



DKR Texas Memorial Stadium

October 16th 2021 Home Game - 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 The DKR Texas Memorial Stadium during the October 16th, 2021 home game against Oklahoma State. Attendance for the game was 99,916.
- 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 and Setup

- Six locations were tested (see slide 6 for details).
- Testing was performed using AT&T, Verizon and T-Mo phones.
- Testing comprised of consecutive FTP download (DL) and upload (UL) tasks on FTP servers dedicated to each operator.
- The AT&T and T-Mobile UE (phone) testing alternated between LTE and 5G. The VZW UE was on LTE only, as 5G was not deployed for VZW in the Stadium during testing.
- 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 TEMS.
- Samsung Galaxy S20's with Engineering SIMs were used for the testing.
- Testing was performed simultaneously by each tester.

Test Locations



Testing Times

Testing performed for each of the 6 locations shown on the left during the following times:

1. Empty
2. Pre-game
3. 1st Quarter
4. 1st Break
5. 2nd Quarter
6. Half-time
7. 3rd Quarter
8. 3rd Break
9. 4th Quarter
10. Post-game

Peak versus Average Throughputs

AT&T	<div>308.25</div> <div>Max of AT&T DL Thput (Mbps)</div>	<div>60.57</div> <div>Average of AT&T DL Thput (Mbps)</div>	<div>38.91</div> <div>Max of AT&T UL Thput (Mbps)</div>	<div>17.01</div> <div>Average of AT&T UL Thput (Mbps)</div>
VZW	<div>173.17</div> <div>Max of VzW DL Thput (Mbps)</div>	<div>21.61</div> <div>Average of VzW DL Thput (Mbps)</div>	<div>26.65</div> <div>Max of VzW UL Thput (Mbps)</div>	<div>7.49</div> <div>Average of VzW UL Thput (Mbps)</div>
T-Mo	<div>309.11</div> <div>Max of T-Mo DL Thput (Mbps)</div>	<div>76.64</div> <div>Average of T-Mo DL Thput (Mbps)</div>	<div>38.95</div> <div>Max of T-Mo UL Thput (Mbps)</div>	<div>19.31</div> <div>Average of T-Mo UL Thput (Mbps)</div>

Observations

- AT&T and T-Mobile Ue's were able to achieve peak DL throughput over 300 Mbps.
- The average throughput outlines the overall data experience during the event.

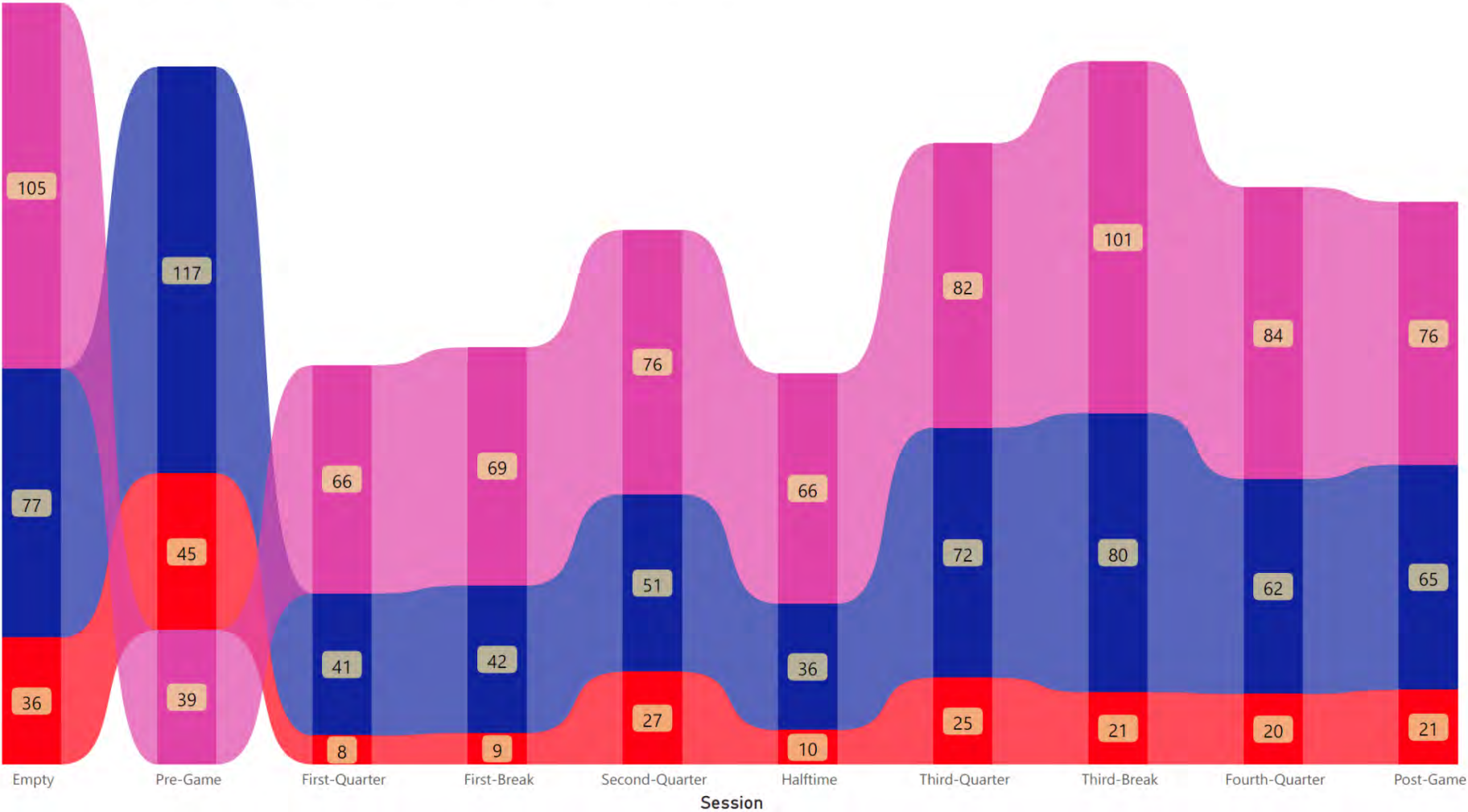
Carrier Aggregation

- During the testing, the following were seen on the UE's:
 - AT&T - 3CA (40 MHz) + 5G
 - VzW - 2CA (20 MHz)
 - T-Mo - 2CA (40 MHz) + 5G

Download Throughput Performance Throughout Event

Breakdown of Throughput (Mbps) by Session

● Average of AT&T DL Thput (Mbps) ● Average of VzW DL Thput (Mbps) ● Average of T-Mo DL Thput (Mbps)



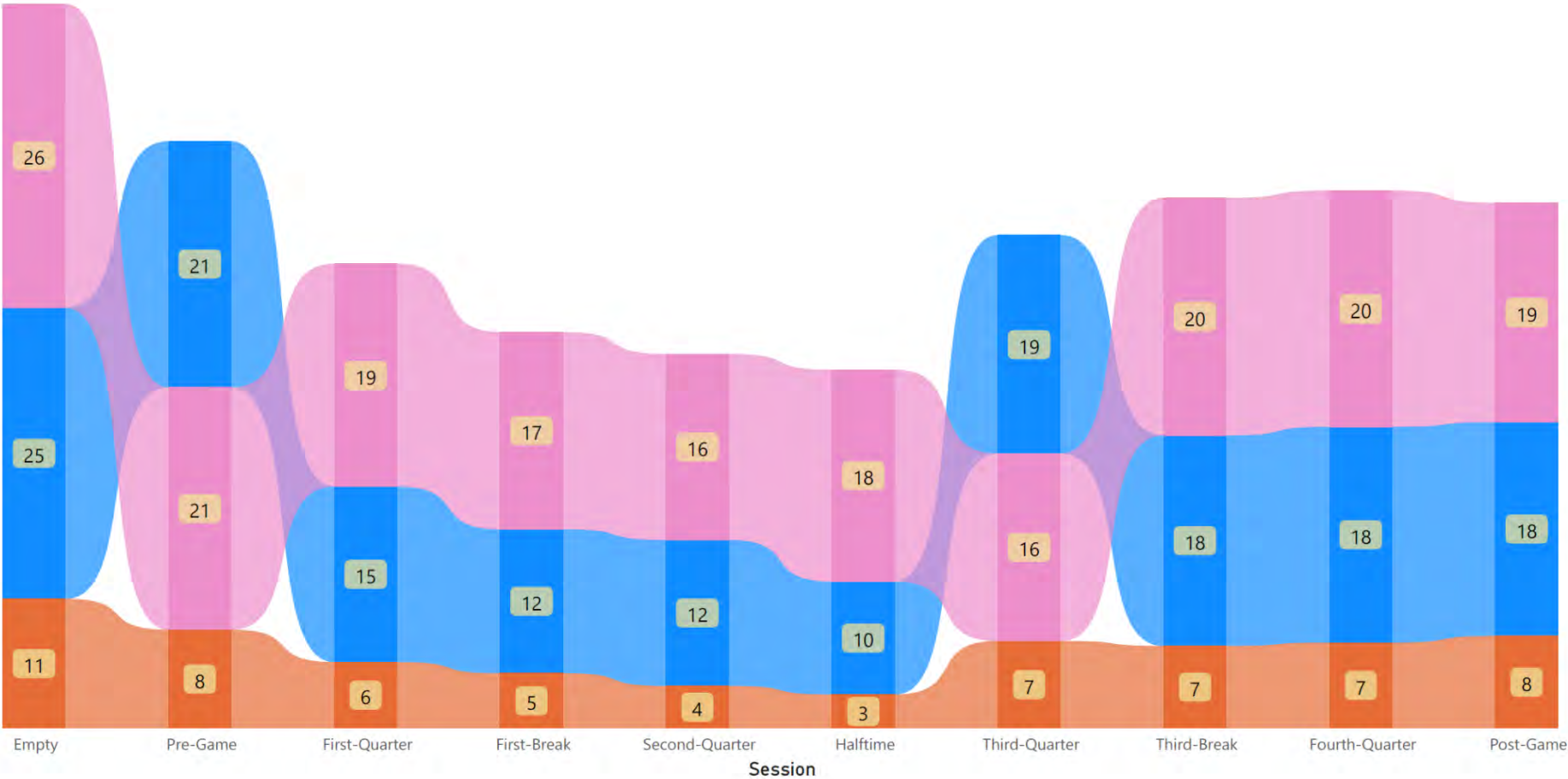
Observations

- T-Mobile and AT&T's performance (both DL and UL) was significantly better throughout the event compared to Verizon.
- The peak data rates were observed when the arena was empty, prior to the game.
- The lowest data rates were experienced during half-time.

Upload Throughput Performance Throughout Event

Breakdown of Throughput (Mbps) by Session

● Average of AT&T UL Thput (Mbps) ● Average of VzW UL Thput (Mbps) ● Average of T-Mo UL Thput (Mbps)



Observations

- T-Mobile and AT&T's performance (both DL and UL) was significantly better throughout the event compared to Verizon.
- 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 during half-time.

Signal Strength, Quality and Throughput

AT&T

Session	Operator	Average of RSRP	Average of RSRQ	Average of SINR	Average of RI	Average of UE Power (PUSCH)	Average of App_Throughput_DL (Mbps)	Average of App_Throughput_UL (Mbps)
Empty	AT&T	-78.76	-12.35	4.58	1.52	-4.78	76.85	24.02
Pre-Game	AT&T	-78.60	-10.28	6.94	1.92	-4.72	116.27	21.00
First-Quarter	AT&T	-77.34	-10.11	9.00	1.88	-5.41	39.90	11.77
First-Break	AT&T	-78.37	-10.04	7.34	1.88	-5.04	41.64	11.75
Second-Quarter	AT&T	-79.92	-10.59	7.79	1.90	-5.58	49.19	9.49
Halftime	AT&T	-79.13	-10.38	7.38	1.90	-6.68	35.10	9.31
Third-Quarter	AT&T	-76.70	-9.31	10.03	1.81	-9.49	71.79	18.63
Third-Break	AT&T	-76.00	-9.39	10.74	1.89	-7.16	79.58	17.86
Fourth-Quarter	AT&T	-76.39	-9.25	10.48	1.90	-9.11	61.70	18.48
Post-Game	AT&T	-76.33	-9.16	10.44	1.87	-10.34	64.47	17.85
Total		-77.78	-10.12	8.41	1.84	-6.92	59.71	16.10

Verizon

Session	Operator	Average of RSRP	Average of RSRQ	Average of SINR	Average of RI	Average of UE Power (PUSCH)	Average of App_Throughput_DL (Mbps)	Average of App_Throughput_UL (Mbps)
Empty	VZW	-75.62	-13.01	4.34	1.62	-12.60	36.36	11.05
Pre-Game	VZW	-79.59	-12.14	5.42	1.94	-9.71	44.96	8.37
First-Quarter	VZW	-74.74	-13.59	6.12	1.65	-11.73	7.54	1.30
First-Break	VZW	-76.09	-13.88	4.87	1.54	-12.61	8.43	2.03
Second-Quarter	VZW	-72.64	-13.77	9.10	1.57	-21.47	25.11	1.72
Halftime	VZW	-74.31	-13.84	7.23	1.47	-13.86	8.24	1.02
Third-Quarter	VZW	-80.62	-13.34	4.82	1.74	-5.87	24.70	6.89
Third-Break	VZW	-77.78	-13.26	6.73	1.71	-8.53	20.60	6.37
Fourth-Quarter	VZW	-77.77	-12.73	5.86	1.63	-6.66	20.12	6.74
Post-Game	VZW	-74.33	-12.09	9.72	1.76	-11.50	21.12	6.02
Total		-76.26	-13.22	6.34	1.65	-10.98	20.68	5.25

Signal Strength, Quality and Throughput (contd.)

T-Mobile

Session	Operator	Average of RSRP	Average of RSRQ	Average of SINR	Average of RI	UE Power (PUSCH)	Average of App_Throughput_DL (Mbps)	Average of App_Throughput_UL (Mbps)
Empty	TMO	-75.46	-10.72	6.78	1.75	-15,551.67	104.46	24.83
Pre-Game	TMO	-76.12	-11.37	6.39	1.87	-10,826.18	38.52	20.74
First-Quarter	TMO	-76.01	-10.07	8.26	1.84	-12,416.90	63.72	19.02
First-Break	TMO	-78.66	-10.28	6.97	1.68	-6,968.96	66.90	14.61
Second-Quarter	TMO	-79.65	-10.70	7.71	1.62	-8,548.56	73.81	12.59
Halftime	TMO	-78.83	-10.64	6.77	1.69	-12,750.35	65.18	15.81
Third-Quarter	TMO	-72.85	-9.27	11.99	1.76	-17,454.96	81.76	15.84
Third-Break	TMO	-73.81	-9.12	10.85	1.77	-15,695.45	100.07	20.27
Fourth-Quarter	TMO	-73.94	-9.34	11.14	1.84	-16,937.09	83.74	19.75
Post-Game	TMO	-74.84	-9.30	10.46	1.83	-12,812.10	74.81	18.66
Total		-76.08	-10.07	8.67	1.76	-129,962.22	75.66	18.22



Summary

- AT&T and T-Mobile Ue's performed significantly better for both data DL and UL
 - With average values above 60Mbps and 17Mbps for DL and UL
 - With peak values reaching over 300Mbps for DL and over 60Mbps for UL
- The best performance for all three networks were observed when the venue had the least number of users (Empty / Pre-game).
- The poorest throughput performance for all three networks were observed during halftime.
 - This is possibly due to this period potentially having the highest traffic utilization.

Thank You

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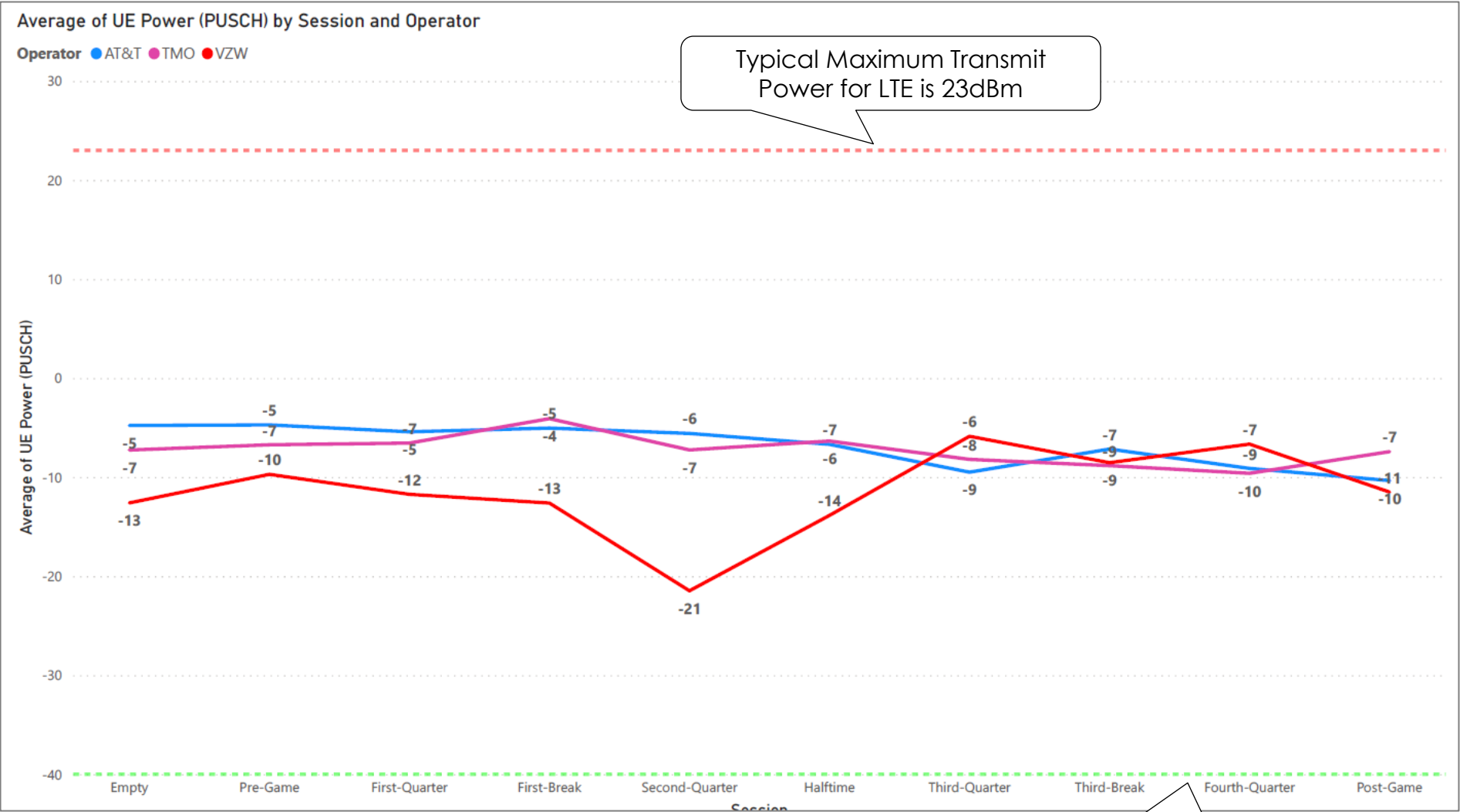


MobileNet
Services



Additional Slides

UE Transmit Power

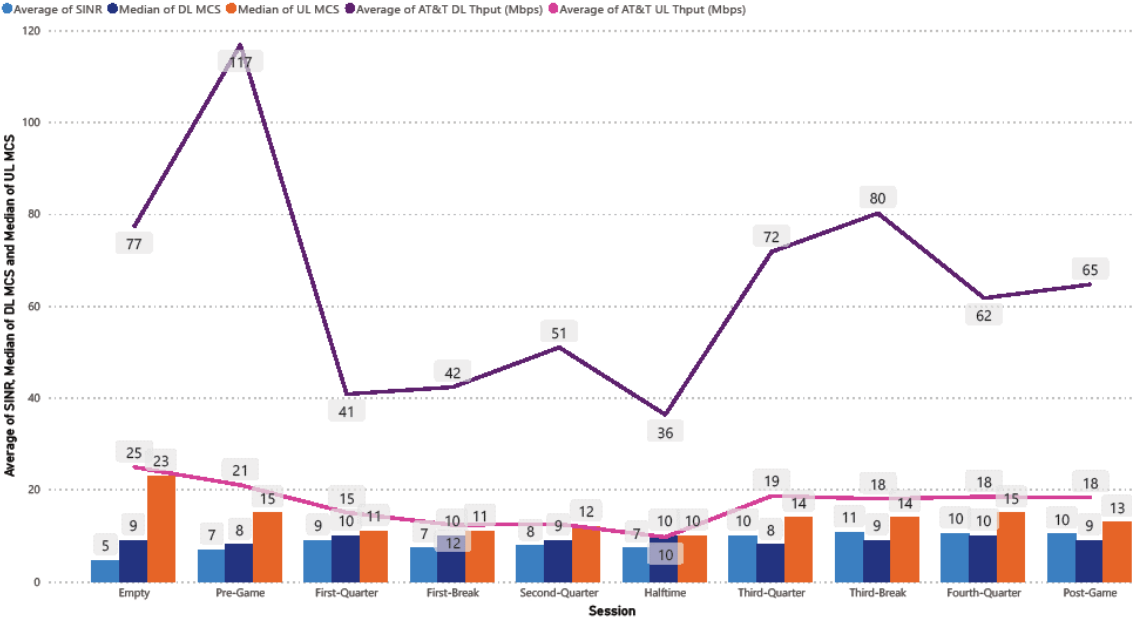


Observations

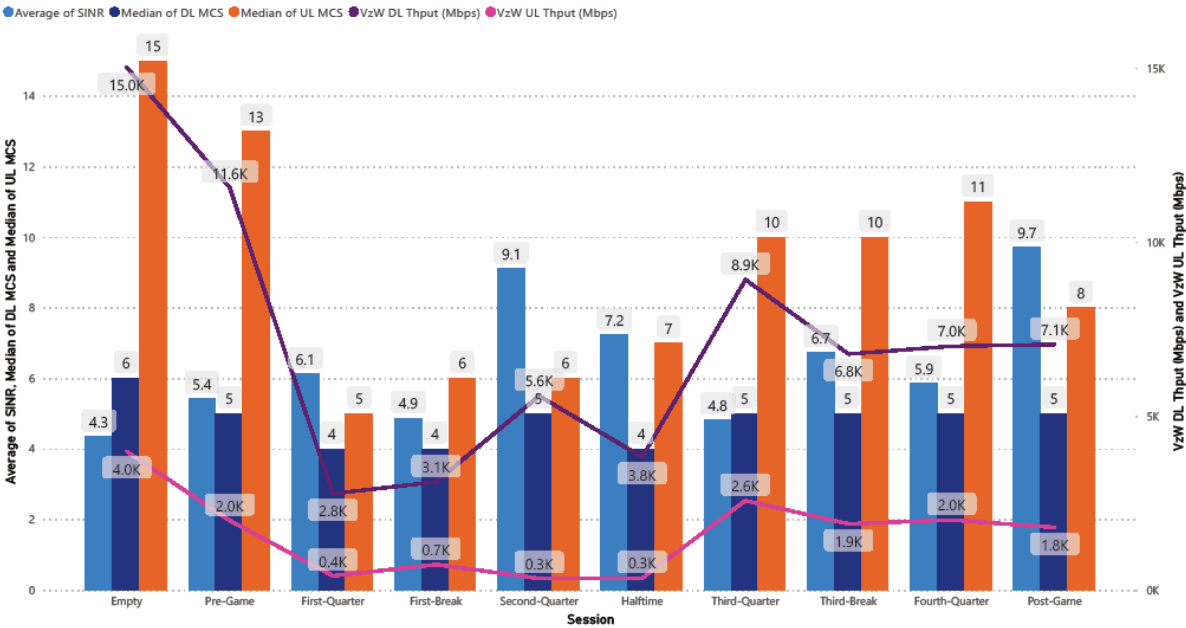
- The UE transmit powers for the all the operators were below 0dBm.

SINR and MCS

AT&T SINR, MCS Index and Thput Breakdown

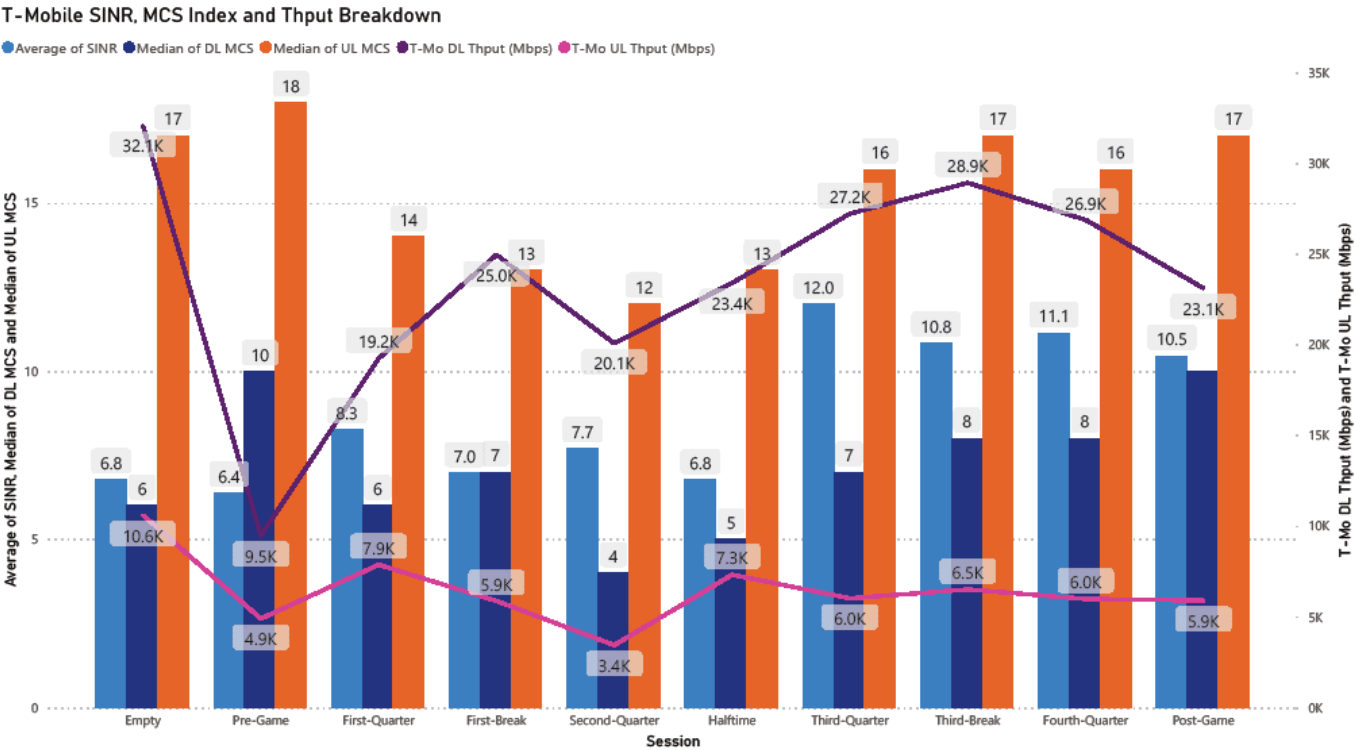


Verizon SINR, MCS Index and Thput Breakdown



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)