ECE 143 Project Presentation
5G Connectivity: Cellular Key Performance Indicators (KPIs) Analysis and Comparison.

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Motivation

- With the cellular development, applications and services utilizing the network has increased along with the need for more bandwidth.

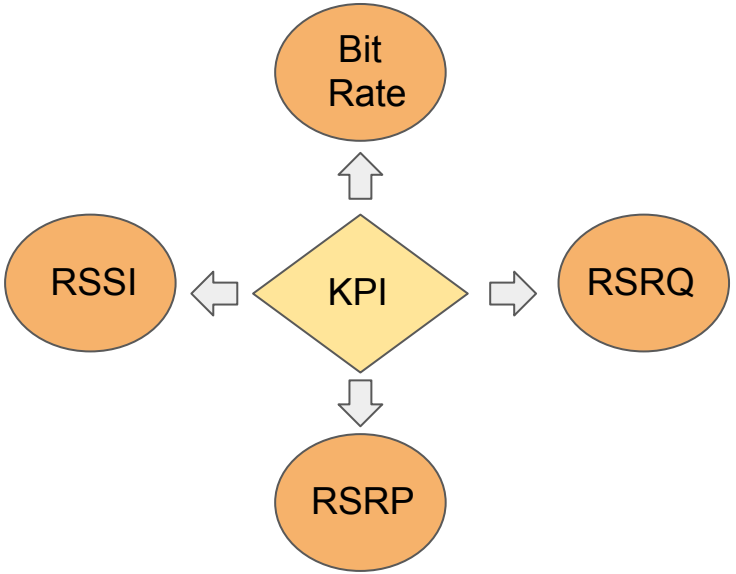
- 5G will provide high data rate, low latency, high connectivity linking many Internet of Things (IoT) applications.

Objective

- The increase in connected devices and multimedia traffic has lead to higher throughput demands
- Analyzing cellular and service data can be beneficial in this regard

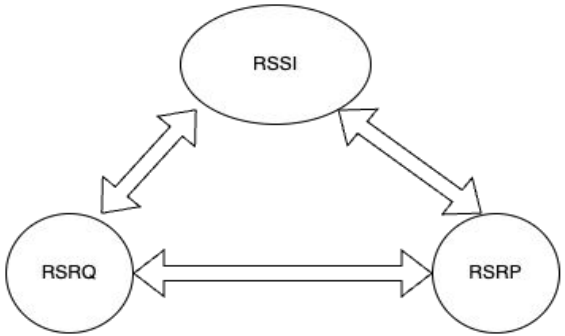
Concept

Various cellular key performance indicators help us understand the **network strength** and **streaming quality**.



Cellular Key Performance Indicator Definitions

- **Downlink Bit Rate**: The rate at which data is transferred from one place to the other through wired or wireless medium.
- **RSSI (Received Signal Strength Indicator)**: A measure of cellular signal strength.
- **RSRP (Reference Signal Received Power)**: The linear average of reference signal power measured over a specified bandwidth.
- **RSRQ (Reference Signal Received Quality)**: It is a measure of the signal quality of a cellular connection.

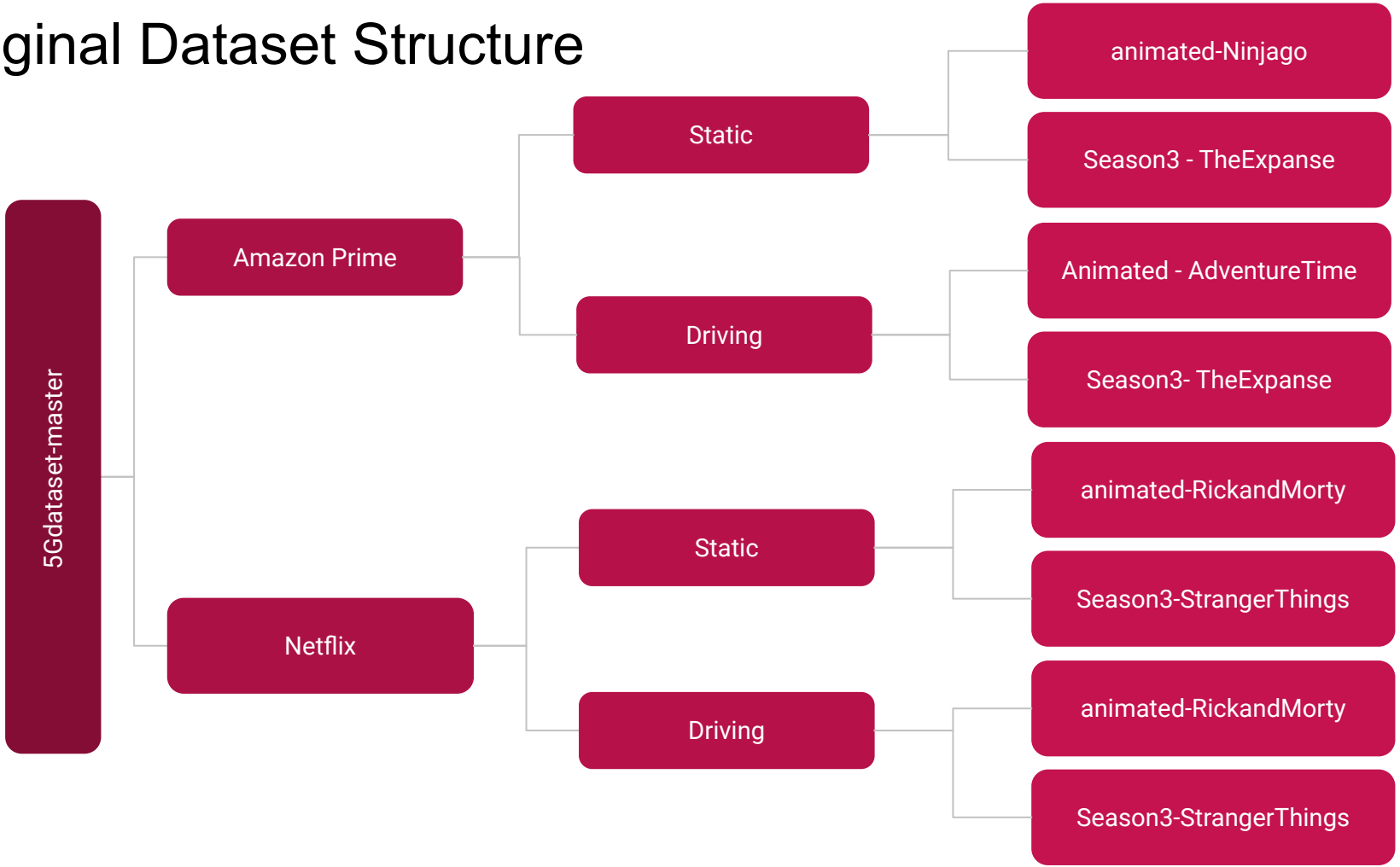


$$RSRQ = \frac{n \times RSRP}{RSSI}$$

Methodology

- Analyze dataset for required fields
- Clean dataset
- Plotting graphs
- Analyzing graphs and inference

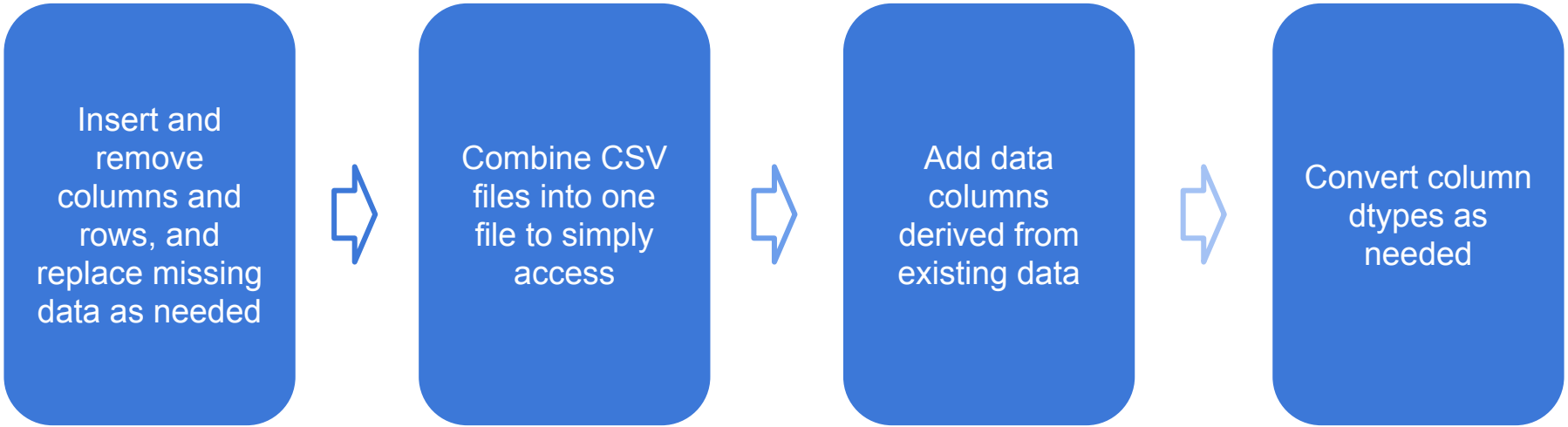
Original Dataset Structure



Timestamp	Longitude	Latitude	Speed	Operatorname	CellID	NetworkMode	RSRP	RSRQ	SNR	CQI	RSSI	DL_bitrate	UL_bitrate	State	PINGAVG	PINGMIN	PINGMAX	PINGSTDEV	PINGLOSS	CELLHEX	NODEHEX	LACHEX	RAWCELLID	NRxRSRP	NRxRSRQ
2019.11.28_07.27.57	-8.388193	51.935608	0	B	12	5G	-102	-10	8.0	14	-	0	0	I	-	-	-	-	-	C	A81B	9CBA	11016972	-102.0	-1.0
2019.11.28_07.27.57	-8.388269000000000	51.935542	1	B	12	5G	-102	-10	8.0	14	-	0	0	I	-	-	-	-	-	C	A81B	9CBA	11016972	-102.0	-1.0
2019.11.28_07.27.58	-8.388269000000000	51.935542	1	B	12	5G	-102	-10	8.0	14	-	0	2	D	-	-	-	-	-	C	A81B	9CBA	11016972	-102.0	-1.0
2019.11.28_07.27.59	-8.388269000000000	51.935542	1	B	12	5G	-102	-10	3.0	14	-	3	2	D	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-3.0
2019.11.28_07.28.00	-8.388269000000000	51.935542	1	B	12	5G	-102	-10	3.0	14	-	9	13	D	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-3.0
2019.11.28_07.28.01	-8.388269000000000	51.935542	1	B	12	5G	-103	-11	6.0	14	-	926	93	D	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-4.0
2019.11.28_07.28.02	-8.388269000000000	51.935542	1	B	12	5G	-103	-11	6.0	14	-	2814	146	D	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-4.0
2019.11.28_07.28.03	-8.388269000000000	51.935542	1	B	12	5G	-100	-11	1.0	14	-	0	0	I	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-5.0
2019.11.28_07.28.04	-8.388269000000000	51.935542	1	B	12	5G	-100	-11	1.0	14	-	1872	165	D	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-5.0
2019.11.28_07.28.05	-8.388269000000000	51.935542	1	B	12	5G	-100	-9	8.0	14	-	23	4	D	-	-	-	-	-	C	A81B	9CBA	11016972	-102.0	-13.0
2019.11.28_07.28.06	-8.388269000000000	51.935542	1	B	12	5G	-100	-9	8.0	14	-	168	17	D	-	-	-	-	-	C	A81B	9CBA	11016972	-102.0	-13.0
2019.11.28_07.28.07	-8.388269000000000	51.935542	1	B	12	5G	-101	-9	11.0	14	-	2719	167	D	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-3.0
2019.11.28_07.28.08	-8.388269000000000	51.935542	1	B	12	5G	-101	-9	11.0	13	-	13321	318	D	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-3.0
2019.11.28_07.28.09	-8.388269000000000	51.935542	1	B	12	5G	-100	-10	12.0	13	-	0	0	I	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-3.0
2019.11.28_07.28.10	-8.388269000000000	51.935542	1	B	12	5G	-100	-10	12.0	13	-	4755	118	D	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-3.0
2019.11.28_07.28.12	-8.388269000000000	51.935542	1	B	12	5G	-100	-9	9.0	13	-	39982	628	D	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-6.0
2019.11.28_07.28.13	-8.388269000000000	51.935542	1	B	12	5G	-100	-9	9.0	13	-	38234	1949	D	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-6.0
2019.11.28_07.28.14	-8.388269000000000	51.935542	1	B	12	5G	-101	-9	9.0	12	-	7677	74	D	-	-	-	-	-	C	A81B	9CBA	11016972	-100.0	-6.0
2019.11.28_07.28.15	-8.388269000000000	51.935542	1	B	12	5G	-101	-9	9.0	12	-	0	0	I	-	-	-	-	-	C	A81B	9CBA	11016972	-100.0	-6.0
2019.11.28_07.28.16	-8.388269000000000	51.935542	1	B	12	5G	-100	-8	6.0	12	-	0	0	I	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-3.0
2019.11.28_07.28.17	-8.388269000000000	51.935542	1	B	12	5G	-100	-8	6.0	12	-	0	0	I	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-3.0
2019.11.28_07.28.18	-8.388269000000000	51.935542	1	B	12	5G	-100	-9	10.0	12	-	0	0	I	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-1.0
2019.11.28_07.28.19	-8.388269000000000	51.935542	1	B	12	5G	-100	-9	10.0	12	-	0	0	I	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-1.0
2019.11.28_07.28.21	-8.388269000000000	51.935542	1	B	12	5G	-99	-10	7.0	12	-	2914	30	D	-	-	-	-	-	C	A81B	9CBA	11016972	-99.0	-2.0
2019.11.28_07.28.22	-8.388269000000000	51.935542	1	B	12	5G	-99	-10	7.0	14	-80	278	6	D	-	-	-	-	-	C	A81B	9CBA	11016972	-99.0	-2.0
2019.11.28_07.28.23	-8.388269000000000	51.935542	1	B	12	5G	-99	-10	10.0	14	-80	0	0	I	-	-	-	-	-	C	A81B	9CBA	11016972	-97.0	0.0
2019.11.28_07.28.24	-8.388269000000000	51.935542	1	B	12	5G	-99	-10	10.0	13	-82	279	8	D	-	-	-	-	-	C	A81B	9CBA	11016972	-97.0	0.0
2019.11.28_07.28.25	-8.388269000000000	51.935542	1	B	12	5G	-99	-13	10.0	13	-82	0	6	D	-	-	-	-	-	C	A81B	9CBA	11016972	-99.0	-2.0
2019.11.28_07.28.26	-8.388269000000000	51.935542	1	B	12	5G	-99	-13	10.0	13	-82	1048	9	D	-	-	-	-	-	C	A81B	9CBA	11016972	-99.0	-2.0
2019.11.28_07.28.27	-8.388269000000000	51.935542	1	B	12	5G	-99	-10	5.0	10	-84	948	25	D	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-2.0
2019.11.28_07.28.28	-8.388269000000000	51.935542	1	B	12	5G	-99	-10	5.0	12	-81	0	0	D	-	-	-	-	-	C	A81B	9CBA	11016972	-101.0	-2.0

Dataset Cleaning

For each of the folders:



How Data was Removed or Replaced

Removed:

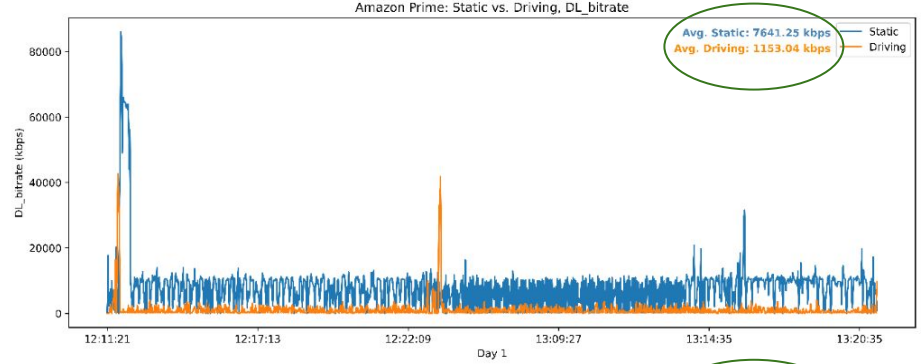
- All rows with idle state (when the device was not downloading)
- All rows with download bitrate below a certain threshold

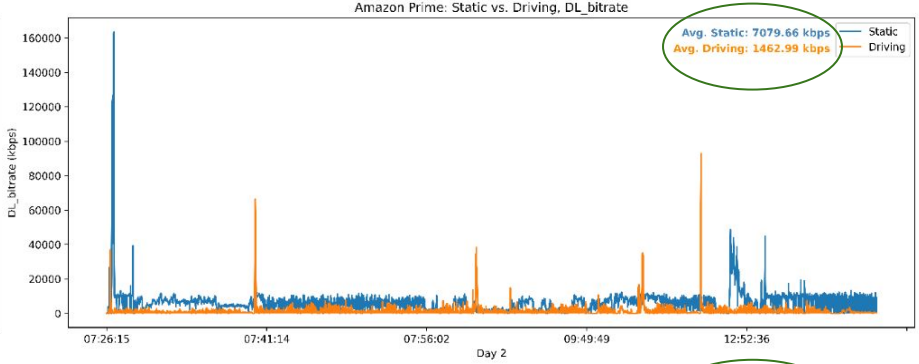
Replaced '-' with approximate minimum values:

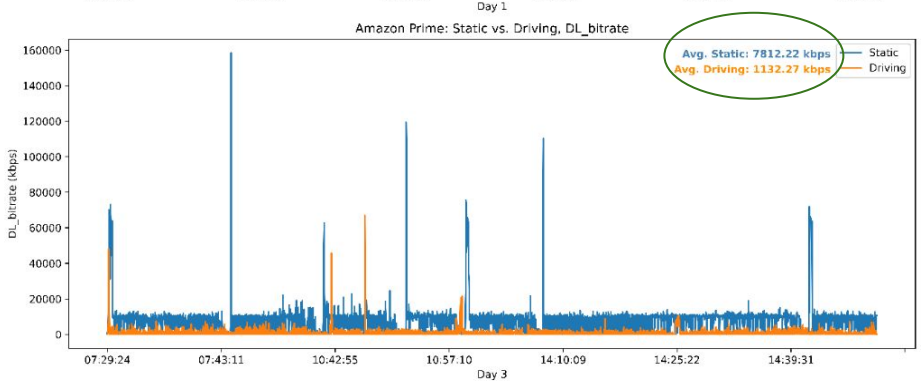
- RSRQ → -19.5 (dB)
- RSSI → -110 (dBm)

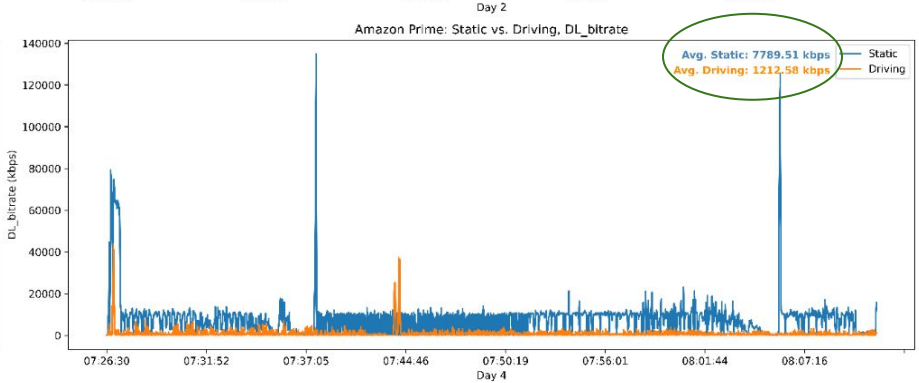
	Timestamp	Speed	NetworkMode	RSRP	RSRQ	SNR	CQI	RSSI	DL_bitrate	UL_bitrate	State
0	10.14.25	0	5G	-89	-10	-3.0	11	-70	0	0	D
1	10.14.26	0	5G	-89	-10	-3.0	11	-70	0	2	D
2	10.14.27	0	5G	-90	-9	7.0	11	-70	0	0	D
3	10.14.28	0	5G	-90	-9	7.0	11	-70	4	5	D
4	10.14.29	0	5G	-89	-15	5.0	11	-70	0	0	D
5	10.14.35	0	5G	-91	-14	5.0	8	-68	12	1	D
6	10.14.37	0	5G	-88	-13	2.0	8	-68	7445	178	D
7	10.14.38	0	5G	-89	-15	2.0	9	-70	270	27	D
8	10.14.40	0	5G	-88	-12	2.0	4	-68	2123	213	D

Download Bitrate (Case 1: Static vs Driving)

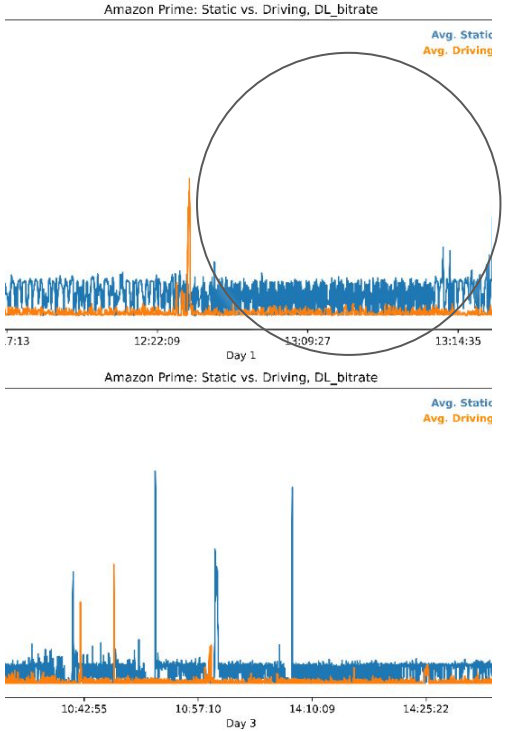


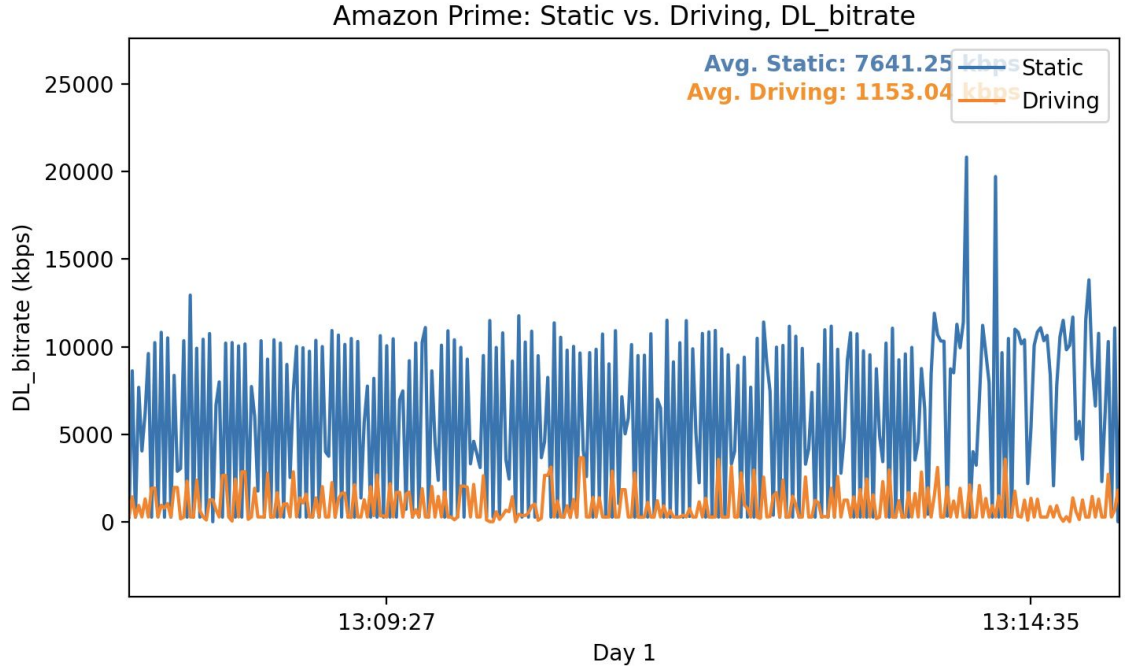




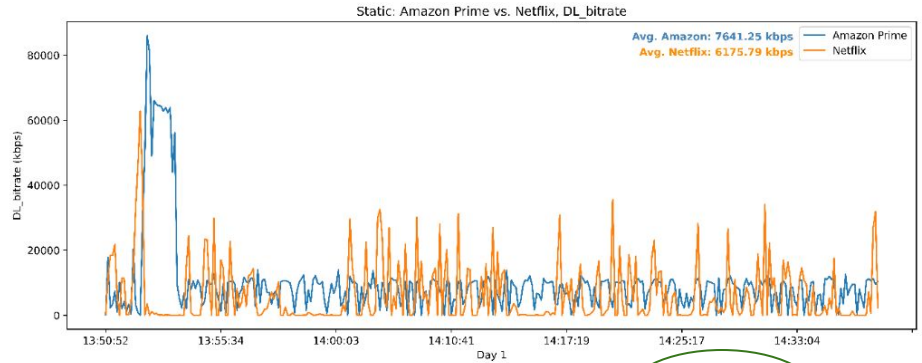


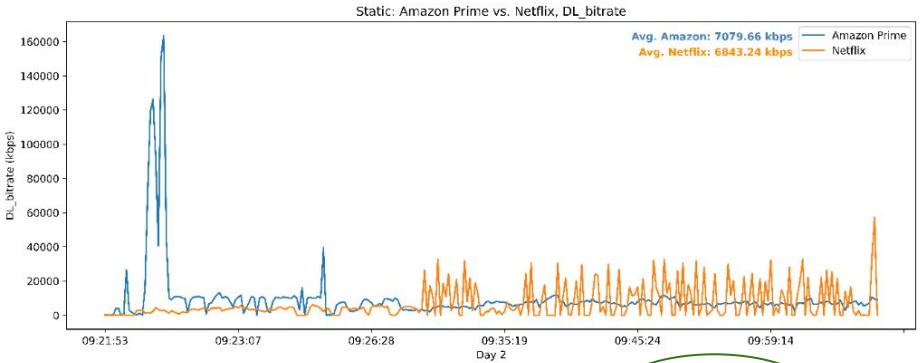
Download Bitrate (Case 1: Static vs Driving)

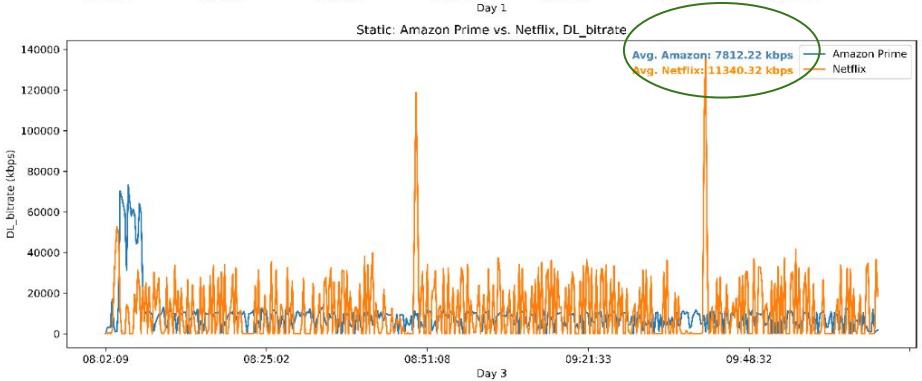


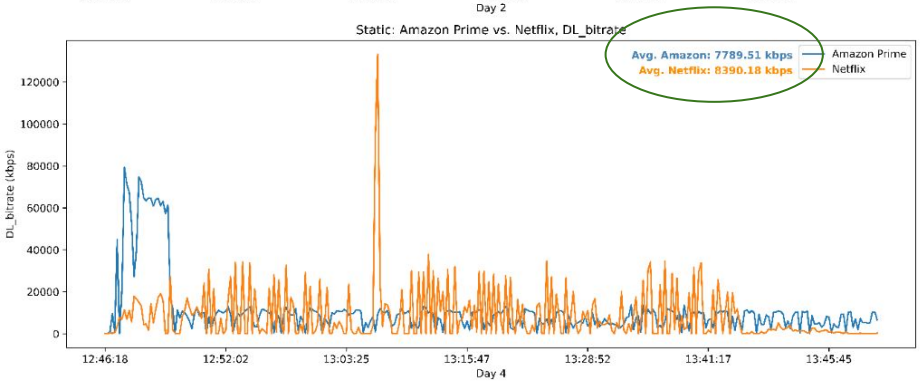


Download Bitrate (Case 2: Amazon Prime vs Netflix -Static)

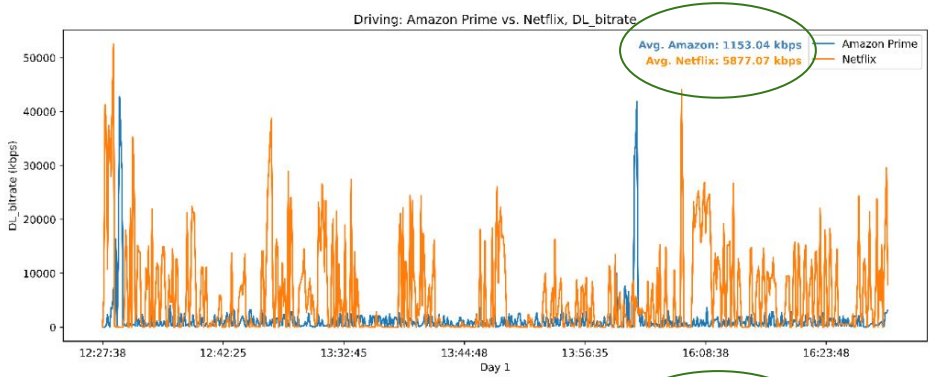


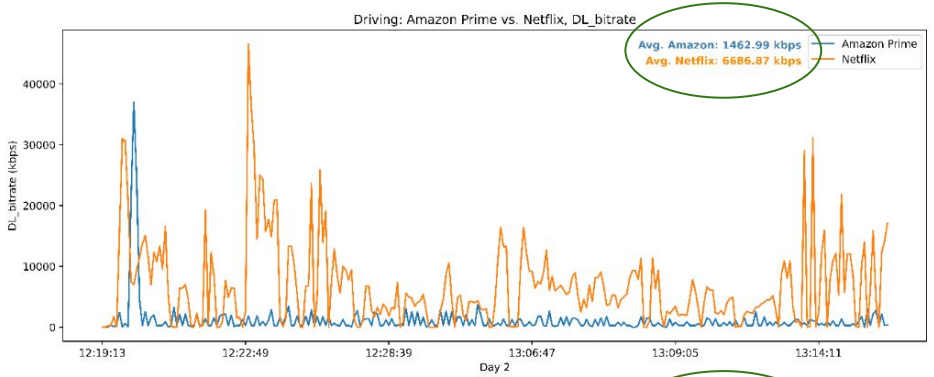


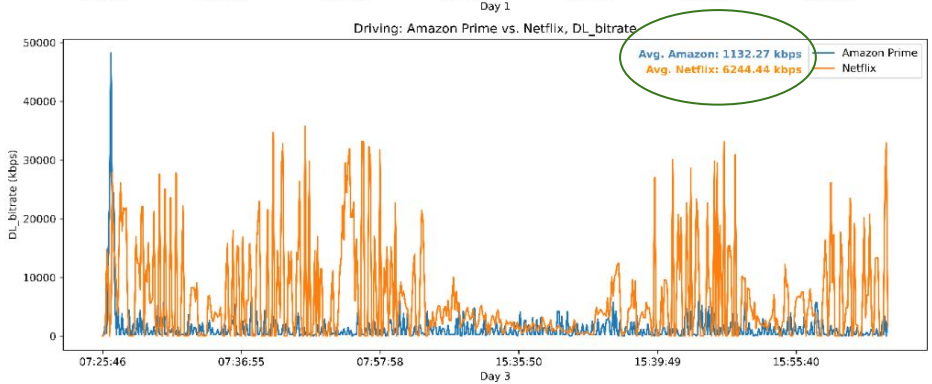


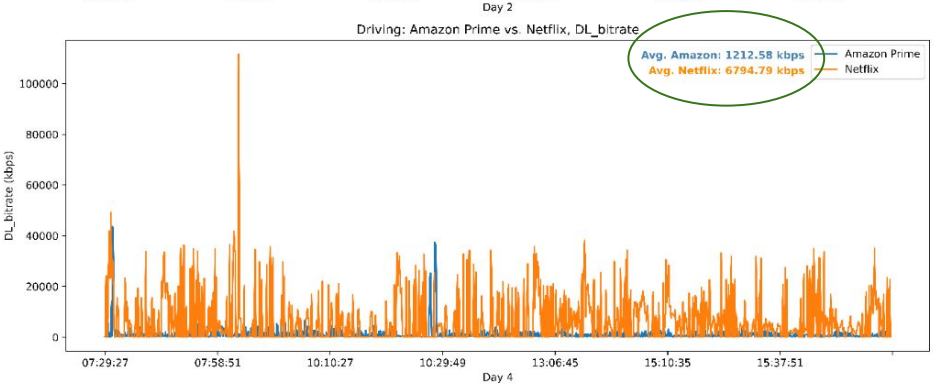


Download Bitrate (Case 3: Amazon Prime vs Netflix - Driving)

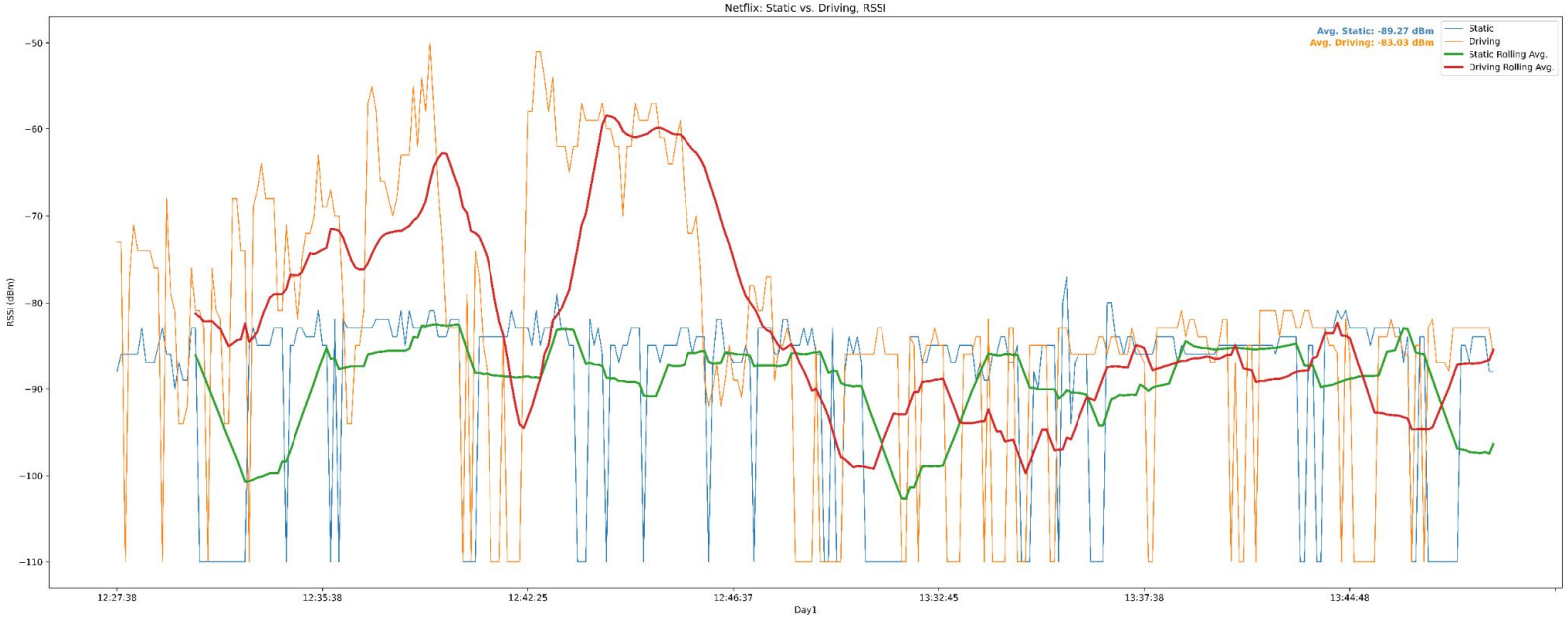








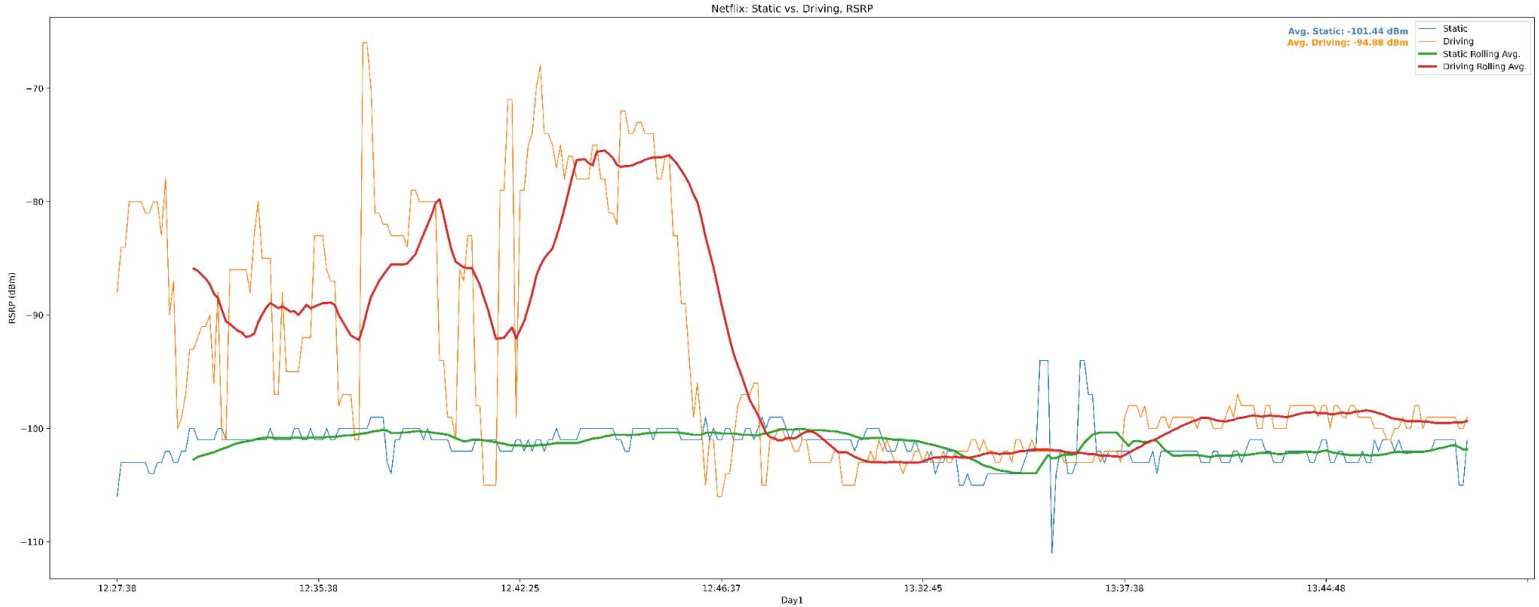
RSSI (Case 1: Netflix Static vs Driving)



A measure of cellular signal strength. RSSI is displayed as a negative number from 0dBm (best signal) to -110dBm (weakest/no signal)

RSSI	Signal Strength
> -79 dBm	Excellent
-80 dBm ~ -89 dBm	Good
-90 dBm ~ -100 dBm	Fair
< -100 dBm	Poor
-110 dBm	No Signal

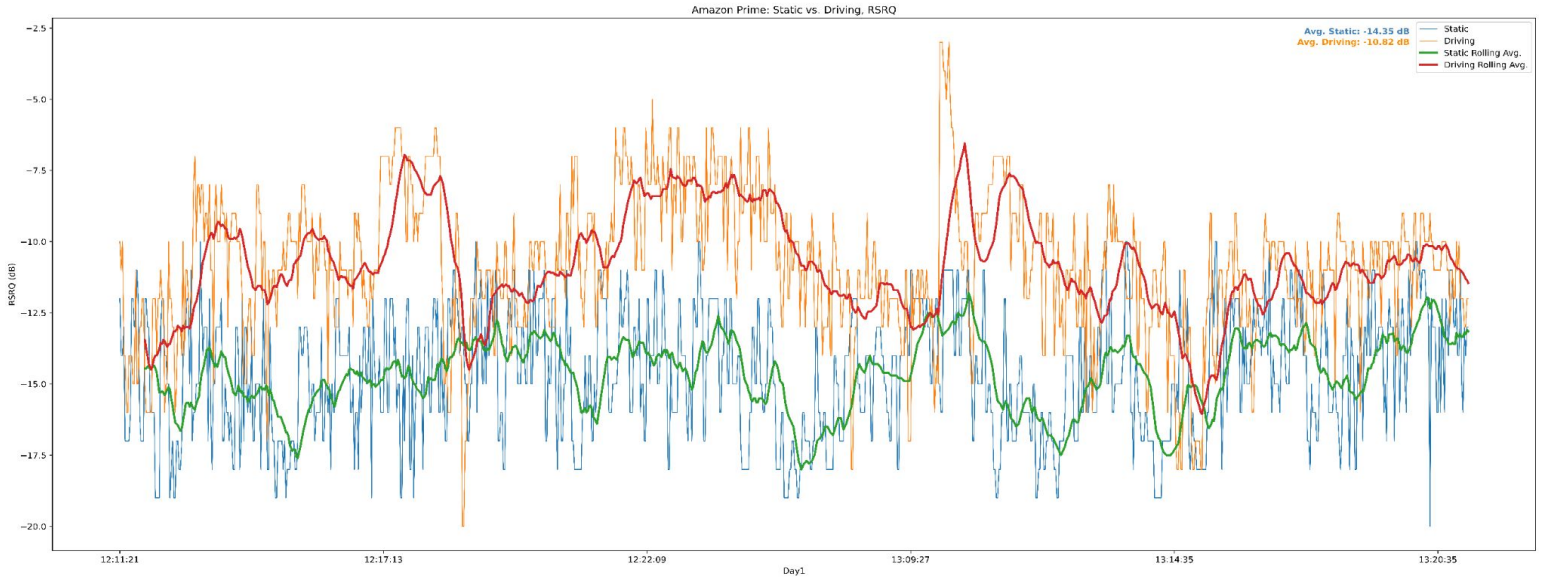
RSRP (Case 1: Netflix Static vs Driving)



The linear average of reference signal power measured over a specified bandwidth. Measured between 0dBm (best signal) to -110dBm (weakest/no signal).

RSRP	Signal Strength
> -90 dBm	Excellent
-90 dBm ~ -105 dBm	Good
-106 dBm ~ -120 dBm	Fair
< -120 dBm	Poor

RSRQ (Case 1: Amazon Prime Static vs Driving)



Wide band power including signal power from serving cell, co-channel neighbor cell, interference from other cell and noise. It is a measure of the signal quality of a cellular connection.

RSRQ	Signal Quality
> -9 dBm	Excellent
-9 dBm ~ -12 dBm	Good
< -13 dBm	Fair to Poor

Conclusion

- Amongst the adaptive clients in 5G multi-cell wireless scenarios Netflix is more optimized for streaming than Amazon Prime and Static case had better and stable numbers over dynamic.

Conclusion

- More 5G Base station towers can be placed for better connectivity for streaming in Driving case

Challenges

- The information in dataset was inconsistent

- The data chosen for analysis

THANK YOU!