Wither Wireless Networks for Rural Development
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Huffman writes about a very important suite of technologies for "bridging the digital divide", namely wireless networks. And he illustrates his comments with a set of examples from India. Hands down India has more exciting and innovative projects using ICT's for social and economic development than any other country; and Huffman is right to turn to the subcontinent for his examples.

But I am reminded of an article I read recently in the *Times of India* about how Kentucky Fried Chicken, the major US fast food chain, is struggling to break into the Indian market. There is a funny thing about eating chicken from KFC (and apologies to the vegetarians). Often enough there is no way to identify what piece of chicken you are being served: a thigh, breast, etc. Sure, it is real chicken and tasty enough, but it comes in pretty odd cuts. Something about Huffman's paper reminds me of KFC chicken. I'll argue, certainly, about various facts and figures. But mostly I am struck by how the paper fails to carve the problem at its natural joints.

Huffman organizes his paper around three elements: 1) CorDECT, a particular *technology offering* developed by the TeNeT group of IIT Madras and based on the DECT standard for terrestrial wireless communication, 2) VSAT, a *product range* based on principles for designing small ground terminals enabling cheaper satellite access, and 3) Spread Spectrum, a *communications technique* for the transmission of signal over some band of radio spectrum designed primarily to enhance performance in the presence of interference, which in turn has been embedded in a set of standards and protocols and reduced to practice in a variety of technologies.

First, let me overview my understanding of these three categories. Then I will conclude with reflections on a new approach to wireless networks.

CorDECT

The CorDECT system is indeed based on the DECT standard which initially was designed for use with cordless telephones. This is not a spread spectrum approach, and instead is based on a protocol called MC-TDMA which performs both time and frequency division in order to accommodate multiple channels[1]. The distances possible between a subscriber unit and a base station is rated at 10km. A relay base stations can be used to extend this distance a further 10km. These distances may be conservative as, given favorable Line of Site and terrain, 40km has been achieved in the field. It is true that the CorDECT system de-multiplexes voice from data at the interface unit and this is one of its strong properties. The advantage, however, is primarily in terms of functionality and recurrent cost savings and does not effect throughput per se. By splitting data and voice, data can be handed straight off to an Internet Service Provider (ISP) and voice off to the public telephone network. In contrast, when you employ a dial-up connection, for instance, you pay the phone company to transmit your packets to your ISP (who you pay to subsequently route your packets onward).

Currently the CorDECT system supports data rates of 35 and 70kbps while work is ongoing to increase this bandwidth. It can be difficult to judge the per line costs of CorDECT only because it advantages scale economies and price is contingent on the number of subscribers per base station. That notwithstanding, Huffman's numbers are reasonable as an often cited price tag is $350 per line. The goal of the TeNeT group is to bring that to $200 per line. Monthly costs (and I am not sure what Huffman means when he uses this phrase), if one includes the backhaul to the Internet, will be a function dominated by things like ISP charges. Other recurrent costs would include maintenance, power, etc. Thus it is hard to generalize such costs since they are highly contingent. That said, for a project in Tamil Nadu we have estimated recurrent costs for ISP charges, rent, electricity, maintenance, and interest and depreciation on a PC and the CorDECT subscriber unit at $70/month[2].

The concept of a Local Service Provider (LSP) is orthogonal to the CorDECT technology itself and is being promoted most effectively by n-Logue Communications Pvt. Ltd., a TeNeT group spin-off[3]. Currently n-Logue utilizes the CorDECT systems, however their business approach certainly could work with other technologies.

VSAT

VSAT's come in a number of sizes and shapes. Thus it is hard to make general comments about these technologies as compared to the specific CorDECT system. Perhaps easiest is to ground the discussion in a particular VSAT offering. Huffman makes reference to BSNL, which is the incumbent, dominant, public telephone operator of India. BSNL offers a VSAT service under the brand name HV-Net[4]. HV-Net appears to be a pretty standard VSAT network with a star topology. Each subscriber VSAT communicates with a satellite transponder (they use the Thaicom III satellite owned by Shinawatra Satellite of Thailand) and on to a Hub earth station situated near Mumbai which in turn provides connectivity to other networks. The capital costs for the subscriber VSAT units have been coming down considerably and, indeed, Huffman's numbers may be on target. HV-Net offers data communication at speeds up to 64kbps.The tariff for usage of the HV-Net is based on the volume of data or length of voice calls. Data can be routed internationally onto the Internet via a Gateway Packet Switching System (GPSS) provided by VSNL, India's privatized international telecommunications provider[5]. Tariffs are roughly $3.5 per Kilo segment, where a segment is 64bytes. Thus the $200/month recurrent fee suggested by Huffman would provide for 3.8 Mbytes of data routed internationally. Note that this 3.8 Mbytes is roughly the size of a couple minute MP3 song. If the data is routed only within India a cost savings of 8.5 times is realized (so your $200 gets you 8.5 songs). Ultimately, these high costs, and the relative lack of flexibility of VSAT networks, is due to the costs and engineering challenges associated with the space segment.

In India, 85% or more of the population lives within 25Km's of fiber. For such communities CorDECT, and other terrestrial wireless solutions, are certain to be the most cost effective. For the roughly 90,000 villages of India that are very far from fiber or in rough terrain (and this would apply to many parts of Africa as well), hybrid VSAT and terrestrial wireless networks, where the VSAT bandwidth is shared amongst a geographic range via a terrestrial wireless network, probably make the most sense. These hybrid networks can connect sparse users in remote regions in a very cost effective manner.

Spread spectrum

Spread spectrum is a radio technique in which the data signal, rather than being packed into as narrow a band of radio spectrum as possible, is spread across a range of frequencies.

There is a significant diversity of technologies that apply spread spectrum approaches. And I am not able to gauge from the writings exactly what sort of system Huffman is referring to. Huffman does mention WiFi systems, and indeed these are very important and promising current technologies employing spread spectrum. WiFi is another name for systems employing the IEEE 802.11 protocols for wireless networks. Today's most popular protocol, 802.11b, allows for bandwidth up to 11Mbps, distances up to 30 Km (or more), and costs for an outdoor router as low as $750 while a wireless network interface for a single PC can cost as little as $50. (Note that you generally cannot optimize all of these variables simultaneously.) Monthly costs for such an 802.11b system can be estimated as we did for the CorDECT system.

Systems conforming to the 802.11b standard operate in a 2.4Ghz band within the microwave spectrum. This frequency band is unlicensed in most countries. In contrast, most other bands of the radio spectrum require a license from a regulatory authority (e.g. the FCC in the US) to operate in. These licenses are generally given out on exclusive terms. For instance, a broadcaster might purchase the license to operate in some narrow band of spectrum within some geographical area and this license will stipulate that no other entity will be allowed to broadcast in the same band within the same region. The unlicensed bands, however, operate differently. Here the regulator stipulates some general requirements on all technologies transmitting in these bands. For instance, they will dictate the maximum emitted radiation. All technologies are required to comport to these general regiments, but the people who own these systems need not apply for any particular license to use them. For example, if you purchase a microwave oven in the US (which emits radiation at 2.45Ghz) you are not required to apply to the FCC for a user license.

There is a risk associated with allowing unlicensed use of the radio spectrum. As opposed to the licensed and exclusive user transmitting within some narrow band, within unlicensed bands it is possible that many users will be simultaneously transmitting on the same frequencies and thus interfering with each other. Systems that spread their signal across a range of frequencies are much more robust to this type of interference than are narrow band systems. Therefore, some regulators insist that technologies operating within unlicensed bands employ spreading to help mitigate interference of multiple devices.

Though to be sure, spread spectrum is no panacea and unlicensed users in the same geographic space can indeed interfere with each other. Huffman overviews two important techniques of spreading – frequency-hopping (FH) and direct-sequence (DS)[6,7]. Early 802.11 systems employed FH. Amongst its advantages, FH spread spectrum systems are particularly resistant to interference from competing and un-coordinated FH networks; these systems combat interference from self-similar networks by simply hopping out of it. Today's popular 802.11b systems, however, employ DS spread spectrum which is able to provide more bandwidth compared to FH. While these DS systems are more robust to narrowband interference, they are not as able to resist interference from competing spread spectrum networks. In other words, multiple 802.11b systems operating in the same area can interfere with one another impacting network reliability (in 802.11b there exists three non-overlapping bands to chose from which is a first step in eliminating such interference). To reduce this interference, some cooperation amongst multiple DS systems in the same area is advised.

Anarchy in the airwaves

Spread spectrum is an elegant engineering approach that can allow better sharing of spectrum by diminishing the effect of interference between multiple devices transmitting on the same radio frequencies. As a technologist, I can see why spread spectrum is important. But focusing on this technical affordance completely misses the central point, in particular when thinking about how to bridge the digital divide. It is the controlled anarchy, where multiple unlicensed users are allowed to operate overlapping (even competing) wireless networks, transmitting all within the same frequency band – it is this anarchy that is so thrilling. Indeed, this bottom-up approach may be nothing less than revolutionary and a central element to bridging the digital divide. Imagine a telecommunications network built bottom-up by a large number of small and local entrepreneurs. Each mini-telecommunications operator can provision services within their local community just by purchasing the basic radio equipment (already costing only hundreds of dollars) and transmitting on these unlicensed frequencies. The model is inexpensive, bottom-up, grows organically, and it scales; as the number of local providers increases so does the overall capacity of the network since each operator conceivably increases the number of pathways between any two points. Examples of such community wireless networks are springing up in the USA and can't be far off in many parts of the South.

My colleague, Nicholas Negroponte, calls this the "lily pad and the frog" effect. Each local entrepreneur is building a lily pad of wireless network connectivity. And other entrepreneurs from surrounding communities are doing likewise. Lily pads grow closer and closer, some even overlap; sooner or later, the pond is going to be covered. And users, the frogs, will jump from network to network.

A living bridge

Huffman raises a number of critical issues that describe the context in which these wireless technologies sit. The importance of human capacity building and skilled professionals, basic infrastructure such as roads and electricity, weather conditions, investment capital, attention to gender issues and empowerment, and the like. These are all of fundamental importance; in fact the technology and engineering aspects of the digital divide problem are comparatively easy to tackle. To this list I'd add the central issue of government policy, and in particular spectrum allocation and management.

What kind of bridge is built by this bottom-up wireless network? You may have heard stories of bridges constructed by troops of ants. Ants from a colony march to some impasse, a small waterway or a gulf between rocks for instance. Each ant climbs one upon the next, ant-by-ant building a living bridge across the divide.

Acknowledgements

Thanks to K. Giridhar of IIT Madras for reviewing a draft of this paper.

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[1] TeNeT Group, IIT-Madras. (Available from: http://www.tenet.res.in)
[2] SARI Project. (Available from: http://edevelopment.media.mit.edu/SARI/mainsari.html)
[3] n-Logue Communications. (Available from: http://www.n-logue.co.in)
[4] Bharat Sanchar Nigam Ltd. (Available from: http://www.bsnl.co.in/service/hvnet.htm)
[5] Videsh Sanchar Nigam Ltd. (Available from: http://www.vsnl.com/english/services/gpss.htm)
[6] Gast, M.S. (2002). 802.11 *Wireless Networks: The definitive guide*. Sebastopol, CA: O'Reilly & Associates, Inc.
[7] Blogh, J.S. & Hanzo, L. (2002). *Third-Generation Systems and Intelligent Wireless Networking.* West Sussex: John Wiley & Sons, Ltd.