Although the ability of scientists to collect and store remote environmental field data is becoming more commonplace in today’s wired world, researchers still need interdisciplinary repositories from which they can easily share and into which they can infuse real-time information straight from the field. In Southern California, the University of California at San Diego and the Scripps Institution of Oceanography are leading efforts to create an environmental observing and monitoring network that demonstrates the collection and streaming of real-time seismic, oceanographic, hydrological, ecological, geodetic, and physical data via wireless networking.

The High Performance Wireless Research and Education Network (HPWREN) was funded by a three-year, $2.3 million grant from the National Science Foundation for the creation, demonstration, and evaluation of a non-commercial, prototype, high-performance, wide-area, wireless network. The network was designed to address the lack of high-speed Internet connectivity, or often any Internet connectivity, away from the urban core. In rural or uninhabited areas, data are being collected for a variety of scientific disciplines, but transmitting those data has previously been a slow process. Alternative options for Internet access, such as fiber optics and satellite links, can be prohibitively expensive; thus a more feasible option was desired, and HPWREN was born.

While working with interdisciplinary scientists ranging from oceanographers to ecologists, the HPWREN team also provides support for the wireless networking aspects of UCSD’s Real-time Observatories, Applications, and Data management Network (ROADNet) project.
ROADNet was spun off from HPWREN to focus exclusively on sensor integration; real-time data transport; and data analysis, discovery, and widespread access (see sidebar). In short, HPWREN is the network on which ROADNet data travel.

**Linking it All Together**

Just how does this network work?

At the outer edges of the network, real-time data are collected by field sensors connected to HPWREN using radio and Internet protocol (IP) methods. Researcher locations, science monitoring sites, and educational sites are connected to relay nodes, which are 3 to 45 miles apart. Individual sites are as far as 70 miles from their relay node (see network map, below left). The data are transmitted via HPWREN’s IP network, which uses a variety of media, including fiber optic cable and wireless networks.

Currently, a variety of geophysical, astronomical, and ecological data are being collected. For example, earthquake sensors in the desert east of San Diego record strain measurements. Images from Palomar Observatory and San Diego State University’s Mount Laguna Observatory are transmitted back to researchers worldwide. At SDSU’s 4,344-acre Santa Margarita Ecological Reserve, capture systems for real-time video and audio, as well as micrometeorology and hydrologic monitoring systems transmit data to the network for common use (see article on page 18). Oceanographic data, including current direction and velocity and ocean temperature, are recorded from sensors in the Pacific Ocean.

As soon as they are collected, real-time data are relayed through HPWREN directly to the research scientists and sent to their assigned servers for widespread access. For example, ocean buoy data are posted to an oceanographic server while data from seismic and geodetic sensors are posted to the IGPP Digital Library. These servers are joined together to form an overall network, which is accessible by users within seconds of data being collected.

**Data Management**

Using a GRID-type infrastructure design, HPWREN’s data management system consists of three primary components:

- data handling system
- information “discovery” system
- real-time analysis system

The data handling system contains the data repositories and distributes the data see ROADNet, page 30
USGS Reports Record Low 2002 StreamFlows in AZ

A compilation of surface-water, water quality, and groundwater data for water year 2002 (October 2001 to September 2002) was released in May by the U.S. Geological Survey in Tucson, Arizona. The report was prepared in cooperation with other agencies and the State of Arizona. According to the report, annual mean streamflow at 29 of 201 streamflow-gauging stations (14 percent) in Arizona during the 2002 water year was the lowest on record. Three of the stations are on the Verde River in central Arizona and 19 are on tributaries of the Verde, Salt, or Gila rivers. Yearly discharge at five key gauging stations during water year 2002 ranged from 29 to 57 percent of the median of yearly discharges computed for the period 1950 to 2002.

The report contains:
- discharge records for 201 streamflow-gauging stations, 29 crest-stage, partial-record streamflow stations, and 48 miscellaneous sites;
- stage or content-only records for 10 lakes and reservoirs;
- water-quality records for 21 streamflow-gauging stations and 65 wells; and
- water levels for 18 wells.

The report was released in printed form and is also available online at pubs.water.usgs.gov/wdraz021/.

Telemetry, continued from page 15

Commercial satellite services offer two-way communications to those users who need to “talk” to their DCPs and who are outside the service area of landline and cellular service and for whom an LOS radio system is impractical.

A satellite phone behaves much like a phone modem. Users can dial into their DCP and manually download data or use software to automate this process. Some satellite services provide an Internet protocol (IP) connection to the DCPs using the more expensive phones, allowing the DCP to send data at any time. Basic satellite phone modems communicating at 2,400 to 4,800 bps cost around $1,500 to $4,000.Phones with higher data rates can cost as much as $10,000. Monthly service charges range from $45 to near $100 per month for low-volume data, and can exceed $100 per month if extended periods of station communication occur frequently.

A key advantage of commercial satellite service is two-way communication, which provides the ability to interact with the DCP to change parameters in its setup or to send control signals. Also, technicians have voice communications available to them at the DCP site. Disadvantages are recurring costs and power consumption. Compared to a GOES DCP, some satellite phones require augmentation of the battery and solar panel size by a factor of three or greater, increasing the site cost significantly. Care must also be taken to ensure interoperability of the data logging equipment and the satellite phone. Reliability for systems using geostationary satellites is very high.

Location, terrain, time sensitivity of the data, and budget are primary factors to consider in deciding which telemetry to use. Consulting engineers, equipment vendors, and other water management agencies can provide information to help you in this process.

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ROADNet, continued from page 17

across a network of heterogeneous storage systems. The information discovery system allows users to find data, including data that they might not have known existed, by searching on geographic location or sensor type, and to extract data based upon characteristics rather than location. The data analysis system allows the collection and performance of operations on data and data streams that are stored in different locations as if they were all from a single location. The ability to extract metadata from real-time data flow is anticipated as a future enhancement.

The San Diego Supercomputer Center’s Storage Resource Broker (SRB) provides the interface for ROADNet’s connection of heterogeneous data sources via HPWREN, as well as acquisition of data from other storage locations. In conjunction with the Metadata Catalog (MCAT), the SRB provides users with an efficient means to access data sets and resources based on their attributes rather than their names, disciplines, or physical locations.

Additional information on the HPWREN system is available at hpwren.ucsd.edu.