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APPENDIX A

3G UPLINK/DOWNLINK SIMULATION ENVIRONMENT

This appendix provides a brief description of the MATLAB 3G Uplink/Downlink Simulation Environment. The simulation environment is controlled through a Graphical User Interface (GUI). This has been developed to provide the user with an integrated 3G CDMA simulation platform for performance evaluations. The package has been developed using MATLAB 5.2, running on a WINDOWS 95/98/NT platform.

A.1 Link Level Simulation

This section will describe the MATLAB link-level software implementations of the uplink and downlink. Figure A.1 and A.2 illustrate the general block diagrams of the transmission links.

For both the up- and downlinks, the data sequence is firstly encoded, interleaved and frame converted before data modulation using QPSK. A frame consists of multiple slots. Tme consists of multiple slots. T- and slot- based processing for the receiver and transmit functions. For the transmitter, the frame based processing consists of frame encoding and interleaving. Then each slot is transmitted and received. When a slot is received and placed into the de-interleaver buffer, the power control command is computed for the next transmit slot. Only when the entire de-interleaver input is filled can the receiver frame based processing (consisting of de-interleaving and decoding) commence. For the uplink, a single transmitter antenna is assumed, while the downlink may include M_T transmit antennas, used either in a CDTD or TDTD signalling configuration (see [84] for more details on the different transmit diversity schemes).

In the simulation system the in-phase and quadrature components of the transmitted signal are multiplied by a random segment of a pre-generated fading channel complex envelope. The channel models under consideration, include the UMTS *indoor*, *outdoor-to-indoor/pedestrian* and *vehicular*. The resulting signals are then summed and finally AWGN of known power is added.

All of the users add their contribution to the centre slot buffer, then each user processes this buffer after the addition of noise, to model AWGN. For each user the data transmitted on the physical channel results from the encoding of an information sequence and the control information transmitted on the channel is randomly generated.

The length of the information sequence and the encoding rate sets the number of binary symbols to be transmitted on the I and Q arms of the modulator. This in turn sets the processing gain of each user. By setting the information sequence length of each user, we may control the processing gain of each user. Users with higher information rates will have correspondingly lower spreading gains. Importantly, the frame interleaver sizes used in the convolutional- and turbo encoding and decoding are also determined by the information data rate.

The receiver first performs chip waveforming matching. Channel estimation is performed on each resolved path, and used in the pilot symbol assisted (PSA) RAKE combiner to resolve each of the transmitted streams from the multiple transmit antennas. The RAKE receiver then consists of a number of correlators (or fingers), operating in parallel. Each finger correlates a shifted version of the received signal with the spreading sequence for the user of interest. The different shifts correspond to the different excess delays for each multipath component received by the mobile terminal. Thus each RAKE finger is synchronized to a different multipath component and picks up the energy associated with that component. The outputs of the RAKE fingers must be combined (once per symbol period) to obtain an estimate of the received symbol.

Closed loop power control is used on the dedicated channels to reduce the imbalance in transmit power (near-far effect). Ideally the base station adjusts the transmitted power such that the mobile terminal observes a prescribed signal-to-interference ratio (SIR). Both pilot and data symbols are used in measuring the instantaneous received signal power, but pilot symbols are used in measuring the instantaneous interference plus background noise power. The measured SIR is then compared with the target value to generate the transmit power control (TPC) command which is sent to the transmitter at the base station at the end of each slot.

A.1.1 Simulation Cases

Three types of users, each having different service requirements, may be considered. The three service types are as indicated in Table A.1.

Parameter	Class 1	Class 2	Class 3
Physical channel rate (uncode)	48 *kbits/*	256 *kbits/*	1024 *kbits/*
Spreading factor, N	32	16	4
FEC rate	1 or 1/3	1 or 1/3	1 or 1/3
Frame Interleaving	10 *ms*	10 *ms*	10 *ms*
DPCCH/DPDCH power	0 *dB*	0 *dB*	0 *dB*

TABLE A.1: Simulation service classes.

Table A.2 provides a summary of the implemented receivers, transmit diversity, and coded techniques and their corresponding labels.

A.2 MATLAB Simulation Software

A.2.1 Getting Started

In order to get the MATLAB simulation platform up and running the following steps should be followed:

Step 1 Create a suitable working directory to which the software will be copied. For example: `'c:\umts_sim'`

Step 2 Copy the downloaded 'p-code' files (`'*.p'`) to the working directory.

Step 3 Create the simulation data directory to which `'error'` and `'log_file'` results will be stored. This directory should be created on the 'C' drive as follows: `'c:\data'`

Step 4 Start MATLAB, and add the directory created under Step 1 to the MATLAB path.

Step 5 You should be able to run the simulation platform. Type in `'umts_sim'` at the MATLAB command line.

Acronym	Description
SICL	Iterated SIC, no clip/linear (3 Iterations)
SICH	Iterated SIC, hard (3 Iterations)
SICL	Iterated SIC, clip (3 Iterations)
PICL	Iterated PIC, no clip/linear (3 Iterations)
PICH	Iterated PIC, hard (3 Iterations)
PICL	Iterated PIC, clip (3 Iterations)
NLMS	Normalized LMS ($\mu = 0.02$)
EMF	Estimated Matched Filter ($\mu = 0.02$)
NO TD	No Transmit-Diversity
O-CDTD	Orthogonal Code-Division Transmit-Diversity
RR-TDTD	Round-Robin Time-Division Transmit-Diversity
AS-TDTD	Antenna-Selection Time-Division
UNC	Uncoded Transmission
RC	Repetition Coding
CC	Convolutional Coding (128 or 256 states)
TC	Turbo Coding (4, 8 or 16 states)
	MAP decoder, 8 Iterations

Table A.2: Implemented single- and multiuser detection, transmit-diversity and channel coding techniques and corresponding labels.

A.2.2 Main Simulation Window

By invoking `'umts_sim.p'` at the MATLAB command line, the main GUI from which different simulation engines are called from will be opened. A screen capture of this GUI window is depicted in Figure A.3.

A.2.3 Simulation Environment Configuration

Figure A.4 shows a screen capture of the simulation environment configuration window. By selecting `'Transceiver/Channel Setup'` button, the configuration window, shown in Figure A.4 will be opened.

The DS/CDMA transceiver and environment parameters controlled through this GUI are given below:

- General transceiver parameters:
  - Number of simultaneous users, K.
  - Users' load in a mixed throughput environment, given as percentage of number of simultaneous transmitting users.
  - Signal-to-Noise ratio range and step increments.
- Channel environment parameters:
  - Type: AWGN, UMTS Indoor, UMTS Outdoor-to-Indoor and Pedestrian, and UMTS Vehicular.
  - Average speed and log-normal shadowing variance.
- Monte-Carlo simulation parameters:
  - Minimum number of bit errors to detect.
  - Minimum and maximum number of frames to receive.
- Parameters common to uplink and downlink:
  - Number of RAKE fingers available.
  - Power control algorithm selection.
- Parameters specific to uplink:
  - Number of receiving antenna.

  - Choice of receiver (choice between single and multi user detectors):
    * Iterated SIC, No clip.
    * Iterated SIC, Clip.
    * Iterated SIC, Hard.
    * Iterated PIC, No clip.
    * Iterated PIC, Clip.
    * Iterated PIC, Hard.
    * Estimated Matched Filter (EMF).
    * Normalized LMS (NLMS).
  - Choice of FEC technique:
    * No coding.
    * Convolutional encoder with soft-input Viterbi decoder.
    * Turbo encoder with iterative MAP decoder (8 Iterations).

- Parameters specific to downlink:
  - Number of transmitting antenna.
  - Transmit diversity selection:
    * No transmit diversity.
    * Orthogonal CDTD.
    * Round-Robin Time-Division Transmit Diversity (RR-TDTD).
    * Antenna-Selection Time-Division Transmit Diversity (AS-TDTD).
  - Choice of receiver:
    * Estimated Matched Filter (EMF).
    * Normalized LMS (NLMS).
  - Choice of FEC technique:
    * No coding.
    * Convolutional encoder with soft-input Viterbi decoder.
    * Turbo encoder with iterative MAP decoder (8 Iterations).

A.2.4 Example

To understand how to use the simulation platform, an example is presented.

Step 1 Type `'umts_sim'` at the MATLAB command line. This will bring up the main interface window (figure), shown in Figure A.3.

Step 2 Click on the `'Transceiver/Channel Setup'` button. This will open the configuration window, as shown in Figure A.4.

Step 3 Select the number of users, K.

Step 4 Change the 'E_b/N_o range in dB' entry to the desired range. Note that this parameter is entered in typical MATLAB style for vectors which is *start:step:end* with *step* defaulting to 1.0 if not specified.

Step 5 Select the desired channel environment.

Step 6 Select the vehicle speed and log-normal shadowing variance.

Step 7 Set up the users' loads as a percentage. Upon exit the entries will be normalized to a total load of 100 %.

Step 8 Change the simulation control parameters.

Step 9 Set up the parameters common to both the uplink and downlink.

Step 10 Set up the uplink specific parameters.

Step 11 Set up the downlink specific parameters. Note that when only a single transmit antenna has selected, that the transmit diversity scheme will be defaulted to the 'No Transmit Diversity (TD)' selection.

Step 12 Click on the `'Continue'` button. This causes the configuration window to close. The theoretical curve for selected uncoded DS/QPSK system will be plotted over the E_b/N_o range in dB.

Step 13 (Optional) Click on the `'Clear'` button to remove the plotted curves.

Step 14 Click on either the `'UPLINK Simulation'` or `'DOWNLINK Simulation'` button to start the simulation. The simulation continuous for each E_b/N_o value specified in the 'E_b/N_o range in dB' entry. Information on 'Simulation Completion' will be displayed. The plot will be updated as the bit error rate of each evaluation point bit error exceeds has been completed. Note that each point is evaluated until the condition where the bit error count exceed the 'minimum number of errors', and the received frame counter exceeds the 'minimum number of simulation blocks', is reached for that particular value of E_b/N_o. At completion of the simulation, a legend is added and results are displayed on the graph. At this stage, the result can be copied to the clipboard to paste in some other application for recalling purposes.

Step 15 The main figure window can now be exit from by clicking on the `'Exit'` button, or more simulations can be performed.

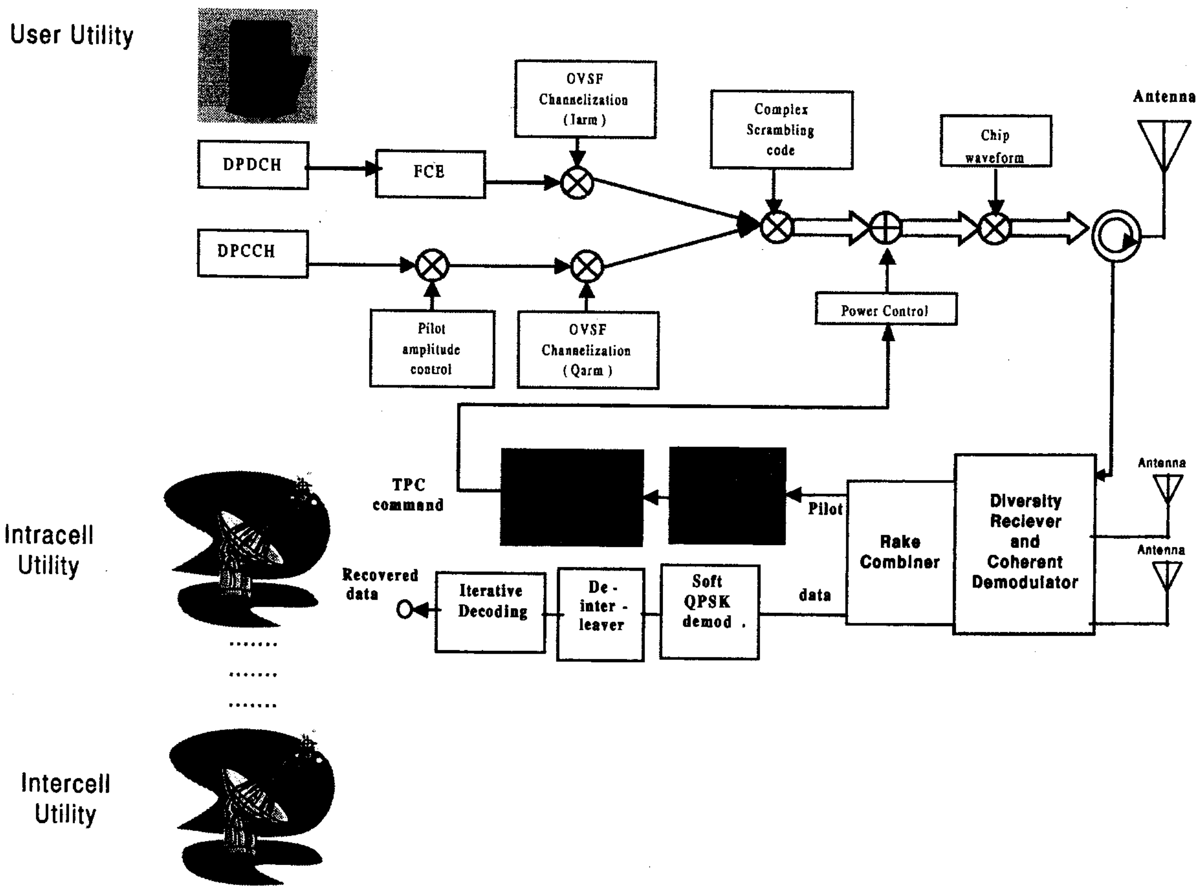

FIGURE A.1: Overall block diagram of the uplink.

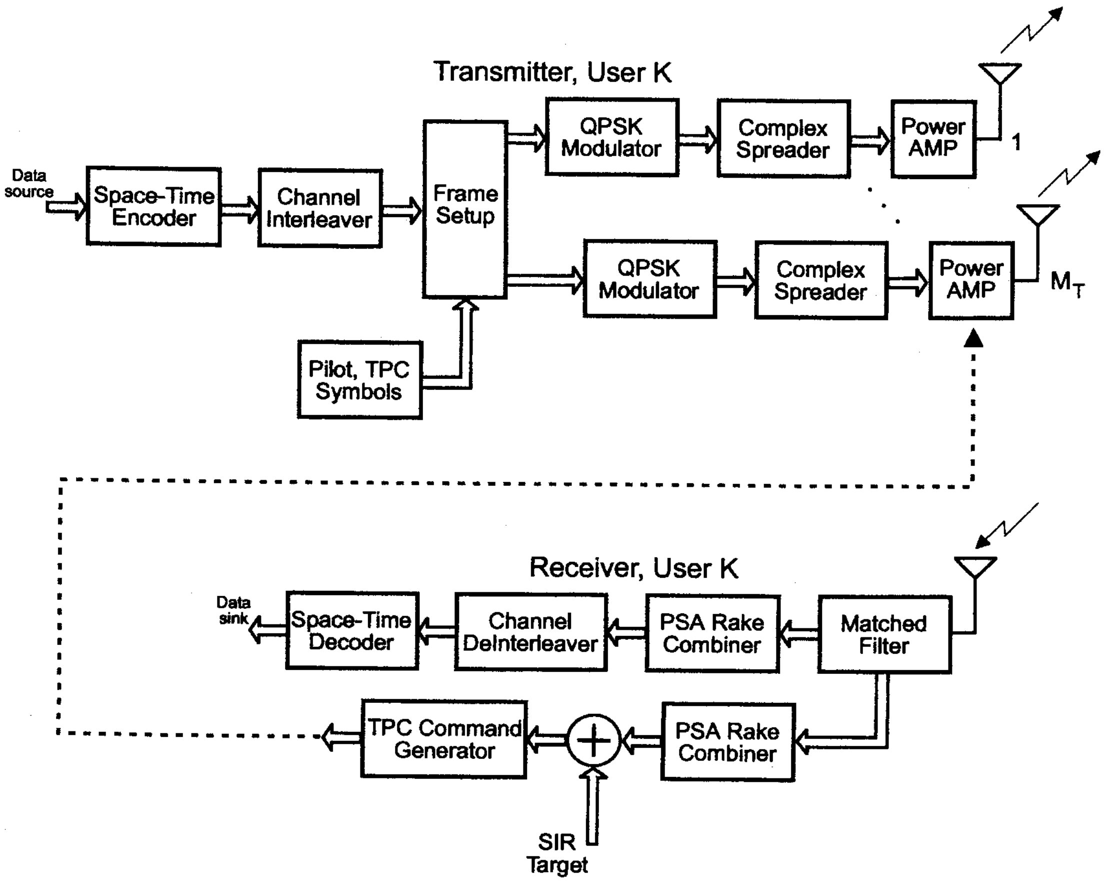

FIGURE A.2: Overall block diagram of the downlink.

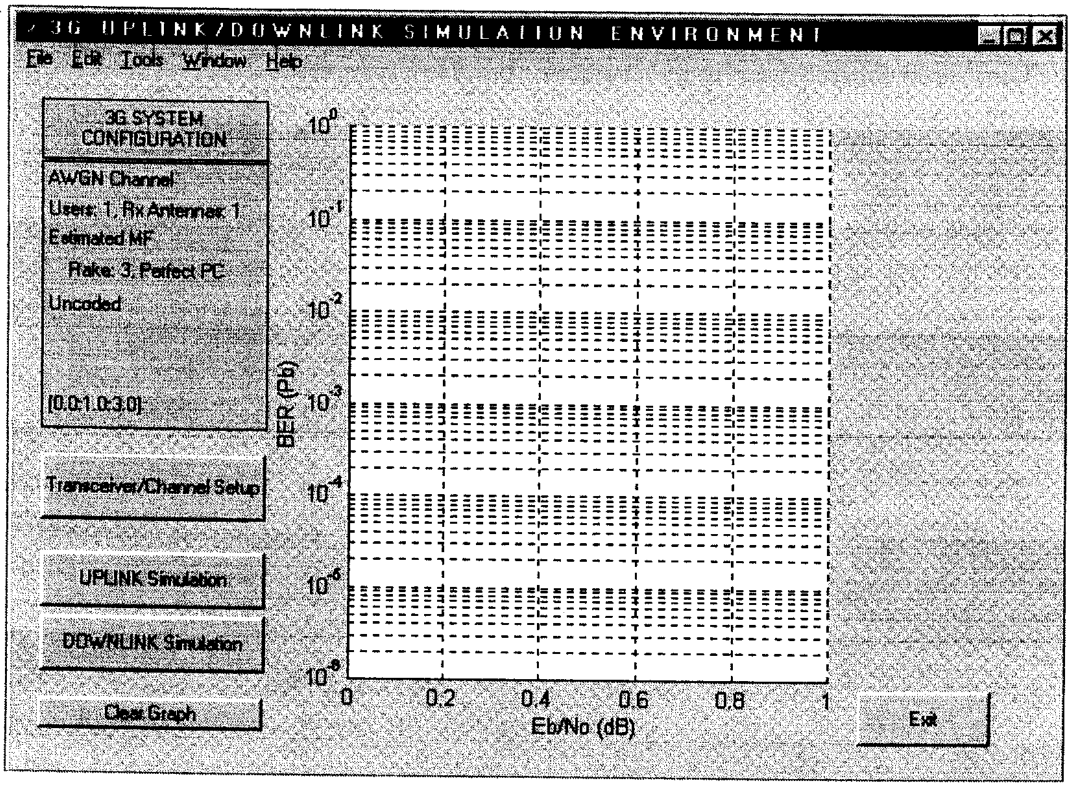

FIGURE A.3: Main interactive simulation platform window.

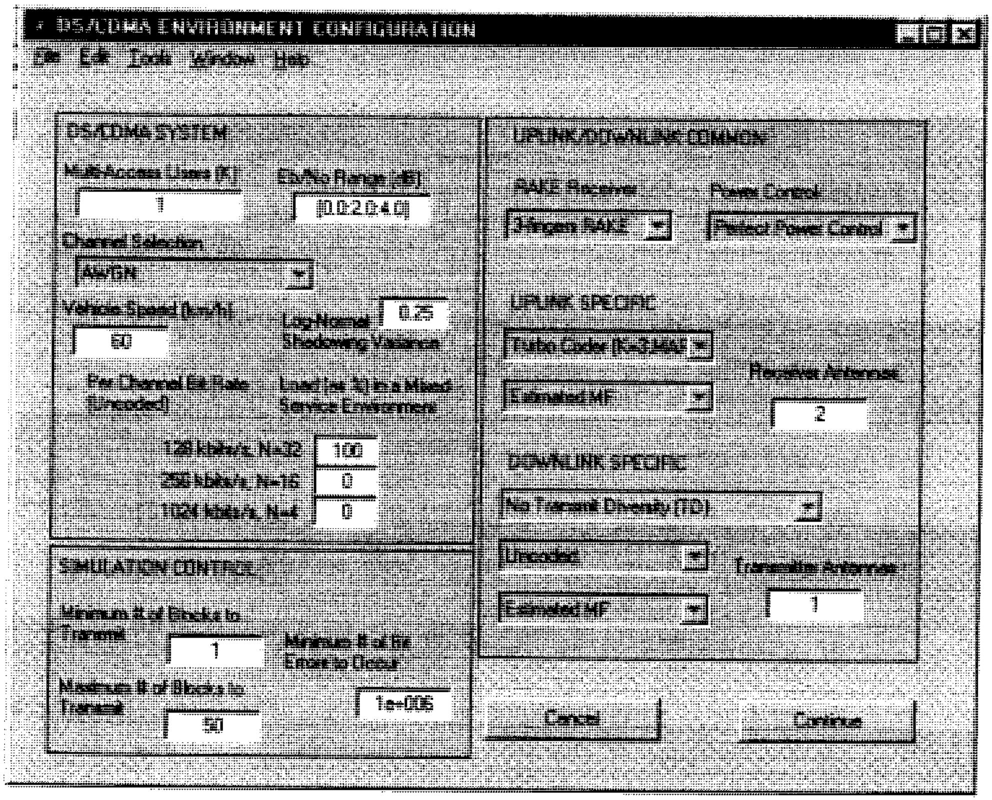

FIGURE A.4: Simulation platform configuration window.

APPENDIX B

SOURCE CODE OF THE ARUWA SIMULATION PACKAGE

```
%function TransOne

global status1; global status2; global status3; global status4;
global status5; status1 = 0; status2 = 0; status3 = 0; status4 =
0; status5 = 0; global AveSigPwr; AveSigPwr = 1;

store = struct(...
    'n'          ,      [],...                  % MAI /simulator
    'h'          ,      [],...                  % channel effect /frame
    'Rayleigh'   ,      [],...                  % Multipath fading /frame
    'shadow',           [],...                  % Shadow /frame
    'userData'   ,      [],...                  % User Data buffer /frame
    'Txsignal',         [],...
                   % Transmitted signal /slot (Text: Transmitted power)
    'Rxsignal',         [],...                  % Received signal /slot
    'profile'    ,      [],...                  % Power Profile /frame
    'PControl'   ,      [],...
                   % Transmitted power & received SIR /slot
    %(Text: Actual SIR & Estimated SIR
    'SIRset',           [],...
    'SIRmea',           [],...
    'PConsump'   ,      [],...                  % Power Consumption /frame
    'ErrorDist',        [],...                  % Error distribution /frame
    'NoisePower',       [],...                  % Noise power at channel
    'AvePw',            [],...                  % Average Transmitted power
    'Pe',               [],...                  % Error Probability /FER
    'iteration',        [],...
    'extrinsic',        [],...
    'iteration1',       [],...
    'extrinsic1',       []);

mud = 8;
                  1: SIC with iterations, no clip
                  2: SIC with iterations, clip
```

```
                      3: SIC with iterations, hard7
                      4: PIC with iterations, no clip
                      5: PIC with iterations, clip
                      6: PIC with iterations, hard
                      7: Normalised LMS
                      8: estimated  MF

rake = 3;              % Rake fingers
fec = 4;               % selected forward error correction scheme
                      1: No error correction coding
                      2: Convolutional coding, K=8, Rate-1/3 (128-state)
                      3: Convolutional coding, K=9, Rate-1/3 (256-state)
                      4: Turbo coding, K=3, Rate-1/3 (4-state)
                      5: Turbo coding, K=4, Rate-1/3 (8-state)
                      6: Turbo coding, K=5, Rate-1/3 (16-state)
chan = 1;                                         % selected channel
                                 1: AWGN Channel, no multipath
                                 2: UMTS Indoor
                                 3: UMTS Pedestrian
                                 4: UMTS Vehicular
                                 5: 1-Path Rayleigh
                                 6: 2-Path Rayleigh
                                 7: 3-Path Rayleigh
logn_s =2;                  % Shadowing variance
v = 60/3.6;                 % speed, convert from km/h to m/s
lRxA = 1;                   % number of receiver antenna
IT = 8;                     % number of iteration to perform for turbo decoder

PwrCtrl = 2;
                                 1: Perfect PC
                                 2: CLPC (2dB)
                                 3: CLPC (1dB)
                                 4: Xia1
                                 5: Xia2
                                 6: fuzzy
%============================================
% System Parameters: UMTS/UTRA standards
%============================================
sys = struct(...
   'Nf', 41472,...                  % # of chips in a frame
   'M' , 16,...                     % # of slots in a frame
   'm' , 1,...                      % current slot
   'Nm', 0,...                      % # of chips in a slot
   'S' , 4,...                      % # of samples per chip
   'Sf', 0,...                      % # of samples per frame
   'Sm', 0,...                      % # of samples per slot
   'B' , 1,...                      % # of receive antenna (diversity)
   's' , [],...                     % long code
   'c' ,     [],...                 % chip waveform
   'Q' , 0,...                      % centre tap of chip waveform
   'chan',chan,...                  % AWGN (selected) channel
   'v',v,...                        % vehicle speed (60/3.6 ms^-1)
```

```
    'h',[],...                              % multipath fading profile at chip rate
    'receiver',mud,...                      % type of receiver (SC, MF, PC)
    'rake',rake,...                         % RAKE fingers
    'fec',fec,...                           % fec type
    'pwr_ctrl',PwrCtrl);                    % power control
sys.Nm = sys.Nf/sys.M;                      % chips per slot
sys.Sf = sys.Nf*sys.S;                      % samples per frame
sys.Sm = sys.Sf/sys.M;                      % samples per slot

% Long Code
s = 2*(rand(sys.Nf,1)>0.5)-1;
sys.s = [s;s];                              % avoid %Nf by replication of long code

% chip waveform
sys.c = chip(2,sys.S,1);
 type 0 = square, type 1 = root raised cosine
sys.Q = floor(length(sys.c)/2);
 index of centre tap (-1), offset in conv

Multifading

channel = 1;                                % channel
store = Multifading(store,channel,sys);
sys.h = store.h;

%==========================================
% User Required Parameters: Data Rate, QoS,
%==========================================

% Single transmit antenna
channel = channels(sys.S,sys.chan);                 % pick type of fading channel
P = size(channel,1);                                % # of multipath delays
if fec == 1
   n = 1;
else
   n = 3;
end

store.profile = channel';

Lu = sys.Nf/32/n; N  = 32;
L  = n*Lu;
                      % # of channel symbols per frame (% # bits out of encoder)
Lm = L/sys.M;                                  % # of channel symbols per slot

Tx(1) = struct(...
   'Lu' , Lu,...          % Data buffer        % # of bits into frame encode
   'L'  , L,...                                % # of bits at encoder output per frame
   'Lm' , Lm,...                               % # of bits at encoder output per slot
   'b'  , [],...                               % User data generate in frame based
   'dI' , zeros(L,1),...                       % Encode user data at output register
   'I'  , [],...                               % bitwise channel interleaver
```

```
    'dQ'  , [],... .                                 % training symbols
    'N'   , N,...                                    % spreading gain
    'cI'  , zeros(N,1),...                           % I arm spreading code
    'cQ'  , zeros(N,1),...                           % Q arm spreading code
    'n'   , 3,...
    'sIp', 0,...                                     % phase of I arm scramble
    'sQp', 0,...                                     % phase of Q arm scrambl
    'w'   , zeros(sys.B*P,1),...                     % adaptive filter
    'P'   , P,...           % Channel parameter      % # of multipath delays
    'hp', zeros(P,sys.B),...                         % phases of multipath profile
    'ho', zeros(P,sys.B),...
                  % offset into fading array of multipath profile into sys.h
    'delay',0,...                                    % group delay (models async to other users
    'power', zeros(P,1),...                          % relative power of fading channels
    'tau', zeros(P,1),...                            % multipath delays measured in samples
    'SINRset',0.5,...       % Receiver parameter     % target received SINR
    'SINR',0,...                                     % measured SINR
    'QoS', 10e-3,...                                 % Target received BER
    'Wtx',zeros(sys.M+1,1));                         % Tx scaling to satisfy SINRset
     [Tx(1).cI, Tx(1).cQ] = tree(N);                 % binary antipodal channelisation code
    % multipath fading\
    J = sqrt(-1);
    homax = length(sys.h)-sys.Nf;                    % max multipath sequence offset%

Tx(1).power = 10.^(channel(:,2)/10);                 % convert MP strengths from dB to linear\
Tx(1).tau = channel(:,1);
                              % assign MP delays as a function of the selected channel
Tx(1).delay = floor(rand*10*sys.S);                  % asynchronism
Tx(1).hp = exp(J*2*pi*rand(P,sys.B));                % phases of multipath profile
Tx(1).sIp = 0; Tx(1).sQp = 0;%
%===========================================
 Initiate Transmitter Parameters
===========================================
Errs = 0;
EbonNodB = 0;
                              % find the required EbonNodB for various data rate, channel,
run = 0;
% diversity scheme and coding
 Interleaver
 cEbNodB = EbonNodB(1);

I=1:L; for i=1:L, j=ceil(rand*L);
   temp=I(j);
   I(j)=I(i);
   I(i)=temp;
end; Tx(1).I=I;
%         Tx(1).dQ = 2*round(rand(L,1))-1;
        % training symbols
        Tx(1).SINRset = (10^(EbonNodB/10))/Tx(1).n;
        % QoS scaling controls Tx power
        Tx(1).Wtx(1) = 0.5;
                                        % rough initial value for Tx amplitude
```

```
        store.PConsump = Tx(1).Wtx(1);
%============================================
% Frame-wise encoding and interleaving
%============================================
while run < 20,
   run = run + 1;
  if fec == 1, Tx(1).b = round(rand(Tx(1).Lu,1));                   %Uncoded system
   else Tx(1).b = round(rand(Lu,1)); end;                            %Coded system
   switch fec
       case 1
        Tx(1).dI = 2*Tx(1).b-ones(size(Tx(1).b));
     case {4,5,6} %Turbo Encoder
                  % Turbo-encoder
            Rc = 1/3;
            Q=fec-2;
            T_out = turboenc(Q,Tx(1).Lu,Rc,Tx(1).b');
            T_out = T_out';
            % Interleaver
            Tx(1).dI = T_out(I);
     end
store.userData = [store.userData,Tx(1).b];

%====================================================
% Slot-by-Slot transmission - Enables Utilized-based PC
%====================================================
      Rx=Tx;
      %save Rx Rx
      %      m=1;
        ebno = 10^(EbonNodB/10);%

      for m=1:sys.M
         sys.m = m;
         Tx(1).ho = m*sys.Nf/16; %ceil(rand(P,sys.B)*homax);
                                                % offset of multipath profile into sys.
            ds = (m-1)*Tx(1).Lm + (1:Tx(1).Lm);
                                                % Index the current user-data buffer
         % Spread spectrum
         dIm= Tx(1).dI(ds);
                                                % User index (ds) to attain slot data
         dQm= Tx(1).dQ(ds);
                                     % Training index (ds) to attain slot training symbols
         xI = kron(dIm,Tx(1).cI);
                                                % spread I arm, chip rate
         xQ = kron(dQm,Tx(1).cQ);
                                                % spread Q arm, chip rate, antenuated
         % Check for orthogonality for cI and cQ
         orthogonal=sum(Tx(1).cI+Tx(1).cQ);
                 x = Tx(1).Wtx(m)*(xI+J*xQ);
% QPSK symbols to scramble, chip rate, power control
         %Scrambling Code
         sI = (m-1)*sys.Nm + Tx(1).sIp + (1:sys.Nm);
                                                % index I scrambling chip sequence for slot
```

```
    sQ = (m-1)*sys.Nm + Tx(1).sQp + (1:sys.Nm);
                                    % index Q scrambling chip sequence for slot m
        s1 = sys.s(sI) + J*sys.s(sQ);
                            % get scrambling sequence (The scrambling assigned for

        y = s1.*x;
                                    % complex scramble, chip rate
                                    % initialise observed sequence
    e = zeros(sys.Sm,sys.B);


    % Diversity
    % no diversity yet at this time
       for b=1:sys.B,
                                        % do for each antenna
           for p=1:Tx(1).P,             % do for each multipath delay
          tau = Tx(1).tau(p);           % no delay first+Tx(1).delay;
          %      w = sqrt(sys.power(p));  % assume average power same on all ants
          sh = Tx(1).ho(p,b) + (m-1)*sys.Nm + (1:sys.Nm);
                                        % indexes of fading sequence
          h = sys.h(sh);                % get path (p,b) fading profile, chip rat
          e(tau+(1:sys.S:sys.Sm),b)=e(tau+(1:sys.S:sys.Sm),b)+y.*h;% tx times channe
          [mf, vf] = gstat(h);
          ea2 = vf+mf;

          euf(tau+(1:sys.S:sys.Sm),b) = y;
          [meuf, veuf] = gstat(euf(:,1));
          eas = meuf+veuf;
          end;
       end;
    AveSigPwr = abs(eas / ea2);          %Average Signal Power per slot
      % Chip pulse shaping:
      % perform chip waveform convolution (after sum_k) since convolution is linear
      for b=1:sys.B,                     % each antenna
          eb = conv(e(:,b),sys.c);       % convolve with chip waveform
          e(:,b) = eb(sys.Q+(1:size(e,1)));
                                         % slide due to convolution
      end;
  if run == 1
         Txsignal = store.Txsignal;
     store.Txsignal = [Txsignal,e];
  end

%=====================================================
% Slot-by-Slot transmission - Multi-Access-Interference (MAI)
%=====================================================
          n = randn(size(e))+...
       sqrt(-1)*randn(size(e));           % generate complex AWGN of unit variance%

   No = 0;
   for k=1:K,
     % for every user calculate noise scaling factor to provide desired Eb/No ratio
```

```
        ecno=ebno/(sys.S*sys.B*Tx(1).N*Tx(1).n); % equal transmit power constraint
          Nok = 1/ecno;
                                             % Thermal noise variance per chip for single user
        No = Nok;
           %        end
           No2 = (No/(1*2))*AveSigPwr;
        if sys.pwr_ctrl == 1,
           % for case of perfect power control
                   No = 3^-1*No2/10;              % Noise power (watt)
                 n = n*sqrt(No2/2);
        else
              No = 1/3*No2;                       % Noise power (watt)
        end;
        e = e + n;                                % add AWGN to rx samples
store.n = n; store.NoisePower(m,run) = No;
         [mn, var]=gstat(e(:,1));
          Le = length(e);
          AVE=sum(e.*conj(e))/Le;
          Ave1=mn+var;%
          AvePw = store.AvePw;
          store.AvePw = [AvePw,AVE];
          %=====================================================
         % Slot-by-Slot Receiver
         %=====================================================
    if run == 1
        Rxsignal = store.Rxsignal;
      store.Rxsignal = [Rxsignal,e];
   end
   [Rx,store] = slotreceiver(e,sys,Rx,store,Tx,run);
        %=====================================================
        % Slot-by-Slot Power Controller
        %=====================================================%

        if sys.pwr_ctrl > 1
          if sys.pwr_ctrl > 1
                   % power control step size in dB
                   G = 10^(GdB/10);
               g = Rx(1).SINRset/Rx(1).SINR;
               Tx(1).Wtx(m+1) = Tx(1).Wtx(m);      % assume no adjustment
                   if     g > G   Tx(1).Wtx(m+1) = G*Tx(1).Wtx(m);
                   elseif g < 1/G Tx(1).Wtx(m+1) = Tx(1).Wtx(m)/G;
                   end
                 Rx(1).Wtx(m+1) = Tx(1).Wtx(m+1);  % copy to Receiver
               else
        % perfect power control
                   Tx(1).Wtx(m+1) = Tx(1).Wtx(m);  % amplification remains fixed
                   Rx(1).Wtx(m+1) = Tx(1).Wtx(m+1);% copy to Receiver
      end;
% Power Consumption   % Transmit Power
PControl = store.PControl; store.PControl = [PControl,
Rx(1).Wtx(m+1)]; store.PControl;
```

```
% Power Consumption   % Transmit Power
PComsump = store.PConsump; store.PConsump = [PComsump,
Rx(1).Wtx(m+1)];
end%
%
            Tx(1).Wtx(1) = Rx(1).Wtx(17);
            Rx(1).dI(1:100) = 1*Tx(1).dI(1:100); % give some symbols to Rx
% Check for Error
sum(gt(Rx(1).dI,0).*2-1==Tx(1).dI);

      %=====================================================
      % Frame Receiver
      %=====================================================
  d = Rx(1).dI;
   switch fec
        case 1
         d = d';
         b = Decide(d,0);                           % return uni-polar array of decisions
         Rx(1).b = b';                              % re-order rows and columns%%
         Err(1) = sum((Rx(1).b)~=(Tx(1).b))         % calculate bit errors
         case {4,5,6}
              d(Rx(1).I) = d; % De-interleaver
                M = fec - 2;
               Rc = 1/3;
                [Errs,store] = TurboMAP(M,Tx(1).Lu,IT,Rc,No,d,Tx(1).b,store,run);
                Err(1) = Errs(IT*2);
      end
   end;
```