Network Protocol Performance Analysis

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1 Introduction

This report analyzes the performance of different network protocols under varying network loads. The protocols studied include Pure ALOHA, Slotted ALOHA, 1-persistent CSMA, 0.5-persistent CSMA, and CSMA/CD. The goal is to understand how each protocol manages traffic and maintains efficiency under different conditions.

2 Simulation Code Explanation

The simulation code models the behavior of each protocol, considering parameters such as the number of devices and network load. The constants and parameters used in the simulation are as follows:

- `PACKET_TIME`: Time taken for one packet to transmit.
- `TIME_SLOTS`: Number of time slots to simulate.
- `device_counts`: A list of different numbers of devices in the network (5 to 50 in steps of 5).
- `protocols`: List of protocols to simulate.

The simulation functions for each protocol (`simulate_pure_aloha`, `simulate_slotted_aloha`, `simulate_1_persistent_csma`, `simulate_0_5_persistent_csma`, `simulate_csma_cd`) model the network behavior for a given number of devices and network load (attempts per packet time `G`).

3 Protocol Behavior

3.1 Pure ALOHA and Slotted ALOHA

- In Pure ALOHA, a device attempts to transmit with a certain probability. A successful transmission occurs if only one device transmits in a time slot.
- Slotted ALOHA improves upon Pure ALOHA by synchronizing time slots, reducing the probability of collision.

3.2 1-persistent CSMA

- Devices sense the channel and transmit immediately if the channel is idle. Collisions occur if more than one device transmits simultaneously.

3.3 0.5-persistent CSMA

- Similar to 1-persistent CSMA, but devices transmit with 50% probability when the channel is sensed as idle. This reduces collision probability compared to 1-persistent CSMA.

3.4 CSMA/CD

- Devices sense the channel and continue transmitting if idle but stop and retry after a random backoff period if a collision is detected. This mechanism helps manage collisions effectively.

4 Results and Discussion

The results of the simulation are presented in the graphs below, showing the channel utilization (throughput per packet time `S`) against the load (`G`) for each protocol.

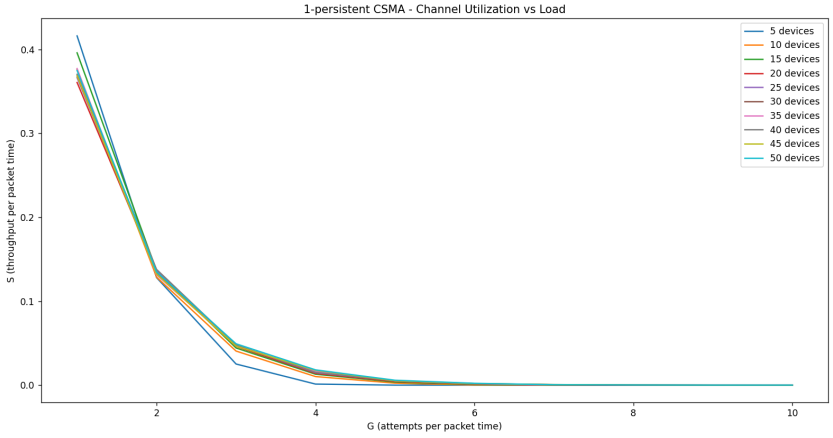

Figure 1: 1-persistent CSMA Throughput vs. Load

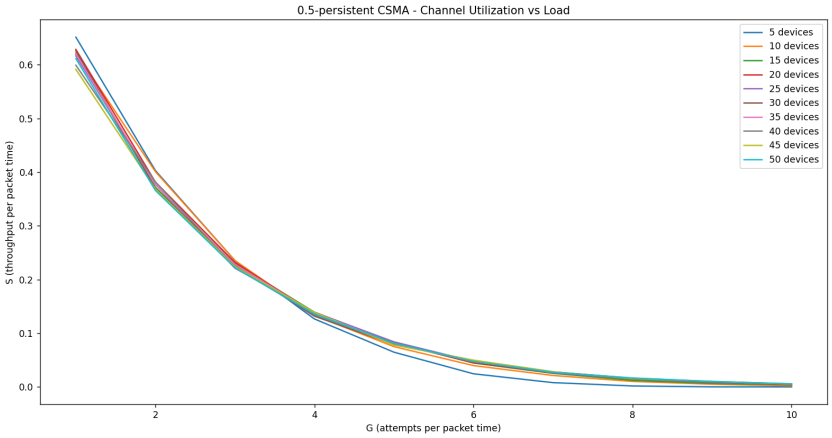

Figure 2: 0.5-persistent CSMA Throughput vs. Load

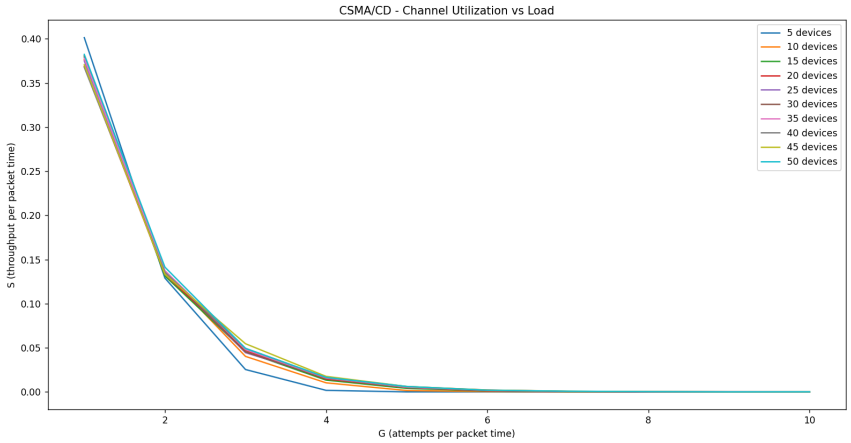

Figure 3: CSMA/CD Throughput vs. Load

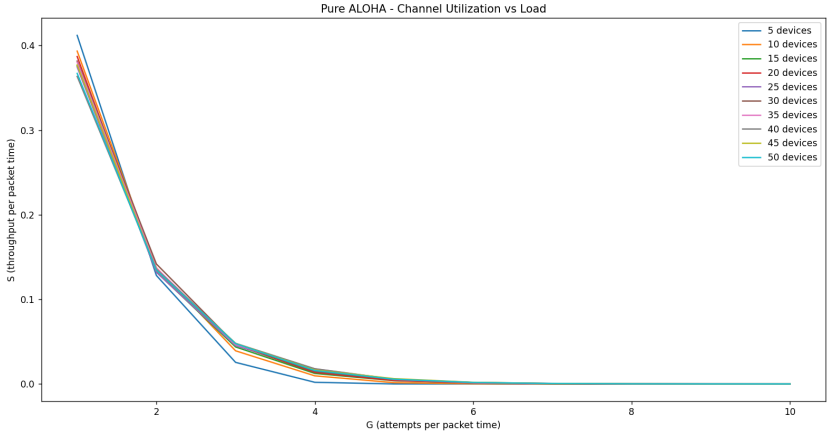

Figure 4: Pure Aloha Throughput vs. Load

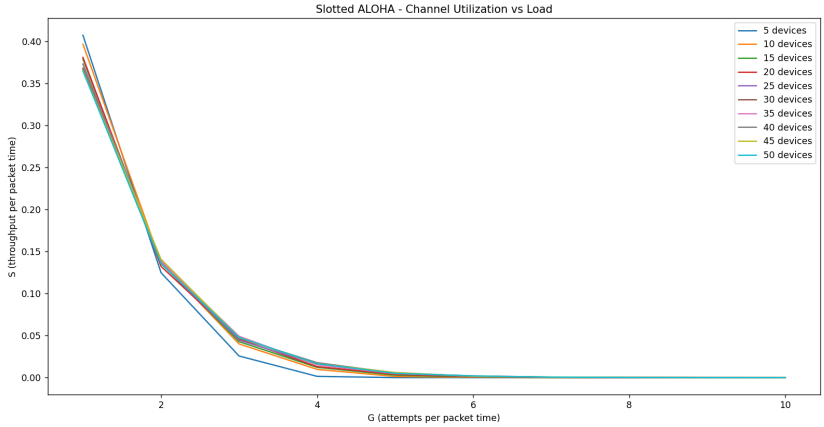

Figure 5: Slotted Aloha Throughput vs. Load

4.1 Pure ALOHA

The throughput (`S`) decreases rapidly as the load (`G`) increases due to high collision rates. Pure ALOHA is highly inefficient at high loads, as it does not have any mechanism to avoid or detect collisions.

4.2 Slotted ALOHA

Slotted ALOHA performs better than Pure ALOHA because it reduces the time frame for potential collisions by synchronizing time slots. However, it still suffers

from collisions at higher loads.

4.3 1-persistent CSMA

The throughput (`S`) rapidly decreases as the load (`G`) increases due to higher collision rates. The throughput stabilizes at a low value for higher loads, indicating inefficient performance under heavy load conditions.

4.4 0.5-persistent CSMA

The decrease in throughput is more gradual compared to 1-persistent CSMA. The 0.5-persistent approach reduces the likelihood of collisions, leading to slightly better performance under high load conditions.

4.5 CSMA/CD

Throughput decreases with increasing load, but CSMA/CD performs better than both 1-persistent and 0.5-persistent CSMA due to its collision detection and avoidance mechanism. CSMA/CD maintains more consistent throughput across different numbers of devices.

5 Conclusion

This analysis shows that each protocol has its strengths and is suited for different scenarios. Pure ALOHA and Slotted ALOHA are simple but suffer from high collision rates. 1-persistent and 0.5-persistent CSMA provide better performance with collision sensing. CSMA/CD offers the best performance among the protocols studied, effectively managing collisions and maintaining higher throughput under various network conditions.