- Assume the maximum transmission power of relay is also one. Compute the amplification gain used by the relay.
- Determine the receive SNR at the destination.
- When the receive SNR is less than a threshold with the value of one, the transmission is in outage (failed).
- Count the number of outage events among all the simulation trials.

Q2) [10%] The SNR mentioned above is the ratio between the transmission power P and the noise power N_0. Suppose $P = 1$ Watt. For a given SNR in decibel, show the formula you used to determine the noise power in Watt.

Q3) [30%] Plot both the simulated and theoretical outage probabilities as a function of SNR in one figure.

- SNR range: $0 \sim 30$ dB.
- Clearly label each curve (simulated or analytical).
- Set y-axis as logarithm scale.

- Colors are not differentiable when printed in black and white. Use different line styles and symbols to represent different curves.

Q4) [20%] Plot the average squared gain versus SNR (dB). Explain how the average squared gain varies with the noise power. With the trend you observed, does the noise amplification problem get worse at higher SNR?