IEEE P802.11
Wireless LANs

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| Draft text to define non-uniform constellation (CID 517) |
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Abstract

This document proposes draft text to define non-uniform constellation (NUC) in Section 30.5.7.4 (CID 517).

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| CID | Clause | Comment | Proposed Change |
| 517 | 30.1.1 | NUC not defined | Comment resolution will be provided. |

**Discussion**

*Background*

* It has been agreed that 11ay includes support for a non-uniform constellation (NUC)
	+ Section 4.3.25 [1] “EDMG STA has optional support of a 64-point non-uniform constellation”
	+ Section 9.4.2.250.1 and 30.3.3.3 [1] include signalling and capability information for NUC.
* However, signal points of NUC are undefined but we have seen various submission in the past e.g. [2,3]
* NUC design depends on
	+ Code rates
	+ Impairments considered during design process
* From an implementation point of view however, it is desired to define a single constellation which fits best to all code rates and impairments (which are partly implementation specific)

*Findings*

* NUC is code rate dependent
	+ A single NUC for all code rates comes with a performance trade-off
		- It is desired to design a single NUC for high code rates as high code rates have strong sensitivity requirements
		- NUC alleviates those strong sensitivity requirements and simplifies frontend implementation especially for code rates 13/16 and 7/8
* NUC design can consider different PHY impairments
	+ AWGN
	+ Phase noise (PN)
	+ Power amplifier (PA) non-linearity
* Observations
	+ PN optimization
		- Residual phase noise is implementation specific as different phase noise mitigation algorithms may be applied
		- Phase noise optimization yields higher PAPR and reduced performance with PA non-linearity
	+ PA optimization
		- Characteristic of PAs non-linearity is implementation specific as different PAs and predistortion techniques may be applied
		- Difficult to include in optimization
	+ AWGN
		- AWGN design very roubust against impairments
		- Differences to reasonable PN, PA optimization are minor
* Proposal
	+ NUC maximizing mutual information in AWGN and for high code rates

*Analysis*

* Analysis of the proposed 64-QAM non-uniform constellation in various scenarios
* AWGN, Rayleigh, AWGN and Phase Noise, AWGN and Phase Noise with PA non-linearity
* Simulation parameters in Appendix

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| Figure 1: FER in AWGN | Figure 2: FER in Rayleigh fading channel |
| Figure 3: FER in AWGN and phase noise channel | Figure 4: FER in AWGN and phase noise channel with PA non-linearity |

*Summary*

The 64-QAM non-uniform constellation proposed below is optimized to maximize mutual information in AWGN. This constellation has been compared with a rectangular 64-QAM in terms of frame error rate for code rates 5/8, 3/4, 13/16, and 7/8 in various scenarios. The proposed non-uniform constellation achieves gains

* between 0.2 and 0.3dB in AWGN
* between 0.4 and 0.6dB in Rayleigh fading channel
* between 0.2 and 1.8dB in AWGN and phase noise channel
* between 0.2 and 2.9dB in AWGN and phase noise channel with PA non-linearity

**30.5.7.4 Modulation mapping**

**30.5.7.4.1 General**

The coded and padded bit stream is converted into a stream of complex constellation points, following the rules defined in 20.6.3.2.4 for π/2-BPSK, π/2-QPSK, π/2-16-QAM, and π/2-64-QAM. The π/2-64-NUC non-uniform constellation modulation is defined in 30.5.7.4.5.

**30.5.7.4.2 Dual carrier modulation (DCM) SQPSK**

**(…)**

**30.5.7.4.3 Space-time block coding (STBC)**

**(…)**

**30.5.7.4.4 Block interleaver**

**(…)**

**30.5.7.4.5 π/2-64-NUC modulation**

In π/2-64-NUC non-uniform constellation modulation, the input bit stream is grouped in sets of 6 bits and mapped according to the following equation:



Each output symbol is then rotated according to the following equation. The constellation bit encoding for the 64-NUC is depicted in Figure 97.

NOTE—The 64-NUC is quadrant symmetric and has an average power of one.

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**Figure 97 – 64-NUC bit encoding**

Strawpoll

Do you agree to include the π/2-64-NUC defined in “11-17-1292-00-00ay-Draft-text-to-define-non-uniform-constellation-(CID-517).docx” to the IEEE 802.11ay Draft 0.5?

**References**

[1] 11ay D0.5

[2] 11-16/0072r0 Performance of Non-Uniform Constellations in Presence of Phase Noise

[3] 11-16/0955r0 Non uniform constellation of HOM for SC in 11ay

[4] 11-15/0866r4 11ay evaluation methodology

Appendix

Simulation Parameters are as follows

* LDPC
	+ 11ad code word lengths, code rates 5/8, 3/4, 13/16, 7/8
	+ SC interleaver/ deinterleaver
* Transmitter
	+ SC modulation
	+ Message length 4096 bytes
* Channel model
	+ AWGN
	+ Rayleigh fading channel with Trms=3ns
		- Exponential decay profile
	+ Phase Noise [4]
	+ Power amplifier [4], Tx mask [1]
* Receiver
	+ Perfect channel knowledge
	+ Regular approx. LLR demapper
	+ FD equalization
* Sensitivity analysis
	+ Reference: Regular uniform 64-QAM [1] with Gray labeling