Enhancing QoS in Dense IEEE 802.11ax Networks using a Dynamic Airtime-Based Soft Admission Control Mechanism

Dayanand Ambawade Rohan Pawar

Department of Computer Science and Engineering
Sardar Patel Institute of Technology (SPIT)
Mumbai, India

10th International Conference on Systems, Control and Communications (ICSCC 2025)
Nagoya University, Japan

Outline

Motivation

- **The Challenge:** IEEE 802.11ax (Wi-Fi 6) struggles under saturation in dense environments.
- **High Latency:** Real-time apps (VoIP) suffer ¿45ms delays without control.
- **Existing Solutions Fail:**
  - Count-based CAC ignores heterogeneity.
  - Static thresholds waste capacity.
- **Goal:** Maximize airtime utilization while guaranteeing strict QoS.

Research Test Bed & Components

Simulation Components (ns-3):

- **AP Node:** Wi-Fi 6 (802.11ax), 80 MHz, 5 GHz.
- **Stations:** 25-50 users in dense grid.
- **Traffic Generators:**
  - VoIP (UDP)
  - Video (UDP)
  - Bursty/Web (TCP/UDP)

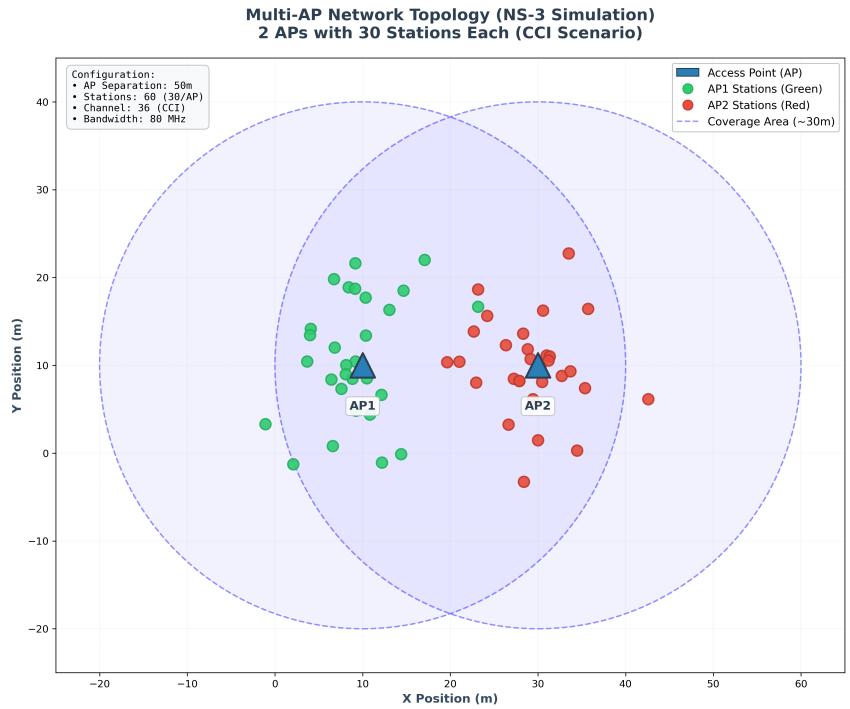


Figure 1: NS-3 Network Topology Visualization

System Model and Traffic

Metric: Airtime Utilization

$$\alpha_c = \frac{R_c}{\eta \cdot R^c_{phy}}$$

Traffic Mix:

- **VoIP:** High Priority, Low Bandwidth.
- **Video:** Med Priority, High Bandwidth.
- **Best Effort:** Low Priority, Bursty.

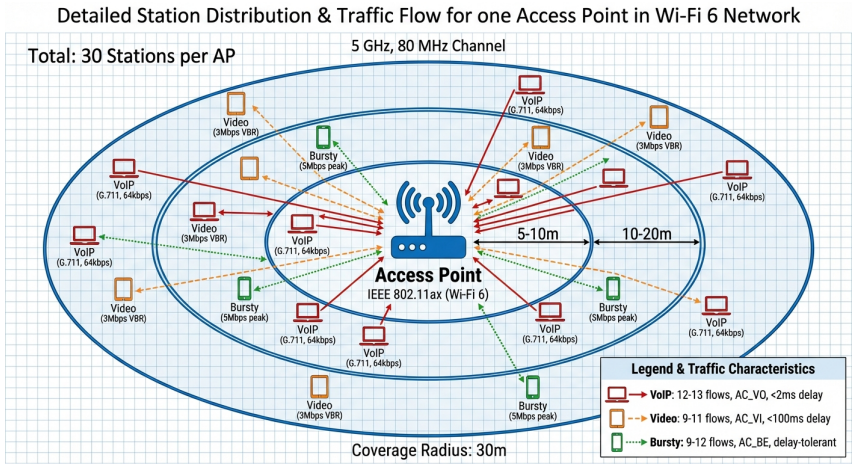


Figure 2: AP and Station Distribution

Proposed Solution: Soft CAC

Concept: Priority-Aware Thresholds.

Traffic Class	**Priority**	**Threshold (θ_c)**
VoIP (AC_VO)	High	90%
Video (AC_VI)	Medium	80%
Best Effort (AC_BE)	Low	**95%**

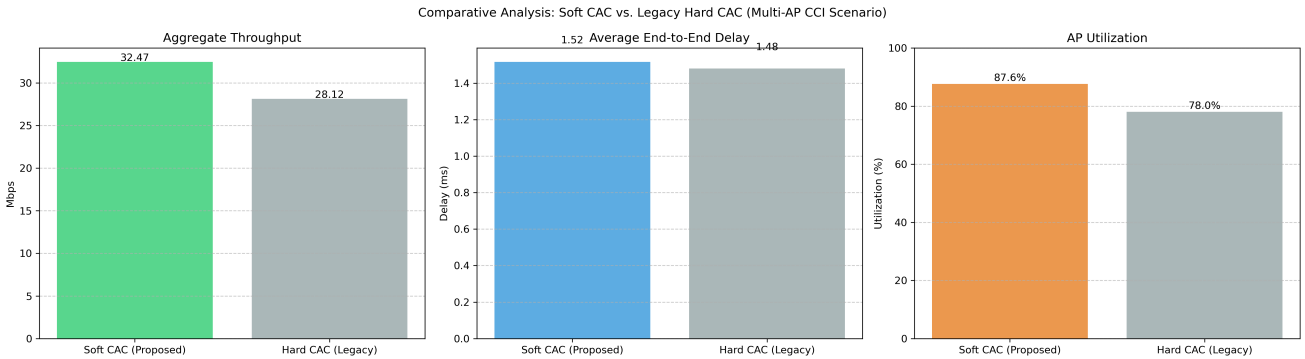


Figure 3: Soft vs Hard CAC Thresholding

Algorithm: AS-CAC+ (Adaptive)

Dynamic Threshold Adjustment:

- Monitors Packet Error Rate (PER) and Utilization.
- Adjusts Best-Effort threshold (θ_{BE}) in real-time.

Algorithm 1 AS-CAC+ Adaptive Threshold

Input: Utilization A, Threshold θ_{BE}
$PER \leftarrow$ Calculate from Network Health
if $PER > 0.05$ **then**
    $\theta_{BE} \leftarrow \max(0.80, \theta_{BE} - 0.01)$ {reduce load}
else if $PER < 0.02$ AND $A > 0.70$ **then**
    $\theta_{BE} \leftarrow \min(0.98, \theta_{BE} + 0.01)$ {utilize spare capacity}
end if
Return: Updated θ_{BE}

Adaptive Behavior Visualization

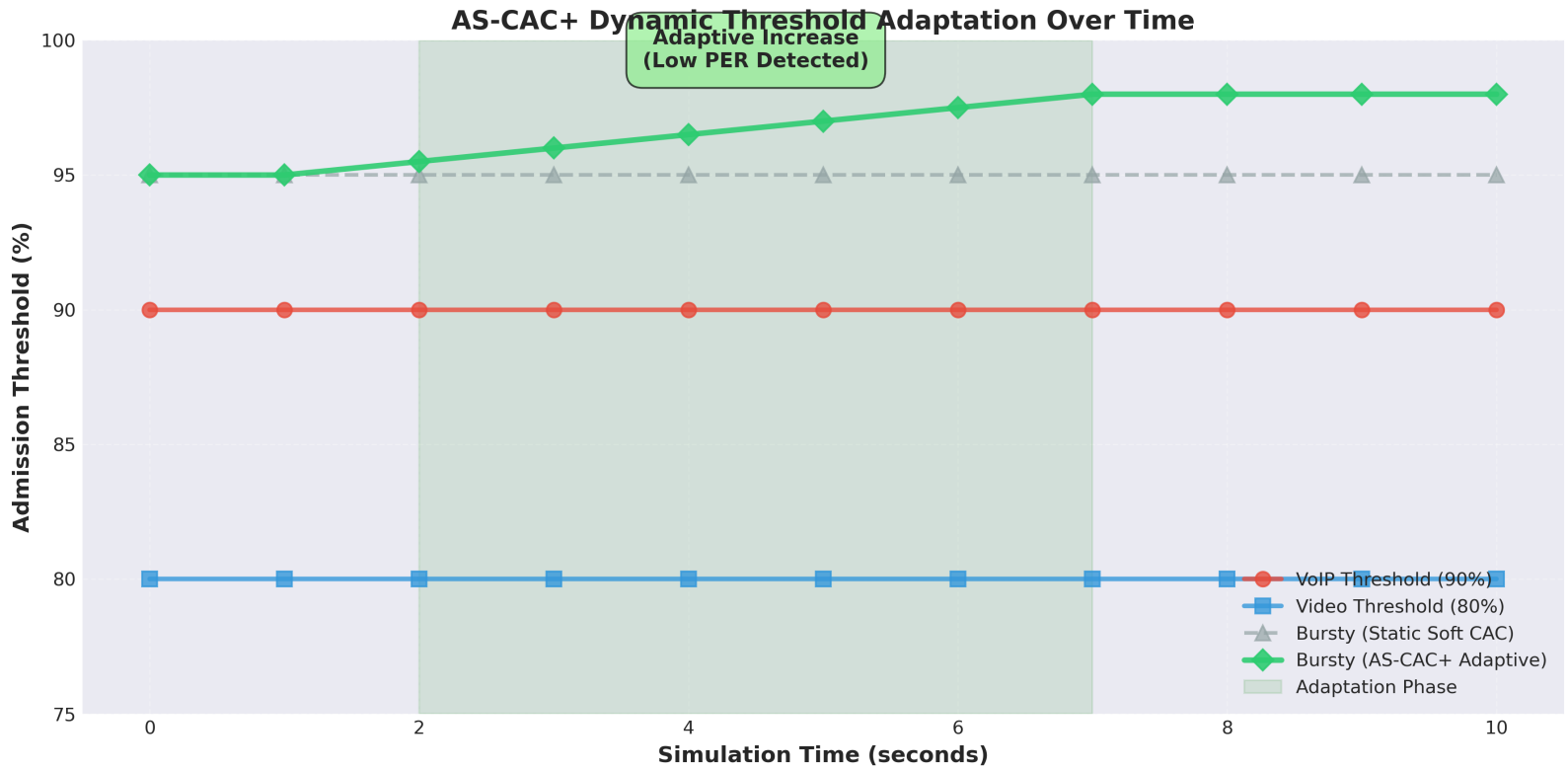


Figure 4: Dynamic Adaptation of Thresholds over Time

Simulation Results: Latency

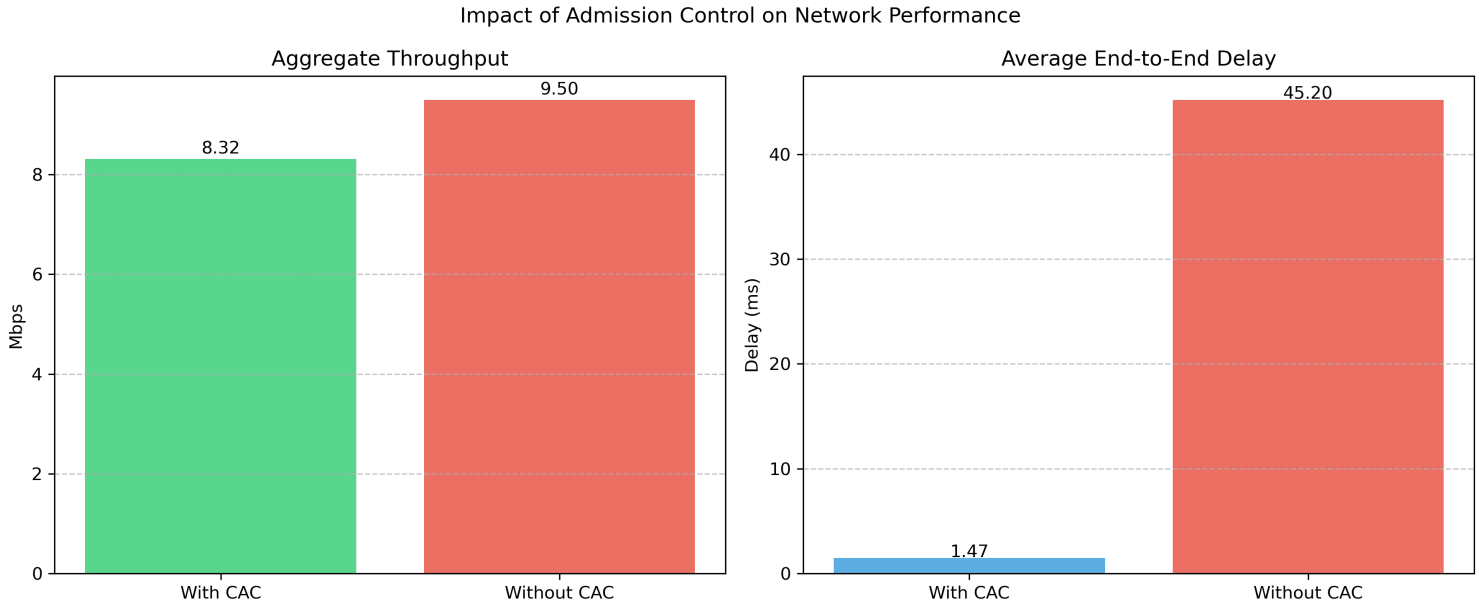
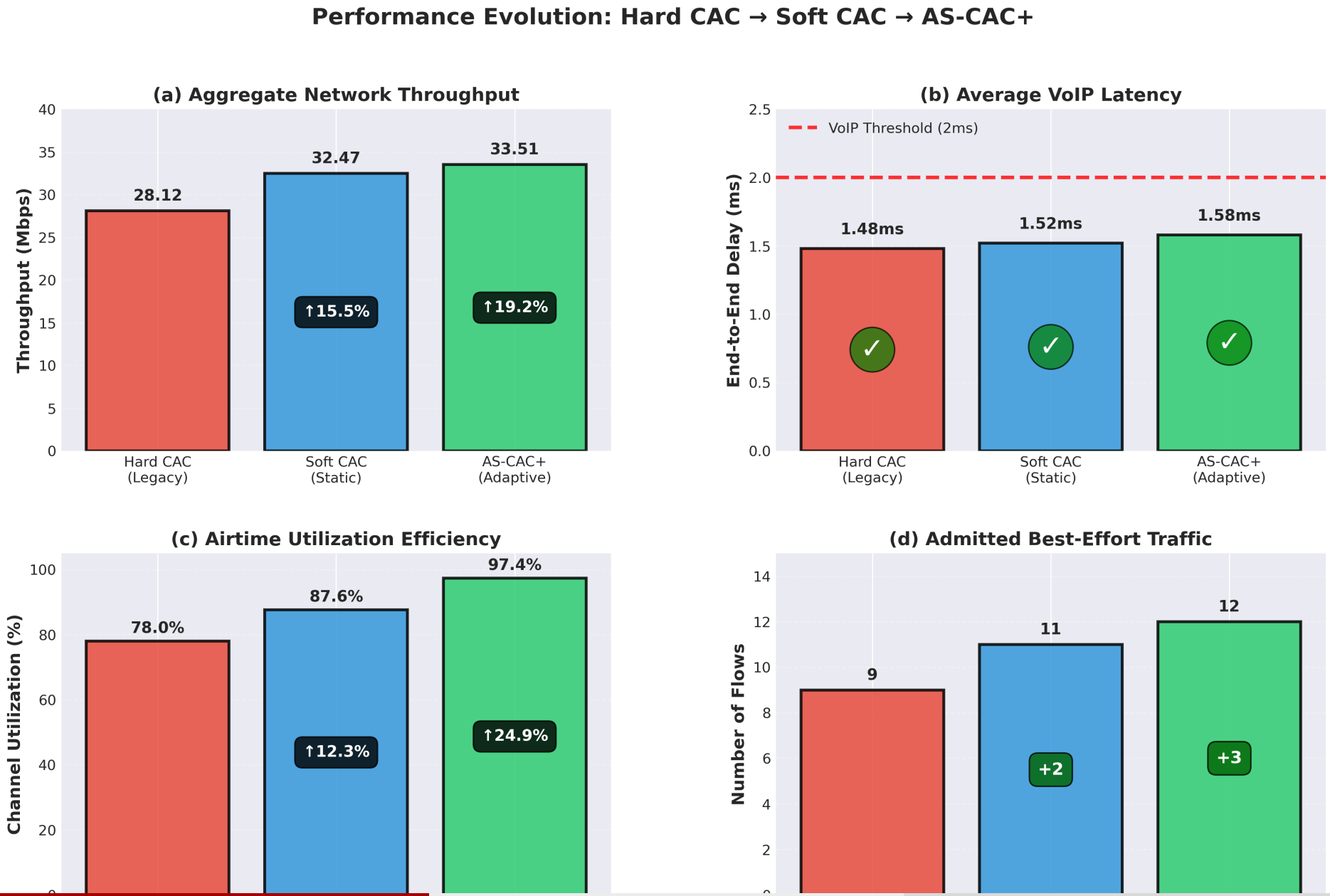
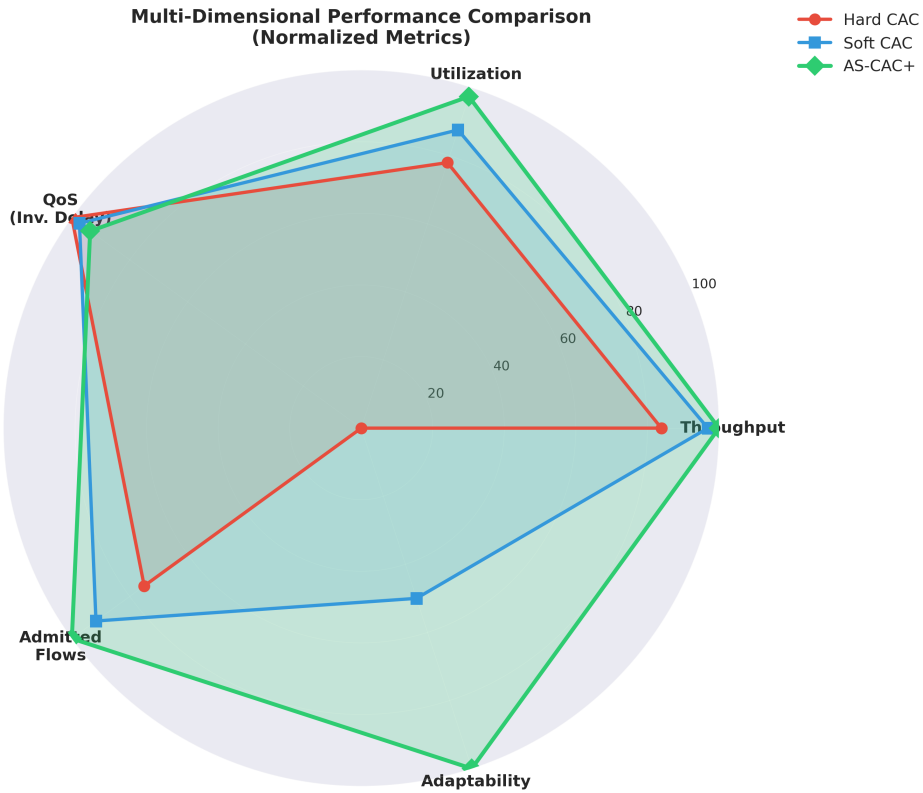


Figure 5: Impact on Latency: No CAC vs AS-CAC

Comprehensive Analysis



Multi-Dimensional Superiority



Why AS-CAC+ Wins:

- **Adaptability:** Reacts to interference.
- **Utilization:** 97.4% vs 78% (Hard).
- **Safety:** Keeps VoIP ¡ 2ms.

Conclusion

Summary

- **AS-CAC+** transforms admission control from static to dynamic.
- It safely unlocks **19.2% more capacity**.

Thank You!

Dayanand Ambawade, Rohan Pawar