A Rural Broadband Strategy

Connecting Rural America to New Opportunities

Microsoft

CONNECTING RURAL AMERICA TO NEW OPPORTUNITIES

Executive Summary

Advancements in technology are rapidly transforming how we work, communicate, access information, and educate our children. Powered by cloud computing, these new capabilities are driving economic growth and innovations that weren't possible a decade ago.

However, 34 million Americans still lack a critical connection to the wealth of opportunities that the cloud presents: a broadband internet connection.

Of these, 23.4 million live in rural areas and their lack of broadband access means they are unable to take advantage of the economic and educational opportunities enjoyed by their urban neighbors.[1]

Yet despite this glaring disparity, real progress to close the rural broadband gap has plateaued in recent years. High costs, the absence of new and alternative technologies, and market and regulatory conditions have all hampered efforts to expand coverage.

But this is changing, thanks to recent advancements in technology, newly-adopted standards, business model innovations, and a growing demand for a broad range of cloud services.

A New Rural Broadband Strategy

The time is right for the nation to set a clear and ambitious but achievable goal: to eliminate the rural broadband gap within the next five years—by July 4, 2022.

We believe the nation can bring broadband coverage to rural America in this timeframe, based on a new strategic approach that combines private sector capital investments focused on new technologies along with affordable public sector support.

This whitepaper presents new directional findings by The Boston Consulting Group suggesting that a combination of technologies can substantially reduce the total cost of extending broadband coverage.

Specifically, a technology model that uses a combination of the TV white spaces spectrum, fixed wireless, and satellite coverage can reduce the initial capital and operating costs by roughly 80 percent compared with the cost of using fiber cables alone, and by approximately 50 percent compared with the cost of current LTE fixed wireless technology.

One key to deploying this strategy successfully is to use the right technology in the right places.

TV white spaces[2] is expected to provide the best approach to reach approximately 80 percent of this underserved rural population, particularly in areas with a population density between two and 200 people per square mile.

Microsoft itself has considerable experience with this technology, having deployed 20 TV white spaces projects worldwide that have served 185,000 users.

But TV white spaces alone will not provide the complete solution. Satellite coverage is expected to be the most cost-effective solution for most areas with a population density of less than two people per square mile, and LTE fixed wireless for most areas with a density greater than 200 people per square mile. This mixed model for expanding broadband coverage will likely bring the total national cost of closing the rural broadband gap to roughly $10 billion.

Microsoft's New Rural Airband Initiative

At Microsoft, we're prepared to invest our own resources to help serve as a catalyst for broader market adoption of this new model. We're committed to three elements on a five-year basis:

1. Direct projects with partners.

   Microsoft will invest in partnerships with telecommunications companies with the goal of bringing broadband connectivity to 2 million people in rural America by July 4, 2022.

   We and our partners will have 12 projects up and running in 12 states in the next 12 months.

   Our goal is not to enter the telecommunications business ourselves or even to profit directly from these projects. We will invest in the upfront capital projects needed to expand broadband coverage, seek a revenue share from operators to recoup our investment, and then use these revenue proceeds to invest in additional projects to expand coverage further.

2. Digital skills training for people of all ages.

   Working through Microsoft Philanthropies, our Rural Airband Initiative will invest in helping train people of all ages in these rural communities on the latest technologies so they can use this new connectivity to improve education, healthcare, agriculture, and transform their businesses.

   Our first partnership under the Rural Airband Initiative will be a multi-year partnership with National 4-H Council—engaging America's largest youth development organization, 4-H, to provide digital literacy skills training to youth, as well as teen-led learning programs in rural communities.

3. Stimulating investment by others through technology licensing.

   Our ultimate goal is to help serve as a catalyst for market investments by others in order to reach additional rural communities.

   That's why we're launching a new program to stimulate investment through royalty-free access to at least 39 patents and sample source code related to technology we've developed to better enable broadband connectivity through the use of TV white spaces spectrum in rural areas.

A Vital Role for the Public Sector

Although we believe the private sector can play the leading role in closing the rural broadband gap, the public sector also has a vital role to play. Three related governmental measures are needed:

First, the Federal Communications Commission (FCC) needs to ensure the continued use of the spectrum needed for this mixed technology model. Specifically, it will be important for the FCC to ensure that at least three channels below 700 MHz—the so-called TV white spaces—are available for wireless use on an unlicensed basis in every market in the country, with additional TV white spaces available in smaller markets and rural areas.

In addition, federal and state infrastructure investments should include targeted funds on a matching basis for the capital investments that will best expand coverage into rural areas that currently lack broadband access. These funds should be made available for use by multiple technologies based on what is most cost-effective in the region, including TV white spaces, fixed wireless, and satellite usage.

Finally, there is a need for improved data collection on rural broadband coverage. The FCC can help by accelerating its work to collect and report publicly on the state of broadband coverage in rural counties, thereby aiding policy makers and the private sector in making targeted investments.

In urban America, we've become accustomed to ongoing capital investments to expand broadband capacity in areas that already have broadband coverage. The time has come to expand this coverage to the rural areas that currently lack it entirely.

We believe a new rural broadband strategy makes this feasible and with Microsoft's Rural Airband Initiative we're prepared to put our own resources and energy behind this effort. We can all innovate together, achieving what none of us can accomplish alone.

And just as we look forward to sharing what we have learned, we look forward to applying over the next five years what we undoubtedly can learn from others. Given the ever-expanding range of cloud services, broadband access is no longer just about watching videos and movies (as enjoyable as this can be). Broadband connections have become indispensable for accessing healthcare, advancing education, improving agriculture, and growing a small business.

As a country, we should not settle for an outcome that leaves behind over 23 million of our rural neighbors. To the contrary, we can and should bring the benefits of broadband coverage to every corner of the nation.

SPOTLIGHT: A HISTORY OF CONNECTING AMERICA

IMAGE SOURCE: MICROSOFT

On March 7, 1916, 800 of America's most prominent leaders from the fields of science, business, art, and government gathered at the New Willard Hotel in Washington, D.C. to honor Alexander Graham Bell and mark the 40th anniversary of his patent for the invention of the telephone.

The event, called "Voice Voyages," was sponsored by The National Geographic Society and featured the unprecedented public demonstration of a coast-to-coast telephone call.

After dinner, receivers were handed out to guests. They listened in as John J. Carty, chief of engineering at the American Telephone and Telegraph Company, connected with people in Pittsburgh, Chicago, Denver, Salt Lake City, Pocatello, El Paso, Boise, Seattle, and even Ottawa, Canada—21 cities in 17 states and one foreign country all in a matter of minutes.

Until that evening, commercial telephone service was mostly limited to exchanges connecting people in relatively contained geographical areas.

That evening's demonstration made clear that telephone service was poised to revolutionize communications and unite every part of the country, from the largest cities to smaller towns. But the event's most amazing demonstration was still to come.

Up to that point in the evening, the calls had been made over copper wires.

Next, Carty placed a call to U.S. Secretary of the Interior Franklin Lane in New York. The call went by wire to the Navy's "Radio Arlington" towers across the Potomac, which dispatched the call over the air to New York. They were now "talking without wires."

"Perhaps never before in the history of civilization has been such an impressive illustration of the development and power of human mind over mundane matter," reported National Geographic Magazine in its coverage of the event.

"And if the occasion was impressive and its setting inspiring, the events of the evening were dramatic beyond measure, for it seemed indeed that fact has outrun fantasy."

Innovations that made it possible to use wires, cables, radio waves, and fiber optics to instantly transmit ideas, images, voices, videos, and data across vast distances have given rise to technological advances that have revolutionized how we live and learn, work and play, create community and share experiences.

Access to the capabilities these technological advances have made possible is a prerequisite for full participation in the economic and social life of modern American society. Communities that lack access are at risk of falling behind as the rest of us continue to move forward.

As we enter a new era of rapid, technology-driven progress—where capabilities that were once beyond imagining are quickly becoming commonplace—it's worth remembering the words of the writer who covered the Voice Voyage in National Geographic Magazine 101 years ago:

"I feel humbled and meek and overwhelmed, for no man can say, after the things we have seen, after the things that we have heard, that anything is no longer possible."

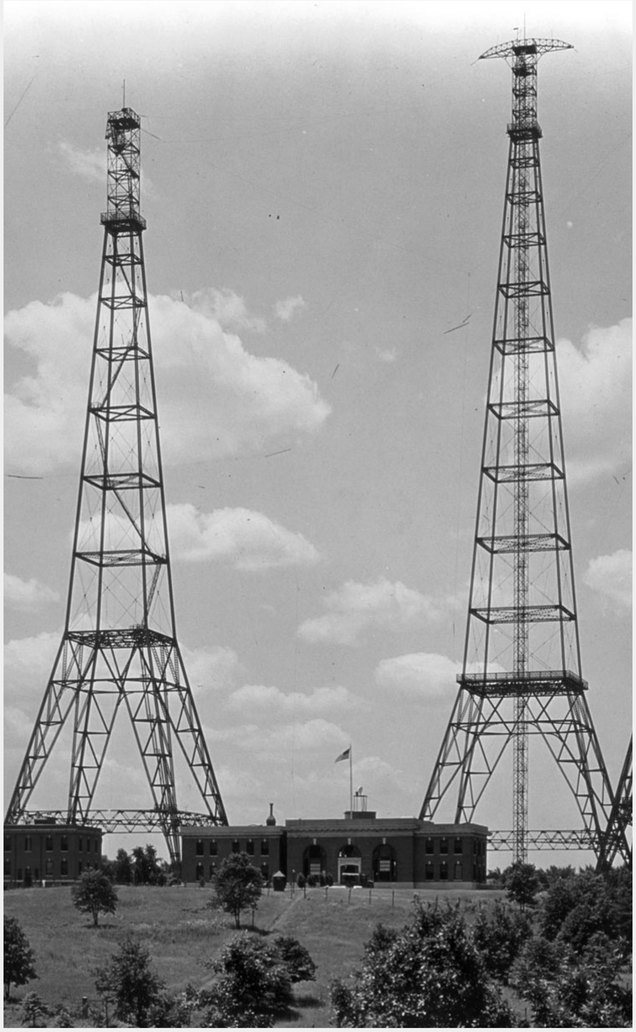


IMAGE SOURCE: THE NATIONAL GEOGRAPHIC MAGAZINE, MARCH 1916

RURAL AMERICA: ON THE WRONG SIDE OF THE DIGITAL DIVIDE

Chapter One

While the rest of the country moves forward into a new era of cloud computing, a significant portion of our country finds itself at a disadvantage. As FCC Chairman Ajit Pai has acknowledged,

"There's a big and growing divide, a 'digital divide,' in this country between those who have high-quality internet access and those who don't. Disproportionately, those living in rural America find themselves on the wrong side of that divide."[3]

People living in rural areas of this country are significantly less likely to incorporate digital technology into their lives than their urban counterparts. They are 7 to 12 percent less likely than those in urban areas to own a smartphone, tablet, or traditional computer.[4] They are less likely to own multiple devices, or to use the internet daily.[5] And 19 percent say that they never go online—compared with 11 percent in urban communities.[6]

Many rural communities simply do not have the broadband access that most Americans take for granted. They rely on dial-up technology to transmit data over copper lines, unable to access online services even at basic download and upload speeds.[7]

In other words, a significant portion of rural communities lack the internet speeds that were available in urban areas over a decade ago.[8]

The Rural America Broadband Gap

The dismal state of rural broadband in America is rooted in four main causes.

First, and most importantly, installing traditional broadband and internet alternatives is expensive. Fewer customers living longer distances apart means less revenue and higher installation costs for telecommunications companies.

Industry estimates suggest that installing fiber optic cable—the gold standard of broadband service—can cost $30,000 per mile.[9] This means that delivering sufficient broadband to remote parts of the U.S. would cost billions of dollars, an expense the private sector has not yet been willing to pay.[10]

Second, the development of alternatives to fiber optic cable has been slow and uneven. While mobile telecommunications technologies such as 4G LTE have given customers broadband-like speed through mobile devices such as smartphones, the cellular model of this technology is designed for densely populated areas and face the same connectivity and capacity gaps as traditional broadband.

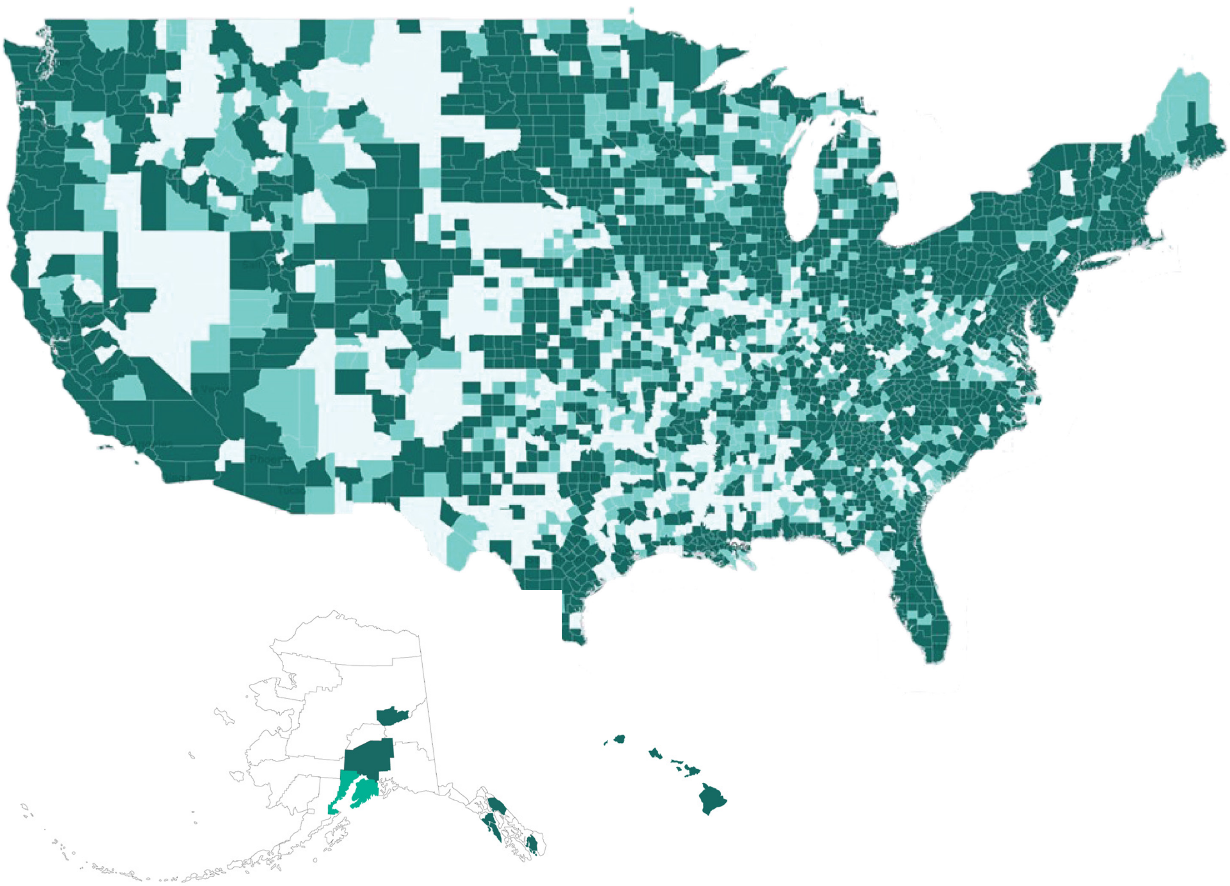
Satellite broadband can be the right solution in very sparsely populated areas, but it often suffers from high latency, lack of significant bandwidth, and high data costs.

Third, regulatory uncertainty has contributed to challenges in bringing broadband to rural America. For example, providers seeking access to critical rights of way for network facilities often face confusing federal, state, and local permitting rules that add time and expense to projects.[11]

Finally, there is a perception that weak demand for broadband in rural areas cannot support private investment. This perception is clearly outdated given the high demand for cloud-based services by small businesses and households.

To date, companies looking to run a sustainable business have not had confidence in the rural market. As a result, low-density communities remain underserved as service providers focus their attention on proven urban markets.

U.S. Broadband Access by County



66-100% of population

33-65% of population

Less than 33% of population

(Average Percentage)

DATA SOURCE: FCC 2016 BROADBAND PROGRESS REPORT

A CALL TO ACTION: A NEW RURAL BROADBAND STRATEGY

Chapter Two

The time is right for the nation to set a clear and ambitious, but achievable goal: to eliminate the rural broadband gap within the next five years—by July 4, 2022—through a new Rural Broadband Strategy.

We believe this new focus can bring broadband coverage to rural America in this timeframe based on a new strategic approach that combines private sector capital investments focused on new technologies with affordable public sector support.

A combination of new technologies can substantially reduce the cost of extending broadband coverage across the nation. Specifically, a technology model that uses a combination of wireless technology leveraging the TV white spaces spectrum, LTE fixed wireless, and satellite coverage can reduce the initial capital and operating costs by roughly 80 percent compared with the cost of using fiber cables alone; and by approximately 50 percent compared with the cost of current LTE fixed wireless technology.

The Breakthrough Promise of TV White Spaces Technologies

After more than a decade of development, new technologies for deploying broadband effectively and affordably to low-density areas are ready to play an important role in connecting rural America and for those living without broadband internet today. Those are technologies leveraging the TV white space.

Wireless technologies that utilize TV white spaces are designed to transmit in VHF and UHF spectrum that was traditionally allocated for broadcast television. By leveraging these unused frequencies, TV white spaces devices can create wireless broadband connections, while protecting broadcasters and other licensees from harmful interference.

In addition, because the characteristics of television spectrum permit signals to travel long distances, it is ideally suited for bringing broadband to rural America.

New directional findings by The Boston Consulting Group suggest that a combination of technologies utilizing TV white spaces are the most efficient technologies to connect areas populated at densities from two to 200 people per square mile.

As the population thins, satellite becomes the most cost-effective solution because the infrastructure costs of building towers make TV white spaces, or any terrestrial wireless technology, less attractive.

In higher-density rural areas, higher-frequency 4G LTE technologies become the most cost-effective option. It is worth noting that this model did not look at higher-frequency Wi-Fi technologies, which might prove more cost-effective than 4G LTE technologies in higher-density areas.

Overall, TV white spaces technologies appear to be the optimal solution for a little more than 19 million people, or about 80 percent of rural America without broadband access.

Under the current regulatory environment, it would take roughly $10 to $15 billion to deploy TV white spaces to connect the 23.4 million people living in rural America without broadband access.

This would be roughly 50 percent less than the cost of using fixed wireless (4G LTE) technology ($15-25 billion) and approximately 80 percent less than the cost for using fiber-to-the-home ($45-65 billion).

However, the most optimal deployment would be to provide a mix of several technologies on a county-by-county basis. This could lower costs by at least 10 percent ($8-12 billion) compared with using TV white spaces alone.

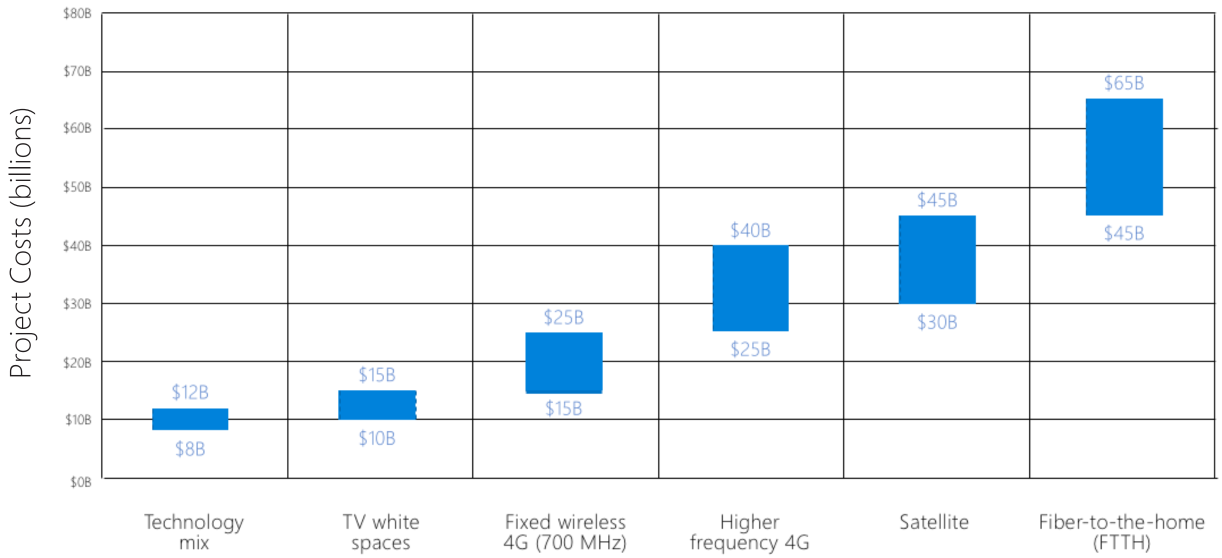
Our confidence in wireless technologies using the TV white spaces is based on a decade-long experience. Along with our industry and academic peers, we have been working to perfect the technology and address the challenges that come with it.

Building on the collective experience of Microsoft and others—in the United States and around the world—we and our network operator partners have found ways to use TV white spaces to distribute broadband efficiently without requiring consumers to engage in any complex engineering.

We found that these deployments of TV white spaces technologies do not interfere with TV broadcast reception and licensed wireless microphones that use the same spectrum band.

Moreover, we have also been able to extend the reach of TV white spaces signals farther than ever before.

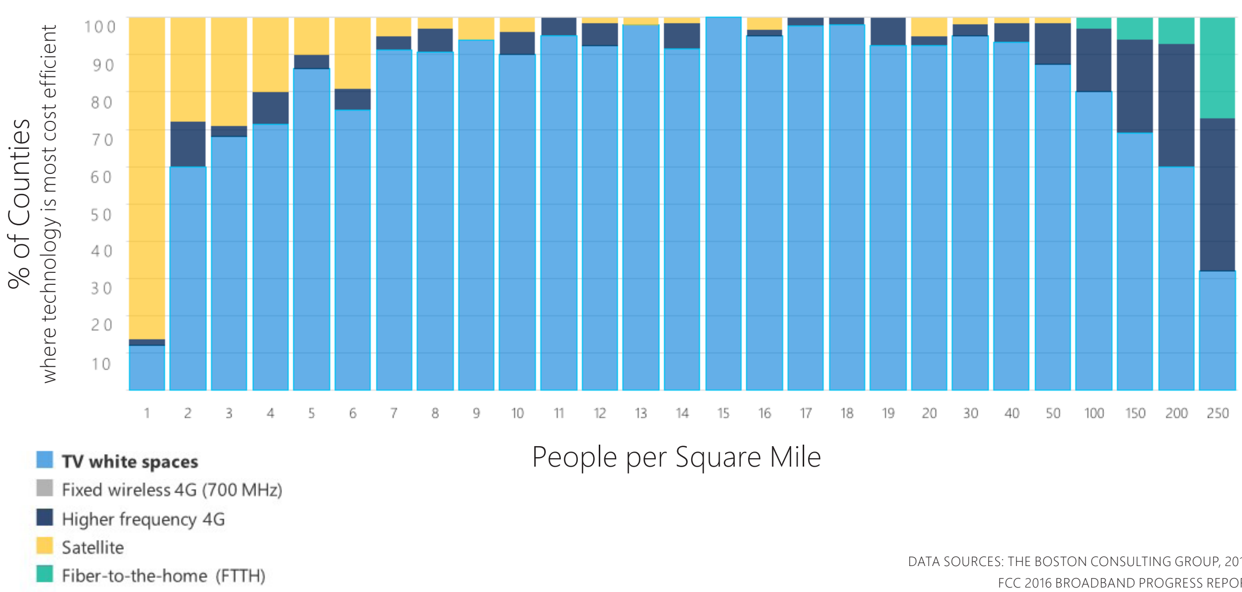
Cost Comparison to Connect 23.4 Million People in Rural America



DATA SOURCES: THE BOSTON CONSULTING GROUP, 2017;
FCC 2016 BROADBAND PROGRESS REPORT

The Best Solutions for Rural Densities

Percentage of counties where a technology is most efficient within each population density band



DATA SOURCES: THE BOSTON CONSULTING GROUP, 2017;
FCC 2016 BROADBAND PROGRESS REPORT

We are excited to deploy TV white spaces as part of a blended set of innovative solutions that will make up the new Rural Broadband Strategy.

How TV White Spaces Work

The term "TV white spaces" refers to the unassigned (or otherwise unused) spectrum below 700 MHz that can be used to deliver broadband access, services, and applications.

This available spectrum is uniquely suited for delivering broadband to rural areas because it can carry communications over far greater distances and penetrate through walls and other obstacles than cellular and other spectrum bands. Because of these unique characteristics, technologies leveraging TV white spaces are sometimes referred to as "Super Wi-Fi."

This technology became a possibility in 2008 during the Bush Administration when the FCC adopted regulations paving the way for more efficient use of such underused spectrum while protecting broadcasters and other licensees from interference.[12]

One example is Dynamic Spectrum Access, a term that describes radio-enabled devices operating in conjunction with an internet database to transmit on available spectrum.

These devices report their location and other information to the database, which identifies which TV white spaces channels are available and an appropriate power level. The database also includes a list of all protected TV stations and frequencies to avoid interference with TV broadcasts and wireless microphone signals.

Once the available spectrum is identified, devices can use those frequencies, and even switch from one group of channels to another as different channels become available. This engineering happens in the background and requires no action by the end-user.

Microsoft's Role in Fostering the TV White Spaces Ecosystem

For more than a decade, Microsoft and other companies, research, and academic institutions around the world have been working to pioneer and perfect software-defined radios and cognitive radio systems for use in TV white spaces and other unused spectrum.

These technologies leverage an evolutionary shift from inflexible hardware-defined radios to increasingly flexible software-defined radios that can dynamically adapt to their changing spectrum environment (e.g., by having software, as opposed to hardware, define power levels, frequencies, channel sizes, modulation schemes, etc.).

By leveraging this flexibility, software-defined radios and cognitive radio systems can more efficiently use limited spectrum resources, in the TV white spaces and in other spectrum bands.

Like cell phones (which took 13 years to go from initial approval to the first available commercial products), Wi-Fi devices (which took 14 years) and 4G LTE devices (which took nine years), TV white spaces technologies presented numerous technological and other hurdles that had to be overcome to make them a feasible solution for closing the digital divide.

Microsoft's first public involvement with these emerging technologies began in 2002 when the FCC Spectrum Policy Task Force recommended that more spectrum should be made available on a dynamic basis. This marked the beginning for the first proposals to make the TV white spaces and other bands available on an unlicensed basis.[13]

Microsoft's first published research on TV white spaces was in 2003.[14] Microsoft and other companies were also involved in the FCC's first field testing of TV white spaces technology in 2008, which helped inform the FCC's 2008 decision to allow unlicensed access to the TV white spaces, under the control of geolocation databases.[15]

Since then, Microsoft has been involved in numerous TV white spaces research projects and other forms of dynamic spectrum access.[16]

Microsoft Research developed the first TV white spaces database research platform. Beginning in 2009, under experimental licenses from the FCC, Microsoft Research conducted the first large-scale, outdoor trials using radios tuned to the TV white spaces on our corporate campus in Redmond, Washington.

This work paved the way for what was the largest TV white spaces field trial in the world in Cambridge, England in June 2011. The Cambridge trial helped inform regulations that were ultimately adopted by the regulator, Ofcom, to allow access to the TV white spaces in the UK.

In April 2012, a consortium of local and global companies was formed to launch series of pilot projects in Singapore, which also helped inform that country's white spaces regulations.

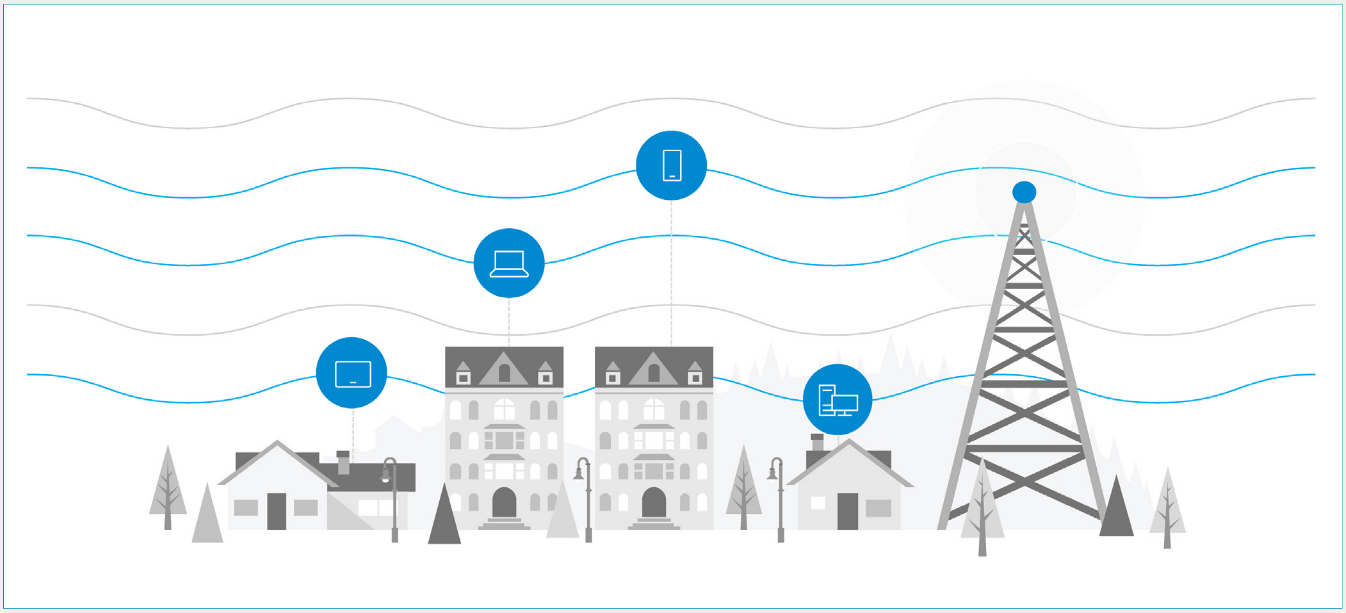
An important part of Microsoft's work in the TV white spaces arena has been to share knowledge and seek collaborative partnerships.

In 2014, Microsoft publicly released the source code for the Microsoft Spectrum Observatory to create an open dialogue with academics, governments, and other members of industry about making the most efficient use of spectrum.[17]

These partnerships have shown that most spectrum in most places is not used most of the time—an idea at the fringes of policy discussions only a few years ago.

Now, there is no question that spectrum is being used inefficiently. Furthermore, spectrum can, and should, be shared across a variety of spectrum bands, and under a range of licensing regimes.

SPOTLIGHT: TV WHITE SPACES SPECTRUM EXPLAINED



“White spaces” spectrum is a name for allocated but unused spectrum. “TV white spaces” are the unassigned or otherwise unused blocks of spectrum below 700 MHz located between the frequencies assigned to TV broadcasters and other licensees.

There is more TV white spaces spectrum in smaller cities and rural areas, which tend to have fewer licensed users of spectrum. TV white spaces can be used to create wireless broadband connections over great distances without interfering with incumbent licensees. The TV white spaces spectrum is great for: last-mile wireless broadband access; in-building and in-home coverage; and the Internet of Things (IoT).

In each case, network operators take advantage of the ability of radio waves in the VHF and UHF broadcast frequencies to travel long distances and pass through natural and manmade obstacles.

Base station radios transmitting via TV white spaces can send and receive signals from up to 10 miles in rural areas, giving consumers broadband connections capable of applications ranging from high-definition video streaming to video conferencing.

The TV white spaces are also useful in more densely populated areas, particularly for expanding coverage in buildings.

IoT encompasses a range of high- and low-bandwidth applications that leverage the propagation characteristics of TV white spaces. This includes a full range of applications used for public safety, transport, energy grids, agriculture, healthcare, and the environment.

The FCC has regulations allowing unlicensed access to TV white spaces. Under those regulations, certified TV white spaces devices operate under the control of a TV white spaces database.

TV white spaces databases are cloud-based services that perform two basic duties for the regulator: (1) providing TV white spaces devices access to broadcast spectrum that is not assigned to a broadcaster or another licensee; and (2) protecting incumbent licensees from interference. The FCC certifies both white spaces databases and devices that are used to access TV white spaces spectrum.

To access TV white spaces spectrum, a TV white spaces device contacts a TV white spaces database over the internet and requests a list of channels at its specified location (as determined through professional installation or geolocation capabilities, such as GPS).

Examples include: a TV white spaces base station radio able to reach the internet over a fiber backhaul connection; an in-home access point able to reach the internet over a cable modem connection; or even a Wi-Fi device able to reach the internet over a 4G LTE connection.

Depending on their operating characteristics and intended uses, the FCC will designate such devices that directly contact TV white spaces databases as either "fixed devices" or "mode two personal portable devices."

Before these devices begin transmitting over the TV white spaces, they obtain lists of available channels (or frequencies) from the TV white spaces database. The TV white spaces device reports its location to the TV white spaces database, which then communicates which channels can be used by that TV white spaces device at that particular location.

The TV white spaces device will only transmit on channels specified by the TV white spaces database. If no channels are returned by the database, the TV white spaces device cannot transmit until it is given another list of channels. Once the device receives a list of channels, it selects the channels to begin transmitting on.

Client devices designated by the FCC as either fixed devices or mode one personal-portable devices will be under the control of devices with direct contact to the TV white spaces database. The client devices will be in listen-only mode and will only begin transmissions upon hearing an enablement signal from the base station, access point, or other device with direct contact with a TV white spaces database.

TV white spaces devices with direct connections to the internet are required to re-contact the TV white spaces database at specified time intervals (or if moved from their current location) for lists of new TV white spaces channels. The activity is invisible to the user and requires no action by the consumer.

Technologies Using TV White Spaces Can Help Bring Broadband to Rural America

After many years of tests and improvements, technologies leveraging the TV white spaces spectrum are ready for widespread adoption. Through trials and pilots, Microsoft and our partners have validated that TV white spaces are particularly well-suited for bringing broadband to remote areas for many reasons:

Greater distances.

TV signals travel over far longer distances compared with conventional Wi-Fi, making white spaces better suited for extending signals over areas that are more spread apart.

At the same power as Wi-Fi operating in the 2.4 GHz band, a TV white spaces signal can travel up to four times the distance (e.g., 400 feet as opposed to 100 feet). That translates to 16 times the coverage area.

However, the FCC allows fixed TV white spaces devices (such as base station radios) to operate at up to 4 watts EIRP and up to 10 watts EIRP in rural areas. Our experience in rural deployments demonstrates that these signals can provide internet connections at up to 10 miles from the base station.

Greater penetration.

In a typical home, Wi-Fi can penetrate through up to two walls, making it less suitable for distributing a signal across spread-out properties with multiple obstructions.

In contrast, like traditional TV signals, signals traveling on TV white spaces can penetrate through more walls and obstacles, including heavy foliage, hills and other topographical challenges presented by rural areas.

Affordability.

Because TV white spaces technology transmits broadband data over the airwaves using spectrum, it avoids the expensive wired infrastructure on which other rural cost estimates are based.

Deploying TV white spaces technology rather than fiber or other wired alternatives can save up to 80 percent of the costs of deployment.

It also has significant cost advantages over traditional wireless services—as little as 50 percent of the cost of deploying 700 MHz LTE and only about 30 percent of the cost of higher-frequency LTE.

Combined, these unique advantages presented by TV white spaces technologies can significantly improve the economics of deploying wireless broadband in rural and other underserved communities.

Moreover, the fact that these technologies operate on an unlicensed basis will make their deployment far more straightforward than if FCC licenses were required for each implementation.

Already, TV white spaces technology has been tested by initiatives that serve the needs of students, farmers, health care providers, and others who are stuck on the wrong side of the digital divide.

In the United States, Microsoft is partnering with a full range of network operators—from major fixed-line operators to nationwide and regional mobile operators, rural cooperatives, and wireless internet services providers—to demonstrate the impact of broadband access based on TV white spaces.

In Southern Virginia, for example, Microsoft has partnered with Mid-Atlantic Broadband Communities, B2X, and the Tobacco Region Revitalization Commission to provide a "Homework Network" to school children in rural and underserved Charlotte and Halifax Counties. The largest of its kind in North America, this project extends wireless broadband from local schools to students' homes using TV white spaces equipment.

In addition, Microsoft has been working in Washington State and upstate New York to bring "precision agriculture" to farms using sensors and algorithms to determine exactly how much water, fertilizer, and pesticides crops need.

The Economist has praised precision agriculture's potential to help "feed a world whose population is forecast to hit almost 10 billion by 2050," and TV white spaces technology could be key to its success.

Through "Farm Beats," an end-to-end IoT platform created by Microsoft, TV white spaces have been harnessed to bring data from various sensors (such as cameras, drones, and soil sensors) to farmers. But for farms that lack broadband, precision farming is not possible.

By setting up a high bandwidth link from the farmer's home to an IoT base station on the farm, Microsoft has been able to extend existing broadband connections to the typically offline farmland, where the sensors can then connect to it.

Moreover, the system is built to work even without grid-based power—the IoT base station's design enables it to use weather forecasts to appropriately cycle different components of the station based on the availability of adequate solar power.

Microsoft's other current and already-planned TV white spaces projects currently include partnerships with:

> MERIT and Allband:
> Providing residential broadband access and connected animal tracking and state park trailhead cameras in rural Alpena and Montmorency Counties in Northeastern Michigan.

Also in Michigan, Microsoft is partnering with the Gigabit Libraries Network to enable pilots using libraries in Gaylord, Lansing, and Marquette as anchors for Wi-Fi hotspot networks.

WildFire:
Deploying residential broadband access in rural areas around the City of Dalton, in northwestern Georgia.

Axiom:
Deploying broadband access for small businesses and residences in rural Washington County, Maine.

Pioneer:
An internet service provider in Southwest Kansas deploying a trial network providing broadband access to residential customers and farms in Scott County.

Microsoft has also significant global experience and research in solving connectivity problems using TV white spaces technology.

For example:

In the Philippines:
Microsoft responded to the devastating series of typhoons that hit the country in 2013 by developing a TV white spaces solution that provided internet connections and Skype calling to affected citizens.

In Kenya:
Microsoft deployed the Mawingu TV white spaces Broadband Project in Laikipia County to help provide the Red Cross with low-cost internet access, which has helped improve the organization's efficiency, scope of services, and bottom line.

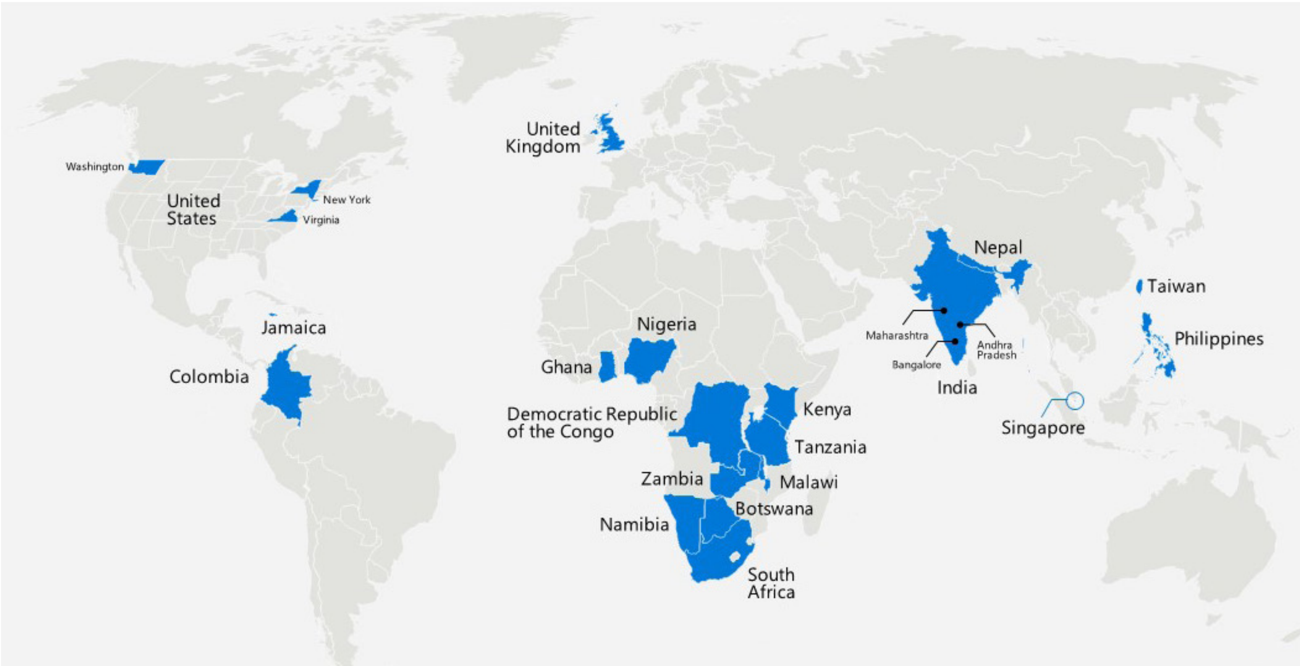
In rural South Africa:
Microsoft leveraged TV white spaces spectrum to bring wireless broadband access to five schools as part of the broader Microsoft 4Afrika Initiative, which aims to bolster Africa's economic development and global competitiveness through innovation, skills, and affordable internet access.

Also in South Africa, we recently announced a partnership with Brightwave to bring TV white spaces and Wi-Fi-enabled broadband access to 609 primary and secondary schools to over 200,000 students.

In the United Kingdom:
Broadband trials in Scotland have connected rural communities on the Isle of Bute and in Orkney.

Microsoft TV White Spaces Pilot Projects

More than 20 projects connecting 185,000 people



Botswana	Jamaica	Nigeria	Tanzania
Colombia	Kenya	Philippines	United Kingdom
DR Congo	Malawi	Singapore	United States
Ghana	Nambia	South Africa	Zambia
India	Nepal	Taiwan	

DATA SOURCE: MICROSOFT, 2017

MICROSOFT'S RURAL AIRBAND INITIATIVE

Chapter Three

Microsoft is prepared to invest our own resources to help serve as a catalyst for broader market adoption of this new model. Through our Rural Airband Initiative, we are committed to three elements on a five-year basis:

Direct Projects with Partners

We will invest in partnerships with telecommunications companies with the goal of bringing broadband connectivity to 2 million people living in rural America by July 4, 2022.

With our network operator partners, we will have 12 projects in 12 states up and running within the next 12 months in Arizona, Georgia, Kansas, Maine, Michigan, New York, North Dakota, South Dakota, Texas, Virginia, Washington, and Wisconsin. And we will continue to grow further from this substantial start.

By investing significant resources, we hope not only to bring connectivity to 2 million citizens, but to stimulate more capital spending by others that focuses on expanding broadband coverage in rural areas.

Our goal is not to profit directly from these projects, although we of course recognize that expanded broadband coverage will bring new commercial opportunities for every company in the tech sector that provides cloud services, including our own. We will rely on a business model focused on investing in the upfront capital projects needed to expand broadband coverage, and then seek a revenue share from operators to recoup our investment. We will use these revenue proceeds to invest in additional projects to expand coverage further over the next five years.

Digital Skills Training for People of All Ages

Working through Microsoft Philanthropies, our Rural Airband Initiative will also invest in helping to train people of all ages in these rural communities on the latest technology so they can use this new connectivity to improve education, healthcare, and agriculture, and transform their businesses.

We will deploy a suite of initiatives to couple the technology itself with efforts to ensure that people will benefit from it, with a special focus on ensuring that technology access and education begin at a young age.

We will work with groups familiar with the unique needs of rural communities to bring skills trainings tailored to the needs of those areas.

Our first partnership under the Rural Airband Initiative will be a multi-year partnership with National 4-H Council—engaging America's largest youth development organization, 4-H, to provide digital literacy skills training to youth, as well as teen-led learning programs in rural communities.

Microsoft is already working with partners to deploy broadband to students in rural Virginia.

Over the next five years, Microsoft will use this model to work with network operator partners to cover at least 500,000 of the 5 million households with school-age children who lack broadband internet access. By combining broadband access with the necessary skills, we hope to increase digital literacy for millions of Americans who are ready to improve their lives with digital tools and data.

Stimulating Investment by Others Through Technology Licensing

Our ultimate goal is to help serve as a catalyst for market investments by others to reach additional rural communities. We therefore are launching a new technology program to stimulate investment through royalty-free access to at least 39 patents and sample source code related to technology we've developed to better enable broadband connectivity through the use of TV white spaces spectrum in rural areas.

Our Rural Airband Technology Program will make our U.S. patents available under a royalty-free license to all comers, including to our competitors, for any work they undertake to stimulate broadband access through TV white spaces. These patents help tackle common problems associated with TV white spaces in a variety of ways:

- They enable the efficient utilization of TV white spaces by dynamically allocating the spectrum among users as needed. For example, Microsoft's patented technology enables selection of a particular band depending on whether the device is moving or fixed, frequency scanning based on a location-based database query, and the use of guard bands for TV white spaces transmission.


4-H
WELCOME!

- They mitigate TV white spaces device interference with incumbent spectrum licensees, such as TV broadcasters and licensed wireless microphones. For example, they enable the detection of an incumbent on a channel and cause a TV white spaces device to switch to an alternate channel.

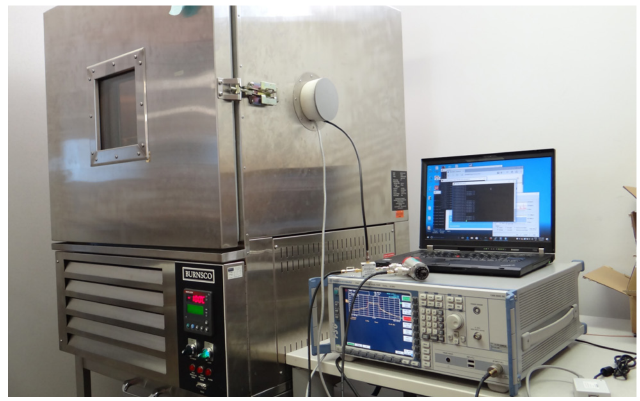
  In addition, they significantly decrease the likelihood that a device will transmit over an occupied channel by shaping a baseband signal according to governing telecommunications policies and local geography to optimize the transmission.

  They also enable multiple TV white spaces devices to measure signals in various frequencies around them, communicate such measurements with one another, and thereby identify where available TV white spaces are located on the spectrum.

- They enable the use of a robust location-based database for signal allocation without the need to rely on spectrum sensing.

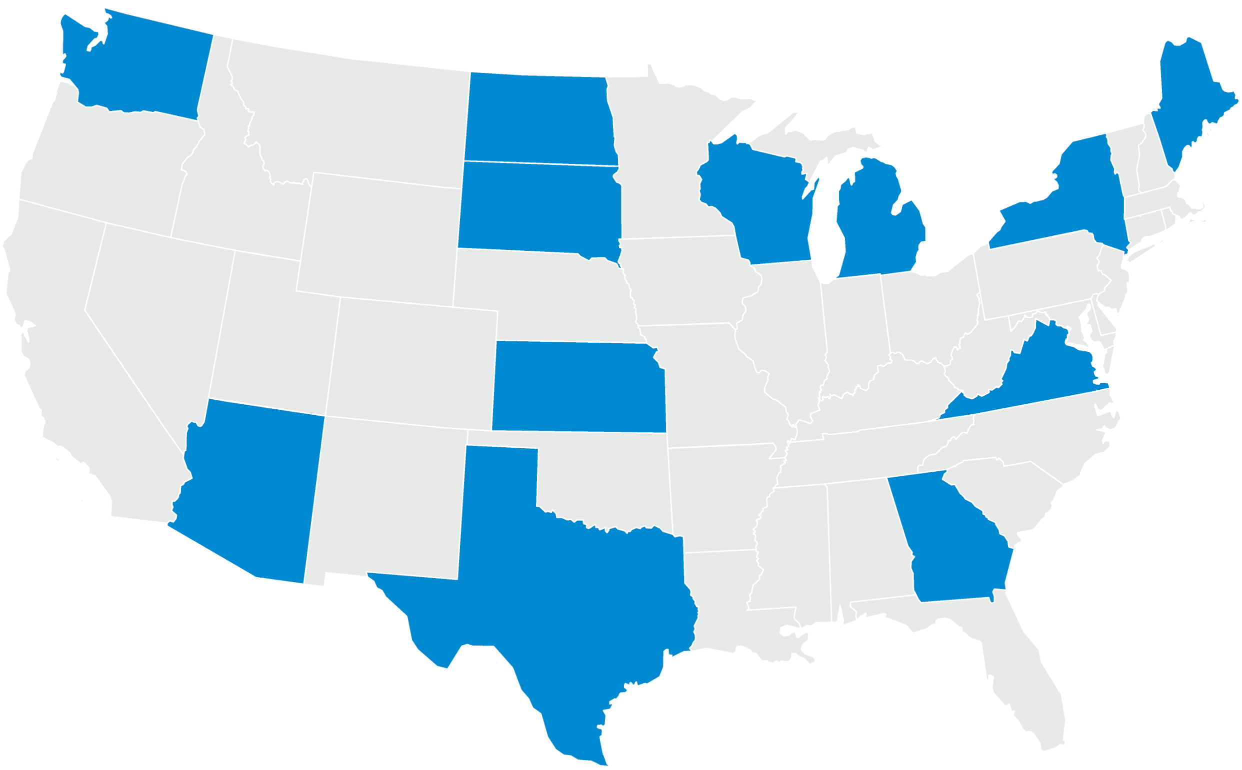
  Microsoft's database-driven TV white spaces technology has continuously been improved through the use of machine learning that populates, maintains, and improves the content of the database, and cloud-based analytics to respond to database queries that, for example, leverages prior spectrum assignments for particular devices.

- They harness cognitive radio to provide greater bandwidth and coverage for broadband over and above cellular in two ways: first, switching from cellular/Wi-Fi to TV white spaces based on a trigger condition (such as bandwidth constraints in the cellular band); or second, simultaneously transmitting in two different spectrums (cellular and TV white spaces).



Microsoft TV White Spaces Pilot Projects: United States

Up and Running 12 Projects, 12 States in the Next 12 Months



Arizona	Maine	North Dakota	Virginia
Georgia	Michigan	South Dakota	Washington
Kansas	New York	Texas	Wisconsin

DATA SOURCE: MICROSOFT, 2017

CASE STUDY: THE HOMEWORK NETWORK
BRINGING BROADBAND ACCESS TO STUDENTS IN RURAL VIRGINIA

Today in the United States, it is estimated that about 5 million households with school-age children do not have broadband connectivity. For these children, almost every aspect of academic success—from keeping up with assignments, to communicating with teachers, to applying for college—is much more difficult than it is for their friends and peers who have high-speed internet at home.

At a time when 70 percent of teachers assign homework and research that requires a broadband connection, this means there are millions of children in this country who are not able to access the tools and information they need to thrive in school and gain the skills and knowledge they will require as they move on to college or enter the workforce.

The homework gap is particularly acute in Charlotte and Halifax counties in southern Virginia, a rural area where half of students don't have broadband access at home. To help close this gap, Microsoft and the Mid-Atlantic Broadband Communities Corporation (MBC) announced the launch of an innovative Homework Network that will provide broadband access for education purposes to more than 1,000 rural households—and about 3,000 students—by the end of 2017.

The Southern Virginia Homework Network will be the largest deployment of TV white spaces technology in the United States thus far. Given the region's scattered rural population, hilly terrain, and dense tree cover, low-band white spaces spectrum is an ideal solution for extending internet services to remote homes without the prohibitive costs required for implementing more traditional broadband infrastructure such as fiber optic cables.

The announcement followed a successful pilot program that reached about 100 households across the two counties. One of the first families to gain access was a household with three school-age children and their mother, who is a teacher. Before the pilot program, the entire family spent most of its evenings at school or a library—where broadband access was available—so they could keep up with assignments and other schoolwork. This is now work they all can do at home.

Currently, the project has moved into the first phase of building out the complete TV white spaces network. Using equipment from Adaptrum—a white spaces technology company based in San Jose—the network will include 18 high-power base stations on towers near fiber-connected schools to deliver long-range coverage that can penetrate hills and trees. MBC is also providing Adaptrum radio receivers for students' homes. The network is being installed by B2X Online, a local internet service provider.

The Homework Network in southern Virginia grew out of Microsoft's Affordable Access Initiative, which aims to support and scale innovative businesses that are developing technologies with the potential to extend broadband access to billions of people around the world who lack connectivity today. The project in Virginia received support from the Virginia Tobacco Region Revitalization Commission.

"Rural southern Virginia is now home to a highly innovative solution, which can serve as a model for other parts of the state, the U.S. and even around the world, to help young people succeed in school," says Virginia State Senator Frank Ruff, who co-chairs the Commission. "We are proud to help support and fund such an important project starting here in Charlotte and Halifax counties."

The Homework Network is a model that offers the promise of affordable broadband connectivity for the millions of students in the United States who face unfair barriers when it comes to essential access to critical digital tools and technology.

THE VITAL ROLE OF THE PUBLIC SECTOR

Chapter Four

While we believe the private sector can play the leading role in closing the rural broadband gap, the public sector also has a vital role to play in achieving the U.S. government's longstanding communications policy goal of ensuring that advanced services, such as broadband, are universally available across the United States.[19]

The leadership of the FCC,[20] the White House,[21] Congress,[22] and the states all have focused on these efforts during the past year, and are poised to act.

We hope that policymakers will take specific actions to accelerate the deployment of broadband to rural America:

First, through FCC action, ensure access to TV white spaces spectrum, so this can be used by innovative, unlicensed wireless technologies to extend the reach of existing infrastructure to provide affordable broadband in rural areas.

Second, ensure that federal and state infrastructure investments include targeted funds on a matching basis for the capital investments that will best expand broadband coverage in rural areas. Critically, public funds should be made available and directed to projects that will spur private investment on a technology-agnostic basis so that the most effective technologies can be deployed to solve the rural broadband challenge.

Third, take concrete steps to ensure that the FCC has the data it needs to accurately measure the availability and adoption of broadband internet access technologies. This will enable the government and private sector to assess the success of different initiatives, technologies, and business models, and to design evidence-based policies in the future.

The FCC Should Ensure Access to TV White Spaces Spectrum

The FCC has the potential to significantly advance the availability of affordable broadband in rural and underserved areas without the need for congressional action or congressional funding.

The single most effective action the government can take to connect rural America is to provide sustained nationwide access to TV white spaces spectrum.

The FCC must finalize outstanding TV white spaces policies in a manner that promotes the growth and evolution of this technology.

A forward-looking decision by the FCC in 2010 made the United States the first country in the world to approve TV white spaces technologies. This act was part of a long and proud tradition of American leadership in spectrum policy. Under former Chairman Kevin Martin, the FCC approved unlicensed access to TV white spaces through a unanimous, bipartisan vote in 2008.

The original TV white spaces regulations were proposed under former FCC Chairman Michael Powell, with bipartisan support. After subsequent revisions to the FCC's technical rules, the current TV white spaces rules went into effect in 2012. Soon thereafter, however, the FCC launched a series of rulemaking proceedings to implement the Television Band Incentive Auction. Congress explicitly ensured that TV white space technologies would continue to advance after the auction, but the auction required a reorganization of the entire TV spectrum band. This introduced regulatory uncertainty and slowed the evolution of and investment in TV white spaces technologies.

Now, with the post-auction band plan locked in place, the FCC can eliminate the remaining regulatory uncertainty that has served as a barrier to meaningful private investment. The Incentive Auction reduced the number of available channels that can be used for TV white spaces technologies.

To make the significant investments necessary to reach economies of scale, potential TV white spaces network operators and device and chip manufacturers have converged on the need for a minimum of three usable TV white spaces channels in every market, with additional TV white spaces available in smaller markets.

Consequently, the Incentive Auction's reduction in the number of channels available for TV white spaces technology led the FCC to put in place new rules to ensure channel availability, so as to support broadband investment.

That brings us to today.

Recognizing the importance of the technology, the FCC has already adopted rules to provide consumers and innovators with two of the needed three TV white spaces channels.

The FCC must preserve those channels going forward and push back on attempts to undermine the use of those channels for broadband. The FCC will also need to act on channel number three, the so-called "Vacant Channel."

The “Duplex Gap.”

First, the FCC approved use of TV white spaces technologies in the small block of spectrum between mobile service uplink and downlink called the “duplex gap.” These rules are in place and will protect nearby licensed mobile wireless services.

Channel 37.

Second, the Commission approved technical rules allowing TV white spaces devices to share Channel 37 with wireless medical telemetry systems used in some medical facilities, but required additional unspecified testing before these rules can go into effect. The FCC’s conservative rules ensure that TV white spaces technologies will not operate in close proximity to these medical telemetry systems. If the FCC moves forward with a trial period, it must not allow an open-ended trial period with no structure that can be manipulated to effectively prevent shared use on Channel 37. Moreover, the trial period should be location- and time-bounded.

The “Vacant Channel” proceeding.

Finally, there are spectrum gaps between full power TV channels everywhere in the country—so-called “vacant channels.” The FCC has proposed to preserve one of these vacant channels in every market for TV white spaces technologies after the post-Incentive-Auction reorganization of the band. Preserving this channel will not impact any full-power broadcaster. An analysis using the FCC’s own software also demonstrates that preserving a TV white spaces channel in most markets is expected to have no impact on low-power TV stations, and a de minimis impact even in the few areas where there is any impact at all.

By preserving access for TV white spaces technologies in the duplex gap, Channel 37, and in vacant channels, as well as positively concluding a number of outstanding TV white spaces issues, Chairman Pai and the FCC will put a pivotal piece in place in the FCC’s pro-broadband, pro-investment, pro-innovation policy.

Public Funding Should Provide Incentives for Effective Private Investment in a Technology-Neutral Manner

While we believe that private sector investment can lead the way in closing the rural broadband gap, public sector spending can accelerate this work.

The public-sector entities funding rural broadband development have already made great strides in bringing telecommunications to rural America, and they can play an additional key role in reaching millions more Americans without connectivity.

In continuing to meet this challenge, we suggest that public sector spending be guided by two key principles:

First, public spending should include targeted funds on a matching basis for private sector capital investments that will best expand coverage into rural areas that currently lack broadband access.

Second, these funds should be made available for use by multiple technologies based on what is most cost-effective in serving the most people in a region, including TV white spaces, fixed wireless, and satellite usage.

Federal Programs

The FCC can follow these principles in supporting the deployment of rural broadband through its universal service authority. The Universal Service Fund appropriately has been reoriented to include support for rural broadband development.[23] Among other programs within the Universal Service Fund, the Commission's E-Rate program remains an important means of bringing broadband to schools and libraries throughout the country; but it could be leveraged further in innovative, cost-neutral ways to help close the digital divide.[24]

We encourage the FCC to continue supporting and accelerating the deployment of spectrum-based technologies in that program, an area where Microsoft has partnered with Virginia educational organizations, local network operators, and state economic development authorities.[25] The FCC can use these funds in a forward-looking, technology-agnostic manner that provides sufficient flexibility for all providers to deploy creative solutions for rural broadband connectivity. To the extent that Congress passes infrastructure legislation addressing rural broadband goals, we hope that funding decisions can be guided by these goals, as well.

State Programs

State governments are taking important steps to foster broadband. In September 2016, the Federal-State Joint Conference on Advanced Services provided a survey to the FCC regarding the status of various state broadband deployment initiatives.[26]

New York State, for example, has devoted $500 million of state funds to build out its "New NY Broadband Program," which aims to ensure that every New Yorker has access to high-speed internet by 2018.[27] Similarly, Wisconsin's Broadband Expansion Grant Program has awarded nearly $4 million worth of grants geared toward constructing broadband infrastructure in underserved areas of the state.

Combined, the 42 grants that have been approved take an "all-of-the-above" approach when it comes to means of deployment—some will focus on fixed wireless systems, some on digital subscriber line (DSL) systems, some for fiber to the home/premises (FTTH), some for fiber and coaxial cable backbone facilities, and one has been approved for a Wi-Fi system.[28] The Public Services Commission of Wisconsin estimates that these projects will connect 600 businesses and over 20,000 homes to broadband service.[29]

We encourage state governments, like their federal counterparts, to focus on funding these and similar initiatives in a manner that can spark investment and innovation from the private sector. In addition, we urge state funders to support programs in a technology-neutral manner that fosters innovative solutions such as those used in the Rural Airband Initiative.

Accelerated Data Reporting on Rural Broadband Coverage

There is a need for improved data collection regarding rural broadband coverage.

Without accurate data it will be impossible to gauge progress and determine where and how to expand work. Moreover, businesses need accurate data to help decide whether, and where, to invest their resources.

Collecting more accurate and up-to-date data regarding the state of broadband in rural America can help make such decisions easier. Currently, the most recent and most widely accepted data regarding broadband availability in rural America dates back to December 2014—nearly three years ago. Given the importance of the goal, the need to move quickly, and the amount of public and private capital at stake, accurate and timely data is essential.

Congress has recognized this need. The House of Representatives is exploring how to improve the accuracy of broadband mapping in rural America to ensure that any "false positives" in those areas can be identified so that benefits available do not go unused.[30] The FCC also needs accurate and current data.[31]

Given the rapid timescale of technology innovation, timely collection of data is essential. We support public-sector efforts to explore creative ways to achieve this goal, including broadband mapping and self-reporting by providers to build out broadband solutions for rural America.

SPOTLIGHT: TV WHITE SPACES STANDARDS EXPLAINED

Source: FCC 2016 Report

Standards Body	Standard	Standard Description
Institute of Electrical and Electronics Engineers (IEEE)	802.11af	Enables wireless local area network operation in TV white spaces spectrum in the 54 and 790 MHz. The standard was approved in February 2014.
IEEE	802.22	Enables wireless wide area network operation using white spaces in the television spectrum band. This standard was finalized in July 2011.
Internet Engineering Task Force (IETF)	Protocol to Access White Spaces Device (PAWS)	Enables international standardization of the interface between the database and white space devices.
U.S. Database Administrators Group	Database Synchronization Interoperability Specification	Defines the method for White Spaces Database (WSDB) Operators in U.S. TV band to interchange records of protected entitles and fixed TV band devices that are registered by one WSDB Operator, but must be supplied to all other WSDB Operators.
European Telecommunications Standards Institute—Broadband Radio Access Networks (ETSI—BRAN)	EN 301 598	Enables European standardization of radio local area network (RLAN) operations in the television spectrum band.

The TV white spaces device ecosystem is rapidly maturing. After substantial investment, the building blocks are falling into place for a globally scalable marketplace for devices capable of dynamically accessing unused TV white spaces spectrum.

With favorable and stable regulations, technologies leveraging TV white spaces spectrum can be as cheap as Wi-Fi technologies, which today carry most of the world's data traffic. Moreover, by using a new Institute of Electrical and Electronics Engineers (IEEE) standard called 802.11af, next generation Wi-Fi radios could access TV white spaces spectrum, extending the range and complementing the throughput of current generation Wi-Fi radios which operate at higher 2.4 GHz and 5 GHz frequencies and therefore are better for short-range, higher-capacity communications.

For radios that leverage the TV white spaces to be as affordable as those that use Wi-Fi, they must be standardized and mass manufactured with silicon-based chips. This will equip device manufacturers to produce a full range of low-cost wireless devices using TV white spaces.

Numerous standards have been developed, including the IEEE's 802.11af standard for local area networks and the 802.22 standard for wide area networks.

Today's Wi-Fi devices are built upon the 802.11 family of IEEE standards. U.S. companies would be willing to mass manufacture 802.11af baseband chips if the FCC ensures that there is sufficient usable TV white spaces spectrum available on a nationwide basis.

By leveraging higher modulation schemes, channel aggregation, and MIMO, wireless devices based on the 802.11af standard should be able to deliver throughput of 400 Mbps or more. With favorable regulations from the FCC, low cost 802.11af-based devices would begin to enter the US market in about 24 months.

Moreover, the Internet Engineering Task Force's Protocol to Access White Spaces Device (PAWS) standardized protocol for device-to-database communication is now stable, with devices and databases now deploying to meet the draft standard.

In addition, the TV white spaces database providers have developed a specification for database-to-database communication, which is being extended to countries beyond the United States.

In Europe, the European Technical Standards Institute (ETSI) completed and approved EN 301 598 in 2014, which forms the basis of the UK's TV white space rules and could become the European (and by default in Middle East and Africa) standard for TV white spaces devices. While there have been a number of standards efforts, the chart best captures the standards work most relevant to the emergence of TV white spaces technology.

Each of these advances is creating opportunities for vendors to begin product development. Indeed, while current TV white spaces technologies are based on proprietary technologies, the first generation of standards-based devices are in development.

Mediatek, for example, demonstrated its first tri-band 5 GHz, 2.4 GHz, and TV white spaces prototype radio based on the 802.11af Wi-Fi standard in a trial in Glasgow, Scotland, in 2015. With sufficient spectrum, the advancement of standardized white spaces technology is set to accelerate.


4-H
19
02
Head Heart Hands Health
HEAD HEART HANDS HEALTH
SINCE
1902
HEAD HEART HANDS HEALTH

NEW OPPORTUNITIES FOR RURAL AMERICA

Chapter Five

For rural communities across America, the introduction to broadband access could mean significant advantages and potential opportunities.

The bridging of the urban–rural digital divide could unleash tremendous potential for the lives and livelihoods of millions of those living in rural America.

Economic Growth and Opportunity

Broadband has consistently been associated with economic growth and higher incomes. A study led by technology provider Ericsson found that doubling broadband speeds can add the equivalent of $126 billion to GDP.[32] Here in the United States, a 2015 study concluded that rural communities with broadband access generally had higher incomes and lower unemployment rates than communities with less broadband deployment.[33]

Beyond individual incomes, expansion of broadband contributes to the growth of competitiveness of rural America.

Rural counties adopting broadband are positioned to attract new businesses, countering the “rural brain drain” crisis, by encouraging talented workers to remain in their communities to find adequate employment.[34]

Many ranchers, farmers, and local merchants could leverage the modern internet to sell their goods. And those working in service industries would be able to use the internet to improve their offerings, communicate with customers, or reach new markets.[35]

Small Businesses and Entrepreneurs

Broadband can particularly benefit small businesses because innovations such as cloud computing lower barriers to entry, increase productivity, and significantly decrease costs.

In addition, the internet provides easy, instantaneous connections to potential customers and diversity of suppliers worldwide. Studies show that businesses in rural areas with access to broadband experience a significant and positive economic impact.

In Iowa, for example, a growing number of small businesses are finally able to sell their goods and services across the state and around the world because of the availability of broadband.[36]

In 2013, this capability resulted in approximately $20 billion in sales, or the equivalent of 12 percent of the state's GDP for that year.[37] Given such figures, it is no surprise that the FCC has recognized and remains committed to addressing the disproportionate impact that the rural–urban digital divide has had on small businesses.[38]

Quality and Accessible Healthcare

Broadband access is also an important part of managing healthcare delivery and wellness programs. Indeed, the availability of "telemedicine" has been an important development in rural areas which often have fewer doctors per capita than urban areas.[39]

In a 2014 study by the State of Utah, it was found that telemedicine availability resulted in increased potential coverage of doctors and increased ability to remotely diagnose medical issues, thereby decreasing the overcrowding of local hospitals.[40]

The Delta Health Partnership, for example, uses videoconferencing to connect diabetes patients with nurse practitioners, physician assistants, and others—consultations that would ordinarily require four-to-six-hour roundtrips by car for patients or their providers.[41]

As another example, the Saint Vincent Health System in Erie, Pennsylvania has used telemonitoring to reduce readmissions rates in its facilities by 44 percent.[42]

Investing more resources to improve the connectivity of broadband to hospitals and health care providers based in rural communities would likely yield better services in health protection and restore greater efficiency to wellness programs for those in need.

By contrast, at Washington County Memorial Hospital, losing internet connections has forced ambulances to find alternative hospitals with better internet connections, even if the alternative hospital is located an additional 40 minutes away.[43]

Greater broadband connection for larger rural health care providers would lessen the demand for more bandwidth, which in turn would lower costs, resulting in more resources to be reinvested in patient care.

Currently, these rural health care providers pay up to three times as much for broadband as their urban counterparts, and many times these providers forgo broadband altogether.[44]

Access to broadband can also help the quality of medical and rehabilitation treatment to groups such as veterans, many of whom live in rural communities.

Broadband can bring patients closer to their care providers and expand the number of services available to them.


Have a fucking concept. Learn to take some
fucking criticism. Make me fucking care.
Use fucking spell check. Do your fucking
research. Sketch
The problem
Think about

Education Outcomes

Rural schools that adopt broadband are cherishing the many new, exciting educational opportunities that the internet has made possible within the past decade.

Such technological advances have given students with broadband access more personalized educational experiences, the ability to conduct internet-based research, the convenience of online testing, and the ability to track progress.[45]

Moreover, students in rural areas who gain internet access at home, will be better suited to deal with a troubling trend called the "homework gap,"[46] a growing educational prerequisite in light of the increasing amount of homework that will require internet access.[47]

In addition to measuring performance in school, extending internet access can better prepare a student's future with access to online applications for tests, jobs and college. Public libraries and other public institutions can also be leveraged as anchors in networks extending broadband access to students at home.

Productive Farming and Agriculture

Access to broadband, and particularly the Internet of Things, promises to enhance agricultural productivity in exciting ways.

Broadband access has given farmers the ability to search for new customers, find buyers willing to pay higher prices, and identify the most affordable sources of seeds, fertilizers, and farm equipment.[48] Farmers also use advanced wireless technologies to conserve resources and boost yields, from web-based irrigation scheduling[49] to "prescriptive planting" technologies that tell farmers how to increase their outputs based on data gathered by tractors.[50]

Having access to such new internet-based technologies will prime many rural farmers to compete more effectively.

Extending broadband connectivity to rural communities could unlock tremendous advantages to education, healthcare, and agriculture, as well as create opportunities for small businesses.

Broadband technology would ensure that all residents within rural communities benefit from technology, access and opportunity.

Whether those transformational benefits empower students with greater educational resources, permit farmers to market produce to more customers, or create better healthcare services to the community, the opportunity for broadband cannot be overstated.

WORKING TOGETHER TO EXPAND ACCESS & OPPORTUNITY FOR RURAL AMERICA

Conclusion

In urban America, we've become accustomed to ongoing capital investments to expand broadband capacity in areas that already have broadband coverage.

The time has come to expand this coverage to the rural areas that currently lack it entirely.

We believe a new rural broadband strategy makes this feasible. And with Microsoft's Rural Airband Initiative, we are prepared to put our own resources and energy behind this effort.

We also believe there is an opportunity for other companies large and small to join in with market-based investments.

We all have the opportunity to innovate together—achieving together what none of us can accomplish alone.

And just as we look forward to sharing what we have learned as a company, we look forward to applying over the next five years what we undoubtedly can learn from others.

Broadband connections have become indispensable for accessing healthcare, advancing education, improving agriculture, and growing a small business. As a country, we should not settle for an outcome that leaves behind 23.4 million living in rural America. To the contrary, we can and should bring the benefits of broadband coverage to every corner of the nation.

We look forward to working in partnership with government leaders at all levels, private sectors companies that have the expertise to develop and deliver affordable solutions, and local community members who can help enable the capabilities that a new generation of digital innovations and cloud computing can provide.

SPOTLIGHT: A CLOUD FOR GLOBAL GOOD
CREATING TRUSTED, RESPONSIBLE, AND INCLUSIVE TECHNOLOGY

Cloud computing is delivering capabilities that promise new ways to expand access to economic opportunity and address some of our most pressing problems.

While the cloud is enabling new opportunities in almost every aspect of our lives—from healthcare, to education, communication, and business—it is creating disruption in other ways. There are deep concerns about whether and how this technology can be used to benefit everyone.

Clearly, we've reached a critical crossroads where we must rethink how people interact, companies conduct business, and governments protect public safety, manage economic growth, and deliver services.

At Microsoft, we are fundamentally optimistic about the future. But we also recognize that the cloud must be used to drive societal and economic opportunity. What's needed is a balanced set of policy and technology solutions that will promote positive change and ensure that the benefits of cloud computing are broadly shared.

A Policy Roadmap

In response to our ongoing discussions with governments to offer policy options to help create the right conditions for a trusted, responsible, and inclusive cloud, Microsoft launched a global policy agenda called A Cloud for Global Good.

This multi-year initiative seeks to encourage lawmakers and policy influencers across the world to consider policies and programs that can help their citizens, cities, countries, and regions embrace the benefits of cloud computing while addressing the disruptions that accompany any major technological change.

While we are excited by the opportunities offered by a future powered by the cloud, we understand that not everyone shares our optimism and that the benefits of cloud transformation are not being felt equally.

Microsoft is upfront and direct about the potential impacts of cloud computing that people around the world are concerned about, including: diminished privacy; job displacement; access to education and skills development; fair access; and the impact on the environment.

Our Cloud for Global Good initiative offers a policy roadmap that seeks to maximize the opportunities of cloud computing and minimize the challenges. This roadmap covers 15 policy areas, from personal privacy and cybersecurity, to tech fraud, public safety, digital literacy, and affordable and ubiquitous access.

Under each policy area, we offer comprehensive recommendations and considerations grounded in the belief that for cloud-based technology to achieve the full promise of the opportunities to improve people's lives at great scale, we need a trusted cloud, a responsible cloud, and an inclusive cloud. These three principles guide everything that we do.

To truly build a cloud for global good, it will be essential for governments, citizens, businesses, and organizations to work together to create a framework for cloud computing—one that respects the things that people care about, opens the door to the achievement of the dreams they aspire to, and provides benefits that are equally accessible for all.

More on the policy recommendations in A Cloud for Global Good can be found at: www.microsoft.com/cloudforgood

ENDNOTES

[1] Based on Form 477 data as of December 31, 2014 relied on by the FCC in its 2016 Broadband Progress Report. See In the Matter of Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act, GN Docket No. 15-191, 2016 Broadband Progress Report, 31 FCC Rcd 699, ¶ 79 (2016) ("FCC 2016 Broadband Progress Report").

[2] Unless stated otherwise, all references to "TV white spaces" in this whitepaper are meant to encompass wireless technologies capable of optimally accessing the TV white spaces spectrum.

[3] "Mason Dockter, FCC chairman visits Iowa, discusses rural broadband access," *Sioux City Journal* (Jun. 7, 2017), http://siouxcityjournal.com/news/local/fcc-chairman-visits-iowa-discusses-rural-broadband-access/article_90754cf6-e35c-5120-9e4b-9c5ce1bcff44.html.

[4] Andrew Perrin, "Digital gap between rural and nonrural America persists," *Pew Research Center* (May 19, 2017), http://www.pewresearch.org/fact-tank/2017/05/19/digital-gap-between-rural-and-nonrural-america-persists/.

[5] Id.

[6] Id.

[7] Jennifer Levitz and Valerie Bauerlein, "Rural America Is Stranded in the Dial-Up Age," *Wall Street Journal.* (Jun. 15, 2017), https://www.wsj.com/articles/rural-america-is-stranded-in-the-dial-up-age-1497535841.

[8] Julianne Twining, "A Shared History of Web Browsers and Broadband Speed," *Platform* (Apr. 10, 2013), https://www.ncta.com/platform/broadband-internet/a-shared-history-of-web-browsers-and-broadband-speed-slideshow/.

[9] Jennifer Levitz and Valerie Bauerlein, "Rural America Is Stranded in the Dial-Up Age," *Wall Street Journal* (Jun. 15, 2017), https://www.wsj.com/articles/rural-america-is-stranded-in-the-dial-up-age-1497535841.

[10] Id.

[11] See Sean Buckley, "Lawmakers introduce new bill to accelerate rural broadband deployments on highway rights of way," *Fierce Telecom* (Mar. 13, 2017), http://www.fiercetelecom.com/telecom/lawmakers-introduce-new-bill-to-accelerate-rural-broadband-deployments-highway-rights-way.

[12] See In the Matter of Unlicensed Operation in the TV Broadcast Bands, and Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket Nos. 04-186 and 02-380, 23 FCC Rcd. 16807 (2008), See also Larry Greenmeier, Taking Waves: FCC Green Lights Unlicensed Use of Wireless 'White Space' Frequencies, *Scientific American* (Oct. 15, 2010), https://www.scientificamerican.com/article/fcc-white-spaces/.

[13] See Report of the Spectrum Rights and Responsibilities Working Group, FEDERAL COMMUNICATIONS COMMISSION SPECTRUM POLICY TASK FORCE (Nov. 15, 2002), https://transition.fcc.gov/sptf/files/SRRWGFinalReport.pdf; Report of the Unlicensed Devices and Experimental Licenses Working Group, FEDERAL COMMUNICATIONS COMMISSION SPECTRUM POLICY TASK FORCE (Nov. 15, 2002), http://transition.fcc.gov/sptf/files/E&UWGFinalReport.pdf.

[14] See Victor Bah, Amer Hassan, & Pierre Devries, Draft Proposal for Comment: Etiquette Rules and Procedures for Unlicensed Bands, MICROSOFT CORP. (Jan. 27 2003), https://www.microsoft.com/en-us/research/wp-content/uploads/2016/02/FCC_proposal_v11.pdf.

[15] See Unlicensed Operation in the TV Broadcast Bands, ET Docket No. 04-186, Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380, Second Report and Order and Memorandum Opinion and Order, 23 FCC Rcd 16807 (2008).

[16] See, e.g., Deepak Vasisht, Zerine Ketanovic, Jong Ho Won, Xinxin Jin, Ranveer Chandra, Sudipta Sinha, & Ashish Kapoor, FarmBeats: An IoT Platform for Data-Driven Agriculture, USENIX (Mar. 27, 2017), https://www.microsoft.com/en-us/research/wp-content/uploads/2017/03/FarmBeats-webpage-1.pdf; Abusayeed Saifullah, Mahbubur Rahman, Dali Ismail, Chenyang Lu, Ranveer Chandra, & Jie Liu, SNOW: Sensor Network over White Spaces, ACM SENSYS 2016 (Nov. 16, 2016), https://www.microsoft.com/en-us/research/wp-content/uploads/2016/12/SNOW-sensys2016.pdf; Sid Roberts, Paul Garnett, & Ranveer Chandra, Connecting Africa Using the TV White Spaces: From Research to Real World Deployments, IEEE (Apr. 1, 2015), https://www.microsoft.com/en-us/research/wp-content/uploads/2016/02/main-5.pdf; Aakanksha Chowdhery, Ranveer Chandra, Paul Garnett, & Paul Mitchell, Characterizing Spectrum Goodness for Dynamic Spectrum Access, IEEE (Oct. 1, 2012), https://www.microsoft.com/en-us/research/wp-content/uploads/2016/02/SpectrumGoodness.pdf. Numerous other publications over the last 15 years may be found at https://www.microsoft.com/en-us/research/project/networking-over-white-spaces-knows/#.

[17] "Microsoft's Spectrum Observatory project opens up for increased collaboration," *Microsoft Corporate Blogs* (Apr. 8, 2014), https://blogs.microsoft.com/on-the-issues/2014/04/08/microsofts-spectrum-observatory-project-opens-up-for-increased-collaboration/.

[18] "TV dinners: Unused TV spectrum and drones could help make smart farms a reality," *The Economist* (Sep. 17, 2016), http://www.economist.com/news/science-and-technology/21707242-unused-tv-spectrum-and-drones-could-help-make-smart-farms-reality-tv-dinners.

[19] See Telecommunications Act of 1996, Section 706, 47 U.S.C. § 1302.

[20] In addition to expanding TV White Spaces, the FCC also has launched initiatives to overcome wireless and wireline infrastructure impediments, which may permit faster and cheaper access to needed infrastructure. See "Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment," WC Docket 17-84, April 21, 2017, https://apps.fcc.gov/edocs_public/attachmatch/FCC-17-38A1_Rcd.pdf; "Accelerating Wireline Broadband Deployment by Removing Barriers to Infrastructure Investment," WC Docket 17-84, April 21, 2017, https://apps.fcc.gov/edocs_public/attachmatch/FCC-17-37A1_Rcd.pdf. The FCC also is exploring the use of spectrum at 3.5 GHz and in the millimeter wave frequencies for rural broadband service. Senator John Thune recently has urged the FCC to focus on innovative uses of spectrum. See Letter from Sen. John Thune to Chairman Ajit Pai, June 21, 2017, available at https://www.commerce.senate.gov/public/_cache/ files/3cefb171-0d50-4c23-9f31-48942e874cc6/4 CAB0C0B754962807BB0C203E951D581.thune-letter-on-mid-band-spectrum.pdf.

[21] President Trump has made infrastructure improvement a centerpiece of his Administration's domestic policy and his budget proposals. On June 21, 2017, the President committed that expansion of rural broadband development would be a part of his national infrastructure initiative. See Alan Bjerga, "Trump Pledges Rural Broadband Support in Infrastructure Package," *Bloomberg* (Jun. 21, 2017), https://www.bloomberg.com/news/articles/2017-06-22/trump-pledges-rural-broadband-support-in-infrastructure-package.

[22] Senator John Thune of South Dakota has taken a leadership role with the MOBILE NOW Act, which would foster innovative licensed and unlicensed wireless solutions, require the government to make available additional spectrum for mobile and fixed broadband use, and require agencies to act on requests for infrastructure quickly, among many other improvements. S. 19, 115th Cong. (2017), https://www.congress.gov/bill/115th-congress/senate-bill/19. In addition, the Gigabit Opportunity Act, introduced by Senator Shelley Moore Capito of West Virginia and Rep. Doug Collins of Georgia, would create "gigabit opportunity zones" in which eligible entities could obtain tax and other advantages for investment in gigabit-capable broadband networks. S. 1013, 115th Cong. (2017), https://www.congress.gov/bill/115th-congress/senate-bill/1013/text.

[23] See Federal Communications Commission, "Universal Service for High Cost Areas - Connect America Fund," https://www.fcc.gov/general/universal-service-high-cost-areas-connect-america-fund; In the Matter of Connect America Fund, Universal Service Reform – Mobility Fund, Report & Order, WC Docket 10-90 (Mar. 7, 2017).

[24] Id.

[25] See "Joint Petition for Clarification or, in the Alternative, Waiver of Microsoft Corporation, Mid-Atlantic Broadband Communities Corporation, Charlotte County Public Schools, Halifax County Public Schools, GCR Company, and Kinex Telecom, In the Matter of Modernizing the E-rate Program for Schools and Libraries," WC Docket No. 13-184 (Jun. 7, 2016).

[26] Notice of Written Ex Parte from the State Members of the FCC's Federal State Joint Conference on Advanced Services filed: In the Matter of Inquiry Concerning the Deployment of advanced Telecommunications Capability to All Americans in a Reasonable and Timely fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act, GN Docket No. 16-245 (Sep. 16, 2016).

[27] "The Plan: The New NY Broadband Program," *New York State*, https://www.ny.gov/programs/broadband-all.

[28] Frequently Asked Questions regarding the Broadband Expansion Grant Program, *Public Service Commission of Wisconsin*, https://psc.wi.gov/Documents/Frequently%20Asked%20Questions%20regarding%20the%20Broadband%20Expansion%20Grant%20Program%20FY18.pdf.

[29] Id.

[30] See Defining and Mapping Broadband Coverage in America, *House Energy & Commerce Committee*, https://energycommerce.house.gov/hearings-and-votes/hearings/defining-and-mapping-broadband-coverage-america; see also Doug Brake, A Policymaker's Guide to Rural Broadband Infrastructure, Information Technology and Innovation Foundation, ITIF (Apr.10, 2017), https://itif.org/publications/2017/04/10/policymakers-guide-rural-broadband-infrastructure.

[31] See FCC 2016 Broadband Progress Report at 82 (noting that figures used are based on December 31, 2014 data).

[32] Press Release, "New study quantifies impact of broadband on GDP," *Ericsson* (Sep. 27, 2011), https://www.ericsson.com/en/press-releases/2011/9/new-study-quantifies-the-impact-of-broadband-speed-on-gdp.

[33] Jennifer Levitz and Valerie Bauerlein, "Rural America Is Stranded in the Dial-Up Age," *Wall Street Journal* (Jun. 15, 2017), https://www.wsj.com/articles/rural-america-is-stranded-in-the-dial-up-age-1497535841.

[34] Id.

[35] Id.

[36] "How Broadband Is Helping Iowa Businesses," *Connect Iowa* (Apr. 2015), http://www.connectiowa.org/sites/default/files/connected-nation/whitepaper-iabusinessadoptiontrends-april2015_final.pdf.

[37] Id.

[38] "2016 Broadband Progress Report" at ¶ 4.

[39] See, e.g., David A. Lieb, "Report: rural Mo. has fewer doctors per capita," *Associated Press* (Jul. 28, 2011), https://www.yahoo.com/news/report-rural-mo-fewer-doctors-per-capita-204225930.html.

[40] Utah Telehealth Study – Phase 1 Report, "Pilot Healthcare Strategies for the Utah Division of Occupational and Professional Licensing" (Mar. 21, 2014), http://dopl.utah.gov/docs/Phase1_Report_Major-trends-drivers-and-data-points.pdf.

[41] Id.

[42] Id.

[43] Jennifer Levitz and Valerie Bauerlein, "Rural America Is Stranded in the Dial-Up Age," *Wall Street Journal* (Jun. 15, 2017), https://www.wsj.com/articles/rural-america-is-stranded-in-the-dial-up-age-1497535841.

[44] Mohit Kaushal, Kavita Patel et. al., "Closing the Rural Health Connectivity Gap: How Broadband Funding Can Better Improve Care," *Health Affairs Blog* (Apr. 1, 2015), http://healthaffairs.org/blog/2015/04/01/closing-the-rural-health-connectivity-gap-how-broadband-funding-can-better-improve-care/.

[45] Darrell M. West and Jack Karsten, "Rural and urban America divided by broadband access," *Brookings Inst* (Jul. 18, 2016), https://www.brookings.edu/blog/techtank/2016/07/18/rural-and-urban-america-divided-by-broadband-access/.

[46] Jessica Rosenworcel, "Bridging the Homework Gap," *Huffington Post* (Jun. 15, 2016), http://www.huffingtonpost.com/jessica-rosenworcel/bridging-the-homework-gap_b_7590042.html.

[47] Id.

[48] Ivan T. Kandilov and Mitch Renkow, "The Impact of the USDA Broadband Loan Program on U.S. Agriculture," *NARDeP* (Aug. 9, 2013), http://www.nardep.info/uploads/Brief_USDABroadbandLoans.pdf.

[49] Liz Morrison, "New tools, technology help farmers increase water use, irrigation efficiency," *Corn + Soybean Digest* (Feb. 24, 2014), http://www.cornandsoybeandigest.com/precision-ag/new-tools-technology-help-farmers-increase-water-use-irrigation-efficiency.

[50] Jacob Bunge, "Big Data Comes to the Farm, Sowing Mistrust," Wall Street Journal (Feb. 25, 2014), https://www.wsj.com/articles/no-headline-available-1393372266.

Microsoft

https://news.microsoft.com/rural-broadband