Wireless Technologies as Accelerants of Digital Equity

By Daniel C. Smith and Edward B. T. Sun

The concept of digital equity is replacing universal service availability as the driving concept behind broadband connectivity. Beyond Internet access, people need equipment, and training on that equipment, so that they can improve their well-being, including expanded access to health care, education, and economic advancement. The concepts are laid out in the Digital Equity Declaration 2020 of the Hawaii Broadband Hui as now endorsed by the Hawaii State Legislature and County Councils. (Hui, 2021). Access is still critical. If digitally literate people with at least modest computers must travel to a public and private facilities that is hardly digital equity in connecting to the internet. We propose here that communities, aided by government resources, take actions to promote and install community Wi-Fi to help themselves.

Buried fiber to the home (FTTH) is a very robust, capacious way to meet the Hui's broadband access Goal which is: "By 2030, consistent, quality internet access is available to 100% of Hawai'i's residents." However, FTTH installation is slow compared to standing up wireless technologies, including but not limited to, cell, satellite, and Wi-Fi. The 2030 goal is too long to wait. We do need buried fiber for capacity and hurricane resistance. We can afford to both bury fiber and quickly set up community Wi-Fi. The need in Hawaii is great: A large majority of census block are eligible for NTIA grants because of being unserved or underserved.

This paper explores how recent Federal broadband infrastructure funding could be reconceived and exploited using a creative mix of wireless technologies and community actions. By quickly extending connectivity, the Hui's access goal can be met well before 2030. Because of rapid installation and service activation, the "rushed" new assets would provide social and economic benefits bolstered by the later arrival of FTTH. This the approach follows PTC's Rethink theme.

Stories abound about students hanging out near libraries or fast-food restaurants to do their schoolwork. In some cases, "Wi-Fi on Wheels" provided connectivity driving vans or buses to areas needing connectivity. Libraries in Hawaii have Wi-Fi useable outside as do many businesses and organizations. On Hawaii Island for example, St. Jude church provides Wi-Fi for students and others

from 6 am to 6 pm. They report 10 -20 users per day, primarily students connecting for schoolwork after getting off the school bus.

On a much larger scale, rapidly responding to the pandemic ,the Hawaii Department of Education issued about 17,000 cellular hotspots to students at its 257 schools.[1] (And about 52K computers or tablets were issued to students, many of whom had internet but needed devices.). For the hotspots DOE has not publicly disclosed the number per school or whether the hotspot need was for family economic reasons or lack of commercial internet access. Such knowledge would be a quick indicator of underserved areas in Hawaii. The point is that substantial sums are being spent for wireless internet services in the emergency of remote learning. With new technologies, more permanent, quickly-installable solutions for the communities around the schools can be served for the same order of magnitude of funding.

In 2021 alone, the FCC's Emergency Connectivity Fund (ECF) provided $34.7 million to the Hawaii Department of Education to support remote learning and homework (FCC, 2021). If we estimate that each DOE-supplied hotspot costs $25/month for service, the total for the year is about $5.1 million. With more flexibility, fewer hotspots would be required and Federal money – yes, including from other programs -- could support community-Wi-Fi without sacrificing student needs.

Large sums will be flowing into Hawaii for broadband. Senator Brian Schatz recently wrote:

Broadband – at least $160 million for Hawai'i

- At least $100 million in funding will be used to help the state deploy and expand broadband access to more Hawai'i families
- The Department of Hawaiian Homelands is set to receive at least $60 million to provide high-speed internet access to more Native Hawaiian families
- At least 280,000 Hawai'i residents will be eligible for a new benefit [ACP] aimed at helping low-income families afford high-speed internet access
- Funding will also support the construction of new broadband infrastructure, including undersea cables (Schatz, 2021)

The DOE numbers show that a substantial population of now computer-literate students are out in neighborhoods and can help the adults in the household as well as neighbors who need. A school or anchor institution model can provide a service based on Wi-Fi to communities beyond just students. It's similar to community or municipal Wi-Fi that exists in some towns. The concept is illustrated by seamless Wi-Fi service provided throughout Waikiki by Sun Global Broadband (Broadband, 2021). Sun

[1] Personal email from DOE, June 30, 2021

Global's system allows visitors to avoid cellular roaming charges while moving around, remaining connected after a single logon. On smaller scales, many airports and entertainment venues provide free "basic" Wi-Fi funding by advertising and paid options for higher speeds.

The community models are illustrated by the graphics below. The distribution of customer would determine the physical and logical topology.

Mesh **Linear**

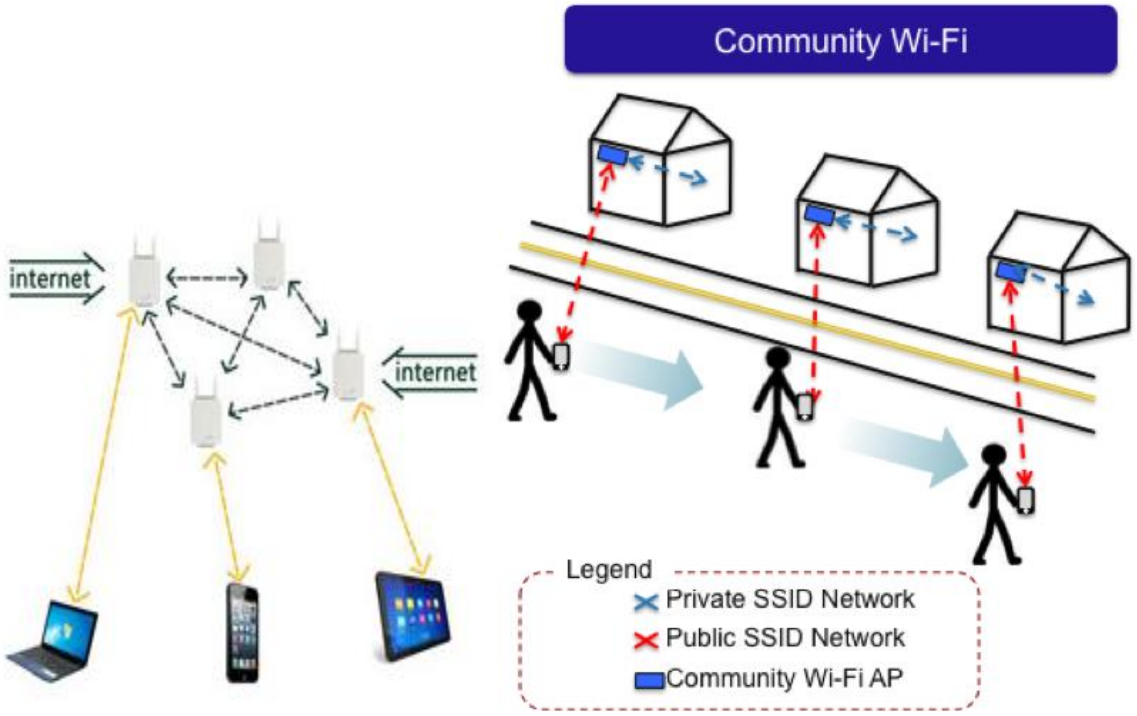

Figure1 Source: www.vtrural.org and https://www.cablelabs.com/community-wi-fi-a-primer

All schools, except for Niihau, which has or will get satellite, have nominal 1Gb or multi-Mbps fiber or cable service. Each of the schools, as well as the 54 libraries and other "anchor institutions" such as community health centers, county recreational facilities and community organizations can install or make available access points. As noted at least one church provides community Wi-Fi as well. Churches, businesses and even individuals can support community Wi-Fi by sharing their excess bandwidth.

Another example is the *Pu'uhonua o Waimanalo* community network project of the Hawaiian sovereignty group that installed fiber and wireless with sweat equity and a grant from the Internet

Society (Internet Society, 2021). The concept is applicable to any community or neighborhood that can mobilize to get good internet access.

The thesis is that commercial grade, long range Wi-Fi access points can and should be set up at anchor institutions/locations and together with extenders can target many of the currently unserved and underserved households. For illustration we will use 500 as the number of locations available.

If the hotspots are distributed equally across all schools -- surely not the case, but a starting point -- that is 66 per school (17,000/257). Consider each school starting with a couple of long-range, remotely managed access points reaching a half mile plus with modest cost and equipment at the user end. Some schools surely have many students served by hotspots and some schools have few. The numbers give the order of magnitude of the equipment requirements for a large population. Consider 500 sites providing coverage of approximately 1.5 sq. mi. or 750 sq. mi. total.

Many school communities could beneficially provide more than two access points. These may be arranged as repeaters and/or independent access points according to the topography, number and distribution of unserved households and suitable, available back-haul point locations. We make no claim that all hotspots can be eliminated but hanging out near accessible Wi-Fi access points to get connections can be greatly reduced. We do, however, for the sake of illustration, assume a substantial number of the 17,000 hotspot households can be served by Wi-Fi – along with additional households. That is, a school community Wi-Fi system will <u>increase</u> the number of households with more than adequate internet service.

Now, consider the rough order of magnitude costs for 400 relatively wide area Wi-Fi sites.

Hardware cost per site

Internet searches provided approximate hardware costs:

Access points, Wi-Fi, remotely manageable, enterprise grade 2 x $5,500 =	$11,000
Antenna, directional 2 x $500 =	$1,000
Mast/tower 30-foot, hurricane resistant	$1,500
Cabling and installation	$3,000
Contingency	$2,000

The total is $18,500 but use $20,000 as a prudent site cost. More or lesser costs can be anticipated in some cases

To summarize, assume each of the 500 sites has two Wi-Fi 6 class, possibly E, remotely managed access points with MU-MIMO directional antennas – aimed in appropriate directions on modest masts when required.

Cost$20,000/site installed. 500 x $20,000 = $10,000,000.

User-side antennas/Wi-Fi adapters -- assume 50% of the users in two groups need either a $300 antenna/adapter or a $100 system. The cost is then 17,000 x 0.25 x $300 + 17,000 x 0.25 x $100 for a total of $1,700,000. The overall system cost is not much affected if more sites need something other than built-in antennas.

There would also be essential hardware costs of access point controllers in a central remote location – and related expenses for the management center. Say $300,000 capital costs. The controllers would manage bandwidth, for example, as well as monitor for fault conditions, authenticate access, etc. Automated controls are needed to prevent a tragedy of the commons by bandwidth hogs, planning for growth, accountability, etc.

Total ROM capital cost for 17,000 households: $ = $10,300,000 or $606 for each of 17,000 households. The 17,000 is used as reference number of known immediate demand – and 17 households per access point (2 per site) would provide good service.

Operational cost

1 each per site 1 Gb/ 1 Gb fiber connections $180/month. 500 x $180 = $90,000 per month or $1,080,000 per year.

Take annual power, management, and maintenance to be $1,000,000. Community Wi-Fi systems would band together, agree on standard equipment and processes so that management and maintenance costs could be shared and contracted for. Estimate $2.08 million annually total operational cost for 17,000 households. Operational monthly cost: $10.20 per household. That can be compared to about the estimated $5,100,000 annual rented hotspot service via the ECF funding, the total of which is $34.7 million but we don't know the relative sums going to hotspots and computers. Management systems for efficiency and to prevent fraud, waste and abuse are of course essential.

Raise the monthly cost to be recovered from the Affordable Connectivity program $20 to $30/month and recover enough (19.80 x 12 x 17,000 = 44,039,200) to pay the capital costs well within three years.

Management

The Federal Communications Commission should allow for ACP funding community organizations to gain formal approval as mini-, cooperative and low-cost ISP approved providers along the model of community Wi-Fi – technologically neutral, call them community connectivity systems. (A comment to that effect was submitted in response to ACP program rule-making notice.) These new providers should be enabled to recover documented costs – including capital costs -- up to $30/month for eligible households for at least 25/3 service with no data caps. Such community Wi-Fi/connectivity coops – some already exist in Hawaii -- could be supported by a State agency or contractor in providing support for systems to protect against waste, fraud and abuse. Shared systems of tech support and National Verifier and USAC access should be part of the package of support for multiple-dwelling systems be they apartment complexes or spread-out community connectivity systems. Components of this organization are illustrated in the figure below.

The Vermont Digital Economy Project has a toolkit (Vermont Digital Economy Project, 2021). They advise, "The most important part of creating a new downtown Wi-Fi zone is not the technology involved. . . . As we have put in more zones, this community aspect of the project has become more and more apparent. The more inclusive a Wi-Fi project can become, the better chance it has of standing on its own once our grant has finished." (While funding several brands of technologies, they did, however, report good experience with Meraki equipment.)

Community Wi-Fi Support Organization Highly Beneficial

An umbrella coop organization, possibly contracted out by the State, would have administrative, operational support and community organizing functions. Strong financial management, beyond affordability of a small community system, is essential for gaining access to the USAC (eligibility) Verifier system and Federal ACP funding. The components could be as shown below.

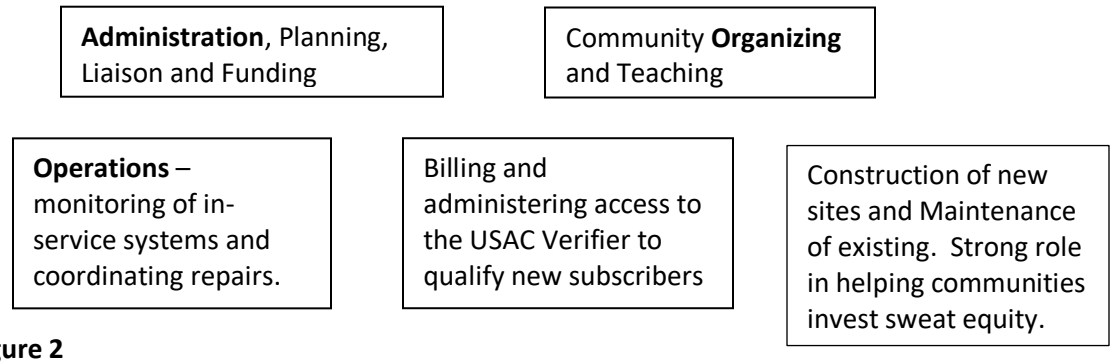

Figure 2

While all functions are important, the community outreach and organizing is the crucial one. Debate and challenge will produce better solutions. The broadband back-haul provider may also be happy to provide administrative support and partnership as part of a bulk bandwidth purchase agreement.

Sources of Funding

We should expect that households with adequate income would be happy to pay about $30 per month for good community Wi-Fi internet service. For low-income households, the recently announced FCC Affordable Connectivity Program (ACP) will pay $30/month of the internet bill of qualifying households receiving benefits such as the SNAP food program, Medicaid, etc. (USAC, 2021) The ACP, like its predecessor, the Emergency Broadband Benefit (EBB) program allows reimbursement for bulk purchases of internet services for multi-family housing complexes. The extension of grants to community Wi-Fi systems are reasonable for capital costs in the context of grant programs awarding several thousand dollars per household for fiber connections.

That the projected costs are in the right ballpark is evidenced by Hawaiian Telcom's Kokua program offering 25/3 for $12.99/mo. and Spectrum's Internet Assist's offering of 30/4 for $17.99/mo. Presumably they are not losing money at those prices.

Discussion

A system has been sketched out that would serve additional households beyond those with K-12 students. The rapid installation and modest cost are consistent with the recently funded Affordable Connectivity Plan of the FCC. There might be some impact on fiber operators planning to connect households in the future (AbouAlmal, October 2020). However, given the substantial number of unserved and underserved locations, there should be plenty of connectivity demand to share.

Community Wi-Fi systems are not a new concept having been discussed and implemented for decades. Equipment manufacturers offer managed wireless and Wi-Fi service to enterprises of all sizes. An analogous community service is already in place for Spectrum customers: "Spectrum Mobile and Internet customers get free, unlimited access to nationwide out-of-home Wi-Fi. Sign in once and automatically connect." (Spectrum, 2021) The Hawaii coverage is shown by the blue dots in the map below.

Figure 3 Source: Spectrum

It's a little bit like the "internet-rich get richer." Those who already have internet service can get free Wi-Fi in many locations around Hawaii. Big telecom operators and the equipment manufacturers know how to do a form of community Wi-Fi. However, note the many unserved areas of Maui and Hawaii Islands. Zooming in on the islands shows many opportunities for community initiatives.

Conclusion

Underserved communities have a credible case to get Federal and/or State funding for community Wi-Fi systems. They may be able to raise funds for equipment and installation on their own but there is a good case for Federal assistance. Nearby bandwidth service points – fiber and/or cable -- can provide purchased service and for-profit and non-profit organizations can also join and donate spare bandwidth. It will be instructive to see what wireless grant proposals get funded under the NTIA broadband infrastructure grants program. (NTIA, 2021).

The island of Niihau will be an interesting case to watch as it gets Starlink satellite service that can be distributed community-wide. Satellite feeding Wi-Fi distribution is done in many locations around the world. We are under no illusions that community Wi-Fi is a magic bullet; it is a complement

to wired and cellular internet distribution run by for-profit companies. We tabulated technology costs, but a support organization will provide "structure for success."

What we do observe is that community activism with elected and administrative officials and local organizations are the keys to success. Communities set the priorities, demand action, and facilitate installations. Squeaky constituents get the service.

In the context of $160+ million in Federal broadband funding coming to Hawaii, a few tens of millions for quickly-installed community Wi-Fi systems that offer "peer-to-peer" communication is a cost-effective approach to increasing digital equity and building sustainable communities. Lives will be improved by rapid installations. Think of it a building social capital that otherwise would be foregone by waiting for the perfect when the good is available.

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