IEEE P802.11  
Wireless LANs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Proposed IEEE 802.11 AIML TIG Technical Report Text for the Subcarrier Grouping Use Case | | | | |
| Date: 2023-02-09 | | | | |
| Author(s): | | | | |
| Name | Affiliation | Address | Phone | Email |
| Eunsung Jeon | Samsung | 1-1, Samsungjeonja-ro, Hwaseong-si, Gyeonggi-do 18448 Korea | +82-10-2317-5808 | eunsung.jeon@samsung.com |
| Myeongjin Kim | +82-10-9120-7244 | mj1108.kim@samsung.com |
| Chulho Chung | +82-10-7294-0729 | ch29.chung@samsung.com |

Abstract

This document contains the proposed technical report text of the IEEE 802.11 AIML TIG, especially for the subcarrier grouping use case.

Revision history:

r0: initial version

# Table of Contents

1. **Introduction**
   1. Terminologies
   2. Background information
2. **AIML Use cases for IEEE 802.11**

Note: use cases potentially can be organized into different categories

Note: use cases potentially can identify KPIs

## Use case 3: Subcarrier grouping

### Use case description

A signal can be transmitted based on a beamforming method in a wireless local area network (WLAN) system such as 802.11n/ac/ax/be [1] [2]. A beamforming is a technique of multiple antennas for steering a beam of an antenna array only to a corresponding STA. The channel state information (CSI) feedback should be preceded for a beamforming transmission. The beamformee feeds back CSI in the angular form of the compressed beamforming feedback matrices associated with a group of subcarriers based on the grouping size (*Ng*). Since only a single compressed beamforming feedback matrix is reported for each group of *Ng* adjacent subcarriers, the overhead for CSI feedback can be reduced by using a large *Ng* value. However, the CSI becomes inaccurate which results in degradation of the PER performance.

The beamformee can reduce the CSI feedback overhead with minimum loss of the PER performance by selecting *Ng* based on the variation on a frequency of the channel in real-time. AIML technique can efficiently provide a beamformee capable of performing *Ng* selection by classifying the channel based on the measurement of the variation on a frequency [3]. For the classification, various machine learning techniques may be available, including Decision Tree, Random Forest, K-Nearest Neighbor (KNN), Support Vector Machine (SVM), Neural Networks, and so on [4]. The advantage of AIML is to classify the channel by using the multi-dimensional channel measurements (e.g., a variance of the frequency of the channel and a mean of the delay spread) and to achieve accurate classification result than the threshold-based method using a single channel measurement (e.g., a variance of the frequency of the channel or a mean of the delay spread) [5] [6].

Simulation results for a 4x2 SU-MIMO show that AIML achieves close to perfect classification performance for all SNR range. When *Ng* value is appropriately selected based on the classification result, the CSI feedback overhead is reduced significantly with negligible loss of PER performance.

This use case proposes to apply AIML technique to subcarrier groping to reduce the CSI feedback overhead with minimum loss of PER performance.

### KPIs

KPIs considered in this use case are proposed as follows:

1. Number of feedback bits
2. Achieved PER
3. Throughput
4. Computation complexity/Latency:
   1. Additional delay or computation is introduced by AIML processing.

Evaluation methodology needs to be established.

### Requirements

1. Backward compatibility with legacy 802.11
   1. Support backward compatibility and coexistence with legacy 802.11 CSI report schemes
2. Performance should follow the guidance below:
   1. **CSI airtime reduction**: achieve airtime reduction of CSI feedback over 802.11be for a given *Nr* x *Nc* MIMO, where *Nr* is the number of rows in the compressed beamforming feedback matrix, *Nc* is the number of columns in the compressed beamforming feedback matrix.
   2. **Packet Error rate (PER)**: guarantee minimum SNR loss compared with 802.11be to achieve the target PER (e.g., 1% and/or 10%) at a given MCS in all types of channels [7].
   3. **Computation complexity/Latency**: minimize the additional computation complexity or latency required by AIML process

### Technical Feasibility Analysis

### Standard Impart

The standard impact may include:

* Additional granularity of *Ng* value (e.g., *Ng* = *Nst* where *Nst* is the total number of subcarriers in a non-punctured non-OFDMA PPDU) required if an additional channel class (e.g., frequency flat channel) is identified by AIML process.

### Technical feasibility

The following metrics will be studied:

1. **Backward compatibility**: The STAs that supports AIML enabled subcarrier grouping shall support the legacy 802.11 subcarrier grouping. This compatibility is expected to be supported since AIML capable STAs are expected to support legacy subcarrier grouping.
2. **Hardware/software capability**: The STAs that use AIML to generate the AIML enabled subcarrier grouping shall have the hardware and software capability to support AIML algorithm(s).
   1. Use case 2
   2. Use case N
3. **Summary**
4. **References**
5. IEEE 802.11-REVme D2.0, October 2022
6. IEEE P802.11be D2.2, October 2022
7. 802.11-23/0032r3, ML-based Adaptive Subcarrier Grouping for Beamforming Feedback
8. S. Szott, K. Kosek-Szott, P. Gawłoicz, J. T. Gómez, B. Bellalta, A. Zubow, F. Dressler, “WiFi Meets ML: A Survey on Improving IEEE 802.11 Performance with Machine Learning,” IEEE Communication Surveys & Tutorials, Vol.24, Issue 3, June 2022
9. E. Kurniawan, L. Zhiwei, and S. Sun, “Machine Learning-based Channel Classification and Its Application to IEEE 802.11ad Communications,” in Proceedings of IEEE GLOBECOM, December 2017.
10. H. Arslan and T. Yücek, “Delay Spread Estimation for Wireless Communication Systems”, in Proceedings of IEEE ISCC, July 2003.
11. 802.11-19/0719r1, IEEE 802.11be Channel Model Document