

Irregular wireless multicast delivery causing poor audio experience

Summary:

I currently work for a company that provides Voice Over WiFi services for large organizations. Customer reported poor audio experience for an audio feature using multicast over wireless on our wireless clients (badges). Badge configuration on the was heavily reviewed and all settings relevant to multicast audio were tweaked accordingly to match customer environment. Wireless vendor QoS and multicast settings were checked as well. Ultimately a bug was found on the wireless network that was deviating from standard 802.11 multicast delivery and once this was addressed, the issue was resolved.

Analysis:

Customer was recreating issue while roaming. Customer presented badge logs and standard optimizations were made to assist with overall badge functionality and performance. Badge roaming policy was found to be 1 less than default value and therefore initiating roam scan at -73dBm RSSI as opposed to -70. Customer SSID utilized 12 – 5GHz channels with channel-bonding up to 40MHz including UNII-1, UNII-2, and UNII-3 channels. No UNII-2e channels were used, nor was 165. Badge did not have 802.11k enabled in an environment where DFS channels were being used. Roaming policy, channel list, and 802.11k were adjusted on the badge configuration.

Customer environment exhibited high amounts of co-channel interference and management overhead. They were broadcasting 13 SSIDs. DTIM was verified to be set to recommended value of '1'. Additional recommendations were made to decrease channel width to 20MHz to address co-channel interference and to reduce the number of SSIDs. Customer agreed to try 20MHz channels in a controlled area of the facility.

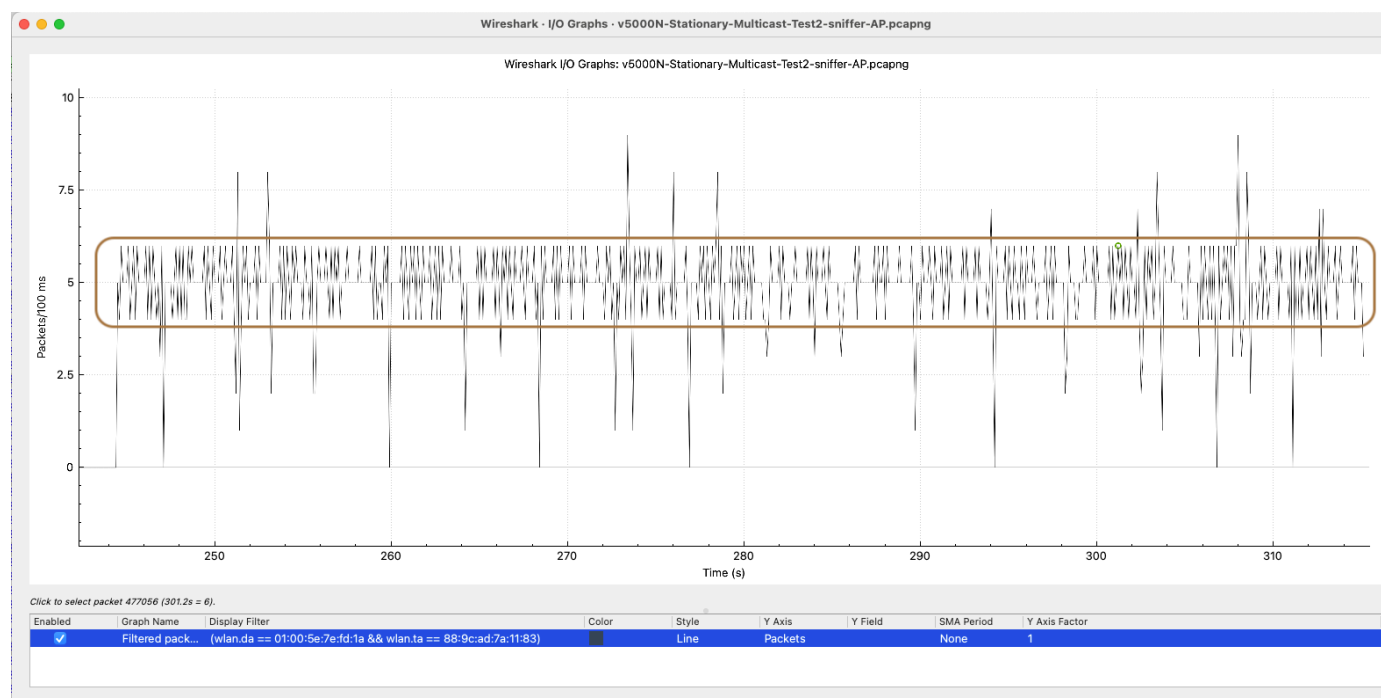
These new settings yielded significant improvement, but audio still had periods of choppiness. Over the air packet captures were requested and taken for subsequent rounds of testing.

Preliminary packet captures showed badge was transmitting audio traffic with QoS UP value of 4 – Video. This was unexpected as badges transmit audio at UP of 6 – audio. Beacon frame WMM Information Element was investigated to find that ACM was enabled for AC_VO category. Our badges don't support TSPEC and are therefore not able to negotiate a call slot when ACM (Call Admission Control) is enabled. Since ACM was not enabled on AC_VI category badge was able to send with this QoS marking without

negotiating via TSPEC. Badge was effectively downgrading QoS markings based on CAC being implemented on SSID.

ACM was disabled for AC_VO on the WLC and QoS on badge traffic was now being sent at UP of 6. Unfortunately, the issue persisted. Distinct periods of choppiness were still present during calls. It was consistent and easily reproduced while clients were stationary.

Wireshark I/O Graphs were used to analyze audio stream latency and jitter. Downstream multicast from the AP was graphed over time using an interval (sampling period) of 100ms. Our badges use the G.711 audio codec which sends an RTP frame every 20ms. With an interval of 100ms we would expect to see approximately 5 audio frames for every point on the graph. An ideal stream presents itself as a zig-zag pattern alternating between 4 and 6. This is outlined in green below. All of the outliers, specifically the drops to 0 packets per 100ms, were especially concerning.



Looking closer at these instances of jitter I noticed there was a change in how the AP was delivering the multicast to the BSS. Most downstream multicast frames were sent using 802.11 standard multicast delivery at the DTIM. With a DTIM of 1, we see 4-6 frames being delivered immediately after each beacon – every ~100ms. See below.

(wlan.da == 01:00:5e:7d:1a && wlan.ta == 88:9c:ad:7a:11:83) (wlan.bssid == 88:9c:ad:7a:11:83 && wlan.fc.type_subtype == 8)							
Frame	Time	Delta	Source	Destination	BSSID	Multicast	Info
445342	2024-02-16 15:00:30.993	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2890, FN=0, Flags=.pm...F.C
445343	2024-02-16 15:00:30.993	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2891, FN=0, Flags=.pm...F.C
445470	2024-02-16 15:00:31.093	0.099	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=883, FN=0, Flags=...
445476	2024-02-16 15:00:31.095	0.001	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2892, FN=0, Flags=.pm...F.C
445477	2024-02-16 15:00:31.095	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2893, FN=0, Flags=.pm...F.C
445478	2024-02-16 15:00:31.095	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2894, FN=0, Flags=.pm...F.C
445479	2024-02-16 15:00:31.095	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2895, FN=0, Flags=.pm...F.C
445480	2024-02-16 15:00:31.095	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2896, FN=0, Flags=.pm...F.C
445481	2024-02-16 15:00:31.096	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2897, FN=0, Flags=.pm...F.C
445644	2024-02-16 15:00:31.196	0.099	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=884, FN=0, Flags=...
445651	2024-02-16 15:00:31.197	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2898, FN=0, Flags=.pm...F.C
445652	2024-02-16 15:00:31.197	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2899, FN=0, Flags=.pm...F.C
445653	2024-02-16 15:00:31.197	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2900, FN=0, Flags=.pm...F.C
445654	2024-02-16 15:00:31.198	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2901, FN=0, Flags=.pm...F.C
445659	2024-02-16 15:00:31.199	0.001	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2902, FN=0, Flags=.pm...F.C
445755	2024-02-16 15:00:31.298	0.099	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=885, FN=0, Flags=...
445762	2024-02-16 15:00:31.299	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2904, FN=0, Flags=.pm...F.C
445763	2024-02-16 15:00:31.299	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2905, FN=0, Flags=.pm...F.C
445764	2024-02-16 15:00:31.300	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2906, FN=0, Flags=.pm...F.C
445765	2024-02-16 15:00:31.300	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2907, FN=0, Flags=.pm...F.C
445875	2024-02-16 15:00:31.401	0.101	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=886, FN=0, Flags=...
445877	2024-02-16 15:00:31.402	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2908, FN=0, Flags=.pm...F.C
445878	2024-02-16 15:00:31.402	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2909, FN=0, Flags=.pm...F.C
445879	2024-02-16 15:00:31.402	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2910, FN=0, Flags=.pm...F.C
445880	2024-02-16 15:00:31.402	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2911, FN=0, Flags=.pm...F.C
445881	2024-02-16 15:00:31.402	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2912, FN=0, Flags=.pm...F.C
445882	2024-02-16 15:00:31.403	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2913, FN=0, Flags=.pm...F.C
445983	2024-02-16 15:00:31.503	0.099	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=887, FN=0, Flags=...
445988	2024-02-16 15:00:31.504	0.001	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2914, FN=0, Flags=.pm...F.C
445989	2024-02-16 15:00:31.505	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2915, FN=0, Flags=.pm...F.C
445990	2024-02-16 15:00:31.505	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2916, FN=0, Flags=.pm...F.C
445991	2024-02-16 15:00:31.505	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2917, FN=0, Flags=.pm...F.C
445992	2024-02-16 15:00:31.506	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2918, FN=0, Flags=.pm...F.C

However, at the times of the jitter, the AP was switching to multicast delivery in real-time, i.e. close to 1 frame per 20ms. Moreover, the beacons were also announcing to the BSS that no multicast frames were buffered for clients, i.e. Multicast bit of the Bitmap control within the TIM Information Element was set to '0'. A column was added to show this as T/F.

(wlan.da == 01:00:5e:7d:1a && wlan.ta == 88:9c:ad:7a:11:83) (wlan.bssid == 88:9c:ad:7a:11:83 && wlan.fc.type_subtype == 8)							
Frame	Time	Delta	Source	Destination	BSSID	Multicast	Info
446192	2024-02-16 15:00:31.707	0.099	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=889, FN=0, Flags=...
446194	2024-02-16 15:00:31.708	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2925, FN=0, Flags=.pm...F.C
446195	2024-02-16 15:00:31.708	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2926, FN=0, Flags=.pm...F.C
446196	2024-02-16 15:00:31.709	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2927, FN=0, Flags=.pm...F.C
446197	2024-02-16 15:00:31.709	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2928, FN=0, Flags=.pm...F.C
446221	2024-02-16 15:00:31.725	0.016	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2929, FN=0, Flags=.pm...F.C
446236	2024-02-16 15:00:31.741	0.015	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2930, FN=0, Flags=.pm...F.C
446252	2024-02-16 15:00:31.752	0.010	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2931, FN=0, Flags=.pm...F.C
446270	2024-02-16 15:00:31.769	0.017	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2932, FN=0, Flags=.pm...F.C
446288	2024-02-16 15:00:31.789	0.019	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2933, FN=0, Flags=.pm...F.C
446321	2024-02-16 15:00:31.811	0.022	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	False	Beacon frame, SN=890, FN=0, Flags=...
446333	2024-02-16 15:00:31.818	0.007	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2934, FN=0, Flags=.pm...F.C
446355	2024-02-16 15:00:31.843	0.024	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2935, FN=0, Flags=.pm...F.C
446382	2024-02-16 15:00:31.861	0.017	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2936, FN=0, Flags=.pm...F.C
446410	2024-02-16 15:00:31.895	0.034	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2937, FN=0, Flags=.pm...F.C
446411	2024-02-16 15:00:31.898	0.003	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2938, FN=0, Flags=.pm...F.C
446439	2024-02-16 15:00:31.912	0.013	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	False	Beacon frame, SN=891, FN=0, Flags=...
446446	2024-02-16 15:00:31.916	0.003	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2939, FN=0, Flags=.pm...F.C
446465	2024-02-16 15:00:31.938	0.022	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2940, FN=0, Flags=.pm...F.C
446485	2024-02-16 15:00:31.952	0.013	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2941, FN=0, Flags=.pm...F.C
446496	2024-02-16 15:00:31.969	0.016	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2942, FN=0, Flags=.pm...F.C
446506	2024-02-16 15:00:31.985	0.016	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2943, FN=0, Flags=.pm...F.C
446559	2024-02-16 15:00:32.015	0.029	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	False	Beacon frame, SN=892, FN=0, Flags=...
446574	2024-02-16 15:00:32.022	0.007	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2944, FN=0, Flags=.pm...F.C
446677	2024-02-16 15:00:32.117	0.094	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=893, FN=0, Flags=...
446684	2024-02-16 15:00:32.119	0.002	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2946, FN=0, Flags=.pm...F.C
446685	2024-02-16 15:00:32.119	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2947, FN=0, Flags=.pm...F.C
446686	2024-02-16 15:00:32.120	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2948, FN=0, Flags=.pm...F.C
446687	2024-02-16 15:00:32.120	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2949, FN=0, Flags=.pm...F.C
446688	2024-02-16 15:00:32.120	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2950, FN=0, Flags=.pm...F.C
446818	2024-02-16 15:00:32.219	0.098	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=894, FN=0, Flags=...
446825	2024-02-16 15:00:32.221	0.001	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2951, FN=0, Flags=.pm...F.C
446826	2024-02-16 15:00:32.221	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2952, FN=0, Flags=.pm...F.C
446827	2024-02-16 15:00:32.222	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2953, FN=0, Flags=.pm...F.C
446828	2024-02-16 15:00:32.222	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2954, FN=0, Flags=.pm...F.C
446829	2024-02-16 15:00:32.223	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2955, FN=0, Flags=.pm...F.C
446990	2024-02-16 15:00:32.322	0.099	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=895, FN=0, Flags=...
446993	2024-02-16 15:00:32.323	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2956, FN=0, Flags=.pm...F.C
446994	2024-02-16 15:00:32.323	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2957, FN=0, Flags=.pm...F.C
446995	2024-02-16 15:00:32.323	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2958, FN=0, Flags=.pm...F.C
446996	2024-02-16 15:00:32.323	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=2959, FN=0, Flags=.pm...F.C

Multiple instances of this would found throughout the packet capture.

(wlan.da == 01:00:5e:7e:fd:1a && wlan.ta == 88:9c:ad:7a:11:83) (wlan.bssid == 88:9c:ad:7a:11:83 && wlan.fc.type_subtype == 8)										+	BA	BART	Roam	BS2N	BS2	BC
Frame	Time	Delta	Source	Destination	BSSID	Multicast	Info									
467527	2024-02-16 15:00:47.075	0.003	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3715, FN=0, Flags=pm...F.C									
467689	2024-02-16 15:00:47.170	0.095	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=1040, FN=0, Flags=...									
467706	2024-02-16 15:00:47.173	0.002	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3716, FN=0, Flags=pm...F.C									
467707	2024-02-16 15:00:47.173	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3717, FN=0, Flags=pm...F.C									
467708	2024-02-16 15:00:47.173	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3718, FN=0, Flags=pm...F.C									
467709	2024-02-16 15:00:47.173	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3719, FN=0, Flags=pm...F.C									
467710	2024-02-16 15:00:47.176	0.002	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3720, FN=0, Flags=pm...F.C									
467715	2024-02-16 15:00:47.180	0.003	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3721, FN=0, Flags=pm...F.C									
467726	2024-02-16 15:00:47.197	0.017	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3722, FN=0, Flags=pm...F.C									
467747	2024-02-16 15:00:47.214	0.017	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3723, FN=0, Flags=pm...F.C									
467770	2024-02-16 15:00:47.234	0.019	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3724, FN=0, Flags=pm...F.C									
467781	2024-02-16 15:00:47.252	0.018	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3725, FN=0, Flags=pm...F.C									
467798	2024-02-16 15:00:47.269	0.016	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3726, FN=0, Flags=pm...F.C									
467810	2024-02-16 15:00:47.273	0.003	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	False	Beacon frame, SN=1041, FN=0, Flags=...									
467842	2024-02-16 15:00:47.287	0.014	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3727, FN=0, Flags=pm...F.C									
467893	2024-02-16 15:00:47.323	0.036	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3728, FN=0, Flags=pm...F.C									
467916	2024-02-16 15:00:47.340	0.016	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3729, FN=0, Flags=pm...F.C									
467924	2024-02-16 15:00:47.358	0.017	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3730, FN=0, Flags=pm...F.C									
467951	2024-02-16 15:00:47.375	0.017	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	False	Beacon frame, SN=1042, FN=0, Flags=...									
468063	2024-02-16 15:00:47.477	0.102	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=1043, FN=0, Flags=...									
468071	2024-02-16 15:00:47.480	0.002	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3731, FN=0, Flags=pm...F.C									
468072	2024-02-16 15:00:47.480	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3732, FN=0, Flags=pm...F.C									
468073	2024-02-16 15:00:47.480	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3733, FN=0, Flags=pm...F.C									
468074	2024-02-16 15:00:47.480	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3734, FN=0, Flags=pm...F.C									
468075	2024-02-16 15:00:47.481	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3735, FN=0, Flags=pm...F.C									
468076	2024-02-16 15:00:47.481	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=3736, FN=0, Flags=pm...F.C									
468190	2024-02-16 15:00:47.580	0.098	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=1044, FN=0, Flags=...									

(wlan.da == 01:00:5e:7e:fd:1a && wlan.ta == 88:9c:ad:7a:11:83) (wlan.bssid == 88:9c:ad:7a:11:83 && wlan.fc.type_subtype == 8)											+	BA	BART	Roam	BS2N	BS2	BD4
Frame	Time	Delta	Source	Destination	BSSID	Multicast	Info										
480003	2024-02-16 15:00:56.491	0.002	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=96, FN=0, Flags=pm...F.C										
480004	2024-02-16 15:00:56.491	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=97, FN=0, Flags=pm...F.C										
480005	2024-02-16 15:00:56.492	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=98, FN=0, Flags=pm...F.C										
480006	2024-02-16 15:00:56.492	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=99, FN=0, Flags=pm...F.C										
480007	2024-02-16 15:00:56.492	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=100, FN=0, Flags=pm...F.C										
480313	2024-02-16 15:00:56.591	0.098	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=1132, FN=0, Flags=...										
480325	2024-02-16 15:00:56.593	0.001	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=101, FN=0, Flags=pm...F.C										
480326	2024-02-16 15:00:56.593	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=102, FN=0, Flags=pm...F.C										
480327	2024-02-16 15:00:56.593	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=103, FN=0, Flags=pm...F.C										
480328	2024-02-16 15:00:56.594	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=104, FN=0, Flags=pm...F.C										
480329	2024-02-16 15:00:56.594	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=105, FN=0, Flags=pm...F.C										
480331	2024-02-16 15:00:56.594	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=107, FN=0, Flags=pm...F.C										
480556	2024-02-16 15:00:56.673	0.079	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=108, FN=0, Flags=p...F.C										
480557	2024-02-16 15:00:56.674	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=109, FN=0, Flags=p...F.C										
480560	2024-02-16 15:00:56.675	0.001	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=110, FN=0, Flags=p...F.C										
480591	2024-02-16 15:00:56.684	0.008	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=111, FN=0, Flags=p...F.C										
480619	2024-02-16 15:00:56.694	0.009	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	False	Beacon frame, SN=1133, FN=0, Flags=...										
480641	2024-02-16 15:00:56.701	0.007	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=112, FN=0, Flags=p...F.C										
480762	2024-02-16 15:00:56.718	0.016	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=113, FN=0, Flags=p...F.C										
480818	2024-02-16 15:00:56.736	0.018	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=114, FN=0, Flags=p...F.C										
480954	2024-02-16 15:00:56.772	0.036	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=116, FN=0, Flags=p...F.C										
481033	2024-02-16 15:00:56.791	0.019	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=117, FN=0, Flags=p...F.C										
481051	2024-02-16 15:00:56.796	0.004	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	False	Beacon frame, SN=1134, FN=0, Flags=...										
481087	2024-02-16 15:00:56.807	0.011	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=118, FN=0, Flags=p...F.C										
481145	2024-02-16 15:00:56.827	0.019	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=119, FN=0, Flags=p...F.C										
481275	2024-02-16 15:00:56.863	0.036	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=120, FN=0, Flags=p...F.C										
481358	2024-02-16 15:00:56.881	0.017	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=121, FN=0, Flags=p...F.C										
481459	2024-02-16 15:00:56.899	0.017	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	False	Beacon frame, SN=1135, FN=0, Flags=...										
481817	2024-02-16 15:00:57.001	0.102	Cisco_7a:11:83	Broadcast	88:9c:ad:7a:11:83	True	Beacon frame, SN=1136, FN=0, Flags=...										
481829	2024-02-16 15:00:57.003	0.001	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=122, FN=0, Flags=pm...F.C										
481830	2024-02-16 15:00:57.003	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=123, FN=0, Flags=pm...F.C										
481831	2024-02-16 15:00:57.003	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=124, FN=0, Flags=pm...F.C										
481832	2024-02-16 15:00:57.003	0.000	VoceraCo_39:8e:c9	IPv4mcast_7e:fd:1a	88:9c:ad:7a:11:83		Data, SN=125, FN=0, Flags=pm...F.C										

implementation of multicast to unicast conversation over 802.11. Proper multicast to unicast behavior was verified via packet capture.

Conclusion:

Voice over WiFi is challenging to implement and maintain. Many factors go into successful audio delivery and positive customer experience. Multicast Voice over WiFi offers additional challenges to implement based on how multicast is delivered per the 802.11 standard. As shown in this example, even after all settings are tweaked, we can still run into vendor bugs. The best way to uncover these is with over the air packet captures and wireshark analysis.