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White Space and the Internet of Things

by Laurie Lamberth

In May, I encouraged the mSolve community to "Think Big about the Internet of Things." With 50 billion connected devices predicted in 2020 – less than a decade away – there will soon be a huge influx of connected devices and "smart objects" dotting our homes, offices and public places. My May article highlighted segments in the global ICT value chain where "extreme innovation" is needed to enable the Internet of Things: device and platform software, semiconductors and modules, wireless access networks and cloud-based services. This month, I'm focusing on an emerging type of wireless access network that will be fundamental to the Internet of Things: TV white spaces.

Today, connected devices communicate using a plethora of technologies: cellular, SMS, Bluetooth, Wi-Fi, Zigbee, Z-Wave, two-way paging, private radio networks, wired Ethernet, "plain old telephone service" (POTs), and soon -- "TV white space." "White space," in the context of wireless communications, means patches of wireless spectrum that are not in use by the spectrum's licensee all the time in all locations. It turns out that there is a LOT of empty spectrum: A September, 2010 study by the Shared Spectrum Company (SSC) found that the radio airwaves between 30 and 300 megahertz – spectrum that in the U.S. includes television, mobile networks, air traffic control, commercial and private radio, Wi-Fi, and more – was unoccupied most of the time in the Washington D.C. suburbs. TV stations and cellular network operators used their spectrum the most with 50-90% and 30-50% utilization respectively, on average. The rest of the spectrum bands were occupied 25% of the time, or less, with 18 out of the 32 bands studied averaging less than 10% usage. These results are similar to SSC's 2005 study finding similar low spectrum occupancy rates in Chicago and New York City.

Much of this spectrum is vacant to prevent interference between licensed users and for network management purposes. A cellular network that used its allocated spectrum more than 80% on a regular basis may not have sufficient capacity to deal with peak loads, a risk highlighted by mobile network outages after August's magnitude 5.8 earthquake near Washington, D.C.

The white spaces that have been allocated for use by the U.S. Federal Communications Commission (FCC) and U.K.'s telecoms regulator Ofcom are between digital TV channels, ranging from 54 to 698 megahertz in the U.S. and 470 and 790 megahertz in the U.K. These bands should provide a lot of available spectrum: in their official statement announcing unlicensed use of TV white spaces last Thursday, September 1, Ofcom said they "expect the amount of white space to be comparable to spectrum that is currently available for 3G services, and significantly more in some locations."

TV white spaces are available to anyone on an unlicensed basis, similar to Wi-Fi. That means any device can use the spectrum so long as it complies with a set of rules that prevent it from interfering with licensed users, wireless microphones and other white space devices. These rules present some fairly steep technology requirements: white space devices must function at restricted power levels, use adaptive power control to ensure they are radiating at the lowest level possible, know where they are, and connect to the Internet in order to access to a geotagged spectrum-availability database. In the

both the U.S. and U.K., proposed requirements that would require white space devices to sense and avoid other signals on the channels they're using were dropped based on technological feasibility, timing and cost, though both regulators would prefer this approach should it become feasible in the future.

With all of these restrictions, one wonders why anyone would bother with white spaces. Reason one: it's free. Free is important: the U.S. Federal Communication Commission's (FCC's) 2008 decision to allow unlicensed use of white spaces was the first expansion in U.S. unlicensed spectrum since the they opened up the Wi-Fi band at 2.4 gigahertz in 1985. Considered "junk spectrum" at the time, the 2.4 gigahertz band came alive with the development of spread-spectrum technology and the 802.11 Wi-Fi standard. Wi-Fi has brought local area network and Internet connectivity to our homes, offices and public buildings and has generated huge improvements in our quality of life. Regulators approving unlicensed use of TV white spaces are hoping for a similar technological revolution tied to this spectrum.

Second, it's powerful. In the U.S. and U.K., TV white spaces occupy positions low on the frequency map meaning that the signals penetrate buildings better, travel farther and cover larger areas than higher-frequency signals. TV white space transmissions can carry as far as 10 km/6.2 miles, which is more than 100 times better than Wi-Fi's operating range of 100 feet indoors and 300 feet outdoors. Data throughput rates in TV white space spectrum are high: 16 megabits per second isn't unusual and manufacturers are angling for significantly greater speeds in future product generations. Because of these attributes, the U.S. Congress and FCC call TV white spaces "Wi-Fi on steroids" and "Super Wi-Fi" (even though white space devices do not conform to IEEE's 802.11 Wi-Fi standard).

Just this year, after a long period of regulatory foundation-building, technological innovation and product development and certification, white space products are finally making it out of lab and into the market. Across the U.S. and Europe, white space trials are demonstrating how this communication technology can improve hospitals, enable the smart grid, support "smart cities" and empower a new generation of high-bandwidth consumer electronics. Cambridge, U.K. hosted white space trials in June which were backed by a consortium including Microsoft, British Telecom, BSkyB, BBC, Nokia, Neul and Adaptrum. The trials featured an XBox 360 steaming HD video from the Internet over white spaces and video chat between two white space-connected Kinect game players without interfering with adjacent TV broadcasts. Neul followed up by launching the first-to-market NeulNET white space base station and terminals.

U.S. white space trials, conducted by Spectrum Bridge with Google, Microsoft and Dell, have demonstrated white spaces' value across a broad set of applications. For example, Spectrum Bridge and Google partnered with Northern California's Plumas-Sierra Rural Electric Cooperative & Telecommunications to monitor and communicate with remote substations, manage the power flow and protect the grid using TV white spaces – and provide broadband Internet service to an underserved community at the same time. Microsoft deployed a "White-Fi" network at their Redmond, WA headquarters that covers the entire 500-acre facility with only two base stations. It would take hundreds of Wi-Fi routers to cover the same area. These companies, along with Intel, Phillips and Samsung, clearly see a big future in white spaces.

While the regulatory and technological barriers to the deployment of white spaces are falling rapidly, other barriers remain to be overcome. One of the thorniest problems is that white spaces aren't available in the same amount or on the same channels everywhere. For example, at my home in Long Beach, CA, the only white space channel that's available is Channel 2 – a channel on which I can only use "fixed" white space devices because portable devices such as laptops and mobile phones can only be used in channels 21 and higher under U.S. rules. Because white space availability is generally better in rural areas, the first white space solutions to be offered for sale may be skewed toward solutions that benefit these communities, such as public broadband services.

Also, at least in the United States, legislators just don't seem to be able to keep their paws off of white spaces. Even though the FCC has already approved unlicensed use of TV white spaces, several members of the U.S. Congress proposed auctioning access to TV white spaces during the summer's debt ceiling debates. While the legislators are hoping for a financial windfall to help close the U.S. budget gap, industry insiders wonder why anyone would pay for non-exclusive access to intermittently-available spectrum. Worse, the proposal would allow a single bidder to swoop in and outbid the total of all other bidders for white space access. In that case, the single bidder would gain an exclusive license to use white spaces, effectively killing public and community access to white spaces.

Globally, the U.S. and U.K. are out in front but other countries are expected to jump onto the TV white spaces bandwagon soon. The E.U.'s Radio Spectrum Committee (RSC) and the European

standardization bodies (CEPT, ETSI) are closely following white space developments. Most analysts expect other E.U. countries to follow the U.S./U.K. lead within the next two years.

Looking ahead, what does the future hold for TV white spaces? Beyond basic product development, market entry, and consumer adoption, white spaces are perfect for connecting smart devices and sensor networks over much larger areas than Wi-Fi – without a cellular or satellite connection that comes with a monthly access charge. Some analysts speculate about products that will merge Wi-Fi and white spaces to create versatile devices that can seamlessly switch between local- and larger-area networks, and provide continuous, free connectivity within areas larger than Wi-Fi networks can provide. Citywide delivery services and other community-based services should flourish.

As in the mid-80's early Wi-Fi days, I'm sure we've only scratched the surface when it comes how we will use TV white spaces to connect people, strengthen communities and improve the bottom line. I can't wait to see how it all unfolds.

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The mSolve Team