Homework 3
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Remove all highlights before typing your answer.

1 802.11

(a) 802.11 doesn't solve the hidden terminal problem completely but does mitigate it through its request to send (RTS) and clear to send (CTS) mechanisms. It also recommends a higher carrier sensing zone which helps.

(b) The fairness problem is solved by 802.11's back-off mechanism. The mechanism gives a fair share of the overall bandwidth to all stations.

(c) Collisions occur in the hidden terminal situation, for example, transmitter 2 can't see a transmission from transmitter 1 to router 1 so it will send a packet to router 2 but this would collide with transmitter 1's transmission.

(d) Roaming happens in layer 2 when a user moves to another access point but stays on the same VLAN and the same IP subnet.

(e) It varies. A distribution system can be one of three things, a wired network, a switch or a wireless network. A wireless distribution system exists when it is interconnecting access points in a WLAN.

(f) The wi-fi direct technology can be useful for quick and easy connections between devices that are already certified. This "pre-certification" process would also minimize malicious or unwanted connections. The features added to 802.11 include avoiding connection to a router or access point to connect to another device.

(g) Transmission for successful carrier sensing is $2x10^{-}9mW$

Physical CS:

Node C: $Pt_{AC} = 10^{-11}mW <$ threshold $Pt_{BC} = 10^{-9}mW <$ threshold

Node D: $Pt_{AD} = 10^{-6}mW >$ threshold $Pt_{BD} = 10^{-6}mW >$ threshold

Node E: $Pt_{AE} = 10^{-10}mW <$ threshold $Pt_{BE} = 10^{-7}mW >$ threshold

Virtual CS: (SINR needs to be greater than $25dBm = 3x10^2mW$)

Node C: $Pt_{AC} = 10^{-11}/10^{-10} = 0.1mW < 3x10^2mW$ $Pt_{BC} = 10^{-9}/10^{-10} = 10mW < 3x10^2mW$

Node D: $Pt_{AD} = 10^{-6}/10^{-10} = 10^4mW > 3x10^2mW$ $Pt_{BD} = 10^{-6}/10^{-10} = 10^4mW > 3x10^2mW$

Node E: $Pt_{AE} = 10^{-10}/10^{-10} = 10^0mW < 3x10^2mW$ $Pt_{BE} = 10^{-7}/10^{-10} = 10^3mW > 3x10^2mW$

2 802.11 DCF

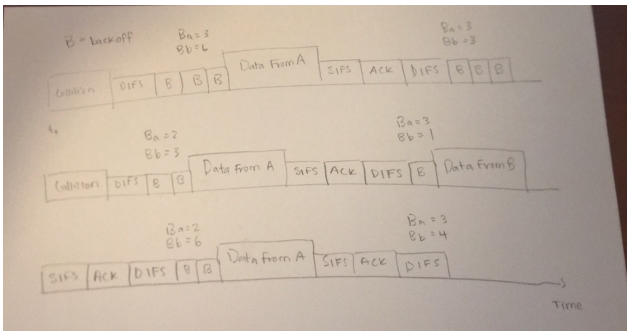


Figure 1: Timeline

(a)

3 Routing

(a) One can modify DSR to transmit multiple routes. Unmodified DSR will return the shortest RREQ at the destination when there are multiple broadcasts. The modification though, at destination can send back all other routes to adjust for the misbehaving node. If one of the nodes drops a signal there are other routes that still connect the sender and receiver.

(b) No. The approach does not ensure that the source node will discover the shortest route. Suppose there is a network of nodes where A ¡-¿ C, A ¡-¿ S, A ¡-¿ B, S ¡-¿ B, B ¡-¿ D, D ¡-¿ C. If S wants to send a packet to D. S broadcasts a RREQ by appending its address to A and B. If there is high traffic on the path between S and B and the RREQ reaches A first, A will append its address to RREQ and broadcast it to B and C. B hasn't received the RREQ from S so it will accept the RREQ from A and when it does eventually receive the RREQ from S it will drop it.

The shortest route would've been SBD but it ended up taking SABD.

(c) N/A

4 Wireshark

(a) In the network, there are two different access points with the Bill Clinternet SSID: `fc:ec:da:3f:b6:43` and `80:2a:a8:42:fd:90`.

(b) The signal strength to the closest access point `80:2a:a8:42:fd:90` is -57dBm.

(c) Using the display filter `wlan.fc.type_subtype == 0x08` we can show only beacon frames for any nearby access points. This shows the SSIDs Bill Clinternet, Hullabaloo Connect Connect, VladimirComputin. There probably are more access points out there, but they aren't visible because Wireshark does not scan all channels simultaneously.

5 Wireshark: RTS/CTS Threshold and Fragmentation Length

(a) Pre-Experiment Questions

(a) Advantages of fragmentation include better immunity to noise (since you will resend only a small part of the total payload if noise corrupts it) as well as better, fairer use of air time.

(b) For the WNDR3400v2 router, the range of allowable fragmentation lengths is $[256, 2346]$.

(c) The smaller the fragmentation length, the higher the protocol overhead (e.g. the ratio of the 802.11 header to the useful payload) will be. If we fragment a packet every 20 bytes, the 802.11 header will take up almost as much time to transmit, making this a very inefficient use of air time.

Experiment 1

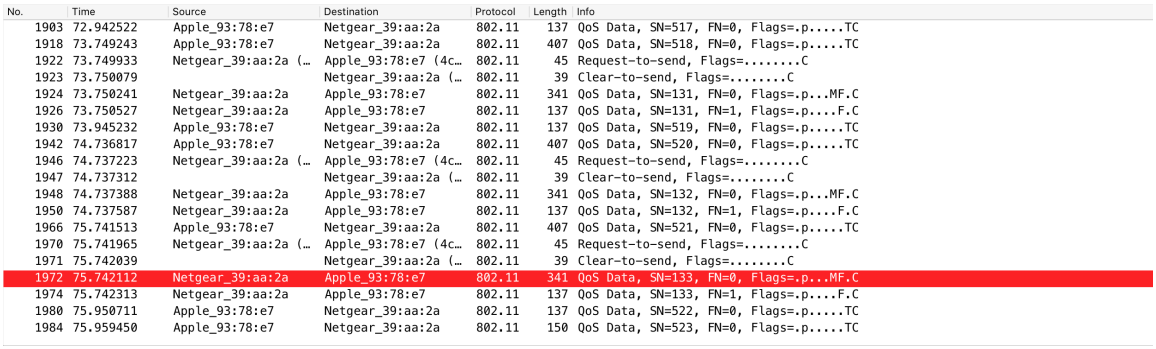
(a) **50 byte ICMP packet size**: RTS/CTS frames are sent, the RTS frame is 16 bytes in length and the CTS frame is 10. No fragmentation is used.

No.	Time	Source	Destination	Protocol	Length	Info
3823	127.787648	Netgear_39:aa:2a	Apple_75:ab:44	802.11	341	QoS Data, SN=390, FN=3, Flags=.p...MF..
3824	127.787764	Netgear_39:aa:2a	Apple_75:ab:44	802.11	341	QoS Data, SN=390, FN=4, Flags=.p...MF..
3825	127.787837	Netgear_39:aa:2a	Apple_75:ab:44	802.11	229	QoS Data, SN=390, FN=5, Flags=.p....F..
3826	127.795076		Apple_75:ab:44 (28…	802.11	39	Acknowledgement, Flags=........C
3827	127.796592	Netgear_39:aa:2a	Broadcast	802.11	182	Beacon frame, SN=331, FN=0, Flags=........C, BI=100, SSID=NETGEAR60
3828	127.796721	Netgear_39:aa:2a (…	Apple_75:ab:44 (28…	802.11	45	Request-to-send, Flags=........C
3829	127.796834	Netgear_39:aa:2a	Apple_75:ab:44	802.11	341	QoS Data, SN=391, FN=0, Flags=.p...MF..
3830	127.796908	Netgear_39:aa:2a	Apple_75:ab:44	802.11	341	QoS Data, SN=391, FN=1, Flags=.p...MF..
3831	127.797028	Netgear_39:aa:2a	Apple_75:ab:44	802.11	341	QoS Data, SN=391, FN=2, Flags=.p...MF..
3832	127.797113	Netgear_39:aa:2a	Apple_75:ab:44	802.11	341	QoS Data, SN=391, FN=3, Flags=.p...MF..
3833	127.797335	Netgear_39:aa:2a	Apple_75:ab:44	802.11	341	QoS Data, SN=391, FN=4, Flags=.p...MF..
3834	127.797409	Netgear_39:aa:2a	Apple_75:ab:44	802.11	229	QoS Data, SN=391, FN=5, Flags=.p....F..
3835	127.797565	Netgear_39:aa:2a	Apple_75:ab:44	802.11	341	QoS Data, SN=392, FN=0, Flags=.p...MF..
3836	127.797640	Netgear_39:aa:2a	Apple_75:ab:44	802.11	341	QoS Data, SN=392, FN=1, Flags=.p...MF..
3837	127.797759	Netgear_39:aa:2a	Apple_75:ab:44	802.11	341	QoS Data, SN=392, FN=2, Flags=.p...MF..
3838	127.797956	Netgear_39:aa:2a	Apple_75:ab:44	802.11	341	QoS Data, SN=392, FN=3, Flags=.p...MF..
3839	127.798073	Netgear_39:aa:2a	Apple_75:ab:44	802.11	341	QoS Data, SN=392, FN=4, Flags=.p...MF..
3840	127.798189	Netgear_39:aa:2a	Apple_75:ab:44	802.11	229	QoS Data, SN=392, FN=5, Flags=.p....F..
3841	127.806203		Apple_75:ab:44 (28…	802.11	39	Acknowledgement, Flags=........C

(b) **300 byte ICMP packet size**: RTS/CTS frames are sent, the RTS frame is 16 bytes in length and the CTS frame is 10. No fragmentation is used.

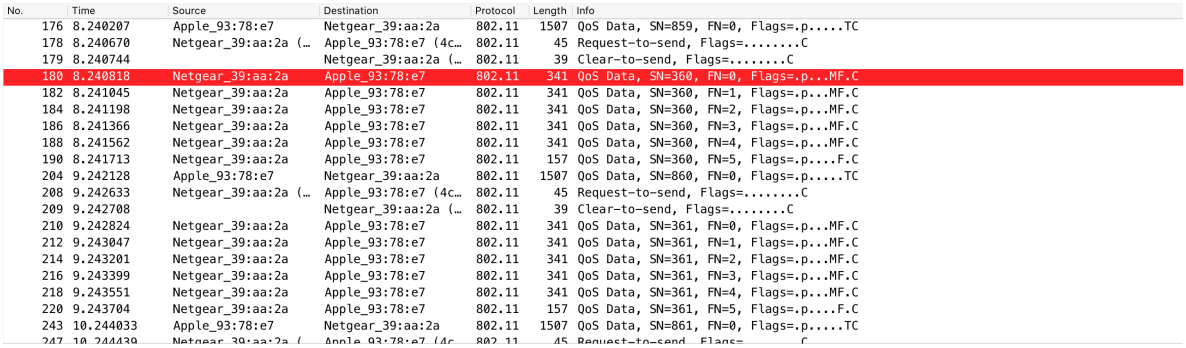
No.	Time	Source	Destination	Protocol	Length	Info
5659	351.526760		Apple_93:78:e7 (4c…	802.11	39	Acknowledgement, Flags=........C
5663	351.848816	Apple_93:78:e7	Netgear_39:aa:2a	802.11	407	QoS Data, SN=24, FN=0, Flags=.p.....TC
5664	351.848940		Apple_93:78:e7 (4c…	802.11	39	Acknowledgement, Flags=........C
5666	351.850436	Netgear_39:aa:2a (…	Apple_93:78:e7 (4c…	802.11	45	Request-to-send, Flags=........C
5667	351.850508	Apple_93:78:e7	Netgear_39:aa:2a	802.11	55	QoS Null function (No data), SN=413, FN=0, Flags=....R..TC
5668	351.850582		Apple_93:78:e7 (4c…	802.11	39	Acknowledgement, Flags=........C
5669	351.850718	Netgear_39:aa:2a (…	Apple_93:78:e7 (4c…	802.11	45	Request-to-send, Flags=........C
5670	351.850791		Netgear_39:aa:2a (…	802.11	39	Clear-to-send, Flags=........C
5671	351.850865	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=14, FN=0, Flags=.p...MF.C
5672	351.850949		Netgear_39:aa:2a (…	802.11	39	Acknowledgement, Flags=........C
5673	351.851022	Netgear_39:aa:2a	Apple_93:78:e7	802.11	137	QoS Data, SN=14, FN=1, Flags=.p....F.C
5674	351.851101		Netgear_39:aa:2a (…	802.11	39	Acknowledgement, Flags=........C
5677	352.055176	Apple_93:78:e7	Netgear_39:aa:2a	802.11	55	QoS Null function (No data), SN=414, FN=0, Flags=...P...TC
5678	352.055253		Apple_93:78:e7 (4c…	802.11	39	Acknowledgement, Flags=........C
5686	352.783462	Apple_93:78:e7	Netgear_39:aa:2a	802.11	111	QoS Data, SN=108, FN=0, Flags=.p.....TC
5687	352.783582		Apple_93:78:e7 (4c…	802.11	39	Acknowledgement, Flags=........C
5688	352.783658	Apple_93:78:e7	Netgear_39:aa:2a	802.11	55	QoS Null function (No data), SN=415, FN=0, Flags=.......TC
5689	352.783732		Apple_93:78:e7 (4c…	802.11	39	Acknowledgement, Flags=........C
5690	352.783869	Netgear_39:aa:2a	Apple_93:78:e7	802.11	139	QoS Data, SN=9, FN=0, Flags=.p....F.C

(c) **600 byte ICMP packet size**: RTS/CTS frames are sent, the RTS frame is 16 bytes in length and the CTS frame is 10. Fragmentation is used as two 300 byte packets typically.



No.	Time	Source	Destination	Protocol	Length	Info
1903	72.942522	Apple_93:78:e7	Netgear_39:aa:2a	802.11	137	QoS Data, SN=517, FN=0, Flags=.p.....TC
1918	73.749243	Apple_93:78:e7	Netgear_39:aa:2a	802.11	407	QoS Data, SN=518, FN=0, Flags=.p.....TC
1922	73.749933	Netgear_39:aa:2a (…	Apple_93:78:e7 (4c…	802.11	45	Request-to-send, Flags=........C
1923	73.750079		Netgear_39:aa:2a (…	802.11	39	Clear-to-send, Flags=........C
1924	73.750241	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=131, FN=0, Flags=.p...MF.C
1926	73.750527	Netgear_39:aa:2a	Apple_93:78:e7	802.11	137	QoS Data, SN=131, FN=1, Flags=.p....F.C
1930	73.945232	Apple_93:78:e7	Netgear_39:aa:2a	802.11	137	QoS Data, SN=519, FN=0, Flags=.p.....TC
1942	74.736817	Apple_93:78:e7	Netgear_39:aa:2a	802.11	407	QoS Data, SN=520, FN=0, Flags=.p.....TC
1946	74.737223	Netgear_39:aa:2a (…	Apple_93:78:e7 (4c…	802.11	45	Request-to-send, Flags=........C
1947	74.737312		Netgear_39:aa:2a (…	802.11	39	Clear-to-send, Flags=........C
1948	74.737388	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=132, FN=0, Flags=.p...MF.C
1950	74.737587	Netgear_39:aa:2a	Apple_93:78:e7	802.11	137	QoS Data, SN=132, FN=1, Flags=.p....F.C
1966	75.741513	Apple_93:78:e7	Netgear_39:aa:2a	802.11	407	QoS Data, SN=521, FN=0, Flags=.p.....TC
1970	75.741965	Netgear_39:aa:2a (…	Apple_93:78:e7 (4c…	802.11	45	Request-to-send, Flags=........C
1971	75.742039		Netgear_39:aa:2a (…	802.11	39	Clear-to-send, Flags=........C
1972	75.742112	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=133, FN=0, Flags=.p...MF.C
1974	75.742313	Netgear_39:aa:2a	Apple_93:78:e7	802.11	137	QoS Data, SN=133, FN=1, Flags=.p....F.C
1980	75.950711	Apple_93:78:e7	Netgear_39:aa:2a	802.11	137	QoS Data, SN=522, FN=0, Flags=.p.....TC
1984	75.959450	Apple_93:78:e7	Netgear_39:aa:2a	802.11	150	QoS Data, SN=523, FN=0, Flags=.p.....TC

(d) **1200 byte ICMP packet size**: RTS/CTS frames are sent, the RTS frame is 16 bytes in length and the CTS frame is 10. There are 6 fragments, the first 5 of which carry 278 bytes of payload, the last 94 bytes.



No.	Time	Source	Destination	Protocol	Length	Info
176	8.240207	Apple_93:78:e7	Netgear_39:aa:2a	802.11	1507	QoS Data, SN=859, FN=0, Flags=.p.....TC
178	8.240670	Netgear_39:aa:2a (…	Apple_93:78:e7 (4c…	802.11	45	Request-to-send, Flags=........C
179	8.240744		Netgear_39:aa:2a (…	802.11	39	Clear-to-send, Flags=........C
180	8.240818	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=360, FN=0, Flags=.p...MF.C
182	8.241045	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=360, FN=1, Flags=.p...MF.C
184	8.241198	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=360, FN=2, Flags=.p...MF.C
186	8.241366	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=360, FN=3, Flags=.p...MF.C
188	8.241562	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=360, FN=4, Flags=.p...MF.C
190	8.241713	Netgear_39:aa:2a	Apple_93:78:e7	802.11	157	QoS Data, SN=360, FN=5, Flags=.p....F.C
204	9.242128	Apple_93:78:e7	Netgear_39:aa:2a	802.11	1507	QoS Data, SN=860, FN=0, Flags=.p.....TC
208	9.242633	Netgear_39:aa:2a (…	Apple_93:78:e7 (4c…	802.11	45	Request-to-send, Flags=........C
209	9.242708		Netgear_39:aa:2a (…	802.11	39	Clear-to-send, Flags=........C
210	9.242824	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=361, FN=0, Flags=.p...MF.C
212	9.243047	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=361, FN=1, Flags=.p...MF.C
214	9.243201	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=361, FN=2, Flags=.p...MF.C
216	9.243399	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=361, FN=3, Flags=.p...MF.C
218	9.243551	Netgear_39:aa:2a	Apple_93:78:e7	802.11	341	QoS Data, SN=361, FN=4, Flags=.p...MF.C
220	9.243704	Netgear_39:aa:2a	Apple_93:78:e7	802.11	157	QoS Data, SN=361, FN=5, Flags=.p....F.C
243	10.244033	Apple_93:78:e7	Netgear_39:aa:2a	802.11	1507	QoS Data, SN=861, FN=0, Flags=.p.....TC

(b) **Experiment 2**

100 bytes, 200μS

Packet loss	**RTT (mS)**
98%	40
98%	50.8
97%	63.1
98%	56.8
99%	59.9
98.0%	54.12

100 bytes, 500μS

Packet loss	**RTT (mS)**
95%	126.3
96%	121.2
95%	152.3
96%	143.1
96%	133.8
95.6%	135.34

100 bytes, 1000μS

Packet loss	**RTT (mS)**
86%	243.5
83%	234.8
85%	239.3
86%	240.3
83%	243.3
85%	240.24

1000 bytes, 200μS

Packet loss	**RTT (mS)**
97%	42.5
98%	60.5
97%	49.3
98%	50.7
98%	57.3
98%	52.06

1000 bytes, 500μS

Packet loss	**RTT (mS)**
94%	158.5
95%	147.2
94%	149.7
96%	152.3
94%	159.1
95%	153.36

1000 bytes, 1000μS

Packet loss	**RTT (mS)**
84%	256.3
90%	250.9
88%	251.7
87%	249.3
90%	243.3
88%	250.3