Wireless In Ulaan Bataar

Learning From A True-Life Mongolian Network Adventure

BY

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In Ulaan Baatar, Mongolia, severe weather conditions prevail, the wired telecommunications infrastructure is very poor, advanced telecommunications technology expertise is limited (although there is considerable local computer expertise), and US access to Mongolian scientific and research facilities is highly constrained by lack of normal Internet connections.

Last year, some of us went to Mongolia to integrate a series of data radios into a wireless network, and then field-test them. Our purpose was to build on and apply knowledge being gained from the "Wireless Field Test (WFT) Project for Education," funded by the National Science Foundation (NSF) and run by Dave Hughes of Old Colorado City Communications, in Colorado Springs, CO.

The Problem

The expedition's mission was an attempt to remedy the lack of a suitable wired telecommunications infrastructure in Mongolia, including across its capital city--a problem typical of thousands of cities in underdeveloped countries. "Suitable," in this case, means public or private circuits capable of carrying data with the reliability and bandwidths necessary for scientific research between institutions, increasingly equipped with advanced in-house computer and even local area networks.

As a result of this deficiency, the primary institutions in Mongolia, such as the Mongolian Technical University, the Mongolian Academy of Sciences and the many other educational facilities which reside in the capital city are inaccessible (via data link) to US scientific institutions, researchers and students.

What exists is a poor and obsolete government postal, telephone, and telegraph voice-telephone system, a holdover from when the Soviet Union controlled Mongolia. Efforts to use even late model error-correcting phone datamodems to link the computers in the various institutions is only partially successful, since the non-digital circuits are so old. It is difficult to maintain even a 14.4Kbps connection without the line dropping many times in an hour.

As a result of the first step to provide Internet access to Mongolia, NSF funded the establishment of a costly ($72K/yr) satellite Internet link. This 128K link, provided by Sprintlink, only reached one set of computers in a single building, in the central part of the city, by direct wiring. The PTT has neither the resources nor the expertise to provide even the lowest speed (56Kbps) wired circuits to connect the numerous other institutions.

The "last mile" problem of connecting this satellite link to the institutions (actually about one to ten kilometers from the satellite ground station), which must then distribute the signal to their own wired intranets, had so far defeated efforts to link it by local telephone facilities. In this respect, Mongolia is typical of scores of underdeveloped nations with a poor telephone infrastructure, too limited to adapt to modern requirements for institutional datalinks to and from other nations, especially the US. Wireless datalinks provide one possible general solution to this problem, not only in Mongolia, but in many other countries.

Challenges

A number of challenges made this a difficult project, as well as one from which valuable lessons and techniques were learned for application elsewhere:

* The weather is more severe in Ulaan Baatar than in the areas in Southern Colorado where our wireless field-test project has been implemented. High winds and average temperatures from -15° to -25°C for entire winter months will subject the radios, connectors, shielding materials, and antennas to extremes of cold and wind.

The question was whether or not economical commercial-grade radios and systems could handle the weather and give similar MTBF (mean time between failure) times to those systems operating in milder climates.

* Whether the electromagnetic environment from the equipment that exists in Mongolia today, some from systems developed and deployed by the Soviet Union in the past, in a different technological regulatory environment, will affect the spread-spectrum dataradios that we intended to deploy, which were developed in the US and operate in environments controlled by FCC rules.

* Could the wireless network be integrated into networks made up of a mish-mash of US and foreign computer and peripheral equipment, and would interoperability be a problem?

* Given the level of in-country expertise able to help install and maintain the wireless network, could local personnel be trained sufficiently in a short period of time to handle the network in the future, with only the assistance of remote expertise to call upon for help?

Groundwork

The Mongolian government had permitted a group of Russian-trained Mongolian engineers to form a private technology company, DataCom Co., Ltd, headed by Dr. Dangaasuren Enkhbat, using facilities at a technical center once occupied by Soviet engineers.

The NSF had turned to this company--with limited liquid assets, but in a suitable central facility in the capital--to provide the critical organizational link between the satellite-based Internet feed and in-country institutions. In return for being able to eventually provide Internet service to private companies in Mongolia, and being given control of the satellite groundstation, DataCom agreed to provide links to Mongolian public, scientific, educational, government, and library institutions for at least two years, at no cost. With initial finding from various sources, and with help from groups such as Sprint, PanAmSat, Comstream, NSF and the us ambassador to Mongolia at the time, Donald C. Johnson, DataCom became the first Internet Service Provider in Mongolia in December of 1995. (The top-level domain name for Mongolia is MN. DataCom maintains a Web site at http://www.magicnet.mn/).

Once the project was approved by NSF, our first task was to determine what would be required for the expedition and what we'd have to do once we arrived in Ulaan Baatar to deploy the wireless network. We made use of maps, videos and communications with the staff of DataCom, in order to determine exactly what types of radios would work in their environment, and what configurations and physical distributions of sites would be required for distribution of Internet services from the DataCom location. The plan was to install a basic wireless Metropolitan Area Network that would consist of eight sites: the DataCom site, and seven sites selected by DataCom. These were all universities, with the exception of the US Embassy.

Based upon our experience in the WFT project, we had made a preliminary decision to use unlicensed Part 15 dataradios developed and marketed in the US by a small Boulder, CO company called FreeWave Technologies, Inc. (http://www.freewave.com/). They make a spread-spectrum radio that can send data at 170Kbps over the air and interfaces to a computer via a serial data interface (RS-232) at 115.2 Kbps. The radio operates in the 902-928MHz part of the spectrum, one of three bands utilized by Part 15 devices in the US. These radios put out 1 watt of power; using various antenna configurations we have been able to obtain/send data with them distances of up to 60 miles. (For more information on the use of these sorts of unlicensed spread-spectrum radios, check out our WFT project Web site at http://wireless.oldcolo.com/).

We learned that the 902-928MHz band was not completely available for our use in Mongolia, since the commercial cellular telephone network there used GSM technology which operated in a portion of the band from 902-915 MHz. In order to use the FreeWave radios in Mongolia, we had to make two things happen.

We first got DataCom to obtain from the Mongolian government permission to operate the radios in the 915-928MHz part of the spectrum, avoiding the conflict with the GSM cellular network. We next got FreeWave to provide us with a special version of their radio which would operate in this smaller portion of the 902 MHz band. As it turns out, this was not difficult--they had already encountered the same problem when they first entered the Australian market, which uses GSM cellular in the same band.

In order to connect each site's radio to the local LAN we determined that we needed a low-cost Internet router that could be installed and maintained at each location. For the WFT project, we had already developed such a router based upon the widely available Linux operating system and a low-cost PC. We decided to use this approach in Mongolia, as we already had a great deal of experience with this router and an attached FreeWave radio. Aside from Linux, all a PC needed to function as a special purpose IP router was a high-speed serial card that would support an interface speed of 115.2Kbps and enough RAM to allow Linux to function properly (in this case we used 16MB).

Also important were the antennas and feedlines. It was clear that we needed an omni-directional antenna for the DataCom site, since it was the point-of-presence (POP) for all Internet services and each remote site would have to connect to it. For the remote sites, we would require a directional antenna that could focus all of the available energy from the radio on the POP.

Although the distances involved in the Ulaan Baatar network would be a good deal less than we had been used to in the US (average about 20 miles), we decided to use the same high-gain omni and directional antennas that had used here rather then taking the time to find lower-gain alternatives--it's better to have more antenna gain than you need than to get there with less and find out that you need more. We also decided to use the same low-loss coax feedline (LMR-400) to connect the radio to the antenna that we had been using in the WFT project.

Even with all the up-front analysis of each site's requirements, we still had no idea of the exact amount of feedline that we would require. As a result, we decided to take three times as much as we thought we'd need.

Finally, there was the issue of electrical power. In Mongolia, they use 220 VAC; we had to obtain the necessary power adapters and connectors to insure that the radios and routers could all operate on local AC power.

As it's common practice with an expedition of this sort to a remote part of the world, we made sure that we had spares for all of the key equipment, especially routers and radios. When it came to just how we were going to get all of the equipment to Mongolia, the NSF intervened and made arrangements with the US ambassador in Mongolia that allowed us to ship everything via diplomatic channels (the famous "diplomatic pouch"). Thus we were able to avoid the normal problems encountered using commercial shipping firms and dealing with customs procedures.

It turns out that spread-spectrum radios cannot be exported to countries such as Mongolia without a special export permit from the US government. Obtaining such a permit can take anywhere from three to six months. As we were trying to get the expedition completed before the harsh Mongolian winter started (December-March) we were fortunate in being able to bypass that requirement by shipping the radios the way that we did.

The downside in using the diplomatic channel for shipping is that once you put your shipment into the system, you only have a rough idea when it is going to arrive at its destination. Thus we had to use estimates on the time it took other items to arrive in Mongolia as the basis for determining just when the expedition team itself should arrive. As it turned out, we were lucky in that most of the equipment arrived before we arrived in Mongolia, with the exception of a few pieces that arrived after we had been in-country about a week.

Installation

A team consisting of Glenn Tenney, AA6ER (of Fantasia Systems, San Mateo) and myself left for Mongolia in October of last year. After we had arrived, made the initial visit to DataCom, and inventoried our equipment that had arrived (except for the few missing items), the first order of business was to survey all of the chosen sites in order to determine just what would be needed to deploy the equipment.

We were shocked to find that DataCom was surrounded by high-rise buildings that effectively blocked line-of-sight to all of the sites where installations were to have taken place. One of the key factors in getting this type of low-power radio to work properly is to have a clear line-of-sight path to any location that you wish to contact. Without major obstructions, it is possible to establish communications over fairly long distances; with obstructions it is usually not possible to go more than a few hundred feet. Given what we saw from the DataCom site, it looked like it was time to wrap things up and get on the way back home. However, we decided to make the best of a bad situation, attempt to proceed anyway, and see just what could be accomplished.

First, we installed the first radio and router at the DataCom site. In order to maximize the power output to the antenna from the radio, we mounted the radio on the roof of the building just a few feet from the antenna in a small equipment shed. This approach allowed us to use just a short coax feedline to the antenna and then a rather long serial-data cable to the router which was on the second floor of a four-story building. Since this location was the main hub for the wireless network., we used an omnidirectional antenna.

We next set up a mobile radio so that it could be powered by batteries and carried about in a car with one of the directional antennas. We decided that we wanted to travel around town and see if it was possible to receive the signal at any distance from the POP location. To our surprise, we were able to get a good signal at most of the sites where we were to have installed a radio--all without having line-of-sight to the POP. After some analysis, we were able to determine that even though Ulaan Baatar is populated with a large number of high-rise buildings, the materials used in their construction are such that they appear to be effectively transparent at the frequency of the radio emissions that we were using. This windfall allowed us to proceed with installation at each site as planned.

The most difficult part of the installation is the proper placement of the antenna and its connection to the radio. The major goal is to minimize the length of feedline used to connect the radio to the antenna--the basic rule being that the longer the feedline, the less power actually gets to the antenna, and hence the lower the signal quality at the remote location. This is where we spent most of our time during the next two and a half weeks. Each site had to be surveyed; then we had to work with the local people in charge of that site to convey to them what needed to be done and make sure that the proper permissions obtained to do the work.

At some sites, nothing major was required, as the antenna and the radio/router ended up being in the same room. In other sites, such as the US Embassy, the antenna had to be mounted on the roof and feedline run several floors to get to the radio and the router. Once the site preparation was complete, it was a very simple matter to install the radio and router.

One major problem developed, once we were over the site preparation issues and got to testing the radios. We found the PCs we selected were unable to have their serial ports run at speeds over 19.2Kbps without data overruns; as soon as we tried to send data to the radios at any speed over 19.2Kbps, nothing worked. After a few days spent in investigating the cause of the problem, we discovered that even though the technical specifications of the PCs indicated that the on-board serial hardware could be run at speeds up to 115.2Kbps, this was not the case. DataCom has some new Pentium PCs that arrived while we were there, intended for a public Internet access center. When we installed Linux on those machines, configured it as a router, and set the serial interface to the 115.2Kbps speed, everything functioned properly.

As luck would have it, we were able to contact someone coming over from the US to Mongolia. This person brought the necessary number of high-speed serial cards over; we were able to install them in the PCs that we had and get them to function properly at the higher datarate. As a result, we were finally able to leave Mongolia, after a slightly longer stay than we'd planned, with the wireless network installed and good connections to the seven remote sites.

The network that we installed is still up and running today. The staff at DataCom has been able to maintain the network and even extend it with additional sites.

Lessons Learned

Here is a summary of some of the key things we learned as a result of this effort:

* A good site survey ahead of installation is the key to the installation's success. The specifics of a survey require people with a good deal of expertise in several areas. If you can't get those people to the site ahead of time to perform the survey, success can be in serious doubt in such remote locations as Mongolia.

* Always make sure that you test the equipment that you're using before you ship it to a remote location. Never believe the specifications for a product until you've tested it yourself! ! !

* Radio is still something like a black art (i.e., magic). There is always something new to be learned. Until we had gone to Mongolia and did this installation, we would have never believed that you could deploy such a wireless network in a dense urban area without having line-of-sight to all locations.

* Low-cost spread-spectrum radio products that are being used in increasing numbers in the US to deliver access to the Internet can be successfully deployed in developing countries with limited expertise in both radio and Internet technologies.

In closing, we'd like to take this opportunity to acknowledge the help and assistance of Steve Goldstein of the NSF, without whose caring and wisdom this effort would not have been possible.