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%% This programe provides SER analysis of amplify and forward cooperative protocol using
QPSK modulation%%%
%% Results are compared with theoratical results for QPSK modulation with AWGN and
Rayleigh fading channels %%%
clear all
clc
N= 10^6; %number of symbols
Pt=1;% Total Tranmited Power
Pb=Pt/2;% Transmitted power of source
Pr=Pt/2; % Transmitted power of Relay
snr_db=[0:40];% SNR in dB
data_BS1 = ((2*(rand(1,N)>0.5)-1) + j*(2*(rand(1,N)>0.5)-1));%% Data generation
data=zeros(1,N); % Received data matrix

%% Channel gains
     channel_BS1_RS1=(1/sqrt(2)).*[randn(1,N)+j*randn(1,N)];% Channel coefficients for
Soure-Relay Link
     a11=sum((abs(channel_BS1_RS1)))/N; %Average channel gain for Soure-Relay Link
Channel

     channel_RS1_MS1=(1/sqrt(2)).*[randn(1,N)+j*randn(1,N)];% Channel coefficients for
Relay-Desination Link
     b11=sum((abs(channel_RS1_MS1)))/N; %Average channel gain for Relay-Desination Link
Channel

     channel_BS1_MS1=(1/sqrt(2))*[randn(1,N)+j*randn(1,N)];% Channel coefficients for
Soure-Desination Direct Link
     c11=sum((abs(channel_BS1_MS1)))/N; %Average channel gain for Soure-Desination Link
Channel
 %% AWGN
     nbr=(1/sqrt(2)).*(randn(1,N)+j*randn(1,N));%AWGN for at Relay for Soure-Relay Link
     nrm=(1/sqrt(2)).*(randn(1,N)+j*randn(1,N));%AWGN for at Desination  for Relay-Desination
Link
     nbm=(1/sqrt(2)).*(randn(1,N)+j*randn(1,N));%AWGN for at Desination  for
source-Desination Link

for     i=1:length(snr_db)
          snr_linear(i)=10.^(snr_db(i)/10);   % Linear value of SNR
          No(i)=Pt./snr_linear(i);           % Noise power

  %% AMPLIFICATION FACTOR
         Beta1=sqrt(Pr./(a11^2.*Pb+No(i)));

  %% RECEIVED DATA AT RELAY FROM BS
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            data_BS1_RS1=sqrt(Pb/2).*data_BS1.*channel_BS1_RS1+sqrt(No(i))*nbr;

  %% RECEIVED DATA AT MS FROM RS

data_RS1_MS1=Beta1.*data_BS1_RS1.*channel_RS1_MS1+sqrt(No(i))*nrm;%+(5.7712e-014
-1.8746e-014i);

  %% RECEIVED DATA AT MS FROM BS
      data_BS1_MS1=sqrt(Pb/2).*data_BS1.*channel_BS1_MS1+sqrt(No(i))*nbm;%+(
5.8496e-008 +4.9957e-007i);

  %%   MRC AT RECEIVER
      data_rd=data_RS1_MS1.*conj(channel_BS1_RS1.*channel_RS1_MS1)+
data_BS1_MS1.*conj(channel_BS1_MS1);

  %% DEMODULATION
      g=data_rd;
      c=real(g);
      d=imag(g);
      data(find(c>=0 & d>=0))=1+1*j;
      data(find(c>=0 & d<0))=1-1*j;
      data(find(c<0 & d>=0))=-1+1*j;
      data(find(c<0 & d<0))=-1-1*j;
      error_af(i)=size(find((data_BS1- data)),2); %% CALCULATING ERRORS

end
%% PLOTTING THE SIMULATION AND THEORATICAL RESULTS
   figure
   %% SIMULATION RESULTS
   simber_af=error_af/N;
   semilogy(snr_db,simber_af,'g.-')
   hold on
   %% THEORATICAL RESULTS (Ref: Digital communication Over Fading Channels  By
Alouini)

theorySer_fad=(3/4)*[1-sqrt(0.5.*snr_linear./(1+0.5.*snr_linear)).*4/(3*pi).*((pi/2)+atan(sqrt(0.5*s
nr_linear./(1+0.5*snr_linear))))];
   semilogy(snr_db,theorySer_fad,'r.-'); % Theoretical QPSK SER for fading channel
   hold on
   theorySer_awgn = erfc(sqrt(0.5*(10.^(snr_db/10)))) -
(1/4)*(erfc(sqrt(0.5*(10.^(snr_db/10))))).^2;
   semilogy(snr_db,theorySer_awgn,'b.-'); % Theoretical QPSK SER for AWGN channel
   %% Theoretical rsult for Amplify and forward (Ref: Cooperative networking ny K.J Ray)
   a1=(var(channel_BS1_RS1));% variance of Soure-Relay Link Channel
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b1=(var(channel_RS1_MS1));% variance of Relay-Destination Link Channel
c1=(var(channel_BS1_MS1));% variance of Soure-Destination Link Channel
p_th=(( 0.3608*No.^2)/0.25).*(1/Pb).*((1/Pb)+(1/Pr));
semilogy(snr_db,p_th,'-*');
grid on
axis([0 40 10^-5 0.5]);
xlabel('SNR(dB)');
ylabel('SER');
title('Amplify and Forward Cooperative Communication')
legend('Simulation-fad','Theory-fad','Theory-awgn','Theory-amp')
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