단말별 전송 이력 기반 IEEE 802.11ax UORA 적응형 접속 제어

Adaptive Access Control for IEEE 802.11ax UORA Based on Per-Station Transmission History

github

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Abstract

In the IEEE 802.11ax uplink OFDMA random access (UORA) environment, multiple stations competitively access a limited number of random access resource units (RA-RUs). The standard binary exponential backoff (BEB)-based contention window (OCW) update mechanism is insensitive to rapid changes in network congestion, making it difficult to simultaneously suppress collisions and efficiently utilize channel resources. This work proposes an adaptive access control scheme in which each station estimates collision and access-hold probabilities solely from its own transmission history and updates the access threshold α and OCW based on sigmoid-normalized sensitivity. The proposed scheme preserves the standard UORA procedure (e.g., OBO decrement and random RU selection) and does not rely on any global network statistics. Simulation results show that the proposed method improves throughput by an average of approximately 15.1% compared to the standard UORA, and achieves maximum performance gains of about 50.0% and 56.8% under (OCWmin, OCWmax) = (31, 511) and (63, 1023), respectively.

Motivation

The standard BEB-based UORA is insensitive to rapid changes in network congestion, which may lead to throughput degradation caused by increased collisions or idle RA-RUs. Moreover, since each station cannot observe global network information, access control based solely on local transmission history is required.

Core Idea

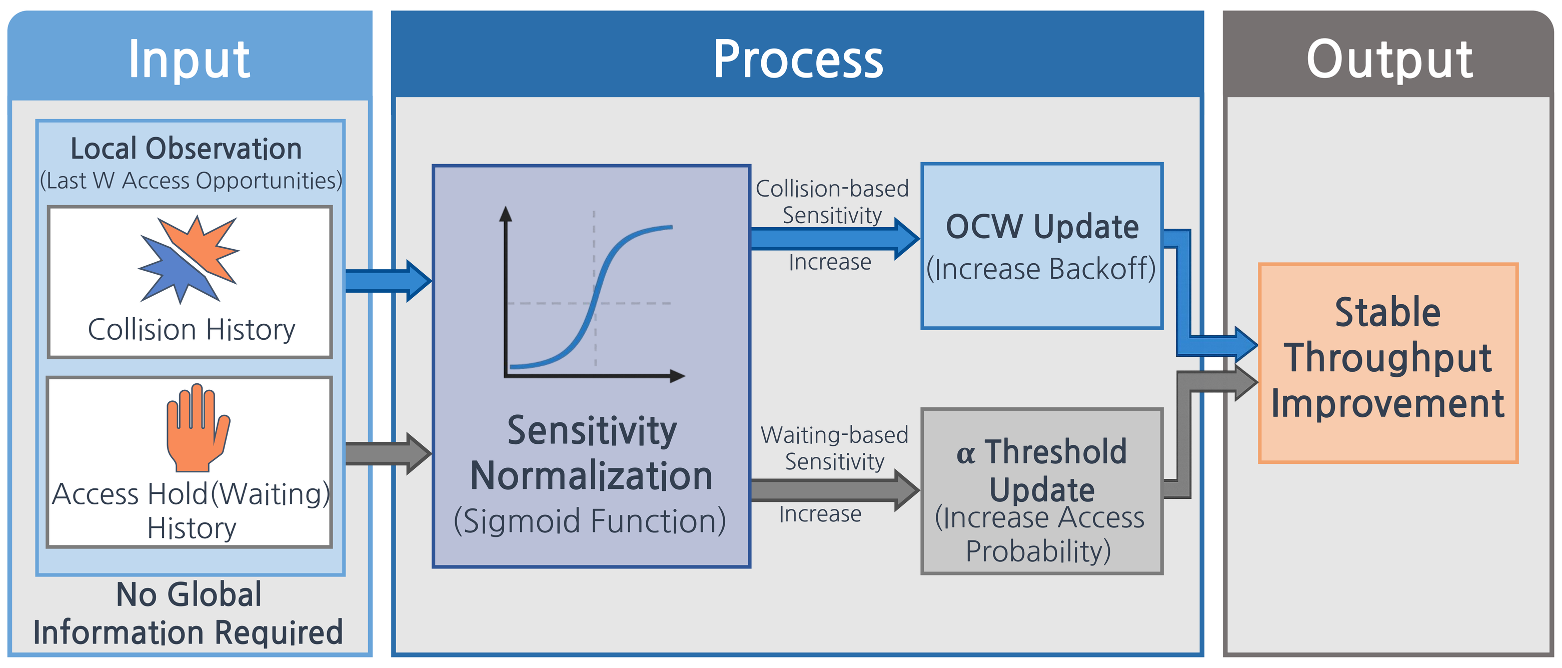

Fig. 1. Architecture of the proposed adaptive access control based on per-station transmission history.

Each device estimates collision and waiting probabilities from recent access history and updates OCW and α via sigmoid normalization.

Algorithm Overview

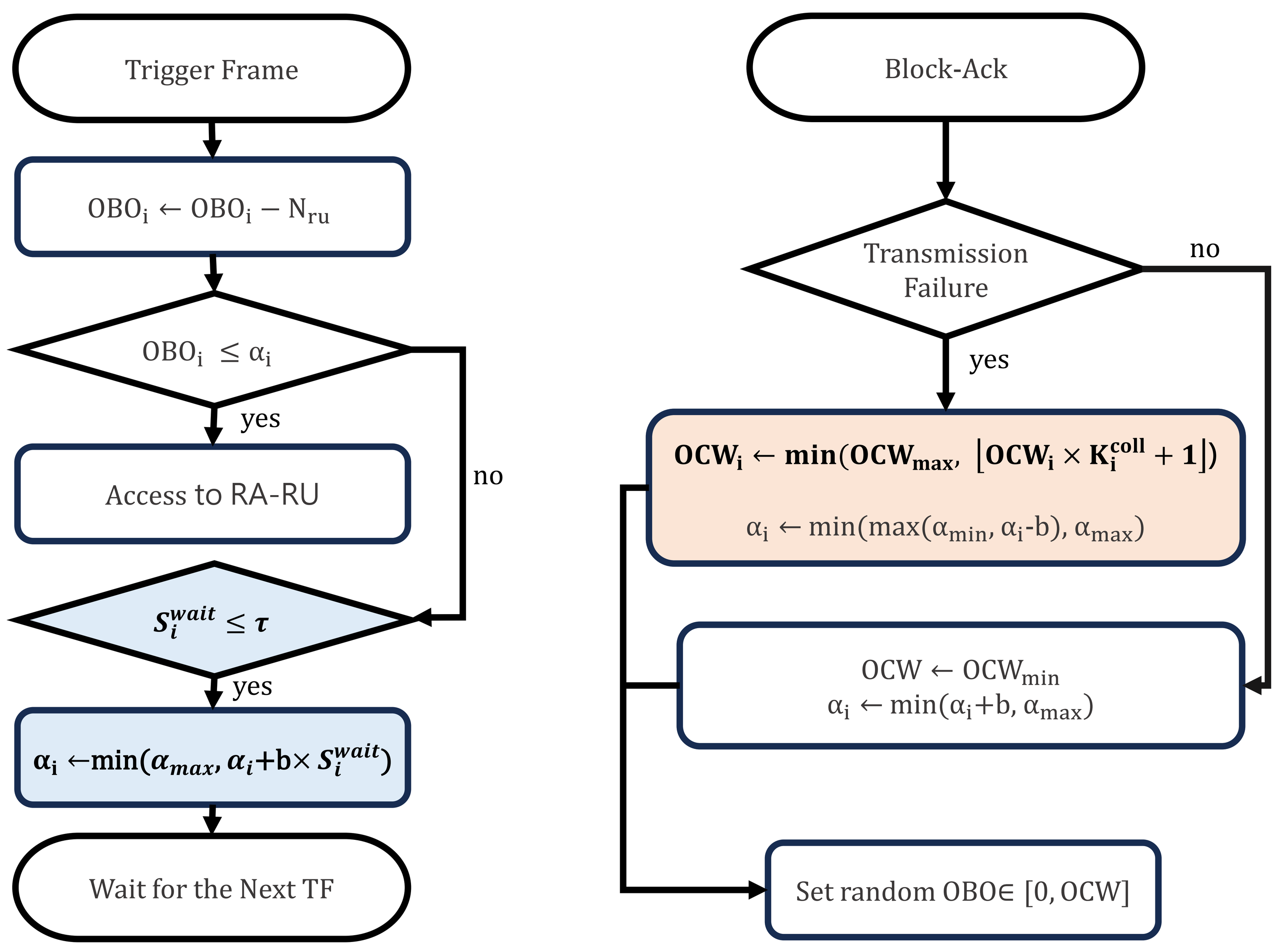

Fig. 2. Flowchart of the proposed adaptive access control for IEEE 802.11ax UORA.

The proposed method adaptively updates OCW and α using local-history-based probability estimation and sigmoid normalization.

Collision-Probability-Aware OCW Control

Each device estimates the collision rate from recent access history and normalizes it using a sigmoid function.

A higher collision rate increases OCW to mitigate contention, while a lower rate avoids unnecessary window expansion.

Upon success, OCW is reset to the initial value as in standard UORA.

Waiting-Probability-Aware Access Threshold α Control

Our method extends the α-based access control in [3] by adding a selective increase rule for low-load conditions.

α controls the aggressiveness of channel access.

Unlike the conventional scheme that simply increases or decreases α after success or collision,
we raise α only when the waiting probability indicates low load.

This reduces idle RA-RUs while preventing congestion.

Results

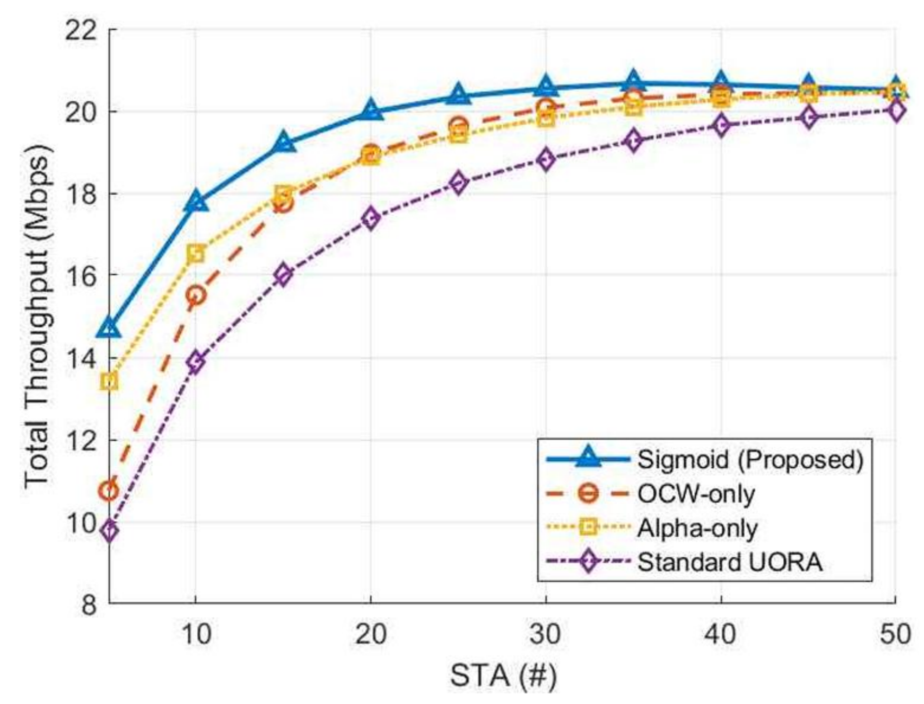

Fig. 3. Throughput comparison (Alpha-only, OCW-only, Proposed, Standard UORA).

Combining α and OCW control achieves consistently higher throughput than using either alone.

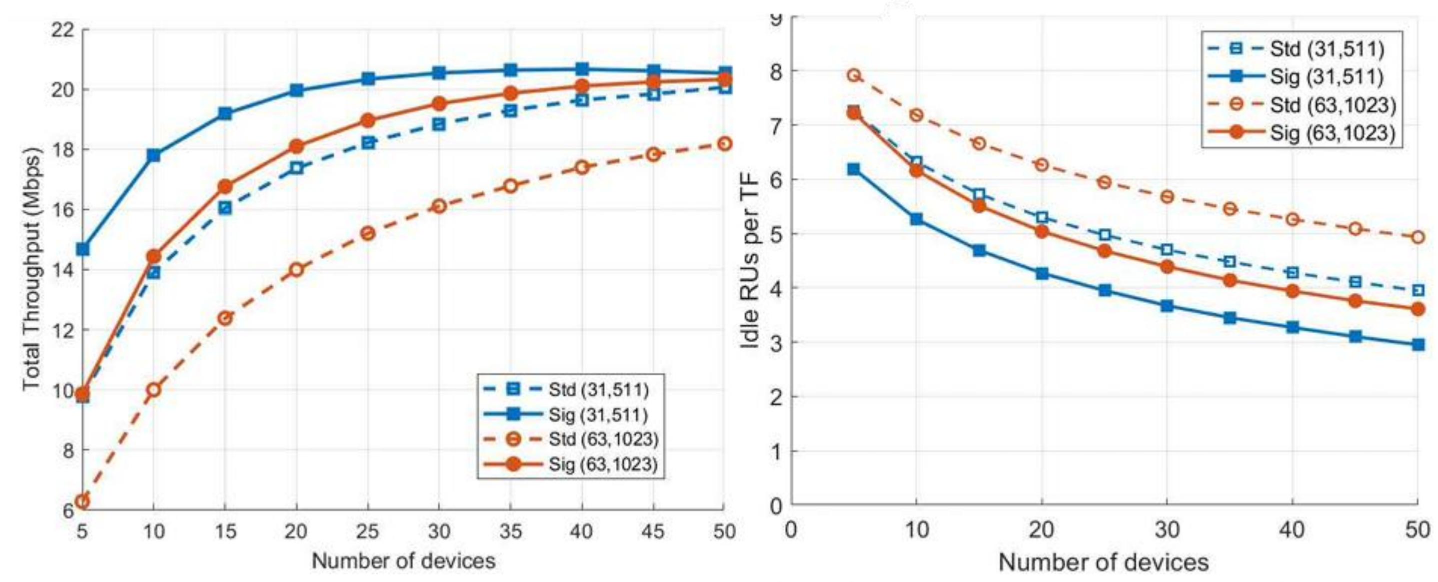

Fig. 4. Comparison between standard UORA (BEB) and proposed method (left: throughput, right: average idle RUs).

Joint α and OCW control consistently improves throughput and reduces idle RA-RUs across different loads and OCW settings.

Conclusion

We propose a joint control of access threshold α and contention window (OCW) using only local transmission history, without global information. The proposed method suppresses collisions while recovering RA-RU utilization, enabling stable channel access under various traffic loads.

References

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3. 구휘모, 권람, 김효경, 박은찬, “IEEE 802.11ax 무선랜에서UORA 효율향상을위한적응적채널접속기법,”한국통신학회학술대회논 문집, pp. 1217-1218, 2024.