Contents


```
% ECE408 - Wireless Communications
% Jongoh (Andy) Jeong
% 802.11b WLAN Standard - Simulation Project
% Date: February 19, 2020
clear all; close all; clc;
```

IEEE 802.11b

```
reset(RandStream.getGlobalStream);
rng default; % for reproducibility

% Simulation Parameters
snrVector = -8:1:30;
nIter = 10;
% packet size: min: 4, max: 8192 as per 802.11 standards
octetNumber = 1024; % number of octets (will be multiplied by 8)
% samples per chip; samples will be up/down-sampled to this reference
spc = 8;

% call objects for modulation / demodulation with appropriate parameters
modFcns = {@(x, rate) ModSchemes.BarkerModulator(x,rate), ...
           @(x, rate) ModSchemes.BarkerModulator(x,rate), ...
           @(x, rate) ModSchemes.CCKModulator(x,rate), ...
           @(x, rate) ModSchemes.CCKModulator(x,rate)};
demodFcns = {@(x, rate) ModSchemes.BarkerDemodulator(x,rate), ...
           @(x, rate) ModSchemes.BarkerDemodulator(x,rate), ...
           @(x, rate) ModSchemes.CCKDemodulator(x,rate), ...
           @(x, rate) ModSchemes.CCKDemodulator(x,rate)};

% supported data rates as per 802.11b standard
dataRates = [1, 2, 5.5, 11];
% bits per symbol for all data rates
BPSes = [1, 2, 4, 8];
% chip spreading rates for all data rates
chipSpreadLengths = [11, 11, 8, 8];

% scrambler initialization seed
% scramInit = 93;
% msgBinSc = wlanScramble(msgBin,scramInit);
% RxBits = wlanScramble(RxBitsDsc, scramInit);

BERVector = zeros(length(snrVector),length(dataRates));
fprintf('Simulation starting...\n'); tic;
for rate = 1:length(dataRates) %correrponding to 4 different rate options (1, 2, 5.5, 11 Mbps)
    fprintf('Data rate: %.1f Mbps\n', dataRates(rate));
    for i = 1:length(snrVector)
        fprintf('SNR: %.1f\t', snrVector(i));
        totalbits = 0;
        nerror = 0;
        for iter = 1:nIter
            % adjust SNR
            sampRate = chipSpreadLengths(rate) * spc;
            snrdB = snrVector(i) + 10*log10(BPSes(rate)) - 10*log10(sampRate);

            % generate packet
            msgBin = randi([0 1],octetNumber*8,1);
            [preamble, header, psdu] = generatePacket(msgBin, dataRates(rate));

            % modulate
            preambleMod = ModSchemes.BarkerModulator(preamble',1);
            headerMod = ModSchemes.BarkerModulator(header',1);
            txSyms = modFcns{rate}(psdu, dataRates(rate));

            % PSDU only: upsample, pass through a pulse shaping filter
            [h, upsampledChips, chipFilterDelay] = Filter.PulseShapeFilter(txSyms, spc);
            samples = filter(h,1,upsampledChips);

            % pack a PLCP packet frame
            txFrame = [preambleMod', headerMod', samples'];

            % pass through an AWGN channel with adjusted SNR
```

```
            txNoisy = awgn(txFrame, snrdB, 'measured')';

            % slice for demodulation
            preambleTx = txNoisy(1:1584);
            headerTx = txNoisy(1585:1585+528-1);
            samplesTx = txNoisy(1585+528:end);

            % filer back (and downsample) PSDU only
            % assumption: perfectly knowing impulse response of the filter
            filtTxSig = filter(h,1,samplesTx); % column vector
            [rxSyms,bitDelay] = Filter.Receiver(filtTxSig, spc, chipFilterDelay, BPSes(rate), chipSpreadLengths(rate));

            % demodulate preamble and header
            frameRx = ModSchemes.BarkerDemodulator([preambleTx; headerTx],1);
            % parse packet frame
            [preambleRx, headerRx] = parseFrame(frameRx');
            checked = checkFrame(preamble, header, preambleRx, headerRx, dataRates(rate));

            % demodulate PSDU by methods specified in the preamble/header
            rxBits = demodFcns{rate}(rxSyms, dataRates(rate));

            if checked == true
                % compute number of error bits
                overlapSequenceMsgBin = msgBin(1:end-bitDelay);
                overlapSequenceRxBin = rxBits(bitDelay+1:end);
                % accumulate error and total bits over iterations
                nerror = nerror + sum(overlapSequenceMsgBin ~= overlapSequenceRxBin);
                totalbits = totalbits + (length(rxBits) - bitDelay);
                fprintf('.');
            else
                error('PLCP preamble and header do NOT match!')
            end
        end
        fprintf('\n');
        BERVector(i, rate) = nerror/totalbits;
    end
end
toc;
fprintf('Simulation completed.\n');
```

```
Simulation starting...
Data rate: 1.0 Mbps
SNR: -8.0       ..........
SNR: -7.0       ..........
SNR: -6.0       ..........
SNR: -5.0       ..........
SNR: -4.0       ..........
SNR: -3.0       ..........
SNR: -2.0       ..........
SNR: -1.0       ..........
SNR: 0.0        ..........
SNR: 1.0        ..........
SNR: 2.0        ..........
SNR: 3.0        ..........
SNR: 4.0        ..........
SNR: 5.0        ..........
SNR: 6.0        ..........
SNR: 7.0        ..........
SNR: 8.0        ..........
SNR: 9.0        ..........
SNR: 10.0       ..........
SNR: 11.0       ..........
SNR: 12.0       ..........
SNR: 13.0       ..........
SNR: 14.0       ..........
SNR: 15.0       ..........
SNR: 16.0       ..........
SNR: 17.0       ..........
SNR: 18.0       ..........
SNR: 19.0       ..........
SNR: 20.0       ..........
SNR: 21.0       ..........
SNR: 22.0       ..........
SNR: 23.0       ..........
SNR: 24.0       ..........
SNR: 25.0       ..........
SNR: 26.0       ..........
SNR: 27.0       ..........
SNR: 28.0       ..........
SNR: 29.0       ..........
SNR: 30.0       ..........
Data rate: 2.0 Mbps
```

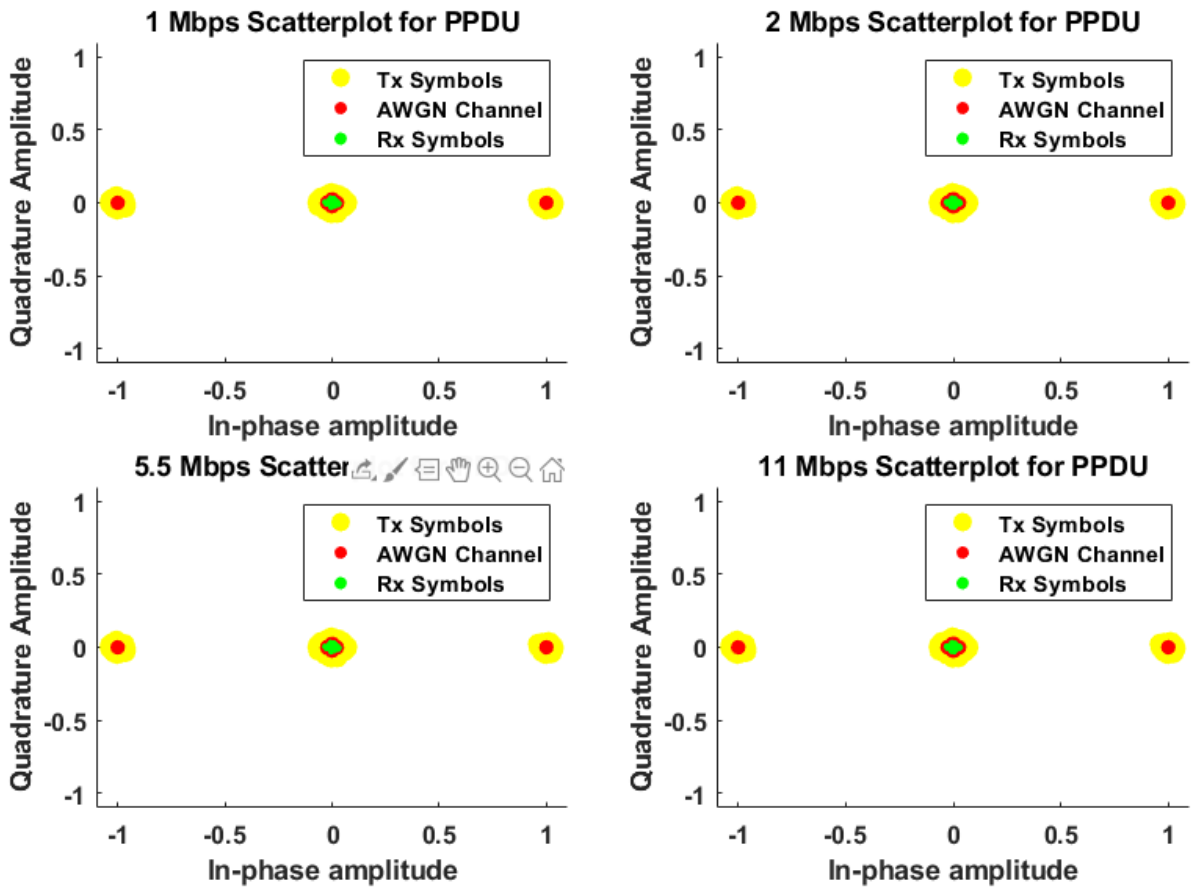
```
SNR: -8.0       ..........
SNR: -7.0       ..........
SNR: -6.0       ..........
SNR: -5.0       ..........
SNR: -4.0       ..........
SNR: -3.0       ..........
SNR: -2.0       ..........
SNR: -1.0       ..........
SNR: 0.0        ..........
SNR: 1.0        ..........
SNR: 2.0        ..........
SNR: 3.0        ..........
SNR: 4.0        ..........
SNR: 5.0        ..........
SNR: 6.0        ..........
SNR: 7.0        ..........
SNR: 8.0        ..........
SNR: 9.0        ..........
SNR: 10.0       ..........
SNR: 11.0       ..........
SNR: 12.0       ..........
SNR: 13.0       ..........
SNR: 14.0       ..........
SNR: 15.0       ..........
SNR: 16.0       ..........
SNR: 17.0       ..........
SNR: 18.0       ..........
SNR: 19.0       ..........
SNR: 20.0       ..........
SNR: 21.0       ..........
SNR: 22.0       ..........
SNR: 23.0       ..........
SNR: 24.0       ..........
SNR: 25.0       ..........
SNR: 26.0       ..........
SNR: 27.0       ..........
SNR: 28.0       ..........
SNR: 29.0       ..........
SNR: 30.0       ..........
Data rate: 5.5 Mbps
SNR: -8.0       ..........
SNR: -7.0       ..........
SNR: -6.0       ..........
SNR: -5.0       ..........
SNR: -4.0       ..........
SNR: -3.0       ..........
SNR: -2.0       ..........
SNR: -1.0       ..........
SNR: 0.0        ..........
SNR: 1.0        ..........
SNR: 2.0        ..........
SNR: 3.0        ..........
SNR: 4.0        ..........
SNR: 5.0        ..........
SNR: 6.0        ..........
SNR: 7.0        ..........
SNR: 8.0        ..........
SNR: 9.0        ..........
SNR: 10.0       ..........
SNR: 11.0       ..........
SNR: 12.0       ..........
SNR: 13.0       ..........
SNR: 14.0       ..........
SNR: 15.0       ..........
SNR: 16.0       ..........
SNR: 17.0       ..........
SNR: 18.0       ..........
SNR: 19.0       ..........
SNR: 20.0       ..........
SNR: 21.0       ..........
SNR: 22.0       ..........
SNR: 23.0       ..........
SNR: 24.0       ..........
SNR: 25.0       ..........
SNR: 26.0       ..........
SNR: 27.0       ..........
SNR: 28.0       ..........
SNR: 29.0       ..........
SNR: 30.0       ..........
Data rate: 11.0 Mbps
SNR: -8.0       ..........
SNR: -7.0       ..........
SNR: -6.0       ..........
```

```
SNR: -5.0       ..........
SNR: -4.0       ..........
SNR: -3.0       ..........
SNR: -2.0       ..........
SNR: -1.0       ..........
SNR: 0.0        ..........
SNR: 1.0        ..........
SNR: 2.0        ..........
SNR: 3.0        ..........
SNR: 4.0        ..........
SNR: 5.0        ..........
SNR: 6.0        ..........
SNR: 7.0        ..........
SNR: 8.0        ..........
SNR: 9.0        ..........
SNR: 10.0       ..........
SNR: 11.0       ..........
SNR: 12.0       ..........
SNR: 13.0       ..........
SNR: 14.0       ..........
SNR: 15.0       ..........
SNR: 16.0       ..........
SNR: 17.0       ..........
SNR: 18.0       ..........
SNR: 19.0       ..........
SNR: 20.0       ..........
SNR: 21.0       ..........
SNR: 22.0       ..........
SNR: 23.0       ..........
SNR: 24.0       ..........
SNR: 25.0       ..........
SNR: 26.0       ..........
SNR: 27.0       ..........
SNR: 28.0       ..........
SNR: 29.0       ..........
SNR: 30.0       ..........
Elapsed time is 535.811740 seconds.
Simulation completed.
```

Constellation Scatterplot

clean up after seeing first zero, and scatterplot In-phase vs Quadrature

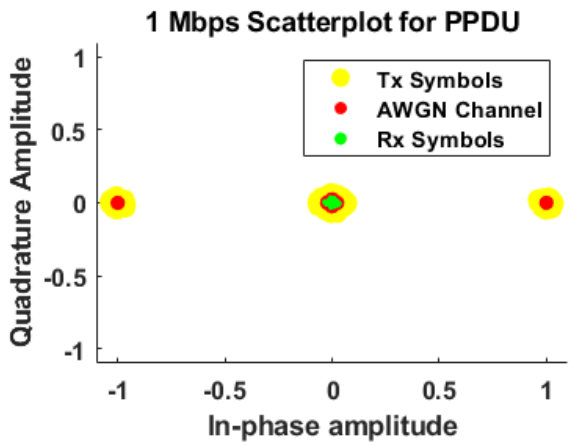
```
figure('Position',[300 300 900 600]); % for scatter plots
for i = 1:size(BERVector,2)
    idxZero = find(BERVector(:,i)==0);
    BERVector(idxZero:end,i) = 0;

    fig = subplot(strcat('22',num2str(i)));
    plotScatter(fig, txFrame, txNoisy, rxSyms, dataRates(i));
end
```

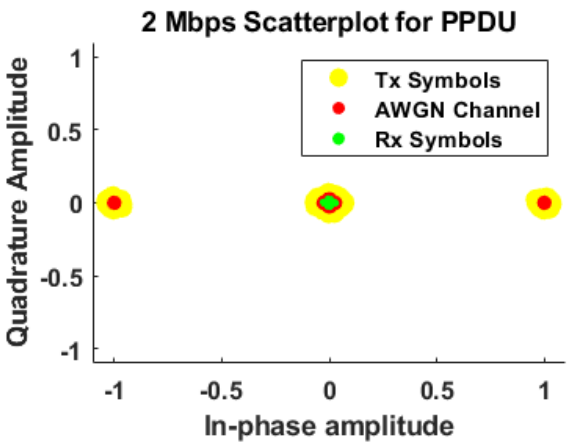


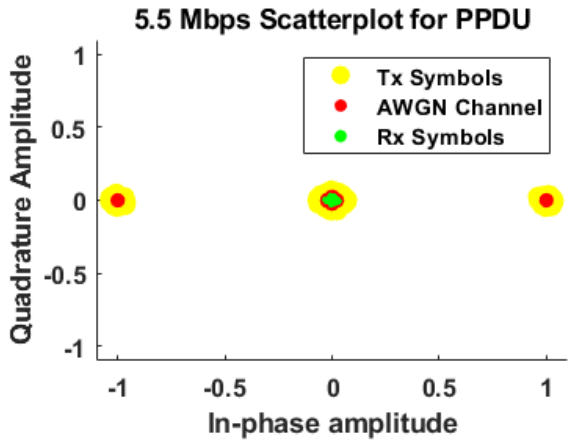
BER curve for each data rate

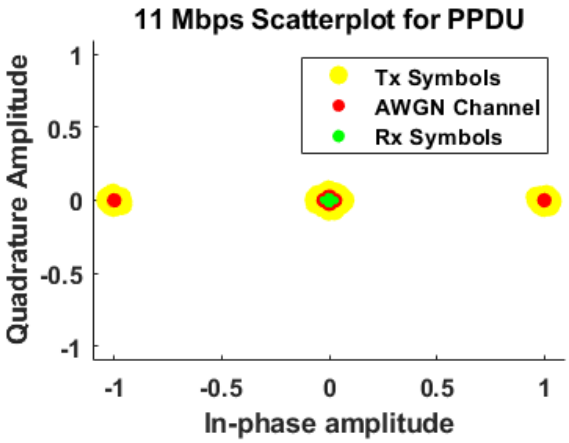
plot BER curve for each data rate separately

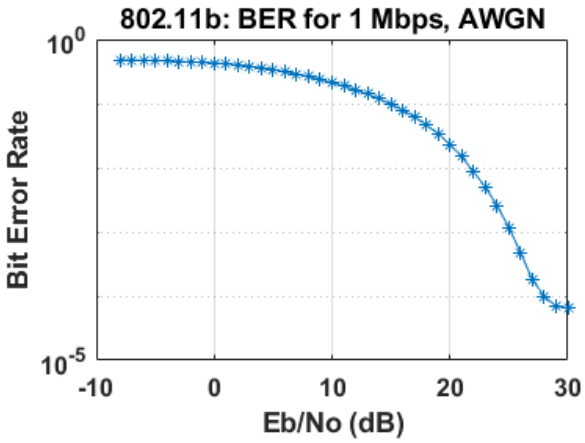
```
figure('Position',[300 300 900 600]);
for rate=1:4
    subplot(2,2,rate);semilogy(snrVector,smoothdata(BERVector(:,rate)),'*-');grid on;
    title_str = {['802.11b: BER for ' num2str(dataRates(rate))...
                  ' Mbps, AWGN']};
    title(title_str); xlabel('Eb/No (dB)'); ylabel('Bit Error Rate');
    set(gca, 'FontSize', 12, 'FontWeight','bold');
end
```

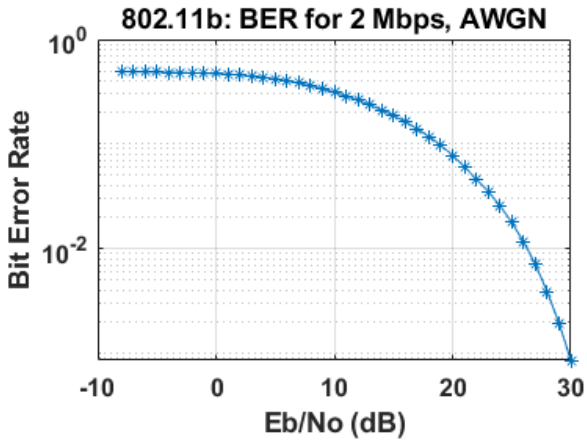


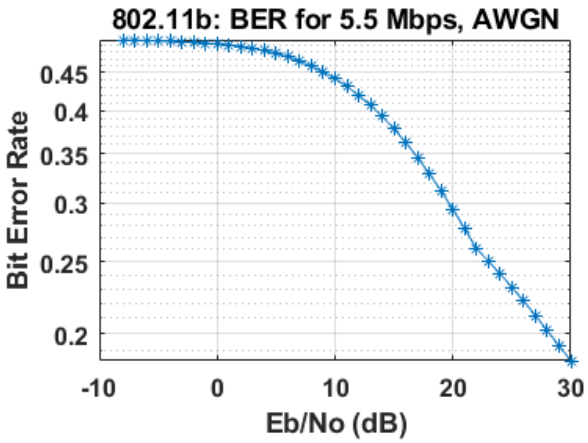


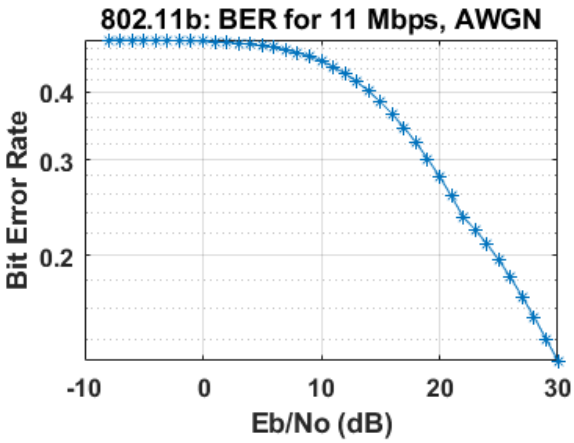










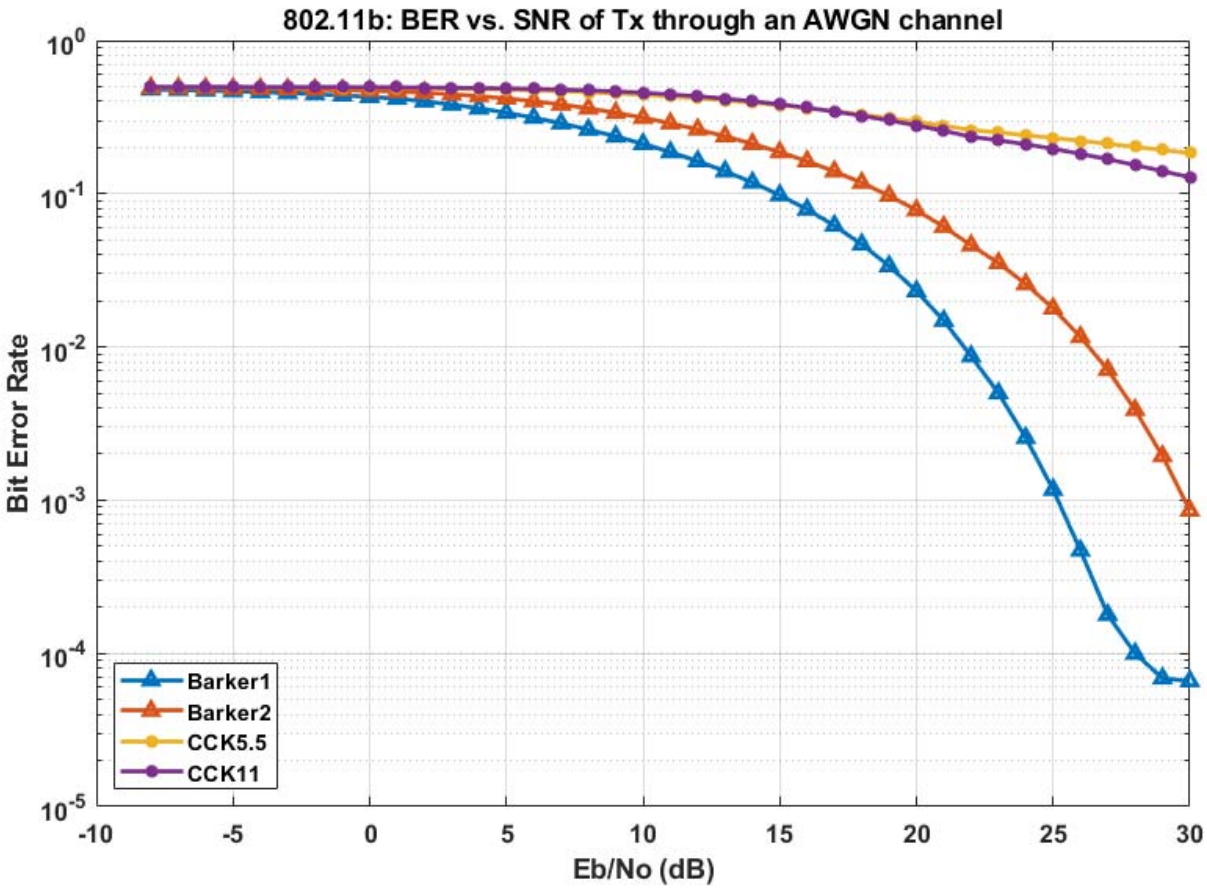


BER curve for all data rates

plot BER curve for all data rates

```
figure('Position',[300 300 900 600]);
```

```
shapes = ["^-","^-","*-","*-"];
for rate=1:4
    semilogy(snrVector, smoothdata(BERVector(:,rate)'),shapes(rate), ...
             'LineWidth', 2); grid on; hold on;
end
hold off;
title('802.11b: BER vs. SNR of Tx through an AWGN channel');
legend('Barker1','Barker2','CCK5.5','CCK11','Location','SouthWest');
xlabel('Eb/No (dB)'); ylabel('Bit Error Rate');
set(gca, 'FontSize', 12, 'FontWeight','bold');
```



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