ALERT real-time weather monitoring and flood warning

Real-time weather and flash flood monitoring can save human lives

The ability to receive relevant, timely information about local weather empowers organizations to react to impending danger in an effective manner. “Mission-critical” users have some very special needs. Their primary job is to move people out of harm’s way. Having real-time weather information allows public safety organizations and emergency managers to effectively plan their resource deployment and to decide as quickly as possible when and where it is appropriate to respond.

Receiving real-time weather information allows other types of operational organizations (for example, private companies, hospitals, schools, public utilities and transportation entities) to prepare and use their own emergency response plans to minimize potential damage and optimize their use of resources. Their primary job is to keep chaos and cost to a minimum while protecting the people who rely on their organization for products and services.

What is ALERT?

Initially developed by the United States National Weather Service (NWS) in the mid 1970s, ALERT describes a related set of radio-based communications protocols, sensing techniques and data formats used for real-time collection of rainfall and other environmental parameters. “ALERT” is an acronym for “automated local evaluation in real time”.

ALERT has become a well-used standard for remote environmental telemetry systems, to which multiple vendors have designed and produced interoperable sensing equipment, transmission hardware, and software applications. For more than 20 years ALERT systems have been deployed in flash-flood prone areas throughout the world, with the heaviest concentration in the United States, Central and South America, Asia and Australia.

Many U. S. cities, counties and some states have incorporated ALERT systems to address flooding issues created by increased urbanization (paving of permeable surfaces and constraint of historically flashy waterways) and to protect settlements in high-risk settings, such as cities that have grown up at the mouths of mountain canyons. Because the technology is relatively simple and inexpensive, it is frequently chosen for use in remote areas and in developing nations.

How ALERT works

ALERT systems are one-way, event-based environmental sensing networks. Each data collection platform (DCP) is programmed to transmit a brief data burst when triggered by environmental changes (for example, receiving 1 mm of rainfall, or recording a change in stream depth of 1 mm). Modern ALERT transmitters can also be set to provide time series data.

Standard ALERT is not well-suited for supervisory control, such as gate operations, because it is a one-way system. However, innovative vendors have extended use of the protocol to operate warning flashers automatically, take sensor sites in and out of service remotely, and switch radio repeater operations remotely.

A typical ALERT “event” is the tip of a tipping bucket signaling the accumulation of 1 mm of rain. The DCP sends a 4-byte message using frequency shift keying modulation at 300 baud. The actual data burst is a “chirp” lasting 133 milliseconds that contains a 13-bit (0 to 8191) number identifying the sensor, and an 11-bit number (0 to 2047) that encodes the data value. Software at the receiving site identifies the transmitted ID and decodes the data value into appropriate engineering units using stored information about the sensor.

ALERT strengths and weaknesses

ALERT systems are among the simplest of telemetry options available for automated environmental monitoring, and therein can be found their greatest strengths and greatest weaknesses. Because the systems use one-way data transmission, there is no need to provide, power, and monitor a receiver at each sensing location. This lowers initial cost, reduces or eliminates the need for solar panels, and simplifies maintenance. The data transmission overhead is minimal as there is no “handshaking” between the data source and its destination.

Because each data collection base station only needs to listen, there can be an unlimited number of independent receiving stations in an ALERT network. In addition, new sensing sites can be easily added to existing networks. Because the data transmissions are event-triggered, ALERT systems are the primary real-time option, offering immediate transmission of data changes and not crowding communications channels with no-change messages.

Some limitations of ALERT stem from its event-driven nature. Two DCPs may, by chance, transmit at nearly the same time on the same radio channel, so the two transmissions partly or completely overlap. This can result in the loss of one or both data transmissions. For rain, this loss of data is tolerable because each transmission encodes an accumulator value, and the base station compares this value to the last successfully received value. Therefore, a missed rain report usually causes no inaccuracy in rainfall totals, but only a loss of information about its temporal distribution. ALERT sensors reporting discrete values, such as stream depth or individual weather parameters, should be programmed so the transmission event threshold is small enough to ensure that multiple data messages will be sent before a critical sensor value is reached.

For real-time severe weather and flood monitoring operations, ALERT’s advantages in cost and bandwidth efficiency far outweigh its limitations. The ability to inexpensively monitor large networks of hydrometeorological sensors from an unlimited number of base stations with virtually no time delay provides compelling advantages.

How the radio spectrum is used

In the United States, ALERT systems operate on a set of federally controlled frequencies set aside for the collection of hydrologic data (from 169 through 171 MHz). Until recently, most ALERT radios occupied 25 KHz bands within this region, but as of 2005 all ALERT channels will have undergone "narrow-banding" to occupy 12.5 KHz bands. Use of these frequencies by local governments or other entities is permitted when the use is endorsed by a cooperating federal agency and the data made available to the federal cooperator.

An ALERT Users Group committee comprising private and public sector entities is currently developing the next generation of ALERT technology with higher data rates, error detection and forward error correction, and the transmission of complete engineering values and additional information. The new protocol should include the option to use two-way communications, thus allowing remote programming, polling and control of the sensor suite and other connected instrumentation. The new protocol will support simultaneous use of the mature protocol, thus permitting existing systems to make a gradual transition.

What about the software interface?

Several base station software applications in use today receive and process data from ALERT systems. The most commonly used applications run on either the Microsoft Windows (e.g., STORM Watch, by DIAD Incorporated, or DataWise) or QNX (e.g., NovaStar or Hydromet) PC operating systems. The purpose of these applications is to automatically collect and archive data from the sensing network, allow base station users to review current and historical data from the sensing sites, provide a basis for the use of additional modeling and analysis tools, and provide automated alarming and notification about critical conditions.

As the use of local and wide area networks has increased, some of these applications have evolved to disseminate data on a real-time basis. Until recently, data users were required either to have a base station with direct radio access to the sensing network, or to use a telephone modem to dial in directly to such a base station. Today, an authorized STORM Watch user anywhere in the world can use the Internet to collect data from "their" STORM Watch server into a local database, process alarms, trigger automatic notification, run hydrologic forecast models and initiate emergency response plans in close to real time (i.e., within a couple of minutes from the time of the environmental event).

Other references of interest

You may also wish to read some of the following sources:

ALERT Users Group web site can be found at http://alertsystems.org/

Gayl, I. E. 1999. *A New Real-time Weather Monitoring and Flood Warning Approach.* Unpublished masters thesis, University of Colorado, Boulder, Colorado. Download anonymously from ftp://ftp.diad.com/GaylThesis.pdf/

Roark, R. C. and Van Wie, D. G. 2000. *Update on Efforts Toward a New ALERT Protocol.* Report to the ALERT Users Group protocol committee, chaired by Todd Mendell, NWS, Sacramento, CA. Download anonymously from ftp://ftp.diad.com/AlertUpdate.pdf/

U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Office of Hydrology. December, 1997a. *Basic hydrology – an introduction to hydrologic modeling. Lesson 6 in Operations of the NWS Hydrologic Services Program.* Washington, D. C.: Government Printing Office.

U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Office of Hydrology. 1997b. *Automated Local Flood Warning Systems Handbook, Weather Service Hydrology Handbook No. 2.* Washington, D. C.: Government Printing Office.

U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service. 1993. *Integrated Flood Observing and Warning System Management Guide.* Washington, D. C.: Government Printing Office.

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Contact information:

+303-774-2033 voice
+303-774-2037 fax
www.diad.com, diadinfo@diad.com