Broadband Availability and Access in Rural Pennsylvania

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Executive Summary

Over 800,000 Pennsylvania residents do not have access to broadband connectivity, according to the Federal Communications Commission (FCC). However, recent research has documented that these official estimates are downplaying the true state of the digital divide because they rely on self-reported data by Internet Service Providers (ISPs).

Therefore, informed policy requires systematic analysis to both verify the FCC's numbers and accurately determine the true state of broadband connectivity across Pennsylvania.

This research collected more than 11 million broadband speed tests from across Pennsylvania in 2018. These tests measured broadband speeds in every Pennsylvania county and found that median speeds across most areas of the state do not meet the FCC's criteria to qualify as broadband.

This research leveraged the expansive resources available via the Measurement Lab (M-Lab) platform, which is an open source project of researchers, industry and public-interest partners, and an international team of network researchers whose expertise span from Geographic Information System (GIS) visualization and telecommunications technologies, to federal, state, and municipal broadband policies. Over the course of the project, the research team developed a transparent and replicable methodology that used open source tools for collecting broadband data.

This year-long research effort focused on precisely measuring median broadband speeds within specific geographic areas, and on identifying the extent of variances between "official" estimates of broadband availability and broadband speed measurements gathered "from the field."

The main findings from these analyses have profound implications for existing and future efforts to bridge the digital divide. The key findings are:

1. The FCC's official broadband maps from December 2017 (updated May 2019) show 100% availability across the entire state of Pennsylvania of broadband speeds that exceed 25Mbps;
2. The research team collected more than 11 million speed tests from across Pennsylvania in 2018 and found that median speeds across most areas of the state did not meet the FCC's criteria to qualify as a broadband connection;
3. At the county level, the 2018 data showed that there were 0 (zero) counties in Pennsylvania where at least 50% of the populace received "broadband" connectivity, as defined by the FCC;
4. Connectivity speeds were substantially slower in rural counties (as defined by the Center for Rural PA[1]) than in urban counties; and
5. By combining 2018 data with a historical archive of an additional 15 million tests from Pennsylvania residents, the research team identified that, since 2014, the discrepancy between ISP's self-reported broadband availability in the FCC's broadband maps and the speed test results collected via the M-Lab platform has grown substantially in rural areas, a trajectory that is not mirrored in urban areas; this

[1] See: Demographics » Rural/Urban PA. (n.d.). Retrieved from http://www.rural.palegislature.us/demographics_rural_urban_counties.html

may indicate a systematic and growing overstatement of broadband service availability in rural communities.

To enable further exploration and refinement of these data, the research team is freely and publicly releasing all of the data, mapping methodologies, scripts, and visualization tools.

This research provides a considerable level of documentation and insight into the state of broadband connectivity experienced by rural residents across Pennsylvania. Unfortunately, efforts to bridge the digital divide have, thus far, fallen far short of official broadband speed goals; and while these efforts have improved connectivity for many, the divide between rural and urban areas may be growing – a divide that is further clouded by the official FCC maps.

As a part of this project, the research team has produced an open, easily-reproducible methodology in collaboration with experts in the field. The goal has been to help create a new "gold standard" for this type of research – a methodology that can be generalized to other states and national efforts and one that represents a best practice for future efforts aimed at determining the extent of broadband access. This project has specifically explored the availability of 25/3 Mbps broadband across the state and provides options for government, community, and civic organizations that want to help support universal broadband availability.

The main implications stemming from the research findings are that successfully addressing the digital divide will require a variety of tactics, some old, but many new. Major investments in both the documentation of on-the-ground realities, as well as directly in infrastructure, should be considered.

Finally, the project team's archival research documents that broadband connectivity has been successfully deployed to previously underserved communities, both within Pennsylvania and across the country, using a diverse array of business models. Therefore, the research team recommends maximizing the options for service provision to ensure true broadband deployment across rural Pennsylvania.

Introduction

Needs Statement and Related Research

Under the 2004 Amendment (Act 183 added section § 3013 - Continuation of commission-approved alternative regulation and network modernization plans) of Chapter 30 of the Pennsylvania Public Utility Code[2], providers were required to make full broadband access available to 100% of Pennsylvania residents by the end of 2015, a goal which the broadband providers claim has already been met.[3] However, "broadband" was defined by a decades-old speed of 1.544 Mbps [Megabits per second] download/128 Kbps [Kilobits per second] upload, and not the current standards set by the Federal Communications Commission (FCC).

Cross-checks using 2010 Census findings and 2016 FCC data show that 187,000 Pennsylvanians lack access to even the minimal connectivity required to meet federal standards for "broadband." According to one report, at least 775,000 Pennsylvania residents do not have access to 25Mbps connection speeds.[4] But some experts,[5] and even the FCC itself, believe that these figures may dramatically overstate the actual availability of broadband services. For example, the FCC's Form 477 data, which Internet Service Providers (ISPs) file to indicate where they offer Internet access service, allows providers to list an entire census block [statistical areas bounded by visible features, such as streets, and by non-visible boundaries, such as property lines] as "served" even if they would only provide service to a single customer. The

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2 (n.d.). Retrieved from https://www.legis.state.pa.us/WU01/LI/LI/CT/HTM/66/00.030..HTM

3 Verizon. (2015). Verizon Offices Equipped for High Speed Internet in Pennsylvania [PDF file]. Retrieved from https://www.verizon.com/about/sites/default/files/pa_hsi.pdf

4 Pennsylvania Internet Service Providers: Availability & Coverage. (n.d.). Retrieved from https://broadbandnow.com/Pennsylvania

5 Kushnick, B. (2017, December 07). Verizon Pennsylvania's Commitment to Have 100 Percent Coverage of High-Speed Broadband by 2015? -- A Quadruple Bait-and-Switch. Retrieved from https://www.huffingtonpost.com/bruce-kushnick/verizon-pennsylvanias-com_b_7532008.html

Form 477 process also allows providers to list the census block as served if it "could" provide service in the future, even if no connectivity at all is currently available for any price.[6]

The Center for Rural Pennsylvania defines 48 of Pennsylvania's 67 counties (72%) as rural, with about 3.4 million Pennsylvanians living in rural counties.[7] According to the FCC, many rural communities are particularly reliant upon cellular and other wireless providers as their main ISP vis-a-vis more urban constituencies. A 2017 Pennsylvania House of Representatives Consumer Affairs hearing noted that "69 percent of all high-speed broadband connections in Pennsylvania are serviced by mobile providers"[8] -- yet most mobile service provision fall well short of the 25/3 Mbps definition of "broadband." Thus, claims of full broadband availability across Pennsylvania[9] appear to be at odds with the on-the-ground broadband reality experienced by many Pennsylvania residents. Furthermore, many rural Pennsylvanians describe their service offerings as "low-quality" and "unreliable," "low-speed" (and even as getting worse over time), and "high-cost."[10] However, while these assessments are all too common, this anecdotal evidence is insufficient for informed decision-making, which is one reason why this empirical assessment of actual broadband speed tests is so important.

6 See, Modernizing the FCC Form 477 Data Program, Further Notice of Proposed Rulemaking, released August 4, 2017, WC Docket No. 11-10, para. 33: FCC Proposes Improvements to Broadband/Voice Services Data Collection. (2018, October 06). Retrieved from https://www.fcc.gov/document/fcc-proposes-improvements-broadbandvoice-services-data-collection

7 Demographics » Quick Facts. (n.d.). Retrieved from http://www.rural.palegislature.us/demographics_about_rural_pa.html

8 Commonwealth of Pennsylvania House of Representatives. (2017). Presentation on the Telecommunications Industry [PDF file]. Retrieved from https://www.legis.state.pa.us/WU01/LI/TR/Transcripts/2017_0039T.pdf

9 Mason, A. (2017, February 27). Is it time to update state law on broadband? Retrieved from https://www.ydr.com/story/news/education/2017/02/27/time-update-state-law-broadband/97288086/

10 Stawser, J. (n.d.). Pennsylvania Pushes for High-Speed Internet. Retrieved from https://www.govtech.com/network/Pennsylvania-Pushes-for-High-Speed-Internet.html

Furthermore, existing broadband availability data are often out of date (e.g., Pennsylvania's BakerBB.com's broadband map,[11] which has not been updated since 2014, and the National Broadband Map, which, as of this writing in early 2019, has only just released 2017 data for Pennsylvania.[12]) The need for a scientifically rigorous, up-to-date broadband research effort is crucial, and developing more up-to-date maps and the mechanisms for continuously updating broadband speed data (and making this information freely and publicly available) is a core part of this initiative's goals.

In 2011, a study by the Investigative Reporting Workshop at American University found that the best values for broadband were in the most affluent areas.[13] Simply put, richer communities paid less for the same amount of connectivity than the poorer areas that they studied. This divide may be even more pronounced considering that actual broadband speeds provided to users are quite often significantly slower than advertised speeds,[14] and that some forms of connectivity have reduced reliability or increased latency - the delay before a transfer of data begins following an instruction for its transfer - compared to fiber (especially mobile and satellite services).

The opportunity costs of not providing communities with affordable access consist of very real impacts on their economic health. A 2006 Massachusetts Institute of Technology study found that "between 1998 and 2002, communities in which mass-market broadband was available by December 1999 experienced more rapid growth in employment, the number of businesses overall, and businesses in IT-intensive sectors, relative to comparable communities

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11 Baker (n.d.) Pennsylvania Broadband and Mapping Retrieved from http://www.bakerbb.com/pabroadbandmapping/index.html#

12 Mansfield, Rich (2018, December 07). Decommissioning of the National Broadband Map and its APIs Retrieved from https://www.broadbandmap.gov/

13 Dunbar, J. (2011, February). Wealthy Suburbs Get Best Broadband Deals; DC, Rural Areas Lag Behind. In Investigative Reporting Workshop (Vol. 28).

14 OfCom (2011, March 02). Average Speed is still less than half advertised speed. Retrieved from media.ofcom.org.uk/2011/03/02/average-broadband-speed-is-still-less-than-half-advertised-speed/; FCC Broadband Performance OBI Technical Paper No. 4 (2010). Retrieved from www.fcc.gov/Daily_Releases/Daily_Business/2010/db0813/DOC-300902A1.pdf.

without broadband at that time."[15] Additional studies have focused on rural communities: "New Media, Technology and Internet Use in Indian Country,"[16] provides a paradigmatic methodology for studying Internet use, including use of nationally normed survey questions to enable direct comparative analyses. A 2012 study by the Hudson Institute, "Broadband for Rural America: Economic Impacts and Economic Opportunities," analyzed opportunity costs for households, including education, healthcare, telecommuting, and e-services, while also looking at the impact on businesses and large institutions.[17] Previous to this, a 2008 study of Broadband Internet Use and Rural Development in Pennsylvania[18] by Penn State University reflected on how different sectors were using broadband access. However, much of this research was conducted over a decade ago, and given the rapid developments in information technologies over the past decade, the results may no longer be relevant to today's shifting needs. A snapshot of national broadband speed averages, conducted by the FCC in 2011, had already documented significant gaps between advertised speeds and observed speeds.[19] Thus, the FCC's continuing declarations over the ensuing 8+ years that broadband availability and speeds self-reported by ISPs reflected on-the-ground reality is particularly troublesome. The most recent claims, as of this writing, include statements that nearly 2/3rds of Americans (205.2 million) have access to 250Mbps broadband service and that roughly 90% (290.9 million) of the U.S. populace have access to 100Mbps

15 Gregory, D. M. (2011). The Martin County Broadband Network. Retrieved from http://cfp.mit.edu/publications/CFP_Papers/Measuring_bb_econ_impact-final.pdf.

16 For sample and nationally normed survey questions, see: Morris & Meinrath, Morris, T. L., & Meinrath, S. D. (2009). New media, technology and Internet use in Indian Country: Quantitative and qualitative analyses. Washington, DC: New America Foundation.

17 Kuttner, H. (2012). Broadband for rural America: Economic impacts and economic opportunities. Economic Summit on the Future of Rural Telecommunications, Washington, DC. Retrieved from: https://www.nheconomy.com/uploads/RuralTelecom-Kuttner--1012.pdf.

18 Glasmeier, A., Benner, C., Ohdedar, C., & Carpenter, L. (2008). Broadband internet use in rural Pennsylvania. Center for Rural Pennsylvania [PDF file]. Retrieved from http://www.rural.palegislature.us/broadband2008.pdf

19 Measuring Broadband America. (n.d.) Actual Versus Advertised Speeds. Fig. 2 [PDF file]. Retrieved from: https://transition.fcc.gov/cgb/measuringbroadbandreport/9ActualVersusAdvertisedSpeeds.pdf

broadband options.[20] By not clearly showing the extent of the broadband divide, and by providing official assessments that are decreasingly accurate over time for rural America, U.S. government policy has, in effect, negatively impacted the economies of rural America by preventing many communities from being eligible for the very funding that would address the growing digital divides that they have faced.

A growing consensus of large-scale research initiatives has documented this actual vs. advertised broadband speed divide. For example, Microsoft's December 2018 research study "concluded that 162.8 million people do not use the internet at broadband speeds, while the F.C.C. says broadband is not available to 24.7 million Americans… [this] discrepancy is particularly stark in rural areas."[21] Yet the FCC's Form 477 data for December 2017 (updated May 2019) paints an entirely different story -- according to the official measures, all of Pennsylvania is served by Internet speeds exceeding the FCC's definition of "broadband speeds" (Figure 1), an official assessment that can be disproved via even a cursory inquiry with residents of rural areas of the state.

20 See FCC Press Release, "REPORT: AMERICA'S DIGITAL DIVIDE NARROWS SUBSTANTIALLY," 02/19/2019. Retrieved from: https://docs.fcc.gov/public/attachments/DOC-356271A1.pdf.

21 See:Lohr, S. (2018, December 04). Digital Divide Is Wider Than We Think, Study Says. Retrieved from https://www.nytimes.com/2018/12/04/technology/digital-divide-us-fcc-microsoft.html

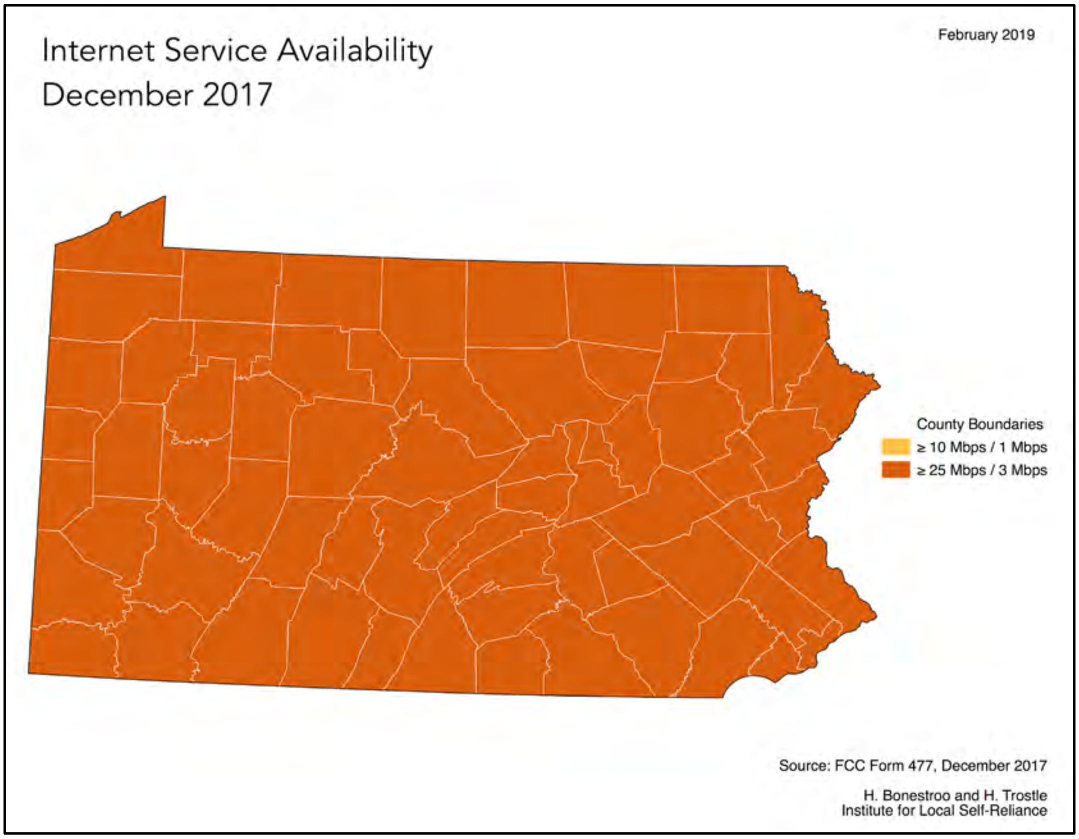

Figure 1 - The FCC's broadband map shows 25mbps-speed broadband is available across 100% of Pennsylvania.

The consistent finding that on-the-ground broadband service realities are remarkably different than official estimates has led to further questions regarding overreliance of claimed coverage via the FCC's maps, rather than using actual broadband speed measures as the basis for informed decision-making. And while prior efforts to document broadband availability have been undertaken, the systematic study and updating of availability information, and the public release of this data, are still needed for key decision-makers to institute well-informed policies. All of this underscores why this research initiative is both so timely and so necessary for Pennsylvania.

As many communities have recognized a need for better Internet access for their businesses and residents, despite state or federal statistics otherwise, they have enacted a variety of models to improve access locally. In addition to exploring the true level of Internet access speeds among communities, this research explored the ways local governments and states have responded with policies to increase investment and improve Internet access.

Project Background

Broadband connectivity is crucial for access to the modern economy, as well as for engagement in contemporary social, educational, and political life. Without adequate study of the availability of broadband connectivity, policymakers are left in the dark as they design programs to modernize communications infrastructure and ensure that telecommunications companies provide broadband/Internet service at the minimum speeds required to take full advantage of online resources (from distance education and telehealth to online shopping and civic engagement). Thus, the Donald P. Bellisario College of Communications at The Pennsylvania State University proposed to study the availability of 25/3 Mbps broadband connectivity across rural Pennsylvania for the Center for Rural Pennsylvania (CRPA) in response to the 2018 Research Grant Program Request for Proposals. This research initiative aimed to provide policymakers with extensive empirical analyses and concise implications regarding on-the-ground broadband availability for rural residents.

The project team collected a total of more than 11 million speed tests from across Pennsylvania in 2018, and has mapped these actual on-the-ground speeds to counties, and state House and Senate districts. All 67 counties are represented in this dataset, and only 5 counties (Sullivan, Forest, Cameron, Clinton, and Potter) had fewer than 10,000 tests run in 2018. Only two counties (Sullivan and Forest) had fewer than 1,000 test results. The number of tests by county spanned between 734 (Sullivan County) to 1,664,918 (Philadelphia County), with the median number of test results by county of 52,946.

This mapping effort across the commonwealth is a highly comprehensive mapping of broadband connectivity for Pennsylvania, and can act as an essential new data source for policy makers interested in addressing current digital divides across the Commonwealth. In addition to this compendium of broadband speed tests from residents across the state, the research team has included self-reported data provided by ISPs for the FCC's National Broadband Mapping effort. Thus, it is possible to compare and contrast the experiences of local residents with the data reported to the federal government and look for areas where these two data sources agree and where they are discrepant.

It should be noted that the exploratory analyses are the first logical step in determining the state of connectivity across Pennsylvania, but that more granular confirmatory analyses should be undertaken. To help facilitate this goal, 100% of the data - including the millions of data points collected over a multi-year broadband speed test archive - methodology, and findings will remain freely and publicly available.

Support for Research Need

Pennsylvania has a demonstrated commitment to ensuring that all of its residents have broadband access, and many legislators have worked diligently to close the digital divide and ensure that affordable broadband is universally available. The 1993 Chapter 30 telecommunications law set a goal of "universal telecommunications services at affordable rates while encouraging the accelerated deployment of a universally available state-of-the-art, interactive, public switched broadband telecommunications network in rural, suburban and urban areas."[22] Universal broadband connectivity was an explicit goal of Pennsylvania Act 183 of 2004, which required that, "The rural telecommunications carrier shall...accelerate broadband availability to at least 80% of its total retail access lines in its distribution network by December 31, 2010, and 100% of its total retail access lines in its distribution network by December 31, 2015."[23] A major telecommunications conglomerate has claimed that it met this obligation,[24] stating that it has "been 100 percent compliant with the mandates in Chapter 30 since the fall of 2015, finishing our deployments several months ahead of schedule [and making] high-speed Internet access available to all of our customers in Pennsylvania, including rural Pennsylvania."[25] At the same time, it was noted by legislators that "we seem to struggle with our more rural areas as it relates to Internet speed."[26] The data suggest not only that universal service

22 66 Pa.C.S. § 3001(1) , from https://www.legis.state.pa.us/WU01/LI/LI/CT/HTM/66/00.030..HTM

23 2004 Act 183. (n.d.). Retrieved from https://www.legis.state.pa.us/cfdocs/legis/li/uconsCheck.cfm?yr=2004&sessInd=0&act=183

24 Though many others have questioned this claim, pointing out that millions of rural Pennsylvanians lack the 45Mbps broadband connectivity they were promised. See: https://arstechnica.com/information-technology/2015/06/22-years-after-verizon-fiber-promise-millions-have-only-dsl-or-wireless/

25 Commonwealth of Pennsylvania House of Representatives. (2017, March 22). Consumer Affairs Committee Public Hearing [PDF file]. Retrieved from http://www.legis.state.pa.us/WU01/LI/TR/Transcripts/2017_0039T.pdf

26 Commonwealth of Pennsylvania House of Representatives. (2017, March 22). Consumer Affairs Committee Public Hearing [PDF file]. Retrieved from http://www.legis.state.pa.us/WU01/LI/TR/Transcripts/2017_0039T.pdf

is not available across Pennsylvania, but also that broadband speeds, as measured by ISPs' customers, fall far short of the advertised broadband speeds ISPs claim are available.[27]

Recently, one major telecommunications company made the decision to decline $23 million in federal funds to build rural broadband infrastructure, stating that "the Pennsylvania Public Utility Commission (PUC) says all companies bound by current law report 100 percent coverage."[28] PUC Chapter 30 regulations[29] require companies to make broadband service available within 10 business days of a request at a speed equal to or greater than 1.544 megabits per second (Mbps) in the downstream direction and equal to or greater than 128 kilobits per second (Kbps) in the upstream direction. In 2016, a bill was introduced in the House to increase the minimal definition of broadband to 10 Mbps/1 Mbps, which itself is still at odds with - and falls far short of - the federal definition of "broadband" set in 2015.[30] The discrepancy that this drives home is that incumbent ISPs are refusing federal funding to build out higher speed Internet access, while at the same time residents of Pennsylvania are desperate for broadband services they claim are not available yet in their area.

In August 2017, the House of Representatives introduced a resolution to "establish an advisory committee to conduct a study on the delivery of high-speed broadband services in unserved areas and underserved areas."[31] The hope was that the new data, and the resources the

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27 The finding that large swaths of Pennsylvania do not have access to broadband connectivity is troubling given testimony before the state legislature that universal connectivity has already been achieved. For example, testimony of Verizon before the House Consumer Affairs Committee Wednesday, March 22, 2017. Retrieved from: https://www.legis.state.pa.us/WU01/LI/TR/Transcripts/2017_0039_0001_TSTMNY.pdf

28 Scicchitano, E. (2017, March 26). Pennsylvania lags behind federal broadband standards. Retrieved from http://www.dailyitem.com/news/local_news/pa-lags-behind-federal-broadband-standards/article_eb0c137a-a8c7-5855-b5ac-d9fcc585ee94.htmll

29 CHAPTER 30 ALTERNATIVE FORM OF REGULATION OF TELECOMMUNICATIONS SERVICES. (n.d.). Retrieved from http://www.legis.state.pa.us/WU01/LI/LI/CT/HTM/66/00.030.HTM

30 Prose, J. (n.d.). Pennsylvania State Lawmaker Proposes Faster Internet for Rural Residents. Retrieved from http://www.govtech.com/network/Pennsylvania-State-Lawmaker-Proposes-Faster-Internet-for-Rural-Residents-.htmll

31 Bill Information - House Resolution 429; Regular Session 2017-2018. (n.d.). Retrieved from http://www.legis.state.pa.us/cfdocs/billInfo/billInfo.cfm?sYear=2017&sInd=0&body=H&type=R&bn=429

study would be making available, might be leveraged to assist efforts to spur broadband buildout across the Commonwealth.

Given the increasing awareness of the importance of broadband connectivity, and ongoing debate about the actual state of broadband connectivity across the state, any research findings will be particularly beneficial to House and Senate committees overseeing consumer affairs and protection, agriculture and rural affairs, economic development, state government, and communications and technology, and others.

Policy Considerations and Literature Review

In the course of this research, the research team found many relevant lessons for Pennsylvania policy makers within the experiences of local and state officials from across the country. In a state as diverse as Pennsylvania, achieving universal high-quality broadband Internet access is likely to require support from the state government, local governments, private businesses and associations, and so on.

Electrifying the entire country is a good case in point, with the private sector having invested tremendously; local governments building thousands of local citywide grids; and the federal government building dams, financing rural cooperatives, and providing credit to purchase appliances in homes across the nation.

To date, the scale of investment and focus on improving broadband access has not even come close to equaling those efforts. As just one example, in the mid-1930s, the Rural Electrification Administration alone was spending roughly 0.3 percent of U.S. GDP [gross domestic product] ($200M/year in 1936 dollars, or just over $3.7 billion in 2019 dollars, was spent on electrical lines and power plants for rural farms) *annually* on government-subsidized loans for rural electrification[32].

There are useful guideposts that exist that detail how each sector can support improving Internet access, several of which are detailed below.

32 Laurence J. Malone, Hartwick College- Market Failure in Delivering Electricity to Rural Areas Before 1930, Retrieved from https://eh.net/encyclopedia/rural-electrification-administration.

Private Sector Investment

The private sector will be intricately involved in all efforts to expand broadband Internet access. In many cases, private sector firms may own the network infrastructure itself, whether in the form of the largest cable company in the United States or smaller local firms. The private sector might often also be involved in financing broadband investments; even those that could be made by local governments -- since private investors often buy the bonds issued for such projects. The private sector manufactures the equipment used to build broadband network and, of course, the private sector is a massive beneficiary of the online markets that are created from improving Internet adoption. Thus, the private sector can be heavily involved in any effort to improve access in the Commonwealth, and is also the major beneficiary of these efforts, however structured.

Electric Cooperatives

Pennsylvania has 13 rural electric cooperatives, all located in rural regions of the state. Tri-County Rural Electric is one of the approximately 100 rural electric cooperatives around the nation that has started offering fiber-optic services to residents and businesses.[33] Tri-County's efforts have been significantly aided by winning auctions for census blocks within its region at a recent Connect America Fund II auction held by the FCC.[34] It was also awarded a $1.5 million grant via the Pennsylvania Redevelopment Assistance Capital Project program.[35] Across the country, rural electric cooperatives are relatively new to the ISP ecosystem for expanding high-

33 Cooperatives Build Community Networks. (n.d.). Retrieved from https://muninetworks.org/content/rural-cooperatives-page

34 Tri-County REC secures federal support for regional high-speed internet project. (n.d.). Retrieved from http://www.tri-countyrec.com/content/tri-county-rec-secures-federal-support-regional-high-speed-internet-project

35 Tri-County REC secures federal support for regional high-speed internet project. (n.d.). Retrieved from http://www.tri-countyrec.com/content/tri-county-rec-secures-federal-support-regional-high-speed-internet-project

quality Internet access in some of the most rural parts of the United States. It is thus essential that all options remain on the table to develop a rich ecosystem of broadband service provision models -- especially given current documentation of shortcomings of broadband service provision across so much of the state.

Though the challenges to wiring each home in a rural region with a fiber-optic cable is similar to that of building an electrical grid, the cooperatives have no monopoly broadband territory that would guarantee their business model. As such, many are assessing the challenges closely before committing to new investments. The dynamic in states like New Mexico, Missouri, and Arkansas is such that one pioneering cooperative builds a fiber-optic network while others watch to learn lessons. In time, more electric cooperatives may recognize the benefits of doing so and may have the advantage of leasing some services from the first-mover cooperative to lower the costs of the new network. The legislature could closely consider how to best motivate electric cooperatives to offer high-quality Internet services as one its strategies to cost-effectively expand access.

Connect America Fund Auction Implications

Though Tri-County Rural Electric won many census blocks in the Connect America Fund II Auction, the vast majority of the other available census blocks were won by a satellite provider (Viasat, Inc.) (see “Connect America Fund Phase II” map below). There is reason to doubt that Internet access delivered by geostationary orbit should qualify as broadband.[36] Though the provider states that it can provide speeds in excess of the 25 Mbps downstream and 3 Mbps upstream threshold set by the FCC, the very high latency prevents commonly used applications

36 Community Networks (n.d) Satellite Is Not Broadband [PDF file]. Retrieved from https://ilsr.org/wp-content/uploads/2018/09/fact-sheet-satellite-not-broadband.pdf

from functioning properly: from audio and video chat services (essential for remote working and telemedicine) to video games and voice assistant devices, such as Alexa. Finally, though satellite Internet access may be the best option in the short term to bring some form of faster-than-dial-up connectivity to homes in rural areas, it is wholly insufficient to support economic development due to issues of high latency and low data caps.

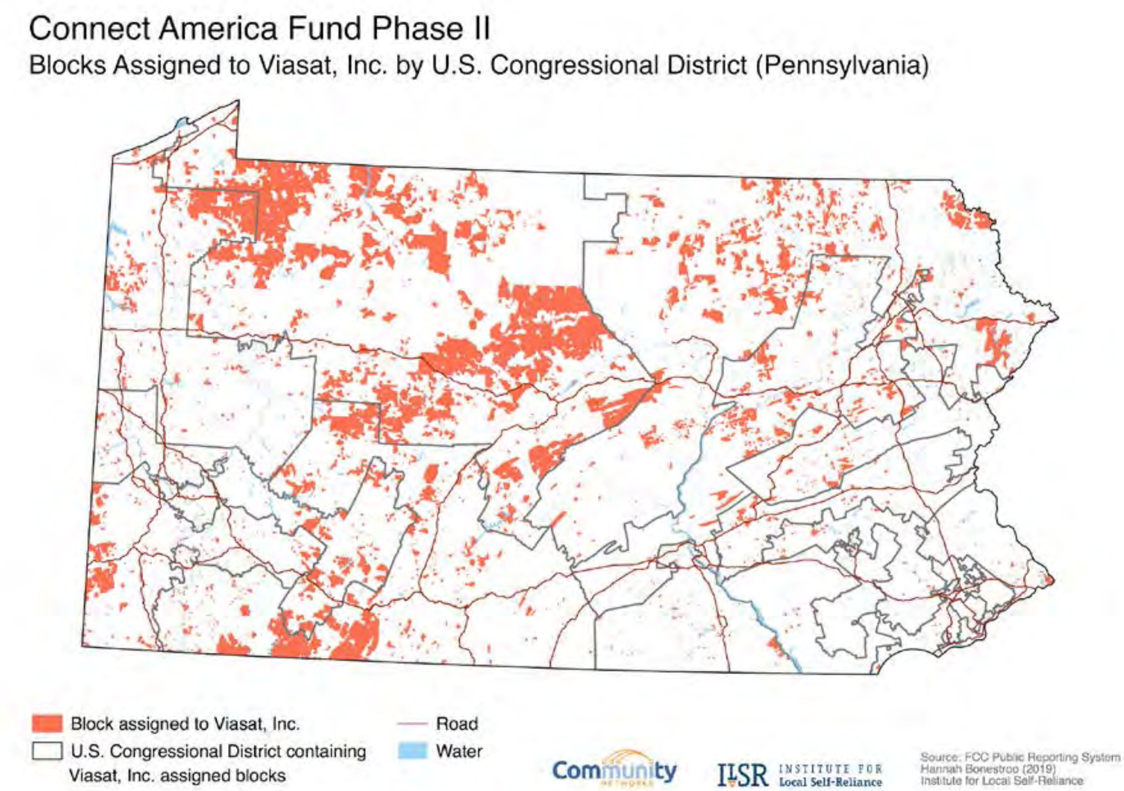

Figure 2. Connect America Fund: Phase II Blocks Assigned to Viasat.

For the next 10 years, the satellite internet provider will receive a yearly subsidy for its satellite Internet service to lower the cost for those who subscribe in those census blocks. Roughly 30 percent of the population that the satellite provider won across the United States (40,000 out of 145,000 Americans) are in Pennsylvania because of the large number of census blocks, and because certain large [non-satellite] telecom companies simply chose to opt-out of the Connect America Fund process and not build out to a large number of these census blocks.

The recent $600 million United States Department of Agriculture ReConnect program, which focuses on support for rural broadband, effectively denies funding to census blocks that have been assigned funding via the Connect America Fund II (CAF II) auction won by the satellite provider.[37] The end result is that Pennsylvania risks being held at a disadvantage because the vast territory that is intended to receive subsidized satellite Internet service may become ineligible for significant federal funds aimed to bring high-quality connectivity to rural regions due to the implementation of this stopgap satellite connectivity. The total yearly CAF II subsidy in Pennsylvania for this satellite provider is nearly $2 million per year for 10 years.[38] Even if it were spent on connectivity to encourage economic development, that $2 million per year may come at a steep opportunity cost of denying those areas access to ReConnect funds. As a result of how federal programs are structured, one must come to the conclusion that there is little help likely under current law outside the Commonwealth for connecting these regions. However, the provider will require a designation as an "Eligible Telecommunications Carrier" (ETC) from Pennsylvania in order to receive those funds; to become an ETC, the provider has to be capable of providing telephone service at reasonable quality levels -- a quality that may be difficult for a satellite service to meet. If the satellite provider cannot meet the telephone quality requirements, those funds may become available to other entities and entrepreneurs that could build better, more useful, terrestrial networks in Pennsylvania, since those areas would then be eligible to apply for ReConnect funds in those regions.

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37 More details on ReConnect: ReConnect Loan and Grant Program. (n.d.). Retrieved from https://www.usda.gov/reconnect

38 This FCC spreadsheet lists funding amounts per recipient per state. (n.d.). Retrieved from https://docs.fcc.gov/public/attachments/DOC-354843A1.xlsx

Local Independent Telephone Companies

In a large number of states, telephone cooperatives are also investing significantly in next-generation networks. Pennsylvania has no telephone cooperatives, but it does have several independent local telephone companies that are making big investments in advanced networks. For example, Citizens Fiber offers a reasonably priced gigabit access to communities within Westmoreland County.[39] The North-Eastern Pennsylvania Telephone Company has also upgraded many of its copper lines to fiber-optic, ensuring its customers have very high-quality Internet access.[40] Local firms like Citizens Fiber and NEP will play an important part in connecting Pennsylvania and should have a seat at the table as the state considers broadband programs.

Local Government Models for Improving Internet Access

Local governments are playing an important role in improving Internet access around the nation, including but not limited to:

- Providing grants and loans to local providers for expansion
- Building infrastructure to lease to existing providers
- Partnering with local providers to offer service
- Directly offering services

This is discussed through various examples in greater detail below. However, it must be noted that Pennsylvania law discourages local governments from building networks or even engaging in partnerships:

39 Gigabit is coming to Latrobe. (n.d.). Retrieved from https://www.citizensfiber.com/

40 Idea Farm Creative, L. (n.d.). NEP Telephone Company | Fiber Optic Broadband Internet, Phone & Video. Retrieved from http://www.nep.net/index

Pennsylvania prohibits municipalities from providing broadband services to the public for a fee unless such services are not provided by the local telephone company and the local telephone company refuses to provide such services within 14 months of a request by the political subdivision. In determining whether the local telephone company is providing, or will provide, broadband service in the community, the only relevant consideration is data speed. That is, if the company is willing to provide the data speed that the community seeks, no other factor can be considered, including price, quality of service, coverage, mobility, etc. (66 Pa. Cons. Stat. Ann. § 3014(h)). [41]

In many cases, local governments are some of the most motivated entities to improve Internet access to ensure local businesses can succeed and the community has a high quality of life. Limiting local authority in such a broad way not only introduces hurdles for local governments that wish to invest in infrastructure, but also dissuades many communities from considering it out of an abundance of caution regarding the real threat of lawsuits if they attempt to navigate these restrictions. The majority of states do not limit local authority in this manner. Historically, local governments frequently have preferred not to get involved in broadband infrastructure or services, but hundreds have once local businesses alerted the local government of their intent to leave the community in search of better Internet access.[42] Nonetheless, any community that chooses to take on this responsibility is one less community for which the state must find a solution. It is worth noting that municipal networks have a "strongly bipartisan dynamic at the local level,"[43] and Pew found that a strong majority of all U.S. adults believe "local governments should be allowed to build their own high-speed networks."[44] When the

41 Baller Stokes & Lide (n.d) State Restrictions on Community Broadband Services or Other Public Communications Initiatives [PDF file]. Retrieved from http://www.baller.com/wp-content/uploads/BallerStokesLideStateBarriers9-1-19.pdf

42 ILSR has documented many examples of local governments spurring economic development with broadband-related investments: Municipal Networks and Economic Development. (n.d.). Retrieved from https://muninetworks.org/content/municipal-networks-and-economic-development

43 Most Municipal Networks Built in Conservative Cities. (n.d.). Retrieved from https://muninetworks.org/content/most-municipal-networks-built-conservative-cities

44 Anderson, M., Horrigan, J. B., Anderson, M., & Horrigan, J. B. (2017, April 10). Americans have mixed views on policies encouraging broadband adoption. Retrieved from http://www.pewresearch.org/fact-tank/2017/04/10/americans-have-mixed-views-on-policies-encouraging-broadband-adoption/

president signed the bill initiated by Congress creating the USDA ReConnect program in 2018, it expressly allowed local governments to apply.[45]

To the extent that local governments have directly invested in or partnered with private partners to develop and/or improve local broadband access, availability and speed, they have used a wide variety of models with varying risk and reward profiles. Some have borrowed significantly while others have made a significant improvement in Internet access without either borrowing or raising taxes. For instance, the city of Santa Monica in California has saved millions of dollars by building a fiber-optic network for its own internal use in addition to serving - and attracting - local businesses.[46] Rather than borrowing money to build the network, it expanded incrementally by re-allocating dollars it was already spending on telecom budgets. At the other end of the spectrum, the city of Wilson, North Carolina borrowed tens of millions of dollars from private investors to build its own citywide municipal fiber network and has been repaying the investors with revenues from the broadband services themselves.[47] The Institute for Local Self-Reliance (ILSR - see Acknowledgement of Support section on p. 76) is currently tracking 500 communities that fall along this continuum.[48] These networks, including one of the nation's first citywide fiber-optic networks in Kutztown, PA, have been criticized most frequently by organizations and academics with strong ties to incumbent telephone and cable companies. ILSR has examined these criticisms, often drafting responses to them that provide much-needed corrections and primary sourcing, and using line-by-line commentary in its

45 Who May Apply. (n.d.). Retrieved from https://www.usda.gov/reconnect/who-may-apply

46 Institute for Local Self-Reliance (2014). An Incremental Approach to Building a Fiber Optic Network [PDF file]. Retrieved from http://www.ilsr.org/wp-content/uploads/2014/03/santa-monica-city-net-fiber-2014-2.pdf

47 Institute for Local Self-Reliance (2012). Wilson Gives Greenlight to Fast Internet [PDF file]. Retrieved from http://www.ilsr.org/wp-content/uploads/2014/03/santa-monica-city-net-fiber-2014-2.pdf

48 Community Network Map. (n.d.). Retrieved from https://muninetworks.org/communitymap

responses to help explain the relevant disputes.[49] Additionally, the FCC examined the relevant arguments and found that municipal broadband expands access to high quality Internet access, and often at lower prices than private industry offers.[50] And, in fact, the FCC's later decision to invalidate some of the state barriers to local investment in broadband service provision was overturned by the Sixth Circuit on grounds unrelated to the record of municipal broadband -- in fact, the courts found that municipal broadband was often a boon to local communities:

> *"The court didn't dispute that municipal broadband networks did lead to greater price and performance competition from incumbent broadband providers in each of the relevant communities — Comcast Corp. and AT&T Inc. in Chattanooga and Time Warner Cable Inc., now a subsidiary of Charter Communications, in Wilson. Nor did it take issue with the overall public interest benefits of municipal broadband."*[51]

While the record of local government investment in broadband is not perfect, and includes a select few locales where networks were mismanaged and/or where cost overruns proved unsustainable, it has nonetheless been sufficiently successful that states would be wise to expand support for this form of solution and ensure that eligibility requirements for broadband investment vehicles include the maximum number of options possible,[52] including, but not limited to municipalities, tribal authorities, community anchor institutions, non-profit organizations, and others.

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49 Correcting Community Fiber Fallacies. (n.d.). Retrieved from https://muninetworks.org/content/correcting-community-fiber-fallacies-page

50 FCC Releases Order Preempting TN & NC Municipal Broadband Restrictions. (2018, October 10). Retrieved from https://www.fcc.gov/document/fcc-releases-order-preempting-tn-nc-municipal-broadband-restrictions

51 Daly, K. (2016, August 17). Sixth Circuit Kills FCC's Municipal Broadband State Preemption Order. Retrieved from https://www.bna.com/sixth-circuit-kills-n73014446456/

52 See, for example, ILSR's discussion of successes and failures within municipal broadband and the importance of separating fact from hype (both in terms of failure and success) regarding these systems. Available online at: https://muninetworks.org/content/successes-and-failures.

Local Government Leasing Infrastructure

Some local governments have chosen to invest in infrastructure as part of a partnership with an independent ISP. However, local or regional firms, and especially large cable and telephone providers, have demonstrated little interest in such partnerships and have often been outwardly antagonistic to "public-private partnerships," with public entities as equal partners or the lead entity.

One good example of a public-private partnership is Westminster, MD, located in Carroll County, just south of the Pennsylvania state line. Westminster is building a publicly owned fiber network that will ultimately connect every household and business. The services are provided by a private company, Ting, that is responsible for making wholesale services available to competing ISPs.[53] In this approach, the local government builds a high-quality network in the same manner it builds streets - open to multiple providers. The exact arrangements have varied across open access models, but a common element is that they are designed to facilitate a truly competitive market for broadband services, with multiple ISPs vying for customers by selling services that use a single broadband infrastructure (similar to what is already happening in many electrical markets).[54]

States such as Pennsylvania, which have erected legislative barriers to local Internet investment, have nonetheless seen some communities adopt creative solutions to encourage broadband buildout.

53 Community Network Map. (n.d.). Retrieved from https://muninetworks.org/communitymap

54 Open Access. (n.d.). Retrieved from https://muninetworks.org/content/open-access

The state of Nebraska has also greatly limited local authority to build networks, which led the city of Lincoln to develop a vast conduit system that it leases to interested ISPs.[55] Many ISPs have used it to lower their cost of market entry and one unique, local ISP is building a citywide fiber-optic network using the system.[56] In Minnesota, rural counties have either applied for grants or simply appropriated money to subsidize cooperative network expansions to their region.[57] In Pennsylvania, Lancaster has created a partnership with MAW Communications, in which the city loaned money to MAW.[58] However, some significant challenges by the PPL Electric Utilities Corporation have significantly hindered that project, as discussed below.

Resources for Local Policymakers

The objective in laying out and describing all these varied municipal approaches is to demonstrate the many different options that already have been developed and are ready to be iterated upon -- not to arbitrarily select one or two as the best model. Pennsylvania has many varied types of communities, and the best solution for one region of Pennsylvania might not be the best option for another region. However, if the goal is to encourage effective broadband buildout, entities should be empowered to select from the maximum number of funding and ownership models possible to best address their unique combination of challenges, assets, local Internet access providers, culture, and other factors.

55 Publicly Owned Conduit: Network Neutrality Can-Do Tool. (n.d.). Retrieved from https://muninetworks.org/content/publicly-owned-conduit-network-neutrality-can-do-tool

56 City of Lincoln Conduit Spurs FTTH, School Network Innovation - Community Broadband Bits Podcast 228. (n.d.). Retrieved from https://muninetworks.org/content/city-lincoln-conduit-spurs-ftth-school-network-innovation-community-broadband-bits-podcast

57 Minnesota Counties Help Fund Cooperative Broadband Projects for Economic Development. (n.d.). Retrieved from https://muninetworks.org/content/minnesota-counties-help-fund-cooperative-broadband-projects-economic-development

58 Lancaster, Pennsylvania - A Community-Based Broadband Solution. (n.d.). Retrieved from https://www.lancityconnect.com/

Next Century Cities, an organization of 200 local governments across the United States who support universal access to high-quality Internet access, has published a toolkit called, Becoming Broadband Ready.[59] This resource offers guidance relevant to any community, including asset mapping, how to encourage collaboration among stakeholders, and "dig once" ordinances that help coordinate capital improvements and lower the cost of broadband infrastructure buildout. These local policies could easily be made available and/or distributed to local governments to help them better understand what options are available.

Additionally, local governments serving areas with larger apartment buildings can work with (or even compel) developers and building owners to improve Internet access within individual units.[60] An all-too-common challenge hampering improvement of Internet access in apartment buildings or condominiums are "exclusive deals" made between building owners and ISPs. Though the FCC long ago prohibited explicit, exclusive contracts in multi-dwelling units,[61] the lack of meaningful choice in many multi-dwelling unit (MDU) buildings led the FCC to open an investigation into this phenomenon, most recently, seeking public comment in 2017.[62] The City of San Francisco has attempted to use California law to address the lack of meaningful choice within MDUs by enacting an ordinance to prohibit landlords from interfering with occupants' choice in communications service providers.[63] In Minnesota, St. Louis Park has

59 Becoming Broadband Ready. (2019, February 20). Retrieved from https://nextcenturycities.org/becoming-broadband-ready/

60 Minnesota's St Louis Park has worked with building owners to develop standards that have helped increase private investment in fiber networks, and San Francisco passed an ordinance requiring landlords to allow competing ISPs into the building: St. Louis Park and Developers Ready The Wires. (n.d.). Retrieved from https://muninetworks.org/content/st-louis-park-and-developers-ready-wires; and San Francisco's MDU Ordinance Is a Win-Win-Win. (n.d.). Retrieved from https://www.bbcmag.com/multifamily-broadband/san-franciscos-mdu-ordinance-is-a-win-win-win; and Granicus, Inc. (n.d.). Retrieved from https://sfgov.legistar.com/LegislationDetail.aspx?ID=2863893&GUID=E010FDC6-4024-4BA7-B282-C0F9DE32D9F4

61 The Associated Press (2008, March 20). F.C.C. Bans Exclusive Phone Deals for Apartments. Retrieved from https://www.nytimes.com/2008/03/20/technology/20fcc.html

62 FCC (2017, June 01). Improving Competitive Broadband Access to Multiple Tenant Environments [PDF file]. Retrieved from https://transition.fcc.gov/Daily_Releases/Daily_Business/2017/db0601/DOC-345161A1.pdf

63 (n.d.) Retrieved from https://sfgov.legistar.com/LegislationDetail.aspx?ID=2863893&GUID=E010FDC6-4024-4BA7-B282-C0F9DE32D9F4

worked with landlords and building managers to enact standards that enable multiple providers to compete for residents without having to run new wires each time a new provider enters the market.[64] These types of policies are extremely low cost, yet encourage competition among ISPs -- which, in turn, can help lower the price of broadband service provision for local residents.

State Policy Considerations

One of the key challenges that any ISP, whether public, private, or cooperative, faces is deployment bottlenecks. These are often physical limiters, like an overpass, bridge, railroad, or similar topographical barrier. Due to federal grants in the 1800s, railroads have supreme authority over how ISPs can cross their rights-of-way. ISPs have reported varying levels of reasonableness and cooperation from different railroad companies; and some states have addressed this challenge by creating reasonable limits on how much a railroad may charge a network to cross its right-of-way.[65]

Like reasonable railroad fees, overpasses and bridges are another challenge where state and local government can help facilitate broadband buildout. By requiring conduit and making it easily accessible (both physically and legally) to all eligible ISPs, states and localities can dramatically reduce the cost of network deployment and foster market competition. As one example, the New York State Bridge Authority has begun leasing dark [unused] fiber to diversify its revenue, creating a relatively easy traversal option for any entity wishing to cross a number of physical barriers.[66]

64 St. Louis Park And Developers Ready The Wires. (n.d.). Retrieved from https://muninetworks.org/content/st-louis-park-and-developers-ready-wires

65 Minnesota adopted the following code: Office of the Revisor of Statutes. (n.d.). Retrieved from https://www.revisor.mn.gov/statutes/cite/237.045

66 (n.d.). Retrieved from http://www.midhudsonnews.com/News/2015/August/04/NYSBA_fiber_lease-04Aug15.html

One of the most common challenges faced by ISPs building a new network is access to utility poles. As the cost for putting fiber underground tends to be more expensive than attaching to existing utility poles, ISPs tend to prefer aerial deployments. However, as noted in a report by CTC Technology & Energy entitled, "Gigabit Communities: Technical Strategies for Facilitating Public or Private Broadband Construction in Your Community," access to existing poles is not guaranteed:

> *"In most communities, the poles are privately owned by phone and electric companies, which have control over both fees and timeframes for new fiber attachments to their poles (and which may be reluctant to facilitate the attachment of entities that will then compete with them to provide communications services)."*[67]

The challenge of pole access is illustrated by numerous complaints against the investor-owned electric company PPL. Lancaster has partnered with a local private company, MAW Communications, for it to deploy a gigabit network across the community.[68] However, MAW alleges that it has been unable to gain access to the majority of utility poles owned by PPL under reasonable circumstances.[69] In Canton, PA, the communications company Zito has also had issues with PPL in accessing utility poles.[70] Though any judgment on these particular cases is outside of the scope of this project, pole owners have frequently been identified as one of the biggest hurdles to increasing investment in fiber-optic networks.[71] In fact, lawmakers from across the political spectrum have supported recent efforts to streamline pole attachments via a

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67 See page 9: Gigabit Communities (n.d.). Technical Strategies for Facilitating Public or Private Broadband Construction in Your Community [PDF file]. Retrieved from http://www.ctcnet.us/wp-content/uploads/2014/01/GigabitCommunities.pdf

68 Full archive of coverage is available here: Full coverage: LanCity Connect fiber-optic broadband. (2017, February 15). Retrieved from https://lancasteronline.com/full-coverage-lancity-connect-fiber-optic-broadband/collection_3013dd06-f3ca-11e6-ad74-472c564e199c.html

69 See FCC Complaint here: (n.d.). Retrieved from https://www.fcc.gov/ecfs/search/filings?limit=50&proceedings_name=19-29&sort=date_disseminated,DESC

70 See FCC Complaint here: (n.d.). Retrieved from https://www.fcc.gov/ecfs/search/filings?proceedings_name=17-284&sort=date_disseminated,DESC

71 For a simple explainer on this topic, see this article by Susan Crawford: Crawford, S. (2017, June 16). Blame Your Lousy Internet on Poles. Retrieved from https://www.wired.com/2016/08/blame-your-lousy-internet-on-poles/

process called One-Touch Make-Ready.[72] Maine has moved forward to empower its Public Utilities Commission to adopt these rules.[73] The legislature could investigate whether pole attachment challenges are decreasing investment in better networks and then take action as needed.

The legislature has considered adopting language that would limit local authority on matters of 5G small cell [access nodes in licensed and unlicensed spectrum with a range of up to a few kilometers] deployment. Nearly half of the 50 states have adopted some type of language that would preempt localities in some manner.[74] The enthusiasm for 5G has led to some confusion and irrational exuberance. As explained in this IEEE [Institute of Electrical and Electronics Engineers] Spectrum 5G explainer, the technology will almost certainly allow new innovations and is genuinely exciting.[75] However, it will take many years for wide scale deployment with one telecommunications provider, for instance, expecting 5-8 years of investment to reach 30 million homes.[76] Most of that investment will be in urban areas, as the small cell technology has a very small radius for its high-capacity signal. As noted in the IEEE explainer, the signal will likely work over a distance of hundreds of meters, not miles. To the extent 5G becomes available in rural America, it will be using spectrum that cannot offer the same high-speeds that will eventually be common in urban areas.[77]

72 See: Brodkin, J. (2018, August 02). FCC sides with Google Fiber over Comcast with new pro-competition rule. Retrieved from https://arstechnica.com/tech-policy/2018/08/fcc-gives-google-fiber-and-new-isps-faster-access-to-utility-poles/

73 See: (n.d). Retrieved from http://tamnet.org/legislative-files/128th406/

74 See: The General Assembly of Pennsylvania. (n.d.) House Bill No. 2564 [PDF file]. Retrieved from https://www.legis.state.pa.us/CFDOCS/Legis/PN/Public/btCheck.cfm?txtType=PDF&sessYr=2017&sessInd=0&billBody=H&billTyp=B&billNbr=2564&pn=3863

75 Everything You Need to Know About 5G. (2017, January 27). Retrieved from https://spectrum.ieee.org/video/telecom/wireless/everything-you-need-to-know-about-5g

76 Verizon Appears to Walk Back 5G Home Buildout Goal. (n.d.). Retrieved from https://www.lightreading.com/mobile/5g/verizon-appears-to-walk-back-5g-home-buildout-goal/d/d-id/749645

77 Segan, S. (2018, December 19). What Will 5G Do for Rural Areas? Retrieved from https://www.pcmag.com/news/365565/what-will-5g-do-for-rural-areas

An increasing number of states are creating programs to subsidize rural broadband investment. Though California had previously set funds aside to subsidize better Internet access in public housing projects, a rules change in 2017 has effectively ended the program by defining the scope of "unserved" in such a narrow manner that eligibility is extremely difficult.[78] Almost all of the states with broadband programs have focused on areas with either no service at all or extremely limited service. The Minnesota Border-to-Border Grant program was an early approach that has been an inspiration for other states in developing a program offering matching grants to qualified projects.[79] Key details involve a requirement that any technology receiving matching funds be scalable to 100/100 Mbps to ensure that taxpayer dollars are invested in long-term assets and will not need to be subsidized again in the near future. Many of the states that have considered similar programs found two major areas of debate: the relevant speed definitions and whether existing ISPs have a right of first refusal if an entity proposes a project in a territory they already serve. Minnesota is one of many states that uses the FCC's broadband definition of 25/3 Mbps for the unserved threshold and the state goal of 100/20 Mbps to define underserved.[80] Colorado set a stronger standard for the right of first refusal after a large telephone company was perceived to have gamed the system to the detriment of the community.[81] Now, if a provider wants to veto a qualified project in an area where the project wishes to upgrade services, the provider has to meet or exceed the speeds and prices proposed by the qualified project.[82]

78 The language used is detailed here and makes no exception for quality of service or cost. California Advanced Services Fund (CASF) – Public Housing Account. (n.d.). Retrieved from http://www.cpuc.ca.gov/general.aspx?id=908

79 Broadband Grant Program. (2019, March 25). Retrieved from https://mn.gov/deed/programs-services/broadband/grant-program/

80 (n.d.). Ibid. Retrieved from https://mn.gov/deed/programs-services/broadband/grant-program

81 Ashby, C. (2018, March 01). Bill takes aim at broadband grant process. Retrieved from https://www.gjsentinel.com/news/western_colorado/bill-takes-aim-at-broadband-grant-process/article_c16febea-1d1e-11e8-bc33-10604b9f7e7c.html

82 For specific language see: Colorado Legislature Revamps Incumbent Right of First Refusal, Blocking Monopoly Battle Tactic. (n.d.). Retrieved from https://muninetworks.org/content/colorado-legislature-revamps-incumbent-right-first-refusal-blocking-monopoly-battle-tactic

Finally, and most importantly, legislators need up-to-date, accurate information to aid them as they develop policies that ensure that rural Pennsylvania is not left on the wrong side of the digital divide. This research initiative helps to not only provide this crucial data, but also assist in developing an open, peer reviewed methodology and open data store that will ensure that state leaders can continue to monitor on-the-ground (broadband) reality for years to come.

Goals and Objectives

The project goal was to comprehensively map the availability of fixed broadband services throughout rural areas of Pennsylvania. Employing a methodologically rigorous, peer-reviewed, extensible research methodology, this research initiative addressed the following five key areas of inquiry:

Advertised Broadband Speeds

1) **What is the current advertised state of broadband availability and speeds according to ISPs and other official data sources?** It's important to note that the report uses the latest FCC broadband data set (December 2017, updated May 2019) as the basis for determining advertised availability/speeds. These data are collected from ISPs by the FCC through the mandatory completion of the FCC's Form 477, a bi-yearly data collection effort, and represent the self-reports of ISPs of the speeds and areas where their services are available.

Measured Broadband Speeds

2) **What are the actual on-the-ground broadband speeds throughout rural Pennsylvania in locations that do have demonstrable access?** Though the FCC has set the definition of 25Mbps download and 3 Mbps upload speed for fixed "broadband" connectivity, it does not specify a standard for confirming whether a consumer's connection to the Internet meets that definition. Different broadband speed measurement tests are available to test connection speed, latency, etc., and all provide useful information about a consumer's Internet speeds and connection quality. In its Measuring Broadband America program (MBA), the FCC uses a combination of two test architectures, "on-net" [on the ISP's network itself] and "off-net" [to a third party location on the Internet], to characterize the connection speeds of U.S. households. As a part of the Measuring Broadband America program, the FCC's contractor for the MBA program, SamKnows, uses the Measurement Lab (M-Lab) platform for "off-net" measurements.[83]

Discrepancies Between Advertised and Actual Broadband Speeds

3) **What discrepancies exist between advertised and actual broadband availability and speeds in rural Pennsylvania? And, do discrepancies between advertised and actual broadband availability and speeds differ by demographic constituency and/or geolocation?**

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83 For more information on the Measuring Broadband America Methodology: Bertschek, I., Cerquera, D., & Klein, G. J. (2013). More bits – more bucks? Measuring the impact of broadband internet on firm performance. Information Economics and Policy, 25(3), 190-203. doi:10.1016/j.infoecopol.2012.11.002. Retrieved from https://www.fcc.gov/general/methodology-measuring-broadband-america.

Because the research team has collected both the FCC's Form 477 speed data (self-reported by ISPs) and M-Lab's tests (conducted by end users on their actual broadband connections), it is simple to show any discrepancies between these two data sources that may exist.

Potential Areas of Low/No Broadband Connectivity

4) **What areas of Pennsylvania have no demonstrable coverage by fixed line (25/3 Mbps) broadband service providers?** Deriving areas where no connectivity exists is challenging using an opportunistic sampling methodology. Overall, using this opportunistic sampling methodology, the research team was able to collect more than 11 million tests from across Pennsylvania in 2018, which, when added to a historic archive of an additional 15 million tests from Pennsylvania, provides over 25 million broadband tests that were used as part of the research team's analyses. However, even with this enormous compendium of data, the best one can do is create a picture of the general areas where tests have come from and where there are "voids" where no tests were received. In essence, the project is "painting" a pointillist-style map where each test is represented by a "dot" and collectively, these dots help us determine areas that may either have no connectivity, or where no one ran a measurement test. Regardless, because these results are exploratory in nature, they represent an initial foray into determining where broadband connectivity might not exist in Pennsylvania; further research using a random or nest-random sampling methodology would be a logical next step if additional confirmation/documentation is of interest.

Implications

5) **What are the implications stemming from these analyses (and how can Pennsylvania policy makers work to increase broadband availability -- what are successful business models and legislative efforts) and what barriers and opportunities exist to providing access to fixed 25/3 Mbps broadband service to areas with limited or no broadband connectivity?**

This research project provides exploratory analyses that show where claimed and measured broadband access speeds differ; documents speed differentials between rural and urban constituencies; shows changes in these measures over time; characterizes communities with lower levels of broadband access; and identifies successful interventions that would generalize to Pennsylvania communities and provide access to fixed wireline 25/3 Mbps connectivity.

Finally, this initiative seeks to inform efforts by policy makers to improve broadband availability across Pennsylvania, helping ensure that they have access to more accurate, more up-to-date, and more illuminating information than they've had previously. One hope is that access to this new compendium of knowledge will be leveraged by leaders to ensure that all residents of the Commonwealth have access to affordable, competitive and reliable wireline broadband access. As the critical infrastructure for 21st Century society, universal broadband connectivity is the foundation for the provision of modern tools for health care, education, job-seeking, civic engagement, and other social and economic benefits[84]. For individuals, businesses, and municipalities alike, the research is quite clear: improved Internet adoption leads to a better economy; as Pennsylvania becomes a more efficient, competitive, and productive Commonwealth, supporting universal broadband adoption requires the due diligence that this initiative makes available.

84 See: Allman, M., & Mathis, M. (2001). A Framework for Defining Empirical Bulk Transfer Capacity Metrics. Retrieved from https://tools.ietf.org/html/rfc3148

Methodologies & Data Sources

In order to analyze the discrepancies between advertised and experienced speeds both in general and by demographics, the researchers completed a literature review of existing mapping initiatives and peer-reviewed research at the beginning of the project and developed a best-practice framework for identifying and comparing discrepancies in advertised versus experienced speeds. Analysis of the data collected was done using this framework during the last quarter of the project and culminated in the maps and online mapping portal developed for this initiative.

This initiative used the Network Diagnostic Tool (NDT) suite first developed by network scientists at Internet2,[85] and later integrated into the M- Lab broadband testing platform.[86] As a suite of diagnostic tools, NDT was developed by and improved upon by the network research community and is an open source [software whose source code is freely available and may be shared or changed] test that enables users to empirically ascertain a variety of different broadband metrics, including upload and download speed, latency [the delay until a transfer of data begins upon the start of a network operation], and jitter [the time differences between when packets are sent and when they arrive]. NDT is an active measurement test that generates random data as its "payload" to test connectivity speeds and latency. Results from running the NDT client are publicly archived without personally identifying information. NDT measures "single stream performance" or "bulk transport capacity," as defined in the Internet Engineering Task

85 See: Internet2. (n.d.). Retrieved from https://software.internet2.edu/ndt/

86 See: Lab. (n.d.). Retrieved from https://www.measurementlab.net/tests/ndt/

Force's RFC 3148[87]. Other popular speed tests use a multiple TCP [a main protocol used in data transmission] streams, and are measurement of a connection's "aggregate capacity," where the level of aggregation is specified and bound. For example: "100 Mbps aggregate capacity using 4 streams." The NDT test on the M-Lab platform was chosen because both the source code for the test itself, and the resulting generated data, are both openly licensed and publicly available, and because this testing suite was developed and is overseen by network research scientists. Furthermore, this openness allows for complete inspection of testing methods, replicability, and contribution from the scientific and research community.

Upon the formal launch of the project, the research team worked with Penn State University's news service to publicly announce the data collection effort.[88] This press advisory garnered extensive interest across Pennsylvania, leading to multiple follow-up inquiries from individuals and organizations across the state. This project launch facilitated the development of an initial outreach strategy to highlight the project among key Pennsylvania stakeholders, with early keynote addresses: at the KinberCon Conference in Harrisburg on April 24, 2018; the Pennsylvania Telephone Association on April 25, 2018 in State College, PA; the Making Connections Regional Broadband Summit on July 23, 2018; and culminating with the team's public engagement prior to the report release at the Pennsylvania Priorities, "Focus on the Rural

87 A Framework for Defining Empirical Bulk Transfer Capacity Metrics. (n.d.). Retrieved from https://tools.ietf.org/html/rfc3148

88 Project initial press release is archived online on Penn State University's news wire. Retrieved from: http://news.psu.edu/story/503910/2018/02/05/research/researchers-begin-11-month-study -rural-pennsylvania-broadband

Broadband Crisis," on April 24, 2019, among other convenings in-between. These keynotes discussed the history of broadband mapping efforts as well as specifics about the project's methodology and goals. The project director also briefed staff at the Pennsylvania Public Utilities Commission and the House Committee on Consumer Affairs about the project, and discussed project specifics with staff from the State Attorney General's and Pennsylvania Governor's offices.

Furthermore, the project team worked with several radio outlets to promote the initiative,[89] as well as with local papers from across the state.[90] The team also worked with reporters and multimedia producers to develop additional useful resources and documentation for the project, itself, as well as around the importance of broadband across the state[91]. Finally, the researchers collected speed tests via two interconnected online platforms, the https://pa.broadbandtest.us website (which also allowed respondents to opt-in and provide additional demographic information regarding their home connections and use characteristics) and via M-Lab's partnership with Google's "One Box" program, which provided one-click

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89 As examples, see: WPSU's "Statewide Research Aims To More Accurately Evaluate Broadband Availability In Pa.": http://radio.wpsu.org/post/statewide-research-aims-more-accurately-evaluate-broadband- availability-pa; and follow-up's by WESA: http://www.wesa.fm/post/researchers-aim-more-accurately-gauge-broadband-availability-pa; and WITF: http://www.witf.org/news/2018/07/research-aims-to-more-accurately-evaluate-broadband-availability-in-pa.php.

90 As examples, see the op-ed in support of the project in Sunbury, Pa.'s The Daily Item, "Study a step forward for broadband.": http://www.dailyitem.com/opinion/study-a-step-forward-for-broadband/article_d5fb2418 -f5f2-53d9-9444-f86bdd602f0f.html; the news story in the Wayne Independent, "Broadband Study in Wayne County": http://www.wayneindependent.com/news/20180720/broadband-study-in-wayne-county; coverage of initiative by Penn State News, "A Broadband Challenge": https://news.psu.edu/story/525994/2018/06/28/research/broadband-challenge; and, Lawrence County's, The New Castle News, coverage of the initiative, "Penn State researchers seek to ID gaps in broadband access.": http://www.ncnewsonline.com/news/penn-state-researchers-seek-to-id-gaps-in-broadband.

91 See the 60-second video synopsis of the project at https://www.youtube.com/watch?v=g4p02rlliGI-access/article_3e9d9659-59ed-5da7-9b16-8467539784db.html; the in-depth multimedia coverage of the initiative and impacts of the current state of broadband connectivity in rural Pennsylvania by the Pittsburgh Post-Gazette, "Lifeline offline: Unreliable internet, cell service are hurting rural Pennsylvania's health.": https://newsinteractive.post-gazette.com/blog/telemedicine; and the compendium of stories developed by McClatchy and the Centre Daily Times as a part of the PA Influencer's initiative and focus on rural broadband: https://www.centredaily.com/news/local/article228780844.html.

access to run the NDT test via a box that would appear above search results when phrases like "broadband speed test" were searched for on Google.

By partnering with a number of media outlets, building partnerships with corporate, non-profit, and government partners, and by leveraging Center for Rural Pennsylvania contacts across the state, the project was able to easily surpass its initial goals for data collection, and ended up collecting more than 11 million tests from Pennsylvania in 2018. In addition, the online system used for this initiative continues to collect data from across the Commonwealth, and continues to enable anyone with a broadband connection to conduct a literally "one click" test to measure their broadband speed.

In order to map areas where there is little to no actual broadband availability, the team cross-referenced claimed service provision areas against M-Lab's NDT dataset of broadband speed tests conducted by end users. While these two measures may sometimes agree, these particular addresses have been spot-checked in areas where particular service tiers are claimed to exist, but where speed test data indicate that they may not (e.g., due to the type of infrastructure available, distance from cable head-ends, etc.). This method has enabled the research team to document the state of 25/3 Mbps service provision in rural Pennsylvania from January 1, 2018 through December 31, 2018, as measured via the M-Lab platform using the NDT test, and compare it with the advertised state of broadband service in the FCC's Form 477 data that is self-reported by ISPs. Because Form 477 data are collected by the FCC, these data are not independently verified by anyone outside that agency, and are based on advertised rates supplied by the ISPs themselves, rather than the speeds experienced by users. The FCC's data used in this study are the latest available and are from the 2017 calendar year (updated May 2019). The FCC's data-collection methodology has resulted in significant overstatements of service, including a vivid illustration recently of a company claiming to offer nearly a gigabit of service to every census block in Pennsylvania and other states[92]. The M-Lab platform uses actual speed tests from households and businesses, allowing the team to broadly compare the actual speeds experienced by Pennsylvania Internet users to the claims made by ISPs.

92 Brodkin, J. (2019, March 07). Ajit Pai's rosy broadband deployment claim may be based on gigantic error. Retrieved from https://arstechnica.com/tech-policy/2019/03/ajit-pais-rosy-broadband-deployment-claim-may-be-based-on-gigantic-error/

Organizational Roles

To accomplish the overarching project goals, the research project plan was divided into six distinct facets, each of which was coordinated by one or more project partners and built on the prior project work, data collection, statistical analyses, and GIS mapping that had been conducted (See Page 76 for more on the project partners).

Facet 1. Assembling the National Project Team (X-Lab).

Upon funding announcement, X-Lab coordinated with national partners to manage staffing, resource allocation, and ramp-up of broadband measurement initiatives.

Facet 2. Research & Literature Review (ILSR, X-Lab).

ILSR conducted an in-depth review of existing initiatives; and X-Lab investigated previous and contemporary peer-reviewed research.

Facet 3. Survey of Broadband Speeds (M-Lab, OTI, X-Lab).

M-Lab and OTI, in consultation with the X-Lab team, implemented the research methodology to integrate M-Lab and FCC Form 477 broadband speed and availability data and developed mapping visualizations for broadband connectivity across Pennsylvania.

Facet 4: Data Aggregation and Statistical Analyses (OTI, M-Lab, X-Lab).

OTI and M-Lab staff developed a data aggregation protocol to aid with speed visualizations and ensure the accuracy of the reported statistics, in consultation with X-Lab's staff. The research team ran statistical analyses and developed GIS mapping systems to identify differences between M-Lab and FCC data and developed maps for state House and Senate districts, and counties; in addition, the research team was able to expand these analyses to include data from historical archives (both from M-Lab and the FCC) to look at trends since 2014.

Facet 5. Documenting Best Practices (ILSR, X-Lab).

ILSR researched and compiled findings from new business models and initiatives; X-Lab's team coordinated integration of best practices into recommendations.

Facet 6. Finalize and deliver final report (X-Lab).

X-Lab's team incorporated feedback from project partners, Center for Rural Pennsylvania staff, and outside reviewers to deliver the final project report.

Advertised Broadband Speeds

To measure advertised broadband speeds in rural Pennsylvania, the team analyzed the FCC's database of ISP-provided data and mapped the availability of service offerings meeting or exceeding the 25/3 Mbps speed set as the definition for fixed "broadband" connectivity. Likewise, census blocks - the smallest geographic unit used by the United States Census Bureau for tabulation of 100-percent data (data collected from all houses, rather than a sample of houses) - have been identified that have no service provider meeting this definition. The FCC's ISP service location data repository is derived from the mandatory annual filings of Form 477,[93] which are required of ISPs and present one of the most comprehensive repositories of claimed service provision areas available. Because the FCC's database included information about service tiers and technologies used to provide broadband connectivity, it has been possible to derive where residents and businesses have access to fixed wireline 25/3 Mbps service, and where other options (e.g., mobile access, satellite connectivity) - which are not functionally equivalent[94] - are the only options available. Building upon these data, the team generated Geographic Information System (GIS) maps down to the census tract level of granularity.

93 Among its findings estimated that "Unlocking the digital potential for rural small businesses across the country could add $47 billion to the U.S. GDP per year." See: Unlocking the Digital Potential of Rural America. (n.d.). Retrieved from http://www.empoweringruralbusinesses.com/

94 (n.d.). Retrieved from https://ilsr.org/wp-content/uploads/2018/09/fact-sheet-satellite-not-broadband.pdf

Measurements of Broadband Speeds

To measure Internet speeds experienced by Pennsylvanians and conduct geospatial mapping to document broadband availability, the project team worked with M-Lab to analyze the data generated by people running the Network Diagnostic Tool (NDT) throughout rural Pennsylvania, which measures the speed and quality of Internet service. These tests collected the latitude and longitude of testers who actively consented to providing their exact location, using HTML5 [a technology used to build websites] geolocation[95].

M-Lab's default geo-location is based on IP address geolocation and is accurate to a broader geographic level than available via HTML5. M-Lab aggregates at this broader granularity to help protect user privacy[96].

M-Lab is the single largest longitudinal open data set of Internet measurements available today, and was built from day one as an open, distributed server platform that hosts a diverse set of active measurement tools. M-Lab's mission is to empower end users with the tools necessary to test different characteristics of their Internet connection (e.g. upload speed, download speed, latency, jitter). M-Lab already has a historic archive of over 15 million broadband speed tests from the years 2009 through 2017, and regularly received over 20,000 tests per month from Pennsylvania residents prior to this study.[97] During 2018, the research team collected more than

95 Pennsylvania Broadband Mapping Initiative. (n.d.). Retrieved from https://pa.broadbandtest.us/

96 Geolocation API Specification 2nd Edition. (n.d.). Retrieved from https://www.w3.org/TR/geolocation-API/

97 Lab. (n.d.). Retrieved from https://measurementlab.net/privacy

11 million tests from Pennsylvania; the research platform will continue to collect broadband speed data from Pennsylvania into 2019 (and beyond), and these data will be made freely and publicly available.

Leveraging the Internet measurement tests hosted by M-Lab, the research team created a website application tailored to Pennsylvania residents to allow end users to run the NDT test. Combining existing measurements from M-Lab with data collected through this research, it has been possible to aggregate and map the measurement data to a geographic area of interest (e.g., census tract, state legislator or congressional district, or neighborhood boundary) documenting the measurements over time of residents in Pennsylvania, and comparing areas within the state and across multiple geographies of interest.

Data collected via M-Lab can provide information on which ISPs are available in a given region, by identifying the number of tests from unique providers. Combined with its NDT single stream performance measurements, the data collected on M-Lab provides a unique view of the last-mile user experience.

All data collected through M-Lab is made openly available and placed in the public domain, where it is accessible by anyone who wishes to examine it. Building on pilot projects from Seattle, WA, Stevens County, WA, and Clearwater County, ID[98], alongside M-Lab and the research team's involvement in the FCC's Measuring Broadband America program - which

98 Lab Viz. (n.d.). Retrieved from http://viz.measurementlab.net/location/nauspa?aggr=month&isps=AS3737_AS6079_AS27364&start=2009-01-01

determines the official broadband speeds across the United States - the project team has developed resources to empower Pennsylvanians to submit data about their Internet connections and help collect a wealth of new information about broadband connectivity across the state.

Advertised vs. Measured Speeds

FCC: Form 477 Data Overview

The first data source leveraged comes from the FCC's broadband mapping efforts. Known as Form 477 data, because ISPs self-report their available broadband speed to the FCC through Form 477, these data document the advertised Internet speeds an ISP reports on a census-block-by-census-block basis. Form 477 data contain information from many ISPs, for nearly every census block in the country, and these data are reported twice yearly (though often, in practice, with a 12 to18 month delay between collection and public disclosure). In addition to their advertised speeds, ISPs report the type of technology used (e.g., satellite, fiber, copper wire) to transmit data, as well as whether business and/or consumer Internet is provided, and various other connectivity metrics.

The second main data source used in this study results from use of the NDT, hosted on the M-Lab platform. NDT is a speed and diagnostic test that reports actual upload and download speeds and as well as a number of other variables to help diagnose potential speed limitations. Of particular note, the NDT test provided by M-Lab is a single-stream performance test that measures a connection's "bulk transport" capacity as defined in the Internet Engineering Task Force's RFC 3148[99] [a formal document from the IETF] to an off-net location (e.g., one not on an ISP's own network). This is important because it is much more representative of the genuine Internet performance users will experience during regular use, measuring actual bandwidth to a different point on the Internet beyond the initial connection to the ISP, rather than just the speed from the user to the ISP's servers. Other multi-stream tests sometimes report different results and

99A Framework for Defining Empirical Bulk Transfer Capacity Metrics. (n.d.). Retrieved from https://tools.ietf.org/html/rfc3148 are different from NDT, choosing to focus on “aggregate capacity,” or the total maximal throughput on that providers own network.

For this report, since the latest available Form 477 data of advertised available speeds is being used, which is for Q3-4 2017, and contrasting that with actual measurements from 2018, one would expect that advertised speeds from 2017 would be less than actual speeds from 2018. However, this is not the case, especially for rural communities; the research found that advertised speeds from 2017 are often substantially greater than the measured speeds from M-Lab tests that people in Pennsylvania ran in 2018.

M-Lab servers reside outside of ISPs’ networks and inside Internet exchange points (IXPs). ISP networks connect to the Internet itself, and where Internet content typically is hosted, which means that NDT data can be very useful in measuring the consumer experience of accessing content anywhere on the Internet. The raw metrics collected by running an NDT test enable the calculation of upload and download speed, latency, and round-trip time. There is no universally agreed upon way to assess broadband speed, and the FCC itself does not provide a universal standard for measuring speeds to accompany its published definitions of broadband. However, M-Lab uses a scientifically standardized measurement suite designed by and for the network research community. The NDT speed test has been rigorously peer-reviewed, implements standards developed by Internet researchers, and is a 100% open source testing suite, which has enabled top researchers to review the code and ensures maximum transparency of the testing protocol as well as replicability of results. Combined with the research team’s focus on measuring connectivity speeds that mirror the everyday user experience (i.e., a connection to the global Internet, not just the speed within a customer’s local ISP), the connectivity speed reported by NDT provides results that align with best practices within the scientific and network research community, the standards of the Internet community concerning connection capacity, and the everyday lived experiences of ISP customers.

IP Addresses, Location & ISP

When a measurement is run against the M-Lab platform, the IP address of the user running the test is collected. IP addresses can be used against reference datasets, such as the Maxmind GeoLite2 database[100] to approximate a user's location quite accurately. Maxmind also provides openly available datasets that allow the IP address to be mapped to the Autonomous System Number (ASN) of the ISP providing the IP address. By looking up a test IP address in the Maxmind database, one can use it to approximate the geolocation and identify the ISP associated with a particular IP address[101].

Comparisons of Form 477 & Network Diagnostic Test Data

Form 477 and NDT datasets can be joined to census GIS files [software to manipulate, analyze and manage types of geographical data], but through different means — the Form 477 data are joined based on the Census Block ID, whereas NDT measurements are joined using a process called a "spatial join," which tests to see if a given latitude, longitude pair is within a specific delineated polygon area. Geographic shapefiles from the U.S. Census Bureau for census tracts, block groups, counties, and state House and Senate districts were downloaded and used to identify which NDT tests were conducted from each defined geographic area within Pennsylvania. Finally, median upload and download speeds were calculated for each geographic area for each of the biannual (6-month) time periods corresponding to the dates when the FCC's

100 GeoLite2 Free Downloadable Databases. (n.d.). Retrieved from https://dev.maxmind.com/geoip/geoip2/geolite2/

101 M-Lab. (n.d.). M-lab/annotation-service. Retrieved from https://github.com/m-lab/annotation-service

Form 477 data are released. Given the volume of NDT measurements, a data processing pipeline was written using the software languages SQL, Python, and R to process these data joins and which then enabled comparison of the NDT and Form 477 data[102].

M-Lab collects all NDT test data and stores them in a Google BigQuery [a service that enables analysis of massive amounts of information] dataset. To compare NDT data with the FCC's Form 477 data releases, each of the seven FCC Form 477 datasets were downloaded and loaded into individual Google BigQuery tables for ease of bulk processing. There are seven of these datasets corresponding to the FCC's data releases in December 2014, June 2015, December 2015, June 2016, December 2016, June 2017, and December 2017. Each separate Form 477 dataset contains close to 60 million speed records, where each speed record is comprised of 17 different variables. The NDT dataset is likewise constantly growing as users take tests and currently contains nearly 2 billion measurements[103] (and each measurement contains over 100 different variables).

Using this standardization process, the NDT data and the Form 477 data became geographically comparable. However, several challenges still remained in making the measurements directly comparable. First, the Form 477 data are the speeds that ISPs report providing in a given region. The NDT data in a given geographic area, on the other hand, represent the broadband speed measurements, as conducted by consumers in that area, and can be summarized in aggregate in a number of ways (e.g. simple descriptive statistics of minimum, median, average, or maximum measured speeds per geographic area). NDT data thus represent measurements from tests conducted by ISP customers themselves while Form 477 data represent

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102 Opentechinstitute. (n.d.). Opentechinstitute/USBB. Retrieved from https://github.com/opentechinstitute/USBB

103 Opentechinstitute. (n.d.). Opentechinstitute/USBB/pipeline. Retrieved from https://github.com/opentechinstitute/USBB/pipeline

self-reported speeds that are claimed to be available to those same customers. These measurements allowed the research team to understand the connection capacity of customers in a given area, and are also exploratory analyses. Because this research initiative documents substantial discrepancies between ISPs' self-reported speeds and those measured by ISP customers using the NDT test, further inquiry is warranted.

The NDT dataset also must be aggregated using techniques to eliminate potentially skewed statistics to provide a fair aggregate measurement of speed for a given geographic region. Since any person can run as many NDT tests as they want, a median-of-medians approach was used to eliminate the skew that can be caused by large numbers of tests from the same low or high bandwidth connections within the same day. Additionally, given the floor effect of broadband speed measurement, averages are a poor indicator of representative speeds. For example, the average of 1, 1, 1, 1, 1, 1, 1, 1, and 10,000 is 1,112. If nine neighbors in a neighborhood had those Internet speeds, no reasonable person would think of the neighborhood as having an average Internet speed over 1,000 Mbps. Reporting the median, instead of the mean or average, helps avoid this misleading figure. Likewise, if any of the 8 neighbors with a 1 Mbps connection, or the 9th neighbor with a 10,000 Mbps connection were to measure their speed 100 times, it would skew the basic median of this group dramatically.

Thus, when aggregating the NDT data by census areas (depending on the map, these areas were either state House and Senate legislative districts or county, however, these data could be aggregated by a variety of additional areas -- e.g., school districts, municipality, etc. -- in future analyses), a "median-of-medians" approach was used. First, all of the NDT speed tests by IP address and census area are grouped, and the median Internet speeds for each IP and census area combination was calculated. It's important to note that IP address is an imperfect proxy for household or subscriber but allows the proxy to work more than well enough for the median-of-medians approach. After calculating the median speeds for each IP address and census area combination, the IP address was dropped, and the medians were grouped solely by their census area, then finally the median of these medians was calculated to get a single median speed for the census area. This method was repeated for NDT tests conducted by users within each of the six month time periods corresponding to the FCC Form 477 release time periods. In the example above, this method would give a median of 1 Mbps, much closer to the speed someone would intuitively assign to the nine-person neighborhood.

The median-of-medians approach was also run on the 477 data, with the ISP functioning similarly to the IP address used with NDT data. Unlike "averages," which can be highly influenced by outliers, this approach helps ensure that the reported result for any geographic area is still highly representative of that district (e.g., representing the point that 50% of the sample is faster and 50% of the sample is slower than). The downside of this approach is that it requires relatively large data sets to ensure validity (often in the hundreds or even thousands of measurements). In addition, in multi-modal distributions, median speeds can sometimes fail to capture an accurate representation of the underlying phenomenon -- though broadband speed tests have tended not to show this sort of distribution.

In each census area, the self-reported advertised speeds of each ISP is reported. ISP and census area were grouped first in order to calculate the median speeds for each type of service offering that each individual ISP reports in the Form 477 dataset. ISPs report speed offerings for different service delivery technologies within a single census area (e.g. cable, fiber, DSL, fixed wireless, satellite, etc.). Thus, if an ISP provides 10 kinds of service to a handful of households in a census area while a large ISP provides Internet service through a single technology to

100,000 residents in that same census area, the "average" Internet speed in the area should be more heavily influenced by the second than by the first. Unfortunately, 477 data do not contain subscriber information. To address the problem in the 477 data, the research team compared the results from both methods and confirmed that a median-of-medians approach is superior because it helps ameliorate this measurement artifact by aggregating reported speed tiers across a geographic area.

For state legislative districts, instead of using the census area shapefiles, state legislature shapefiles (one set for state House districts and another for state Senate districts) were compared with the latitude/longitude coordinates for each M-Lab test, using a well-known "point in polygon" technique from the GIS field[104]. Using this technique, the census area in which each NDT test latitude/longitude point originated was identified, saving the NDT test data along with an area identifier into a new BigQuery table. Due to the large amounts of data in both the NDT and 477 datasets, a data processing pipeline was used to complete this process using Google's Cloud Dataflow service[105].

Creating maps of broadband speeds by state legislative districts does, however, pose a challenge for the FCC's Form 477 data since, as mentioned, these data are reported at the census block level. Unfortunately, there are sometimes errors in the mapping of census blocks with state legislative districts (although census blocks are used to build those districts). For example, many state legislative districts are smaller than their overlapping counties so that a single county will contain several state legislative districts. These irregularities thus require a heuristic for mapping Form 477 data to state legislative districts. The method used to calculate the median speed for a

104 See, for example, https://automating-gis-processes.github.io/2018/notebooks/L3/point-in-polygon.html

105 More information about these broadband mapping projects is available here -- Seattle: (n.d.) Retrieved from http://seattle.gov/broadband-speed-test; Stevens County: (n.d.). Retrieved from http://stevenscountybroadband.net; Clearwater County: (n.d.). Retrieved from https://ed-broadband.clearwatercounty.org.

state legislative district is to take the median of medians for any Form 477 data coming from a census area that overlaps with the given state legislative district. For example, suppose the aim is to calculate the average for state House District A. District A overlaps with Census Blocks A, B, and C. To find the median of medians, ISPs are matched across Census Blocks, the ISP medians are generated, the median of those medians is calculated, and this new median is assigned to District A.

Finally, to compare NDT data with Form 477 data, several similar methodologies are used. At the county level, where the geographic medians are calculated identically for both datasets, one can directly compare them. In the case of comparative maps, it is necessary to subtract the Form 477 median speeds from the NDT median speed to get a measurement of their differential. At the level of the state legislative district, however, directly comparing NDT data with Form 477 data is more complicated since a heuristic is used to calculate the Form 477 median. It is thus logical to apply the same heuristic to the NDT data that is applied to the Form 477 data, even though the more accurate legislative district breakdown for NDT data is also available. Thus, at the legislative district level, when presenting the difference between NDT and Form 477 data—and only when presenting the difference—NDT speeds are calculated using a median-of-medians heuristic by averaging the colocated counties' median.

Taken together, these statistical analyses represent a huge leap forward in helping us understand the state of broadband connectivity across Pennsylvania. As exploratory analyses, they provide far-reaching insights and a wealth of new information that can prove useful in formulating effective policies to address the digital divides facing the Commonwealth. Furthermore, because transparent and replicable methodologies, open source measurement tools, and the raw data are published in the public domain, this report is likely to spur additional inquiry and confirmatory research that can further improve upon an understanding of broadband availability across the state.

Archival Research & Business Model Compilation

The staff at the Institute for Local Self-Reliance lead efforts to investigate business models and success stories from around the country. Drawing from the compendium of case studies it has collected as a part of its https://muninetworks.org online resource portal; ILSR chose a number of exemplar initiatives that highlighted specific options relevant to the Pennsylvania context.

Scripts, Code, & Data Repositories

The code, applications, tools and platforms leveraged to analyze, study and generate data behind the maps are open source and freely available for others to study, modify or improve upon. The repositories where this code and data can be accessed, along with a synopsis of each, follows:

- This Github repository contains code in the R and YAML programming languages, documentation, instructions and examples of various maps that can be generated from M-Lab (or other geocoded) data: https://github.com/opentechinstitute/USBB
- M-Lab publishes all data it collects in raw form as archives on Google Cloud Storage (GCS) at the following location: https://console.cloud.google.com/storage/browser/archive-measurement-lab

- M-Lab provides query access to its datasets in BigQuery at no charge to interested users. Following the steps at the link below allows anyone to use BigQuery to search M-Lab datasets without charge when the measurement-lab project is selected in your Google Cloud Platform console, or set as your project in the Google Cloud SDK. However, queries from Google Cloud Platform projects you create, saving query results to BigQuery tables, etc. may incur costs to you: https://www.measurementlab.net/data/docs/bq/quickstart/
- The Network Diagnostic Tool (NDT) is used to diagnose network performance and configuration problems. This tool can determine the speed (Dial-up to OC-192) and duplex (full or half) settings of the slowest link on the end-to-end path between a desktop computer and a server running the NDT. It can determine if performance is limited by network congestion (e.g., competing traffic over the shared portions of the end-to-end path). It can also determine if the throughput is limited by the client's network configuration parameters. Finally, the tool looks for and reports serious error conditions, duplex mismatch and faulty hardware: https://github.com/ndt-project/ndt/
- The collectd-mlab package provides a collectd plugin and associated scripts for continuous monitoring and periodic export of metrics for each M-Lab server location. The resulting data allows M-Lab to monitor its infrastructure capacity, and to confirm the capacity of a given M-Lab server location at a given time. This package is designed to run in the M-Lab experiment environment: https://github.com/m-lab/collectd-mlab

- The collectd data for M-Lab’s infrastructure can be reviewed, queried, and inspected in M-Lab’s public *switch* dataset: https://console.cloud.google.com/bigquery?project=measurement-lab&p=measurement-lab&d=switch&page=dataset
- This project contains the repository for the Measurement Lab visualizations web client provided online at https://viz.measurementlab.net : https://github.com/m-lab/mlab-vis-client
- mlab-speedtest is an Angular.js application provided on the website: https://speed.measurementlab.net
- The app code currently uses gulp to integrate language localization pre-deployment: https://github.com/m-lab/mlab-speedtest

Results

The research team collected more than 11 million tests from across Pennsylvania in 2018 as a part of this research project. Given this substantial data repository, the research team was able to aggregate and analyze broadband speed information for every state House and Senate district, and for every county in the state, and to conduct in-depth exploratory analyses comparing advertising claims and measurements of connection capacity throughout Pennsylvania. Using the FCC’s minimum definition of broadband (25 Mbps downstream and 3 Mbps upstream) enables policy makers to better judge what level of intervention is necessary (and where these interventions should be targeted) and helps ensure that Commonwealth residents, community anchor institutions, and businesses have access to “state-of-the-art” connectivity options. A more in-depth discussion is provided below. However, the main findings from these analyses are:

1. The FCC's official broadband maps from December 2017 (updated May 2019) show 100% availability across all of Pennsylvania of broadband speeds that exceed 25 Mbps;
2. The research team collected more than 11 million speed tests from across Pennsylvania in 2018 and found that median speeds across most areas of the state did not meet the FCC's criteria to qualify as a broadband connection;
3. At the county level, the 2018 data documented that there were 0 (zero) counties in Pennsylvania where at least 50% of the populace received "broadband" connectivity, as defined by the FCC;
4. Connectivity speeds were substantially slower in rural counties (as defined by the Center for Rural Pennsylvania[106]) than in urban counties; and
5. By combining 2018 data with a historical archive of an additional 15 million tests from Pennsylvania residents, the research team identified that, since 2014, the discrepancy between ISPs' self-reported broadband availability in the FCC's broadband maps and the speed test results collected via the M-Lab platform has grown substantially in rural areas, but not in urban areas; this may indicate

106 See: Demographics » Rural/Urban PA. (n.d.). Retrieved from http://www.rural.palegislature.us/demographics_rural_urban_counties.html

systematic and growing overstatement of broadband service availability in rural communities.

The research team is freely and publicly releasing all of the data, mapping methodologies, scripts, and visualization tools to enable further exploration and refinement of these data; while these are exploratory analyses, the scale of data collection provides substantial support for the claim that the FCC's official maps of broadband availability are not a true measure of actual broadband speeds and availability, especially for rural communities.

This initiative has developed both data collection and analysis tools, as well as over 1,000 maps that document what capacity is available in different areas of Pennsylvania; how many service providers are operating in each geographic area; and how the services, as measured, differ from advertised claims. While the report includes baseline maps in the report's electronic appendices, these maps integrate multiple layers, and the project's online mapping portal (https://pa.broadbandtest.us) allows for comparisons of key metrics, enabling thousands of additional maps to be generated. As a part of the current analyses, the project team is also providing a discussion of a variety of policy options that have been used to better meet the broadband needs of local residents, providing policy makers with a set of options to improve the broadband availability in those areas where adequate broadband facilities and services do not yet exist.

This project documents that there are very few areas in Pennsylvania where the median speed (i.e., from at least 50% of the households running the NDT broadband speed test) meets the minimum criteria set by the FCC to qualify as "broadband connectivity." These results hold whether the research data is aggregated by county, state House district, or state Senate district. In addition, the research team found that areas where observed median speeds did meet the FCC's minimum definition of broadband connectivity were clustered around major metropolitan areas (especially Philadelphia and Pittsburgh), and that outside of a handful of urban cores, almost no areas of the state qualified as having median speeds that met the FCC's definition for broadband.

In addition, by running comparative analyses of historic speed test data (composed of an additional 15,121,002 broadband speed tests from Pennsylvania), the research team found that between 2014 and 2017 (the last year that the FCC released broadband speed information from Form 477), the self-reported availability of broadband speeds ISPs claimed were available increased dramatically -- to the extent that by December 2017, the FCC reported that 100% of Pennsylvania was covered by broadband connectivity speeds exceeding 25 Mbps. Yet NDT tests over this same period documented that ISP customer speeds did not increase commensurately.

The research team found that the latest NDT speed measurements more closely reflected the FCC's data in 2014 than they did in 2017 -- underscoring that the FCC's official maps appear to be becoming less accurate over time. The project team did not observe the same level of growing inaccuracy for urban areas. Therefore, it appears that systematic growing inaccuracies are directly affecting rural Pennsylvania. An initial review of national-level data underscore a phenomenon whereby this trend (of official maps becoming less accurate over the past half-decade) appears to hold across nearly every state in the country. These growing inaccuracies may be leading to a misinformed notion of progress in closing the digital divide, and an increasingly inaccurate overstatement of broadband availability in rural areas. One result may be the lowering of program eligibility for government funding to the very areas where service provision is lacking.

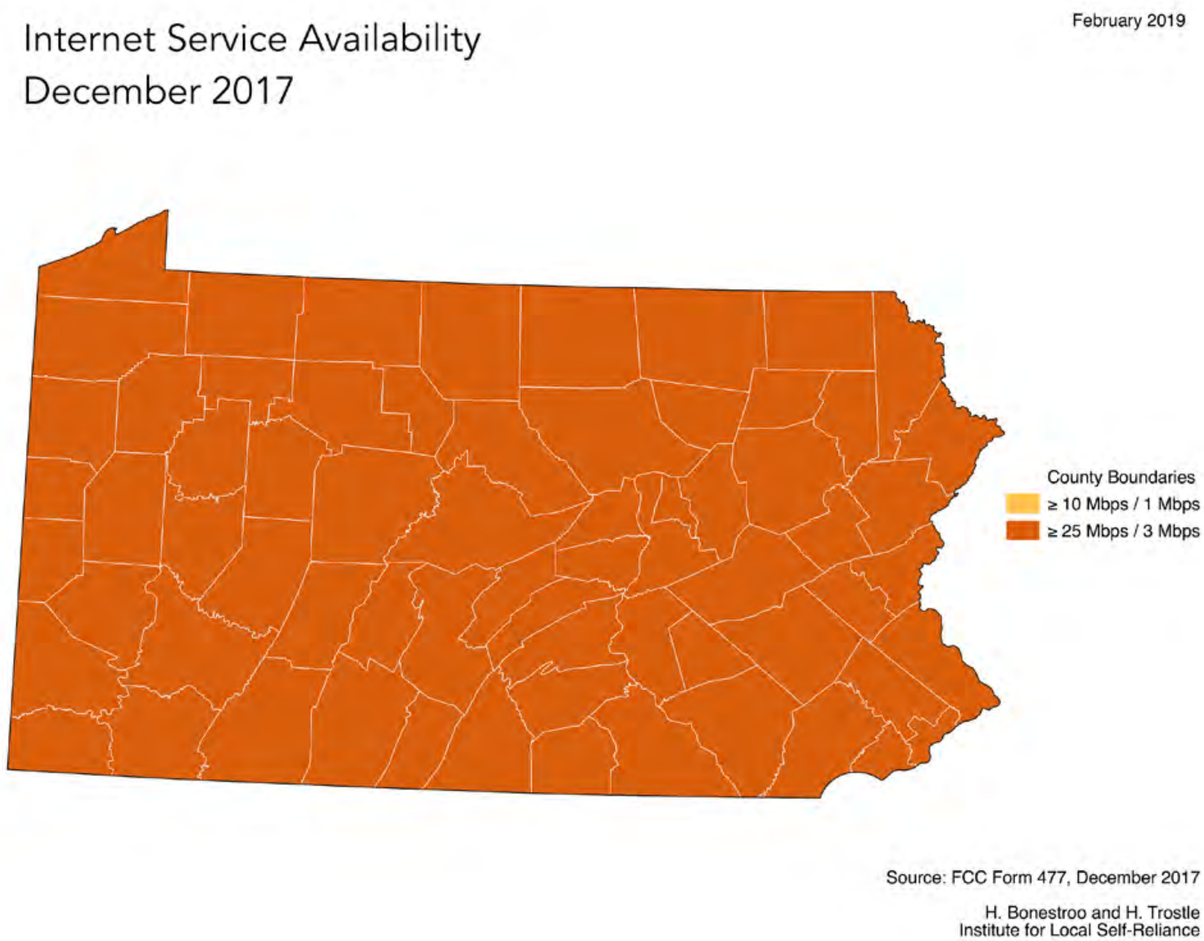

Figure 3 - The FCC's broadband map from December 2017 shows 25Mbps-speed broadband is available across 100% of counties in Pennsylvania.

Figure 4 - Measured NDT speed tests through 2018 - median speeds of 25Mbps-speed broadband were not available in any county in Pennsylvania.

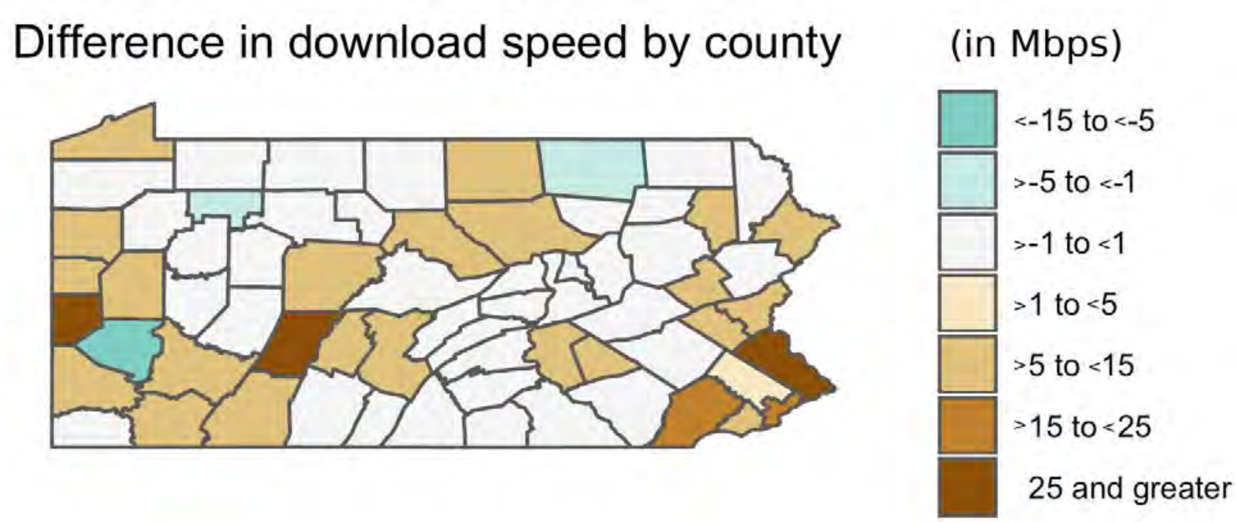

Figure 5 - Differences between the FCC map June 2017 data and the M-Lab 2018 map data by county (preliminary results). Many counties experience slower measured speed than the availability shown in the FCC's maps.

This research initiative delivers a systematic modeling and empirical documentation of broadband availability across rural Pennsylvania. The core set of deliverables are geospatial maps of advertised available broadband speeds self-reported by ISPs to the FCC and broadband speeds measured by ISP customers, collected via the M-Lab platform. These maps are meant to enable policy makers to gain a bird's-eye view of the current state of broadband across rural Pennsylvania and the state as a whole. By integrating data from multiple sources, the team has leveraged these data to create interactive, multi-layered, extensible GIS maps spanning a half-decade of data and containing millions of individual broadband speed tests. The research team has conducted assessments of different characteristics of current broadband service provision initiatives, with the goal of determining whether discrepancies exist between claimed and measured service availability, as well as whether claimed and measured speeds differ by geographic area. These exploratory analyses should help determine potential service provision concerns as well as areas where further data collection and research are necessary.

In addition to these quantitative assessments, the project team has also conducted qualitative research documenting both successful and unsuccessful initiatives that have aimed to foster increased broadband availability. These analyses specifically seek to identify commonalities across these projects to help determine best practices (and pitfalls to avoid) that help close the digital divide. Based upon these quantitative and qualitative results, recommendations for state and local policy makers on how to increase demand (thereby improving both economic and social/civic outcomes for residents of rural Pennsylvania), can be derived.

Finally, in keeping with the goal of developing a best-practice methodology, these outcomes are delivered via three major formats that may to help spur continuing research and maximum accessibility to the data and results:

A. Data collected during this research initiative is publicly available (with standard privacy safeguards) in open, online data repositories;
B. GIS analyses are made freely available via online maps in open and extensible (industry standard) formats; and,
C. The reports summarizing the research methodology, results, and recommendations are delivered to the Center for Rural Pennsylvania and made available under a Creative Commons license.

Overall, this research initiative aims to help forward the network research field, as a whole, by developing a transparent and repeatable process for documenting how available broadband speeds that are self-reported by ISPs, and broadband connectivity, as measured by ISP customers, differ; and how these two measures (and the discrepancies between the two) differ by various geographic regions (e.g., state House and Senate districts and counties).

Conclusions

This research project provides a considerable level of documentation and insight into the state of broadband connectivity experienced by rural residents across Pennsylvania. By using an open platform and methodology that is designed and peer-reviewed by the network science community and adopted by the FCC to document official broadband speeds for the United States, and by leveraging a vast, open archive of broadband data, this initiative has prototyped measurement and mapping best practices that are generalizable to any locale interested in researching and documenting the measured and advertised state of broadband connectivity, and the potential discrepancies between these two data sources.

As a part of this research initiative, the team has produced an open, replicable methodology in collaboration with experts in the field. The goal has been to help create a new “gold standard” for this type of research -- a methodology that can be generalized to other states and national efforts and represents a best practice for future efforts aimed at determining the extent of broadband access. This project has specifically explored the availability of 25/3 Mbps broadband across the state and provides options for government, and community and civic organizations that wish to help support universal broadband availability throughout the Commonwealth.

This report contains an in-depth explanation of the quantitative analyses and their implications for Pennsylvanian policy makers and government officials. The written report explains the methodologies used and contains links to primary sourcing for all data analyses and visualization tools. In addition, the electronic appendices to this report contain the most recent broadband mapping visualizations available at the time of writing and the https://pa.broadbandtest.us online portal provides companion resources for visualizing historic (and future) broadband data for Pennsylvania. The qualitative analyses contained in this report include case studies of how public, private, and public-private partnerships have increased broadband access and, where possible, illustrate how a diverse array of public, private, and public-private partnership efforts are being implemented, both across the country and within Pennsylvania.

These comparative case studies have been included with a final analysis of the research updated through the last quarter of a 14-month engagement, including updates to geospatial mapping, continued collection of broadband speed measurements collected by ISP customers, and analyses of discrepancies existing between these speeds and the FCC's reported broadband speeds. Finally, in keeping with the goal to maximize the accessibility of research results, the project team will continue to make itself available to present the research consortium's results to interested parties in Harrisburg, PA, and Washington, DC.

As the research makes clear, it appears that the divide between actual (speed test data) and advertised speeds (self-reported by ISPs via the FCC's Form 477) is far greater in rural areas of the state than in urban areas. Additionally, longitudinal data spanning multiple years show that the discrepancy between actual and advertised speeds has grown dramatically over the past half-decade for rural communities -- and, at a rate that far surpasses any discrepancies that have been found in more urban areas. The take-home message from these analyses is this: it appears that official broadband maps are becoming less accurate over time - particularly those for rural areas - and that the methodology used by the FCC not only overstates broadband speeds and availability, but are showing results that are less and less accurate year-after-year.

Looking forward, there would also be benefits to cross-referencing these analyses with data from the Connect America Fund[107], which illustrates where ISPs have accepted funds to deliver services of at least 10 Mbps downstream and 1 Mbps upstream by 2021. And, finally, now that the general magnitude of the problem has been documented via an in-depth exploratory analysis (spanning over 25 million tests collected over a half-decade), follow-up, in-depth work is recommended to take place in parallel with necessary interventions to address these broadband shortcomings. In particular, increasing the level of granularity of Pennsylvania's broadband maps and ensuring regular updating of these resources, would enable both more informed (and targeted) policy interventions, and ensure that more communities are eligible for earmarked support to help bridge existing digital divides.

107 Connect America Fund (CAF). (2017, May 17). Retrieved from https://www.fcc.gov/general/connect-america-fund-caf

Acknowledgment of Support

This project was made possible, in part, by a grant from the Center for Rural Pennsylvania, a legislative agency of the Pennsylvania General Assembly, and the support of generous core project partners:

ILSR - The **Institute for Local Self-Reliance** challenges concentrated economic and political power, and instead champions an approach in which ownership is broadly distributed, institutions are humanly scaled, and decision-making is accountable to communities. ILSR believes that democracy can thrive only when economic power is widely dispersed; communities are healthiest when they possess the authority, capacity, and responsibility to chart their own course. ILSR calls this vision local self-reliance. ILSR's Community Broadband Networks program fosters the creation of high-quality, locally accountable broadband networks. More information about how communities are investing in their own infrastructure to promote economic prosperity and improve quality of life is on ILSR's broadband page: https://ilsr.org/broadband.

X-Lab - The X-Lab is a future-focused think tank at Penn State University responding to the significant technology policy challenges facing society. X-Lab is composed of a consortium of technologists, developers, policy experts, innovators, business leaders, academics, entrepreneurs, researchers and futurists working to ensure that citizens don't need to choose between fundamental rights and equitable access to technological resources. X-Lab studies the implications of disruptive eventualities in sectors such as AI-driven manufacturing, telecommunications, consumer protections, privacy and civil liberty, and smart infrastructure. By

bringing together experts from across the technological, political and scientific spectrums, X-Lab empowers leaders with the expertise to make better-informed decisions.

OTI - The **Open Technology Institute** works at the intersection of technology and policy to ensure that every community has equitable access to digital technology and its benefits. OTI promotes universal access to communications technologies that are both open and secure, using a multidisciplinary approach that brings together advocates, researchers, organizers, and innovators. OTI's focus areas include surveillance, privacy and security, net neutrality, broadband access, and consumer privacy. OTI conducts data-driven research, develops policy and regulatory reforms, and builds real-world pilot projects to impact both public policy and physical communications infrastructure that people interact with every day. The Open Technology Institute supports free expression and open technologies at home and around the world, and is committed to supporting engaged, self-sufficient communities by promoting safe and affordable access to connectivity. Technology is not as an end in and of itself, but a means.

M-Lab - Measurement Lab is an open source project with contributors from civil society organizations, educational institutions, and private sector companies dedicated to:

1. Providing an open, verifiable measurement platform for global network performance;
2. Hosting the largest open Internet performance dataset on the planet; and,
3. Creating visualizations and tools to help people make sense of Internet performance.

M-Lab aims to advance Internet research by empowering consumers with useful information about their Internet performance. By providing free, open Internet measurement data, researchers, regulators, advocacy groups, and the general public can get a better sense of how the Internet is working for them, and how to maintain and improve it for the future. Real science requires verifiable processes, and M-Lab welcomes scientific collaboration and scrutiny. This is why all of the data collected by M-Lab's global measurement platform is openly available, and all of the measurement tools hosted by M-Lab are open source. Anyone with the time and skill can review and improve the underlying methodologies and assumptions on which M-Lab's platform, tools, and data rely. Transparency and review are key to good science, and good science is key to good measurement. M-Lab assists scientific research by providing widely distributed servers and ample connectivity for researchers' use. Each researcher-developed test uses allocated dedicated resources on the M-Lab platform to facilitate accurate measurements. Server-side tools are openly licensed and operated, allowing third parties to develop their own client-side measurement software.

Appendices

Appendix A: Tables of FCC Form 477 Broadband Coverage Data (2014-2017)

(All Technologies) Pennsylvanians with access to 25 Mbps / 3 Mbps: FCC Form 477 Data

	Total	Urban	Rural
December 2017	100.0%	100.0%	100.0%
December 2016	98.9%	99.9%	95.5%
December 2015	93.5%	97.4%	79.0%
December 2014	93.6%	97.3%	79.9%

(Excluding Satellite) Pennsylvanians with access to 25 Mbps / 3 Mbps: FCC Form 477 Data

	Total	Urban	Rural
December 2017	100.0%	100.0%	100.0%
December 2016	94.9%	98.2%	82.9%
December 2015	93.5%	97.4%	79.0%
December 2014	93.6%	97.3%	79.9%

(Wireline) Pennsylvanians with access to 25 Mbps / 3 Mbps: FCC Form 477 Data

	Total	Urban	Rural
December 2017	100.0%	100.0%	100.0%
December 2016	94.9%	98.1%	82.7%
December 2015	93.4%	97.3%	78.9%
December 2014	93.6%	97.3%	79.9%

Appendix B: FCC Form 477 Data Maps (2014-2016)

The FCC's official maps of broadband availability across the state of Pennsylvania shows a remarkable expansion of connectivity that does not appear to correspond with speed tests run from rural households during this same period. Key maps are included below.

December 2016

Including Satellite

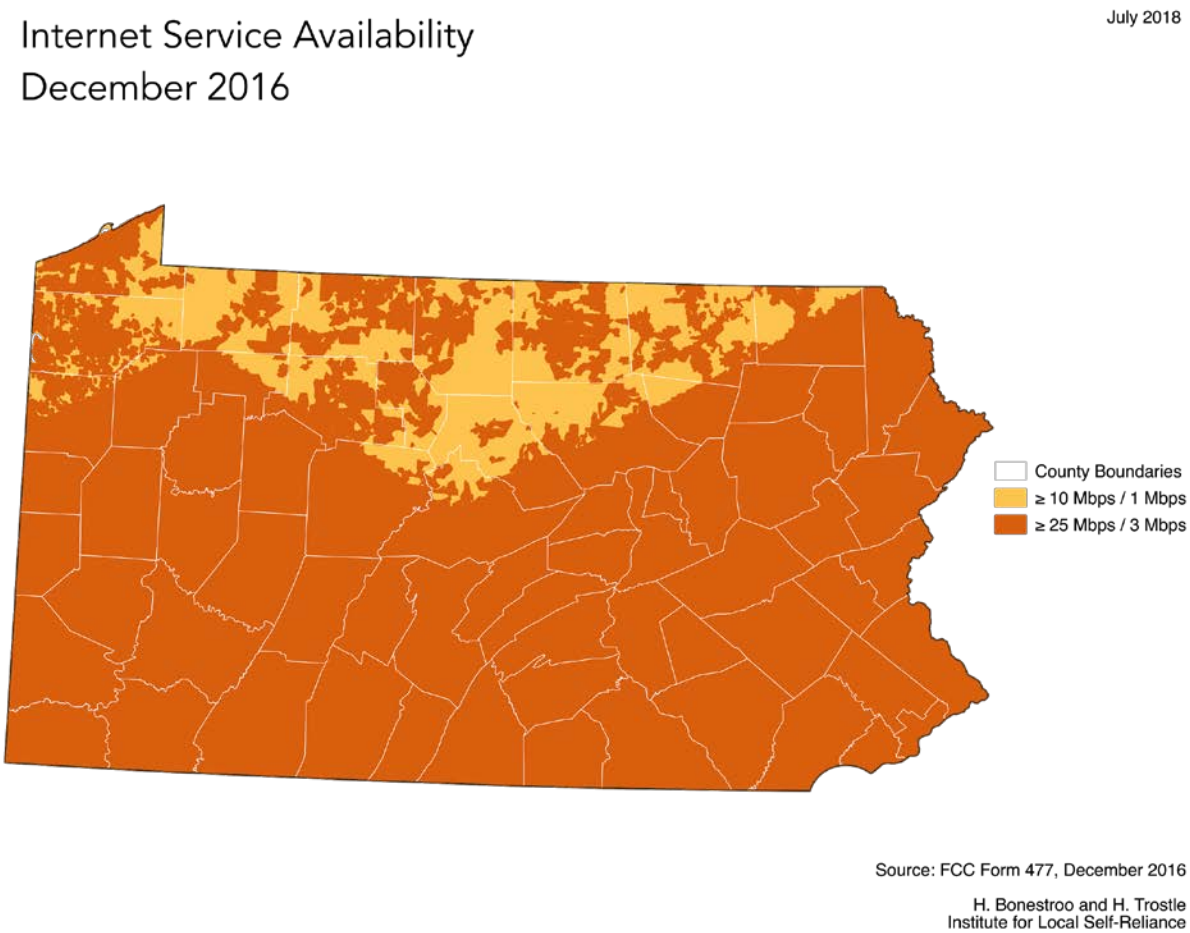

Figure 6. FCC Form 477: Broadband service availability in Pennsylvania (including satellite connections), December 2016.

By Technology Type

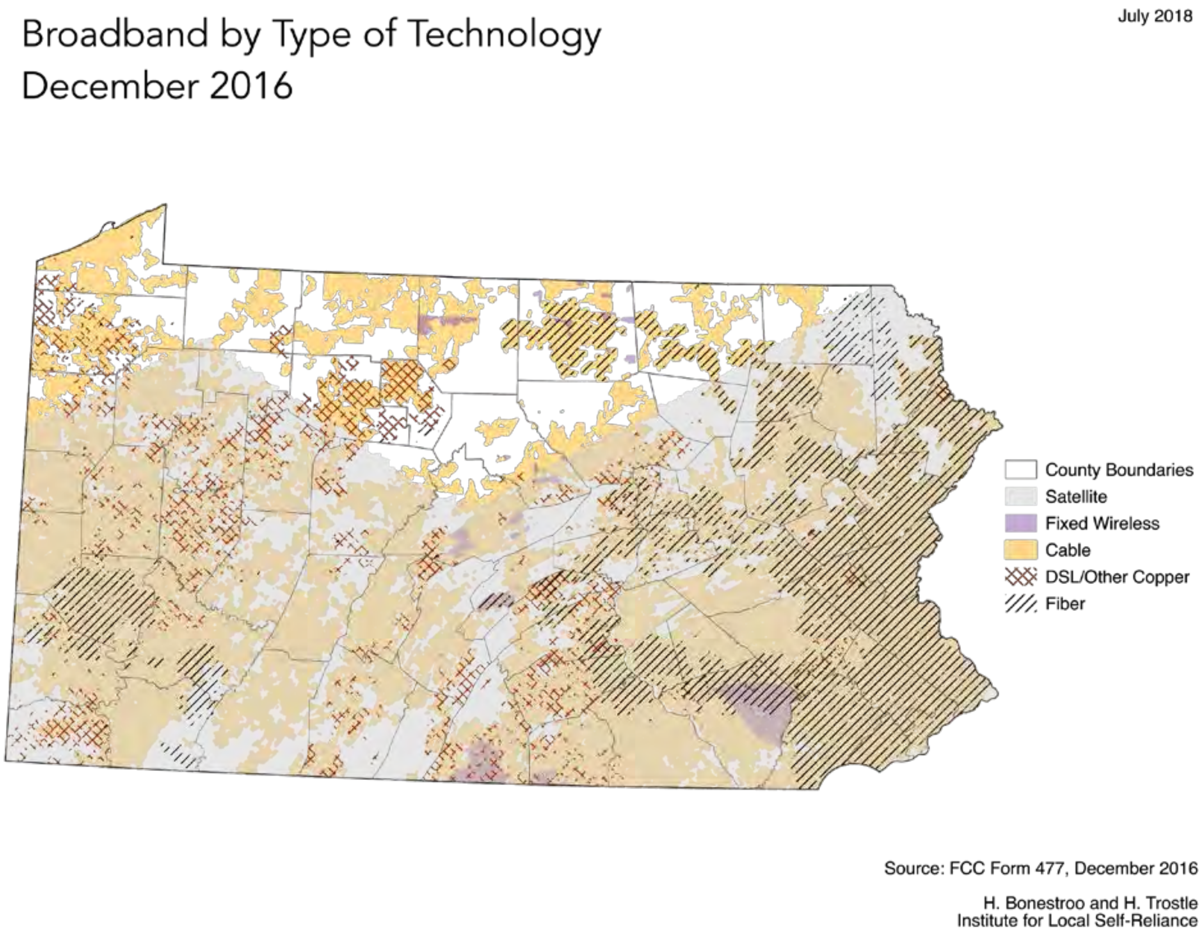

Figure 7. FCC Form 477: Broadband service availability in Pennsylvania by technology type, December 2016.

June 2016

Including Satellite

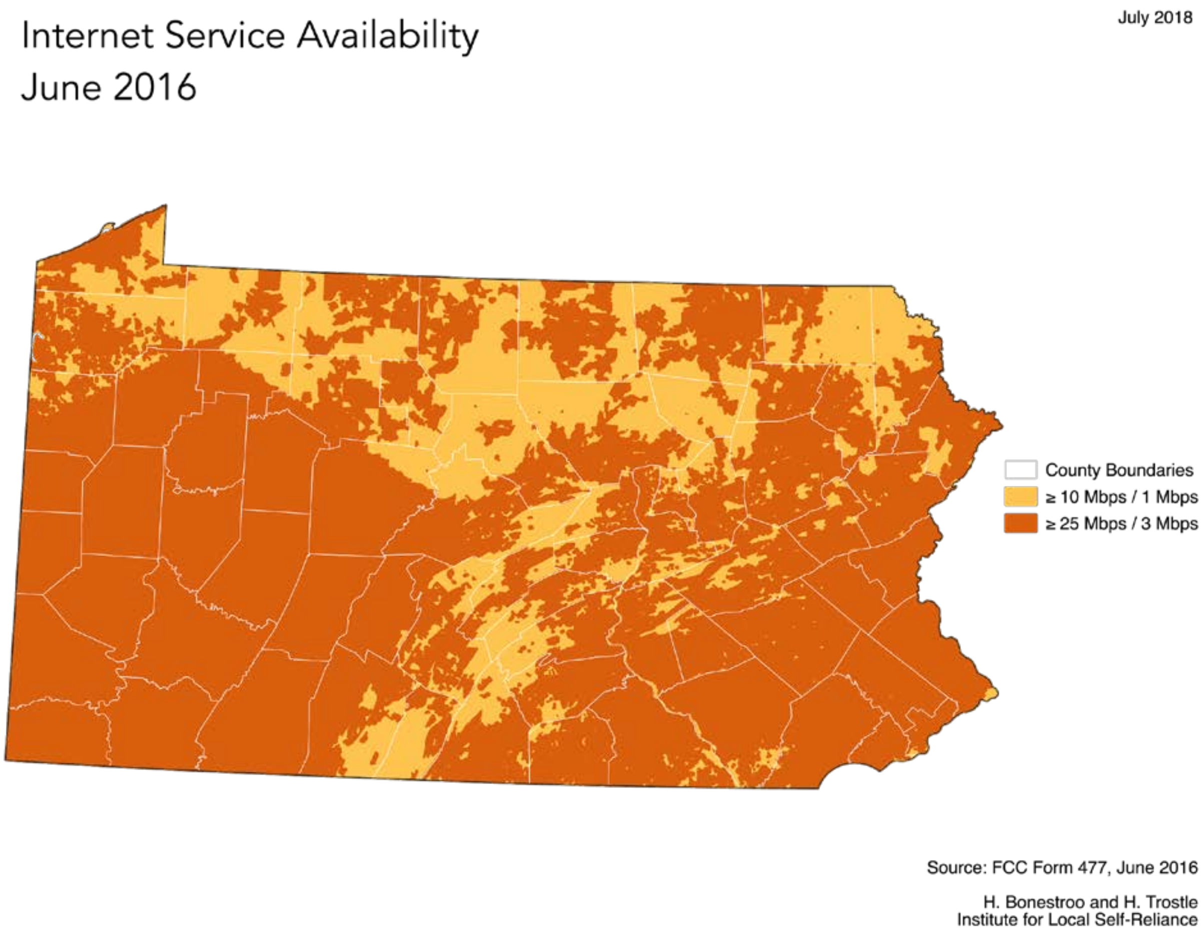

Figure 8. FCC Form 477: Broadband service availability in Pennsylvania (including satellite connections), June 2016.

By Technology Type

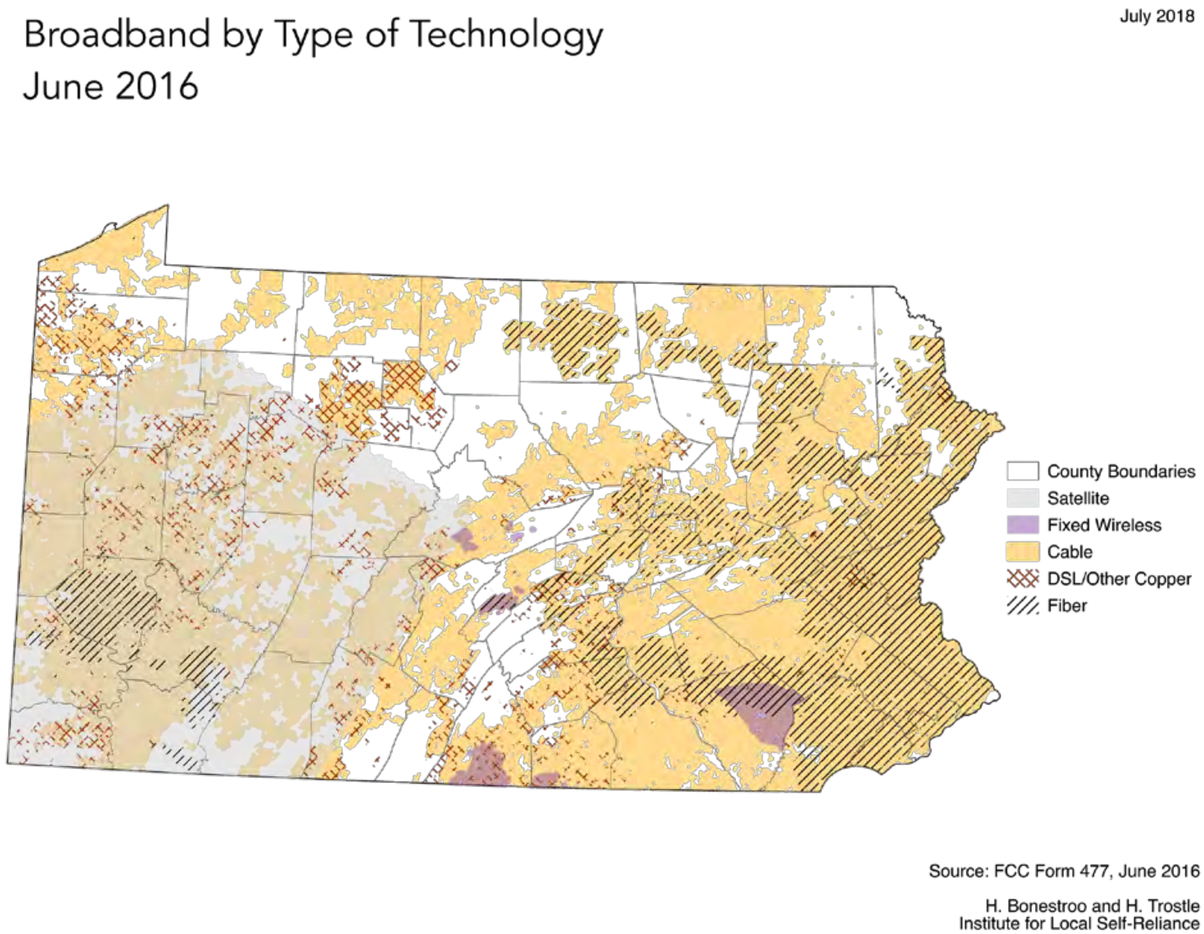

Figure 9. FCC Form 477: Broadband service availability in Pennsylvania by technology type, June 2016.

December 2015

Including Satellite

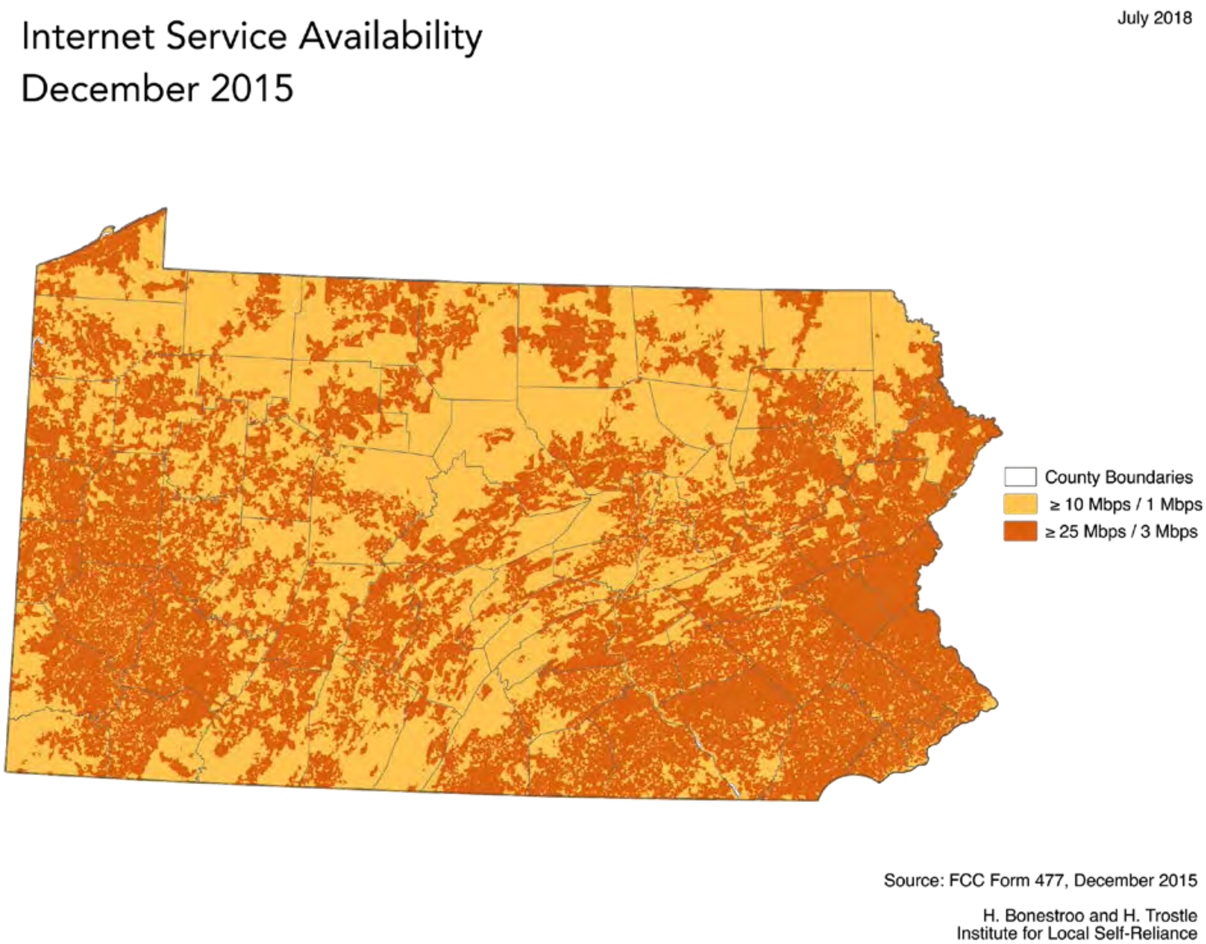

Figure 10. FCC Form 477: Broadband service availability in Pennsylvania (including satellite connections), December 2015.

Excluding Satellite

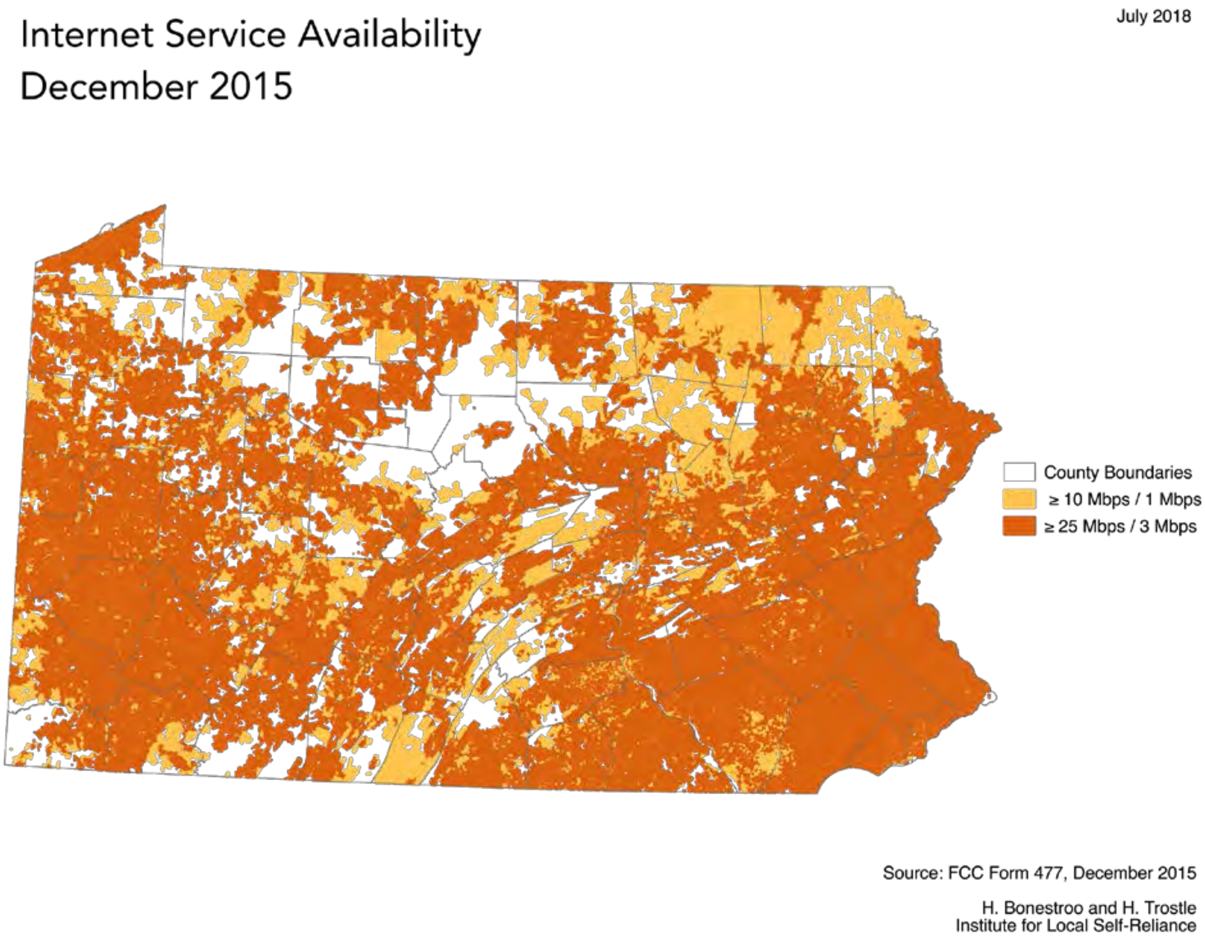

Figure 11. FCC Form 477: Broadband service availability in Pennsylvania (excluding satellite connections), December 2015.

By Technology Type

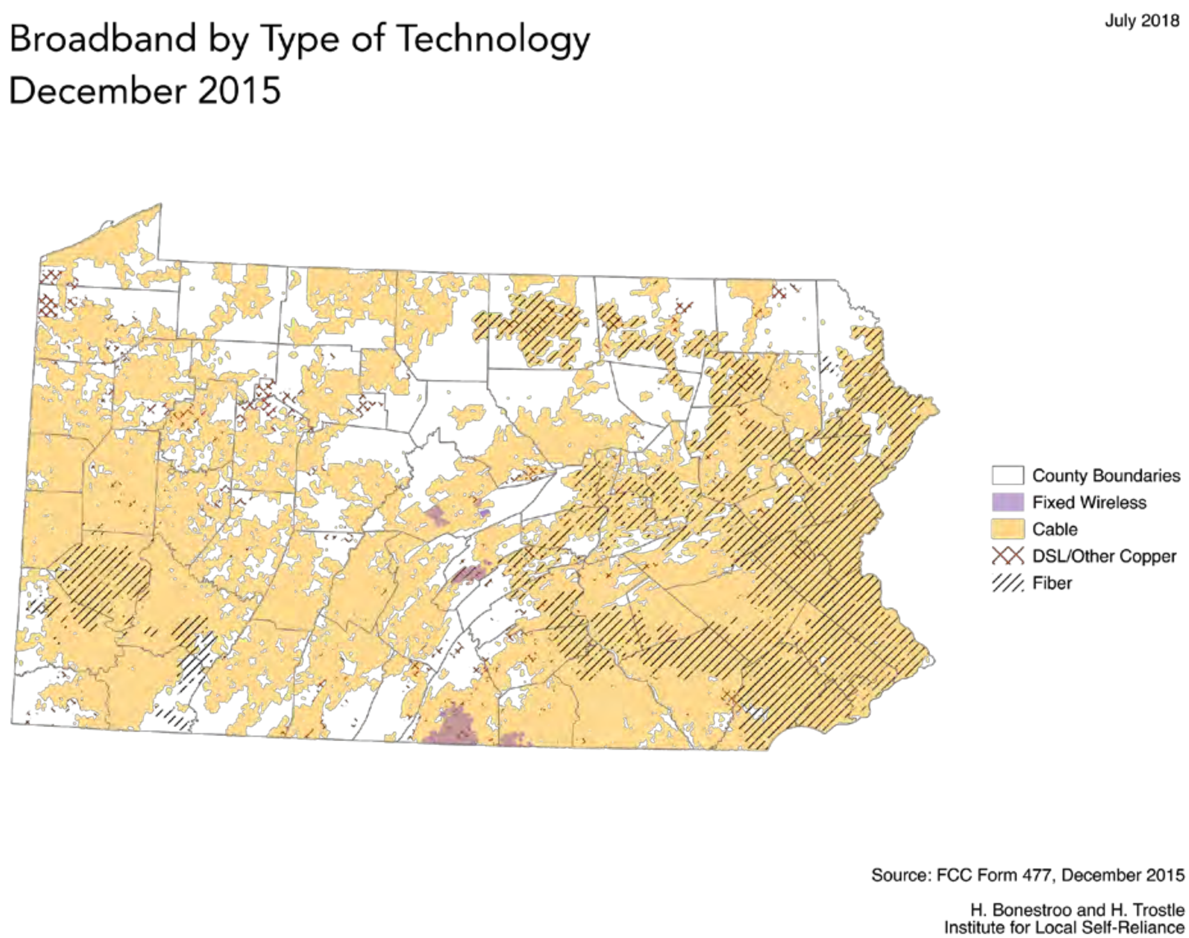

Figure 12. FCC Form 477: Broadband service availability in Pennsylvania by technology type, December 2015.

June 2015

Including Satellite

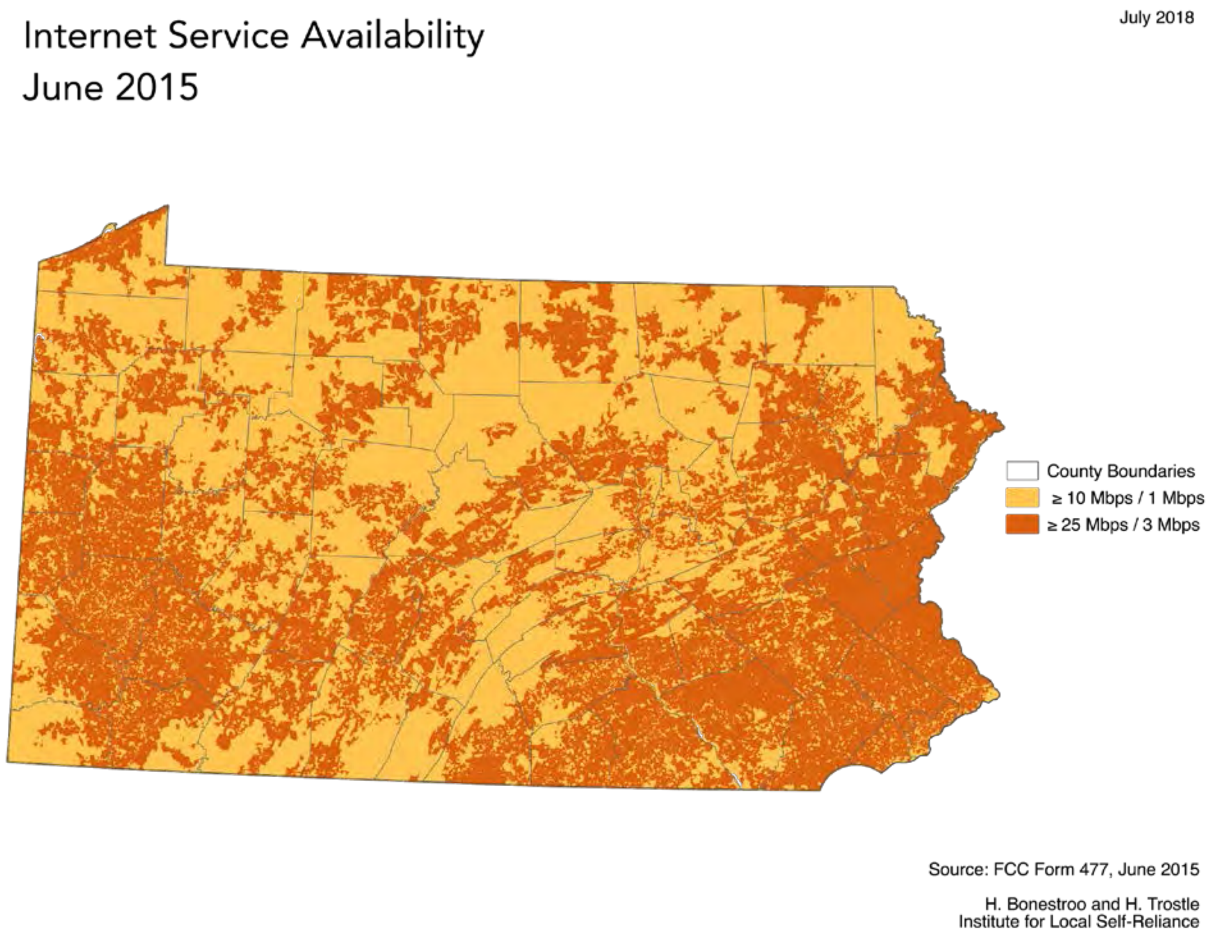

Figure 13. FCC Form 477: Broadband service availability in Pennsylvania (including satellite connections), June 2015.

Excluding Satellite

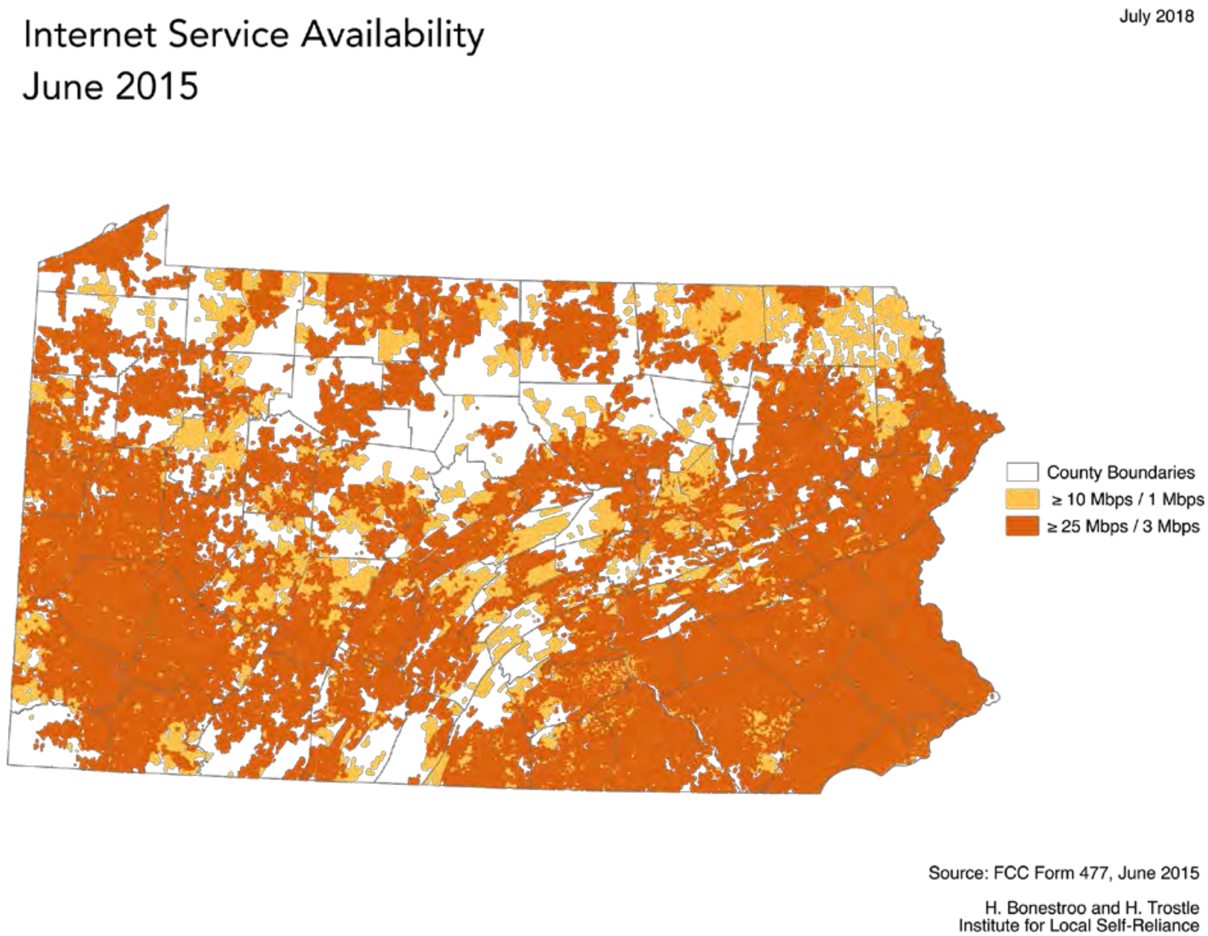

Figure 14. FCC Form 477: Broadband service availability in Pennsylvania (excluding satellite connections), June 2015.

By Technology Type

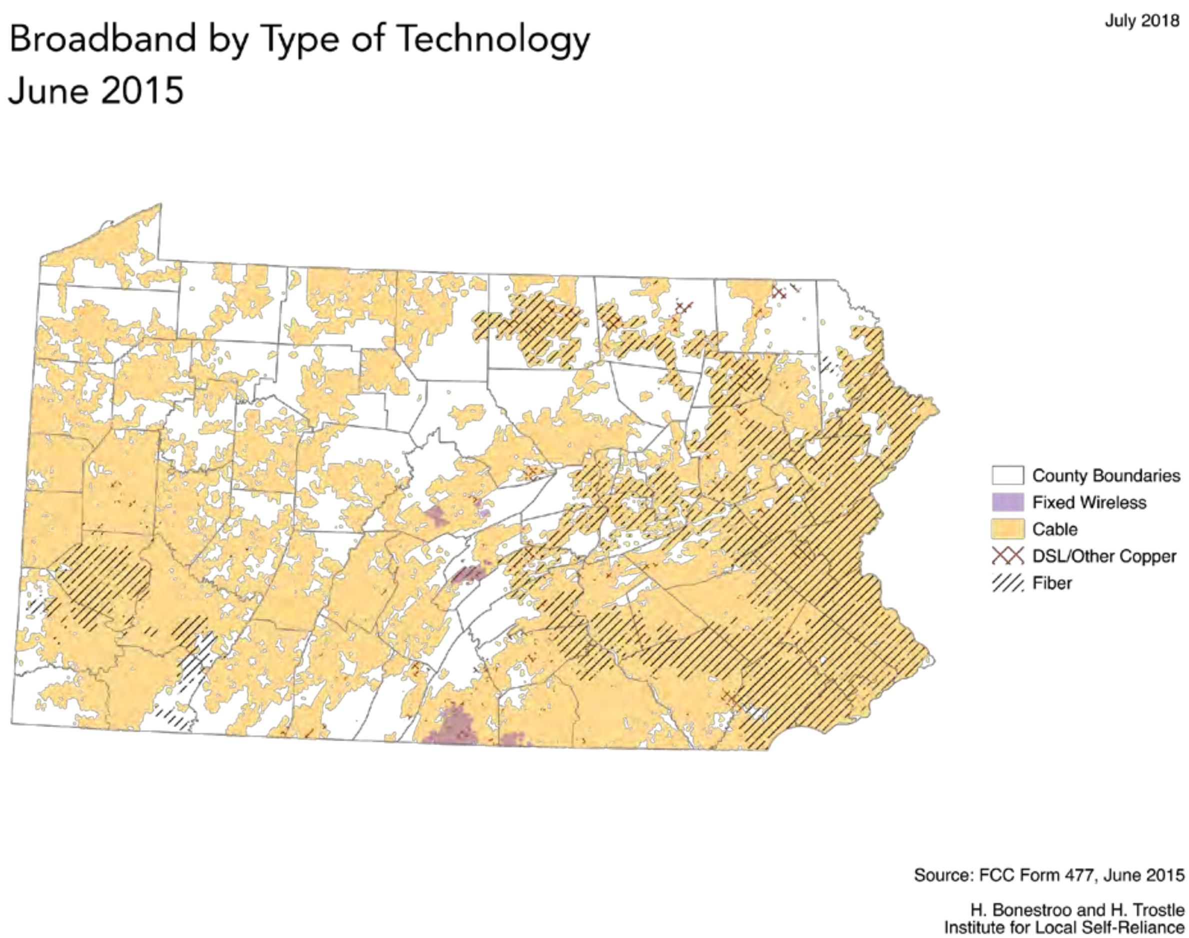

Figure 15. FCC Form 477: Broadband service availability in Pennsylvania by technology type, June 2015.

December 2014

Including Satellite

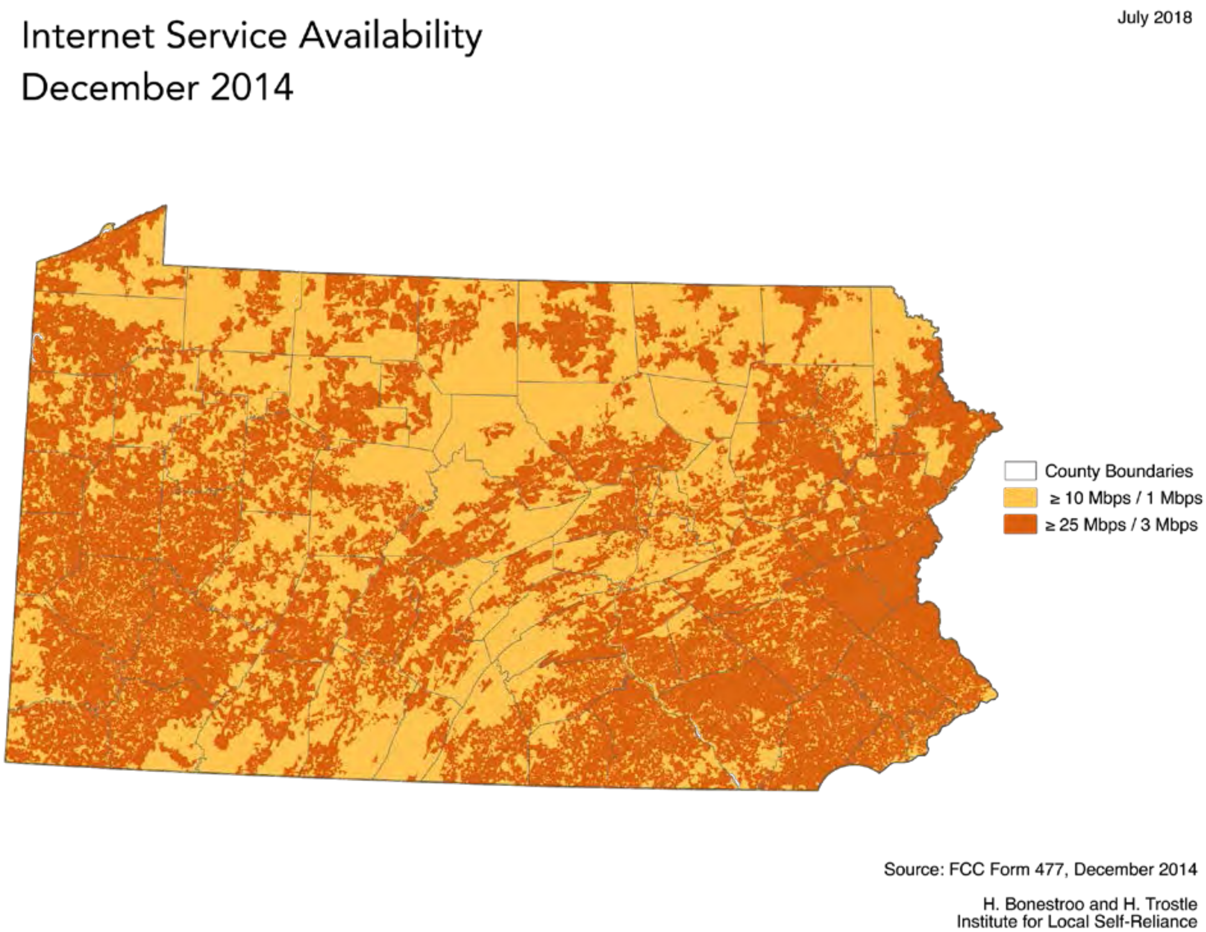

Figure 16. FCC Form 477: Broadband service availability in Pennsylvania (including satellite connections), December 2014.

Excluding Satellite

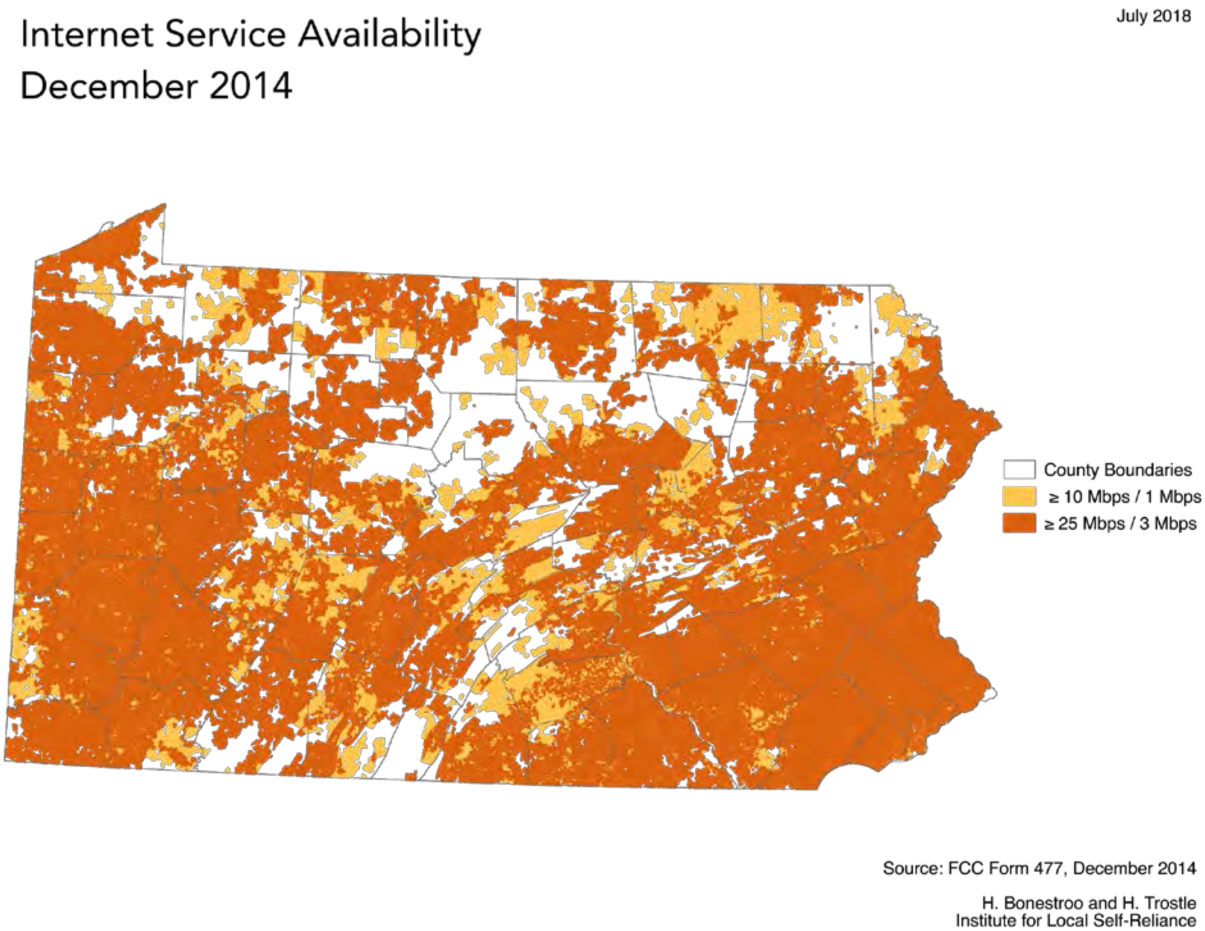

Figure 17. FCC Form 477: Broadband service availability in Pennsylvania (excluding satellite connections), December 2014.

By Technology Type

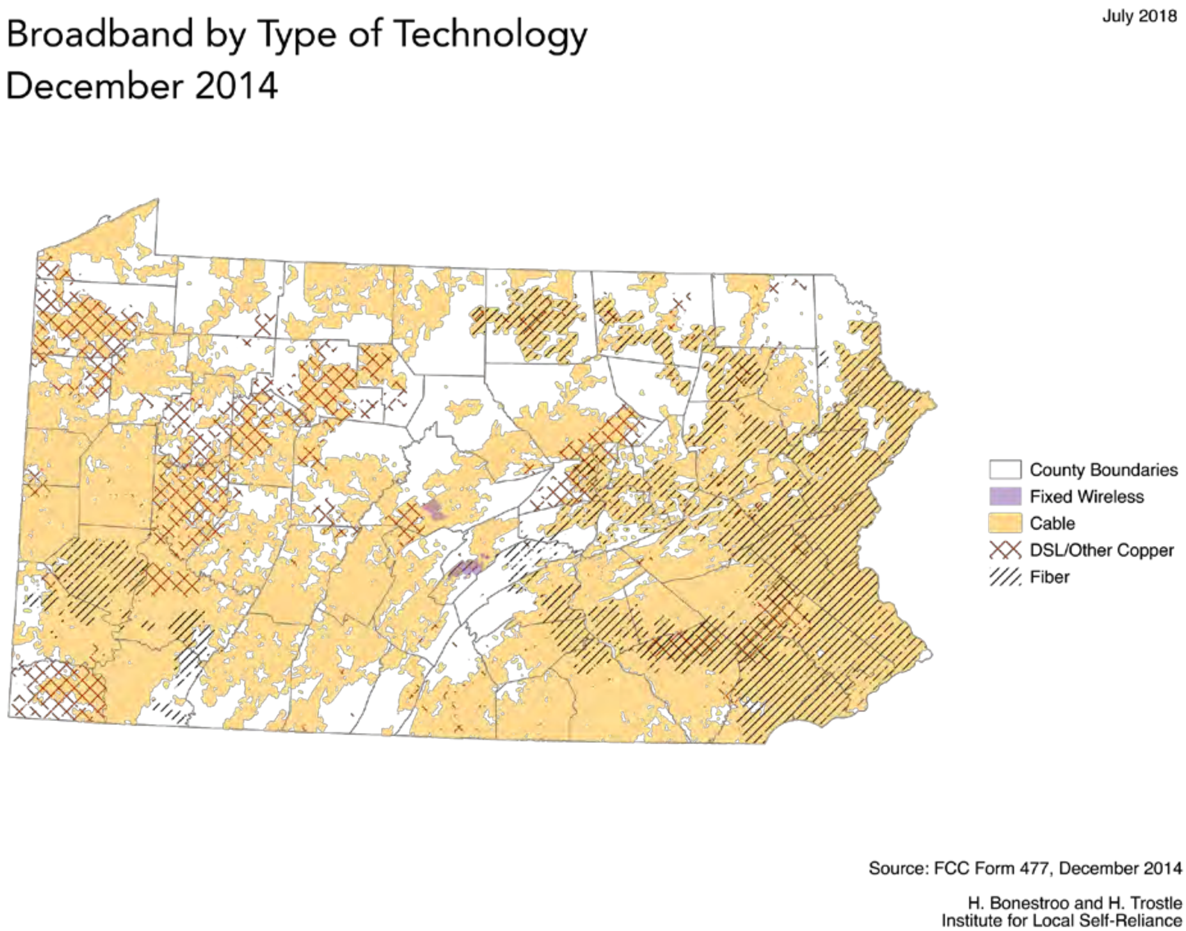

Figure 18. FCC Form 477: Broadband service availability in Pennsylvania by technology type, December 2014.

Appendix C: Select Additional Literature

There is a growing array of supporting documentation and related research documenting the importance and impact of broadband connectivity and the need for comprehensive mapping of fixed broadband service provision as an aid for informed policy-making. A selection of relevant work, its focus, and links to both primary sourcing and online portals where additional, related work is available are presented below. Here is a brief summary of some of the differences between Internet service technologies and the effects that access - or lack thereof - can have on a region:

Impact of Municipal Networks on Economic Development

This article from the Muni Wireless group includes useful statistics and numbers around the economic benefits that can be witnessed with increased broadband connectivity:

> "When municipalities choose to deploy fiber networks, they introduce Internet services into the community that are not only significantly faster than DSL and cable, but more reliable. With more reliable fiber connections, businesses and individuals are far less likely to experience temporary blackouts that can halt productivity in vexing and expensive ways. And because these networks are locally-owned and operated, business owners do not have to spend hours on the phone with an absentee Internet Service Provider like AT&T in the (albeit unlikely) event of a problem."
>
> *Municipal Networks and Economic Development. (n.d.). Retrieved from: https://muninetworks.org/content/municipal-networks-and-economic-development*

Prospects for Poor Neighborhoods in the Broadband Era: Neighborhood-Level Influences on Technology Use at Work

This article documents concomitant skills that suffer and negative behavioral outcomes due to digital exclusion; in particular, how online engagement (or lack thereof) reverberates across a number of different social and economic domains.

> "Through a survey with a representative sample of Dutch Internet users, this article examines compound digital exclusion: whether a person who lacks a particular digital skill also lacks another kind of skill, whether a person who does not engage in a particular way online is also less likely to engage in other ways, and whether a person who does not achieve a certain outcome online is also less likely to achieve another type

of outcome. We also tested sequential digital exclusion: whether a lower level of digital skills leads to lower levels of engagement with the Internet, resulting in a lower likelihood for an individual to achieve tangible outcomes. Both types of digital exclusion are a reality. Certain use can have a strong relation with an outcome in a different domain. Furthermore, those who achieve outcomes in one domain do not necessarily achieve outcomes in another domain. To get a comprehensive picture of the nature of digital exclusion, it is necessary to account for different domains in research."

Kaplan, D., & Mossberger, K. (2012). Prospects for poor neighborhoods in the broadband era: Neighborhood-level influences on technology use at work. Economic Development Quarterly, 26(1), 95-105. Retrieved from: https://journals.sagepub.com/doi/full/10.1177/0891242411431450

Evaluating the Impact of Broadband Inclusion Efforts

The Open Technology Institute's paper on assessing success of efforts aimed at closing the broadband adoption gap contains useful information about methodologies that can be leveraged to apply measurable goals and key performance indicators to such efforts:

"From 2014-2015, the Open Technology Institute partnered with the digital inclusion organization EveryoneOn to develop an assessment framework and a set of evaluation tools to understand the program's impact and success. EveryoneOn is a digital access platform created to target gaps in broadband adoption through partnerships with Internet Service Providers (ISPs), community organizations, and nonprofits. It emerged from the Federal Communications Commission's (FCC) 2011 Connect2Compete (C2C) initiative, which was designed to help close the broadband adoption gap by leveraging in-kind commitments from cable companies, technology industry representatives, and nonprofits. In 2013, C2C partnered with the Ad Council to promote the importance of digital literacy skills and motivate individuals to access free resources and trainings offered by partners. The new campaign expanded the public-private partnership model to include more ISPs. With its expanded platform, EveryoneOn was officially designated as a 501(c)(3) organization in 2014. Its activities are designed "to help all Americans access technology through free digital literacy training, discounted high-speed Internet, and low-cost and refurbished computers."

Bullen, G., & Byrum, G. (2016, February 9). OTI and EveryoneOn. Retrieved from: https://static.newamerica.org/attachments/12529--456/OTI_and_Everyoneon_final.67e1aa379c61449493b92261826fe771.pdf

Survey of Internet performance measurement platforms and related standardization efforts

The IEEE (Institute of Electrical and Electronics Engineers) runs through a list of various methods used to measure internet performance and provides a high-level explanation of how measurement platforms work:

> “A number of Internet measurement platforms have emerged in the last few years. These platforms have deployed thousands of probes at strategic locations within access and backbone networks and behind residential gateways. In this paper, there is a taxonomy of these measurement platforms on the basis of their deployment use-case. These platforms are described in detail by exploring their coverage, scale, lifetime, deployed metrics and measurement tools, architecture and overall research impact. The survey is concluded by describing current standardization efforts to make large-scale performance measurement platforms interoperable.”
>
> *Bajpai, V., & Schönwälder, J. (2015). A survey on internet performance measurement platforms and related standardization efforts. IEEE Communications Surveys & Tutorials, 17(3), 1313-1341. Retrieved from: https://ieeexplore.ieee.org/abstract/document/7076582/*

Measurement Lab: overview and an invitation to the research community

The *ACM SIGCOMM Computer Communication Review* runs through an overview of M-Lab and makes plain its relationship with other organizations and researchers:

> “Measurement Lab (M-Lab) is an open, distributed server platform for researchers to deploy active Internet measurement tools. The goal of M-Lab is to advance network research and empower the public with useful information about their broadband connections. By enhancing Internet transparency, M-Lab helps sustain a healthy, innovative Internet. This article describes M-Lab's objectives, administrative organization, software and hardware infrastructure. It also provides an overview of the currently available measurement tools and datasets, and invites the broader networking research community to participate in the project.”
>
> *Dovrolis, C., Gummadi, K., Kuzmanovic, A., & Meinrath, S. D. (2010). Measurement lab: Overview and an invitation to the research community. ACM SIGCOMM Computer Communication Review, 40(3), 53-56. Retrieved from: https://dl.acm.org/citation.cfm?id=1823853*

The digital reality: e-government and access to technology and internet for American Indian and Alaska Native populations

An insightful examination of the realities of access to technology and Internet services for tribal governments. Many of the same challenges, solutions and principles can be transposed onto a rural reality:

> "Information and communications technologies are powerful resources and tools for tribal governments to engage with their constituents, deliver services, conduct efficient and transparent administration, interact with other governments, and carry out policies. Digital government may in many ways be even more critical for tribes than for many other governments. As sovereign nations, tribal governments are engaged in complex relationships with other governments: local, state and federal governments. They are frequently in geographically isolated locations, with often-dispersed populations. The capacity to bridge distance can convey benefits for service delivery and civic engagement, and can connect communities with resources for health, economic development, and education. In this paper, we review research on Native American technology use and the limitations of available data. Because of the contrast between residents of urban areas and tribal lands, we examine differences in cell phone, computer and Internet use for metropolitan and nonmetropolitan Native populations, by education and income. We propose a research agenda using this data, to support action to remedy disparities and to harness the potential of technology for tribal governments."
>
> *Parkhurst, N. D., Morris, T., Tahy, E., & Mossberger, K. (2015, May). The digital reality: e-government and access to technology and internet for American Indian and Alaska Native populations. In Proceedings of the 16th Annual International Conference on Digital Government Research (pp. 217-229). ACM. Retrieved from: https://dl.acm.org/citation.cfm?id=2757424*

Visualizing Internet-Measurements Data for Research Purposes: the NeuViz Data Visualization Tool

This is a comprehensive overview of a tool used to identify networks where certain protocols seemed to be discriminated against, and provides a technical explanation of the technology being used.

> "In this paper we present NeuViz, a data processing and visualization architecture for network measurement experiments. NeuViz has been tailored to work on the data produced by Neubot (Net Neutrality Bot), an Internet bot that performs periodic, active network performance tests. We show that NeuViz is an effective tool to navigate Neubot data to identify cases (to be investigated with more specific network tests) in which a protocol seems discriminated. Also, we suggest how the information provided by the NeuViz Web API can help to automatically detect cases in which a protocol seems discriminated, to raise warnings or trigger more specific tests."

Futia, G., Zimuel, E., Basso, S., & De Martin, J. C. (2019). Visualizing Internet-Measurements Data for Research Purposes: the NeuViz Data Visualization Tool. Retrieved from: https://iris.polito.it/bitstream/11583/2516321/1/paper.pdf

Monitoring network neutrality: A survey on traffic differentiation detection

The following is a higher-level look on methods used to verify and inspect traffic for net neutrality purposes.

> "Network neutrality is becoming increasingly important as the global debate intensifies and governments worldwide implement and withdraw regulations. According to this principle, all Internet traffic must be processed without differentiation, regardless of origin, destination, and/or content. Neutrality supporters claim that traffic differentiation can compromise innovation, fair competition, and freedom of choice. However, detecting that an Internet Service Provider (ISP) is not employing traffic differentiation practices is still a challenge. This paper presents a survey of strategies and tools for detecting traffic differentiation on the Internet. After presenting basic neutrality definitions as well as an overview of the worldwide debate, we describe ways that can be used by an ISP to implement traffic differentiation, and define the problem of differentiation detection. This is followed by a description of multiple existing strategies and tools. These solutions differ mainly on how they execute network measurements, the metrics employed, traffic generation techniques, and statistical methods. We also present a taxonomy for the different types of traffic differentiation and the different types of detection. Finally, we identify open challenges and future research directions."

Garrett, T., Setenareski, L. E., Peres, L. M., Bona, L. C., & Duarte, E. P. (2018). Monitoring network neutrality: A survey on traffic differentiation detection. IEEE Communications Surveys & Tutorials, 20(3), 2486-2517. Retrieved from: https://iris.polito.it/bitstream/11583/2516321/1/paper.pdf

The Compoundness and Sequentiality of Digital Inequality

This work discusses the interplay between Internet use and beneficial outcomes (for both individuals and their communities). Using advanced statistical analyses, the authors investigate which specific community factors account for higher and lower Internet use.

> "This research explores the role of place in Internet use at work, investigating the role that neighborhood context may play in opportunities to gain technology skills and access to relatively better paying jobs. Examining both individual and neighborhood attributes, the authors carry out a comprehensive survey of individuals within three distinct cities in Northeast Ohio combined with a methodology that allows generation of location-specific contextual information.Together, these data are modeled in a series of logistic regressions that compare the importance of both individual and contextual

attributes. The findings demonstrate that individual characteristics, especially job type, education, and income, are strongly related to workplace Internet use and that neighborhood unemployment is associated with lower probabilities of technology use at work."

Van Deursen, A. J., Helsper, E., Eynon, R., & Van Dijk, J. A. (2017). The compoundness and sequentiality of digital inequality. International Journal of Communication, 11, 452-473. Retrieved from: https://ijoc.org/index.php/ijoc/article/view/5739/1911

Estimating Residential Broadband Capacity using Big Data from M-Lab

Close in line with the methods used to measure broadband speeds across rural Pennsylvania, the following paper runs through the steps used to build a useful map of broadband speeds within a geographical region:

"Knowing residential broadband capacity profiles across a population is of interest to both consumers and regulators who want to compare or audit performance of various broadband service offerings. Unfortunately, extracting broadband capacity from speed tests in public datasets like M-Lab is challenging because tests are indexed by client IP address which can be dynamic and/or obfuscated by NAT, and variable network conditions can affect measurements. This paper presents the first systematic effort to isolate households and extract their broadband capacity using 63 million speed test measurements recorded over a 12-month period in the M-Lab dataset. We first identify a key parameter, the correlation between measured speed and congestion count for a specific client IP address, as an indicator of whether the IP address represents a single house, or a plurality of houses that may be dynamically sharing addresses or be aggregated behind a NAT. We then validate approach by comparing to ground truth taken from a few known houses, and at larger scale by checking internal consistency across ISPs and across months. Lastly, we present results that isolate households and estimate their broadband capacity based on measured data, and additionally reveal insights into the prevalence of NAT and variations in service capacity tiers across ISPs."

Deng, X., Feng, Y., Gharakheili, H. H., & Sivaraman, V. (2019). Estimating Residential Broadband Capacity using Big Data from M-Lab. arXiv preprint arXiv:1901.07059. Retrieved from: https://arxiv.org/abs/1901.07059

Internet Topology Mining: from Big Data to Network Science

This dissertation includes several techniques used to turn massive datasets - including broadband speed measurements tests - into a useful outline of the Internet's topology:

"Data has become one of the most valuable resources in today's world where we have greater digital presence. Large volumes of data are generated through various platforms including web, social networks, mobile devices, scientific instruments, infrastructure sensors, and many other IoT devices. A challenge for researchers is to mine valuable relevant information from big data efficiently and in a timely manner. Internet is the largest man-made complex system whose underlying network has not been characterized precisely. Internet topology is shaped by tens of thousands of network providers optimizing local communication efficiency without a central authority. Numerous methods and platforms have been developed to accurately measure and analyze the Internet topology data. In this dissertation, we perform a comprehensive analysis of existing Internet topology data sets, develop and deploy our measurement platform to obtain detailed topologies of Autonomous System (AS) networks, and analyze collected data to understand path stability and topological characteristics of backbone networks. Our results indicate that the use of multiple data sets from different vantage points is important for building a comprehensive picture of the Internet topology as each data set provides a unique contribution into visibility of a network. Analyzing earlier measurement data sets, we implement an Internet topology mapping and analysis system that collects detailed measurements from a set of measurement nodes on top of the large-scale topology data shared in public repositories. Our design intelligently uses the big data collection and processing approaches for mapping the Internet's underlying topology in order to better understand network characteristics and discovers more than thirteen times links then all other data repositories combined. Analyzing collected network data, we observe that most of these networks have star-like topologies where high degree hubs connect low degree routers but tier-1 ASes often have a power-law degree distribution in a small-world network topology; there are persistent routing anomalies and loops in the end-to-end communication over the Internet; and network paths within individual ASes are mostly non-shortest paths indicating load distribution by the Internet Service Providers (ISP)."

Canbaz, M. A. (2018). Internet Topology Mining: from Big Data to Network Science (Doctoral dissertation). Retrieved from: https://scholarworks.unr.edu/handle/11714/4537

Strategic choice and broadband divergence in the transition to next generation networks: Evidence from Canada and the US

This paper investigates, among other topics, operator incentives to increase fixed broadband speeds and invest in fiber-to-the-premises (FTTP) technologies, documents the growing divergence between broadband capacity and the service quality that operators deliver:

"This article investigates how infrastructure competition among broadband network infrastructure operators in Canada and the U.S. has influenced their incentives to increase fixed broadband connection speeds and invest in next generation fiber-to-the-premises (FTTP) technologies. The evolution of measured broadband speeds since the late 2000s documents growing differences in the incentives of dominant broadband operators to respond to demand for higher speed connectivity by increasing connectivity speeds they deliver to their customers. Dominant network operators in Canada have shown relatively stronger incentives than their counterparts in the U.S. to invest in and increase the capacity of legacy platforms. In the U.S. FTTP deployment incentives have been somewhat stronger, but network operators have been more reluctant to upgrade legacy technologies to deliver higher speeds. Diversity of strategic choices by large operators helps explain increasing regional and local broadband infrastructure gaps within the two countries. A high dividend payout financial strategy and increasing vertical integration appear to enhance the potential for overinvestment and inefficient duplication in legacy platforms by competing infrastructure providers."

Rajabiun, R., & Middleton, C. (2018). Strategic choice and broadband divergence in the transition to next generation networks: Evidence from Canada and the US. Telecommunications Policy, 42(1), 37-50. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0308596117301143

Collaborative Connections: Designing Library Services for the Urban Poor

In line with the key opportunities in bringing increased broadband speeds to rural areas, disenfranchised urban areas are also faced with many of the same challenges as outlined in this journal:

"Urban public libraries have implemented many changes in response to modern information technology. Although these changes have met the needs of many users, some users have been disenfranchised, particularly those who prefer to interact with information orally. This article reports findings from the Oral Present, a 3-year research project focusing on one such group, the urban poor. This project employed a participant-action method that involved interviews, observations, surveys, and a focus group with various stakeholders. The findings center around how libraries are meeting the information needs of the urban poor and how such services can be better designed and evaluated. These findings cohere as "collaborative connections," a model for information provision to the urban poor. This model provides guidance for libraries to establish partnerships with other community agencies to effectively meet the information needs of underserved populations."

Turner, D., & Gorichanaz, T. (2018). Collaborative connections: Designing library services for the urban poor. The Library Quarterly, 88(3), 237-255. Retrieved from: https://www.journals.uchicago.edu/doi/abs/10.1086/697704

Community-owned fiber networks: Value leaders in America

An in-depth paper examining pricing and demand between a number of communities focusing on fiber-to-the-home services being offered by municipalities:

"We collected advertised prices for residential data plans offered by 40 community-owned (typically municipally owned) Internet service providers (ISPs) that offer fiber-to-the-home (FTTH) service. We then identified the least-expensive service that meets the federal definition of broadband — at least 25 Mbps download and 3 Mbps upload — and compared advertised prices to those of private competitors in the same markets. We found that most community-owned FTTH networks charged less and offered prices that were clear and unchanging, whereas private ISPs typically charged initial low promotional or "teaser" rates that later sharply rose, usually after 12 months. We were able to make comparisons in 27 communities. We found that in 23 cases, the community-owned FTTH providers' pricing was lower when averaged over four years. (Using a three year-average changed this fraction to 22 out of 27.) In the other 13 communities, comparisons were not possible, either because the private providers' website terms of service deterred or prohibited data collection or because no competitor offered service that qualified as broadband. We also made the incidental finding that Comcast offered different prices and terms for the same service in different regions."

Talbot, D., Hessekiel, K., & Kehl, D. (2018). Community-owned fiber networks: Value leaders in America. Berkman Klein Center Research, (2018-1). Retrieved from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3099626

Thinking relationally about digital inequality in rural regions of the US

This paper provides a thorough examination of digital inequality, looking at how infrastructure and Internet access, notably in a rural and remote framework, shape experience and use of the Internet:

"This article reconsiders the concept of digital inequality drawing from recent developments in science and technology studies, including evolving theories of materiality (Barad, 2003; Bennett, 2010; Ingold, 2012), work on critical media infrastructures (Parks and Starosielski, 2015), and on maintenance and repair (Jackson, 2014; Edgerton, 2007). New ways of thinking about the material world move away from an examination of the cultural significance of 'objects' to consider the relationality, vibrancy, and continual "becoming" of materials that we live amidst and interact through. These innovative theoretical developments offer new ways of framing present-day problems and consequences of disparate connectivity by drawing attention to connecting infrastructures instead of the end points of access. I draw from ethnographic fieldwork on Internet access and use in a rural and remote part of northern California to show how the uneven and patchy deployment of the Internet and its physical infrastructures across space shapes rural experiences of the Internet."

Burrell, J. (2018). Thinking relationally about digital inequality in rural regions of the US. First Monday, 23(6). Retrieved from: http://firstmonday.org/ojs/index.php/fm/article/view/8376

Free library hotspots: Supporting broadband adoption in Philadelphia's low-income communities

This article examines the effects of meaningful Internet use (and availability) outside of the home and in public spaces, such as libraries. It also contains tips and lessons learned on community engagement through broadband technology to underserved areas:

> "Earlier studies of broadband adoption have focused on Internet use in the home. This article suggests that Internet use outside the home can provide a context in which meaningful measures of broadband adoption can be developed. Findings are presented from a study of the Free Library of Philadelphia Hot Spots, which used an innovative community engagement strategy to bring broadband technology and library services to underserved neighborhoods. The study shows that the sense of comfort (i.e., support, trust, safety, and respect) at the Hot Spots was important to residents as a precursor to technology access and use, and it suggests that these factors be considered in broadband policies to support sustainable broadband adoption in low-income communities."
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> *Rhinesmith, C. (2012). Free library hotspots: Supporting broadband adoption in Philadelphia's low-income communities. International Journal of Communication, 6, 2529-2554. Retrieved from: https://goo.gl/exeEpC*

The Growing Importance of Being Always On—A First Look at the Reliability of Broadband Internet Access

To learn more about the effects of broadband reliability on user behavior - that is, how the consistency and stability of an Internet connection affects how citizens access and leverage resources on the Internet, the following paper is a good primer:

> "In this paper, we empirically demonstrate the growing importance of reliability by measuring its effect on user behavior. We present an approach for broadband reliability characterization using data collected by many emerging national initiatives to study broadband and apply it to the data gathered by the Federal Communications Commission's Measuring Broadband America project. Motivated by our findings, we present the design, implementation, and evaluation of a practical approach for improving the reliability of broadband Internet access with multihoming. "
>
> *Bischof, Z., Bustamante, F., & Feamster, N. (2018). The Growing Importance of Being Always On—A First Look at the Reliability of Broadband Internet Access. Retrieved from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3121942*

Measuring (in a time of crisis) the impact of broadband connections on economic growth: an OECD panel analysis

The following is another look at the relationships between broadband Internet access and economic growth, with relevant discussions around high-speed Internet access in rural areas for different parts of the world:

> "Technological innovation has always been considered a major stimulus for economic growth. High-speed internet access via broadband infrastructure has undergone rapid development since the end of the 1990s, thanks to the deployment of both fixed and mobile technologies. The present study investigates the impact of fixed broadband diffusion as a technological determinant of economic growth on the basis of a panel of 23 OECD countries over 15 years (1996–2010). The time horizon chosen is suitable for verification of the causal effect on growth of the transition from traditional copper to partially fibre networks. Through implementation of a dynamic panel by using the generalized method of moments (GMM) combined with an instrumental variable (IV) two-stage approach, we found a positive correlation between broadband diffusion and economic growth, even after controlling for countries initial endowment of information and communication technologies (ICT) and for the years of economic crisis. Our main finding provides evidence, through a continuous time interpretation of our estimations, of a quantitatively relevant relationship between broadband diffusion and economic dynamics in the short, medium and long runs. Our findings may be useful to policy makers in that they permit forecasting of the benefits of further transition from broadband to ultra-wide broadband networks."
>
> *Castaldo, A., Fiorini, A., & Maggi, B. (2018). Measuring (in a time of crisis) the impact of broadband connections on economic growth: an OECD panel analysis. Applied Economics, 50(8), 838-854. Retrieved from: https://www.tandfonline.com/doi/abs/10.1080/00036846.2017.1343448*

A broadband agenda for the (eventual) infrastructure bill

This article from March 19, 2019 raises some key concerns and questions about how to include provisions for rural broadband, including technology choice and enabling local communities to address the digital divide:

> "What should be the broadband agenda for such legislation? Here are some key principles. Provide more dedicated funding to broadband. The latest White House infrastructure proposal placed some of the burden of funding broadband onto the states. As I explained when that proposal was released, institutional and political roadblocks would likely result in none of those dollars going to broadband. Governors have internal agencies and incentives for spending federal discretionary funding on traditional infrastructure sectors like water, sewer, and roads, a point missed in the White House's argument that money would flow to rural broadband. If we want universal connectivity, the reality is that we need dedicated funds."

Levin, B. (2019). A broadband agenda for the (eventual) infrastructure bill. Brookings Metropolitan Infrastructure initiative. Retrieved from: https://www.brookings.edu/blog/the-avenue/2019/03/19/a-broadband-agenda-for-the-eventual-infrastructure-bill/

An Office of Rural Broadband: We've Heard This Before

A short run-down of the reasons why a separate entity to specifically address the broadband realities of rural communities is needed:

> "'Rural' is a contentious issue in American regulation, so much so that the 2008 Farm Bill ordered USDA to evaluate the various definitions of the term used within the department. USDA's report mapped well over 30 different iterations of the word. The report ultimately concluded that a universal understanding of "rural" should be adopted. USDA furthermore recommended that the standard definition be a community under 50,000 people. Coincidentally, or not, this is the definition employed in the 2008 Farm Bill.
>
> A universal definition was never adopted, and, as a result, the smorgasbord of definitions continues to pervade regulatory discourse both at USDA and across federal and state agencies and departments. A stronger mandate for the Office of Rural Broadband would be to standardize the definition of rural within telecommunications policy and regulation as a component of its primary mission of coordination and inter-agency cooperation."

Ali C. (March 18 2019). An Office of Rural Broadband: We've Heard This Before. Benton Foundation. Retrieved from: https://www.benton.org/blog/office-rural-broadband-we%E2%80%99ve-heard

Five Steps to Advance Rural Broadband

The following post contains useful information regarding concrete future steps that would help advance broadband across rural America:

> "As a result of the Federal Communications Commission's reforms, Universal Service Fund recipients now have enforceable requirements to meet broadband performance obligations in exchange for support. With a known cash flow for a defined period, companies will be more willing to make investments in rural America. The FCC has adopted a regime with improved accountability and consequences for non-compliance. There may be more work to be done on the margins but big picture – we now have verification of performance and an ability to track progress in closing the digital divide."

Mattey C. (March 18 2019). Five Steps to Advance Rural Broadband. Benton Foundation. Retrieved from: https://www.benton.org/blog/five-steps-advance-rural-broadband

Appendix D: Additional Literature and Resources

Community Broadband Bits Podcast:

"Community Broadband Bits is a short weekly audio show featuring interviews with people building community networks or otherwise involved with Internet policy. "

https://muninetworks.org/broadbandbits

Community Broadband Networks:

"Discover how communities are investing in their own Internet infrastructure to promote economic prosperity and improve quality of life. "

https://MuniNetworks.org

Broadbandmatters.com Reference Guide: A Resource for Digital Stakeholders:

"The following broadband information is directly from the Broadband Reference Guide: A Resource for Digital Stakeholders produced by the WI Public Service Commission, UW-Extension Madison, and the Center for Community Technology Solutions."

https://broadbandmatters.com/broadband101

America's Electric Cooperatives Telecommunications & Broadband Resources:

"There is a demand in unserved and underserved locations for broadband services, which are essential to community development, economic growth and prosperity, and educational attainment."

https://www.cooperative.com/topics/telecommunications-broadband/Pages/default.aspx

Nebraska Rural Broadband Task Force Resources:

"The task force is charged with reviewing issues relating to availability, adoption, and affordability of broadband services in rural areas of Nebraska."

https://ruralbroadband.nebraska.gov/about/index.html

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