

A wide-angle photograph of Amalie Arena at sunset. The arena's glass facade reflects the warm orange and yellow light of the setting sun. In the background, two tall, modern skyscrapers rise against a sky filled with soft, wispy clouds. The foreground shows a body of water, likely Lake Eola, which perfectly mirrors the arena, the buildings, and the sky. The overall atmosphere is serene and picturesque.

Amalie Arena

2022 Stanley Cup Finals (Game 4) - User Experience (AT&T, Verizon and T-Mobile)

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Overview and Testing Methodology

- MobileNet Services was tasked with testing mobile data user experience inside Amalie Arena during The Stanley Cup Finals – Game 4 (June 22nd, 2022) for the 2022 season. Attendance for the game was 19,092.
- Stationary comparative testing was opted over walk testing as most users are stationary as well as due to the difficulty of performing repeatable walks of the entire venue throughout the game.
- Six locations were chosen for testing before, during and after the game to compare how the performance varied throughout the game.

Testing Methodology

- The six locations were tested across Levels 100, 200 and 300 – (see slide 6 for details).
- Testing was performed with AT&T, Verizon and T-Mobile phones.
- Testing comprised of consecutive FTP download (DL) and upload (UL) tasks using FTP servers dedicated to each operator.
- Two Test Engineers performed the testing, collecting data during various timeframes throughout the game (see slide 6 for details).

Test Equipment

- Testing was performed using InfoVista Pocket TEMS
- Samsung Galaxy S20's were used for testing.
- Engineering SIM's were used for all three operators.
- Testing was performed simultaneously by each tester.

Test Locations



Testing Times

Testing was performed for each of the six locations outlined during the following times:

1. Empty (Morning)
2. Pre-game
3. 1st Period
4. 1st Break
5. 2nd Period
6. 2nd Break
7. 3rd Period
8. Post-game

Peak versus Average Throughputs

AT&T	<div>905.26</div> <div>Max of DL Throughput (AT&T) Mbps</div>	<div>32.25</div> <div>Average of DL Throughput (AT&T) Mbps</div>	<div>170.82</div> <div>Max of UL Throughput (AT&T) Mbps</div>	<div>10.11</div> <div>Average of UL Throughput (AT&T) Mbps</div>
VZW	<div>236.92</div> <div>Max of DL Throughput (VzW) - Mbps</div>	<div>30.87</div> <div>Average of DL Throughput (VzW) - Mbps</div>	<div>66.89</div> <div>Max of UL Throughput (VzW) - Mbps</div>	<div>16.39</div> <div>Average of UL Throughput (VzW) - Mbps</div>
T-Mo	<div>277.50</div> <div>Max of DL Throughput (T-MO) Mbps</div>	<div>41.56</div> <div>Average of DL Throughput (T-MO) Mbps</div>	<div>65.01</div> <div>Max of UL Throughput (T-MO) Mbps</div>	<div>14.80</div> <div>Average of UL Throughput (T-MO) Mbps</div>

Observations

- AT&T had the higher max throughput. Over 3 times that of the other two.
- The average throughput outlines the overall data experience during the event.

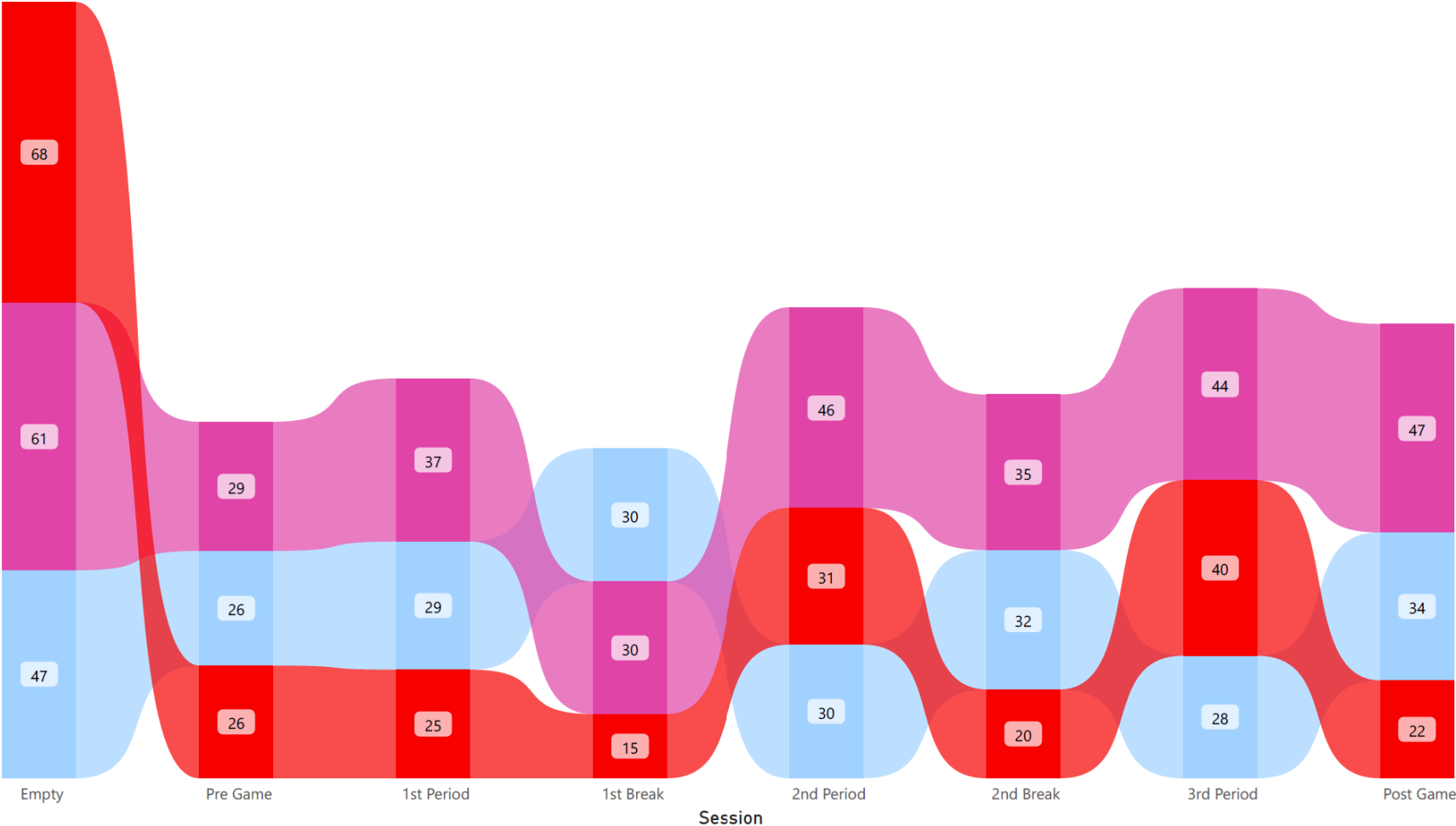
Carrier Aggregation

- During the testing, the following were seen on the UE's:
 - AT&T - 3CA (40 MHz)
 - VzW - 2CA (30 MHz)
 - T-Mo - 2CA (30 MHz) + 5G

Download Throughput Performance Throughout Event

Breakdown of Throughput (Mbps) by Session

● Average of DL Throughput (AT&T) MBps ● Average of DL Throughput (T-MO) MBps ● Average of DL Throughput (VzW) - MBps



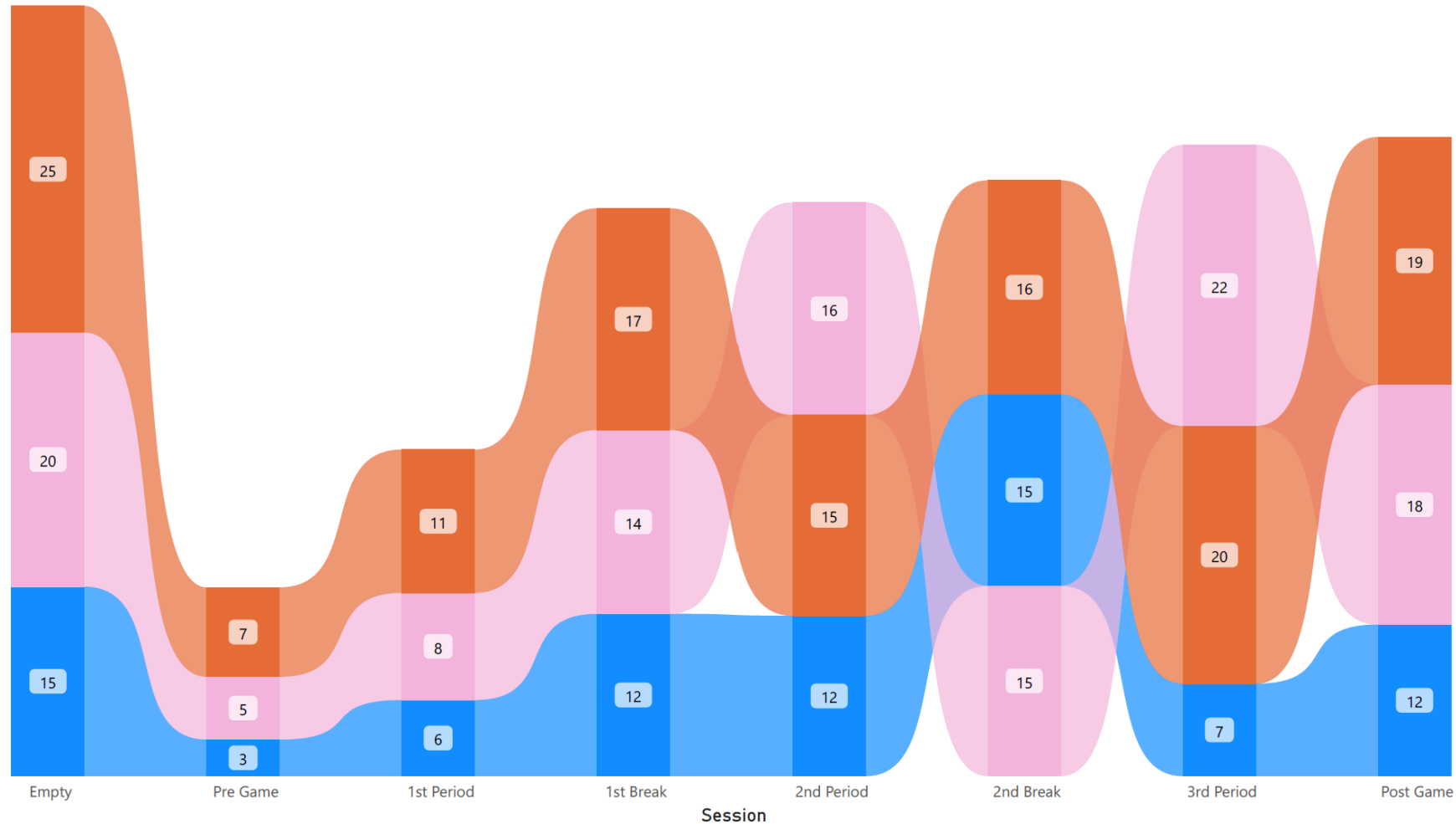
Observations

- T-Mobile’s performance for DL throughput was overall better throughout the event compared to the other two operators.
- The peak data rates were observed when the arena was empty, prior to the game.
- The lowest data rates were experienced during the 1st break.

Upload Throughput Performance Throughout Event

Breakdown of Throughput (Mbps) by Session

● Average of UL Throughput (AT&T) Mbps ● Average of UL Throughput (T-MO) Mbps ● Average of UL Throughput (VZW) - Mbps



Observations

- Verizon had the best overall performance for UL throughput throughout the event.
- UL Throughput for all operators was similar.
- The peak data rates were observed when the arena was empty, prior to the game.
- The lowest data rates were experienced just prior to game starting.

Signal Strength, Quality and Throughput

AT&T

Session	Average of RSRP	Average of SINR	Average of RSRQ	Average of RI	Average of UE Power	Average of DL Throughput (AT&T) MBps	Average of UL Throughput (AT&T) MBps
Empty	-71.47	5.31	-13.16	1.86	-2.18	47.45	14.57
Pre Game	-70.82	5.67	-13.72	1.99	-0.61	26.20	2.81
1st Period	-71.10	5.69	-13.83	1.81	-2.38	29.27	5.85
1st Break	-70.41	4.86	-13.29	1.57	-4.02	30.38	12.48
2nd Period	-73.05	4.72	-14.04	1.80	-5.78	30.49	12.33
2nd Break	-70.99	5.15	-14.19	1.69	-4.60	31.83	14.72
3rd Period	-73.12	6.16	-13.55	1.93	-5.89	27.95	7.10
Post Game	-72.22	6.28	-13.58	1.95	-5.22	33.80	11.65
Total	-71.66	5.48	-13.67	1.83	-3.84	32.25	10.11

VZW

Session	Average of RSRP	Average of SINR	Average of RSRQ	Average of RI	Average of UE Power	Average of DL Throughput (VzW) - Mbps	Average of UL Throughput (VzW) - Mbps
Empty	-76.79	3.92	-15.51	2.03	-11.86	68.49	25.10
Pre Game	-77.37	0.37	-17.89	1.73	-9.45	25.67	6.87
1st Period	-78.20	0.71	-17.68	1.70	-8.68	24.73	11.01
1st Break	-77.15	0.51	-17.22	1.48	-11.37	14.59	17.04
2nd Period	-77.80	1.40	-17.11	1.93	-14.53	31.16	15.44
2nd Break	-78.08	0.50	-18.24	1.58	-10.25	20.23	16.46
3rd Period	-80.40	1.83	-17.20	1.79	-11.63	39.99	19.81
Post Game	-80.08	1.20	-17.12	1.77	-10.86	22.28	19.05
Total	-78.23	1.32	-17.24	1.75	-11.08	30.87	16.39

T-Mo

Session	Average of RSRP	Average of SINR	Average of RSRQ	Average of RI	Average of UE Power	Average of DL Throughput (T-MO) Mbps	Average of UL Throughput (T-MO) Mbps
Empty	-85.03	3.80	-13.27	1.95	-4.42	60.93	19.55
Pre Game	-75.65	5.69	-14.83	1.98	-5.52	29.43	4.83
1st Period	-83.39	1.77	-15.17	1.98	-2.59	37.17	8.25
1st Break	-81.64	3.59	-14.65	1.88	-1.37	30.26	14.15
2nd Period	-81.72	4.63	-14.19	1.99	-3.04	45.58	16.35
2nd Break	-80.75	2.73	-15.40	1.78	-2.98	35.45	14.63
3rd Period	-77.43	6.18	-14.25	1.98	-0.06	43.63	21.63
Post Game	-83.69	3.38	-14.55	1.91	-5.26	47.37	18.45
Total	-81.38	3.79	-14.52	1.93	-3.21	41.56	14.80

Summary

- T-Mobile had the best overall performance.
 - With average values above 66Mbps and 16Mbps for DL and UL.
- AT&T had the best max throughput
 - 3 times that of the other two.
- The best performance for all three networks were observed when the venue had the least number of users (pre-game).

Thank You

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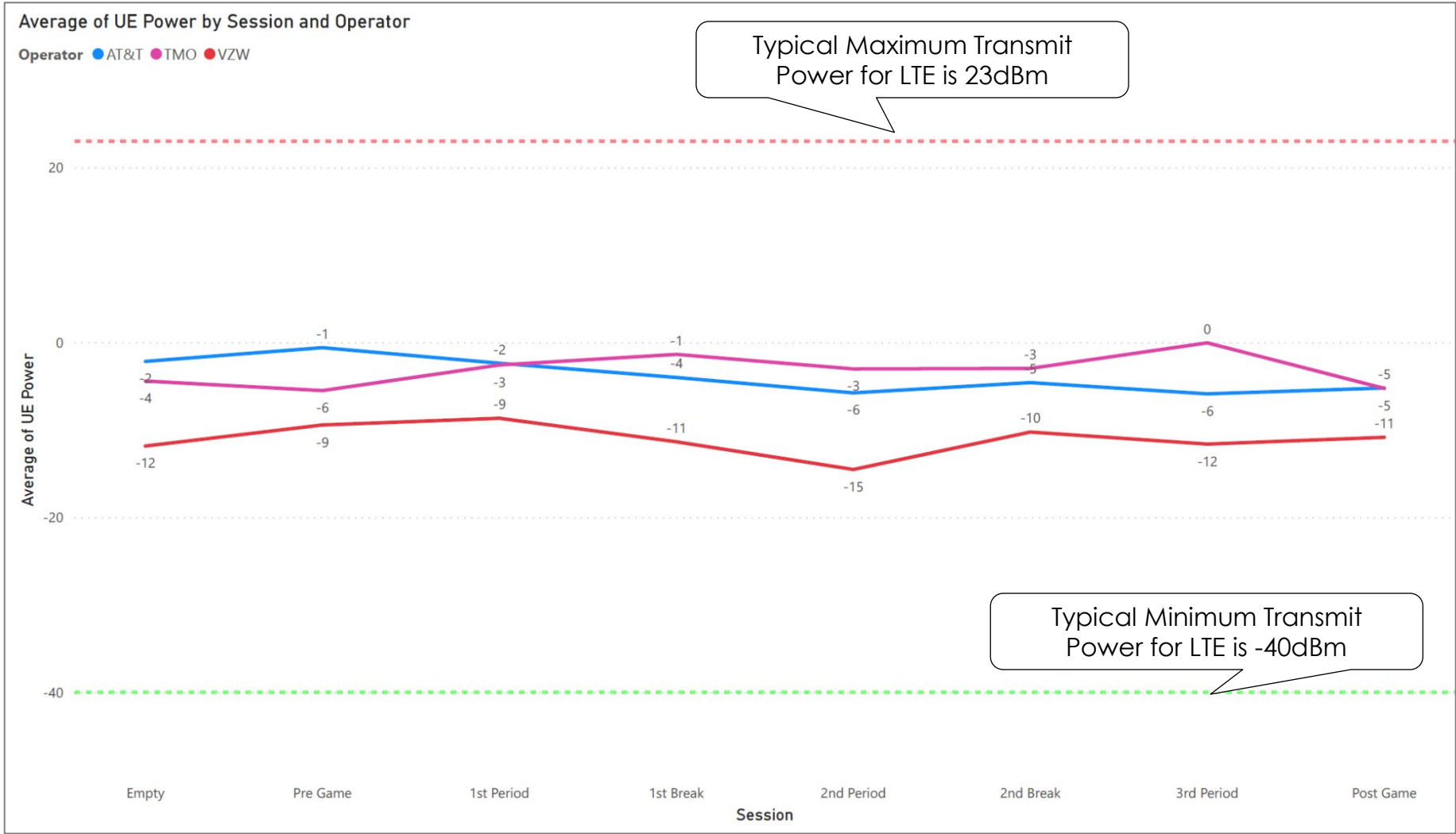


**MobileNet
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Additional Slides

UE Transmit Power



Observations

- The UE transmit powers for the all the operators were similar

SINR and MCS

AT&T

Session	Average of SINR	Median of DL MCS	Average of UL Throughput (AT&T) MBps	Median of UL MCS	Average of DL Throughput (AT&T) MBps
1st Break	4.86	9	12.48	11	30.38
1st Period	5.69	10	5.85	10	29.27
2nd Break	5.15	10	14.72	11	31.83
2nd Period	4.72	9	12.33	11	30.49
3rd Period	6.16	12	7.10	11	27.95
Empty	5.31	11	14.57	16	47.45
Post Game	6.28	12	11.65	13	33.80
Pre Game	5.67	10	2.81	8	26.20
Total	5.48	11	10.11	11	32.25

VZW

Session	Average of SINR	Median of DL MCS	Average of DL Throughput (VzW) - Mbps	Median of UL MCS	Average of UL Throughput (VzW) - Mbps
1st Break	0.51	11	14.59	27	17.04
1st Period	0.71	11	24.73	23	11.01
2nd Break	0.50	10	20.23	22	16.46
2nd Period	1.40	12	31.16	25	15.44
3rd Period	1.83	11	39.99	24	19.81
Empty	3.92	14	68.49	27	25.10
Post Game	1.20	11	22.28	23	19.05
Pre Game	0.37	11	25.67	20	6.87
Total	1.32	11	30.87	23	16.39

T-Mo

Session	Average of SINR	Median of DL MCS	Average of DL Throughput (T-MO) Mbps	Median of UL MCS	Average of UL Throughput (T-MO) Mbps
1st Break	3.59	13	30.26	17	14.15
1st Period	1.77	12	37.17	16	8.25
2nd Break	2.73	14	35.45	17	14.63
2nd Period	4.63	13	45.58	17	16.35
3rd Period	6.18	13	43.63	18	21.63
Empty	3.80	14	60.93	20	19.55
Post Game	3.38	12	47.37	18	18.45
Pre Game	5.69	12	29.43	13	4.83
Total	3.79	13	41.56	17	14.80

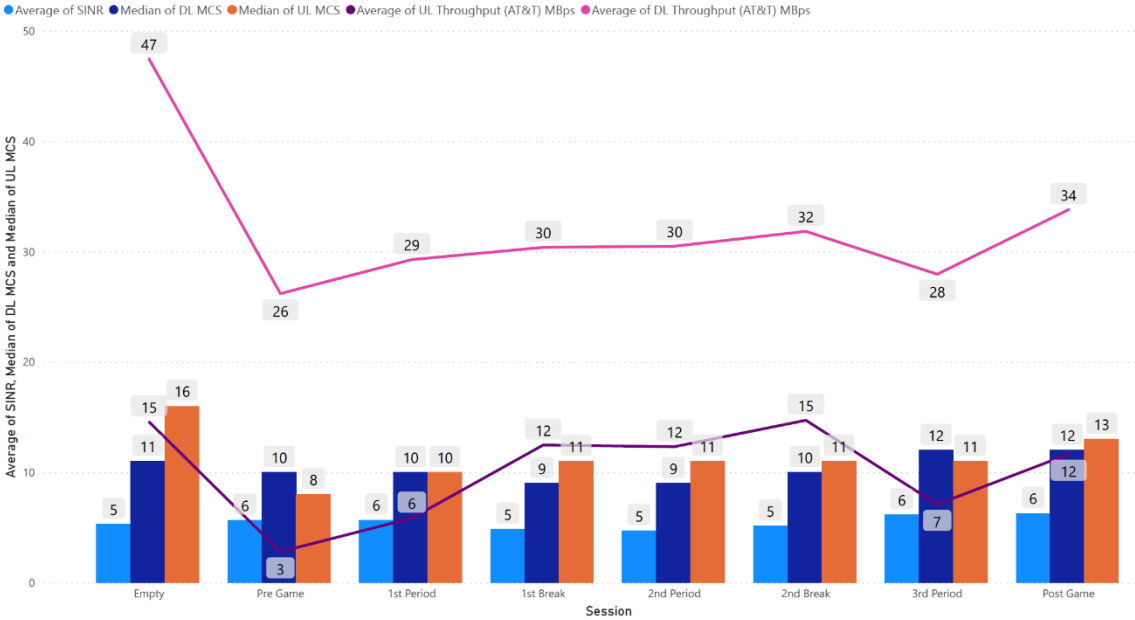
Observations

- Comparing SINR, Throughput and MCS (Modulation and Coding Scheme) Index, we can see that for all three operators, DL MCS Index Mean was 9 or better throughout the game.
- The higher order modulation impact can be seen in the Throughput values throughout the game.

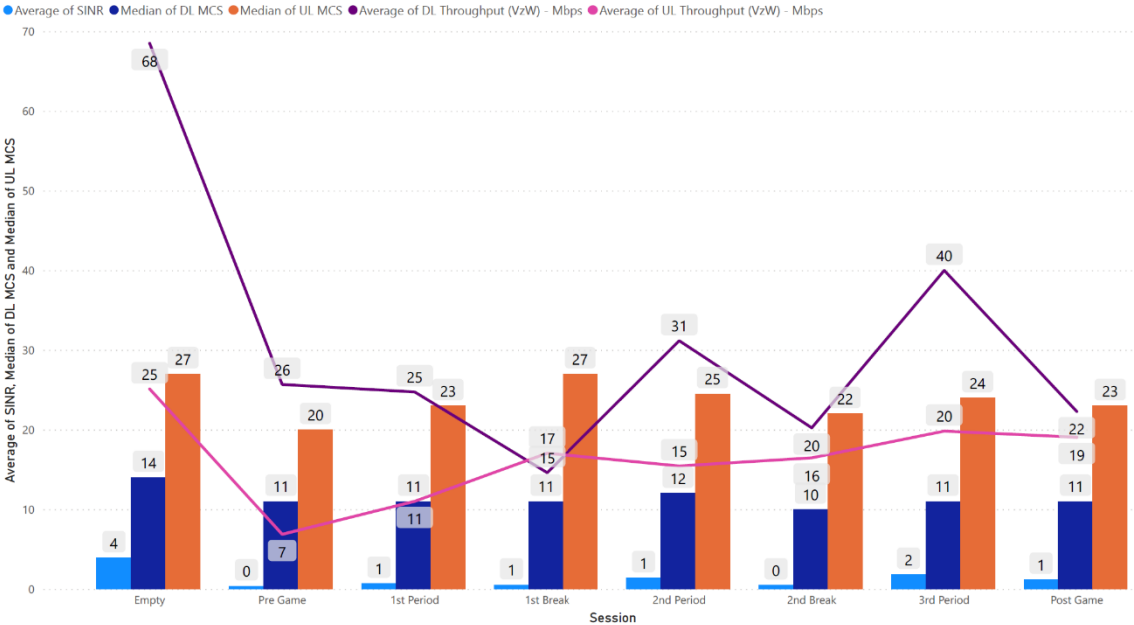


SINR and MCS (contd.)

AT&T SINR, MCS Index and Thput Breakdown

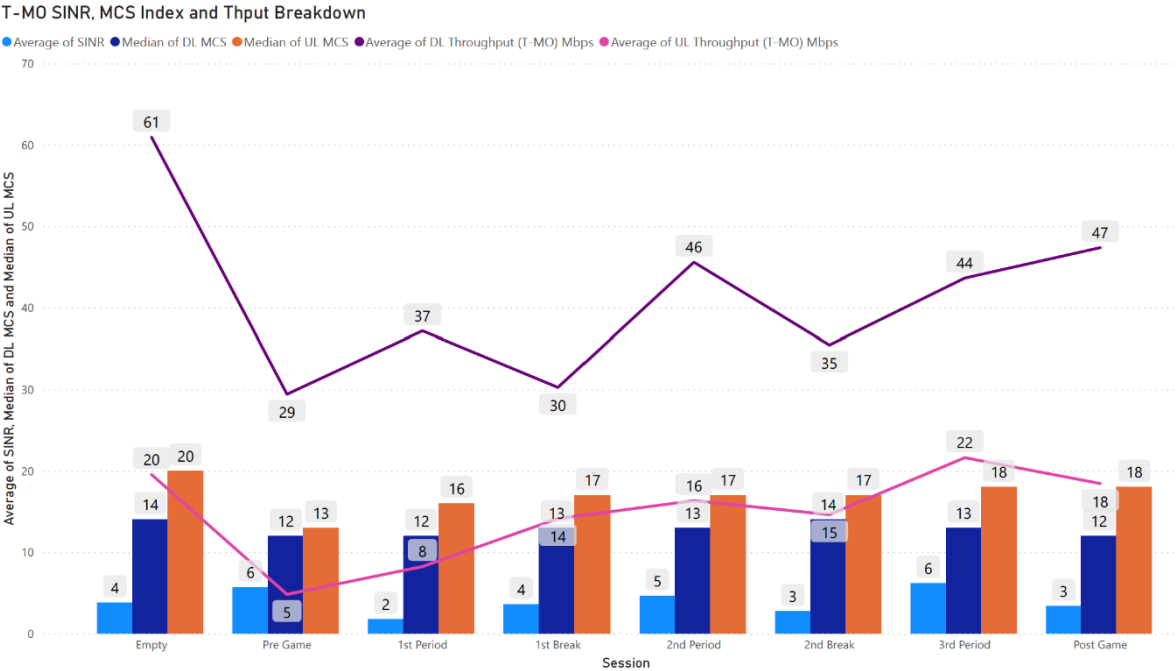


VzW SINR, MCS Index and Thput Breakdown



The plots above outline the interaction of the various KPI's that impact throughput (SINR, MCS Index, and throughput)

SINR and MCS (contd.)



The plots above outline the interaction of the various KPI's that impact throughput (SINR, MCS Index, and throughput)