Your Mileage May Be Different

Reflections on megabits per second and miles per day.

By David Maxson, WCP

Returning the rental car was the last obstacle after three weeks of wireless benchmarking across the state of Utah. We monitored the performance of six broadband wireless services across the 29 Utah counties, with a total of 50 gigabytes of throughput — but it was the 9,328 miles we put on the rental car that stumped the system. The rental returns attendant typed the final odometer reading into her handheld terminal, and it was too much for the device. The terminal "thought" it had to be a data entry error; so many miles in so little time. It would not let her enter the odometer reading.

It was a fascinating journey that brought our team to the Salt Lake City Airport car rental pavilion. It all began with an economic meltdown in 2008. Among the projects funded by the federal government to help stimulate the tanking economy was the Broadband Technology Opportunities Program (BTOP) and its companion, the State Broadband Initiative (SBI, also known as the State Broadband Data and Development program, or SBDD). These were two results of the American Recovery and Reinvestment Act (ARRA) and the Broadband Data Improvement Act. The programs are administered by the National Telecommunications and Information Administration (NTIA). Private parties applied for BTOP grants to support the development of broadband infrastructure in unserved

Cell tower in northwestern Utah near Park Valley, pop. 270 (nowhere near Park City) with curious cattle looking on.

and underserved areas of the United States. This writer volunteered as one of the many peer reviewers of these applications in 2009.

Federal funds

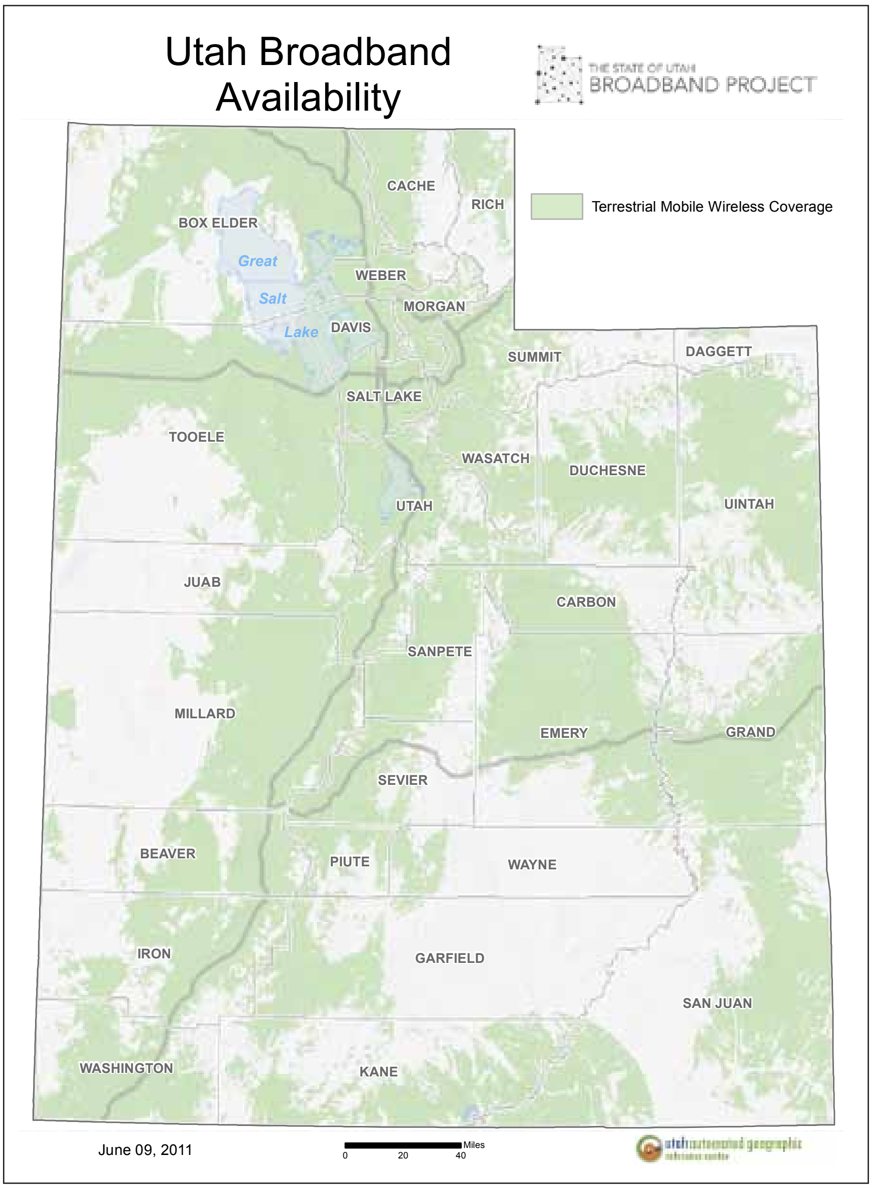
Meanwhile, each state, territory and district of the United States was given the opportunity to apply for federal funds to support state broadband initiatives. SBI funding is intended to "support the efficient and creative use of broadband technology to better compete in the digital economy" (*www.ntia.doc.gov/SBDD*). One objective was to foster the development and maintenance of a National Broadband Map (*http://broadbandmap.gov/*). State programs have been developed for diverse purposes, including supporting the efforts of community institutions and small businesses to use broadband technology more effectively, informing the development of policy and reduction of broadband barriers, and increasing the transparency of information about and access to broadband services.

All states applied for and received SBI funding. The state of Utah developed a broadband website and interactive map (*www.utah.gov/broadband*) and has been working on "a planning framework to assess and expand accessibility to broadband infrastructure and services." (Utah Broadband Mapping, Analysis and Planning Project Program Abstract, August 2009) Tara Thue, a project manager with the Utah Governor's Office of Economic Development, reported that all of the broadband service providers in Utah, including mobile and fixed wireless and wireline services, have been supportive and forthcoming with information to support the Utah Broadband Map initiative.

Broadband service

In the terms of SBI and BTOP, broadband service is defined as 768 kilobits per second (kbps) or greater on the downlink and 200 kbps or greater on the uplink. In consumer data communications, this asymmetry between the link down to the subscriber and the link up from the subscriber is the general rule. On traditional wired subscriber connections, it has always been good practice to design links that favor providing bandwidth from the server to the subscriber. Subscribers tend to consume more information from the server than they send up through the server, and biasing the design in favor of a high downlink data rate makes sense. When it comes to mobile wireless links, there is an additional factor that promotes the downlink/uplink asymmetry: equipment constraints. Unlike the base station, the subscriber's user equipment (UE) is compact, portable and battery operated. The uplink from the UE to the base station will need to run more slowly than the downlink to compensate for the weaknesses of the UE-to-base link.

When measuring in a mobile wireless environment, actual performance is hard to pin down for comparison to the 768/200 kbps thresholds. The national broadband map is largely based on "advertised service." When it comes to describing the speed available on a mobile wireless network, advertised service and actual performance at a given location within the



Broadband map created by the Utah Automated Geographic Reference Center with funding from the federal State Broadband Initiatives program.

During drive testing in Little Cottonwood Canyon, the Isotrope test car stops for equipment check beside Alta ski area on the Fourth of July.

service area may not coincide. The reasons why this is the case all fall under the umbrella of it being the nature of the beast.

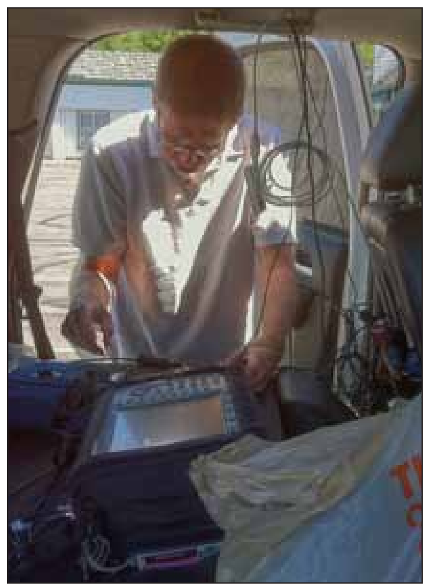
Wireless links

The mobile radio channel is a dynamic and challenging environment. Mobile wireless links continuously adapt to the channel conditions of the data link. For example, the 3G (third-generation) UMTS technology employed by some major carriers in the United States can adjust the power level of the UE 1,500 times a second in order to maintain a signal level that is not too low and not too high for the network to work. (*www.umtsworld.com*) Similarly, the specifications for another 3G technology, EVDO, include a data rate control (DRC) feature that adjusts the link data speed between 38 kbps and 3.1 Mbps in 14 steps, depending on the channel conditions. (*www.howcdmaworks.com/340.pdf,* p. 35) It is also well established that when the UE is in motion, the data link is challenged more than when it is standing still, resulting in lower average mobile data rates compared with stationary in-building use.

In the case of the Utah broadband map, the primary source of information was the service providers. Utah did a sanity check of the submitted data by cross-checking with independent sources. Wireless service providers know where their facilities are and can estimate where the coverage of each of their operating technologies lies. Major wireless carriers provide online coverage check maps for subscribers, including separate data coverage and voice coverage maps.

LTE service

Wireless service providers have to decide how to advertise their data



Isotrope CTO Steve Riggs tends to the drive test data-collection system, gathering broadband throughput statistics on six mobile wireless services across the state of Utah.

coverage. Do you list the maximum rate the installed technology will offer, or do you describe a real-world "average" expected performance? For example, Verizon Wireless seems to have found a safe spot between overstating and understating in its advertising. It promotes its new LTE

Fiber optics reach into remote areas of Utah, supporting the provision of broadband wireless services via cell sites.

service (as equipped today), saying, "With Verizon Wireless' 10 + 10 MHz implementation, LTE will be supporting average data rates per user of 5 Mbps to12 Mbps in the forward [down] link, and 2 Mbps to 5 Mbps in the reverse [up] link."

A quick look at the theoretical performance of LTE technology suggests Verizon Wireless is being realistic. Table 1 shows an estimate of best-case LTE speeds in nine scenarios. The 10 megahertz channel at the outer edge of the LTE cell (highlighted in Table 1) is theoretically capable of delivering 14 Mbps down and about 5 Mbps up. This is close to the upper side of the Verizon Wireless estimate (12/5 Mbps down/up). Of course, this estimate is based on general signal-to-noise conditions versus distance and on full capacity being available to the one subscriber, so there may be more degradation in actual performance from interference and user traffic, depending on the

	Relative Distance from Cell Center		
Channel Bandwidth	Close	Medium	Far
5 MHz	17/5.6 (Down/Up) Mbps	11/3.7	5.6/1.8
10 MHz	43/14.4	28/9.5	14/4.8
20 MHz	85/28	56/18	28/9.5

Estimated net LTE user data peak rates down/up by channel bandwidth and distance from cell center. Source: Aviat Networks, February 2011

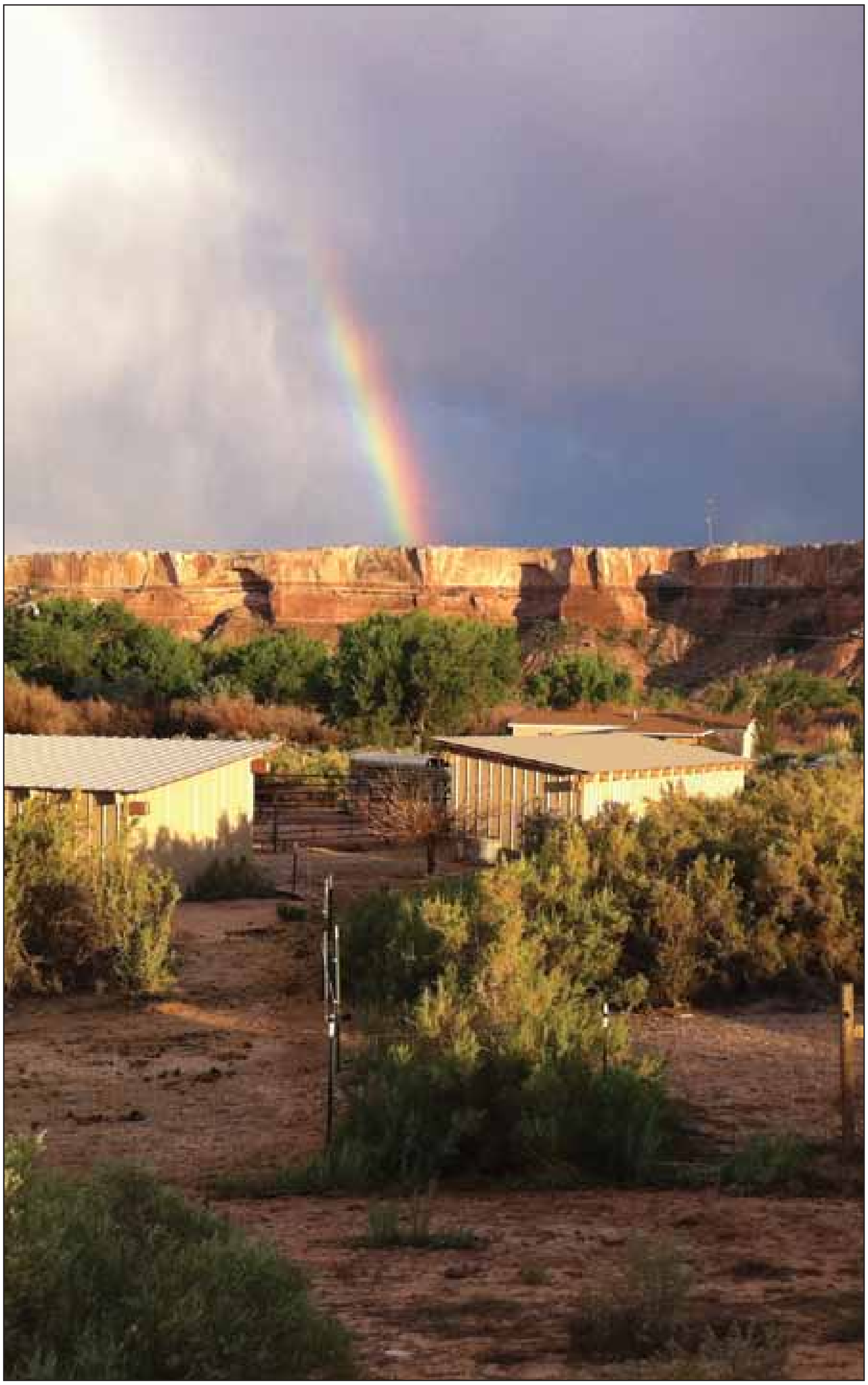
circumstances. ("Your mileage may be different"!) Under ideal channel conditions and close to the cell site, Table 1 shows that much higher performance is possible, compared with the advertised speed.

Service availability

With the officially defined threshold for broadband service (768/200 Mbps) and an online broadband map showing data service availability by provider, the state of Utah sought other ways to look at the question. The Utah broadband website has an online speed test that broadband subscribers are invited to run. Such test tools provide a useful snapshot of data speeds that subscribers actually obtain where they use their broadband services (wireless and wireline). Of course, the results are entirely dependent on who runs the speed test, the quality of their connection, and the type and condition of their user equipment.

To obtain another glimpse at the geographic distribution of mobile wireless broadband services, the Utah SBI team commissioned a statewide drive test of broadband mobile wireless services. To guide the drive test, Bert Granberg of the Utah Automated Geographic Reference Center (the state's geographic information systems department) assembled a set of first-, second- and third-class roads spanning the state's varied terrain and land use. The plan was to reach into every corner of Utah life, including urban, suburban, rural, mountain, valley, canyon, desert, park, range, resort and reservation. Isotrope won the contract to conduct the survey under the auspices of the state's broadband consultant, International Research Center. Utah is a beautiful place to tour, even if just passing through.

We installed test-receiving gear in an air-cooled radome mounted on the roof of the vehicle. It was connected to a professional drive-test controller manufactured by ZK Celltest with further support from laptop computers. All mobile wireless technologies active in Utah were supported during the test. In addition to logging the availability of wireless service by carrier and technology, the test platform was configured to download and upload data files and record the resulting effective transfer rates.



A rainbow and cell tower in Bluff, Utah (pop. 283). Look closely to see the cell tower on the bluff that serves the town and the surrounding area, rain or shine.

Efficient drive route

Using our GIS technology, we took in Bert's map and created the most efficient drive route we could compute. Ironically, our most up-to-date road map from a national vendor lacked a few of the newer parkways on the Utah GIS map. And to Bert's credit, we found only one "road" in his inventory that did not exist. Also, the Utah Department of Transportation is well-organized, publishing a statewide road construction advisory map that alerted us to places we could expect bottlenecks and plan accordingly. Nevertheless, we randomly encountered surprises along the way, including three mountain passes closed due to landslides, forcing route changes on the fly.

Speaking of published specs versus real performance, our test vehicle was equipped with a "miles remaining" indicator. One day, 30 miles from anywhere, we were confronted with a road sign with this ominous message: "No Services Next 102 Miles." The road was to be straight and mostly level, and the weather was fine. Knowing the risk, we counted on the indicator telling us we had 120 miles of gas left — a good 15 percent margin of error — so we plowed on. Sure enough, Murphy's Law was in force, and we got within 2 miles of the next fueling station and ran out of gas. So much for the "official estimate" from the on-board computer. Fortunately, even in this desolate location our instruments told us one of the wireless services had enough signal for us to make a call, and gas was quickly on its way. Terrestrial wireless served us well, and we did not have to break out the sat-phone in the luggage.

Distant coverage

Coming from New England, we are used to not only frequent fuel stations, but also lots of trees that soak up wireless signals. Also, a tall cell tower back East is only 190 feet, with typical cell towers being substantially shorter. Consequently, wireless signal levels drop off rapidly with distance from the cell site. In wide-open Utah rangeland, we were impressed with how far a good signal could reach from distant cell towers as tall as 300 feet. As one might expect, the technologies installed at cell sites in remote areas were often still 2G or 2.5G, supporting the essential voice call, but with limited data capabilities. In some aspects, coverage in the canyons was more problematic — line of sight is a rare commodity.

The Utah broadband team now has much data to crunch. They are presenting key data online to further illuminate the broadband discussion, and they welcome inquiries about the program. When checking out the results, just remember, whether it is miles per gallon, miles per rental, or megabits per second, your mileage may be different. Back at the airport, with a bright smile, the rental car returns attendant fudged the too-large odometer reading to get the check-in terminal to give us a receipt. The discrepancy report was decidedly low-tech: She wrote a note in grease pencil on the window. ■

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