Meeting the Challenges of Real-Time Data Transport and Integration: HPWREN and ROADNet

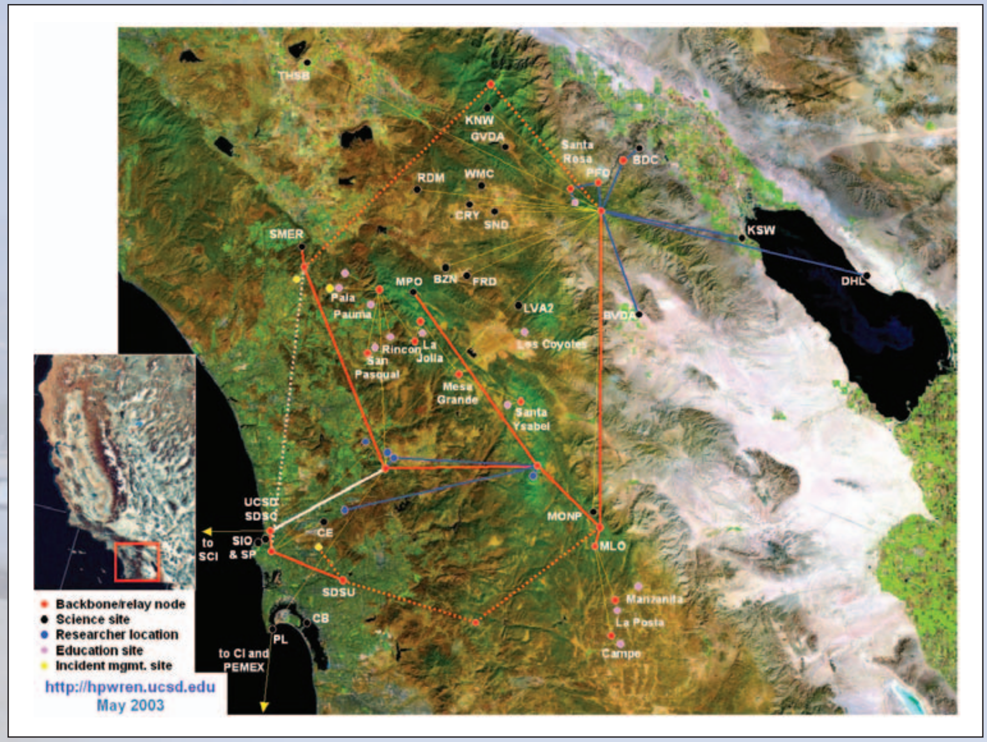
***Betsy Woodhouse, Ph.D**. – Southwest Hydrology, SAHRA and **Todd Hansen** – System Coordinator, ROADNet*

Photos courtesy of the HPWREN team.

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.

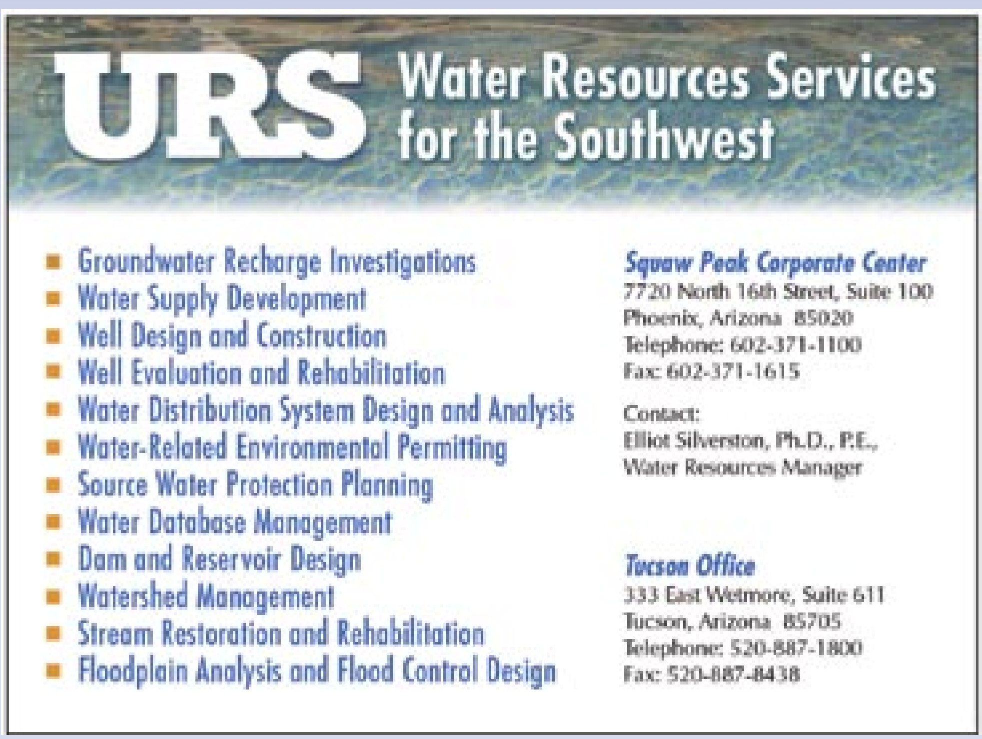
Data Management

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



The Focus of ROADNet

The University of California at San Diego developed the ROADNet program as a spinoff of HPWREN to facilitate real-time data integration, transport, analysis, and discovery. ROADNet was developed on a platform originally designed to handle the data requirements of seismic researchers who wanted to conduct real-time analysis of seismic events. It has expanded to allow users to collect, post, analyze, and retrieve data from seismic stations, lowland river watersheds, mountainous watersheds, observatories, ocean buoy research vessels, and GPS observatories.

Data are collected from a variety of sensors in remote field locations and sent to a data transport and analysis system that manages multiple connections to multiple field sensors. The system not only provides data to multiple users in real time, but can also interface with more traditional databases. An additional interface is under development that will be able to reconfigure and prioritize data capture and analysis dynamically, directly from the sensor networks. ROADnet's data transport network consists of a series of computers that act as data relays and buffers in the case of network problems.

All of the real-time data are now accessible through the ROADnet Web site at roadnet.ucsd.edu/rtd.html. Data currently available include seismic and strain meter data, meteorological data, streamflow and water quality measurements, and ocean currents and temperatures from stations in remote San Diego County, offshore islands, and ships and buoys in the Pacific. A new status feature at mercali.ucsd.edu/status.cgi allows each research group to show the most recent data collected.

The ROADNet project is interested in working with other research groups that could benefit from the data integration and analysis system that is being developed.

For more information, visit roadnet.ucsd.edu.

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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.