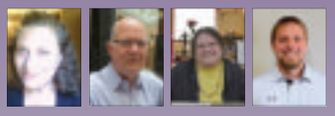

"By implementing a TVWS network, libraries have the potential to support access and inclusion in new ways."

Addressing the Homework Gap with TV White Space Networking Technology

A Case Study from Beatrice, Nebraska

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Anderson (2017) defines the "homework gap" as "the gap between school-age children who have access to high-speed internet at home and those who don't" and estimates "that 5 million school-age children do not have a broadband internet connection at home, with low-income households accounting for a disproportionate share" (n.p.).

The Federal Communications Commission (FCC, 2011) defines community anchor institutions (CAIs) as "schools, libraries, hospitals and other medical providers, public safety entities, institutions of higher education, and community support organizations that facilitate greater use of broadband by vulnerable populations, including low-income, the unemployed, and the aged" (p. 38). As the FCC suggests, through their role as CAIs, schools have the potential to close the homework gap by providing internet access to community members.

TV WHITE SPACES

TV white space (TVWS) represents an emerging low-cost wireless technology that has the potential of expanding schools' abilities to extend their Wi-Fi signals beyond the building and beyond school hours to public spaces such as subsidized housing, schools, clinics, museums, senior centers, and other community spaces (Rebmann, Te, & Means, 2017). As CAIs, schools (and, by extension, school libraries) can plan and develop TVWS-enabled wireless networks, which make possible the implementation of Wi-Fi hotspots in public spaces previously unserved by the internet. Some examples of spaces that can host TVWS-enabled hotspots include public parkland, housing initiatives for homeless populations, postal centers, and spaces for seniors. Libraries are key leaders in the adoption path of TVWS due to their recognized role in supporting the nation's underserved populations with access to broadband (Horrigan & Duggan, 2015; Inklebarger, 2015; Pew Research Center, 2015).

Traditionally, libraries have only been able to provide internet access to patrons within the library building and spaces located within Wi-Fi range. By implementing a TVWS network, libraries have the potential to support access and inclusion in new ways. This article describes TVWS wireless technology and efforts to use it to close the homework gap. Focus is placed on one case of a TVWS network implementation in Beatrice, Nebraska. This case study describes the design and implementation of the network and associated hotspots. This study extends previous descriptions of TVWS in libraries (Rebmann & Means, 2017; Rebmann, Te, & Means, 2017) by focusing specifically on the homework gap.

WHAT IS TVWS?

In 2008, the Federal Communications Commission released bands of spectrum, located in the lower frequency bands, designated by license-free use by the public. These bands of frequency are referred to as TVWS. There are several benefits to using TVWS to propagate internet signals: (1) limited "line of sight" requirement, (2) strong signal propagation, (3) ability for signal to pass through certain physical obstructions (e.g., buildings or trees), (4) free access, and (5) libraries can extend signals beyond their buildings to provide internet access to hotspot locations hundreds or even thousands of meters away (Chavez, Littman-Quinn, Ndlovu, & Kovarik, 2015). The power

(and value) of TVWS lies in the fact that it uses free public spectra and does not require subscription fees beyond the purchase of equipment. Whereas traditional Wi-Fi networks can only reach patrons in the immediate vicinity of the school, TVWS-enabled implementations can support internet hotspots anywhere the community identifies need and populations of underserved.

Small and rural schools and school libraries have an advantage with the potential for installing TVWS networks. For example, rural communities have greater channel availability, and competition for those channels (from independent broadcasters and private media companies) is low. Despite these advantages, smaller communities may face the challenge of having slower backhaul (broadband connection rates). For this reason, their connections might not meet requirements for successful TVWS installations. TVWS networks require a minimum backhaul of at least 30 megabits per second. Schools are wise to work with information technology professionals to identify broadband availability/speed and to ascertain the presence of channels in their area.

Once an organization decides that it is ready to design and implement a TVWS network, it follows several steps:

1. Ensure the current connection to the internet is at least 30 megabits per second.
2. Identify community locations where internet access is needed.
3. Investigate channel availability and noise floor. Use a database like the one provided by Spectrum Bridge, Inc., to find channels with relevant noise estimates (http://whitespaces.spectrumbridge.com/whitespaces/home.aspx). Schools should search for fixed devices (mobile devices are not yet available) based upon their city and state or zip code. Relevant channels are in the range of 14 to 51. Noise estimates should achieve a noise floor threshold of -90 dBm or smaller (-100 would be more optimal than -90 and so on).
4. TVWS equipment suppliers will coordinate the process (with schools and/or school libraries) needed to access TVWS frequencies and complete the equipment installation for a new network. Networks require a TVWS base station (integrated with an existing wired connection to the internet) and several TVWS hotspots for installation at planned community spaces to broadcast and receive internet signals.
5. Some schools and libraries may choose to partner with local internet service providers or equipment installers to implement new networks.
6. Troubleshooting installations addresses challenges associated with signal strength, software/firmware updates, and equipment functionality.

RESEARCH STRATEGY

In 2016, the Institute of Museum and Library Services (IMLS) awarded the project team a grant to develop five TVWS installations across the United States. Beatrice Educational Service Unit 5 (ESU 5) and Beatrice Public Library (in Beatrice, Nebraska) received one of the subawards. ESU 5 provides several school districts in Nebraska with services in the areas of school improvement and staff development, special education and early childhood development, interactive and web-based distance learning, behavior management, alternative high school, media services, curriculum and instruction, and leadership training. This article charts the early stage implementation of the equipment and answers the following research questions:

1. What is the feasibility of TVWS being successfully implemented in a small community in rural Nebraska?
2. Will a TVWS network result in increased network usage by community members and youth participating in afterschool programs?
3. What challenges will emerge as part of this project design and implementation?

SETTING

ESU 5 and Beatrice Public Library's goal for TVWS was to bridge the afterschool (internet) homework gap for students in their community. Economic pressures and the high cost of home broadband have created a large population of underserved. The vision for Homework Hotspots (sponsored by a district-community-public library collaboration) would increase access and inclusion for students. New (portable) TVWS-enabled hotspots would also support community events and disaster preparedness.

RESULTS

What is the feasibility of TVWS being successfully implemented in a small community in rural Nebraska? The research site in Beatrice represents collaboration among schools, a public library, and several community spaces. Using TVWS technology, project plans included four remote sites from ESU 5 to the public library, Hannibal Park, Scott Street Ball Fields, and the Community Players Theater in the city of Beatrice (see Figure 1).

Figure 1. TVWS-enabled hotspots in Beatrice, Nebraska

The Beatrice collaborative successfully installed a base station at ESU 5 (see Figure 2) and installed remote hotspot locations at targeted spots: the Community Players Theater, Beatrice Public Library (see Figure 3), the Scott Street Ball Fields (see Figure 4), and Hannibal Park (see Figure 5).

Of the various hotspots, the Community Players Theater (for their afterschool program) has enjoyed the greatest usage. This afterschool program hosts youth interested in drama activities and performance. Their facilities include a greenroom (see Figure 6) and theatre with stage (see Figure 7) where youth can complete homework or access the internet when not engaging directly in performances.

Will a TVWS network result in increased network usage by community members and youth participating in afterschool programs? The Beatrice TVWS-enabled homework hotspots closed the homework gap by providing internet access to children during out-of-school time. Particularly in good weather, students spend significant amounts of time at community parks. The Community Players Theater also hosts youth after school in targeted programs. Technology-infused curricula are increasingly the norm in public schools, making digital access a necessity for students. From June 1, 2018, to July 1, 2018, these sites hosted 967 clients across the Homework Hotspot sites using over 74 gigabytes of bandwidth. Before going live, the park and theater sites did not have any Wi-Fi internet connectivity.

What challenges will emerge as part of this project design and implementation? The Beatrice TVWS network faced challenges associated with the need for updated equipment/firmware, connection challenges at the public library hotspot installation, and equipment damage due to a possible lightning strike at Hannibal Park. ESU 5 and Beatrice Public Library staff are working together (with help from city representatives) to address challenges with connections at the library. One of the possible challenges associated with the library installation is the location of the hotspot antennae (attached to the top of a large, copper cupola). The copper cupola might be causing interference, making connections quite difficult. Likewise, equipment might need replacing/modification at the Hannibal Park location due to a possible lighting strike, something to consider in areas that experience extreme weather patterns. Finally, with the recent surging popularity of TVWS, many equipment manufacturers are responding to high demand with updates to equipment and software/firmware. These changes impacted Beatrice insofar as they delayed their plans

Figure 2. TVWS base station mounted on a 60-foot pole

Figure 3. TVWS hotspot antennae serving Beatrice Public Library

Figure 4. TVWS hotspot antennae serving Scott Street Ball Fields

Figure 5. TVWS hotspot antennae serving Hannibal Park

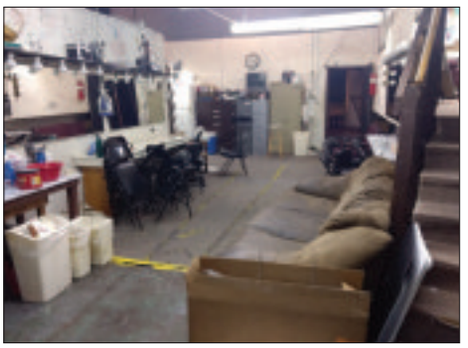

Figure 6. Community Players Theater greenroom

Figure 7. Community Players Theater and stage

for implementation and introduced new complexity to their design.

CONCLUSION

The TVWS network installed in Beatrice works to close the homework gap by placing TVWS-enabled Wi-Fi hotspots in community spaces enjoyed by youth during out-of-school time. In this case, ESU 5 and the Beatrice Public Library are leading a community effort to address digital access and inclusion by providing internet access in places frequented by youth. Rural spaces, such as those exemplified by communities like Beatrice, are most likely to benefit from TVWS technology due to strong channel availability and little competition for access to frequencies. Teacher librarians, school technology professionals, and public librarians can play a strong role in the successful adoption of TVWS technology due to their strong presence in schools, understanding of the increasingly technology-infused character of curricula, and ability to capitalize on existing relationships with municipalities to form plans regarding the strategic design of new networks.

This article focuses on answering feasibility questions of TVWS implementations to close the homework gap, whether network usage can be increased through these networks, and what challenges these initial installations face. This case demonstrates the feasibility of such a plan, with the caveat that TVWS networks are not yet "plug and play" and require time and expertise to implement. These initial findings are quite promising, but more work needs to be done to understand the sustainability of networks, the patterns of usage, and the impact these new forms of access might make on learning and achievement.

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