

802.11ax Preamble Design and Auto-detection

Date: 2015-05-10

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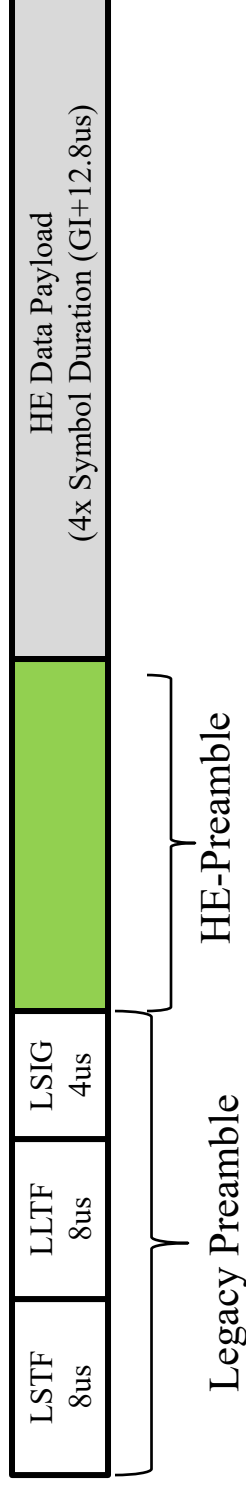
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Introduction

- **Background**
 - Based 802.11ax SFD [1]:
 - An HE PPDU shall include the legacy preamble (L-STF, L-LTF and L-SIG), duplicated on each 20 MHz, for backward compatibility with legacy devices.
 - HE-SIG-A and HE-SIG-B fields are included



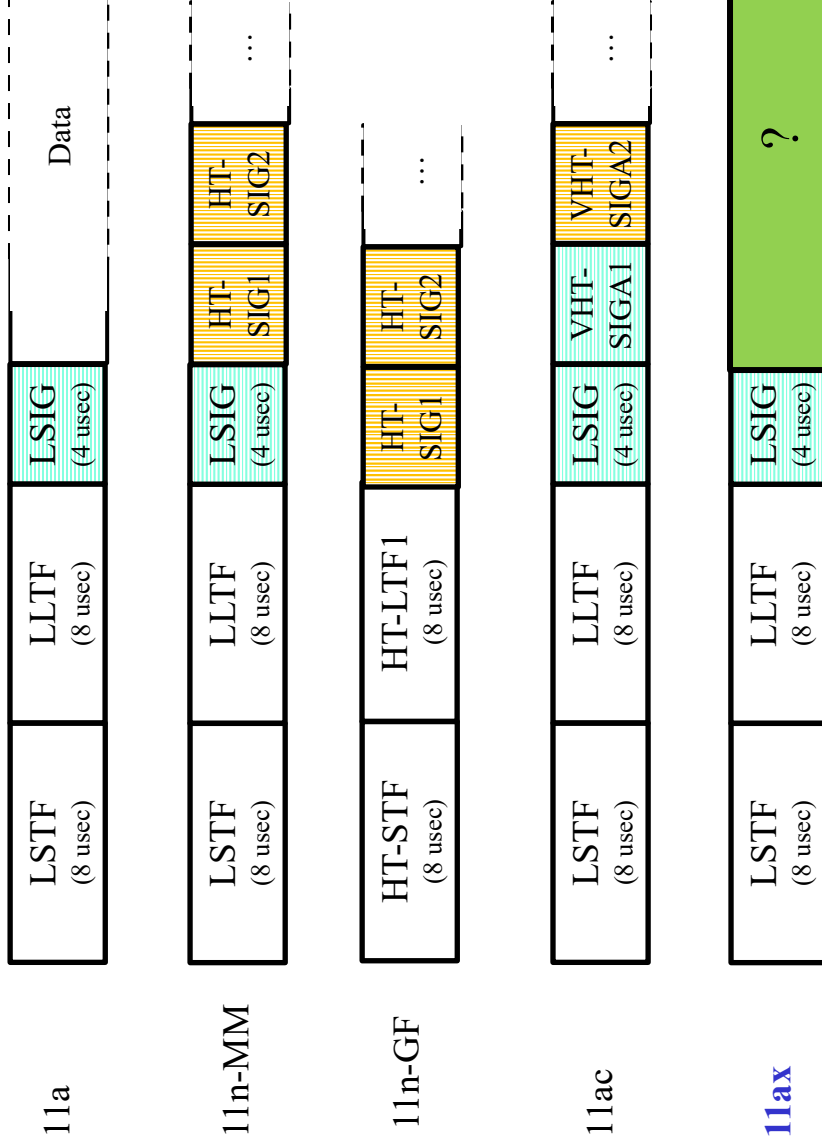
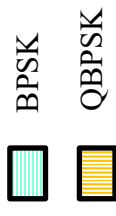
- **Highlights of this contribution**
 - Focus on the 11ax packet autodetection design;
 - Propose an LSIG repetition based 11ax packet autodetection scheme.

Desired Attributes of 11ax Preamble Design for 11ax Packet Autodetection

- Robust autodetection:
 - Backward compatible, allowing legacy spoofing
 - High reliability in
 - Dense deployments with high interference
 - All 11ax channels of interests, including outdoor UMI channels.
 - Very low false triggers
- Early autodetection:
 - Differentiate from 11a/n/ac packets as early as possible, to reduce the number of different hypotheses at the receiver.
- Simple and unified design

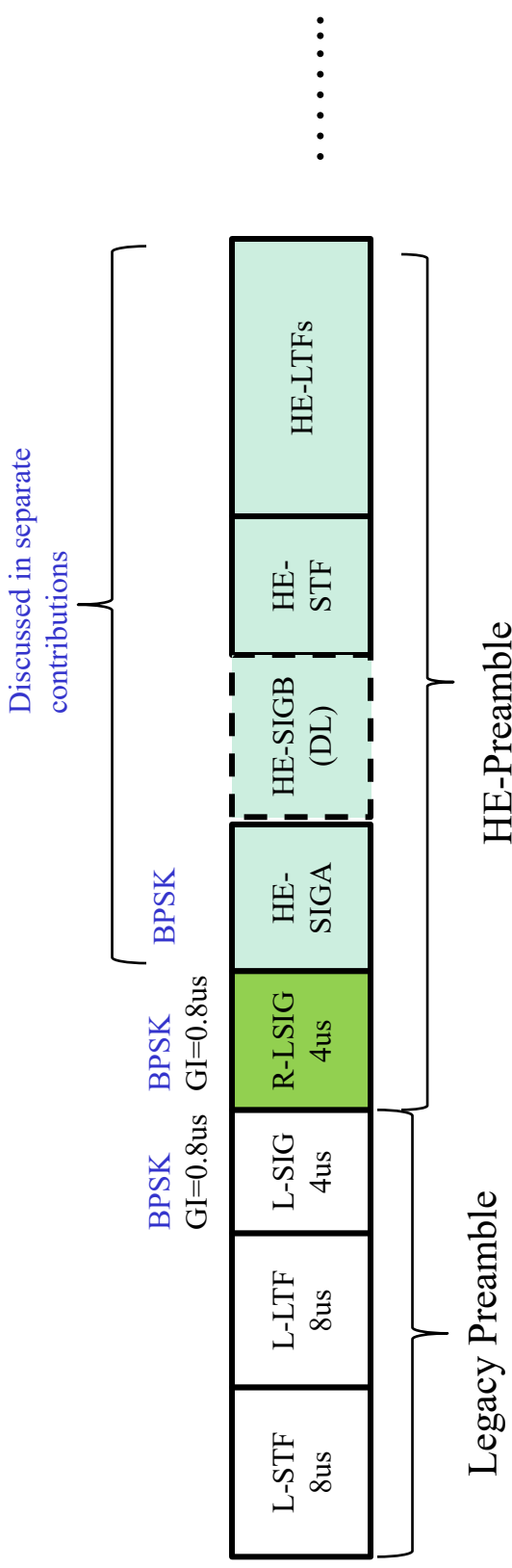
Existing 802.11 OFDM Packet Classifications

Auto-detection based on QBPSK Detection



Proposed 11ax Packet Format

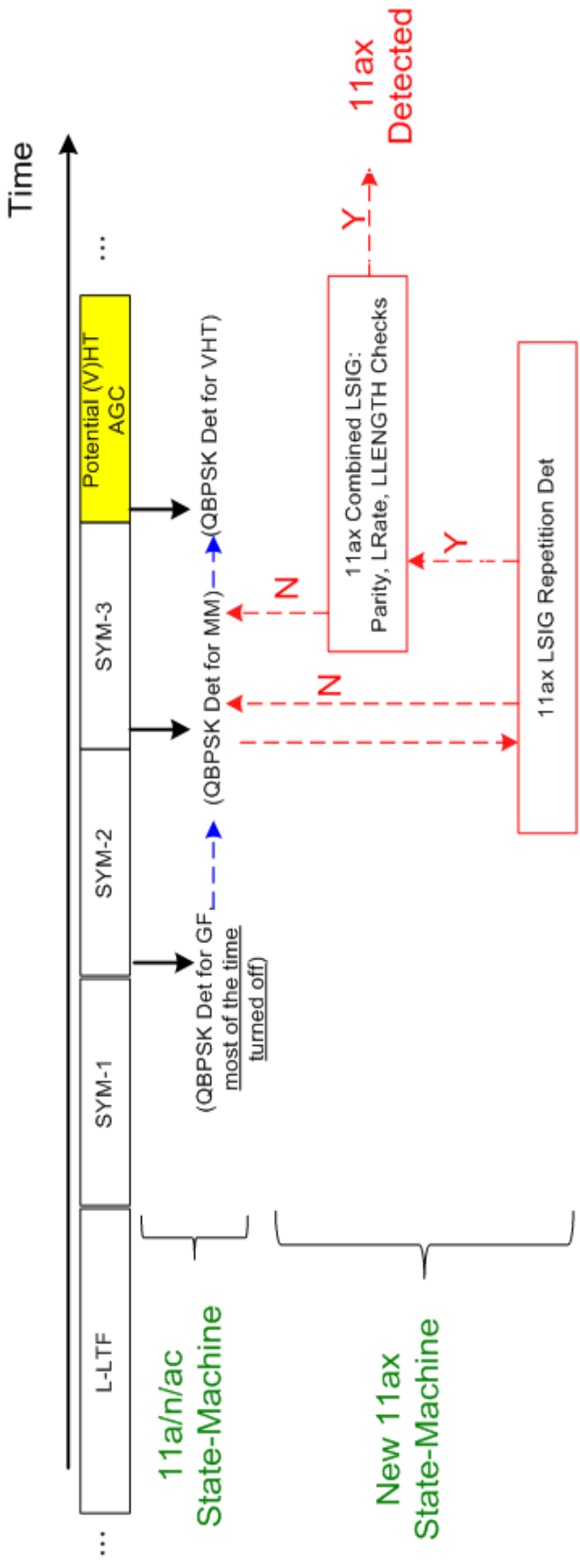
- Use L-SIG repetition for 11ax packet autodetection, i.e.,
 - Having a 4us symbol repeating the L-SIG content, in the 11ax preamble right after the legacy section
 - Modulating the R-LSIG (LSIG repetition) symbol with BPSK and rate $\frac{1}{2}$ BCC.
 - The next symbol (HE-SIGA) after RLSIG is also BPSK, legacy devices will detect the packet as 11a/g.



Example of Detection Procedure at Rx

- **Step-1:** LSIG and RLSIG repetition detection.
- **Step-2:** LSIG and RLSIG MRC, and demodulate/decode.
- **Step-3:** Content Check: e.g. Parity bit, Rate=6Mbps and L-LENGTH!=3x.
- When both steps 1 and 3 passes, 11ax is detected, otherwise jump back to 11a/n/ac state machine.
- Note that steps 2 and 3 are required as part of the packet decoding anyways (similar to 11ac)!

Illustration of the achieved Early 11ax Detection



- Early 11ax detection
 - LSIG Rep detection + LSIG Content check finishes approx at 3us after end of R-LSIG
 - Before the potential (V)HT-STF field in 11n/ac
 - No need to revise the old 11a/n/ac detection state-machine.
- In the case of repetition false trigger, receiver may still fall back to conventional 11n/ac state-machine on time (for AGC).

Other Benefits

- Reliable detection performance: miss detection is lower than the error rate of combined LSIG+RLSIG field, and with very low false detection probability.
 - Refer to the simulation results in subsequent slides.
- Improve LSIG field error rate: therefore beneficial for the following cases
 - Outdoor (UMI channel).
 - High density low SINR.
 - Reduce the chance of collision (more reliable CCA determination), therefore reducing the extra overhead caused by re-transmissions.
 - Reducing LSIG false positive probability at 11ax receivers.
 - Enabling possible range extension.

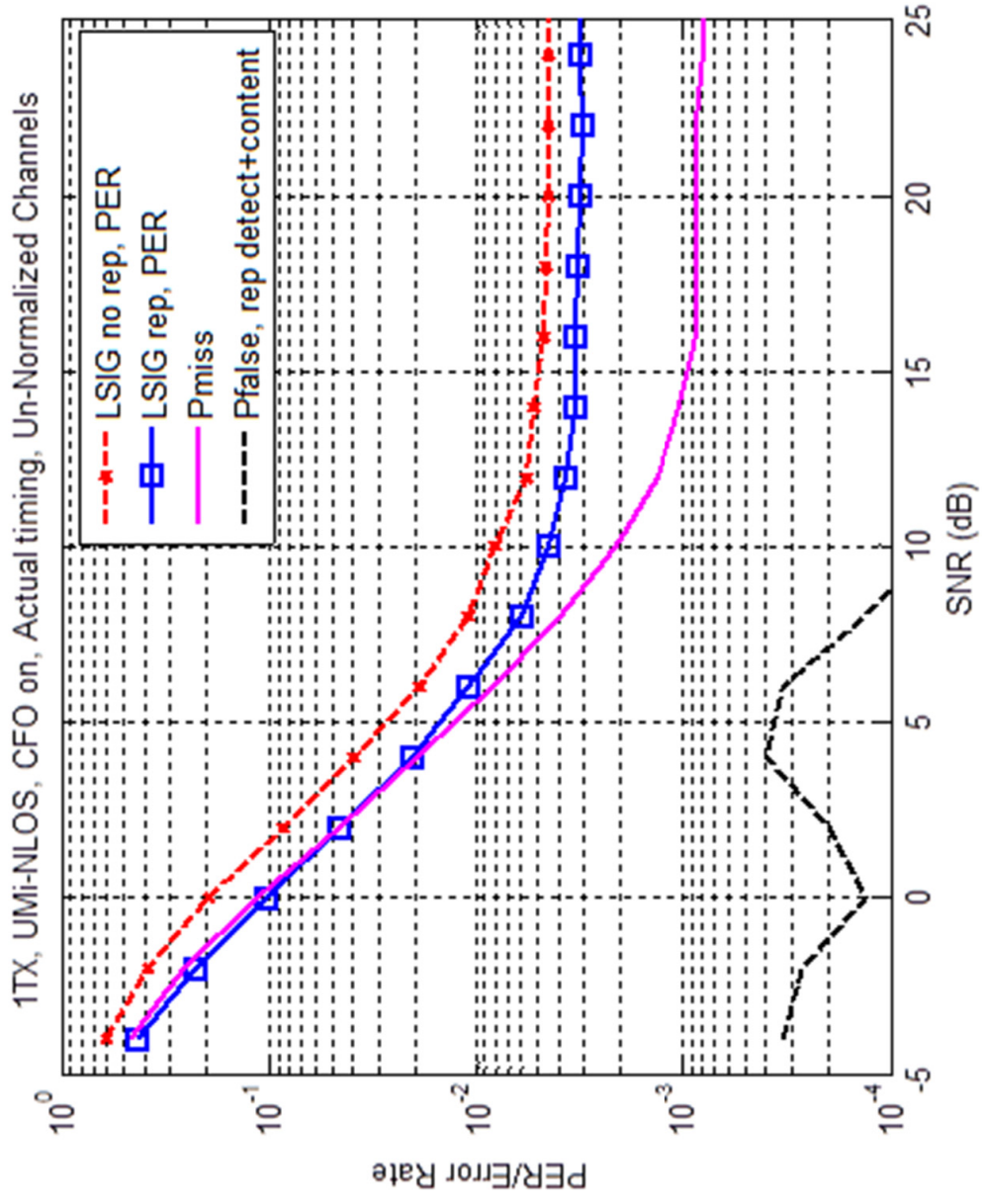
On Detection Algorithm

- It is recommended to conduct the repetition detection in frequency domain (post FFT).
 - For better performance.
- There are multiple ways of frequency domain repetition detection, some of which are simple and get reliable miss and false detection performances.
 - Refer to simulation results.
- The LSIG content check (after combining) happens right after the repetition check, therefore serves as an additional checksum.

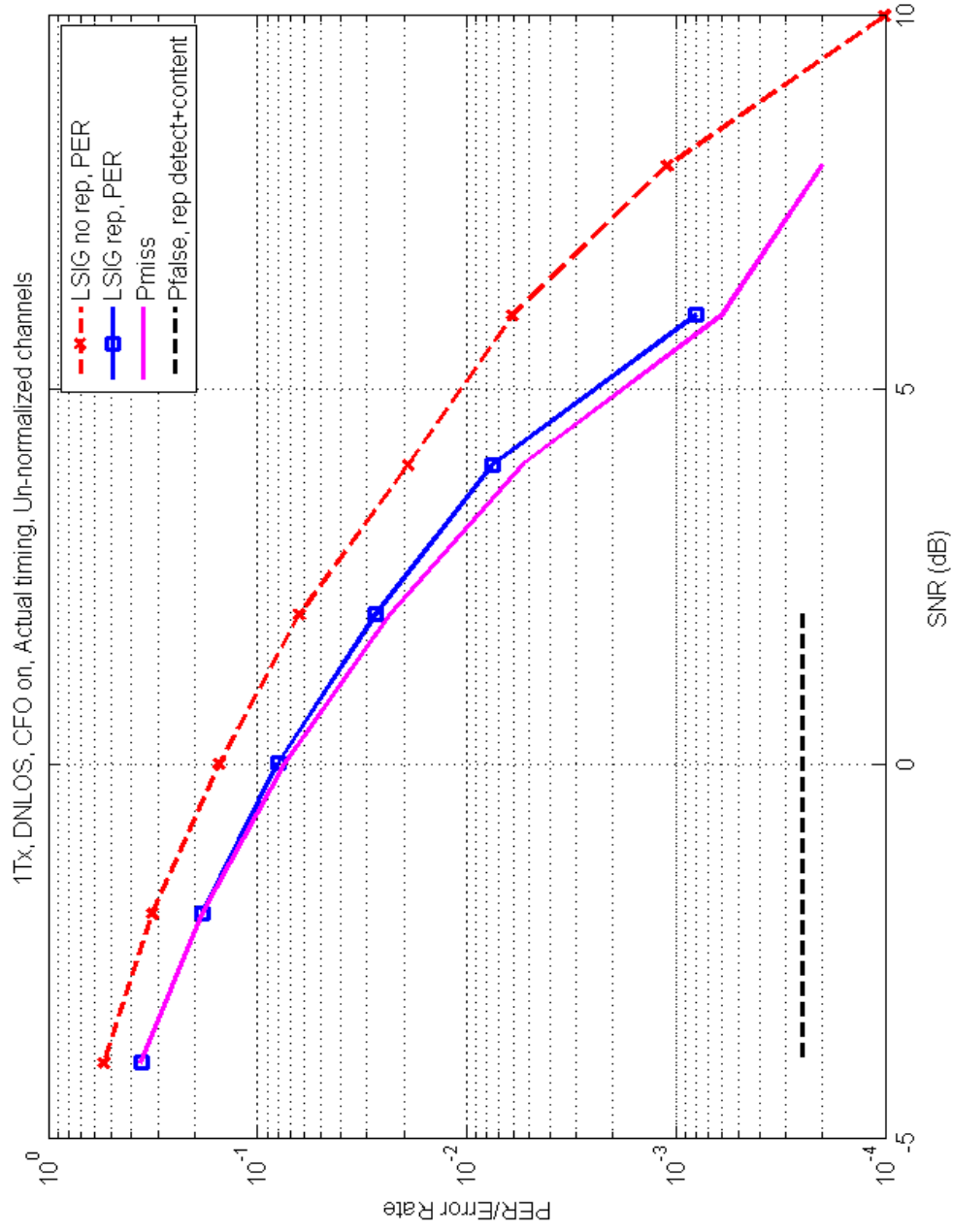
Simulation Setup

- 20 MHz.
- 1/2/4Tx, and 1Rx antennas
- UMi-NLOS, and DNLOS channels
 - Ensemble normalized
- CSD values per Antenna (2/4Tx)
 - [0, -50, -100, -150]ns as 1lac
 - Or [0, -50, -100, -150]*2 ns
- Actual 40ppm CFO and phase/CFO tracking
- Actual timing.

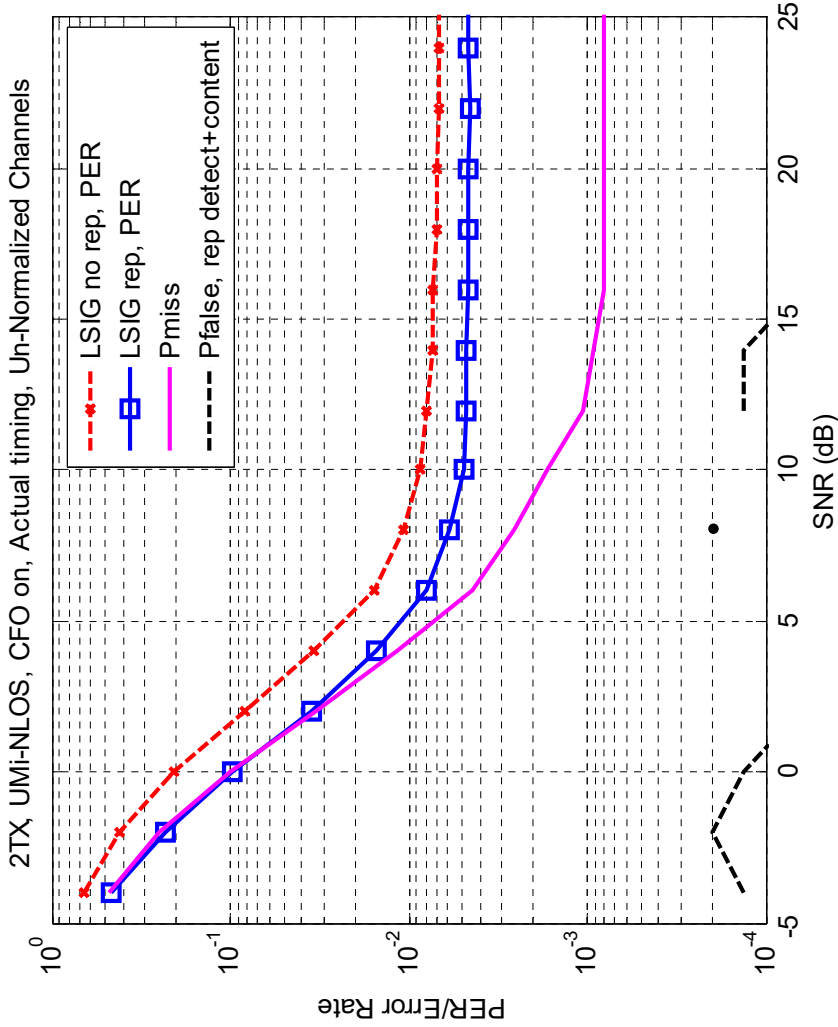
1x1, UMI



1x1 DNLOS

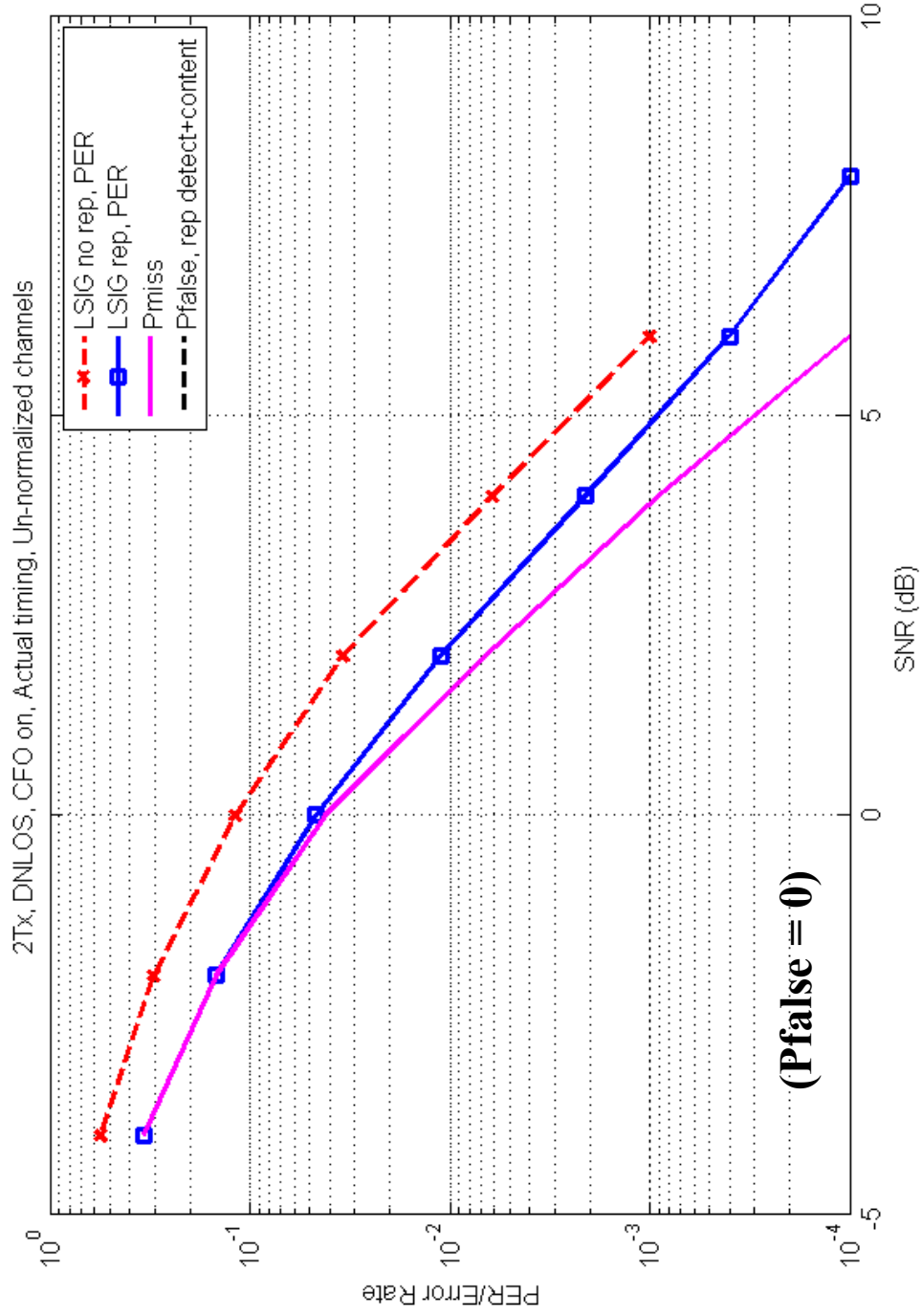


2x1, UMI

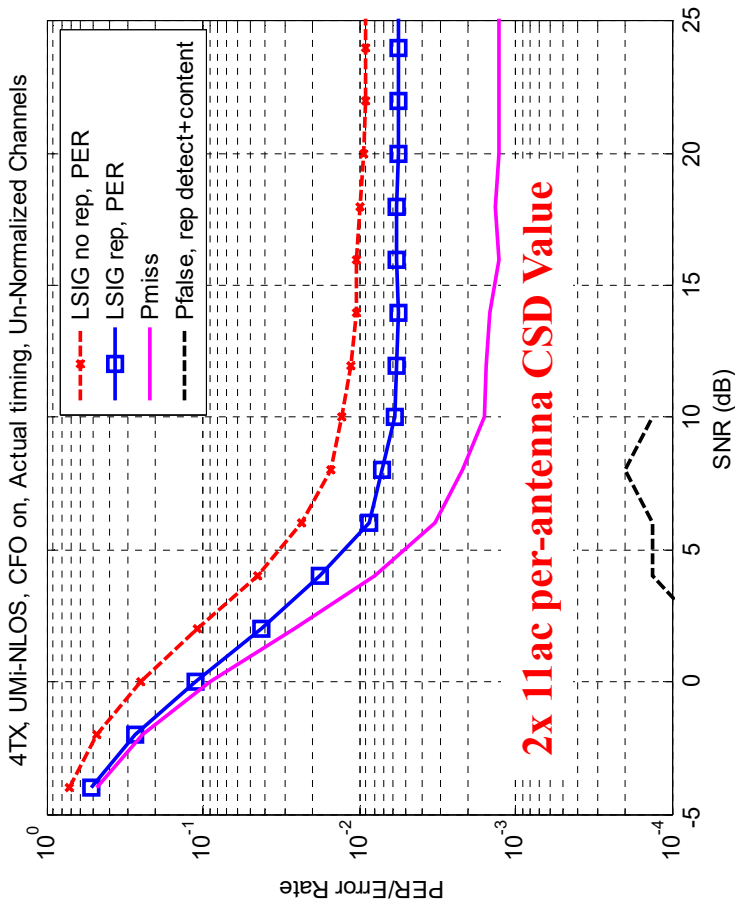
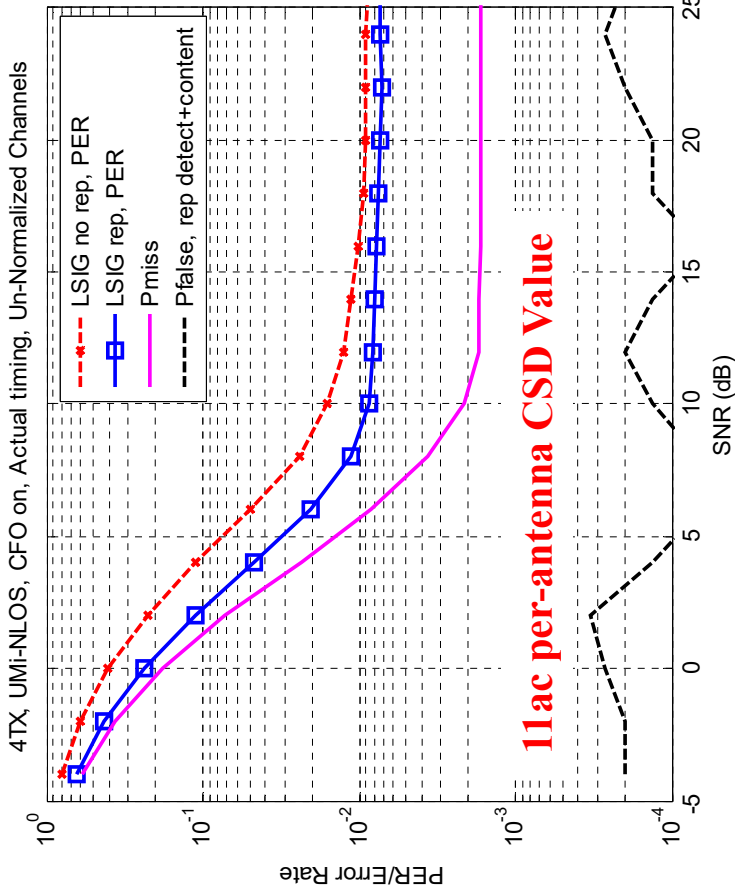


- No false trigger happens for 2Tx + 1lac per-antenna CSD.
- 1lac per-ant CSD values works fine for 2Tx.

2x1 DNLOS



4x1 UMI



- 2x CSD values improves detection and decoding performances.
- Miss and False triggering probability are still very low for both CSD values.

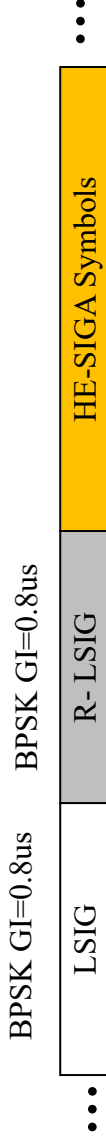
Conclusions

- We propose to repeat LSIG field and use it as the 11ax autodetection mechanism.
- By simulations, this method shows reliable miss detection and false detection performances in both indoor and outdoor channels.
- It realizes early 11ax detection, enabling simple and clean receiver design state-machine.
- It improves the LSIG performance for outdoor and highly dense deployments.

Straw Poll #1

Do you support having a 4us symbol repeating the L-SIG content, in the 11ax preamble right after the legacy section?

- This symbol shall be modulated by BPSK and rate $\frac{1}{2}$ BCC.



Straw Poll #2

- Do you agree that in an HE PPDU, both the first and second OFDM symbols immediately following the L-SIG shall use BPSK modulation.
 - NOTE–This is to spoof all legacy (11a/n/ac) devices to treat an HE PPDU as a non-HT PPDU.

References

- [1] 11-15-0132-02-00ax-spec-framework