Assignment -5
CS342: Computer Networks Laboratory
Deadline: 11:59 pm, 10 November 2024
TOTAL MARKS = 100

In this assignment you need to simulate an ethernet and wifi network using the discrete event network simulator ns-3. You can download the software and documentation of ns-3 from the website https://www.nsnam.org. The assignment will be solved in groups. Continue with the same group you had for the last assignment. Follow the instructions given below.

Instructions:

1. Install ns-3 on your computer, write programs and simulate the network as described below, and answer the questions given.
2. Use ns-3's Flow Monitor module to collect and store the performance data of network protocols from the simulation. Do not use PCAP + Wireshark for the trace collection. No marks will be awarded if your application uses PCAP files for trace collection.
3. Submit your set of source code files, along with a report clearly mentioning all observations, explanations, containing the graphs, and all the answers, as a zipped file on teams. The ZIP file's name should be the same as your group number, for example, "Group_3.zip", or "Group_3.rar", or "Group_3.tar.gz". Submission without a report will not be awarded any marks.
4. Write your own source code and do not copy from any source. Plagiarism and use of unfair means will be penalized by awarding NEGATIVE marks (equal to the maximum marks for the assignment).

Q1) Exploring Collision Management in Ethernet (CSMA/CD) and Wi-Fi (CSMA/CA) using NS-3

Objective

This assignment aims to help you understand the collision detection and avoidance mechanisms used in Ethernet LAN and Wi-Fi networks by simulating CSMA/CD and CSMA/CA protocols in ns-3. Through this assignment, you will observe how these protocols handle collisions and prevent further issues in a shared network environment.

Part A: Ethernet LAN with CSMA/CD

1. **Network Setup**
    a. Set up a simple Ethernet LAN in ns-3 with the following:
        i. 5 hosts (nodes) connected to a single Ethernet switch or hub.
        ii. Use the CSMA (Carrier Sense Multiple Access) protocol with Collision Detection (CSMA/CD).
        iii. Configure the CSMA channel with a reasonable data rate (e.g., 100 Mbps) and a delay (e.g., 0.1 ms).
2. **Traffic Generation**
    a. Generate traffic from multiple hosts simultaneously:

i. Implement a continuous flow of packets between different hosts using the *OnOffApplication* in ns-3.
ii. Adjust the packet size and inter-packet interval to simulate high traffic that can lead to collisions.

3. **Observing Collisions and CSMA/CD in Action**
    a. Use ns-3 logging to observe how the CSMA/CD protocol detects collisions and applies a backoff mechanism.
    b. Explain the following:
        i. How CSMA/CD detects a collision in a shared medium.
        ii. How the exponential backoff algorithm works to prevent further collisions after detection.
    c. Capture packet traces to visualize the collisions and analyze the impact on network performance.
        i. Use a graphing tool (e.g., Python with Matplotlib, MATLAB) to visualize the extracted metrics. Here's how to plot each metric:
            1. Throughput vs. Time: Shows the rate of data transfer over time, helping to analyze the impact of collisions on bandwidth utilization.
            2. Packet Loss vs. Time: Highlights collision-related losses, showing spikes where collisions likely occurred.
            3. Average Delay and Latency: These metrics can be plotted to show delays over time, helping to visualize how collisions and exponential backoff affect end-to-end communication delays.

4. **Analysis and Report**
    a. Report on how CSMA/CD functions in this Ethernet setup and discuss:
        i. Why CSMA/CD works well in wired networks but may not be as effective in wireless scenarios.
        ii. How the protocol detects collisions and how exponential backoff helps mitigate them.

Part B: Wi-Fi Network with CSMA/CA

1. **Network Setup:**
    a. Create a 5x5 wireless ad-hoc network configured in a grid layout.
    b. Use the example file located at examples/wireless/wifi-simple-adhoc-grid.cc as a starting point.
    c. Install the OLSR (Optimized Link State Routing) protocol for routing within the network.
2. **Traffic Configuration:**
    a. Establish three UDP traffic flows:
        i. One flow along each diagonal of the grid.
        ii. One flow along the middle of the grid.
    b. Set these traffic flows to operate at high transmission rates.
3. **Flow Monitoring:**
    a. Implement the ns-3 Flow Monitor to track the performance of each UDP flow.
4. **Scheduling:**
    a. Schedule the initiation of each traffic flow at staggered times:
        i. Flow 1 at 1 second
        ii. Flow 2 at 1.5 seconds
        iii. Flow 3 at 2 seconds

5. **Data Collection:**
    a. Using the Flow Monitor, observe and record the throughput for each UDP flow.
    b. Utilize the tracing mechanism to monitor the number of packet collisions and drops occurring at intermediary nodes.
    c. Analyze the data to determine which nodes are experiencing the highest rates of collisions and drops.
6. **RTS/CTS Experimentation:**
    a. Repeat the entire experiment with the RTS/CTS mechanism enabled on the Wi-Fi devices.
    b. Compare and contrast the results with and without RTS/CTS regarding throughput and packet drops.

Analysis and Reporting:

- Provide a detailed report summarizing your findings from both (with and without RTS/CTS) experiments.
- Highlight the differences in throughput and packet loss between the two scenarios, and discuss the implications for wireless network efficiency.

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