```
% Thanh Luan Nguyen, Tri Nhu Do, and Georges Kaddoum,
% "Performance Analysis of Multi-user NOMA Wireless-Powered mMTC Networks:
% A Stochastic Geometry Approach,"
% IEEE Transactions on Communications, Oct., 2022

clear all
close all

% ====================== Initialize Network Setting ====================== %
disp('Initializing Network...');
tic;
init_mMTC_NOMA;
toc;
% ======================================================================== %

% ========================== Simulation Results ========================== %
disp('Running Simulation Result...');
tic;
P0dBm_SIM = -60:5:150;
% linspace(-60,150,15);
for iP0 = 1:length(P0dBm_SIM)
    P_0 = 10^(P0dBm_SIM(iP0)/10);

    P_BTEH_t = [P_0*ones(1,nbits); zeros(M-1,nbits)]; % Transmit Power of
 DI_(1) -> DI_(M-1) for BTEH
    P_BPEH_t = [P_0*ones(1,nbits); zeros(M-1,nbits)]; % Transmit Power of
 DI_(1) -> DI_(M-1) for BPEH
    for tt = 2:(M-1)
        P_BTEH_t(tt,:) = (M-1)*alpha_t(tt)*eta_t(tt)/(1-
alpha_t(tt))*P_BTEH_t(tt-1,:).*phi_t(tt,:).*(isEH(tt,:))...
            + P_0*(~isEH(tt,:));
        P_BPEH_t(tt,:) =
 beta_t(tt)*eta_t(tt)*P_BPEH_t(tt-1,:).*phi_t(tt,:).*(isEH(tt,:))...
            + P_0*(~isEH(tt,:));
    end

    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    % TQoM - MTCD_I
    OP_BTEH_MTCD_I_SIM(:,iP0) =
 OPS_BTEH_MTCD_I(M,PA_QoMS,CPA_QoMS,P_BTEH_t,phi_t,noiseVar,R_M_TQoMS,isExist,tauBTEH);
    % TQoM - MTCD_II
    OP_TQoM_MTCD_II_SIM(:,iP0) =
 OPS_TQoM_MTCD_II(M,PA_QoMS,CPA_QoMS,P_BTEH_t,varphi_t,noiseVar,R_M_TQoMS,R_t_TQoMS,tauBTE
    % TCoM - MTCD_II
    OP_TCoM_MTCD_II_SIM(:,:,iP0) =
 OPS_TCoM_MTCD_II(M,K_t,PA_CoMS,CPA_CoMS,P_BTEH_t,varphi_tk,noiseVar,R_M_TCoMS,R_tk_TCoMS,

    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    % PQoM - MTCD_I
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    OP_BPEH_MTCD_I_SIM(:,iP0) =
 OPS_BPEH_MTCD_I(M,PA_QoMS,CPA_QoMS,P_BPEH_t,beta_t,phi_t,noiseVar,R_M_PQoMS,isExist,isEH)
    % PQoM - MTCD_II
    OP_PQoM_MTCD_II_SIM(:,iP0) =
 OPS_PQoM_MTCD_II(M,PA_QoMS,CPA_QoMS,P_BPEH_t,varphi_t,noiseVar,R_M_PQoMS,R_t_PQoMS,tauBPE
    % PCoM - MTCD_II
    OP_PCoM_MTCD_II_SIM(:,:,iP0) =
 OPS_PCoM_MTCD_II(M,K_t,PA_CoMS,CPA_CoMS,P_BPEH_t,varphi_tk,noiseVar,R_M_PCoMS,R_tk_PCoMS,
end
toc;

% ========================== Analytical Results ========================== %
disp('Running Analytical Result...');
tic;
P0dBm_ANA = -60:5:150;
% 0:2.5:70;
% 0:5:200;
% linspace(0,250,25);
for iP0 = 1:length(P0dBm_ANA)
    P_0 = 10^(P0dBm_ANA(iP0)/10);
    g_0 = P_0/noiseVar;
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    % TQoM - MTCD_I
    OP_BTEH_MTCD_I_ANA(:,iP0) =...

 OP_BTEH_MTCD_I(M,PL_I2I,r_t,PA_QoMS,CPA_QoMS,rho_t,eta_t,alpha_t,g_0,lambda_t,R_M_TQoMS,'
    OP_BTEH_MTCD_I_ASY(:,iP0) =...

 OP_BTEH_MTCD_I(M,PL_I2I,r_t,PA_QoMS,CPA_QoMS,rho_t,eta_t,alpha_t,g_0,lambda_t,R_M_TQoMS,'
    % TQoM - MTCD_II
    OP_TQoM_MTCD_II_ANA(:,iP0) =...

 OP_TQoM_MTCD_II(M,PL_I2I,m_t,theta_t,mu_t,PA_QoMS,CPA_QoMS,rho_t,eta_t,alpha_t,g_0,R_M_TQ
    % TCoM - MTCD_II
    OP_TCoM_MTCD_II_ANA(:,:,iP0) =...

 OP_TCoM_MTCD_II(M,K_t,rho_t,eta_t,alpha_t,g_0,PL_I2I,PL_I2II,pathlosExp,PA_CoMS,CPA_CoMS,
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    % PQoM - MTCD_I
    OP_BPEH_MTCD_I_ANA(:,iP0) =...

 OP_BPEH_MTCD_I(M,PL_I2I,r_t,PA_QoMS,CPA_QoMS,rho_t,eta_t,beta_t,g_0,lambda_t,R_M_PQoMS,'A
    OP_BPEH_MTCD_I_ASY(:,iP0) =...

 OP_BPEH_MTCD_I(M,PL_I2I,r_t,PA_QoMS,CPA_QoMS,rho_t,eta_t,beta_t,g_0,lambda_t,R_M_PQoMS,'A
    % PQoM - MTCD_II
    OP_PQoM_MTCD_II_ANA(:,iP0) =...

 OP_PQoM_MTCD_II(M,PL_I2I,m_t,theta_t,mu_t,PA_QoMS,CPA_QoMS,rho_t,eta_t,beta_t,g_0,R_M_PQo
    % PCoM - MTCD_II
    OP_PCoM_MTCD_II_ANA(:,:,iP0) =...
```
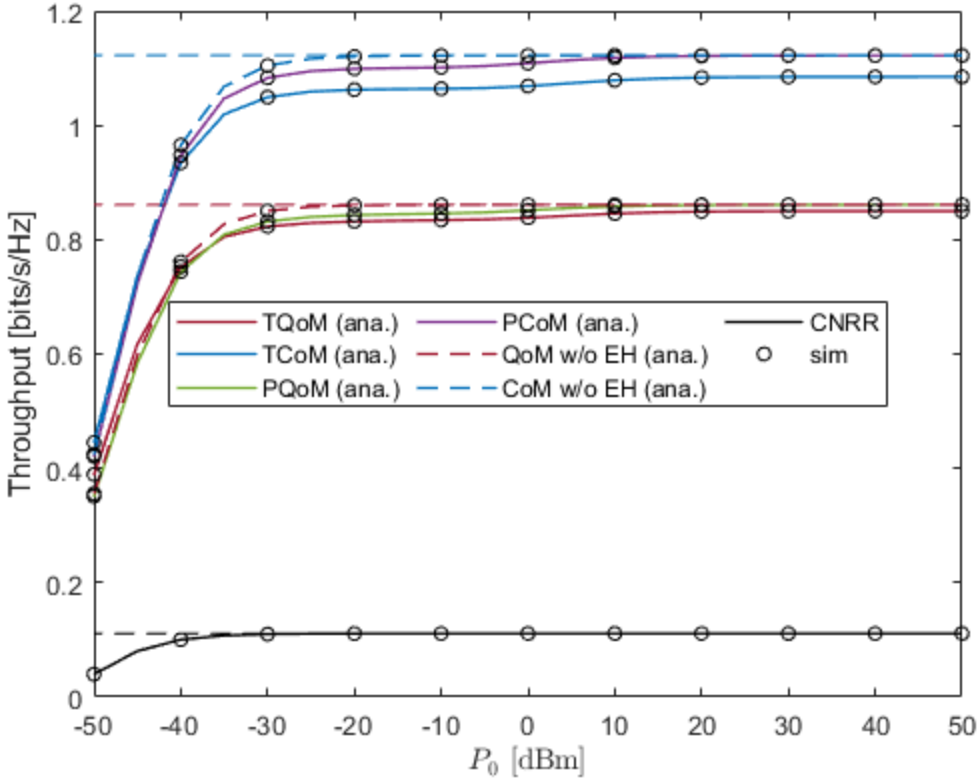
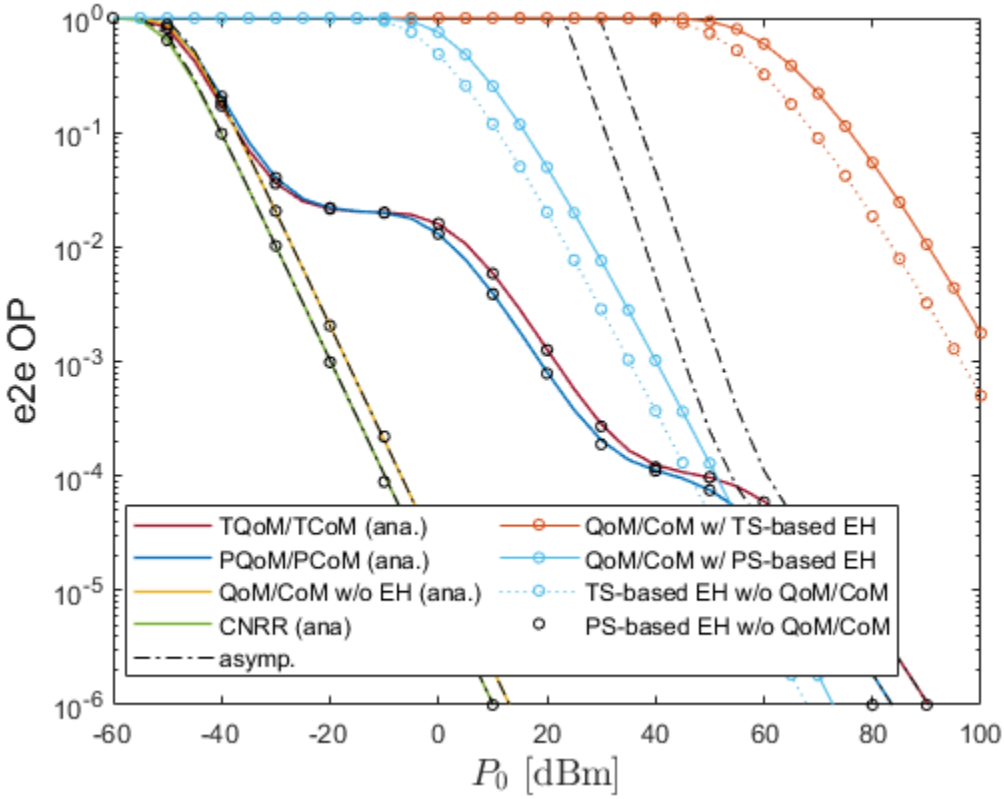

```
 OP_PCoM_MTCD_II(M,K_t,rho_t,eta_t,beta_t,g_0,PL_I2I,PL_I2II,pathlosExp,PA_CoMS,CPA_CoMS,R
end
% ========================================================================== %
toc;
% ========================== The e2e OP ========================== %
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%
OPe2e_BTEH_MTCD_I_SIM = OPe2e_BXEH_MTCD_I(M,OP_BTEH_MTCD_I_SIM);
OPe2e_BPEH_MTCD_I_SIM = OPe2e_BXEH_MTCD_I(M,OP_BPEH_MTCD_I_SIM);

OPe2e_TQoM_MTCD_II_SIM=
 OPe2e_XQoM_MTCD_II(OP_TQoM_MTCD_II_SIM,M,OP_BTEH_MTCD_I_SIM);
OPe2e_PQoM_MTCD_II_SIM=
 OPe2e_XQoM_MTCD_II(OP_PQoM_MTCD_II_SIM,M,OP_BPEH_MTCD_I_SIM);

OPe2e_TCoM_MTCD_II_SIM=
 OPe2e_XCoM_MTCD_II(K_t,OP_TCoM_MTCD_II_SIM,M,OP_BTEH_MTCD_I_SIM);
OPe2e_PCoM_MTCD_II_SIM=
 OPe2e_XCoM_MTCD_II(K_t,OP_PCoM_MTCD_II_SIM,M,OP_BPEH_MTCD_I_SIM);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%
OPe2e_BTEH_MTCD_I_ANA = OPe2e_BXEH_MTCD_I(M,OP_BTEH_MTCD_I_ANA);
OPe2e_BTEH_MTCD_I_ASY = OPe2e_BXEH_MTCD_I(M,OP_BTEH_MTCD_I_ASY);

OPe2e_BPEH_MTCD_I_ANA = OPe2e_BXEH_MTCD_I(M,OP_BPEH_MTCD_I_ANA);
OPe2e_BPEH_MTCD_I_ASY = OPe2e_BXEH_MTCD_I(M,OP_BPEH_MTCD_I_ASY);

OPe2e_TQoM_MTCD_II_ANA=
 OPe2e_XQoM_MTCD_II(OP_TQoM_MTCD_II_ANA,M,OP_BTEH_MTCD_I_ANA);
OPe2e_PQoM_MTCD_II_ANA=
 OPe2e_XQoM_MTCD_II(OP_PQoM_MTCD_II_ANA,M,OP_BPEH_MTCD_I_ANA);

OPe2e_TCoM_MTCD_II_ANA=
 OPe2e_XCoM_MTCD_II(K_t,OP_TCoM_MTCD_II_ANA,M,OP_BTEH_MTCD_I_ANA);
OPe2e_PCoM_MTCD_II_ANA=
 OPe2e_XCoM_MTCD_II(K_t,OP_PCoM_MTCD_II_ANA,M,OP_BPEH_MTCD_I_ANA);
% ========================================================================== %
plot_throughput;
% ========================================================================== %
plot_e2e_OP;
```

```
Initializing Network...
Elapsed time is 40.865339 seconds.
Running Simulation Result...
Elapsed time is 57.586034 seconds.
Running Analytical Result...
Elapsed time is 68.949405 seconds.
Warning: Ignoring extra legend entries.
Warning: Negative data ignored
```


Throughput [bits/s/Hz]
P_0 [dBm]
TQoM (ana.)
TCoM (ana.)
PQoM (ana.)
PCoM (ana.)
QoM w/o EH (ana.)
CoM w/o EH (ana.)
CNRR
sim


e2e OP
P_0 [dBm]
TQoM/TCoM (ana.)
PQoM/PCoM (ana.)
QoM/CoM w/o EH (ana.)
CNRR (ana)
asymp.
QoM/CoM w/ TS-based EH
QoM/CoM w/ PS-based EH
TS-based EH w/o QoM/CoM
PS-based EH w/o QoM/CoM

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