Appendix C

ALERT and IFLOWS System Descriptions

Automated Local Evaluation in Real Time (ALERT)

The ALERT system was initially developed in the 1970s by the California-Nevada River Forecast Center in Sacramento, California (U.S. Department of Commerce. 1997a), and consists of automated event-reporting meteorological and hydrologic sensors, communications equipment, and computer software and hardware. In its simplest form, ALERT sensors transmit coded signals, usually via very high frequency (VHF) and ultra high frequency (UHF) radio, to a base station, often through one or more relay or radio repeater sites (refer to Figure C.1 from U.S. Department of Commerce 1997b). The base station, which consists of radio receiving equipment and a microprocessor running ALERT software, collects these coded signals and processes them into meaningful hydrometeorological information. Processed information can be displayed on a computer screen according to various preset criteria, with both visual and audible alarms activated when these criteria are reached. Some systems have the capability of automatically notifying individuals or initiating other programmed actions when preset criteria are exceeded.

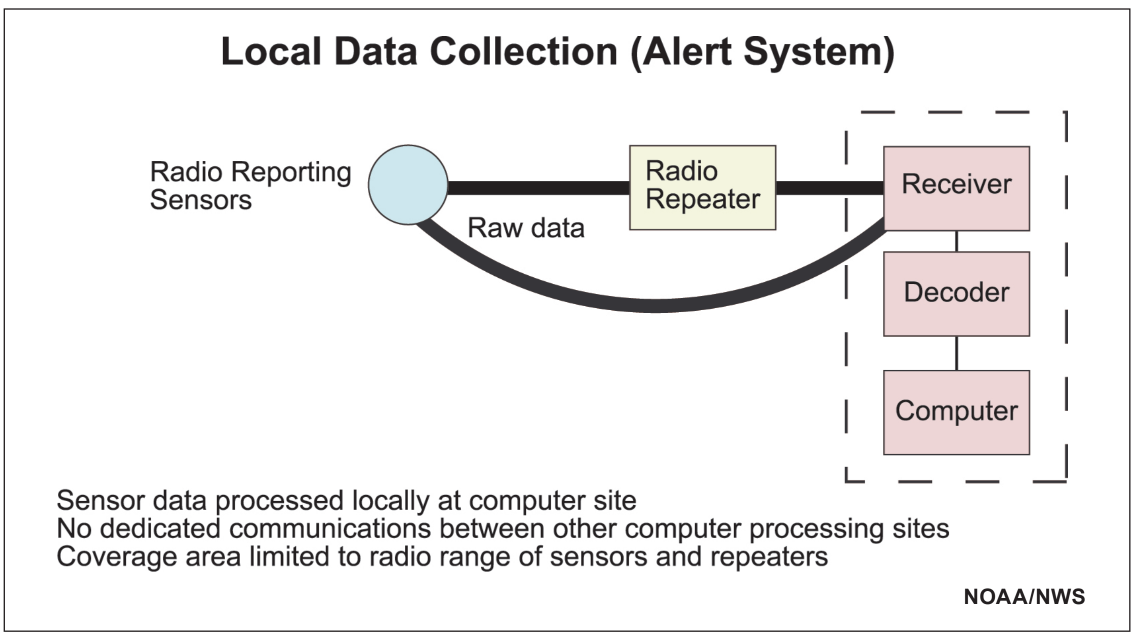

Figure C.1 Schematic of an ALERT system

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 systems in use today can be quite sophisticated. Some have the capability to graphically display information singly or in combination (such as the areal extent of flooding, inundation of roads, evacuation routes, supply depots, hospitals, and population centers) on wall-size projection screens. Also, the observed data can be ingested into a rainfall-runoff model to produce forecasts. A system can consist of more than one base station connected through repeater networks to pass along raw, unprocessed information from one user group to another. However, ALERT systems are basically one-way data collection systems developed to deal with specific local problems and normally have little or no computer networking capability.

ALERT systems are generally locally funded and supported. These systems are relatively cost effective. A new sensing site can be installed for a few thousand USD. The only recurring costs are for site and sensor maintenance (which is too often ignored). The sensor and data communications systems used are low-tech by today's remote sensing standards, yet the impact of having real-time data can be invaluable. In choosing ALERT, a group is investing in a sensor network that is highly functional and can be expanded as their requirements grow and change.

There are several very active and growing regional ALERT user groups in the United States. Many U. S. cities, counties, and some states have set up ALERT systems to address flooding issues created by increased urbanization (paving of permeable surfaces and constraining historically flash-flood prone or frequently high volume 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.

Many systems are owned or maintained by more than one participating organization; each ALERT participant owns or maintains only a small portion of the entire system. In many cases, the NMHS does not own any of the equipment in a particular system. In some cases, local system sponsors have provided equipment (radios, computers, etc.) to the NMHS for use in its field offices because they recognize the benefits of NMHS forecasts and warnings. Private vendor versions of this software are available and in use. See the following section on ALERT software below or U.S. Department of Commerce (1997b) Chapter 12 and other sources for lists of references. ALERT systems are found throughout the United States and in some foreign countries, primarily in Asia, Australia, and South America.

ALERT Strengths and Weaknesses

ALERT systems are one of the simplest telemetry (automatic measurement and transmission of data by wire, radio, or other means from remote sources) options available for automated environmental monitoring, and therein can be found their greatest strengths and greatest weaknesses. Strengths include:

- The systems use one-way data transmission so there is no need to provide and power 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" (passwords, authentication, etc.) between the data source and its destination.
- Since each data collection base station only needs to listen, there can be an unlimited number of independent receiving stations in an ALERT network.
- 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. They offer immediate transmission of only data changes and do not crowd 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.

How the Radio Spectrum Is Used in ALERT Systems

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 were "narrow-banded" 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 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 previous protocol, thus permitting existing systems to make a gradual transition.

ALERT Software

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 OneRain 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 alarms 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 place 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).

Integrated Flood Observing and Warning System (IFLOWS)

As noted by Gayl (1999) and the U.S. Weather Service Hydrology Handbook No.2 (1997b), the NWS supports a computer software and network application designed to assist state and local emergency services as well as NWS offices in detecting and managing flash flood events. The software receives and disseminates data from a network of real-time weather sensors, primarily rain gauges, that covers part of the eastern region of the United States. The system as a whole is known as the Integrated Flood Observing and Warning System (IFLOWS). The system is quite dated, but is useful here as an example of an approach that has been successful.

IFLOWS was created in the late 1970's to assist flood-prone communities in Appalachian states with development of automated flood warning systems. IFLOWS is a cost-sharing partnership between Federal, state, and local government agencies. IFLOWS networks currently collect data from over 1000 gauges in 200 counties throughout the northeastern US. The website for IFLOWS is **http//www.afws.net**. IFLOWS can be viewed as a wide-area network of ALERT-type systems with enhanced, full, two-way communications capability (voice, data, and text). If desired, IFLOWS can be configured as a stand-alone system for a local community. On the other hand, the ALERT system is normally configured as a stand-alone system for a local government entity. The potential user of the LFWS, in the design phase, should consider the network configuration with its associated area-wide capabilities and costs as well as the stand-alone configuration with its local capabilities.

IFLOWS serve as both a regional data collection and information dissemination network, i.e., IFLOWS software operates as a polled network of ALERT-type systems (refer to Figure C.2 from U.S. Department of Commerce 1997b). In addition to performing real-time data acquisition and processing functions, IFLOWS software handles inter-computer networking and information transfer. IFLOWS computers collect and process remote sensor information; act as data concentrators, allowing more information to pass over a given communications channel in a fixed period of time; and serve as ports into regional communications networks. Not all ports into an IFLOWS network perform all of these functions continuously. They all, however, remain continuously on-line. In case of network failure, an IFLOWS computer can function as a stand-alone, ALERT-type base station.

The IFLOWS software uses a dedicated communications port to exchange data and text information with other locations in the IFLOWS network, using an error-controlled packet data format, sometimes called the "IFLOWS backbone." One designated polling site per network directs traffic on the backbone, routing data to correct destinations and preventing data packet collisions among the polled stations. Current IFLOWS backbone communications circuits use VHF/UHF radio, microwave, leased telephone lines, satellites, and the internet to convey data between computers. This configuration enables each locality that directly receives gauges to operate alone, while enabling that locality to also share data with other sites in the network. IFLOWS software also has the ability to display gauge data, set alarms, and exchange text messages with other network users.

As shown in figure C.2 the IFLOWS network is divided into a series of sub-networks, each containing one control node computer and a number of remote nodes. Some nodes act as bridges (i.e., they belong to two networks and pass data between them). A control node polls each of the remotes in its network on a continuous, round-robin basis, requesting that they send new data or re-send data. All remotes receive all transmissions from the control node, whereas only the control node sees the polled responses. A remote responds to a poll when it sees its own address on the poll message. After the control node receives new data from the remotes, it re-broadcasts the data to all remotes. In this way, all remotes share their data.

Sensor technology for both IFLOWS and ALERT networks is basically the same. IFLOWS software is presently limited to precipitation and river-stage gauge applications, while ALERT can handle several other parameters. IFLOWS networks have a backbone communications infrastructure. While the original IFLOWS concept envisioned an all-radio/microwave network, present systems employ leased telephone lines, satellites, VHF/UHF radios, and microwave communications links.

IFLOWS, by its very nature, integrates system administration and operation. Multiple levels of government and various agencies at each level of government are involved in operating the systems. Individual systems are usually networked at the state level. Connections between state systems are established at gateways, which are usually at NWS offices.

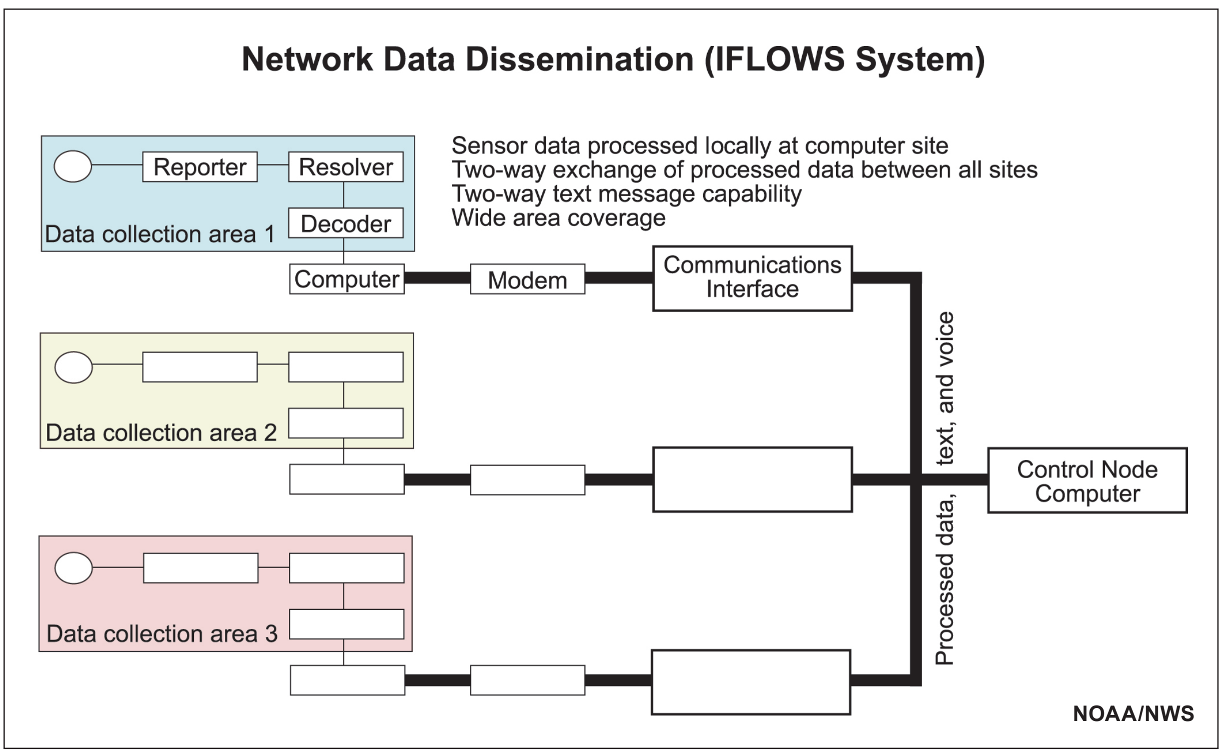

Figure C.2 Schematic of an IFLOWS system

IFLOWS Data Exchange Advantages

- An extremely positive aspect of the IFLOWS architecture is the principle that every node should receive every other node's data. The control node polls its remote nodes every 15 minutes and then re-broadcasts the polled data after completing a round. In this way each node can keep track of events unfolding around them.
- Once a day each control node re-broadcasts all the data for that day, permitting nodes that were unable to receive some data to be filled in.

IFLOWS Data Exchange Constraints

The IFLOWS software was a well-designed application for its time. It made creative use of limited hardware and software resources, and it used a parsimonious networking architecture to share data fairly quickly and inexpensively among many faraway sites. However, the application has neither progressed forward at the speed with which technology has been updated, nor has it fulfilled all of its original goals. Its constraints can be summarized in part as follows:

- Proprietary data storage format prevents both users and non-PC/IFLOWS applications from freely accessing data for other tasks.
- Proprietary network protocol limits data exchange and dissemination to methods included in PC/IFLOWS.
- The polling architecture and slow hardware in place result in the actual data exchange transpiring much more slowly than real time (sometimes hours instead of minutes) because of the number of sites covered today.
- If the round-robin polling takes too long, then the re-broadcast doesn't take place and data aren't re-disseminated to the local nodes.
- The application has only recently begun to support more than rain-type sensors and is still limited in the sensor types it recognizes.
- The application, the networking, and the data exchange are inextricably tied to the PC/IFLOWS platform – users cannot choose other applications to collect, share or access the IFLOWS data without being left out of the network, and without removing their own data from the network.

Many LFWS owner-operators in the northeastern US continue to use IFLOWS software configurations and software in their LFWS. Because IFLOWS is a network-based system, data from IFLOWS is usually available from more than one location. The primary software/network application in use today is called PC/IFLOWS. The following list summarizes the locations from which IFLOWS data can generally be obtained:

- US NWS AWIPS
- PC in local office
- PC in another office that is part of the state IFLOWS network

- ihe Internet at **www.afws.net**
- IFLOWS PC at the LFWS owner-operator location

Documentation for IFLOWS software and its interface to AWIPS is found at **http://www.afws.net/ldadsupport.htm**.

References

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