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Keeping Students Connected and Learning

Strategies for Deploying School District Wireless Networks as a Sustainable Solution to Connect Students at Home

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Strategies for Deploying School District Wireless Networks as a Sustainable Solution to Connect Students at Home

U.S. Department of Education

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Introduction

Closing the Digital Divide

In spring 2020, the coronavirus disease 2019 (COVID-19) pandemic and the shift to hybrid and remote learning for most schools turned what was once a "homework gap" into a "learning opportunity gap" as devices and internet access became necessary to keep students connected and learning.

Over the past 10 years, the country has made huge strides to connect 99 percent of our school buildings to **broadband.**[1] This progress is the result of coordinated federal, state, and local efforts — from targeted federal funding through the modernized E-Rate program, to state E-Rate matching funds, to creative partnerships in local communities and advocacy from organizations. A similar effort is needed to ensure home internet access for students to enable anytime, anywhere learning.

Broadband refers to high-speed internet access that is faster than dial-up and delivered through several types of technologies including fiber, wireless, cable, Digital Subscriber Line (DSL), and satellite. A broadband connection has two speeds: download and upload. Download speed is the speed of getting information from the web to your computer and upload speed is the reverse. The U.S. Federal Communications Commission (FCC) sets the minimum bandwidth for a broadband connection to be 25 Mbps download and 3 Mbps upload.

A June 2020 report from Common Sense Media found that up to 16 million K–12 public school students live in households either without an internet connection or without a device adequate for remote learning at home. Approximately 9 million of these students live in households with neither an adequate connection nor an adequate device for remote learning. The report also found that approximately 400,000 teachers lacked adequate connectivity or devices to support remote teaching from home.[2]

1 EducationSuperHighway. (2019). *2019 State of the states: The classroom connectivity gap is closed.* Retrieved from https://3x4u3i1w2onf4vhj418itzm1-wpengine.netdna-ssl.com/wp-content/uploads/2019-State-of-the-States-Full-Report-EducationSuperHighway.pdf. This report notes that 99% of schools are connected at speeds of 100 Kilobits per second per student, the FCC minimum recommended bandwidth to enable digital learning in the classroom. Starting in 2018, the FCC raised this standard to 1 Megabits per second (Mbps) per student. In 2020, Connect K–12 reported that 47% of school districts are meeting the 1 Mbps per student goal: https://connectk12.org/static/media/Connect_K12_2020_Executive_Summary_Full_Report.d84a960a.pdf.

2 Chandra, S., Chang, A., Day, L., Fazlullah, A., Liu, J., McBride, L., Mudalige, T., & Weiss, D., (2020). *Closing the K–12 digital divide in the age of distance learning.* San Francisco, CA: Common Sense Media. Boston, Massachusetts, Boston Consulting Group. Retrieved from https://www.commonsensemedia.org/kids-action/publications/closing-the-k-12-digital-divide-in-the-age-of-distance-learning

Research shows that lack of high-speed broadband is disproportionately common in low-income, rural, tribal, and other under-resourced communities.[3] A 2018 study by the U.S. Department of Education's Institute of Education Sciences shows that geography directly impacts home internet access. Students in "remote rural" areas had more limited home internet access than students in suburbs, cities, or towns due to a lack of available broadband infrastructure. The study also shows additional gaps among students of different poverty levels and racial/ethnic groups. For example, Black (41 percent) and Hispanic students (26 percent) in remote rural areas were more likely than White (13 percent) or Asian students (11 percent) to have either no internet access or only dial-up access at home.[4]

Disparate access to the internet and devices required for learning results in significant consequences for students. According to a study conducted by the Quello Center at Michigan State University, "After controlling for socioeconomic factors, quality of home internet access has an impact on a range of student performance outcomes." The study found that "students who do not have access to the internet from home, or who are dependent on a cell phone alone for access, perform lower on a range of metrics, including digital skills, homework completion, and grade point average."[5]

Before the pandemic, schools, districts, and states were taking a variety of approaches to address the homework gap — from purchasing and lending mobile hotspots, to parking buses equipped with Wi-Fi hotspots near under-connected neighborhoods, to allowing students to use the school's internet before or after school. In many cases, however, unserved or underserved students have had to piece together internet access via smartphones with limited cellular data plans or travel to a library or fast-food restaurant to use free Wi-Fi. Even these basic solutions have become more difficult to navigate as schools, libraries, and businesses have closed or limited access to the public during the pandemic. As the pandemic has made clear, many of the solutions we have been employing are not enough to equitably meet students' needs.

District and state leaders have used emergency stimulus funding[6] along with state and local funds to implement immediate connectivity solutions (e.g., mobile hotspots, temporarily paying for home internet subscriptions) to ensure continuity of learning for students. For some students, these immediate solutions have proven sufficient for short-term, remote learning; however, for others, including those sharing a single hotspot with several siblings, the bandwidth offered by mobile hotspots has been too slow to

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3 U.S. Congress Joint Economic Committee. (2017). *America's digital divide.* Retrieved from **https://www.jec.senate.gov/public/_cache/files/ff7b3d0b-bc00-4498-9f9d-3e56ef95088f/the-digital-divide-.pdf**

4 U.S. Department of Education, National Center for Education Statistics. (2018). *Student access to digital learning resources outside of the classroom: Executive summary* [NCES 2017-098]. Retrieved from **https://nces.ed.gov/pubs2017/2017098/index.asp**

5 Hampton, K. N., Fernandez, L., Robertson, C. T., & Bauer, J. M. (2020). *Broadband and student performance gaps.* James H. and Mary B. Quello Center, Michigan State University. **https://quello.msu.edu/broadbandgap/**

6 States and districts have received three rounds of emergency stimulus funding through the Coronavirus Aid, Relief, and Economic Security (CARES) Act, the Coronavirus Response and Relief Supplemental Appropriations Act, 2021 (CRRSA), and the American Rescue Plan Act of 2021 (ARP). Information about these programs is available on the Department's website: **https://oese.ed.gov/offices/education-stabilization-fund/**

engage in sustained remote learning.[7] Further, mobile hotspots are unusable for students in rural and urban communities with spotty cellular service because there is nothing for the hotspot to connect to.[8] In addition, most of these solutions will be cost-prohibitive after emergency stimulus programs end and states and districts must find ways to cover these new, recurring expenses in already limited budgets. Some states and districts are also planning for longer-term sustainable solutions (e.g., off-campus wireless networks). In talking with state and district leaders who are tirelessly working to deploy creative solutions to connect students at home, one thing is clear: solving this challenge is bigger than the education community alone. It requires creative community partnerships to bring the necessary resources, expertise, and solutions to the table.

The purpose of this brief is to present strategies for deploying off-campus wireless networks as a sustainable solution to provide home connectivity to all students and educators.

This brief shows how school districts have taken diverse approaches to build off-campus wireless networks. Off-campus wireless networks offer a possible long-term approach to solving the home connectivity gap. They may not be a viable solution in all districts; however, we hope the examples highlighted in this brief contribute to the discussion of sustainable, long-term solutions for providing equitable access to high-quality education. This is a community effort and will require a team.

Background

Home Internet Access for All Students: It's Complicated

The FCC E-Rate program has helped our country connect 99 percent of U.S. schools, including those in rural areas, to high-speed broadband by providing dedicated funding for school building connectivity. However, while the E-Rate program helped bring connectivity to and through our school buildings, it currently limits the use of that connectivity to the boundaries of the school campus. This means students and teachers who have access to high-speed internet at school might have limited internet access at home if that access is not accessible or affordable.

In rural communities, internet service providers (ISPs) often choose not to build and maintain expensive fiber networks to geographically remote locations with low population densities due to the limited return on investment. In urban communities, there is documented evidence of "digital redlining," where ISPs invest in building fiber infrastructure in wealthier neighborhoods while under-investing in low-income

7 Johnson, S., & Burke, M. (2020). *More California students are online, but digital divide runs deep with distance learning.* EdSource. Retrieved from **https://edsource.org/2020/more-california-students-are-online-but-digital-divide-runs-deep-with-distance-learning/630456**

8 Salman, J. (2020). *Hotspots no silver bullet for rural remote learning.* Hechinger Report. Retrieved from **https://hechingerreport.org/hotspots-no-silver-bullet-for-rural-remote-learning/**

communities. This results in low-income broadband users with more expensive, slower access.[9] Access to consistent broadband can also be a challenge for unhoused and highly mobile families due to the lack of a permanent address.[10] Further, students from low-income families are more likely to be disconnected, primarily due to issues of affordability.[11] According to the 2017 Current Population Survey, 34 percent of households with children aged 3–18 and no internet cite affordability as the major reason for not having a connection.[12]

In communities where internet access is available and affordable, there may be other barriers limiting adoption by families that schools and other trusted community-based organizations can help address. Often, the sign-up process has not been designed to be accessible to all families and relies on applicants having fluency in the dominant language and the digital skills to successfully navigate the process. Families may also be hesitant to share personal information, like Social Security numbers, that can be required to secure service. These barriers may disproportionately impact English learners, children of undocumented immigrants, or students experiencing homelessness. Analysis of the U.S. Census Bureau's Household Pulse Survey by Common Sense Media noted that efforts by states and districts to address home access for students during the pandemic may have had a greater impact on closing the digital divide for Black students as compared to Hispanic or Latino students.[13]

To help schools and libraries provide devices and connectivity to students, school staff, and library patrons during the pandemic, Congress established a temporary $7.2 billion Emergency Connectivity Fund as part of the American Rescue Plan Act of 2021 (ARP).[14] Funding from the Emergency Connectivity Fund will be distributed to eligible schools and libraries for the purchase of eligible equipment and advanced telecommunications and information services for use by students, school staff, and library patrons at locations other than a school or library. The FCC published final rules for the program on May 10, 2021.[15]

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9 Electronic Frontier Foundation: **https://www.eff.org/deeplinks/2021/01/fcc-and-states-must-ban-digital-redlining**

10 Shapiro, E., & Brittainy Newman, B. (2019, Nov. 19). 114,000 students in N.Y.C. are homeless. These two let us into their lives. *The New York Times.* Retrieved from **www.nytimes.com/interactive/2019/11/19/nyregion/student-homelessness-nyc.html**

11 Ali, T., Chandra, S., Cherukumilli, S., Fazlullah, A., Hill, H., McAlpine, N., McBride, L., Vaduganathan, N., Weiss, D., & Wu, M. (2021). *Looking back, looking forward: What it will take to permanently close the K–12 digital divide.* Common Sense Media. **https://www.commonsensemedia.org/sites/default/files/uploads/kids_action/final_-_what_it_will_take_to_permanently_close_the_k-12_digital_divide_vjan26_1.pdf**. Students from families with annual household incomes of less than $50,000 are approximately 30% of the overall K–12 population yet account for more than 50% of all disconnected students.

12 U.S. Department of Education, National Center for Education Statistics. (2021). *Children's internet access at home.* **https://nces.ed.gov/programs/coe/indicator_cch.asp**

13 Ali, T., Chandra, S., Cherukumilli, S., Fazlullah, A., Hill, H., McAlpine, N., McBride, L., Vaduganathan, N., Weiss, D., & Wu, M. (2021). *Looking back, looking forward: What it will take to permanently close the K–12 digital divide.* Common Sense Media. **https://www.commonsensemedia.org/sites/default/files/uploads/kids_action/final_-_what_it_will_take_to_permanently_close_the_k-12_digital_divide_vjan26_1.pdf**

14 American Rescue Plan Act of 2021, Pub. L. No. 117-2, H.R. 1319, 117th Cong., tit. VII, § 7402 (2021). (enacted), available at **https://www.congress.gov/bill/117th-congress/house-bill/1319/text**

15 Federal Communication Commission. *FCC to Launch $7.17 Billion Connectivity Fund Program* (2021). **https://www.fcc.gov/document/fcc-launch-717-billion-connectivity-fund-program-0**

Short- and Long-Term Solutions

One of the most difficult challenges of addressing home internet access for students is that the solutions are not one-size-fits-all. Many districts have used emergency stimulus funding to expand their pre-pandemic solutions — lending mobile hotspots and devices to students, parking school buses in poorly connected neighborhoods to create **Wi-Fi hotspots**, and extending Wi-Fi to school parking lots so students and families can park and use the internet. Other districts have adopted a sponsored service model to temporarily cover the cost of monthly home internet subscriptions for students.[16] A January 2021 report from Common Sense Media found that efforts made by states and districts during the pandemic succeeded in temporarily narrowing the digital divide for students from an estimated 15 to 16 million students in June 2020 to approximately 12 million students in December 2020. The report notes, however, that "more than 75% of state and local student digital divide efforts will expire in the next one to three years."[17,18]

Wi-Fi hotspots are locations, such as an airport or coffee shop, where people can wirelessly connect their device(s) to the internet using Wi-Fi via a wireless local area network. A mobile or portable hotspot uses the smartphone's data connection to connect or "tether" their device(s) to the internet.

Other school districts are increasingly considering the feasibility of building **off-campus Wi-Fi networks** as a long-term, sustainable solution to address the lack of affordable, high-speed internet access within the homes of many students.

An **out-of-school** or **off-campus Wi-Fi network** is a school-owned Wi-Fi network that provides free, basic wireless internet access to the homes of students or other community sites often in neighborhoods with the greatest need.

16 EducationSuperHighway. (n.d.). *An introduction to sponsored service.* https://www.educationsuperhighway.org/a-guide-to-sponsored-service/

17 Ali, T., Chandra, S., Cherukumilli, S., Fazlullah, A., Hill, H., McAlpine, N., McBride, L., Vaduganathan, N., Weiss, D., & Wu, M. (2021). *Looking back, looking forward: What it will take to permanently close the K–12 digital divide.* Common Sense Media. https://www.commonsensemedia.org/sites/default/files/uploads/kids_action/final_-_what_it_will_take_to_permanently_close_the_k-12_digital_divide_vjan26_1.pdf

18 2 C.F.R. § 200.313. Equipment – Electronic Code of Federal Regulations e-CFR (ecfr.io) https://ecfr.io/Title-2/Section-200.313

Prior to the pandemic, some school districts were already exploring the use of spectrum to deploy off-campus Wi-Fi networks to connect students lacking internet access at home. Spectrum refers to the radio frequencies that wireless signals travel over and supports wireless communication.[19] Districts, including those highlighted in this brief, have used several spectrum bands, including the Citizens Broadband Radio Service (CBRS) spectrum, the 2.5 GHz (formerly Educational Broadband Service (EBS)) spectrum, and TV white space.

Citizens Broadband Radio Service Spectrum

In April 2015, the FCC established the CBRS by opening 150 MHz of spectrum in the 3.5 GHz to 3.7 GHz band that was previously reserved for military and other government-approved uses. The FCC has authorized sharing of the CBRS among three tiers of users: incumbent users, priority access license (PAL) users, and general authorized access (GAA) users. Tier 1 incumbent users such as the federal government, fixed satellite users, and grandfathered wireless users receive top priority and are protected from interference by other users. PAL users are licensed users who acquire spectrum licenses through an FCC auction. GAA users can use any CBRS spectrum not used by PAL holders or the protected incumbents; however, GAA users do not receive interference protection.[20]

2.5 GHz Band (formerly EBS Spectrum)

Until recently, the former EBS service was the only licensed spectrum available specifically for educational institutions.[21] Educational institutions that hold a license in this band can choose to self-deploy a wireless network or lease their excess spectrum to provide low-cost or free mobile internet to schools and low-income households while maintaining provisions for educational use. This spectrum has been leveraged to build countywide wireless broadband networks for schools and residents, often resulting in affordable access to broadband where it was not previously available or too costly to adopt. After licensing of unused spectrum in the former EBS service was frozen in 1995, the FCC granted waivers to a few educational institutions for new licenses; however, districts and other educational institutions that do not currently hold an existing license may be unable to obtain a new license. In July 2019, the FCC determined that, following a priority window for tribal entities to obtain unassigned 2.5 GHz spectrum over their rural tribal lands, any remaining unassigned 2.5 GHz spectrum in this service will be made available for commercial use via competitive bidding.[22] District leaders

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19 CTIA. (2018). *What is spectrum? A brief explainer.* **https://www.ctia.org/news/what-is-spectrum-a-brief-explainer**

20 CBRS Alliance. (2020). *OnGo private LTE deployment guide.* **https://ongoalliance.org/resource/ongo-private-lte-deployment-guide/**

21 Eligibility to hold an EBS service license was limited to (1) accredited public and private educational institutions, (2) governmental organizations engaged in the formal education of students, and (3) nonprofit organizations whose purposes are educational and include providing educational and instructional materials to accredited institutions and governmental organizations. Those eligibility requirements were eliminated in 2019.

22 Federal Communications Commission. (2019). *Transforming the 2.5GHz band.* **https://docs.fcc.gov/public/attachments/FCC-19-62A1.pdf**

can check with local educational institutions or organizations such as community colleges, community organizations, and local government to see who may hold any existing license(s) in their community and whether they are currently being leased. To the extent the 2.5 GHz spectrum is being leased, it may not be available for the types of projects discussed in this document.

White Space

White space refers to the unused gaps between active TV channels in the very high frequency (VHF) and ultra high frequency (UHF) spectrum bands as well as available spectrum in the adjacent 600 MHz band service. White space devices may operate in the 54 MHz to 88 MHz (VHF-TV channels 2–6), the 174 MHz to 216 MHz (VHF-TV channels 7–13), and the 470 MHz to 698 MHz spectrum bands.[23] These “buffer” channels in the TV band were left vacant to prevent interference between adjacent TV channels; however, due to advancements in technology these “white spaces” are no longer needed. Wireless internet that uses white space can travel up to 10 kilometers through mountainous terrain, forests, and other obstacles. In October 2020, the FCC amended its rules governing unlicensed wireless services provided to allow expanded use of white space devices for the delivery of broadband services in rural and underserved communities while protecting broadcast television stations and other licensed services from interference.[24]

Considerations for Implementation

The districts highlighted in this brief considered the following factors prior to implementing their off-campus Wi-Fi networks. Schools or districts considering a wireless network solution should reflect on these key considerations.

KEY CONSIDERATION 1: Establish Measurable Home Internet Access Goals

Our school or district has established measurable goals for providing home internet access to students using an off-campus Wi-Fi network.

- ✓ We have identified how students and teachers will use the network to support learning goals (e.g., online instruction, hybrid learning, homework help) and what device, apps, and filtering needs must be met by the network.

23 The UHF TV band extends from 470–614 MHz. White space devices may also operate on available channels in the 600 MHz Band Service (617–652 MHz and 663–698 MHz) in areas where mobile broadband licensees have not commenced service. White space devices may also operate at 657–663 MHz nationwide.
24 Federal Communications Commission. (2020). *Unlicensed white space device operations in the television bands.* https://www.fcc.gov/document/fcc-increases-unlicensed-wireless-operations-tv-white-spaces-0

- ✓ We have established expectations about what broadband speeds are needed to support our learning goals and the total number of devices we can provide.[25]
- ✓ We have made plans and set aside resources to train and provide tech support to students and families, including in home languages, so they can successfully access and use digital learning resources.
- ✓ We have allocated the necessary resources (e.g., time, funding) to provide job-embedded professional development for teachers to ensure effective use of digital learning resources.

KEY CONSIDERATION 2: Conduct Needs and Topography Assessments

Our school or district has collected data and assessed the student needs and the technology requirements for implementing an off-campus wireless network.

- ✓ We have mapped student address data to determine where the unserved or underserved students live.
- ✓ We have identified students who are unhoused or highly mobile and are considering tailored solutions including mobile hotspots or partnerships with local homeless shelters to provide access.
- ✓ We have assessed local topography (mountainous land may hinder execution), access to towers or tall structures (tall structures are beneficial for expanding long-term evolution (LTE) outreach), and line-of-sight requirements.
- ✓ We have developed an inventory and mapped the location of tall structures (e.g., buildings, water towers, grain siloes) that may be used for placement of customer premises equipment (CPE) and identified which are publicly or privately owned.
- ✓ We have a topographical map of the planned service area to help determine the necessary tower height and address line-of-sight requirements.
- ✓ We have arranged for legal access to the students' homes for CPE installation.
- ✓ We have identified a mix of different connectivity solutions that are aligned with our goals and will provide appropriate coverage for different situations.

KEY CONSIDERATION 3: Build Relationships That Lead to Partnerships and Collaborations

Our school or district has considered existing and potential partnerships or collaborations to help implement the network, including leveraging economies of scale and shared infrastructure to keep costs low and avoid the need for additional appropriations.

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25 EducationSuperHighway provides recommended **K–12 Bandwidth Goals** for school connectivity. These benchmarks paired with the **BroadbandNow Bandwidth Calculator** may be helpful in determining bandwidth goals for home connectivity.

- ✓ We have built relationships with the local government (e.g., counties, municipalities) and identified opportunities to share resources (e.g., equipment, funding, staff).
- ✓ We have built relationships with other community anchor institutions (e.g., libraries, public housing authority, homeless shelters) and publicly owned utilities and identified opportunities to discover if any have infrastructure installed that can be used to create a wider network.
- ✓ We are collaborating with service providers and equipment vendors (e.g., ISPs, state or regional education networks), private businesses, and nonprofit organizations.
- ✓ We are doing research to identify local wireless and wireline service providers.

KEY CONSIDERATION 4: Research Relevant Laws or Policies

Our school or district has researched the local, state, and federal laws and policies that may impact broadband deployment, such as where towers can be built, how to use publicly owned facilities in a network design, and the types of internet services to be offered.

- ✓ We have researched and acquired government approvals for an off-campus Wi-Fi network plan.
- ✓ We understand state and local laws with regard to telecommunications companies and municipal broadband.
- ✓ We are monitoring pending federal legislation that may impact state and local laws.
- ✓ We are aware of current limitations of the E-Rate program on extending E-Rate-funded connectivity off-campus and are monitoring updates regarding the temporary FCC Emergency Connectivity Fund to support the purchase of eligible equipment and advanced telecommunications and information services for use at locations other than a school or library.[26]

KEY CONSIDERATION 5: Identify Funding Sources

Our school or district considered a range of funding sources to support our digital access initiative in the short-term and sustainability over time.

- ✓ We are using federal or state funding (e.g., CARES Act, ARP funds).
- ✓ We have explored local corporations, businesses, or philanthropic programs.
- ✓ We have considered holding a **bond issue**.

> ? **Bond Issue:** Education bonds are voter-approved funds that can only be used for school facilities. The local bond is similar to a loan, like a home equity line, but for the school district.

26 Federal Communications Commission. (2021). *Report and Order Establishing Emergency Connectivity Fund to close the homework gap.* Retrieved from: **https://docs.fcc.gov/public/attachments/FCC-21-58A1.pdf**

School District Wireless Network Models

This brief discusses six models that school districts have deployed to create out-of-school or off-campus Wi-Fi networks to serve students in their communities. Many of the districts featured in this brief had already begun planning projects to address the digital divide prior to the pandemic. As a result, they were positioned to scale up pilot projects or apply emergency federal funding to accelerate implementation.

The six models presented in this brief are compelling solutions that districts of various sizes, in various geographic locations, have deployed to serve their students. Each example describes real-life challenges in educational networking, illustrates best practices, and provides advice to school and district leaders on how to tackle the challenges of providing home access to students. Each example includes a description of the approach and technology used, funding and partnerships, challenges and successes, outcomes and impacts, next steps, and implementation advice.[27]

The six models highlighted below include:

1. ACPS@Home Initiative, Albemarle County Public Schools, Albemarle, VA
2. Northeast Nebraska Tribal Education Broadband Service, Nebraska Indian Community College, Northeast NE
3. ICOE BorderLink Infrastructure Initiative, Imperial County Office of Education, Imperial County, CA
4. LUSD Community Wi-Fi Network, Lindsay Unified School District, Lindsay, CA
5. Livewire ConnectME Program, Boulder Valley School District, Boulder, CO
6. Connect2Learn Initiative, Fresno Unified School District, Fresno, CA

27 The details for each model were obtained via survey and follow-up interviews with the district project lead.

Model 1: Leasing 2.5 GHz Spectrum to Connect Students at Home

Albemarle County, VA

Program Name: ACPS@Home Initiative

Location: Albemarle County Public School District (ACPS), VA

Project Lead: Dr. Christine Diggs, Chief Technology Officer

ACPS serves more than 14,000 students and is comprised of 26 rural, urban, and suburban school buildings surrounding the city of Charlottesville, VA. More than 30 percent of the student population is economically disadvantaged or participates in the Free or Reduced-Price Lunch (FRPL) program, and approximately 10 percent identify as English learners. Given this diverse learning population, the district views digital equity as a critical component for meeting the learning needs of all students.

The ACPS vision for student learning is "All learners believe in their power to embrace learning, to excel, and to own their future."

ACPS@Home

- Student population: 14,345
- Demographics:
  - White 63%
  - Hispanic/Latino 14%
  - Black/African American 11%
  - Asian 5%
  - Other 7%
- Economically disadvantaged/FRPL: 33%
- Location: urban, rural, & suburban
- Area covered by network: 726 mi²
- Cost to construct: Approx. $500,000
- Cost of project staff: None
- Cost per square mile: $689
- Number of students served: 1,175
- Populations served by network: Students & households with & without students

Approach

Leverage partnerships and available 2.5 GHz spectrum to provide internet connectivity to students.

In 2019, ACPS established the ACPS@Home initiative to double-down on its commitment to provide internet connectivity to students at home. Through the ACPS@ Home initiative, the district issues mobile hotspots to students, partners with local government to expand broadband throughout the county, and serves as the financial sponsor for providing broadband service to students in areas where it is available from the partner ISP. The district has also established a dedicated digital equity position within its technology department.

A key component of the ACPS@Home initiative was the creation of a public-private partnership through which ACPS leases its 2.5 GHz spectrum to a commercial ISP. Leasing the district's EBS spectrum provides essential, sustainable funding for the mobile hotspots issued to students. The public-private partnership includes an agreement with a commercial ISP to provide broadband internet connections through the company's low-cost internet program. ACPS serves as the financial sponsor to ensure that all economically disadvantaged students living in the ISP service area receive adequate internet access.

The district also forged a key partnership with the county information technology (IT) department. Through this partnership, the county's connectivity is measured by location through online speed tests, which provide more accurate upload and download speeds than those published by the ISPs.

ACPS also collaborates with the Albemarle Broadband Authority on the Virginia Telecommunications Initiative grants they have received from the State of Virginia. A recent grant that extends broadband service to currently unserved areas in the county will connect over 200 students' homes. ACPS supports their efforts to provide open Wi-Fi from community centers and by expanding school Wi-Fi to parking lots for greater accessibility when schools are closed.

Technology Used

Exhibit 1 provides an overview of Albemarle County's LTE network topography map.

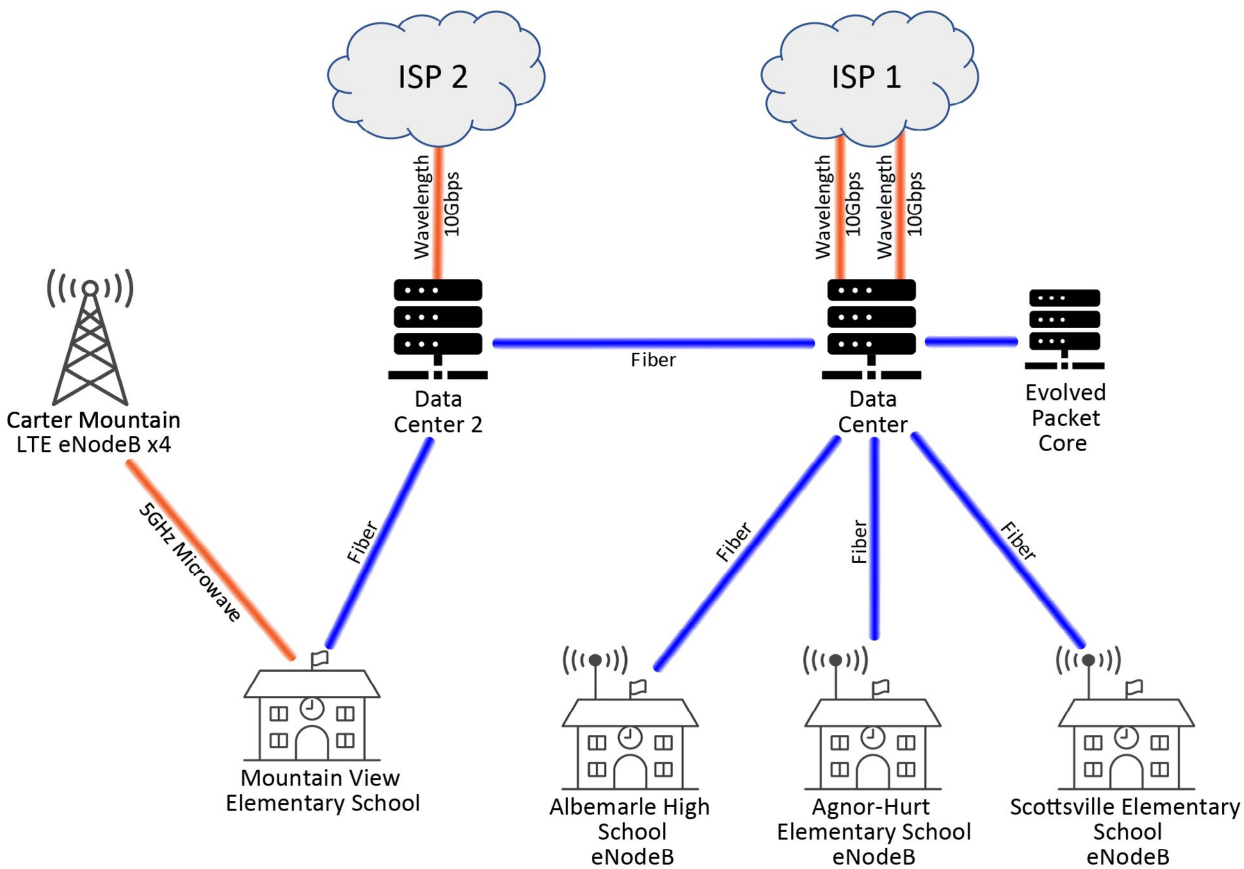

Exhibit 1: Albemarle County, Virginia, LTE Network Topography Map

ACPS's off-campus wireless network was developed using spectrum that ACPS leases in the 2.5 GHz band, which is a spectrum band that can be used to provide high-speed, high-capacity broadband service via cellular wireless communication systems.

ACPS uses commercially available, cellular industry standards-based equipment to provide wireless data services via a private LTE network covering an area exceeding 100 square miles. They utilized existing network infrastructure that was already available to the school district, including facility rooftops, radio towers, and leased and school district-owned **fiber-optic (or fiber)** for data transport to minimize recurring costs. E-Rate funds were not used to support this initiative.

> **Fiber:** Fiber is the fastest method of delivering high-speed internet and can transmit data at faster speeds over longer distances. Fiber consists of a thin cylinder of glass encased in a protective cover that uses light rather than electrical pulses to transmit data. Each strand of the cable can pass a signal in only one direction, so fiber-optic cable must have at least two strands: one for sending data and one for receiving data. Fiber-optic cables are not subject to electrical interference, which greatly increases the transmission distance.

Outcomes and Impact

Having either an off-campus wireless network, or a combination approach to connecting students, has been ACPS's highest priority for ensuring students have the access they need for 21st century learning and their future success. Although ACPS faced multiple challenges to providing internet access to students, partnerships with local government and other public/private entities have resulted in a positive impact for unconnected students and teachers.

ACPS was well-positioned to quickly accelerate its ACPS@Home project timeline when the COVID-19 pandemic hit. Each teacher and high school student who needed internet access and lived in an area with a cell signal was issued a mobile hotspot. Because the district serves a broad geographic area, this approach proved advantageous. If students were not able to receive a signal from one type of mobile hotspot provider, they switched to a device serviced by another carrier.

When ACPS faced a total school closure during the spring of 2020, many teachers and students found the mobile hotspots valuable for maintaining a feeling of connectedness and community since they could connect with one another visually, even when speaking via cell phones.

Next Steps

ACPS plans to grow and expand the ACPS@Home initiative by upgrading the mobile hotspot data plans to unlimited data plans and expanding the initiative to reach up to 90 percent of students. ACPS will continue to partner with the Albemarle Broadband Authority and the county IT department to expand internet connectivity around the county, with a priority emphasis on providing broadband access to students' homes.

ACPS also plans to conduct a mapping exercise to get detailed information on the home internet connections it provides. It will continue to focus on digital equity related to internet access, computing devices, teacher professional development, support for digital technologies, as well as the intentional delivery of specific software and hardware that ACPS delivers to district-owned student devices.

Implementation Advice from ACPS

- Consider topography challenges ahead of time because they can impede signal strength. For example, tree density, numerous rolling hills, mountains, and valleys have posed a challenge for delivering access to many of our more rural locations.
- Ensure financial resources are available to properly staff the project. Be aware of the availability of contract workers in your area that can trench fiber-optic or climb towers for installations. These workers can be in short supply or have limited availability.
- Be cognizant of local zoning ordinances or possible restrictions on tower height that may impact the number of students you can reasonably serve.
- Remain cognizant regarding the availability of client equipment for use within households.
- Clearly define who needs access, and make sure there is a mechanism to acquire accurate data regarding who has no internet access and who has limited internet access — and be able to plot those addresses on a map.
- Establish a strong **Acceptable Use Policy** before expanding student access to the internet outside of school property.

Model 2: Using New 2.5 GHz Licenses to Bring Low-Cost Wireless Access to Tribal Homes

Northeast Nebraska

Program Name: Northeast Nebraska Tribal Education Broadband Service (NNTEBS)

Location: Northeast Nebraska

Project Catalyst: Tom Rolfes, Education IT Manager, State Office of the Chief Information Officer

The Nebraska Indian Community College (NICC) is working with five public school districts on the Santee and Omaha reservation land to implement a mobile/fixed private LTE wireless network using 2.5 GHz spectrum. Santee and Omaha are in Knox and Thurston counties in northeast Nebraska.

The new wireless network will serve approximately 2,100 students in grades K–14 across 580 square miles. For many families, this will be their first home internet access. The NNTEBS project aims to improve the college-bound student rate and other positive educational outcomes (e.g., homework completion).

NNTEBS

- Student population: 2,078
- Demographics:
  - American Indian/Alaska Native 57%
  - White 40%
  - Hispanic/Latino 2%
  - Other 1%
- Economically disadvantaged/FRPL: 78%
- Location: rural
- Area covered by network: 580 mi^2
- Cost to construct: $275,000
  - Equipment: ~$160,000
  - Towers: ~$80,000
  - Installation: ~$35,000
- Cost of project staff: In-kind, hiring 1.0 FTE
- Cost per square mile: $474
- Number of students served: 2,100
- Population served by network: Students in grades K–14

Approach

The NNTEBS project leverages public funds to implement a private LTE wireless network carried over the newly licensed 2.5 GHz spectrum for tribal entities. The project plans to use up to 10 new and existing towers or vertical assets on public property, each with fiber-optic backhaul to Network Nebraska, the statewide education network that serves public and private K–12 schools and higher education institutions.

In 2018, the Nebraska Department of Education (NDE), Nebraska Educational Television, and the State Office of the Chief Information Officer submitted joint EBS comments to the FCC that outlined a proposal for a regional 2.5 GHz network and evaluated the feasibility and scalability of this approach for meeting the connectivity needs of the region's students.[28] Information provided by the Digital Learning Guidance document co-developed by the NDE, Educational Service Unit Coordinating

28 Joint comments submitted on August 18, 2018, by the NDE, Nebraska Educational Television, and the State of Nebraska Office of the Chief Information Officer to the FCC on transforming the 2.5 GHz band can be found here: https://ecfsapi.fcc.gov/file/108082718222025/FCC-EBS-NPRM_Nebraska_20180808.pdf

Council, and Network Nebraska ensured the selection of the most appropriate wireless technology for quick and affordable deployment.[29] The rural topography of the NNTEBS project area consists mostly of rolling hills and is sparsely populated. Less expensive line-of-sight wireless technologies were not found to be scalable due to the large numbers of unserved households and the hilly topography of the region. The goal is to create a ubiquitous wireless network so that students who are transported by bus, who travel for activities between school districts, or who live in another partner school district will all have access.

Technology Used

Exhibit 2 provides an overview of the Northeast Nebraska LTE topography map.

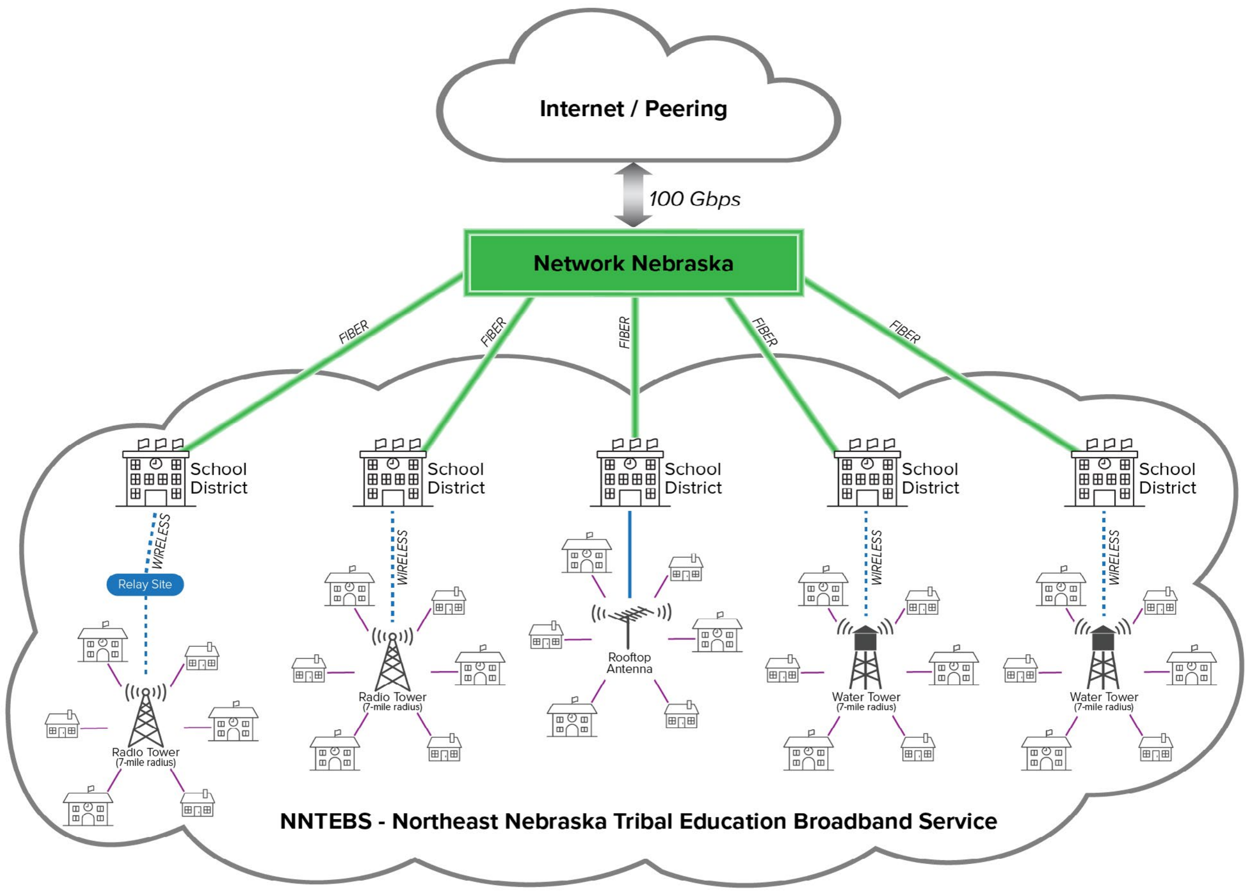

Exhibit 2: Northeast Nebraska LTE Topography Map

Multiple private LTE base stations will be installed on vertical "assets" or towers, extend a wireless coverage area of 360 degrees in all directions, and operate in the 2.5 GHz band. Each base station will be connected via point-to-point wireless to its own high-bandwidth internet source, which originates at the school. Each school receives its

29 Nebraska Department of Education. (2020). Digital learning guidance for summer programming and beyond. Retrieved from: **https://www.launchne.com/wp-content/uploads/2020/06/DigitalLearningGuidanceFinal2020.pdf**

internet from Network Nebraska. More than 700 sets of CPE will include radios with mid-power and high-power antenna options, as well as 2.5 GHz Mi-Fi hotspots for student households that are in closer range to a base station. The Evolved Packet Core (EPC) handles all the incoming call transactions from the student devices and will be a cloud-based service until the project grows to the point where an LTE EPC appliance would be more cost-effective on the core network. Fiber-optic circuits for each school district and NICC base station were upgraded to provide 500 Mbps to 1,000 Mbps capacity. In two locations, fixed base point-to-point wireless transport was needed to reach a water tower or community high point to provide line-of-sight connectivity.

Funding and Partnerships

The NNTEBS project is funded in part by the federal postsecondary Title III Part A-Strengthening Institutions program, the Bureau of Indian Education Fund, an American Indian Higher Education Consortium grant, CARES Act Elementary and Secondary School Emergency Relief funding, and local school districts. The project is considering additional grant sources to grow and improve the wireless network.

The primary objective of the project was to connect the unserved and underserved students in the project area. To achieve this objective, several formal and informal partnerships were formed:

- The superintendents from the five public school districts of Bancroft-Rosalie, Pender, Santee, Umonhon Nation, and Walthill and the President of the NICC signed agreements to define their project responsibilities.
- A contractual relationship was formed between NICC, as the primary fiscal entity, and Red Rover, LTD, as project integrator.
- Baicells Technologies was selected as the equipment manufacturer (e.g., LTE CPEs, unlicensed LTEs, indoor/outdoor base stations).
- The NDE, Nebraska Educational Television, and the State Office of the Chief Information Officer provided in-kind support and connections to outside experts.
- As the statewide E-Rate applicant, the State Office of the Chief Information Officer developed cost allocations based on the proportion of internet access that was to be shared to student homes.

Challenges and Successes

- **Installation Labor.** The biggest challenge on the project was the installation of the student household CPE. The project owners had neither the staffing nor expertise to go door-to-door to install exterior or interior equipment. A search for an installer revealed that all wireless and tower installers were busy with other local, regional, or national implementations tied to FCC, U.S. Department of Agriculture (USDA), or state funding. Eventually, the project owners found a wireless installer from Missouri to train local volunteers and oversee the installations.

- **Aggressive Timeline.** Another major challenge was the project timeline. It is unusual to move a major project from concept to completion in less than 6 months. The NICC President's leadership and the partnerships developed with the school districts were critical to the project's success. As a result, the stakeholders stayed focused on the objective: to get students connected to the internet as quickly as possible.

Outcomes and Impact

The NNTEBS project area has some of the highest student poverty rates and one of the highest frequencies of underserved and unserved internet households in the state. Because of the great need, state agencies and technology integrators have been quick to support the project, and the tribal governments, tribal college, and the associated public school districts have been willing collaborators.

NNTEBS project success will be tracked using four key metrics:

1. The number of student households connected annually.
2. The consistency of the wireless connection bandwidth and reliability for end-users.
3. The number of wireless sessions per student device per academic term.
4. The academic progress per newly connected student as a result of the enhanced internet access.

Next Steps

NNTEBS completed the equipment installations and pushed to connect almost every Mi-Fi student by the start of the 2020 school year, September 1, 2020. Several student households that required antenna installations were not connected until October 2020. Next steps include re-involving a school district that dropped from the project and reaching out to the Winnebago Tribe of Nebraska, which is interested in developing an LTE wireless network for Little Priest Tribal College and two public school districts on adjacent tribal lands.

Implementation Advice from NNTEBS

- Determine which students do not have internet service at home using questionnaires, follow-up phone calls, and student information system data.
- Map student addresses or geocodes and draw concentric rings on the map at 1-mile radii from the network base station(s).
- Decide which wireless technologies should be implemented.
- Estimate the upfront and ongoing costs of constructing and operating the network.
- Calculate and marshal the financial and human resources to sustain the network.

- Research local, state, or federal policies or statutes that could impede the project. The National Conference of State Legislatures has a searchable tool for identifying broadband legislation for many states.[30]
- Take a day or two and visit a location where a similarly situated network has been operating with similar equipment and ask about lessons learned or what could be done differently.
- Devise a game plan to install and recover CPE at student homes.
- Set a project timeline and, if possible, hire a project integrator or project management officer.

30 In the 2020 legislative session, 43 states and Guam addressed broadband in issue areas such as educational institutions and schools, dig once, funding, governance authorities and commissions, infrastructure, municipal-run broadband networks, rural and underserved communities, smart communities, and taxes. Thirty-one states enacted legislation or adopted resolutions. Morton, H. (2020, August 20). *Broadband 2020 legislation*. National Conference of State Legislatures. Retrieved from **https://www.ncsl.org/research/telecommunications-and-information-technology/broadband-2020-legislation.aspx**

Model 3: Using 2.5 GHz Licenses to Provide Home Access Across a Vast Geographic Area

Imperial County, CA

Program Name: Imperial County Office of Education (ICOE) BorderLink Infrastructure Initiative

Location: Imperial County School District, CA

Project Lead: Luis Wong, Chief Technology Officer, ICOE

ICOE serves 17 school districts and 37,375 K–12 students in Imperial County, a rural, remote, and economically distressed area of Southern California. Imperial County (population estimate: 181,215; U.S. Census Bureau, 2019) sits on the border with Mexicali, Mexico, and is located 120 miles southeast of San Diego, CA, and 60 miles west of Yuma, AZ. Imperial County spans 4,482 square miles of arid desert with a substantial agricultural-based economy.

The mission of ICOE is to improve the community's quality of life by promoting strong families and students who are prepared for life, college, and career.

Recognizing the need to bridge the homework gap to allow students to reach their full academic potential, ICOE launched an infrastructure initiative that helps ensure equal access to internet services throughout the county. The goal is to ensure that every student has adequate access to the internet regardless of whether they are at school, home, or elsewhere in the community.

BorderLink

- Student population: 37,375
- Demographics:
  - Hispanic/Latino 85%
  - White 10%
  - Black/African American 2%
  - Other 3%
- Economically disadvantaged/FRPL: 93%
- Location: rural
- Area covered by network: 1,400 mi²
- Cost to construct: $2,000,000
- Cost of project staff: 2 FTEs ($150,000/year) during construction phase; transitioning to 1 FTE ($90,000/year) in operational/maintenance mode
- Cost per square mile: $1,400
- Number of students served: 3,000, expanding to 15,000
- Population served by network: Students; families (student households)

Approach

BorderLink uses an LTE network that operates on 100 MHz of 2.5 GHz spectrum to provide home access to students.

Two decades ago, ICOE established a state-of-the-industry fiber-optic communications network in Imperial County. Thanks to these efforts, Imperial County teachers and students have enjoyed the educational benefits of having reliable high-speed internet access at school. Relying on this robust backbone and the 2.5 GHz licenses it had available, ICOE decided to use wireless connectivity to expand its terrestrial fiber-optic network outside of the school.

To create an off-campus Wi-Fi network, ICOE adopted a proven consortium model through the Imperial Valley Telecommunications Authority (IVTA). IVTA is a collaborative of all Imperial County school districts, city agencies, county agencies, Imperial Community College, San Diego State University-IVC, and the Imperial Irrigation District. IVTA is an innovative partnership and is officially recognized as a public "Joint Powers Authority." It includes 31 agencies and 115 sites that are connected, mostly via private and licensed microwave systems.

This consortium model provides several key benefits:

- It provides the ability to connect all communities.
- It leverages ICOE network staff, which offers expertise and cost-efficiently utilizes 2–3 Full-Time Equivalent (FTE) to support the network.
- It leverages community assets, such as poles, communication towers, and power-protected facilities.
- It offers economies of scale and a consortium cost recovery model that yields low costs per connection.

Technology Used

Exhibit 3 provides an overview of Imperial County's LTE topography map.

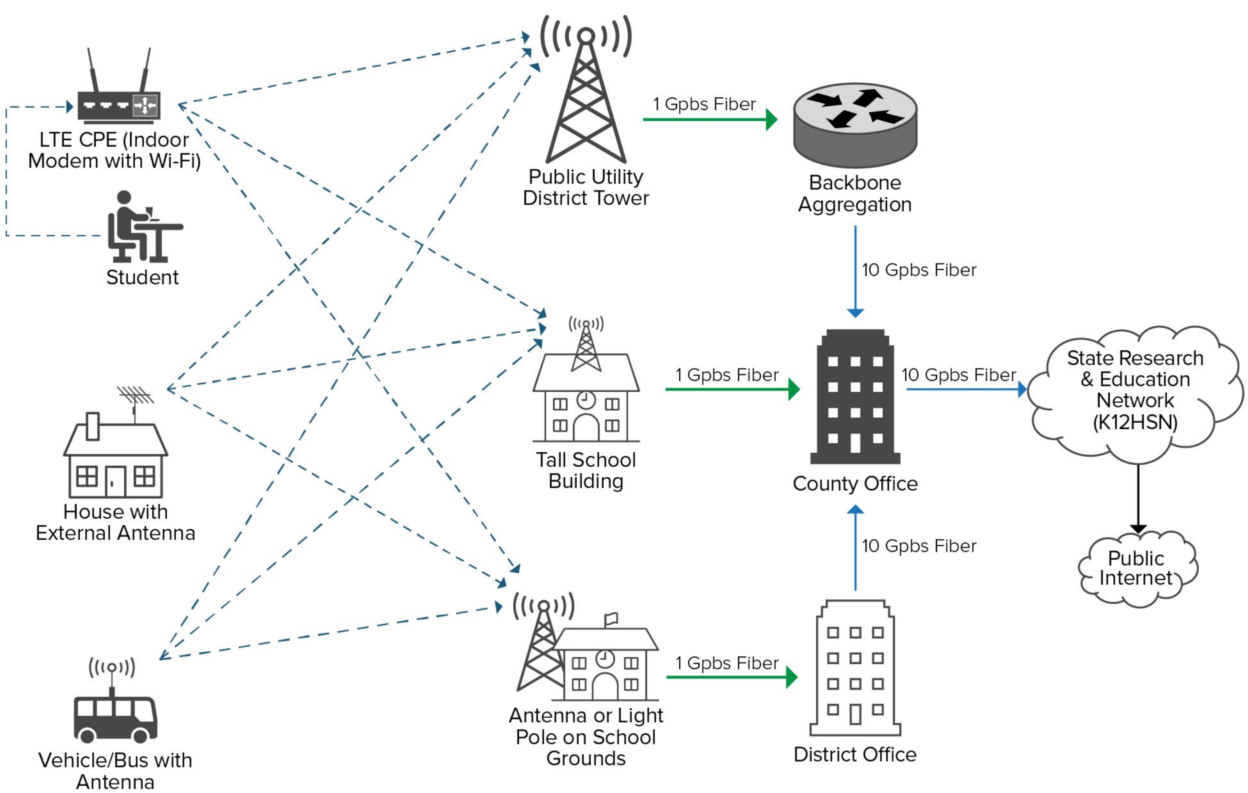

Exhibit 3: Imperial County, California, LTE Topography Map

The LTE network, named BorderLink, consists of 19 towers providing more than 1,400 square miles of coverage throughout Imperial County. Each tower is connected via a 1 gigabit fiber-optic connection fed by a 10-gigabit backbone that is also owned, operated, and maintained by IVTA. IVTA utilizes member agency-owned vertical assets such as gymnasiums, radio towers, and buildings with pre-existing connections to reduce deployment costs. The LTE network operates on 80 MHz of 2.5 GHz spectrum, which is licensed to IVTA member agencies. With this infrastructure, ICOE can fulfill its mission of providing exemplary support and leadership in technology to schools, districts, and the community, all of which are critical to student success.

There are several modalities for students and families to connect to this LTE network:

- **Mi-Fi Device.** A Mi-Fi device provides a connection for up to five devices.
- **LTE-Enabled Equipment.** Equipment has a built-in LTE-capable modem, such as the newest tablets.
- **Indoor Modems.** An indoor modem connects to the LTE network, which then provides Wi-Fi in the residence.
- **Outdoor LTE Antennas.** For residences that are farthest from the antenna, an outdoor LTE antenna can be placed outside the home to provide the signal. This outdoor unit can also provide connectivity to multi-residence complexes (e.g., high-density, low-income housing units) since they offer more data throughput capacity and can serve more students and families.

Funding and Partnerships

IVTA/ICOE built the Borderlink LTE network using local funds and federal grants. No federal or state subsidies (such as E-Rate) were used. The BorderLink project launched its first pilot in 2017–18 with the installation of six antenna systems. In August 2018, IVTA/ICOE received a series of USDA Community Facilities Grants totaling $840,000 to expand BorderLink's reach to include eight additional antennas to cover the most remote rural communities.[31] In October 2020, ICOE was awarded $1 million under the USDA Distance Learning and Telemedicine Program to provide devices to students in 22 school sites.[32] Recently, school districts in Imperial County supported the expansion using federal support from Elementary and Secondary School Emergency Relief and Governor's Emergency Education Relief funds during the COVID-19 pandemic.

ICOE leveraged strategic partnerships, shared technical expertise, and achieved economies of scale, which were instrumental in successfully deploying the BorderLink infrastructure. Partners allowed ICOE to gain access to multiple vertical assets (tall buildings, towers, etc.), allowing ICOE to place antennas in strategic locations and use

31 Staff Reporter. (2018, September 12). BorderLink project receives $840K in USDA grants to expand access across Imperial County. *The Desert Review*. Retrieved from **https://www.thedesertreview.com/education/borderlink-project-receives-840k-in-usda-grants-to-expand-access-across-imperial-county/article_04046c08-b6ba-11e8-a854-671b960f8344.html**

32 Staff Reporter. (2020, October 8). BorderLink Receives $1M USDA Grant. *Calexico Chronicle*. Retrieved from **https://beyondbordersnews.com/borderlink-receives-1-million-usda-grant/**

existing tall structures to provide coverage at no extra cost to ICOE. ICOE also took advantage of economies of scale.

Challenges

The BorderLink project faced several challenges, including setting a shared vision, identifying funding, accessing spectrum, finding adequate network resources, and securing technical expertise to manage and deploy the network.

- **Develop the Vision.** With a variety of stakeholders, it was important to develop a shared vision to ensure that each stakeholder group supported the work. They funded a small pilot project to solidify their vision for the BorderLink project and articulate the benefits to the community.
- **Connect All Students.** The geographic service area of incumbent 2.5 GHz licenses is limited to a 35-mile radius; it does not cover some of the most remote communities in Imperial County. While new 2.5 GHz licenses will be issued on a county basis, the Commission has eliminated the educational eligibility requirements on 2.5 GHz licenses, and new licenses will be awarded through competitive bidding. ICOE is actively looking for solutions to connect these communities. They have been working with different partners and commercial ISPs to coordinate use and spectrum. ICOE is exploring using the CBRS, which operates at the 3.6 GHz frequency.
- **Acquire Equipment.** ICOE found it challenging to acquire equipment during the pandemic. Planning is the key to sourcing materials and equipment, which often requires 3 to 4 months of lead time.

Successes

BorderLink successfully deployed its infrastructure, implemented its pilot initiative, and was built on successful partnerships with schools and the community to ensure that all students have adequate internet connectivity at home and access to the digital tools they need to thrive academically. It attributes its success to stakeholders' laser-focused vision, leadership and strategic partner support, ideal market conditions, and a knowledgeable IT team capable of deploying and managing the network infrastructure.

Outcomes and Impact

In March 2020, and again at the beginning of the 2020–21 school year, Imperial County schools transitioned to remote learning as a result of the pandemic. During each transition, the district offered assistance to families who did not have devices or internet connectivity at home. BorderLink is playing a critical role in ensuring that learning continues relatively uninterrupted during school closures. The small BorderLink pilots implemented in the spring and fall of 2019 were essential to local schools' ability to quickly deploy hundreds of devices. The BorderLink system saw a 100 percent increase in use within 2 weeks after the California stay-at-home order went into effect and 10 times growth at the start of the new school year. The BorderLink team prepared and deployed more than 1,000 Mi-Fi devices to the students lacking sufficient internet connectivity at home. In total, the BorderLink program deployed 2,000 devices and has 14 towers strategically located across Imperial County.

Next Steps

ICOE needs additional resources to enhance the BorderLink infrastructure, ensure IVTA meets the increasing demand placed on the network, and eliminate coverage gaps in some parts of the community. A dramatic increase in data traffic will strain the network. As a result, ICOE is looking to increase the network's capacity as IVTA continues to serve a growing number of users during the pandemic and beyond. IVTA is working with community stakeholders to plan next-generation upgrades in preparation for 5G networks to serve Imperial County.

Implementation Advice from Imperial County

- Secure spectrum (either 2.5 GHz spectrum or CBRS) or partner with the agency that holds 2.5 GHz or CBRS licenses in your area. To see the 2.5 GHz licenses available, click on the following link: **https://wireless2.fcc.gov/UlsApp/UlsSearch/searchAdvanced.jsp**. After clicking the link, select "ED- Educational Broadcast Service" in the service group drop-down box. Note that existing licensees may have leased their spectrum to third parties, which may limit availability of the 2.5 GHz spectrum. As noted above, new 2.5 GHz licenses will be issued via competitive bidding.
- Cultivate partnerships. Local partnerships are critical throughout this process. Working relationships with county and city officials, as well as all the agencies involved in the process, will allow a smooth implementation. The right partners can help coordinate resources and assets, including properties, vertical assets, communication, and power. It is also important to include your partners in discussions about future growth.
- At the beginning of the project, build your infrastructure using equipment that can handle high density. It is more cost-effective to add maximum capacity to the antennas at the outset of the project rather than at a later point.
- Reach out to districts or other agencies that have similar implementations in place and visit as many sites managing similar initiatives as possible.

Model 4: Harnessing Multiple Solutions to Bring Access to Students & Families

Lindsay, CA

Program Name: LUSD Community Wi-Fi Network

Location: Lindsay Unified School District (LUSD), California

Project Lead: Peter Sonksen, Network Administrator

LUSD ensures 24/7 internet access to online curriculum to all students/learners in an underserved rural community in central California. Through both a cellular-based service and a traditional wireless broadband solution, systems are in place to support learning.

Ensuring internet access for students has been a major priority for the district since 2007, when it worked with the community to develop a strategic design that called for 24/7 access to learning for all LUSD students.

LUSD Community Wi-Fi Network

- Student population: 4,200
- Demographics:
  - Hispanic/Latino 94%
  - White 3.5%
  - Asian 1.5%
  - Other 1%
- Economically disadvantaged/FRPL: 89%
- Location: rural
- Area covered by network: 25 mi²
- Cost to construct: $700,000
- Cost of project staff: 1 dedicated field technician; 2 FTE with other campus roles (primary network administrator & clerical/receptionist)
- Cost per square mile: $28,000
- Number of students served: 3,000
- Population served by network: Students, households with & without students at home & in public areas such as parks, community centers, etc.

Approach

LUSD uses multiple approaches to deliver internet access, including Mi-Fi units for its LTE network and an unlicensed 5 GHz spectrum. The district is also exploring the CBRS spectrum.

Before beginning this project, LUSD provided devices to students to access online curriculum and online instruction. However, as many as 60 percent of student homes had no internet service. LUSD discovered that many homes have only one internet service subscription option and, in many cases, that option could not reach internet speeds beyond ~1.5 Mbps. LUSD's goal is to provide high-speed broadband (15–25 Mbps) at no cost to ensure access to high-quality instructional materials.

The Wi-Fi project has been implemented entirely by the district. After researching services provided by existing telecommunication providers, the district determined that it could deliver faster, more cost-effective services. LUSD stopped its attempts to partner with utility providers to access their poles and lights once it became clear there was not enough money to proceed. LUSD opted for a lower-cost option: providing individual Mi-Fi units for the LTE network and conducting physical residential installations for the highest-performing CPE.

Technology Used

Exhibit 4 provides an overview of Lindsay's community LTE topography map.

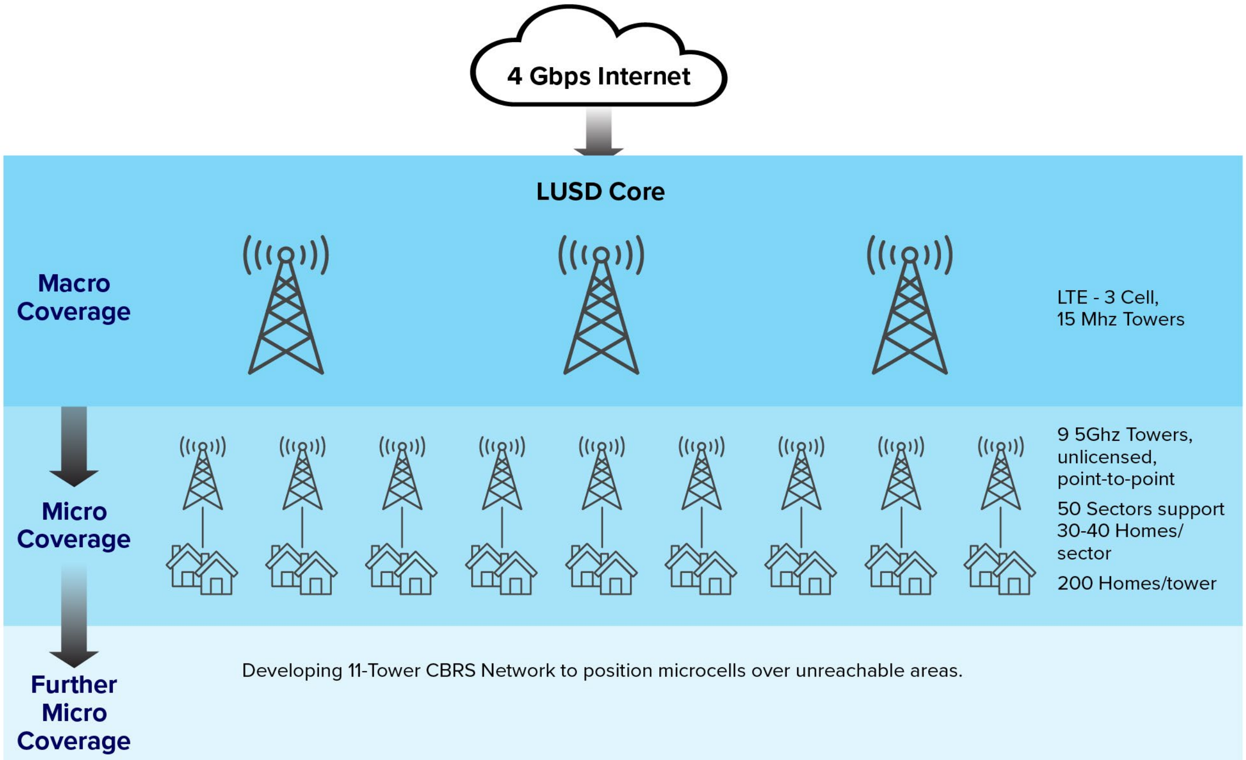

Exhibit 4: Lindsay, California, LTE Topography Map

LUSD's Community Wi-Fi Network consists of two wireless technologies, with a third technology in development. Internet infrastructure consists of a 4-gigabit internet line and connectivity to support 1 gigabit for Community Wi-Fi. Children's Internet Protection Act-compliant filtering costs are supported by LUSD and provided for Community Wi-Fi.

- **LTE.** LUSD has three LTE towers consisting of three cells for each tower running 15 MHz bands servicing max capabilities of 60–70 Mbps per cell. The LTE access points connect in many cases to a local controller. This controller connects to another controller owned and operated by an organization (or shared between many) and is often referred to as a core. LUSD hosts its own core but is planning to integrate with a core that is being purchased by the county.
- **Unlicensed 5 GHz Point-to-Point Spectrum.** LUSD has nine towers with 50+ sectors using traditional unlicensed 5 GHz spectrum. These towers reside on LUSD school property, city/public property, and other select businesses that have tall buildings. These sectors support, on average, about 30–40 homes per sector. LUSD provides a field service technician to support occasional repair needs. While this technology offers the highest potential bandwidth, it covers a much smaller area per sector compared to LTE. It is also more susceptible to interference and

overall system degradation due to spectrum rule changes and increased public and residential use over time.

- **CBRS *(in development)*.** LUSD is building out a CBRS network to position microcells to cover densely populated areas that cannot be reached with 5 GHz installations or enough LTE density to support bandwidth needs. This technology provides a greater coverage area than 5 GHz, but it offers lower potential bandwidth capabilities. CBRS provides greater potential bandwidth than LTE, but with a smaller coverage area.

Funding and Partnerships

LUSD uses general funds to build and maintain these networks. LTE, 5 GHz, and CBRS technologies and equipment have been funded entirely by general funds. Federal grants such as the Teacher and School Leader Incentive Program, the former Race to the Top District program, and others have provided additional sources of staff funding, which has allowed LUSD to free up other funding sources for the off-campus student internet network.

A partnership between LUSD and the City of Lindsay has made it possible to access ideal tower locations. LUSD also contracts with third parties to take on liability and perform the initial installation of physical residential installations.

Challenges

- **Equipment Access.** The biggest challenge regarding LTE and CBRS is the availability of equipment that supports the EBS and CBRS bands. LTE equipment manufacturers heavily cater to major cellular providers. As a result, it can be difficult for schools to find compatible CPE devices or infrastructure pieces to support these technologies. It is also costly and difficult to predict district needs to purchase bulk supplies. LUSD has worked with other school districts to find alternative solutions as equipment nears the end of life.
- **Legal Hurdles.** LUSD worked with its lawyers and County Council to determine legal liabilities of accessing and implementing systems. These liabilities included potential residential damage due to CPE installation and employee safety that needed to be addressed.
- **Connectivity and Installation Process.** LUSD has thoroughly vetted all sign-up forms used by families to apply for internet access, as well as processes for how those installations are handled. These forms and processes are now publicly available on the LUSD website.[33]

33 **https://www.lindsay.k12.ca.us/community-wifi-15816854**

Successes

During COVID-19 facility closure, LUSD ensured continuity of learning. Students continued learning and communicating with their teachers and other district health services during facility closures. While core learning target completion has slowed in the current remote learning format, there are still meaningful gains and completion of targets in all grade levels and content areas.

Outcomes and Impact

Since LUSD has proven itself a superior internet provider to underperforming DSL or other wireless ISPs in the area, many families have opted into LUSD's no-cost service. LUSD saves its community more than $700,000 per year by providing faster service than other options. It also continues to update and improve its services over time.

Next Steps

LUSD is working to help coordinate all central California school districts to build a massive learning network for all California Central Valley learners. Eventually it may be possible to create a California-wide educational network to support home access for students in Northern and Southern California.

Implementation Advice from Lindsay Unified

Know the minimum bandwidth necessary for your students and teachers to use and access educational resources. This can help you balance how and where your students receive service.

- Be sure to have tech-support hotlines in place for families to call when they are experiencing connectivity issues and be mindful of families' primary home languages in your area.
- When considering implementing a wireless solution of any type, never assume you will achieve theoretical maximum capabilities (e.g., throughput) of that network. Recognize that every solution has limitations.
- Familiarize yourself with the coverage capabilities of the types of technology you are considering — 5 GHz and CBRS are great solutions in rural areas but are often more challenging to implement in urban/developed areas. Test and confirm real-world service capabilities of any solution you are considering.
- Be realistic in what you are looking to accomplish.

Model 5: Building Public-Private Partnerships to Connect Low-Income Students at No Cost

Boulder, CO

Program Name: Livewire ConnectME Program

Location: Boulder Valley School District (BVSD), Colorado

Project Lead: Andrew Moore, Chief Information Officer

BVSD serves both the city and suburban communities of Boulder, CO. It includes 56 schools located in 11 communities. BVSD has a FRPL population of 20 percent; however, some schools exceed 65 percent. Secondary schools use a 1:1 Chromebook-enabled learning model. Elementary schools use cart-based Chromebooks as needed throughout the day.

"Excellence and Equity" is BVSD's motto. This motto guides decision-making to ensure all students have an equitable opportunity to learn.

BVSD's mission is to create challenging, meaningful, and engaging learning opportunities so that all children thrive and are prepared for successful, civically engaged lives.

ConnectME

- Student population: 31,169
- Demographics:
  - White 68%
  - Hispanic/Latino 19%
  - Asian 6%
  - Black/African American 1%
  - Other 6%
- Economically disadvantaged/FRPL: 20%
- Location: urban, rural, suburban
- Area covered by network: 500 mi²
- Cost to construct: $0 for BVSD
- Cost of project staff: .5 FTE
- Cost per square mile: n/a
- Number of students served: 300, expanding to 750–1,000
- Population served by network: Students, families (student households)

Approach

BVSD established a public/private partnership with Livewire Networks (Livewire) called ConnectME. BVSD provides real estate (schools), power, and access to dark fiber-optic lines in exchange for free internet services to all FRPL-qualifying students and their families. BVSD also receives 25 percent of Livewire's revenue generated from any necessary equipment installed on any BVSD site. If Livewire sells its service to the non-FRPL school community in which they have installed equipment, BVSD receives 25 percent of that revenue.

In the early 2010s, BVSD offered internet access from its nearby fiber network to a neighboring public housing community, only to learn the E-Rate-funded service could not be used outside of traditional brick and mortar schools. BVSD submitted an FCC waiver[34] request for permission to continue carrying out the project. Although the request was released for public comment in 2016, the FCC has yet to issue a ruling. This has forced BVSD to search for other ways to get internet access to all qualifying

34 The waiver request can be found at the following URL: https://ecfsapi.fcc.gov/file/60001843683.pdf

students in need. BVSD's initial goals were to identify an over-the-air/wireless service provider and test the feasibility of exchanging access to district-owned real estate for the free internet service to qualifying low-income students. The 2.5-year pilot began in 2017. In April 2020, the board of education approved a contract to expand the technology district-wide.

This approach was developed to ensure all students had an equitable opportunity to learn when the existing telecommunications companies either did not have a low-cost internet option available or requirements for participation in the low-cost option proved to be barriers for some families. The limitations of the E-Rate Program further restricted BVSD's ability to address the issue alone and pushed the district to identify a novel approach that would benefit both BVSD and private ISPs.

Technology Used

Exhibit 5 provides an overview of Boulder Valley's LTE topography map.

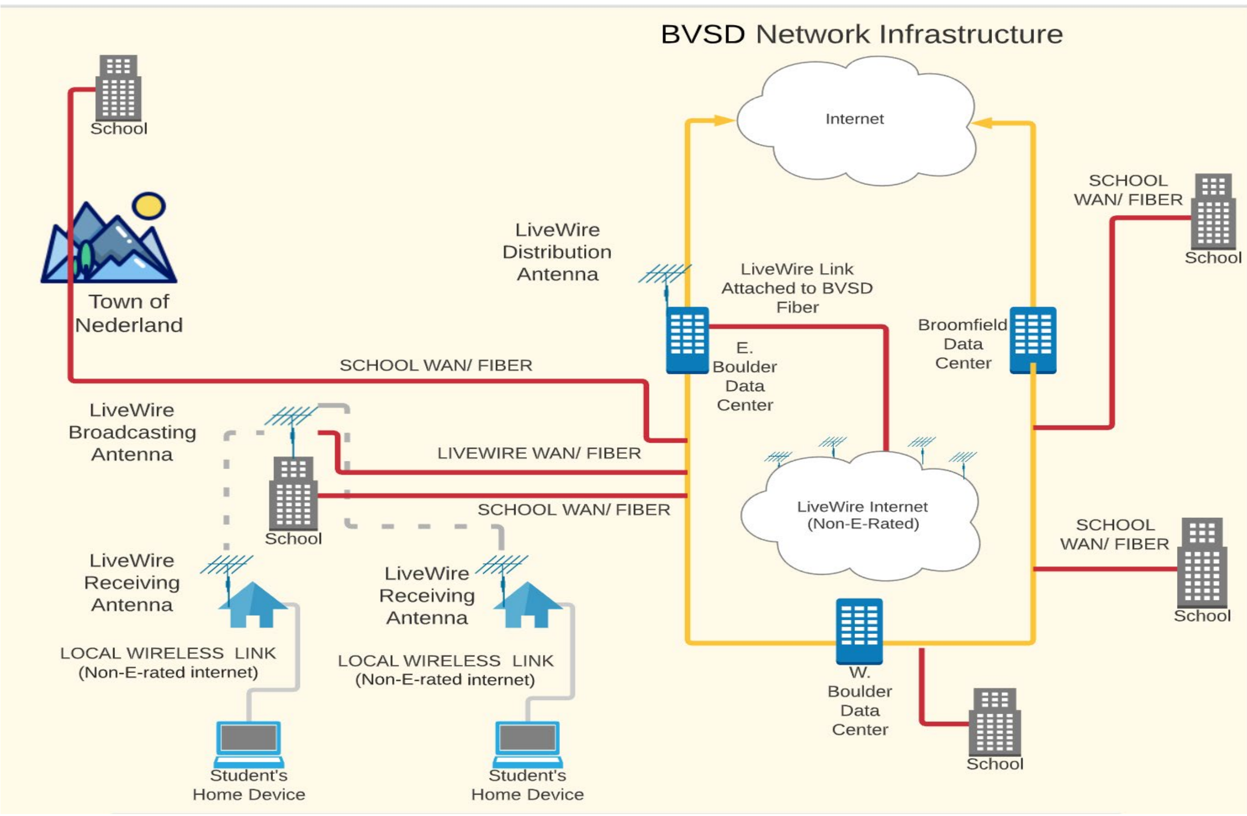

Exhibit 5: Boulder Valley, Colorado, LTE Topography Map

Livewire Assets:

- All school-based transmitting/receiving equipment, including antennas.
- All student home-based equipment, including wireless routers.

BVSD Assets:

- Backhaul using a single strand of BVSD bond-funded dark fiber-optic line per school that was not funded with E-Rate support.
- Homerun (dedicated line) of the dark fiber-optic line Livewire uses to a central facility where non-school internet access can be obtained.

Funding and Partnerships

The 100-mile BVSD fiber-optic line that serves as the backbone of the network was paid for by BVSD taxpayers in a 2007 voter-approved bond. This line is a critical asset that was necessary for facilitating the Livewire partnership. If the fiber-optic line had been funded using E-Rate funds, BVSD would have faced restrictions that would prevent it from using the network to connect students off-campus. Livewire covers all other costs, including the connection costs for FRPL-qualified students.

Finding and establishing the partnership with Livewire over the pilot period was critical to signing the 10-year agreement. The partnership would not have happened without a win-win partnership mentality from both BVSD and Livewire built on trust established during the pilot. The pilot phase allowed BVSD and Livewire to work together through technical and political challenges to develop the agreement.

Challenges

- **E-Rate Restrictions.** BVSD's main challenge was navigating E-Rate rules that restricted the district from extending internet off-campus to the homes of students in need. These restrictions remain a hurdle for many districts, but BVSD found a way to be E-Rate-compliant through its partnership with Livewire.
- **Parent Concerns.** BVSD also ran into a period of parent concern on the use of technology, which delayed the development and signing of the contract for about a year. BVSD alleviated parent concerns by purchasing and deploying a web-filtering and classroom-monitoring solution. The solution provides web filtering away from school on any student device on a Chrome browser and logged in with their student ID. It also allows teachers to "see" what students are working on and allows teachers to restrict what tabs/sites are open.

Successes

Success is directly measured by how many students have been successfully connected through the ConnectME program. This number has increased 25 percent since the contract was signed in April 2020.

Outcomes and Impact

The goal of this project is to allow any student who otherwise would not have had internet access at home to have the same opportunities as other students who have in-home internet connectivity. A student lacking internet access at home must go to the library or other commercial place with free Wi-Fi to do homework. A student with home broadband simply needs to log on. During the pandemic, all students need in-home internet access to participate in synchronous remote learning environments and receive an equitable learning experience.

Next Steps

BVSD will continue working with Livewire to find ways to speed the deployment to all BVSD schools. The agreement allows 3 years for full buildout. BVSD is looking for ways to extend the agreement.

Implementation Advice from Boulder Valley

- Districts should be aware of and carefully consider the E-Rate funding restrictions when they consider building new networks. E-Rate-funded fiber-optic lines include restrictions that limit flexibility for providing off-campus access for students and permit revenue-generating agreements.
- Do not hesitate to try different approaches, especially around the different spectrums.
- Have patience — it will take time.
- Know there are others who can help if you run into problems. Connect with other district leaders through organizations like the Schools, Health, and Libraries Broadband Coalition (SHLB) at shlb.org and CoSN (Consortium for School Networking online) at cosn.org.

Model 6: Leveraging Partnerships to Bring Fiber Optics and Private LTE to Underserved Students

Fresno, CA

Program Name: Connect2Learn

Location: Fresno Unified School District, California

Project Lead: Dr. Philip Neufeld, Executive Officer, Information Technology

FUSD in Fresno, CA, has more than 70,000 students, 4,000 teachers, and 90 schools. FUSD prepares students with the knowledge, skills, and dispositions they need to navigate a dynamic, interconnected, technology-infused world. FUSD believes that the intentional use of technology in teaching engages students, enables adaptive and inclusive learning experiences, and cultivates modern skill competencies. FUSD students are economically challenged with high poverty levels and have an ethnically diverse population in which students speak nearly 100 languages.

FUSD's Connect2Learn initiative demonstrates that students who are provided with personalized, blended learning perform better on state assessments, are more engaged, and become better prepared for their futures.

ConnectME

- Student population: 74,000
- Demographics:
  - Hispanic/Latino 68%
  - Asian 11%
  - White 9%
  - Black/African American 8%
  - Other 4%
- Economically disadvantaged/FRPL: 88.3%
- Location: urban
- Area covered by network: 20 mi^2
- Cost to construct: $1,400,000
- Cost of ongoing maintenance: $150,000
- Cost of project staff: 2 FTE
- Cost per square mile: $70,000

Implementation of the Connect2Learn initiative over the past several years and the subsequent use of hybrid learning in response to COVID-19 have revealed a strong need for long-term off-campus digital access for all students.

Approach

During the past 12 months, FUSD increased students' access to mobile hotspots and families' adoption of broadband, built-out fiber-optic infrastructure and consulted with the California Public Utilities Commission and local providers. FUSD considered technologies, such as EBS and CBRS, and strategies, such as deploying LTE networks, that would reduce deficiencies in internet access, especially among underserved students.

FUSD listened to students, families, and educators during remote school sessions and learned about variations in the quality and capacity of neighborhood networks. They found that mobile hotspots occasionally left students disconnected from class meetings when their local cellular service was inadequate or when they exceeded monthly data usage limits. Cellular carriers also have far fewer cell towers in poorer neighborhoods, which results in inferior internet service. Many families cannot afford cable broadband subscription services and families that did have cable broadband services found that these services had insufficient bandwidth when families needed to share the network for learning and working.

Based on this research and the listening sessions, FUSD developed a multi-layered approach to advocate for more affordable broadband, collaborate with anchor institutions to improve fiber infrastructure, and provide internet access to students who need it. FUSD awarded a request for proposal to deploy private LTE services for students in serviceable areas around schools in the southern region of Fresno. FUSD chose to leverage its fiber-optic backhaul and school buildings as platforms to deploy a private LTE CBRS service to deliver internet to students. Phase I included LTE at 15 school facilities and towers covering about 20 square miles and supporting 6,500+ concurrent student connections in an area with approximately 18,000 students.

Technology Used

Exhibit 6 provides an overview of Fresno's topography map.

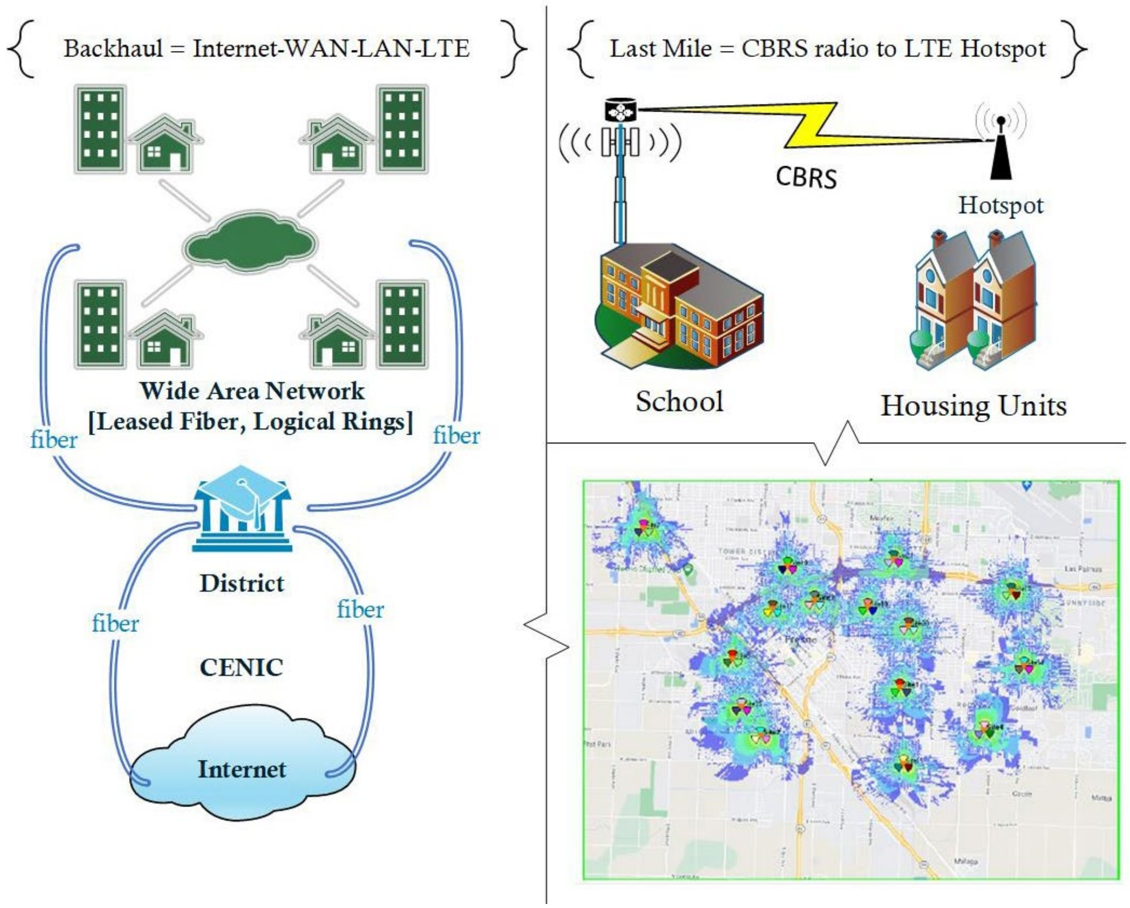

Exhibit 6: Fresno, California, LTE Topography Map

The district leveraged existing fiber backhaul, including the district's wide area network (WAN) that connects more than 111 sites to the district headquarters, as well as two internet fiber paths that connect the district headquarters to CENIC's California Research and Education Network. The district's WAN includes switched **ethernet circuits** and a leased fiber ring. FUSD used district facilities at 15 schools as elevated platforms to reduce permitting requirements and time to deployment of LTE radios/antennas. The LTE radios transmit to CPE, using hotspots.

> An **ethernet circuit** is high-speed ethernet bandwidth of 1 Mbps to 10 Gbps delivered as ethernet over fiber, ethernet over DS3, ethernet over T1, or ethernet over copper phone lines. Ethernet internet access is also known as an ethernet circuit, ethernet Line, or ethernet Access.

Funding and Partnerships

FUSD is using CARES Act funding to build the network and general funds for ongoing operations and maintenance. FUSD is partnering with anchor institutions and seeking additional funding to further the reach of the LTE network.

Challenges and Successes

The criterion for success is that all students have basic internet access sufficient to the speed requirement for the district's standard learning platforms. This requires addressing each of the following layers: providing more fiber-optic in underserved areas, offering more connections to community centers and apartment complexes, providing more available, affordable broadband for student internet service, and creating LTE that reaches beyond the campus. FUSD faces many challenges, including:

- Lower adoption of broadband cable in underserved neighborhoods.
- Inadequate cellular data service in underserved neighborhoods.
- Hotspots limited in data use with costs that are not financially sustainable by district.
- Unavailable access to licensed spectrum. Because the 2.5 GHz spectrum in Fresno is licensed to commercial carriers, FUSD is using the CBRS GAA level.

To address the challenges above, the district is in conversations with broadband providers and cellular carriers to find ways to improve service to these target areas. It is also leading community conversations about how to hold these carriers accountable to deliver equitable internet access to students.

Outcomes and Impact

Improvements to the district's Wi-Fi, WAN, and internet over the past 5 years were the necessary conditions for substantial improvements in teaching and learning. Following school re-openings, the off-campus digital learning gap will be amplified unless students have access to reliable, affordable, high-performance internet access at community centers and within housing units. Improvements to the digital ecosystem —

including more fiber-optic infrastructure, better broadband for student internet access, and internet around the campus using LTE — will support rich, relevant learning for all students.

Next Steps

Next steps include deploying private LTE, rolling out leased fiber WAN, and collaborating with public and private partners to better solve for equitable student access across Fresno.

Implementation Advice from FUSD

- Recognize there are multiple challenges requiring a multilayered approach.
- Reach out to equipment manufacturers, systems integrators, and other districts to learn what does or does not work, and to identify sustainable solutions.
- Consider variations in housing units and patterns of technology adoption when selecting solutions.
- Find ways to leverage existing assets and partner with public organizations and private entities.

Conclusion

The pandemic has revealed underlying gaps in our national broadband infrastructure that impact educational opportunities and outcomes for students. As students return to school buildings and we move from pandemic response to recovery, it is important to remain focused on addressing the digital divide for students. While we hope that we never experience another disruption on this scale, disruptions are inevitable and continuity of learning will be threatened by natural disasters, snow days, and when individual students face long-term illnesses or other absences. It is essential to take note of the lessons learned, build on the creative solutions employed, invest in the partnerships built, and plan for long-term, sustainable solutions to strengthen our resilience in the face of future disruptions.

Key Takeaways

- **Design for all student experiences.** Consider the range of student home environments that your network will need to operate within and select technology solutions and design policies that are flexible enough to accommodate a range of internet access, affordability, and adoption challenges. For example, households with multiple siblings may need more bandwidth; students who split time between different homes may need access at both locations; unhoused or highly mobile students will need solutions that can travel with them and still provide reliable access; and English learners and their families may need tech support in their home language.
- **Planning.** Design and build with the future in mind. Plan your network to serve the number of students you have now and future student population growth. Start small with pilot projects to demonstrate viability and build support, but consider your long-term needs to avoid higher costs down the road. Bandwidth needs will grow as technologies change, so ensure your plan is scalable.
- **Partnerships.** Develop partnerships with organizations in your community. Collaborating with local government, civic organizations, libraries, and other groups will open doors to resources and expertise that will support planning and execution of the network. Consider starting a local broadband team to build your plan.
- **Coalitions.** Consider forming coalitions with nearby districts to leverage economies of scale and lessons learned. Shared problems can lead to creative and cost-effective shared solutions.
- **Consider federal and state grant opportunities.** The districts profiled in this brief used Race to the Top funding, state competitive grants, CARES Act funding, and the USDA Community Facilities Direct Loan and Grant Program to fund components of their networks. Consider collaborating with community partners who may have access to additional grant funding not available to schools.

- **Talk with telecommunications companies.** Talk with every telecommunications company that serves your district, including start-up ISPs and larger cellular companies. Attempt to negotiate deals for student purchases. Discuss how you can work together to share ownership and maintenance of network equipment, including towers. Consider placing towers on all school facilities.
- **Learn from successful implementations.** Virtually visit places that have successfully built what you are planning. Learn about their main roadblocks and how they developed solutions. Education technology leaders are eager to share their solutions with their peers. Utilize their knowledge.
- **Check the availability of the proposed wireless solutions in your area.** If you consider leveraging 2.5 GHz, CBRS, white space, or 5 GHz spectrum, explore whether they are available in your area and how much of that availability is saturated.
- **Track federal legislation and funding developments.** Several professional organizations closely track federal broadband legislation and funding developments for their members. As federal agencies develop new grant programs or make changes to existing programs (e.g., E-Rate), there are often opportunities for the public to weigh in via the public commenting process. Consider weighing in on proposed updates that impact education stakeholders by providing supporting research, data, and examples.
- **Be realistic about the budget.** Finally, look carefully at spending over time. Consider your current and future baseline budget as well as emergency stimulus funding that may be temporarily available. Understand which expenses are one-time expenses and which are ongoing expenses. Ensure that your plan is financially sustainable and can provide for future needs.

Glossary of Terms

Term	Definition
Acceptable Use Policy (AUP)	A set of rules applied by the administrator of a computer network, website, or service that outlines how site visitors and customers use or operate a set of computing resources. *Source: Institute for Local Self Reliance*
Backbone	The main network connections that interconnect different networks to provide a path for long-distance communication. Examples include local area networks (LAN) such as offices or campuses. Several LANs interconnected over vast areas result in a wide area network or metropolitan area network. *Source: Techopedia*
Backhaul	The segment of a network between the core network or backbone network and the small subnetworks at the edge of the network (e.g., the connection from a community network hub in a small town to a carrier hotel where it connects to the internet backbone). *Source: Institute for Local Self Reliance*
Bandwidth	The rate at which the network can transmit information. Generally, higher bandwidth is desirable. The amount of bandwidth available to you can determine whether you download a photo in 2 seconds or 2 minutes. *Source: Institute for Local Self Reliance*
Bond Issue	Education bonds are voter-approved funds that can only be used for school facilities. Districts collect this money by taxing property owners on the assessed value of their properties. Districts sell the bond to investors. The local bond is similar to a loan. It is much like a home equity line, but for the school district. *Source: Institute for Local Self Reliance*
Broadband	Broadband internet is a speed benchmark set and updated by the FCC. The benchmark was last updated in 2015 to define broadband as 25 Mbps download speeds and 3 Mbps upload speeds. "Broadband" is generally shorthand for quality internet service. Broadband provides high-speed internet access via multiple types of technologies, including fiber-optics, wireless, cable, DSL, and satellite. *Source: Institute for Local Self Reliance*

Term	Definition
Children's Internet Protection Act (CIPA)	A requirement for K–12 schools and libraries using E-Rate discounts to operate "a technology protection measure with respect to any of its computers with Internet access that protects against access through such computers to visual depictions that are obscene, child pornography, or harmful to minors." *Source: Federal Communications Commission*
Citizens Broadband Radio Service (CBRS)	150 MHz of spectrum in the 3.5 GHz band (3550–3700 MHz) in the United States with a three-tiered access and authorization framework to accommodate shared federal and non-federal use. On January 27, 2020, the FCC authorized full-scale commercial deployment in the CBRS band. *Source: Federal Communications Commission*
Cloud-based	Digital data that is stored, managed, and processed on a network of remote servers hosted on the internet rather than on local servers or personal computers. As we gain access to faster internet connections (particularly on the upstream), cloud services may offer cheaper means of accomplishing tasks and more reliable backups. *Source: Institute for Local Self Reliance*
Community Facilities Direct Loan & Grant Program	This program within the United States Department of Agriculture (USDA) provides affordable funding to develop essential community facilities in rural areas. An essential community facility is defined as a facility that provides an essential service to the local community for the orderly development of the community in a primarily rural area. *Source: https://www.rd.usda.gov/programs-services/community-facilities-direct-loan-grant-program*
Customer Premises Equipment (CPE)	The box or antenna on the side of a house that receives and sends the signal from the wired or wireless network, connecting the subscriber. *Source: Institute for Local Self Reliance*
Dark Fiber	Unused fiber-optic infrastructure that has not been "lit" with internet service. When someone is building a fiber-optic network, the cost of adding more fiber-optic than is immediately required is negligible and the cost of having to add more fiber-optic later is very high. Therefore, many include dark fiber-optic in projects. These fibers can be leased to others or held in reserve for a future need. *Source: Institute for Local Self Reliance*

Term	Definition
Dial-Up Access	A connection from your computer that goes through a regular telephone line. You use special communications software to instruct your modem to dial a number to access another computer system or a network. *Source: Institute for Local Self Reliance*
Digital Equity	A condition in which all individuals and communities have the IT capacity needed for full participation in our society, democracy, and economy. Digital equity is necessary for civic and cultural participation, employment, lifelong learning, and access to essential services. *Source: National Digital Inclusion Alliance*
Digital Redlining	The practice of creating and perpetuating inequities between already marginalized groups specifically through the use of digital technologies, digital content, and the internet. For example, ISPs invest in building fiber infrastructure in wealthier neighborhoods while under-investing in the broadband infrastructure in low-income communities, resulting in low-income broadband users with more expensive, slower access. *Source: DigitalInclusion.org*
Digital Subscriber Line (DSL)	Internet access offered over phone lines that allows users to use the internet at speeds greater than dial-up while also using the phone line for telephone conversations. DSL uses frequencies not used by human voices. Unfortunately, these frequencies degrade quickly over distance, meaning customers must live within a mile or even much closer to the central office to get the fastest speeds. Upstream speeds over DSL tend to top out at 5 Mbps. *Source: Institute for Local Self Reliance*
2.5 GHz or Educational Broadband Service (EBS)	The former EBS, previously known as the Instructional Television Fixed Service (ITFS), is a service in the 2.5 GHz spectrum band that the FCC previously set aside for educational institutions but is now open to flexible use. *Source: https://www.fcc.gov/wireless/bureau-divisions/broadband-division/broadband-radio-service-education-broadband-service*
E-Rate	The FCC's E-Rate program makes telecommunications and information services more affordable for schools and libraries. With funding from the Universal Service Fund (fcc.gov/general/universal-service-fund), E-Rate provides discounts for telecommunications, internet access, and internal connections to eligible schools and libraries. *Source: https://www.fcc.gov/consumers/guides/universal-service-program-schools-and-libraries-e-rate*

Term	Definition
Ethernet	Network technology that enables data to travel at 10 Mbps. An ethernet connection is often referred to as a "direct connection" and is capable of providing data transmission speeds over 500 Kilobits per second. *Source: Dataprise.com*
Federal Communications Commission (FCC)	The FCC regulates interstate and international communications by radio, television, wire, satellite, and cable in all 50 states, the District of Columbia, and U.S. territories. *Source: Federal Communications Commission*
Fiber-optic	A system that uses glass (or plastic) to carry light, which is used to transmit information. Typically, each side of the fiber is attached to a laser that sends the light signals. When the connection reaches capacity, the lasers may be upgraded to send much more information along the same strand of fiber. This technology has been used for decades and will remain the dominant method of transmitting information for the foreseeable future. *Source: Institute for Local Self Reliance*
Free or Reduced-Price Lunch (FRPL)	A federally assisted meal program operating in public and nonprofit private schools and residential childcare institutions. It provides nutritionally balanced, low-cost or free lunches to low-income children each school day. *Source: U.S. Department of Agriculture/Food and Nutrition Service*
Fixed wireless	A connectivity model that uses stationary wireless transmission to bridge the "last mile" between the internet backbone and the subscriber. *Source: Institute for Local Self Reliance*
Homework Gap	The homework gap is a term used to describe the inequities between students who have devices and internet connectivity at home and those who don't and, as a result, struggle to complete schoolwork at home.
Hotspots	Wi-Fi hotspots are physical locations, such as an airport or coffee shop, where people can wirelessly connect their device(s) to the internet using Wi-Fi via a wireless local area network. A mobile or portable hotspot uses the smartphone's data connection to connect or "tether" their device(s) to the internet.
Hybrid Learning	Hybrid learning occurs when a student uses both in-class and online instruction to learn course material.
Internet Service Provider (ISP)	An organization that provides services for accessing or using the internet.

Term	Definition
Joint Powers Authority (JPA)	An entity permitted under the laws of some U.S. states (e.g., California) whereby two or more public authorities (e.g., local governments, or utility or transport districts), not necessarily located in the same state, may jointly exercise any power common to all of them. By combining their commercial efforts, public authorities can achieve economies of scale or market power. For example, National IPA is a purchasing consortium of local government and education agencies. *Source: California Association of Joint Powers Authority*
Line-of-sight	Line-of-sight wireless provides a fixed wireless internet connection to buildings that have a clear line-of-sight to an antenna, often on a tower or mast but potentially on the roof of another building. This eliminates the need to install cables underground or on utility poles, provides faster installation times, and lowers the initial cost to deploy.
Long-Term Evolution (LTE)	The LTE network is a standard for 4G wireless broadband technology that offers increased network capacity and speed to mobile device users. The next upgrade in LTE, 5G, is underway. *Source: Institute for Local Self Reliance*
Mi-Fi	A Mi-Fi device works as a mobile Wi-Fi hotspot that allows multiple end users and devices to share the broadband connection. *Source: Institute for Local Self Reliance*
Out-of-School/Off-Campus Wi-Fi Network	A network that can be accessed and used by students and parents at home or at other community sites to obtain internet access.
Spectrum	Spectrum allows for transmission of information (such as data or sound) via radio waves measured in kilohertz, megahertz, or gigahertz.
Telecommunications company	A provider of telecommunications services such as voice (telephony) and data services, commonly called carriers or local exchange carriers. Incumbent local exchange carriers (ILECs) are incumbent providers, such as AT&T or Verizon.
Throughput	The speed of message delivery.
White Space	The unused TV channels between the active ones in the VHF and UHF spectrum as well as available spectrum in the 600 MHz band service. These are typically referred to as the “buffer” channels. This unused spectrum between TV stations and available spectrum in the 600 MHz band service is called white space and encompasses the 54–88 MHz (VHF-TV channels 2–6), the 174–216 MHz (VHF-TV channels 7–13), and the 470–698 MHz spectrum bands. *Source: FCC*

Term	Definition
Wi-Fi	Wi-Fi is a popular wireless networking technology that uses radio waves to allow computers and other devices to communicate over wireless high-speed signals.
Wireless Router	A wireless router connects directly to a modem by a cable. This allows it to receive information from — and transmit information to — the internet. The router then creates your home Wi-Fi network using built-in antennas.

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Project Team

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