Thinking Outside the Sphere!

State of Utah Wireless Broadband Speed Drive Test Comparison 2011 to 2013

Executive Summary

Isotrope measured wireless broadband speeds[1] throughout the State of Utah in 2011 and again in 2013. These drive tests were conducted for the Utah Automated Geographic Reference Center on behalf of the Utah Broadband Project. In 2011, the 3G wireless broadband speeds for AT&T, Cricket, Sprint, T-Mobile and Verizon were measured. Verizon's 4G LTE speed was measured in 2011, the only carrier to have 4G active at the time. In 2013, Isotrope repeated the 2011 3G measurements as well as measured 2 additional carriers, Breakaway Wireless and Strata Networks. At the time of measurements in 2013, AT&T and T-Mobile had begun 4G LTE deployment. Areas of 4G LTE coverage were captured on portions of the 3G footprints. Verizon, AT&T and T-Mobile 4G LTE coverage naturally overlays portions of their existing 3G network coverage as the carriers retrofit existing cell sites for 4G LTE service.

Generally, there were several significant improvements in the availability of broadband service in Utah from 2011 to 2013. We see that 3G broadband speeds increased amongst all the carriers, perhaps in part by upgrading 3G technologies at the cell sites, and perhaps in part due to the upgrading of backhaul capabilities necessary to support 4G LTE at each cell site. Between 2011 and 2013, Verizon expanded its 4G LTE coverage from Salt Lake County to across the state. We did not see any appreciable increase in 3G coverage among the carriers, only an increase in speed. We did see changes in coverage by county for Sprint and Cricket; this appears to be due to changes in roaming. See Appendix A for a comparison of 3G speed by county and carrier from 2011 to 2013.

Drive Test

A Test Plan document was created in 2011 and some tweaks were made for the 2013 drive test. Those documents are available under separate cover.

The Route

In November of 2013 Isotrope again drove the roughly 6600 miles of roads assigned by Utah AGRC. It took approximately 9000 miles and 21 days of driving to cover the assigned roads, taking into account the dead-heading and looping necessary to cover all designated roads most efficiently. We improved on our routing technique from 2011. In 2011 we planned the route in a laptop-based map software (Delorme Street Atlas) and then used the GPS-enabled laptop in the vehicle for navigation cues. In 2013 we changed routing software manufacturers and used Garmin BaseMap. BaseMap allowed us to import

[1] For simplicity, this report uses the term "speed" in place of "throughput rate" to indicate the number of megabits per second of data transmission/reception. "Speed" does not refer to the vehicle speed.

the routes into a Garmin Navigation unit that we could place on the Dashboard. Having a dashboard mounted navigation device that gave out turn by turn directions helped the driver stay on route, particularly in areas where the route either doubled back on or crossed over other portions of the route. Interestingly, both Street Atlas and BaseMap appeared to be using the same routing engine. As in 2011, we still used a GPS-enabled laptop running Street Atlas to log our route as we were driving in 2013. Our rented Chevy Tahoe of the 2011 test was replaced with a Nissan Armada in 2013. There were several snowy and icy locations in the mountains where the Armada's 4-wheel drive and traction control came in handy. Unlike 2011, in 2013 we had no vehicle issues, no flat tires, and we didn't run out of gas! In 2013 we had to accommodate several additional cell phone mounts and a second drive test management platform to accommodate all the devices under test.

Devices

For 2013, the same user devices were used to measure 3G broadband speeds for AT&T, Cricket, Sprint, T-Mobile and Verizon as were used in 2011. These devices were placed in a plastic cargo carrier on the roof, as was done in 2011. For the 2013 drive test we were asked to directly measure Strata Networks and Breakaway Wireless. Strata and Breakaway provided 3G devices that were compatible with our test platform: 3G variants of the Samsung Galaxy S3.

To measure the 4G LTE services we had to use devices that were compatible with the test platform. In the case of AT&T and T-Mobile we used 4G LTE variants of the Galaxy S3. For Verizon 4G LTE, we used an HTC Thunderbolt. In order to be compatible with the test platform, Android Speed test applications were run on the Galaxy S3s (both the 3G and 4G LTE variants) and the Thunderbolt. The test platform captured all the signal quality data from the phones as well as the results of the speed tests performed by the applications running on the phones. The phones running the speed test applications required a little more "hands-on" attention and thus these phones were mounted inside the vehicle on the dashboard.

Figure 1 - Dual Drive Test Platform Controls and Three 4G LTE Test Devices on Dashboard

Data

We used the same file sizes for upload and download in 2013 as in 2011. Anticipating that there would be increased throughput in 2013 than in 2011 due to more LTE coverage, Isotrope leased a dedicated server with a high capacity connection to the internet.

Our device data plans from the carriers were either unlimited or allowed us to go over in data usage and pay for the overages without “throttling.”

The Strata and Breakaway devices were operated in counties where the 2 carriers are licensed to provide native services, i.e. where their devices were not roaming. The intent in limiting Strata and Breakaway devices to their native counties was to prevent them from roaming in other counties where other devices were already testing a given cell network. This method prevented multiple devices from competing for limited capacity on the same cell site and potentially biasing the results.

2011 to 2013 Comparison

In 2013 we transferred approximately 150 Gigabytes of data with our server, 3 times the 50 GB we transferred in 2011. The increase can be attributed primarily to the increase in 4G LTE service, and to a lesser degree the incremental increases in 3G speeds.

Appendix A has a series of tables comparing 3G measurements from 2011 to 2013. These measurements are categorized by carrier and county. The first table is a statewide comparison.

Some Notes about the tables:

- 3G Data comes from field 20 of Data CSV files, "Current Throughput". Current Throughput is defined as MegaBits/second, over most recent Throughput Interval. The Throughput Interval in most cases is 5 seconds. This has the effect of smoothing out some of the instantaneous peaks and valleys that naturally occur with wireless transmission.[2]
- 4G Data comes from field 22 of Data CSV files, “RLC Downlink Throughput” [3] . Throughput is defined as Mb/s and includes all data transferred through RLC layer.
- Measurements in the table are rounded to the nearest thousandth Megabit (0.001 Mb/s).
- Records with no speed or "0" speed were eliminated
- Data was logged once per second
- For GSM/UMTS technology carriers (AT&T and T-Mobile), only data from higher speed 3G HSPA records are shown
- A variability in the total number of measurements for a given carrier, between 2011 and 2013, is caused by many factors, the most significant of which appears to be changes in roaming coverage for some carriers.

[2] Values in field in the CSV file are in bytes per second, for the purposes of this report we multiplied by 8 to get bits per second.

- There was no attempt to screen out "handshaking" records. This has the effect of lowering the average speed and median speeds. Because of this, it is recommended to use the 85th Percentile figures.
- Maximum throughput speeds mostly match the maximum speed of the technology and device. This suggests that cell sites are typically equipped with enough backhaul capacity to support the maximum that the wireless connection can deliver. A closer review of the data by region and signal quality might reveal whether there are remote areas where the capacity of the backhaul is the limiting factor.

Appendix B contains a comparison table of 4G LTE measurements as well as maps showing how the 4G LTE service overlaid the existing 3G service for AT&T, T-Mobile and Verizon in 2013. There is also one map showing Verizon's service in 2011. These maps show where data was successfully transferred, they do not necessarily correspond to the signal strength from each carrier.

Observations by Carrier (alphabetical order)

AT&T

The number of AT&T measurements taken[3] was about the same between 2011 and 2013 suggesting that overall coverage didn't increase. We do see a 50% increase in 3G speeds statewide, in some counties it was a 100% increase. One can conclude that AT&T worked to increase 3G data speeds between 2011 and 2013.

Since 2011, AT&T has activated its 4G LTE coverage. We measured 4G LTE coverage in the urban areas around the Salt Lake and Wasatch front although it is believed that AT&T's 4G LTE network expanded into other areas of the state in the months following the drive test. Of the three measured carriers with 4G LTE service, AT&T was fastest in 2013.

Cricket

The number of Cricket measurements taken decreased about 40% between 2011 and 2013. Cricket service disappeared from some counties (Kane, Piute, San Juan, Wayne, and Weber). Cricket added some service to Beaver County. We attribute these changes in counties served to changes in roaming. The counties where we did not see measurements in 2013 were counties where the Cricket device had roamed to a roaming carrier in 2011. We do see a 500% increase in Cricket wireless broadband speeds statewide. In some counties we could see that the 3G carrier technology must have been implemented as we saw 3G speeds in 2013 where we measured 1xRTT(2G) speeds in 2011. This change in technology is captured in the increase in maximum speeds measured between 2011 and 2013 (most notable in Box Elder, Carbon, Daggett, Duchesne, Emery, Tooele, Uintah, Utah, and Wasatch).

[3] The "number of measurements taken" field is somewhat unreliable as a determination of change in coverage due to many variables, such as: traffic, uplink speeds, and changes in downlink speeds. Measurements were taken once per second while the device had service.

Cricket had no 4G LTE coverage. Following the drive test, AT&T closed on its purchase of Cricket and Cricket has become a brand running on the AT&T UMTS/HSPA/LTE network. The Cricket CDMA network, which our drive test measured, has been shut down.

Sprint

The number of Sprint measurements taken increased about 10% between 2011 and 2013. On our test devices, Sprint roaming service disappeared from two counties (Kane and Piute). Sprint added some service to San Juan County. We attribute these changes in counties served to changes in roaming agreements[4]. The counties where we did not see measurements in 2013 were counties where the Sprint device had roamed to a roaming carrier in 2011. We did not see an appreciable increase in Sprint broadband speeds statewide. In some counties we saw speeds decrease significantly between 2011 and 2013 (Daggett, Duchesne, Weber). Other counties show a modest increase (Beaver, Emery, Garfield, Grand, Iron, Morgan, San Pete, Sevier, and Summit).

Sprint had no 4G LTE coverage at the time of the drive test. Sprint's 4G LTE network was activated in areas of the state in the months following the drive test.

T-Mobile

The number of T-Mobile measurements taken was about the same between 2011 and 2013 suggesting that overall coverage didn't increase. We do see a 100%+ increase in 3G speeds statewide. In many counties speeds increased significantly, some by as much as 500%. One can conclude that T-Mobile worked to increase data speeds between 2011 and 2013.

Since 2011, T-Mobile has activated its 4G LTE coverage. 4G LTE coverage was measured in the urban areas around the Salt Lake, Wasatch front and St. George.

Verizon

The number of Verizon measurements taken was about the same between 2011 and 2013. We do see that Rich County was added to Verizon's service area since 2011. We do see a 100%+ increase in 3G speeds statewide. In many counties speeds increased significantly, some by as much as 500%. One can conclude that Verizon worked to increase data speeds between 2011 and 2013.

Since 2013, Verizon has added 4G LTE coverage throughout parts of the state. Verizon's 4G LTE coverage is not statewide and is in urban areas as well as along major routes through the state. Our Verizon 4G LTE measurements include the measurements for Strata Network's 4G LTE service area in Uintah and Duchesne Counties. Strata and Verizon cooperated on developing an LTE network in these counties using Strata infrastructure and Verizon LTE frequencies.

[4] We have not confirmed the cause of the lost counties for Sprint. Our methodology included ensuring the test phones had the most recent roaming tables from the carriers.

Thoughts about Future Drive Tests

3G coverage and speeds are unlikely to increase significantly in the future since the technology has reached maturation at cell sites and the benefit of expanding service area does not warrant the infrastructure costs. Published reports indicate that LTE penetration reached 30% of subscriptions in the USA in the first quarter of 2014[5]. Carriers are concentrating on rolling out 4G LTE service. We would recommend that future tests concentrate on measuring 4G LTE speeds and coverage especially if the devices can roll back to 3G connectivity when 4G LTE service is lacking during the tests.

Remote areas are likely to be the last to receive LTE upgrades due to fewer subscribers, less vehicular traffic, and potentially low capacity backhaul for cell sites. From a policy perspective, it might be informative to ask carriers when they expect to convert all sites to LTE. Some remote areas are served by roaming carriers who do not offer service to the public, but instead generate revenues by serving multiple carriers though roaming fees. These carriers may also be able to report their improvement plans in terms of both coverage and technology.

Voice calling on 3G (or even 2G) networks will remain in place for some time to come. While voice telephone service over LTE (VOLTE) is expected to become available on the various providers' LTE networks in the coming year, it will take time for LTE user devices that are not equipped for VOLTE to be replaced. Also, some subscribers, particularly in remote areas, may be relying on 2G and 3G phones because there is no support for LTE in their areas yet.

In 2013 we were able to take advantage of unlimited data plans and plans that allowed subscribers to pay for overages. We do not believe that the 2013 data usage was throttled back by the carriers, based on the behavior of the devices throughout the test. Published reports and subscriber contracts for unlimited plans indicate there is selective priority management of heavy users of unlimited service.[6] Unlimited service users with more than about 5GB of usage in a month may be placed at lower priority when there is congestion on a cell site. We exceeded 5GB on all phones used statewide. The Sprint and T-Mobile devices were on unlimited plans. Since the test continuously moved from the influence of one cell site to another and it is not likely that multiple cell sites in a row would have been heavily congested for 4G LTE data traffic, we expect priority reduction, if applied at all, would have had no material impact on the results for these two services. The other service providers charged for the extra gigabytes over a minimum, and no throttling is applied in pay-for-overages plans.

In future testing, especially of 4G LTE services, it will be prudent to avoid unlimited plans and rely on pay-per-GB plans to avoid throttling, despite the additional testing expense for overages.

Having conducted drive tests in July and November, we would recommend doing them in early fall when it has cooled off a little bit but not so much that snow or ice affect the routes and driving conditions. The

[5] http://www.4gamericas.org/index.cfm?fuseaction=page&pageid=2043

[6] For example, http://arstechnica.com/business/2014/07/its-not-just-verizon-all-major-us-carriers-throttle-unlimited-data/

Nebo Loop was closed from snow at high altitude, forcing a long run around to complete as much of the route as possible. Off season testing helps with efficiency by avoiding some tourist congestion.

Figure 2 – Highway 31 Summit in Blizzard Conditions During the Test

In future testing, it might be just as effective to test downloads only, rather than test upload and download speeds. The primary indicator of network capacity is download performance. Downloads, being typically faster than uploads by design, allow the testing process to stress the capability not only of the wireless connection from user to base, but also the capacity of the cell site and backhaul infrastructure. Upload speeds are largely defined as a fraction of the download speeds, depending on the technology.

Comparing the mobile speed testing with provider advertised speeds could provide insight into the amount of variation in performance over the coverage areas of the cell sites (farther from the cell site, the speeds degrade with distance from the cell site), plus the variations due to vehicle motion (static performance is usually better than in-motion performance, all other things being equal), also how often the advertised speed is obtained. Since it is the over the air technology that sets the speed limit, if all carriers migrate to 4G LTE service (which they are) then all carriers will one day have the same capacity and the external factors discussed above will control the user experience on any particular network (the capacity of the backhaul network, the reception factors mentioned above, and the user load on a given cell site).

It appears likely that the efforts of the federal FirstNet initiative to build a national public safety broadband network (NPSBN) will likely use existing infrastructure. Public safety service would be similar to the commercial networks if public safety were to use the same tower infrastructure as the commercial networks. The tests done to date can inform the planning of that network with regard to assets available, network performance, and an understanding of the deployment patterns and trends over time. Similar drive tests may be useful as part of planning and operations for the NPSBN.

Appendix A: Rough Comparison of 3G Wireless Broadband Speeds by Carrier and County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements	% change in measurements
Cricket	2011	0.096	0.059	0.136	0.057	1.509	170635	
	2013	0.351	0.229	0.724	0.002	1.834	103999	-39
Sprint	2011	0.201	0.114	0.420	0.127	2.370	138770	
	2013	0.286	0.173	0.563	0.007	2.089	153146	10
AT&T (HSPA)	2011	0.645	0.570	1.170	0.026	3.737	135324	
	2013	1.003	0.904	1.785	0.640	4.062	134801	0
VZW	2011	0.228	0.114	0.496	0.127	2.425	208638	
	2013	0.426	0.242	0.941	1.671	2.321	199025	-5
T-Mobile (HSPA)	2011	0.458	0.283	0.913	0.026	3.598	26355	
	2013	1.083	0.923	1.949	0.643	5.014	28581	8

Table 1: Statewide

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011						
	2013	0.692	0.640	1.171	1.671	1.834	1373
Sprint	2011	0.265	0.205	0.464	0.114	1.223	703
	2013	0.534	0.440	0.904	1.671	2.089	2408
AT&T (HSPA)	2011	0.678	0.642	1.127	0.642	2.701	5214
	2013	0.976	0.851	1.736	0.640	3.324	3600
VZW	2011	0.160	0.116	0.197	0.134	2.058	6779
	2013	0.336	0.133	0.849	1.671	2.089	4224
T-Mobile (HSPA)	2011						
	2013						

Table 2: Beaver County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.109	0.097	0.148	0.095	0.577	7287
	2013	0.384	0.310	0.749	0.002	1.671	3890
Sprint	2011	0.143	0.102	0.218	0.134	1.678	11641
	2013	0.226	0.142	0.451	0.128	1.671	9604
AT&T (HSPA)	2011	0.657	0.598	1.161	0.157	3.640	2357
	2013	0.814	0.722	1.622	0.002	3.458	2618
VZW	2011	0.366	0.175	0.799	0.134	1.775	9366
	2013	0.746	0.700	1.338	1.671	2.162	6089
T-Mobile (HSPA)	2011	0.338	0.262	0.586	0.157	2.568	1290
	2013	1.345	1.279	2.285	0.049	3.882	788

Table 3: Box Elder County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.124	0.102	0.178	0.095	0.964	5789
	2013	0.329	0.240	0.661	0.002	1.448	6042
Sprint	2011	0.172	0.107	0.320	0.053	1.678	5078
	2013	0.171	0.114	0.322	0.007	1.668	7304
AT&T (HSPA)	2011	0.675	0.574	1.221	0.026	3.254	3357
	2013	0.806	0.675	1.549	0.640	2.856	4227
VZW	2011	0.304	0.178	0.611	0.002	1.933	4044
	2013	0.495	0.372	0.939	1.671	2.089	5033
T-Mobile (HSPA)	2011	0.449	0.370	0.883	0.253	3.600	680
	2013	0.959	0.822	1.686	0.011	4.612	1612

Table 4: Cache County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.058	0.053	0.071	0.051	0.197	508
	2013	0.460	0.345	0.783	1.671	1.770	639
Sprint	2011	0.238	0.151	0.487	0.127	1.638	2723
	2013	0.279	0.138	0.552	0.128	2.089	2891
AT&T (HSPA)	2011	0.583	0.531	1.036	0.070	2.470	2396
	2013	1.149	1.135	1.989	0.640	3.163	2098
VZW	2011	0.251	0.123	0.545	0.134	1.891	4682
	2013	0.337	0.155	0.788	1.671	2.018	3565
T-Mobile (HSPA)	2011						
	2013	0.240	0.183	0.401	0.125	0.755	1480

Table 5: Carbon County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.068	0.056	0.103	0.053	0.422	2124
	2013	0.379	0.208	0.784	0.126	1.671	982
Sprint	2011	0.396	0.371	0.813	0.009	1.290	857
	2013	0.102	0.095	0.140	0.007	0.654	2512
AT&T (HSPA)	2011	0.796	0.760	1.371	0.070	3.034	2409
	2013	1.367	1.367	2.126	0.640	3.474	1730
VZW	2011	0.222	0.086	0.547	0.056	1.678	3047
	2013	0.503	0.369	1.018	1.671	1.671	1608
T-Mobile (HSPA)	2011						
	2013						

Table 6: Daggett County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.270	0.144	0.598	0.021	1.678	2485
	2013	0.291	0.206	0.566	0.007	1.671	5652
Sprint	2011	0.193	0.107	0.380	0.009	1.678	3303
	2013	0.233	0.156	0.449	0.021	1.671	5929
AT&T (HSPA)	2011	0.513	0.330	1.049	0.026	3.190	2757
	2013	0.897	0.811	1.537	0.640	2.866	4112
VZW	2011	0.286	0.144	0.631	0.130	1.678	2883
	2013	0.507	0.420	0.948	1.671	2.270	4418
T-Mobile (HSPA)	2011	0.248	0.169	0.460	0.026	1.890	3991
	2013	1.121	0.930	2.011	0.571	4.471	2893

Table 7: Davis County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.057	0.053	0.067	0.053	0.510	15700
	2013	0.128	0.091	0.175	0.002	1.671	4000
Sprint	2011	0.234	0.118	0.513	0.120	1.678	4609
	2013	0.109	0.093	0.168	0.007	1.266	9113
AT&T (HSPA)	2011	0.614	0.568	1.107	0.642	2.917	10325
	2013	1.052	0.948	1.869	0.640	3.511	4971
VZW	2011	0.085	0.058	0.125	0.014	1.678	12678
	2013	0.447	0.370	0.822	1.671	1.800	8032
T-Mobile (HSPA)	2011						
	2013						

Table 8: Duchesne County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.056	0.053	0.067	0.056	0.220	3144
	2013	0.689	0.640	1.232	1.671	1.778	1007
Sprint	2011	0.329	0.143	0.774	0.127	1.249	4719
	2013	0.566	0.452	1.005	1.671	2.070	2703
AT&T (HSPA)	2011	0.748	0.697	1.279	0.104	3.067	5186
	2013	0.998	0.928	1.721	0.002	3.263	2782
VZW	2011	0.174	0.109	0.285	0.132	1.697	9056
	2013	0.367	0.169	0.824	1.671	2.089	7684
T-Mobile (HSPA)	2011						
	2013	0.268	0.204	0.545	0.051	0.618	19

Table 9: Emery County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.098	0.053	0.188	0.056	1.003	3576
	2013	0.787	0.710	1.250	1.671	1.671	980
Sprint	2011	0.261	0.155	0.549	0.056	1.516	1842
	2013	0.525	0.411	0.966	0.130	1.772	2099
AT&T (HSPA)	2011	0.592	0.487	1.121	0.104	2.389	2844
	2013	1.270	1.343	2.088	0.004	3.530	2019
VZW	2011	0.254	0.081	0.634	0.056	1.678	5266
	2013	0.485	0.182	1.161	1.671	2.150	5031
T-Mobile (HSPA)	2011						
	2013						

Table 10: Garfield County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.059	0.053	0.067	0.053	0.301	4193
	2013	0.159	0.126	0.343	0.130	0.535	76
Sprint	2011	0.208	0.107	0.507	0.128	1.518	5315
	2013	0.623	0.499	1.196	1.671	2.075	4233
AT&T (HSPA)	2011	0.805	0.762	1.405	0.130	3.214	5018
	2013	0.935	0.819	1.824	0.640	4.022	4647
VZW	2011	0.273	0.130	0.597	0.127	2.066	8044
	2013	0.479	0.286	1.062	1.671	2.089	9216
T-Mobile (HSPA)	2011	0.568	0.589	0.873	0.002	1.308	321
	2013	2.096	2.089	3.240	0.618	4.487	231

Table 11: Grand County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.214	0.148	0.412	0.042	1.029	3673
	2013	0.451	0.395	0.780	0.128	1.671	4261
Sprint	2011	0.218	0.116	0.491	0.127	1.645	5942
	2013	0.508	0.427	0.852	1.671	1.819	6153
AT&T (HSPA)	2011	0.607	0.517	1.100	0.104	2.888	8622
	2013	0.947	0.834	1.770	0.640	3.550	7327
VZW	2011	0.112	0.100	0.141	0.127	1.838	11215
	2013	0.372	0.160	0.899	1.671	2.089	8236
T-Mobile (HSPA)	2011						
	2013						

Table 12: Iron County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.147	0.074	0.288	0.053	0.938	824
	2013	0.548	0.530	1.044	0.002	1.671	1643
Sprint	2011	0.160	0.097	0.241	0.127	1.678	2335
	2013	0.260	0.208	0.522	0.002	0.782	1807
AT&T (HSPA)	2011	0.722	0.642	1.233	0.058	3.247	4215
	2013	1.048	0.960	1.883	0.640	3.836	3428
VZW	2011	0.220	0.116	0.455	0.134	1.729	5444
	2013	0.381	0.162	0.907	1.671	2.089	4660
T-Mobile (HSPA)	2011	0.341	0.344	0.519	0.007	1.175	93
	2013						

Table 13: Juab County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.047	0.023	0.065	0.007	0.644	1877
	2013						
Sprint	2011	0.075	0.070	0.123	0.028	0.229	607
	2013						
AT&T (HSPA)	2011	0.456	0.375	0.877	0.007	2.121	3788
	2013	0.940	0.815	1.791	0.640	3.201	1288
VZW	2011	0.342	0.141	0.769	0.006	1.678	5404
	2013	0.355	0.133	0.857	1.671	2.065	4948
T-Mobile (HSPA)	2011						
	2013						

Table 14: Kane County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.447	0.449	0.670	0.730	0.908	259
	2013	0.452	0.376	0.841	0.002	1.671	2437
Sprint	2011	0.201	0.114	0.449	0.127	1.678	5016
	2013	0.354	0.278	0.642	0.002	1.746	4337
AT&T (HSPA)	2011	0.841	0.785	1.394	0.070	3.081	9819
	2013	1.209	1.128	1.986	0.640	3.803	8337
VZW	2011	0.250	0.125	0.536	0.127	1.726	13432
	2013	0.507	0.304	1.120	0.007	2.089	11758
T-Mobile (HSPA)	2011						
	2013						

Table 15: Millard County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.205	0.127	0.410	0.002	1.310	2185
	2013	0.527	0.458	0.955	1.671	1.671	2056
Sprint	2011	0.152	0.102	0.220	0.127	1.678	3332
	2013	0.273	0.186	0.498	0.130	1.671	3133
AT&T (HSPA)	2011	0.672	0.596	1.153	0.776	3.301	687
	2013	1.084	1.059	1.738	0.640	2.981	2077
VZW	2011	0.478	0.410	0.907	0.125	2.425	2430
	2013	0.727	0.645	1.367	1.671	2.213	2123
T-Mobile (HSPA)	2011						
	2013						

Table 16: Morgan County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.043	0.027	0.065	0.007	0.558	1299
	2013						
Sprint	2011	0.047	0.044	0.073	0.051	0.176	350
	2013						
AT&T (HSPA)	2011	0.751	0.828	1.301	0.012	1.727	114
	2013	1.087	0.981	2.071	0.030	3.453	374
VZW	2011	0.269	0.107	0.637	0.025	1.738	1066
	2013	0.312	0.153	0.697	0.100	2.089	1773
T-Mobile (HSPA)	2011						
	2013						

Table 17: Piute County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.282	0.259	0.477	0.241	1.020	2762
	2013	0.608	0.611	1.098	1.671	1.671	971
Sprint	2011	0.178	0.109	0.380	0.099	0.999	4114
	2013	0.988	0.098	0.145	0.121	0.408	2649
AT&T (HSPA)	2011	0.138	0.111	0.183	0.127	1.383	4319
	2013	0.668	0.523	1.260	0.640	2.623	1209
VZW	2011						
	2013	0.734	0.714	1.303	1.671	2.089	1298
T-Mobile (HSPA)	2011						
	2013						

Table 18: Rich County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.281	0.157	0.593	0.051	1.678	11816
	2013	0.355	0.261	0.703	0.002	1.729	18204
Sprint	2011	0.278	0.170	0.570	0.009	1.678	13082
	2013	0.275	0.182	0.557	0.002	1.965	18282
AT&T (HSPA)	2011	0.591	0.461	1.166	0.131	3.737	12014
	2013	0.923	0.825	1.653	0.640	3.156	15244
VZW	2011	0.287	0.132	0.663	0.144	1.868	4638
	2013	0.494	0.378	0.978	1.671	2.321	17770
T-Mobile (HSPA)	2011	0.586	0.415	1.132	0.131	3.274	9997
	2013	1.110	0.944	1.951	0.643	5.014	8873

Table 19: Salt Lake County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.049	0.050	0.065	0.056	0.232	282
	2013						
Sprint	2011						
	2013	0.787	0.631	1.330	1.671	2.003	126
AT&T (HSPA)	2011	0.862	0.806	1.514	0.641	2.872	3789
	2013	0.896	0.748	1.723	0.640	3.654	4325
VZW	2011	0.182	0.086	0.369	0.007	1.936	13955
	2013	0.251	0.091	0.594	0.007	1.791	12563
T-Mobile (HSPA)	2011	0.718	0.718	0.962	0.252	1.406	26
	2013	2.044	2.176	3.082	2.988	3.781	77

Table 20: San Juan County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.159	0.095	0.340	0.095	1.105	4980
	2013	0.385	0.270	0.745	0.121	1.671	760
Sprint	2011	0.092	0.097	0.146	0.120	0.278	1003
	2013	0.420	0.329	0.819	0.002	1.809	759
AT&T (HSPA)	2011	0.656	0.582	1.135	0.642	2.718	6459
	2013	0.733	0.642	1.330	0.640	2.900	7127
VZW	2011	0.186	0.108	0.315	0.127	1.678	8416
	2013	0.383	0.222	0.824	1.671	2.107	9047
T-Mobile (HSPA)	2011						
	2013	0.216	0.186	0.320	0.186	0.780	725

Table 21: San Pete County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.285	0.227	0.584	0.056	1.316	5742
	2013	0.433	0.330	0.859	0.002	1.671	3716
Sprint	2011	0.283	0.182	0.575	0.051	1.158	1359
	2013	0.500	0.424	0.821	1.671	1.784	4778
AT&T (HSPA)	2011	0.554	0.514	0.936	0.002	2.495	4182
	2013	0.899	0.791	1.600	0.640	3.004	5052
VZW	2011	0.317	0.152	0.683	0.063	1.923	7959
	2013	0.328	0.160	0.762	1.671	2.089	9852
T-Mobile (HSPA)	2011						
	2013						

Table 22: Sevier County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.112	0.056	0.134	0.053	1.678	4064
	2013	0.461	0.388	0.904	0.128	1.691	3106
Sprint	2011	0.161	0.107	0.269	0.132	1.500	8195
	2013	0.364	0.278	0.731	0.002	1.671	6048
AT&T (HSPA)	2011	0.690	0.631	1.245	0.056	2.590	863
	2013	1.196	1.191	1.948	0.640	3.576	3718
VZW	2011	0.249	0.125	0.555	0.127	1.678	7538
	2013	0.374	0.148	0.921	1.671	2.089	6475
T-Mobile (HSPA)	2011	0.912	0.951	0.176	0.378	2.110	29
	2013	1.619	1.557	2.410	1.963	4.646	353

Table 23: Summit County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.081	0.081	0.114	0.056	0.373	6278
	2013	0.299	0.130	0.692	0.128	1.671	3466
Sprint	2011	0.137	0.097	0.188	0.134	1.290	10512
	2013	0.179	0.119	0.334	0.002	1.671	7076
AT&T (HSPA)	2011	0.850	0.792	1.435	0.157	3.081	3416
	2013	1.275	1.215	2.123	0.640	3.625	6084
VZW	2011	0.356	0.155	0.794	0.134	1.678	8341
	2013	0.675	0.594	1.258	1.671	2.089	5641
T-Mobile (HSPA)	2011	0.820	0.767	1.422	0.033	3.339	938
	2013	1.257	1.164	2.280	0.002	4.388	1000

Table 24: Tooelle County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.060	0.053	0.093	0.056	0.528	7148
	2013	0.251	0.130	0.425	0.126	1.671	3265
Sprint	2011	0.082	0.067	0.130	0.056	0.732	6720
	2013	0.104	0.035	0.147	0.007	1.671	6761
AT&T (HSPA)	2011	0.662	0.609	1.191	0.116	2.560	5261
	2013	1.013	0.892	1.785	0.640	3.068	4650
VZW	2011	0.139	0.079	0.162	0.127	1.678	7591
	2013	0.426	0.313	0.857	1.671	1.671	5600
T-Mobile (HSPA)	2011						
	2013						

Table 25: Uintah County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.073	0.056	0.118	0.053	0.459	16276
	2013	0.278	0.178	0.565	0.002	1.671	19897
Sprint	2011	0.216	0.123	0.446	0.021	1.678	14970
	2013	0.301	0.210	0.561	0.002	2.089	21407
AT&T (HSPA)	2011	0.517	0.359	1.017	0.026	3.589	10711
	2013	1.000	0.939	1.607	0.640	4.062	14688
VZW	2011	0.316	0.163	0.687	0.007	2.097	12569
	2013	0.410	0.271	0.852	1.671	2.252	17376
T-Mobile (HSPA)	2011	0.397	0.197	0.850	0.026	3.468	6511
	2013	1.181	1.091	1.794	0.642	4.678	8307

Table 26: Utah County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.061	0.054	0.070	0.053	0.489	5841
	2013	0.584	0.558	0.962	1.671	1.813	3342
Sprint	2011	0.326	0.238	0.632	0.130	1.550	3787
	2013	0.372	0.296	0.645	0.103	1.880	5404
AT&T (HSPA)	2011	0.655	0.586	1.100	0.116	2.620	3389
	2013	1.312	1.322	2.065	0.640	3.347	3138
VZW	2011	0.162	0.118	0.207	0.130	1.678	5994
	2013	0.297	0.129	0.717	0.002	1.671	5631
T-Mobile (HSPA)	2011						
	2013	0.824	0.746	1.267	0.827	1.689	55

Table 27: Wasatch County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.109	0.071	0.194	0.056	1.210	5618
	2013	0.200	0.119	0.404	0.002	1.671	5117
Sprint	2011	0.196	0.095	0.436	0.035	1.447	10156
	2013	0.236	0.157	0.442	0.002	1.671	8093
AT&T (HSPA)	2011	0.510	0.426	0.871	0.255	2.771	9665
	2013	1.096	1.011	1.864	0.640	3.931	7536
VZW	2011	0.177	0.088	0.287	0.035	1.749	13084
	2013	0.331	0.127	0.833	1.671	2.089	10252
T-Mobile (HSPA)	2011						
	2013	1.587	1.563	2.341	2.084	3.945	430

Table 28: Washington County

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Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.054	0.049	0.067	0.056	0.435	3862
	2013						
Sprint	2011						
	2013						
AT&T (HSPA)	2011	0.739	0.710	1.198	0.642	2.570	2915
	2013	0.970	0.897	1.678	0.645	3.735	2086
VZW	2011	0.136	0.079	0.155	0.056	1.678	3961
	2013	0.274	0.115	0.583	0.100	2.089	3462
T-Mobile (HSPA)	2011						
	2013						

Table 29: Wayne County

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011	0.270	0.181	0.544	0.026	1.678	3637
	2013						
Sprint	2011	0.252	0.134	0.542	0.026	2.370	4920
	2013	0.198	0.126	0.360	0.128	1.671	6399
AT&T (HSPA)	2011	0.495	0.296	1.034	0.026	2.886	3010
	2013	0.840	0.708	1.560	0.640	3.916	3958
VZW	2011	0.274	0.132	0.603	0.002	1.678	3583
	2013	0.468	0.331	0.893	1.671	2.089	4405
T-Mobile (HSPA)	2011	0.339	0.223	0.652	0.026	2.280	2469
	2013	0.987	0.806	1.824	0.547	3.387	1724

Table 30: Weber County

Appendix B: Comparison of 4G LTE and 3G Wireless Broadband Service

Carrier	Year	average speed	Median Speed	85 percentile speed	Most common value	Max Speed	Number of measurements
Cricket	2011						
	2013						
Sprint	2011						
	2013						
AT&T (HSPA)	2011						
	2013	3.807	2.148	8.422	0.004	30.442	58847
VZW	2011	0.644	0.525	1.081	0.131	4.461	7248
	2013	2.984	1.170	7.673	0.004	16.073	121083
T-Mobile (HSPA)	2011						
	2013	9.400	0.093	3.124	0.093	13.590	76149

Table 31: Statewide LTE

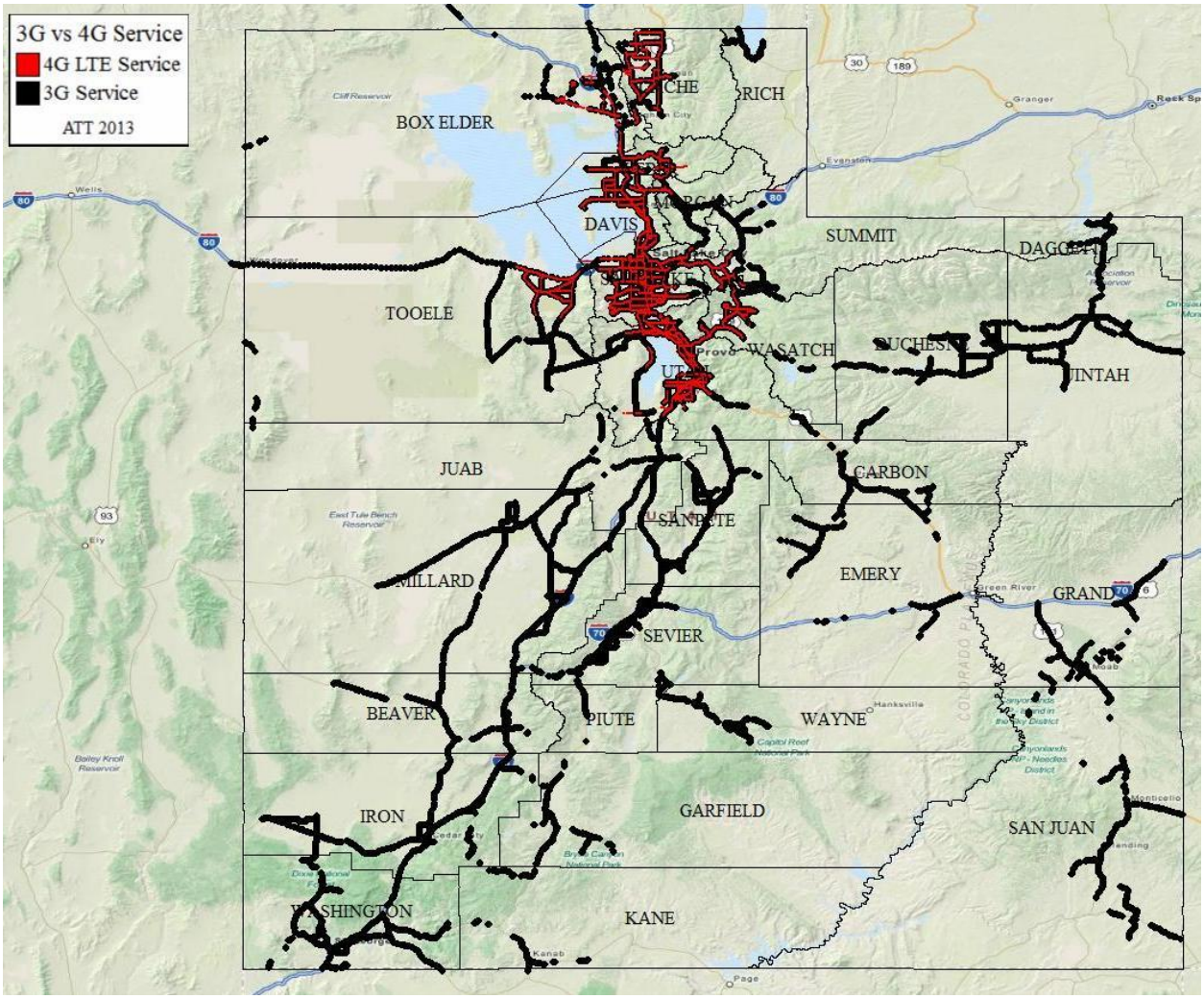

Figure 1: AT&T 2013 LTE Service vs 2013 3G Service

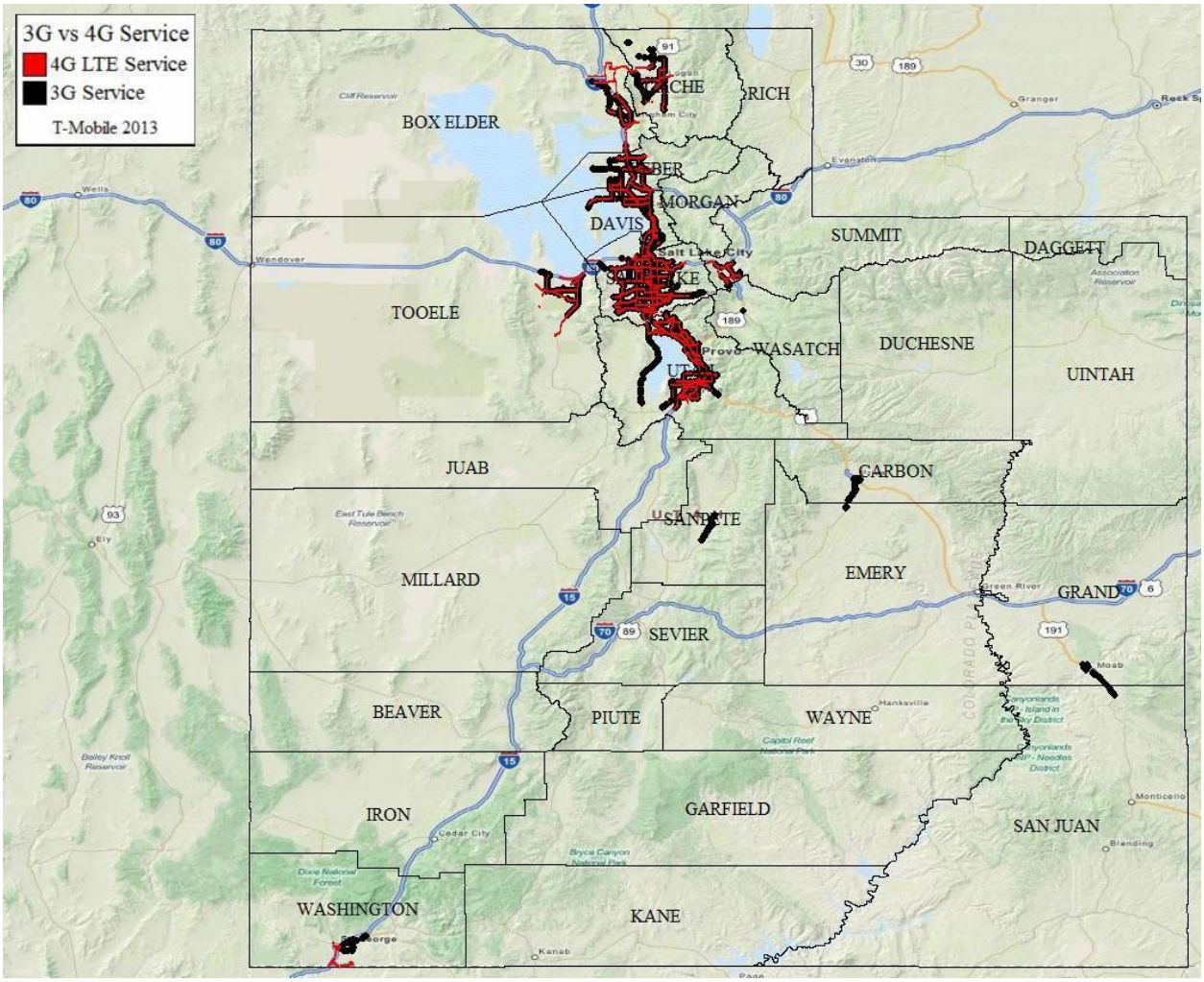

Figure 2: T-Mobile 2013 LTE Service vs 2013 3G Service

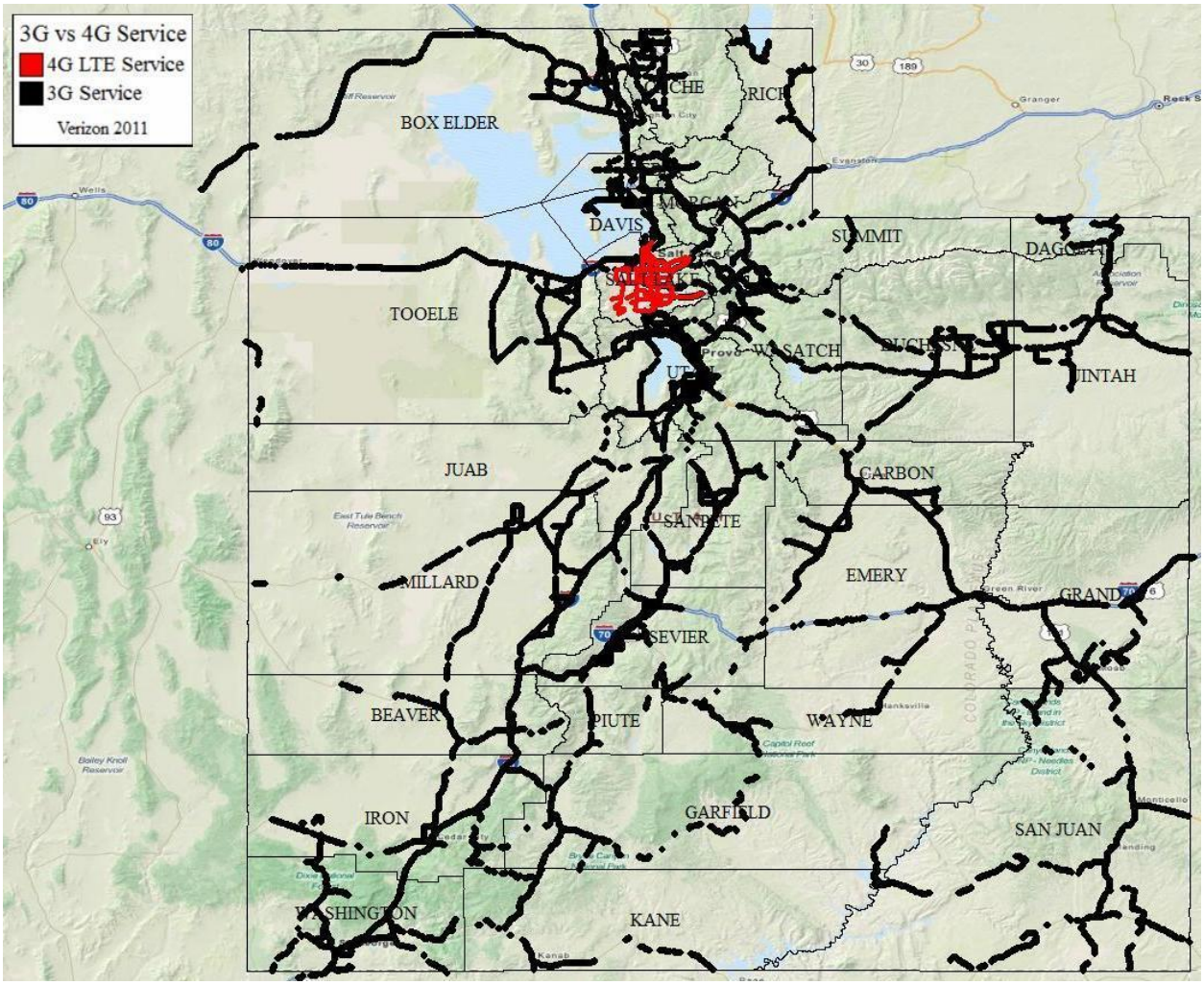

Figure 3: Verizon 2011 LTE Service vs 2011 3G Service

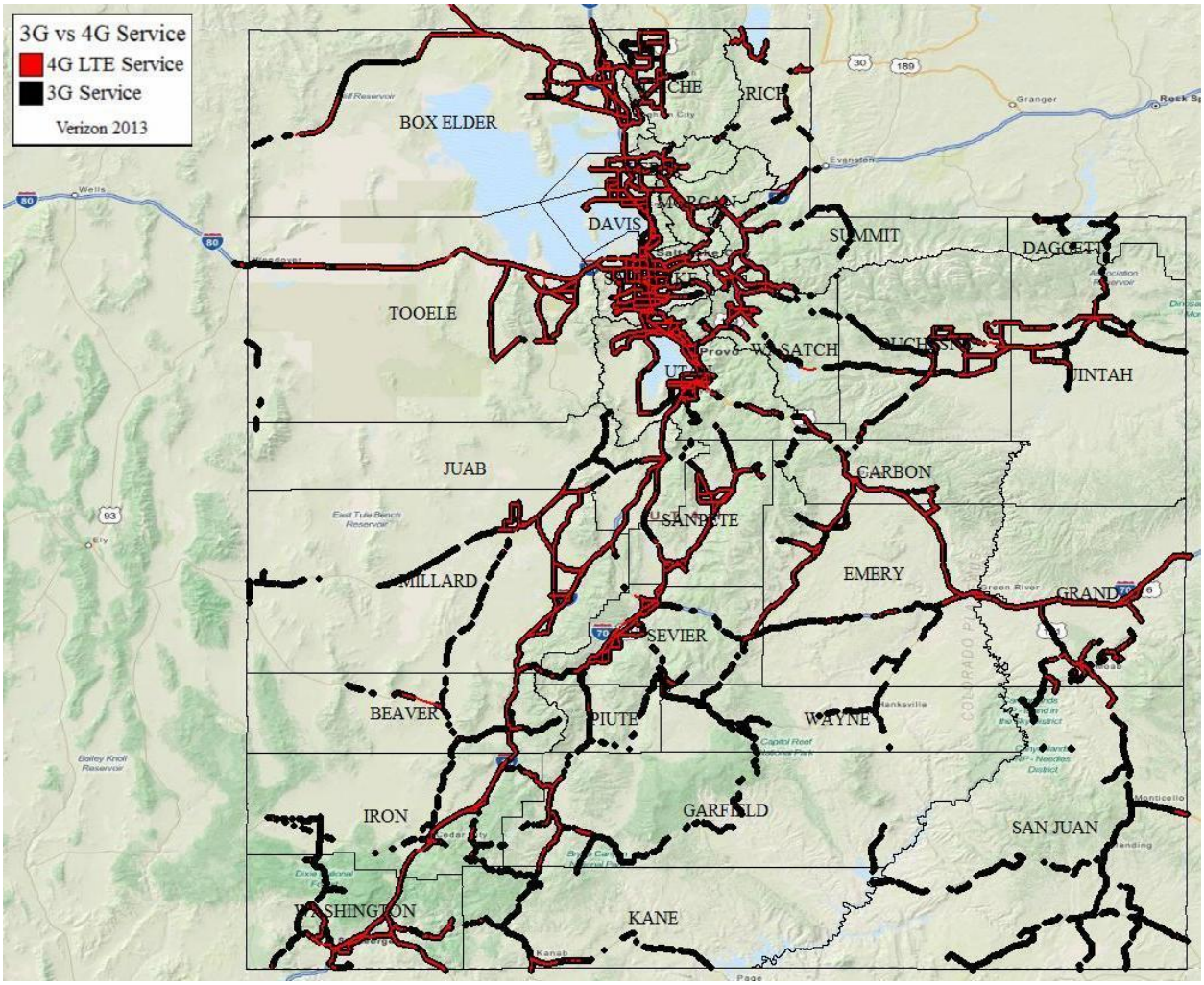

Figure 4: Verizon 2013 LTE Service vs 2013 3G Service