Collecting and Disseminating Weather Data From Non-Federal Airports

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Background

Automated Weather Observation Systems (AWOS), located at over 1,900 airports across the country, sense current weather conditions every minute. These observations are voiced and made available to pilots and the public through radio broadcasts and via public telephone lines. But AWOS systems also produce weather sensor output in digital form, usually one observation per minute. Some of the digital observations are reported to the FAA's national network (NADIN), which then disseminates the data to many constituencies, including Flight Service Stations, NOAA, and commercial outlets such as the Weather Channel.

An airport that has made a large investment in AWOS equipment is not getting the most out of the system if the observations are only available locally. There are clear economic and safety reasons for reporting the currently untapped METAR data. For example, many charter and commercial flight (e.g. FAA part 135) operations cannot begin approaches to airports experiencing bad weather unless the weather is above published minimums. In the absence of reporting from the airport, routine operations to such an airport are risky (pilots may not know until they arrive that they can't land). This imposes an economic hardship on the community served by this airport if the AWOS data cannot be reported. The general public is also served if they can see the latest observations from their own town on the Weather Channel or on Internet weather services rather than seeing observations from the nearest larger city.

The anyAWOS division of Mackinac Software, LLC is the provider of nation-wide access to the instantaneous voiced weather observations from every AWOS in all 50 states. By calling a single number (877-ANY AWOS) pilots can hear current weather from any AWOS in the country. anyAWOS is now positioned to also collect and process digital observations, and send them to NADIN through our anyAWOS Weather Nexus product. This paper describes the capabilities of anyAWOS Weather Nexus and discusses some of the design decisions that were made in the development of a solution for those airports that want to report their AWOS data to NADIN, but need a solution that is (1) economical, (2) flexible, (3) secure, (4) reliable, and (5) universally available.

Problem

The problem is how to collect METAR observations and disseminate them to constituencies, including NADIN, that require current weather data.

Possible Solutions

While designing anyAWOS Weather Nexus a number of possibilities for collecting and disseminating the AWOS data were considered. The descriptions below briefly discuss the pros and cons of various approaches that were considered.

Direct Connection of AWOS's to NADIN Through Internet

In the interconnected age we live in, the most obvious solution seems to be to use the Internet. It's economical, and the technology is widely used and understood. Couldn't one use the Internet for sending this data from the airport directly to NADIN? That is, can't collection of the observations from the AWOS's and dissemination to NADIN be done in a single step?

The answer is no. NADIN has no connections to the Internet, and uses a different communications protocol (X.25 rather than IP). Furthermore, the FAA is deeply concerned about having its operational systems even remotely connected to a network (the Internet) that has exhibited a number of security issues that make users vulnerable to a variety of attacks. NADIN is a closed network, for good reasons. Although the FAA is undergoing a change to use the Internet Protocol (IP) internally rather than X.25, it will remain a closed network with carefully controlled access points. Even when the transition from X.25 to IP is complete, it is highly unlikely the FAA is going to allow direct access from AWOS systems to NADIN without at least an intermediate server.

In addition, since NADIN only accepts 3 observations per hour, a direct connection to NADIN still allows 95% (57 of 60 observations per hour) of the data to escape unarchived, unless they are captured in some other way.

Given that there is no way to directly connect individual AWOS's to NADIN, the problem can be broken down into two subparts, which implies the use of an intermediate server:

1. *Collection*: actual collection of data from the airports to the intermediate server
2. *Dissemination*: supplying the data from the intermediate server to the constituency users (including NADIN)

We will first discuss supplying data from the intermediate server to the constituency users, including NADIN, (Dissemination) and then describe some of the possible solutions for actual collection from the AWOS's to the server (Collection).

Dissemination

In order to send data to NADIN, one must go through a process of approval and testing with the FAA in order to ensure security and reliability of the network. The technical challenges include support for the X.25 protocol, proper control of data flow to NADIN, and adhering to the FAA's various connection requirements. The technical challenges pale, however, in comparison to the arduous bureaucratic and policy challenges. anyAWOS has been pursuing such a connection for some time, and has already passed all but the final tests required for connection. Approval for a connection to NADIN via Indianapolis (ZID) has been received and telecomm equipment has been ordered.

One aspect of AWOS data collection and reporting that is often overlooked is the possibility of having all the AWOS data available for other constituencies, regardless of the existence or frequency of reports to NADIN. For example, a state that owns several AWOS's may want to report observations to NADIN three times per hour (as required by NADIN), but may want to save observations every five minutes for other purposes (to display on the World Wide Web, or to generate internal reports for other state agencies). With anyAWOS Weather Nexus the airport owner is free to set up any schedule desired for collection of the observations, in addition to what NADIN requires. In fact, airport owners can collect data on anyAWOS's servers without sending it to NADIN at all.

One other advantage to anyAWOS Weather Nexus is that *every* one minute observation from the AWOS is archived, and can be retrieved for historical purposes. Even for airports that only require communication of the observations every 20 minutes, it might be useful, after a severe weather event, to go back and look at every one minute observation for the time frame when the storm was developing and passing through. With anyAWOS Weather Nexus, this valuable data is not lost.

Collection:

The remainder of this paper describes the collection phase of the problem; some of the possible approaches and pros and cons of each.

AWOS's on the Internet

Even though NADIN itself cannot be connected to the Internet, one set of solutions involves using the Internet as the collection pathway from the individual AWOS's to a central server, which can then transmit to NADIN. There are five possible variations on this theme; each is examined in more detail below. However, note that this requires Internet access at smaller airports, many of which are in small town or rural areas where Internet access is relatively scarce. Furthermore, there are still FAA security concerns since the server is still connected to the Internet and becomes a vulnerability to the FAA's closed network.

Possible technologies for Internet transmission from airports to the server include cable broadband, satellite, DSL, modem, and wireless (cell) technology. Each of these potential means of connection is examined below.

Cable Broadband

Cable offers high-speed access, but the data transmission problem at hand does not require significant speeds. On average, only about 200 bytes *per hour* are transmitted (assuming 20 minute intervals), or 800 bytes per hour assuming 5 minute intervals; therefore, the significant cost of broadband is largely wasted. In addition, maintaining a node at an airport online all the time (such as a small data collection computer) presents severe security problems. Internet attacks of unprotected cable-connected computers are well-documented. Such an "always on" computer requires careful hardening and protection, such as firewalls, whose expense is usually confined to complex servers.

Cost is also a significant issue. Most small airports are located hundreds (to thousands) of feet from the cable right-of-way (if there is one). Cable companies usually charge for extending a drop and this can be expensive. For example, a quote we obtained estimated almost $15,000 for a drop to Mason Jewett Airport in Mason, Michigan even though the cable runs adjacent to the airport property.

Satellite Uplink

A satellite uplink can potentially avoid the "always on" security problems of a cable connection, but the up-front costs can be similar. One needs a dish installation and a significant amount of equipment. Furthermore, many satellite links suffer from outages in poor weather, just when they are needed most. Cost and reliability are both issues for satellite. Once again, satellite is intended for high volume throughput, which is not required for this application.

DSL connection

DSL has become increasingly popular as a broadband alternative. While less expensive than cable, DSL connections still suffer from the "always on" problems described above. However, the major problem with DSL is availability. DSL connections must be less than a certain number of "cable feet" from the telephone central office. The distance varies with equipment used but is generally a problem for smaller airports. Even if the cable distance is not a problem, the telephone offices must have all the proper equipment installed for DSL to be an option. In residential areas, DSL can be as inexpensive as $15/month, but for commercial installations in areas away from development (such as small airports), DSL can be $60 per month and up.

Modem/ISP Connection

Telephone lines are available everywhere, so another approach is a dial-up Internet connection using an Internet Service Provider (ISP). The monthly costs are relatively low for the ISP account but either the connection must stay up all the time, or the airport computer must dial the ISP when there is a requirement to transmit data. On-demand dialing implies incurring a cost of approximately 8 cents per call. Assuming three transmissions an hour, this adds up to $178 per month *per airport* just for phone access charges. Staying connected longer (if the ISP permits) raises the "always on" problem. There are also hidden administrative costs with ISPs. For a large number of airports, someone has to track and maintain a series of ISP accounts, including user IDs, passwords, and account payment. It is even possible that not all accounts will be with the same supplier.

Airport to Server via Modem

An alternative to the modem/ISP scheme is to have the AWOS computer call a central server using a modem and regular phone lines. This *always* incurs the local dial cost penalty of approximately $178 per month (for 3 transmissions per hour), not to mention long distance charges. The server must be ready to take the call, so either careful scheduling is required, or a large number of inbound phone lines must be available. The AWOS computer must be prepared to re-dial in the event of connection failures, which adds complexity to the airport end of the connection.

Server-polled Connection

A central server can poll each airport on a regular basis using regular modems to establish a connection. Central phone lines can be configured to avoid the per/call cost and scheduling is much easier when initiated from the server end of the connection. Since the AWOS is not always online, the "always connected" problems are not present. No ISP is involved so extra costs and administration are not an issue, although long distance charges will be incurred from the server to remote airports. With this approach, some provision must be made for hackers calling the AWOS phone line attempting to break into the airport computer's open modem connection.

Wireless Connection

Similar to a satellite connection, a wireless connection avoids most of the problems associated with phone lines. The connection is reasonably private but is still usually IP based. This implies either a connection is made each time data is transferred or the airport has to have a fixed IP address and be "always on". As noted above, "always on" connections require hardening for security that greatly increases cost and complexity of the airport computers. From a cost standpoint, wireless is expensive. Accounts can range from $50 to $180 per month (per airport) and switched accounts (non-fixed IP) have a cost-per-call. Perhaps the biggest problem with wireless is availability. In rural areas cell coverage drops off very quickly. In addition, data transmission usually requires special protocol services beyond normal voice that are not widely available outside of metropolitan areas.

anyAWOS Weather Nexus Collection Strategy

The anyAWOS Weather Nexus strategy for collecting AWOS observations addresses each of the following concerns:

- Cost
- Flexibility
- Security
- Reliability
- Availability

anyAWOS places a small Linux-based computer at each airport that collects data directly from the AWOS computer. The only communication facility that is uniformly available at even the most remote locations is plain voice telephone circuits (so-called POTS lines). As the discussion above indicates, polling from a central server entails the least number of scheduling and cost problems, hence anyAWOS Weather Nexus uses a server polling scheme, on a scheduled interval than can be every 20 minutes to satisfy NADIN requirements, or more frequently (such as every 5 minutes) to satisfy other requirements.

anyAWOS does not employ modems for actual data transfer. Instead, anyAWOS uses a proprietary board that connects directly to an ordinary telephone line using a robust encoding scheme that is faster than a modem for small short transmissions such as a METAR. Modern modems can take several seconds to "sync up" after answering. During this time the modems examine the line and exchange information to optimize the data flow rate, however, as noted above, data rate is not an issue. By contrast, our signaling method transmits as soon as the phone is answered. Typical times for data collection range from 6 to 12 seconds for an entire METAR, almost faster than a modem can sync. For cost and scheduling purposes, collection transaction times are what count, not data rate.

Special software encodes the data prior to transmission in order to provide compression, encryption, and error checking. After transmission, the server decodes the transmitted data and checks for transmission errors.

anyAWOS conducted tests of its prototype systems at KTEW and KFPK from August 1st through November 4th, 2005. During that time, transmission intervals ranging from 20 minutes to 2 minutes were tested. Over 7,160 observations were retrieved from KTEW from Aug 1 through Nov 4, and over 5,820 observations from Aug 25 through Sept 15 were retrieved from KFPK. Throughout the testing period, there were no transmission errors in almost 13,000 transmissions. Since the airport computer does not have an active open modem, hackers are denied access to the computer. In fact, the phone line used for data collection *can actually be shared* with other, outbound services (although this is not recommended). For example, in our tests, the computer at KTEW shared a phone line with a WSI weather display station. If it turns out that the phone line is busy when the server calls, it simply tries again (immediately) until it gets through.

The anyAWOS Weather Nexus airport computer saves *every* observation the AWOS produces regardless of phone line state or availability. On a non-real time basis this data is brought back to the central anyAWOS data server where it is made available for clients. Scheduled real time transmission of observations can be done at any interval required (that is, every 20 minutes for NADIN, or every 5 minutes for the National Weather Service). These scheduled transmissions are sent in real time both to the archival server and to the server that connects via X.25 to NADIN, or whoever else needs the real time transmissions. However, regardless of the real time transmission interval, *every one minute observation* is automatically archived at no additional cost. In the tests from Aug 1 – Nov 4, 69,402 METARS from TEW and 21,728 from FPK were read and saved, for a total of 91,130 archived observations.

anyAWOS understands that there are many potential users of weather data, and thus makes *all* observations available to client computers in raw or processed form. The observations mentioned above were made available on the web during the test period. anyAWOS can supply METAR data in any form with any analysis required. Please contact us for details. In fact, for airport operators that only require a flexible display of METAR data and no not currently wish to send data to NADIN, anyAWOS Weather Nexus is the perfect solution. Alternatively, client IT departments can access and utilize all observations made by the AWOS's, and deliver them to other users of weather data in any format, at any frequency, using any transmission mode that they wish, once the raw METARS are collected by anyAWOS Weather Nexus.

There are many approaches to collecting and disseminating AWOS observations in order to make the most out of an AWOS investment. Some approaches are not feasible, some are not reliable or secure, and some are too expensive. anyAWOS Weather Nexus provides owners of non-federal AWOS's the opportunity to make the most of their data observations with a solution that is reliable, secure, available everywhere, and cost effective.