Redefining "The Field" : How Wireless is Expanding the Network Edge

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The fabled Pony Express of the American West started carrying mail on April 3, 1860. At a time when the typical wagon train required four or five months to travel from Missouri to California, the Pony Express used relays of fresh horses and riders to cover the same distance in just 10 days. Well planned and well executed, it represented the cutting edge in western communications.

The first transcontinental telegraph was completed on October 18, 1861. And that was the end of the Pony Express. The company may have achieved enduring fame and glory, but it was only in business for 18 months. Technology doesn’t stand still.

We’re at the threshold of a similar revolution in communications technology. Just as the telegraph made it dramatically cheaper and easier to expand the communications network back in the days of the Wild West, new developments in wireless communications, integrated circuitry and power requirements are allowing us to greatly expand our own.

Remote Power

The telegraph operators who put the Pony Express out of business often powered their telegraph lines with gravity batteries that they assembled themselves. A glass jar held a copper cathode on the bottom and a zinc anode was suspended beneath the rim. The operator would scatter sulfate crystals around the cathode and fill the jar with distilled water. These batteries were neither powerful nor portable, but battery technology improves so slowly that versions of the gravity battery remained in use for nearly a century. The limitations of battery power have often determined what could be deployed out in the field.

But integrated circuits are steadily becoming smaller, smarter and more energy efficient. Back in 1965 Intel co-founder Gordon E. Moore noted that the number of transistors that could be placed in an integrated circuit was doubling every year. The trend has continued. Combined with developments in solar power, micropower and power harvesting, the integrated circuit’s decreasing size and power requirements are making it possible to install remote circuitry and intelligence in locations that used to be far beyond the network edge.

The United States Geographical Survey (USGS), for example, monitors water conditions all over the country with an array of automated sensors

that test water at fixed intervals and transmit the data back to the USGS. Many of their sensors are placed in locations that are so remote that there is no practical way to access the power grid or any wired Internet infrastructure. B&B Electronics was called in to provide a solution. B&B equipped the sensors with solar panels and maintenance-free batteries to deal with the lack of access to the power grid. Today's smaller, smarter sensors with embedded intelligence only need about 0.60 Amp hours per day to do their jobs, so using them eliminated any need to run AC power out to the test sites. There was no need to run data cables, either. The B&B team deployed small, smart, IP67-rated outdoor radio transmitters which only use around 2.4 Amp hours per day. The installed 50 W solar panel provides enough power for both the smart sensor and transmitter while simultaneously charging the attached 12 V battery for transmission after sundown. (See Fig. 1) The system works because it doesn't need much power, and because its embedded intelligence allows it to overcome distance and interference by storing and retransmitting data until reception has been confirmed.

The Advent of Wi-Fi

While smaller, smarter, low power integrated circuits are helping to expand the network's edge, new developments in radio are doing the same. In clear air radio waves attenuate with the square of the distance. Thus, merely doubling the range should require a four-fold increase in power. And the longer the range, the more opportunities there are for multipath propagation. Multipath propagation occurs when radio waves are absorbed or reflected by intervening objects like trees or buildings, causing them to arrive at the receiver at different times and out of sequence.

Rather than trying to overcome these behaviors, the latest Wi-Fi standards embrace them. The current multiple-input multiple-output (MIMO) technology used in 802.11n Wi-Fi deploys multiple antennas at both the transmitting and receiving sides of the wireless connection and splits the data into numerous spatial streams. The streams are transmitted through the separate antennas and collected by corresponding antennas at the other end, where software algorithms process the signal and interpret the incoming data. MIMO 802.11n devices also employ

precoding and postcoding techniques like spatial beamforming to help smooth things out. Spatial beamforming modifies the phase and relative amplitude of the signal to create a pattern of constructive and destructive interference in the wavefront, making it easier for the receiver to interpret incoming signals. 802.11n also adds frame aggregation to the MAC layer. Grouping several data frames into a single, larger frame allows management information to be specified less often, improving the ratio of payload data to total data volume. Adding 40 MHz channels to the physical layer has doubled the available bandwidth. Together, these techniques give Wi-Fi radio greatly enhanced range and reliability.

The multiple radios and multiple antennas would otherwise increase power requirements, so MIMO devices transmit their data in bursts and hibernate when inactive.

Cellular Networking

There is another way to network remote sites and M2M equipment with wireless: the cellular telephone system. Cellular telephone coverage has already become so extensive that many of us find it to be a bit of a surprise when we can’t get a signal. Wireless carriers are eyeing M2M as a strategic growth market, and data plans are becoming quite M2M-friendly. Both Verizon and AT&T have recently announced shared-data plans that are designed to stimulate the addition of non-phone devices.

Companies like Conel, in the Czech Republic, have developed hardware and software that allow users to expand the range of their data communications networks to include any location that has cellular access. The network remains under the user’s own control and the packet transfer system lets users employ any station in the network as an end or retranslation station. Users can create networks with complex topologies and virtually unlimited size, data transfer can be encrypted, and the system will support multiple protocols. 3G technology is already mature enough that cellular systems serve as the backhaul for telecommunications and broadband services in countries like Belize, where a fiber build-out would be impractical due to jungle and mountain terrain.

Interoperability

The proprietary protocols and equipment that hampered system designers in the past are giving way to universal IP-based standards as more and more end users insist upon interoperability. Even legacy serial devices are migrating to IP communications. Manufacturers have developed small, smart, wireless serial-to-Ethernet embeddable modules that can connect serial devices to existing networks or allow them to create self-sustaining Wi-Fi hotspots for communications with laptops, tablets and smart phones. (See Fig 2.)

Convergence

The IPv6 addressing standard, with its ability to provide 3.4 × 1038 unique IP addresses, is an indication of what is coming. Devices will continue to become smaller and smarter, and their power requirements will continue to drop. Improvements in wireless will continue to expand its range and coverage. It will soon be possible to network-enable just about anything, just about anywhere. And the concept of “The Field” will seem as antiquated as the Pony Express.

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