ECE 578 Project1. DCF of 802.11 Draft5

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1 Introduction

Comments for Jimmy: I think the data and the graphs make sense, expect for the hidden terminal with VCS, when the frame rate is beyond 300 the fairness index is actually worse compare to the hidden terminal without VCS. We need to somehow explain this part. The rest I think fit intuitions pretty closely. I plotted the normal FI mentioned in the project description in D2L it shows the same problem, so it is not the different method of FI.

1.1 Transmission Topology

In this project, our objective is to investigate the performance of various access protocols within a wireless environment, with a specific focus on two scenarios illustrated in Figure 1. Both scenarios will be evaluated against one another by examining the performance of Carrier-Sense Multiple Access with Collision Avoidance (CSMA/CA) and Carrier-Sense Multiple Access with Virtual Carrier Sensing (CSMA VCS) network protocols.

1.2 Responsibilities

The tasks among the team are split as follow: Both member participate in the programming and simulation, with Tianrui's idea of coding the problem as a state machine, and Jimmy addressing bugs and validating the event based simulation. After achieving a satisfactory level of simulation integrity, then the report was developed involving Tianrui initially creating the outline and rough draft. Subsequently, Jimmy conducted peer reviews, and finally, Tianrui and jimmy collaboratively analyzed the presented data.

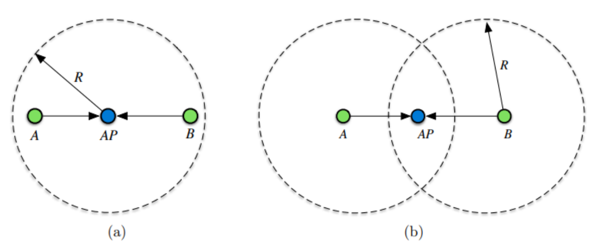


Figure 1: (a) The configuration for concurrent transmissions occurring in a shared collision domain, (b) the arrangement for concurrent transmissions when A and B function as hidden terminals.

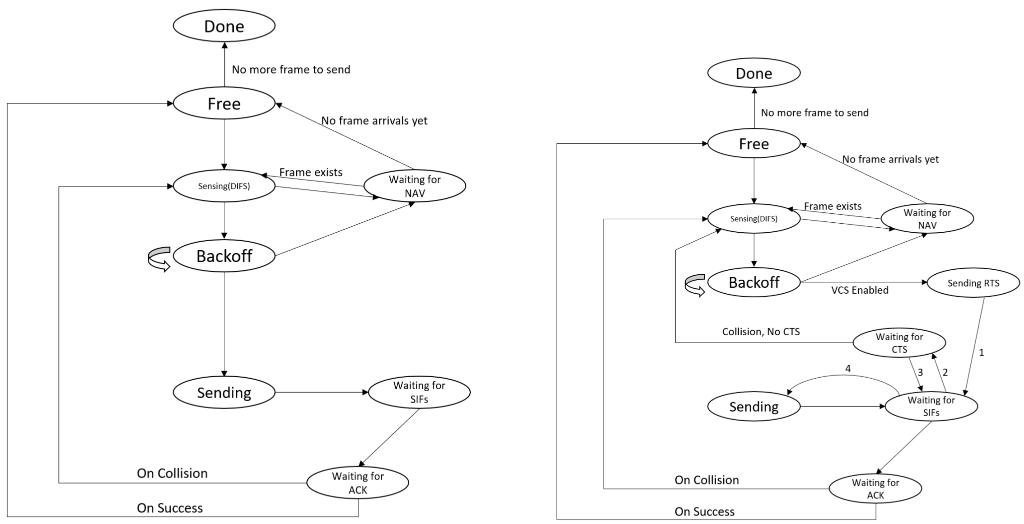
2 Simulation and Development

All the programming is done in Python. In our simulation, we integrated the concept of a state machine. As shown in Figure 3, both the stations and the access point transition through different states in response to specific events and scenarios outlined in the problem statement. The terminals then use the feedback received to determine their next state. The simulation results are shown in Figure 2.

The simulation's parameters are detailed in the table 1. To calculate the data frame size in slots, $\big((1500 \text{ bytes} \times 8) \ / \ 10\text{Mpbs}\big) \ / \ 10 \ \mu\text{s} = 120$ slots.

		Frame Rate (frames / sec)					
		100	200	300	500	800	1000
Shared Collision Domain (No VCS)	Successes (A)	1000	2002	3003	3431	3542	3450
	Successes (B)	1001	1999	3000	3472	3327	3428
	Collisions (A)	1	8	18	758	791	782
	Collisions (B)	1	8	18	758	791	782
Hidden Terminals (No VCS)	Successes (A)	993	1204	1535	1465	1740	1116
	Successes (B)	999	1424	1211	1270	1066	1670
	Collisions (A)	1412	3296	3410	3354	3518	3154
	Collisions (B)	1413	3414	3236	3262	3151	3443
Shared Collision Domain (VCS Enabled)	Successes (A)	999	1997	2997	3507	3650	3681
	Successes (B)	1000	1998	3001	3624	3486	3456
	Collisions (A)	2	5	7	828	777	809
	Collisions (B)	2	5	7	828	777	809
Hidden Terminals (VCS Enabled)	Successes (A)	999	1998	3002	4696	5217	4181
	Successes (B)	999	1999	3001	2383	1891	2929
	Collisions (A)	22	73	1469	359	303	274
	Collisions (B)	27	64	1432	343	299	276

Figure 2: The simulation results



(a) VCS Disabled

(b) VCS Enabled

Figure 3: State Diagrams

Parameter	Value	Parameter	Value
Data frame size	1,500 bytes	ACK, RTS, CTS size	3 slots
Slot duration	10 µs	DIFS duration	4 slots
SIFS duration	1 slot	Bandwidth	10 Mbps
CW_0	8 slots	CW_{max}	512 slots
$\lambda_c = \lambda_A$	{100, 200, 300, 500, 800, 1000} frames/sec	Simulation time	10 sec

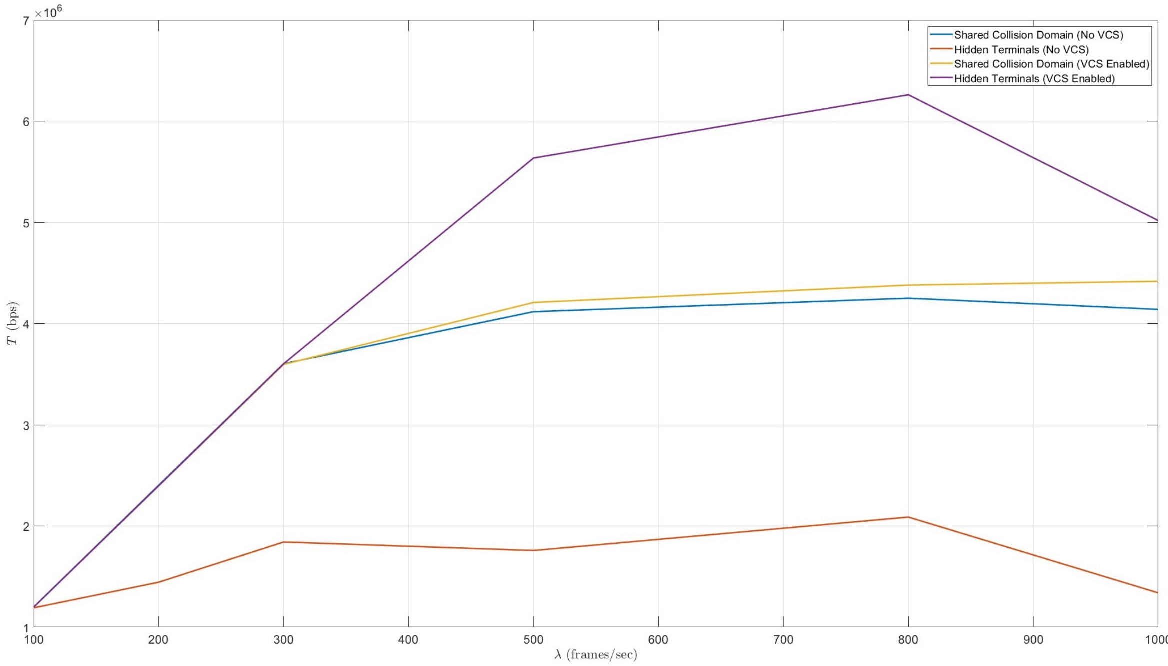
Table 1: Simulation parameters.

3 Analysis

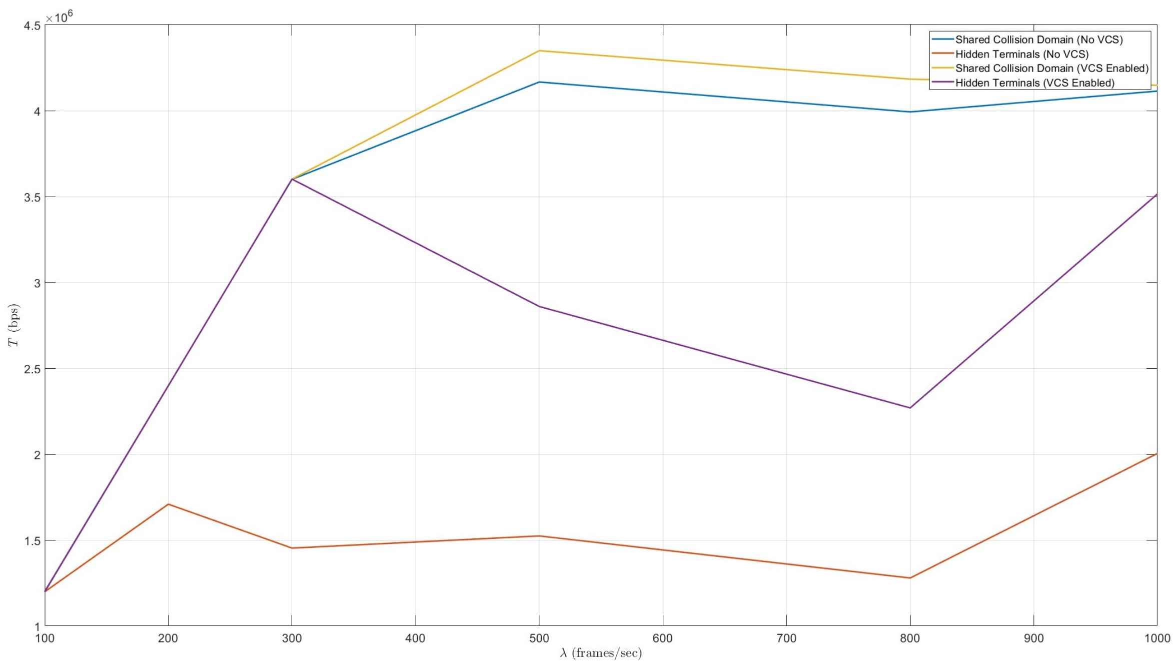
3.1 Throughput

The formulation used for our analysis of throughput is shown in equation 1. As Figure 4 illustrated,

$$T = \frac{\text{Data frame size} \times 8 \times \text{successful transmission}}{\text{simulation time}} \tag{1}$$



(a) Station A Throughput

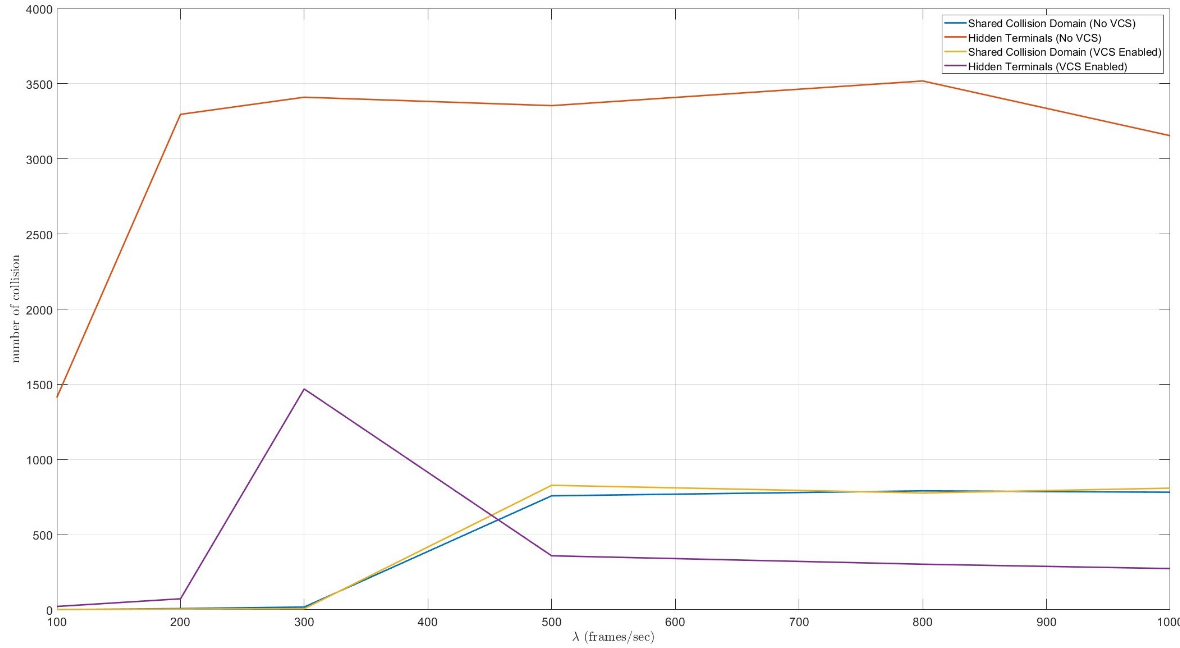


(b) Station B Throughput

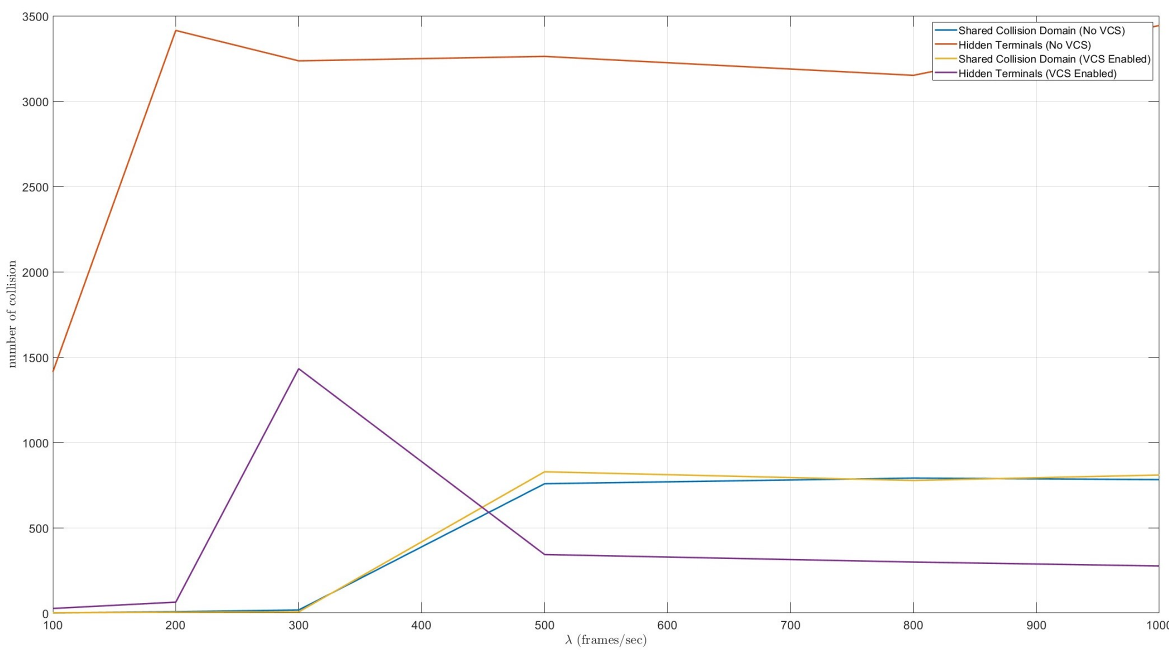
Figure 4: Throughput T

3.2 Collisions

Collisions are detected by assessing whether the node states are concurrently in the 'transmitting' state. The Collision vs. λ graphs are represented in Figure 5



(a) Station A Collision



(b) Station B Collision

Figure 5: Number of Collision

3.3 Fairness Index

In the field of network engineering, fairness metrics play a crucial role in assessing whether system resources are distributed equitably among users or applications. Various mathematical and conceptual definitions of fairness exist for this purpose. In this report we will use the Jain's fairness index, 2. Here, x_i indicates the i_{th} throughput. The outcome of $\mathcal{J}$ ranges from $1/n$ at its lowest (representing the worst-case scenario) to 1 at its peak (illustrating the best-case scenario). The highest value is attained when all users receive equal resource allocations. In Figure 6,

$$\mathcal{J}(x_1, x_2) = \frac{(\sum_{i=1}^{2} x_i)^2}{2 \cdot \sum_{i=1}^{2} {x_i}^2} = \frac{\overline{\mathbf{x}}^2}{\overline{\mathbf{x}^2}} \tag{2}$$

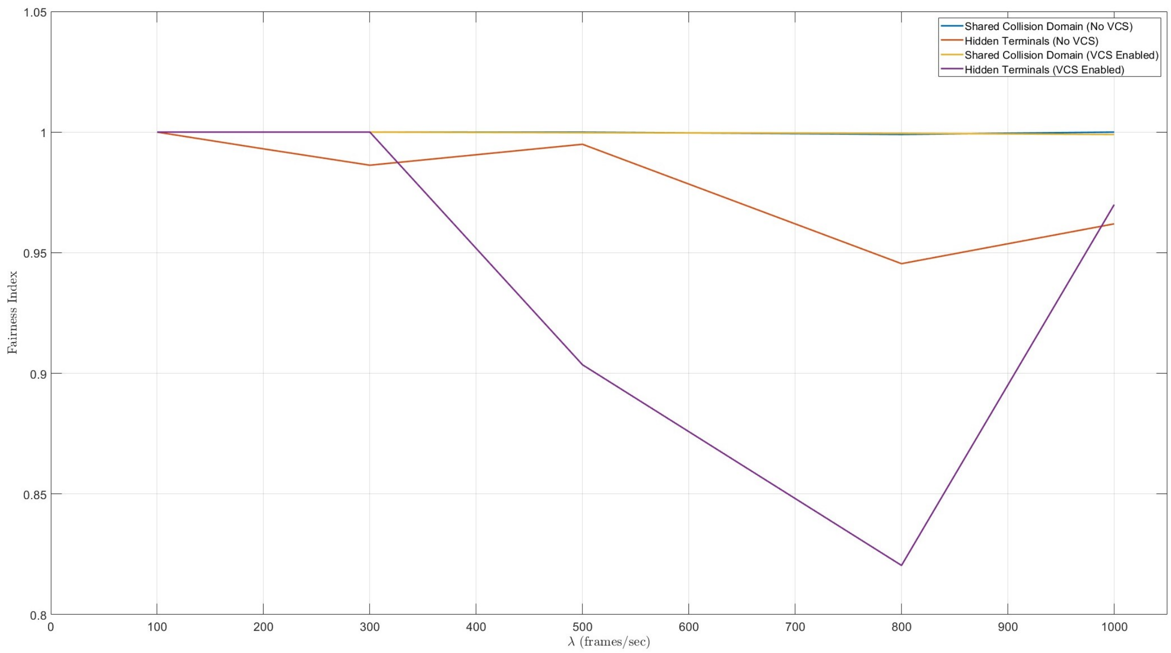


Figure 6: The Jain's Fairness Index