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Understanding Carrier Sensing and Interference in Wi-Fi: A Project Guide

Wi-Fi networks are everywhere, but sometimes, even with a strong signal, you might notice slow speeds. This is often caused by two key phenomena: **carrier sensing (CS) blocking** and **interference**. Understanding these effects is crucial for designing better wireless networks. This summary explains these concepts using a simple two-cell Wi-Fi scenario and guides you on how to simulate and analyze them as a student project[1].

Key Concepts

- **Wi-Fi Infrastructure**: Most Wi-Fi networks use access points (APs) that serve client devices (STAs). Each AP and its STAs form a "cell." Multiple APs create a multi-cell network, often using the same channel due to limited frequency options.
- **Carrier Sensing (CS)**: Before transmitting, a Wi-Fi device listens to check if the channel is busy. If it detects another transmission above a certain threshold (e.g., -82 dBm), it waits. This is a sender-side phenomenon.
- **Interference**: Even if a device doesn't detect another's transmission, signals from nearby devices can interfere at the receiver, causing packet loss. This is a receiver-side phenomenon.
- **Hidden and Exposed Nodes**: In multi-cell setups, some devices may not detect each other (hidden nodes), leading to collisions, while others may unnecessarily defer transmission (exposed nodes).

The 2AP-2STA Scenario

Imagine two APs (AP1, AP2) and two STAs (STA1, STA2) lined up. Each AP communicates with its STA. The distances between APs, STAs, and AP-STA pairs are varied to create different scenarios. By changing these distances, you can observe seven unique cases of CS blocking and interference, each affecting network performance differently[1].

The Seven Scenarios

Scenario	Description	Key Effect
1	AP-STA pairs are independent	No blocking or interference
2	STAs in CS range	Exposed node problem
3	STAs in interference range	Hidden node collisions
4	AP-STA cross pairs in CS range	Asymmetric blocking
5	AP-STA cross pairs in interference range	More collisions

Scenario	Description	Key Effect
6	APs in CS range	Symmetric blocking
7	APs in interference range	All nodes interfere

Simulating the Scenarios

You can simulate these scenarios using **NetSim**

- **Download Project Files**: Ready-to-use configuration files are available for import into NetSim[1].
- **Set Parameters**: Use IEEE 802.11g, 2.4 GHz, 100 mW transmit power, and a log-distance path loss model.
- **Traffic Model**: Use a full buffer (constant traffic) so queues are always full.
- **Measure**: Analyze throughput (Mbps), packets per second, and packet failure probability for each scenario.

Results and Insights

- **Basic Access (No RTS/CTS)**: In most cases, basic access gives higher throughput, except when hidden node collisions are severe (scenario 3), where performance drops sharply[1].
- **RTS/CTS Mechanism**: This four-way handshake helps reduce collisions from hidden nodes but adds overhead. It's most beneficial in scenario 3, where it can improve performance by an order of magnitude. In other scenarios, the overhead can reduce throughput[1].
- **Fairness and Utility**: By calculating the sum of the logarithms of throughputs (network utility), you can see how fairness and performance trade off in each scenario.

How to Pursue as a Student Project

1. **Import Scenarios**: Use the provided NetSim files to set up the 2AP-2STA network.
2. **Experiment**: Vary the distances between APs and STAs to observe different cases.
3. **Analyze Results**:
    - Use NetSim's results window to calculate packets per second and packet fail probability.
    - Compare throughput and fairness across scenarios and access mechanisms (basic vs. RTS/CTS).
4. **Extend the Study**:
    - Try different Wi-Fi standards (e.g., 802.11n/ac).
    - Change transmit power or CS threshold.
    - Modify the network layout or increase the number of devices.

5. **Document Findings**: Summarize how CS blocking and interference impact Wi-Fi performance and propose strategies to mitigate problems.

Why This Matters

By simulating and analyzing these scenarios, you'll gain practical insights into real-world Wi-Fi performance issues. This project builds foundational knowledge in wireless networking and prepares you for advanced research or industry roles in network design and optimization[1].

Ready to start? Download the project files, follow the simulation steps, and explore how small changes in network layout can dramatically affect wireless performance[1].

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