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Potential Solutions to Rural Broadband Internet Deployment

J. Kirk Atkinson
Western Kentucky University, kirk.atkinson@wku.edu

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Kirk Atkinson, Assistant Professor
Western Kentucky University

Abstract

Broadband availability in rural areas continues to be a major topic of concern in many areas of the country but especially in our rural communities. Several grassroots organizations including the Wireless Communication Association International, and the Rural Broadband Coalition were created for the sole purpose of closing the "Digital Divide" for underserved Americans. Government should support efforts to offer broadband to the masses, but in some cases special legislation is required to pave the way. In Kentucky, the Supreme Court rendered an August 2005 decision that may have severely hindered broadband deployment by restricting rural electric cooperatives from providing any service other than that of electricity. It is unclear whether this decision adversely affected rural cooperative's plans to pursue providing high-speed Internet to their constituents but it certainly caused them to their entrance into a less than competitive market for rural areas.
Reacting relatively quickly to this decision the Kentucky Legislature passed legislation that empowered these organizations to once again offer services like Internet, long distance telephone, and propane gas service (ConnectKentucky, 2006).

HISTORICAL PERSPECTIVE

According to the Connect Kentucky Web-site, the percentage of Kentuckians with high-speed Internet access has grown to 92%. Connect Kentucky is a designated 501(c)3 not-for-profit organization commissioned by Governor Ernie Fletcher to ensure all citizens have broadband access by the end of 2007 by coordination of "the planning, funding, deployment and adoption of high-speed Internet, also called broadband, and related technology at the local level" (ConnectKentucky, 2006). Several issues may be unclear however, for example what is defined as broadband access, and whether affordability is a primary concern, for example, is *high speed dialup* included in the broadband categorization? Cellular telephones providers like Cingular, Verizon and Sprint are all offering broadband services to select areas that tout broadband download speeds (Lawton, 2005). Most common to rural areas is the EDGE (Enhanced Data GSM Environment) network which affords 384 kbps burst speeds (Duryee, 2005). The FCC (2001) defines broadband as 200 kbps for both upstream and downstream transmission speeds from provider to subscriber, but also refers to 200 kbps capabilities in a single direction as sufficient to qualify. Dennis (2002) defines any communication circuit with data speeds of 1 Mbps or greater. What remains in question is whether 200 kpbs is truly fast enough to handle the expanding venue the Internet offers users?

BARRIERS

Competition

The issues surrounding implementing broadband Internet to rural America are more complex that one might imagine. Beyond the political wrangling for funding and *turf* control, there are other and perhaps more difficult issues lurking. Politicians are often concerned with only constituents in their district, or are under pressure from lobbyists who have only a particular company or industry's best interest at heart as opposed to the citizenry. Telephone, cable and other companies are too often embroiled in deregulation issues which boil down to control over certain geographic regions (Pressler, 2006). Bellsouth, which covers large areas of Kentucky recently announced an increased commitment to wireless Internet availability but still continues to expand into markets where choices already exist (Rush, 2006; Walker, 2006). Further examining of this issue might lead one to conclude that state and local governments will need to be involved as in the cases of Virginia, where Internet service demand is aggregated in with governmental agencies, or Maryland and West Virginia who share resources like statewide fiber networks (Strover, Oden and Inagaki, 2001). Rural cooperatives already serve 1.5 million constituents in Kentucky (KAEC, n.d.) and some are interested in providing high-speed Internet access. Because of their unique position already serving rural residents they should be considered prime contenders for assisting in closing the gap of the underserved (Parker, 2000).

Costs

People's ability to pay for broadband Internet access perhaps ranks as one of the chief barriers for achieving saturation of coverage in rural areas (ConnectKentucky, 2006). Minimum wage earners and those living on low, fixed incomes are naturally going to be most concerned with basic living necessities and expensive Internet access will not be received well. Competition or the lack thereof has a dramatic impact on low income earners ability to afford high-speed access especially in rural America (Grubesic & Murray, 2004). According to Jeannine Kenney, senior policy analyst for Consumers Union (Banos, 2006), "Fudging the facts won't provide high-speed Internet access to those who need it most. If the FCC is content to let cable and phone companies control the broadband market, then consumers need a third option; wireless broadband that is less expensive and which doesn't depend on DSL or cable modems. It offers the best and perhaps now the only way to close the digital divide."

Culture

Even when people can afford broadband, this doesn't automatically mean that they will subscribe. Culture plays a huge role in such decision-making. For example, many senior citizens are intimidated by technology and often barely know how to send and receive email, and illiterate American's who struggle to read might avoid computer technology. There are also reasons that disabled Americans, certain religious-oriented, and even some minority groups might avoid active, persistent use of the Internet (Crabtree & Roberts, n.d).

Lack of Perceived Need

Perhaps among the most difficult barriers to overcome are not technical in nature, but have more to do with human nature (Turner, Thomas, and Reinsch, 2004). Perceptions by those in rural areas are often driven by traditions that are not entirely trusting of technological advances and fail to understand the potential of, in this instance, high-speed Internet (Obilade, 2001). People often see these advances as necessary for the improvement of public education but do not have any notion of the potential beyond K-12. Perhaps being perceived by their peers as a technical "geek" or as one who "thinks they are smarter than everyone else" is also an inhibitor (Ball, 2005). Convincing people of the value proposition is closely related to the cost of Internet access as evidenced by the ConnectKentucky Technology Assessment Study (2005). According to this study on a single Kentucky County, 12% of households reported that they do not own a computer, 38% indicated that they do not need the Internet and another 8% said that it is too expensive. Additionally, 34% of those polled indicated that broadband was either too expensive or unavailable to them.

Geography

Considerable technological considerations become apparent when one examines the deployment of broadband capability. Mountainous terrain dominates much of eastern Kentucky and in many cases; many miles of cable must be attached to utility poles or buried which is expensive. Often residents simply live too far from the necessary equipment for DSL service or the terrain isn't suitable for wireless connectivity (Dern, 2005). Even satellite reception requires a clear view of particular regions of the sky which isn't always viable in mountainous or heavily forested regions.

Potential Solutions

Satellite

Satellite access is commonly touted as one viable alternative as high-speed access for rural citizens. While satellite access has progressed with speeds that qualify as high-speed, the initial cost of equipment ranges from $300 to $600 and inflated monthly subscription fees, usually ranging from $50 to $125 per month, can hardly be considered inclusive. Additionally satellite systems often require a specific directional view of the sky which is not always possible and can be adversely affected by weather. This option does help to fill the void for rural consumers left by the incumbent local telephone providers who are busy scrambling to maintain their competitive edge. This option is usually depicted as the solution for consumers who are too far from the RBOC's switch thereby eliminating DSL as a viable alternative and where cable companies rarely venture (Prieger, 2003).

There are few providers in this individual consumer market in the United States. They are HughesNet, WildBlue, and StarBand (Cope, 2000; Pappalardo, 2002; Ohrman, 2005). HughesNet and Starband both use the Ku band (11.7 to 12.7 GHz) presently which requires a "blanket" effect to ensure coverage (Poe, 2005). Various plans are available with download speeds ranging from 500 kbps up to 1.5 mbps. Pricing of course is the issue and prices do vary between providers but generally range from $49.99 to $129.99 monthly. Current projections by Northern Sky Research (2005) predict that North American based satellite Internet users will exceed 1 million by 2009. Most providers use the Ku band while WildBlue, a relatively new AT&T venture, uses the Ka band. Ka band (18 to 31 GHz) uses "spot beams" in an attempt to optimize the available bandwidth, offer consumers reduce dish sizes and most importantly, reduces the latency at the network operations center which may enable services like virtual private networking, voice over Internet Protocol (VoIP) and video conferencing (Poe, 2005; Sukow, 2001). The disadvantages at this point are that rain fade will likely be an issue and there is only a single satellite which translates to down time for consumers should there be an equipment failure.

Cable

Cable delivered Internet is perhaps among the most desired by consumers mainly due to the delivered speeds and reliability (Thierer, 2002). Cable companies that are already providing cable television service have the advantage of existing coaxial copper wire at many consumers' locations. Cable Internet service is usually superior to DSL and involves the use of a cable modem. The customer can then easily build a wired or wireless network through the use of inexpensive routers. Cable companies also understand the value to consumers by offering bundled television, Internet and even telephone (VoIP) services (Zitcherman, 2006).

Cable is not a major player for rural areas simply because of the lack of infrastructure currently in existence. The number of miles of copper wire that is required to be installed on utility polls makes for a less than likely business case (Strover, Oden, et.al, 2005).

DSL

Digital Subscriber Lines or DSL have been in existence since the late 1990's but have not found their way into much of rural America. Perhaps the most likely reason is the absence of the necessary equipment in remote regions of the country, like DSLAM's (digital subscriber line access multiplexers) and the presence of other equipment that inhibits efficient data transmission (Prieger, 2003; Kruger, 2003). Providers in Kentucky like Bellsouth and Alltel have made some progress in rural areas where a set number of consumers are willing to agree to a contract usually lasting 2 years. Once again the primary constraint is how far the desired area of service is from the telephone company's central office switch (Dodd, 2005). To achieve the most commonly desired data rates using asymmetric or splitterless DSL, there is an 18,000 foot limitation from the DSLAM to the DSL modem. DSLAM's aggregate the traffic from the subscriber modems and transmit the data on to the Internet via an ISP like AT&T (Dodd, 2005).

One alternative solution is for telephone companies to install digital loop carriers (DLC) that are located in proximity of the potential customers that include a DSLAM. These DLC's must be connected to the central office via fiber cable and copper from the DSLAM to the customer modem (Rosengrant, 2002). This of course requires considerable investment by the regional Bell Operating company (RBOC) and many areas still are not served because a business case isn't viable. A contributing factor to the general lack of availability of DSL to rural areas is because telephone companies must remove loading coils and bridge taps from copper lines. These devices were originally placed in the lines to ensure voice quality in local loops exceeding 18.000 feet and to allow for expansion of the system as additional houses were built in the area being served. The loading coils are used to boost signals on analog wires and the bridge taps enable copper wire run from the central office to feed multiple locations (Moore, Pritsky, Riggs & Southwick, 2002). Telephone companies typically remove the loading coils but do not remove bridge taps due to the expense.

DSL will probably not be installed in many rural Kentucky areas for two primary reasons. First, the distance factors coupled with the expected low commitment rate from homeowners will continue to be cost prohibitive for the RBOC's. Secondly, telephone companies are vested in other forms of communications like wireless. Cingular, Verizon and Sprint all offer wireless data plans for mobile users. Bellsouth owns Cingular and Verizon is also in the *landline* telecommunications business. Additionally, Bellsouth is now aggressively pursuing pre-WiMAX offerings (Rush, 2006). Many urban areas in the state now have the choice of this service and Bellsouth is committing to additional service areas. Paducah, Kentucky is the latest Kentucky city to receive this service offering. Paducah is a small city of less than 30,000 but can hardly be classified as rural especially in light of the other alternatives available in the area including DSL and cable (Walker, 2006).

Wireless

There are many questions surrounding whether wireless technology is viable for addressing rural Kentucky's high-speed Internet needs. Many providers and communities have already deployed such technology but in most cases the target sites are urban areas with a rural contingent in the surrounding suburbs (HMPLS, 2005; OMU, n.d.). Another problem is the relatively small number of providers that all wish to dominant their particular markets. For example, Cingular has perhaps the best overall cellular coverage with their towers in south central Kentucky but offers their own GSM-based Internet packages and would resist deployment of more suitable technologies like WiMAX. Cingular does offer their 3G EDGE network in larger metropolitan areas and has expanded their coverage to include many rural locations. Both of these technologies required a wireless PC card that utilizes SIM chips and connects to a single computer through the PCMCIA slot. This approach has limitations such as not being to easily network the Internet accessibility for other machines without establishing shared connections through the primary laptop. Once again, should that laptop be used at other locations as mobile machines typically are, then the home access is unavailable for the duration of the loss of the laptop while traveling. EDGE average download speeds are 50 to 135 kbps with burst speeds approaching 200 kbps. Verizon & Sprint use EV-DO

(Evolution-Data Optimized) for their mobile Internet offerings. This technology is available only in metropolitan areas according to the Sprint and Verizon Web sites. UMTS (Universal Mobile Telecommunications System) is also becoming available in larger metropolitan areas, at present by Cingular, and also offers the 400 to 700 kbps downstream speeds (Lawton, 2005). As EV-DO and UMTS become more widely available in rural areas this technology may afford significant opportunities for consumers willing to commit to a contract and purchase a fairly inexpensive PCMCIA card. The need for another device is also clear, an adapter that uses USB or similar technology enabling the user to connect the wireless card to any PC whether a PCMCIA slot exists or not. This also alleviates the issue of tying a laptop up for the sole purpose of providing shared Internet access with other home computers.

Fixed (Broadband Fixed Wireless). Owensboro Municipal Utilities deployed a fixed wireless solution in Owensboro, Kentucky for $25 a month subscription fee. Henderson a city roughly half the size of Owensboro has followed suit and deployed a FWBB system (HMPLS, 2005). Their basic residential plan offers 512 kbps speed at a reasonable $30 per month with a commercial offering at $55 monthly for 1 Mbps downstream speeds. In both cases these deployments occurred to primarily serve citizens living within the municipal's service area.

WiFi (Wireless Fidelity) is a generic term for any 802.11x network (Newton, 2005). The issue with WiFi is the limitation of range of signal especially in areas where long distances is an issue. In the United States the 802.11b and 802.11g operate in the 2.4 GHz band while the 802.11a uses 5 GHz. 802.11a and 802.11g outdoor ranges are limited to something less than a mile, while 802.11b can be in a fixed point-to-point range of up to 5 miles (Dennis, 2002). WiFi, due to limitations relatively short distances is probably not a primary solution for rural Kentucky. The topography of the state with its many hills, valleys, mountains and trees would create significant obstacles for wide range deployment (Dern, 2005). Does this preclude WiFi as a player in the deployment of broadband? Certainly without the use of other technologies it is unlikely, but in a hybrid approach where other guided mediums are used, for example fiber or broadband over power lines to transport the necessary bandwidth and speeds to wireless access points located strategically in rural areas, WiFi remains a strong candidate. The fact that so many portable devices come equipped with 802.11 support helps to underpin this philosophy (Molta, 2005; Newton, 2005).

WiMAX (Worldwide Interoperability for Microwave Access) according to many experts holds the most promise for deployment coverage to the masses (Richardson, 2004) but it is unclear whether this would include sparsely populated areas. WiMAX is based upon the 802.16-2004 (Fixed WiMAX) standard approved in 2004 provides up to a 31 mile linear service range and does not require line-of-sight (Agis, Mitchel, et. al., 2004). Additionally, since WiMAX is capable of shared rates of 70 Mbps there is sufficient capacity to service both business and residential consumers. WiMAX differs from 802.11 a, b, and g in that the type of packet scheduling approach is more efficient in terms of bandwidth management and tends to provide stability especially when the system becomes stressed under heavy loads (Ghosh, Andrews, et. al., 2005). The customer premises equipment or *CPE* needed for the end consumer is minimal, costs around $300 and can be self-installed. There is the option of an indoor or outdoor CPE, and trade-offs with both. The outdoor CPE is more expensive but will reduce signal loss, whereas the indoor unit is cheaper and can be purchased by the homeowner (WiMAX Forum, 2005).

Assuming providers continue to use the same model to determine their deployment strategies, urban areas will see WiMAX first and rural areas only when a business case is made (Zitcherman, 2006; Prieger, 2003). It is more likely that a hybrid of technologies will be necessary to actually reach the more remote and sparsely populated areas. Mesh network technology is a technique where each receiver also serves as a transmitter so that devices that are too far from the tower allow for connectivity with other transceivers creating a "net", hence the name mesh net. Meshnet technology is current being used in New Orleans, Louisiana for a city-funded WiFi network for 300 kbps free service with paid tiers for higher levels of service (WirelessNews, 2006). But is meshnet viable for rural areas? If meshnet can work in this country where only a very small minority of homes has landlines and where a rugged topography is an issue, then it is a potential solution for rural Kentucky. Perhaps the best known case of mesh deployment is Chaska, Minnesota. This community of 20,000 people located near Minneapolis used mesh routers from Tropos Networks to deploy wireless service with 1 Mbps downstream speed for $16 a month (Molta, 2005).

Fiber Optics (FTTH)

Fiber to the home offers the most available bandwidth and speeds, but it is extremely expensive. Estimates from as little as one year ago were between $1,200 and 1,500 per household, but more recent figures indicate a significant drop in cost to as low as $800 per household. Last mile fiber affords many opportunities including on demand video, VoIP, and very high Internet speeds through a single fiber connection (Green, 2006).

An optical access network uses optical fiber as a transport medium providing enormous bandwidth, has considerably more information carrying capacity, and can span very long distances. For example, a fiber optic cable with the same capacity as a comparable copper wire is less than 1% of both the size and weight. Additionally, because light is used to transport data as opposed to electricity it is immune to electromagnetic interference. It can be ATM or Ethernet based and can be either a passive, active or hybrid network (Dennis, 2002; Green, 2006).

Passive Optical Networks (PONs) are the most common type of optical network because they require power only at each end of the system. Optical splitters are used to separate and aggregate signal between the optical link terminator (OLT) and the customer homes. In an active node model, there is power between OLT and customer sites implying that should power fail at local levels then service would be disrupted. Hybrid networks use both power after the signal leaves the OLT but prior to when the signal reaches splitters. Yet another emerging form of fiber solutions may be OG technology. In this case, fiber optic cable is attached to the ground wire on utility poles. This solution may best be considered a viable alternative by the rural cooperatives as they schedule routine wire replacement (Phillip Coleman, personal communication, October 8, 2006).

BPL (Broadband over Power Lines)

This technology perhaps affords the greatest opportunity for rural consumers simply because most homes are already "on the grid" for electrical power (Bangeman, 2004). This technology works by running fiber optic or T1 lines alongside overhead or underground power lines into the service area. There the line is run from a transformer box to a conversion unit that intercepts the Internet signal, converts it into data and passes it into the electrical lines. The Internet signal is then accessible from the standard electrical outlets in the home utilizing a receiver box that is plugged into one of the outlets (O'Neal, 2006; Ellis, 2005). Routers may also be used by simply plugging them into an outlet to provide connectivity for laptop users providing portability.

One criticism of BPL is that harmful interference is caused that affects ham radio operators (Bangeman, 2004). According to the National Association of Amateur Radio (ARRL), "received signal levels of BPL broadband noise at typical amateur stations would be anywhere from 33.7 dB to 65.4 dB higher than typical ambient noise levels in the worst-case situations." A second criticism is that BPL may be cost prohibitive especially if implementing to remote areas with estimated rates of acceptance as high as 15%. Most of these costs are associated with running the initial lines needed and bypassing transformers (Ellis, 2005). In Cape Girardeau, Missouri, Big River Telephone Company began offering BPL to residents as part of their overall strategy to service all customers, especially those in rural areas (Rehagen, 2004). Residents are finding that connection speeds and pricing are competitive with DSL and cable rates. Cinergy Corporation in conjunction with Current Communications Group is planning to deploy BPL to approximately 1.5 million homes in Ohio, Indiana and Kentucky based from a Cincinnati location (Ellis, 2005). The tier-service plans will offer 1 to 3 mbps downstream for between $30 and $40 per month, respectively. The BPL alternative is considerably less costly than a satellite solution and barring lightning strikes or downed lines not as weather affected.

BIG (Broadband in Gas Lines)

Another potential player in the mix may be broadband in gas lines. In San Diego, California, a small startup company called Nethercomm has developed the technology to deliver broadband Internet and television services through natural gas pipelines. The signal in the ultrawideband uses radio energy across numerous frequencies to help avoid packet loss. Since FCC regulations that limit the strength of ultrawideband signals do not apply to underground pipes it is feasible that household bandwidth could approach 6 Gbps (Davidson, 2006). According to the American Gas Association (2006), 62% of American homes are served by natural gas. The idea has at least sparked the interest of other natural gas providers in Chicago and Atlanta and should the technology be proven during trials will attract many more providers. The natural gas providers receive a huge side benefit with this technology, they are able to use the broadband to monitor usage and pipe integrity (Davidson, 2006). Additionally they might be inclined to lease their pipelines to interested cable and telephone companies looking for lower cost increased in their bandwidth needs. This technology would require the installation of an ultrawideband transmitter that is linked to an Internet backbone and a receiver that would be installed on the customer's gas meter. The estimate for build out costs is around $200 per household as compared to $600 per home for BPL and $1,000 for cable and telephone (Davidson, 2006; Access Intelligence, 2006).

Conclusions

While traditional technologies like DSL and cable will continue to serve a large percentage of high-speed Internet users in areas already served by those offerings, satellite, wireless variants and broadband over power line technologies will most likely become more common for rural areas. It is not clear whether communities in Kentucky will see BPL or FTTH in the near future, but as rural cooperatives realize that as power lines need replacement the time to include a rural broadband solution may become a viable alternative. Most American's view cellular alternatives as purely for mobile solutions while traveling. Satellite technology remains expensive for the rural user and provides lower service levels than most DSL and wireless alternatives (Poe, 2005). As technology is enhanced and as additional providers enter the marketplace consumer prices should decrease. The recent announcement by WildBlue Satellite of their collaborative partnership with DirecTV and DishNetwork may also bring some eventual relief in terms of pricing and in the reduction of the number of dishes required for both television and Internet. Broadband in gas pipelines may afford some opportunities to those rural citizens who have natural gas pipelines servicing their residence but again this assumes that natural gas providers are willing to pursue the technology.

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