- LTE and 5G (frequency used) - normal throughput for UL and DL

- LTE

Frequency used:

1. FDD LTE Bands (Frequency Division Duplex):
   Low bands (e.g., 700 MHz, 800 MHz): Such as Band 12, Band 13, Band 17, Band 20, etc.
   Mid bands (e.g., 1800 MHz, 2100 MHz): Such as Band 1, Band 3, Band 7, etc.
   High bands (e.g., 2600 MHz): Such as Band 7, Band 38, etc.
2. TDD LTE Bands (Time Division Duplex):
   Mid bands (e.g., 2300 MHz, 2600 MHz): Such as Band 38, Band 40, Band 41, etc.
3. Special Bands:
   Band 14: Specifically used for public safety networks.
   Band 46: Used for unlicensed LTE operations (LAA).
4. Emerging Bands:
   With the advancement of 5G, some bands are beginning to be used for both LTE and 5G NR (New Radio) coexistence, such as n78 band, etc.

Normal throughput for UL and DL:

1. LTE Category 4: This is an early form of LTE technology. Downlink: Real-world speeds typically range from 10 to 30 Mbps, but can peak at 150 Mbps under ideal conditions. Uplink: Usually around 5 to 15 Mbps, with a maximum of 50 Mbps.
2. LTE-Advanced (LTE-A): An upgrade of LTE, LTE-A supports carrier aggregation (CA), which increases throughput by using multiple frequency bands simultaneously. Downlink: Users can often see speeds between 30 and 100 Mbps, with peaks potentially reaching up to 300 Mbps or more in very good conditions. Uplink: Speeds might range from 10 to 50 Mbps, with potential peaks of up to 150 Mbps or more.
3. LTE-Advanced Pro (LTE-A Pro): This is a further enhancement of LTE, introducing more advanced features such as 256 QAM and 4x4 MIMO. Downlink: In real-world scenarios, speeds might range from 100 Mbps to several hundred Mbps. Under ideal conditions, it can theoretically go as high

as 1 Gbps or more. Uplink: Real-world speeds can be significantly higher than LTE-A, potentially ranging from 50 to 200 Mbps.

Band	UL (MHz)	DL (MHz)	Simp. BW (MHz)	Total BW (MHz)	Mode	Notes
1	1920 - 1980	2110 - 2170	60	120	FDD	EMEA, Japan
2	1850 - 1910	1930 - 1990	60	120	FDD	Quad band GSM
3	1710 - 1785	1805 - 1880	75	150	FDD	Quad band GSM. DCS 1800
4	1710 - 1755	2110 - 2155	45	90	FDD	AWS
5	824 - 849	869 - 894	25	50	FDD	Quad band GSM
6	830 - 840	875 - 885	10	20	FDD	Not applicable to 3GPP
7	2500 - 2570	2620 - 2690	70	140	FDD	EMEA
8	880 - 915	925 - 960	35	70	FDD	Quad band GSM. GSM 900
9	1749.9 - 1784.9	1844.9 - 1879.9	35	70	FDD	1700 MHz. Japan
10	1710 - 1770	2110 - 2170	60	120	FDD	Extended AWS
11	1427.9 - 1452.9	1475.9 - 1500.9	25	50	FDD	1.5 GHz Lower, Japan
12	698 - 716	728 - 746	18	36	FDD	Lower 700 MHz, C Spire+USCC-LTE
	N/A	716 - 722	6	6	DL only	Originally Ch.55 for QCOM mDTV venture - MediaFLO. Spectrum was sold to AT&T.
13	777 - 787	746 - 756	10	20	FDD	Upper 700 MHz, VzW-LTE
14	788 - 798	758 - 768	10	20	FDD	US FCC Public Safety
15	1900 - 1920	2600 - 2620	20	40	FDD	
16	2010 - 2025	2585 - 2600	15	30	FDD	
17	704 - 716	734 - 746	12	24	FDD	AT&T-LTE
18	815 - 830	860 - 875	15	30	FDD	Japan 800 MHz Lower
19	830 - 845	875 - 890	15	30	FDD	Japan 800 MHz Upper
20	832 - 862	791 - 821	30	60	FDD	800 MHz EMEA
21	1447.9 - 1462.9	1495.9 - 1510.9	15	30	FDD	1.5 GHz Upper. Japan
22	3410 - 3490	3510 -3590	80	160	FDD	3.5G
24	1626.5 - 1660.5	1525 - 1559	34	68	FDD	
25	1850 - 1915	1930 - 1995	65	130	FDD	AWS-G. Sprint LTE within this band
	1915 - 1920	1995 - 2000	5	10	FDD	AWS-H, will be auctioned by Feb. 2015.
26	814 - 849	859 - 894	35	70	FDD	Sprint / Nextel iDen
27	807 - 824	852 - 869	17	34	FDD	Lower 850 MHz
28	703 - 748	758 - 803	45	90	FDD	700 MHz APAC
	2000 - 2020	2180 - 2200	20	40	FDD	Dish Network to deploy LTE-A by 2016.
33	1900 - 1920		20		TDD	
34	2010 - 2025		15		TDD	China Mobile (CM) TD-SCDMA
35	1850 - 1910		60		TDD	
36	1930 - 1990		60		TDD	
37	1910 - 1930		20		TDD	
38	2570 - 2620		50		TDD	European - TD-LTE
39	1880 - 1920		40		TDD	CM TD-SCDMA
40	2300 - 2400		100		TDD	CM TD-LTE
41	2496 - 2690		194		TDD	TDD 2.5 GHz
42	3400 - 3600		200		TDD	TDD 3.5 GHz
43	3600 - 3800		200		TDD	TDD 3.6 GHz
44	703 - 803		100		TDD	700 MHz APAC

- 5G

Frequency used:

1. Low-Band (Sub-1 GHz): These bands are typically used for wide coverage and penetration capabilities, such as 700 MHz, 800 MHz, and 900 MHz. Low-

bands offer good coverage range and strong building penetration but have lower data transmission rates compared to higher frequency bands.

2. Mid-Band (C-Band, approximately 1 GHz - 6 GHz): This is the most commonly used spectrum in 5G networks, including frequencies like 3.5 GHz (n78), 2.6 GHz (n41), and 3.7-4.2 GHz (n77). Mid-bands provide a balanced choice with higher data transmission rates while maintaining reasonable coverage and penetration.
3. High-Band (Millimeter Wave, above 24 GHz): Includes bands like 24 GHz, 28 GHz, 39 GHz, etc. These high-frequency bands offer very high data transmission rates, suitable for high-bandwidth applications, but have limited coverage and penetration capabilities, typically used in urban centers, stadiums, or other densely populated areas.

Normal throughput for UL and DL:

1. Low-Band 5G (Sub-6 GHz): Downlink: Often in the range of 50-250 Mbps, but it can be higher in some cases. Uplink: Typically ranges from 10-100 Mbps.
2. Mid-Band 5G (C-Band, around 1-6 GHz): Downlink: Commonly sees speeds between 100-900 Mbps, with potential peaks reaching 1 Gbps or more in ideal conditions. Uplink: Usually falls between 10-100 Mbps, but can exceed these figures under optimal circumstances.
3. High-Band 5G (Millimeter Wave, above 24 GHz): Downlink: Can exceed 1 Gbps, with peaks often reaching 2 Gbps or more in optimal conditions. Uplink: Speeds can be significantly higher than lower bands, often ranging from 100 Mbps to 1 Gbps.

- Jitter measurement in networks

1. Measuring Jitter with Ping:

   Although primarily used to measure network latency (i.e., round-trip time, RTT), ping can also be indirectly used to observe jitter. By running ping continuously and observing the variation in the return times of the packets, one can get a rough estimate of jitter. For example, significant variation in RTT values over consecutive ping attempts could indicate the presence of some level of jitter in the network.

2. Measuring Jitter with Iperf:

   When using iperf to measure jitter, it's typically done in UDP mode. This is because UDP, unlike TCP, does not have congestion control mechanisms, making it more suitable for jitter measurement. In iperf's UDP tests, the server side reports the jitter statistics for the received packets, providing a direct measurement of jitter. For example, you can start iperf as a server on one end (using the command iperf -s) and as a client on the other (using the command iperf -c [server address] -u) to initiate a UDP test. After the test, iperf will display average jitter values and other relevant statistics.

Reference

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