Testing Gateway LTE Performance

SIERRA WIRELESS®

Introduction

A common task when selecting an LTE gateway is evaluation of live mobile network performance. Most users will be interested in two key performance areas:

1. LTE Connectivity: how well the gateway stays connected to the LTE network; and
2. Throughput: how fast the gateway sends and receives data to/from the mobile network.

Performance in these areas is primarily determined by the radio module used for mobile network connectivity; the attached antennas and cabling; and network capacity and coverage at the time of the tests.

LTE connectivity

The gateway's connection to the LTE network is influenced by a number of factors including:

1. LTE Network coverage;
2. Mobile network behavior such as load balancing; and
3. RF signal quality

The first two factors are largely outside of the gateway's control. However, in some specific cases, the gateway can take actions to increase the likelihood of connecting to the LTE network. For example, on many networks, a gateway will not transition from 3G to LTE unless the radio has been idle for a period of time. If data is being continuously sent and received, the radio will not become idle and will appear to be 'stuck' on 3G. To resolve this issue, Sierra Wireless gateways have the ability to temporarily pause and buffer data transmission, which allows the radio enough time to go idle and transition to the LTE network.

The final factor, RF signal quality, is mainly determined by the radio module and the attached antennas and cabling. Both antenna location and spacing can have a significant impact on RF signal quality and MIMO performance. It is important to keep in mind that, where RF signals are concerned, antenna spacing or differences in separation of more than a wavelength (12cm to 43cm in the case of mobile networks) can have a significant impact.

Throughput

The gateway's throughput is influenced by several factors:

1. Loading on the base station and the mobile network operator's backhaul and core networks;
2. Bandwidth available in the currently selected band;
3. RF signal quality; and
4. The ability of the gateway electronics to efficiently process packets from the attached device and the radio module.

The first two factors are outside of the gateway's control. Base station and network loading can fluctuate wildly depending of the number of connected users and the amount of data they are sending and receiving. Bandwidth is network operator-dependent and, where multiple bands are available, dependent on which band the mobile network instructs the radio module to connect to.

RF signal quality is primarily determined by the radio module and the attached antenna and cabling. Poor signal quality can result in a base station using a less efficient modulation technique to communicate with the gateway which results in lower throughput.

Test Methodology

In order to properly evaluate live mobile network performance, ensure that each of the gateways under test is using exactly the same antenna and cabling. To compare test results, the following information should be collected from the gateway under test at regular intervals (e.g., every five seconds):

Item	Notes
Cell ID	It is possible for two gateways located side by side with identical antennas and cabling to be connected to different base stations. This will likely have an impact on RF signal quality. In order to determine if this is occurring, collect the Cell IDs for the base stations the gateways are connected to over the duration of the test.
Network technology	Used to determine if the gateway is connected to LTE.
LTE Band	Used to determine which band the gateway is connected to and how much bandwidth is available.
Received Signal Reference Power (RSRP)	A measure of the power of the signal received from the base station.
Received Signal Reference Quality (RSRQ)	A measure of the quality of the signal received from the base station.
Signal to Interference + Noise ratio (SINR) - if available	Another measure of the quality of the signal received from the base station.

LTE connectivity

To evaluate LTE connectivity, a drive test is recommended as this is frequently the most challenging situation for a gateway due to the resulting handoffs between base stations. Stationary testing is less likely to yield useful results as the gateway under test will usually stay connected to the same cell tower and LTE band and have a constant signal quality for the entire duration of the test.

Throughput testing

To evaluate throughput, stationary testing is recommended as signal quality and cell towers can change rapidly while moving making it difficult to compare test results. It is also necessary to perform multiple tests and average the results in order to compensate for unknown base station and network loading. Experience suggests a minimum of 10 tests for 20s each over a 48 hour period are required in order to produce useful results. Continuous throughput testing is not recommended as this may result in significant data usage charges.

Simultaneous throughput testing is not recommended as this will result in both gateways under test competing for the same base station and network capacity. It is unknown how the network will allocate capacity in such situations, making it difficult to compare test results.

Finally, it is desirable to use test software that provides a good level of detail about maximum and average throughput for the test duration. While speedtest.net is a useful tool, its focus is on determining ping times and maximum sustained performance for an internet connection. iperf3 is a popular open-source performance testing tool that can provide fine-grained information about throughput, jitter and packet loss for both TCP and UDP. It is recommended that TCP be used for performance testing as it is self-limiting. This will avoid flooding the network with large amounts of traffic that may be discarded due to congestion.

Sierra Wireless GX450 vs Competitor Gateway Test Results

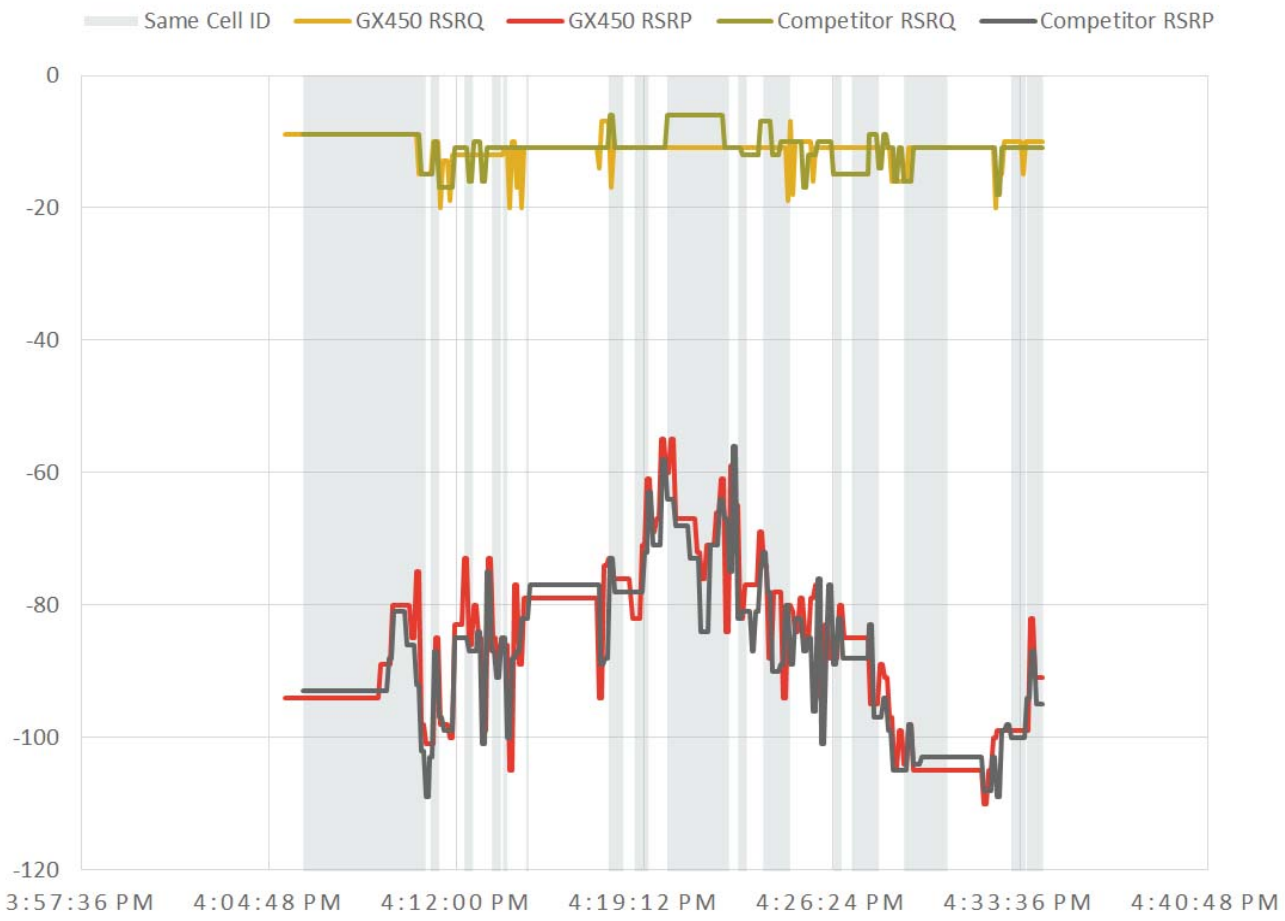
LTE connectivity and throughput testing was conducted using a Sierra Wireless GX450 and a competitor's gateway. Both gateways use the Sierra Wireless MC7354 radio module to provide mobile network connectivity. Testing was performed on the Rogers LTE network in Vancouver, Canada.

LTE Connectivity

For the LTE connectivity test, both gateways were attached to Taoglas MA750 antennas which were mounted on the top of a vehicle and spaced approximately 50cm apart. LTE signal quality metrics were collected at 5s to 10s intervals during a 28 minute drive test. A plot of RSRP and RSRQ, along with an indication of when the gateways were both

connected to the same base station (same Cell ID) can be found below:

Both gateways stayed on LTE band 4 for the duration of the test. As shown, both RSRQ and RSRP are similar for the duration of the test. The largest differences tended to occur when the gateways were attached to different cell towers. Smaller differences are likely to be the result of the slightly different antenna positions.



Throughput

For the throughput test, both gateways were attached to Taoglas MA750 antennas spaced approximately 40cm apart in an office environment. The test was conducted over a 48 hour period and the antennas were swapped between the gateways under test approximately halfway through this period.

Both gateways stayed connected to LTE band 4 on the same base station (same Cell ID) for the entire duration of the test. The resulting RSRP and RSRQ for each gateway/antenna combination are show below:

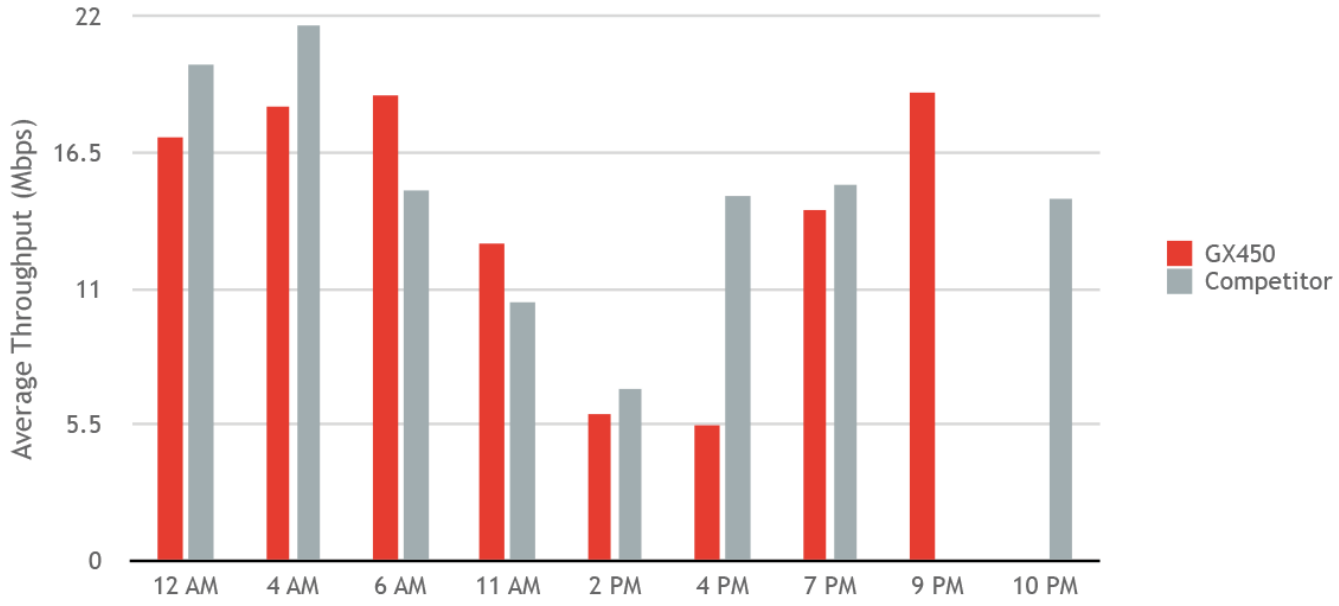
	Antenna 1		Antenna 2	
	RSRP	RSRQ	RSRP	RSRQ
GX450	-109	-10	-110	-9
Competitor	-110	-10	-111	-9

RSRP and RSRQ were constant for the entire duration of the test. The competitor gateway RSRP was 1dB lower on both antennas but this may be the result of rounding. In general, the signal quality for both gateways could be described as average to poor.

Throughput for both gateways is shown below:

	Average Throughput (Mbit/s)	Maximum Throughput (Mbit/s)
GX450	13.28	23.1
Competitor	13.24	23.4

As expected, average and maximum throughput over the entire test duration are approximately the same. It was interesting to note that throughput changed depending on the time of day with tests in the afternoon generally resulting in the lowest throughput. The results of the throughput test broken down by time of day can be seen below.



An important observation during the testing process was that throughput can vary dramatically between tests that were run within minutes of each other. For example, in one test run at 4pm the competitor gateway throughput was significantly higher than that of the GX450. This is most likely because the base station loading was higher during the GX450 test.

Both gateways were connected using 2x2 MIMO to the same Rogers base station on LTE band 4. A search of the Industry Canada Spectrum Direct database[1] shows that this base station is using 10MHz per sector in LTE band 4. According to Motorola's whitepaper on realistic LTE experience[2], average sector throughput for such a setup will be approximately 16.7Mbps. In this case, just one or two users on the same base station sector consuming a large amount of data can have a significant impact on gateway performance.

Conclusion

Performance testing on a live network is difficult as there are many factors that influence performance and not all can be controlled. Despite this, a well-designed test can provide useful information about comparative gateway performance.

Test results for the GX450 show that its performance is the same or better than a competitor gateway using the same radio module. However, the GX450 and other Sierra Wireless gateways have some unique features that can increase the percentage of time spent on LTE compared to 3G and 2G networks.

For more information on gateway performance testing, please contact your authorized AirLink reseller or Sierra Wireless representative.

References
(1) http://sd.ic.gc.ca/pls/engdoc_anon/web_search.geographical_input
(2) http://www.motorolasolutions.com/web/Business/_Documents/static%20files/Realistic_LTE_Experience_White_Paper_FINAL.pdf