Wireless Internet Service Providers Association

The Essential Role of Fixed Wireless in Universal Broadband Coverage

Prepared for WISPA by Interisle Consulting Group, August 2015

Bringing broadband services to all parts of the United States has proven to be a challenge for industry and government alike. While a majority of urban and suburban homes have access to one or two fixed service providers, many rural areas, and even some urban pockets, have little or no access to the services they need for a broad range of applications.

The major telephone companies, as well as the cable companies, are no longer subject to traditional utility rate regulation. They are allowed to invest where they choose, and take what profits they can. Telephone companies are still required by some states to provide basic dial tone service to all of their service areas, even the rural unprofitable parts. But they usually aren't required to upgrade their facilities to make broadband available there, and often don't. What was once derided as "cream skimming" is now national policy.

Subsidies finance rural fiber upgrades

Small rural telephone companies receive subsidies that enable them to provide service where it is otherwise uneconomical. Many have upgraded their plant to fiber optics, sometimes at a cost exceeding $10,000 per subscriber. Little of this is paid for by their own subscribers. The subsidy funds flow from a tax (technically a fee) on all interstate telecommunications service. This has already reached over 17% and could continue to rise as more ambitious goals are funded by a dwindling pool of revenues (mainly interstate toll charges). This is not a sustainable model, and it promotes a monopoly model of both telephone and Internet service.

Mobile wireless service is not a substitute for fixed service

Wireless services are quite different from wired ones, and mobile wireless service is nothing like a fixed service. Mobile service, such as cellular[1], is much more widely known. In rural areas, cell towers may be

[1] The term Commercial Mobile Radio Service (CMRS) applies to a range of similar services, including the original 800 MHz cellular, 1900 MHz PCS, 700 MHz services, and the various AWS bands. Since a given mobile handset tends to support whichever of these that the carrier uses, they are transparently selected and all appear to be "cellular", though that term formally only applies to two licenses per market as defined in FCC Rules Part 22 subpart H.

relatively tall and spaced farther apart, and have a service radius of at least several miles. In urban areas, cells are more closely spaced, enabling the same frequencies to be re-used in different parts of the same city.

Mobile services are now much more data-centric than the original voice services that predated them. To many users, a cell phone is primarily a pocket computer used for "apps" and texting more than for talking. Mobile wireless, however, is not really a substitute for fixed broadband. Even when it advertises high burst data speeds, it is almost always far costlier – by an order of magnitude or more – than fixed alternatives, especially when typical fixed usage is taken into account. Mobile carriers paid large sums of money at auction for their licenses, and the type of base station equipment they use is very expensive. It is optimized for mobility, which adds considerable complexity, and it includes direct connections to the telephone network, adding additional expense. And the total capacity of these networks is limited by the combination of spectrum limits, tower site availability, and equipment cost. So while mobile data service is very useful for its intended purpose, it would not make a good substitute for wired Internet access.

Fixed wireless is much more than local Wi-Fi

Yet high-quality, inexpensive wireless broadband service is used by millions of Americans, and others around the globe. *Fixed* wireless service is entirely different from mobile. Its performance is closer to wireline cable or DSL service, and sometimes comes close to fiber-based services. Its cost is comparable to wireline as well, without the high usage charges or restrictions associated with mobile data plans. Best of all, it does this across rural areas without subsidies, without exclusive licensing, and without depending on the big telephone and cable companies.

Thousands[2] of small Wireless Internet Service Providers (WISPs), mostly small, local entrepreneurs, operate across the United States. Unlike the big cable and phone companies, which are consolidating into ever-bigger monopolies, most WISPs are local businesses that know their communities and their customers. While the big companies' customer service undertakes a "race to the bottom", more and more customers are moving to WISPs, the only sector of the ISP marketplace where the number of service providers is growing.

While the heart of WISP activity is in rural areas that don't have cable or other high-speed fixed line options, some WISPs operate in urban areas, even in the middle of the biggest cities. They offer competition to the big carriers, especially to business customers in the many buildings not served by competitive fiber optic providers. WISPs often bring in high-speed service, via a small antenna, in days, rather than the weeks or months it would take to install a new fiber optic line, and without needing to open the street or arrange pole attachments.

Given these advantages, it is somewhat odd that public discourse about bringing broadband service to all Americans often omits mention of the fixed wireless sector. Perhaps it has not yet had time to be noticed. Fixed wireless was only a tiny business as recently as a decade ago, and has exploded with several new generations of radio technology that have lowered costs, improved performance, and simplified installation. Assumptions that may have been valid a decade ago no longer hold true. Certain limits imposed by the laws of physics and the regulations of the government still do apply, but remarkable progress has been made within them.

Wi-Fi was designed for indoor use

Of course almost everyone nowadays makes some use of fixed wireless *indoors*. Wi-Fi – an evolving set of wireless local area network standards developed by the IEEE 802.11[3] Working Group and promoted by

[2] WISPA has over 800 members, most of the Wireless ISPs in the United States, and estimates a total of approximately 3000 in the country.

[3] http://grouper.ieee.org/groups/802/11/

the Wi-Fi Alliance[4] – has become the most common type of local interconnection, used on everything from laptops and smartphones to thermostats and new "Internet of Things" device controllers. Wi-Fi was primarily designed for indoor, short-range use. Most Wi-Fi devices have only small built-in antennas and use the low power levels needed to cross a room or a house. They are optimized for high speed and low cost, not long range.

Public Outdoor Wi-Fi is very limited

Short-range outdoor Wi-Fi is not the same as the longer-range systems used by WISPs. The first has seen some deployment in cities, and is now being deployed by some cable companies in their own footprints. They put up Wi-Fi access points outdoors, in the latter case often hung from their cable, to allow direct connections from laptops, smartphones, and other devices. It is very convenient for transient users, such as tourists and park visitors. But it does not address the problem of reaching most unserved or underserved populations. The usable range of such access points is only a few hundred feet. Not only do buildings and other urban obstructions block the signal, but the intended client devices use nondirectional antennas and low power. It is really just the indoor Wi-Fi model on the other side of the wall. And because it is generally open to the public, it lacks security – most such systems do not use any form of encryption, so information transmitted over public Wi-Fi is vulnerable to eavesdropping.

Another word frequently heard in this context is "mesh". This idea, which dates back to the earliest government packet radio experiments of the 1970s[5], regularly pops up among users hoping to find a cheaper alternative to commercial service providers. The popular version of the mesh concept has cheap home Wi-Fi access points configured to relay each other's signals hop by hop until they reach a shared upstream connection (injection point). The same channel is used for both access and relaying. In practice, this approach does not work well at all – it typically works well for about one hop from the injection point, but after that, its performance drops off rapidly. The concept may work well enough to send short messages from a "thing" or across a battlefield, but cannot provide competitive broadband service. In practice, the major users of mesh technology turn out to be utilities, who use it for remote meter reading, not a true broadband application.

Fixed wireless can have a much longer range than Wi-Fi

Figure 1. Fixed wireless sector antenna, grid antenna, and 15" backhaul dish on a hillside.

But the same technology used to create inexpensive local Wi-Fi can be adapted for outdoor, longer-range use too. Vendors have taken advantage of the semiconductors mass-produced for Wi-Fi, and use adapted hardware and high-gain antennas along with software optimized for outdoor use. They have created outdoor radio systems that combine the low cost of Wi-Fi with the high performance that only a few years ago required specialized microwave radio systems costing thousands of dollars per unit. These have empowered WISPs to bring low-cost service to subscribers who may be several miles away from the nearest access point or tower. It is truly an example of Moore's Law[6] being applied to communications.

Several factors make this work better than Wi-Fi and more cheaply than mobile wireless. A mobile subscriber is often indoors or in a car, using a small antenna. A WISP subscriber radio, in contrast, is outdoors, and uses a directional antenna that has *gain* to make the effective signal hundreds of times stronger than what a mobile handset would receive. This allows a low-power access point to cover greater distances, at higher speeds, at lower cost. It's like the difference between

[4] http://www.wi-fi.org/

[5] E.g., the ARPA PRNET experiments described by Kahn, Gronemeyer, Burchfiel and Kunzelman in *Advances in Packet Radio Technology*, Proceedings of the IEEE, Vol. 66 No. 11 Nov. 1978.

[6] https://en.wikipedia.org/wiki/Moore%27s_law

watching over-the-air TV with rabbit ears vs. having a large outdoor antenna – one may work in the city, but the other is needed for fringe-area coverage. But thanks to the higher frequencies, WISP radios are still pretty small; the largest subscriber dishes are only about the size of a modern home satellite dish.

Access sectors can provide broadband service for several miles

A WISP subscriber access sector antenna nowadays typically supports a shared capacity in the 50 to 100 Mbps range (sum of both directions). Since most consumer Internet usage is bursty and *average* utilization is only in the 1 Mbps range in the faster direction, a sector can comfortably support 20-30 users, each seeing an effective speed of 10 Mbps or even higher. And as the next generation of radios comes to market, substantially higher speeds will become available.

These are far smaller and less obtrusive than cell towers. While some are mounted on actual towers, they may also be attached to walls, roofs, poles, or even grain legs. They use little power and transmit with no more power than is allowed for Wi-Fi devices. But by carefully shaping their coverage patterns and placement, and linking to outdoor subscriber radios, they typically serve a range of several miles.

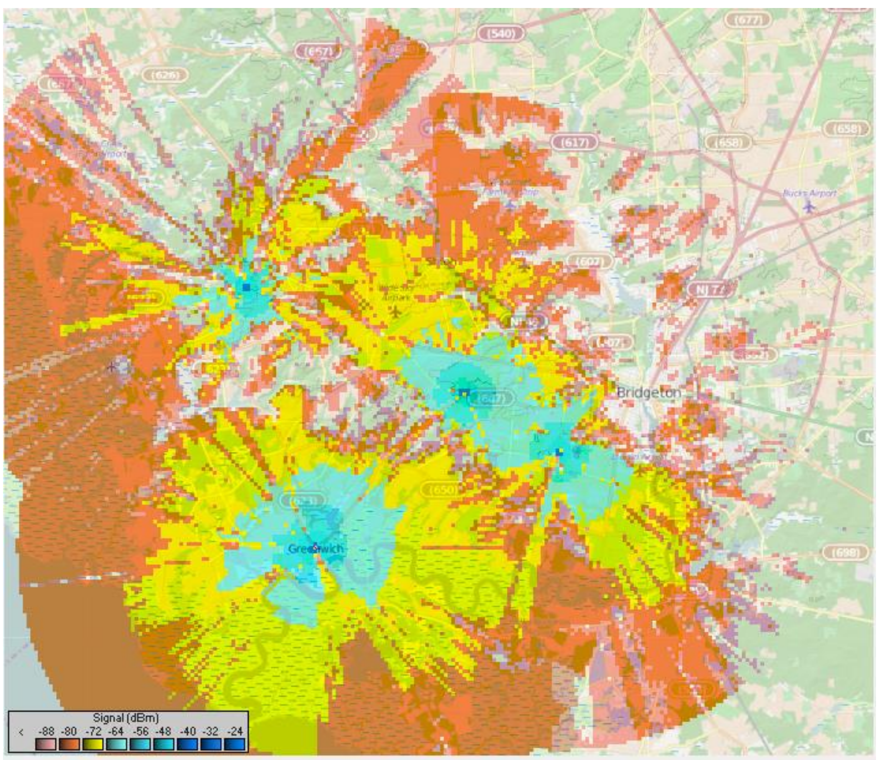

Figure 2 A forecast of potential coverage from four sites, each 50 feet tall, in a gently rolling area of mixed farms, forest, and wetland. Coverage with 70% probability of success is plotted to a maximum of 5 miles from each site; areas in yellow or blue are most likely to achieve full speed, while areas in orange may be subject to reduced speeds. A conventional Wi-Fi outdoor access point model would likely be limited to the areas in blue, largely due to its using non-directional antennas, especially at the subscriber end.

Point to point applications are also important

While traditional licensed microwave systems are still widely used, many applications can now make use of inexpensive unlicensed systems instead, at much lower cost. Licensed systems are granted exclusive use of a given frequency on a given path; unlicensed systems take advantage of the bursty nature of data traffic to gracefully share channels, though often the highly-directional antennas used on point to point links create, in effect, a clear path. These are widely used by WISPs for backhaul connections (to connect their access sectors to the Internet backbone), and to connect to their larger commercial customers.

A typical unlicensed point-to-point radio would use a dish antenna of about 15 inches diameter. iven a clear path, that is likely to be sufficient for 10 miles or so of high-speed range. In rural areas, where very long backhaul may be needed, larger antennas can be used. A 3-foot dish could allow for a path of greater than 50 miles to be covered – if only the curvature of the Earth doesn't get in the way. But such long links do exist between mountaintops or tall towers. At such distances, rain fade needs to be taken into account. While rain fade at 5.8 GHz is only about 0.2 dB/km for a 50 mm/hour rainfall, that does add up to a meaningful 10 dB on a 50 km path. Other atmospheric effects, including ducting caused by thermal inversions, can have an even more serious impact. That's one reason why the telephone companies, when they built their backbone networks out of microwave radios before the advent of fiber optics, often used path diversity – the worst fade events are often very local. So this too is in the rural operator's bag of tricks, though nowadays it is most often accomplished by using IP routing

For short hauls, higher-frequency bands allow even higher data speeds. The 24 GHz band allows radios with a 1-foot dish to support data rates of up to 1 Gbps or so, for a distance of 1-2 miles, limited primarily by rain fade. Equipment is becoming more common for the unlicensed 60 GHz band, allowing these and faster data rates, though reliable range is usually only about half a mile or so. These bands are especially useful for business links and urban backhaul.

The upshot is that remarkable things can be done, and are, being done in the unlicensed bands. But even more is possible using new technologies and frequency bands. Recent changes in regulation, and pending ones, create more opportunities to address markets not well served by more common fixed wireless technology.

TV White Space opens non-line-of-sight coverage

A key weakness with microwave radio technology, especially on the bands above 5 GHz, is that it does not penetrate obstructions very well. A single tree in the wrong place can have a substantial impact on performance, and signals do not follow the curvature of the earth, and thus are blocked by hills and tall buildings.

But the UHF television band, from 470 to 700 MHz, is perfect for non-line-of-sight applications. It penetrates foliage well, and can slip around some degree of obstructions. TV channels that are not in use in a given area – so-called TV White Space (TVWS) – are now available for unlicensed use. In most rural areas away from major markets, more than 10 channels are typically available, and even urban areas are expected to have some white space available after 2016's Incentive Auction leads to the repacking of the UHF TV band[7].

TVWS often has a greater range than 5 GHz, especially in rough terrain or wooded areas. Fixed wireless users, then, can use TV White Space as a fallback medium for reaching users in locations where the 5 GHz path does not work, while using the wider bandwidth of the higher frequencies to reach easier locations, and for high-speed backhaul. They are thus quite complementary.

The new CBRS band offers more options for rural users

Another new slice of the spectrum was opened in 2015. The Citizens Broadband Radio Service makes use of the 3.55-3.65 GHz frequencies previously reserved in the United States for government purposes,

[7] In August, 2015, the FCC released new rules for TV White Space which generally increase availability for unlicensed use. In the repacking of TV channels as part of the incentive auction, the FCC intends to leave at least two channels available for white space use everywhere, even urban markets.

mostly radar. It also includes the 3.65-3.7 GHz band previously available in many parts of the country for lightly licensed[8] use.

The FCC created a novel 3-tier system for CBRS. Top priority goes to Incumbent users, licensed before the new rules took effect, including government radars and existing 3.65 GHz systems. (Because the radar is primarily coastal, the new frequencies will initially only be available at inland locations.) Part of the remaining capacity is then auctioned off to Priority users, such as mobile carriers, for whom the principal intended purpose is “small cells”. The carriers can then use this for additional mobile broadband capacity, especially in urban areas. Band-sharing rules are expected to allow unlicensed (General) users to make use of both frequencies that are not otherwise encumbered, and frequencies whose Priority licensees have not actually placed them into service yet. This will prevent the “spectrum banking” that has allegedly kept much of the auctioned spectrum from being used, especially in rural areas.[9]

The WISP industry began by taking advantage of unlicensed frequencies originally intended for short-range and indoor use. Licensed spectrum was reserved for auction winners. In contrast, CBRS rules were written with fixed wireless users in mind, with capacity shared between auctioned Priority and free General usage. This reflects how fixed wireless is coming of age, no longer just an afterthought in spectrum regulation.

It’s an entrepreneurial industry

Perhaps one reason fixed wireless gets so little attention is because it is not widely used by large, publicly-traded corporations. Most providers are small, local businesses operating in rural areas. It therefore has a low profile to the financial community. Some of the equipment vendors are public corporations, but it is still only a niche sector.

It’s also not very visible to most parts of the telecom regulatory community, precisely because it is so cost-effective. WISPs generally use unlicensed radio frequencies. They operate without subsidies in areas where wireline telephone companies have long depended on the Universal Service Fund or other subsidy flows. WISPs don’t employ the armies of lobbyists, accountants, and other specialists that surround the traditional telecommunications industry. They are most visible to their communities and customers, but would be almost invisible to Washington, were it not for their representation by WISPA.

But isn’t that the way business should be? Fiber, cable and mobile systems are often run by top-down corporations that have little connection to their communities. Their customer service calls are often answered in other countries. Service is impersonal. Employee relations are often strained.

The small businesses that constitute the bulk of the fixed wireless service providers can’t be like that. Their owners are often on the front lines dealing with customers directly. They have no subsidies, no government franchises, no assurances of a rate of return. And yet they succeed in places where others fear to invest their own money.

The FCC’s Connect America Fund (CAF) subsidizes telephone companies to provide broadband access in their incumbent franchise territories. While small rural carriers have long been supported by the Universal Service Fund, in its new guise as the CAF, it added a subsidy program for the biggest incumbent carriers,

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[8] The lightly-licensed model allows for nationwide licenses, non-exclusive, requires fixed stations to be listed in an FCC database, and expects licensees to work out conflicts privately. New 3.65 GHz licenses and fixed station listings were frozen when CBRS was created.

[9] Mobile wireless licenses cover much larger areas. The original cellular licenses were awarded by SMSA (Standard Metropolitan Statistical Area). Later wireless auctions were by Major Trading Area and Basic Trading Area, roughly the areas served by big-city and second-tier daily newspapers as defined by Rand McNally’s 1994 Commercial Atlas, and somewhat larger Economic Areas defined by the government. A licensee must built out to reach most of the population in each license area, but they often do not serve rural areas on the fringes of their licensed areas.

to give them a one-time incentive to invest in broadband where it would otherwise be unprofitable. CAF funding does not go to places where unsubsidized competitors – mostly WISPs and cable companies – were offering both broadband and telephone service in 2012. But in other areas, WISPs will face new competition from old companies. Most, however, seem agile enough to survive.

Incumbent carriers did not all elect to take CAF money. In places where they did not – this includes the Verizon-East states and a few other areas – there will be a reverse auction. Whoever accepts the least support for a promise to serve a given unserved census block will win. You can guess which industry is well poised for this, at least *if* the FCC bidding rules are not rigged against them.

Price Cap Carrier	Homes & Businesses Served	Support Amount in Dollars
Carrier Subtotal	3,629,996	$1,500,895,507
AT&T	1,117,806	$427,706,650
Cincinnati Bell	7,084	$2,229,130
CenturyLink	1,174,142	$505,702,762
Consolidated	24,698	$13,922,480
Fairpoint	105,220	$37,430,669
Frontier	659,587	$283,401,855
Hawaiian Telcom	11,081	$4,424,319
Micronesian Telecom	11,143	$2,627,177
Verizon*	114,610	$48,554,986
Windstream	404,625	$174,895,478

Connect America Fund subsidy levels accepted by the largest US telephone companies in 2015. These support amounts will be given to the named carriers annually for six years, an average per-line subsidy total of $2481. Carriers then pledge to make 10/1 Mbps Internet access available to all of their customers in the states for which they elected subsidies; the number of customers shown is the number that are not yet served and are thus covered by the subsidy. Source: FCC press release, August 27, 2015.

The Wireless ISP industry is growing

It is no secret that the independent ISP industry has, for the most part, suffered badly since the turn of the century. While the dial-up era was said to have spawned at least 8000 ISPs in the United States alone[10], new regulations reduced the obligations on incumbent telephone companies to sell services to ISPs. Thus most customers today can only get wireline Internet service from one telephone company and one cable company.

But while this was happening, the wireless ISP industry was exploding. Growing demand led equipment vendors to produce new products at higher volumes and lower prices. This encouraged more ISPs to enter the wireless arena, especially in rural areas where other options were least likely to be available. By the time the FCC reformed its voice-centric Universal Service Fund to become the broadband-focused Connect America Fund, it had to take into account the widespread availability of unsubsidized competitors – primarily WISPs – who had set up shop in rural areas where voice services had only been made available via subsidies given to traditional telephone companies. The wireless ISP industry's ability

[10] Estimated by ISP World, link no longer active but cited in http://dspace.mit.edu/bitstream/handle/1721.1/1481/shin_correa_weiss.pdf: "The number of North American ISPs for the past several years is an evidence of low entry barrier in the downstream market: 1447 (February 1996), 3640 (February 1997), 4470 (February 1998), 5078 (March 1999), 7463 (April 2000), and 7288 (March 2001)."

to deploy to rural areas, without subsidies or public funds[11], has created the first real challenge to the entrenched subsidized monopolies that cost ratepayers billions of dollars per year.

Wireless ISP	Homes & Businesses Served	Support Amount in Dollars
Total	>3,000,000	$0

Connect America Fund and previous Universal Service Fund total subsidies to the Wireless ISP industry.

Unsubsidized fixed wireless can't solve 100% of the nation's broadband access. There are a few places so remote, or so blocked by hills and trees, that even a WISP can't succeed there, at least not without help. But such places are far less common than those where fiber can't be deployed economically, and even these most remote locations, fixed wireless is usually the lowest-cost way to provide broadband or even telephone service. A WISP can serve areas with a population density of only a few subscribers per square mile, even lower under favorable circumstances.

And urban WISPs serve niche markets in the heart of America's biggest cities. They provide alternatives to monopoly cable and telephone companies that often ignore whole urban communities, or whose fiber bypasses many buildings. The distances covered may not be as great but their business model is the same: Provide better service, at less cost, than wired alternatives. No wonder competitors would rather pretend they don't even exist.

Further information regarding the Fixed Wireless Industry can be obtained by contacting Veronica Perrin from WISPA at vperrin@wispa.org or Promotion Committee Chair, Forbes Mercy at forbes@wispa.org.

[11] See for instance *Wireless Broadband is Not a Viable Substitute for Wireline Broadband*, March 2015, prepared by Vantage Point Solutions for NTCA – The Rural Broadband Association, most of whose members are recipents of Universal Service Fund subsidies. Section 2 is titled *Public Funds Should be Invested in the Best Broadband Technologies*.