

Final Report on the COMET Partners Project:

**Development and Evaluation
of a Prototype
Wireless Storm Spotter and Mariner Reporting System (WSSMRS)
UCAR Award No. S03-38663**

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Executive Summary and Recommendations

Investigators from the University of North Florida and the Jacksonville Forecast Office of the National Weather Service (NWS) have worked together to develop and evaluate a prototype Wireless Storm Spotter and Mariner Reporting System (WSSMRS). The prototype system that was developed and tested in this COMET Partners Project provides “proof of the concept” that commercial off-the-shelf GPS and wireless/web-enabled Personal Digital Assistants (PDAs) and cell phones can successfully be used by trained mariners and storm spotters to provide a severe weather verification feedback system that will enhance, improve and reinforce forecast products, advisories and warnings issued by NWS forecasters.

The prototype system integrates several technologies including mobile computing, wireless communications, global positioning system (GPS) and the Internet and utilizes platform-independent coding environments and open-source operating systems (Java and Linux) as the basis for the software components of the system. To encourage other developers to refine and extend the current prototype system, the open-source software code developed for this project can be freely downloaded from the prototype web site (skywarn.jimmi.org).

The primary recommendation resulting from this project is that implementation of operational system should be pursued by the NWS. The secondary, but more significant, recommendation to the NWS is that an operational system should focus on the use of web and GPS-enabled cell phones rather than PDAs. This recommendation is based on both the project team’s experience and on the feedback from cooperating storm spotters. Everyone seems to agree that they would rather upgrade their cell phones and service contracts (purchase a new phone with GPS capability and web access services) than purchase a PDA device with those capabilities.

Section 1: Project Objectives and Accomplishments

1.1 Objectives

The objectives of this project were:

- 1) To develop the software infrastructure needed to support a prototype WSSMRS.
 - Based on design requirements specified by NWS partner investigators.
 - Utilizing a platform-independent, open-source software coding approach.
 - Including software for mobile devices and a prototype website.
- 2) To test and evaluate the prototype WSSMRS software on both PDA’s and cell phones.
- 3) To conduct system tests in the NWS Jacksonville Warning Area and nearby coastal waters.
- 4) To conduct a “proof of concept” demonstration and evaluation event with local meteorologists and storm spotters.

1.2 Project Accomplishments

Overview. This project was conducted in two phases. In the first phase, a prototype system was implemented using PDAs with externally attached GPS receivers (see Figure 1 below). In the second phase of the project, cell phones with integrated GPS receivers were used to implement an alternative version of the prototype WSSMRS.

In both versions of the prototype system, severe weather reports are sent wirelessly from a trained storm spotter's or a mariner's PDA/cell phone to a database maintained on an application/web server computer. The server processes the data and displays it on a web site for use by NWS forecasters in the preparation and/or verification of severe weather events.

The prototype system utilizes platform-independent coding environments and open-source operating systems (Java and Linux) as the basis for the software components of the system. A generalized discussion of the programming approach used is included in this report. However, to encourage other developers to refine and extend the current prototype system, all of the open-source software code developed for this project can be freely downloaded from the prototype system web site (skywarn.jimini.org).



Figure 1: PDA with external GPS receiver and cell phone with integrated GPS receiver.

Phase I – PDA-based Version of the Prototype WSSMRS

Hardware Issues

This version of the prototype utilized 3 Palm OS-based PDA's (Palm, Inc. - Model 715) equipped with external GPS receivers (Delorme, Inc. - Earthmate Model). This Palm PDA model was chosen because it had wireless Internet access capability. Internet access required a 'Palm.Net' monthly service agreement contract for each PDA. An external GPS receiver was used for this prototype since, at the time of initiating this phase of the project, there were no commercially available PDA units that had an integrated GPS receiver. It is important to note that recently several manufacturers have introduced more integrated PDA/GPS hardware solutions, and these are much easier to use than a PDA with an external GPS receiver.

Software Development Approach

The primary task in phase I was to develop a software infrastructure that could support the graphics interface used for Palm-OS-based PDAs, Java-enabled cell phones, and Windows CE-OS-based PDAs. The development team chose to use the Java MIDP package, which is designed for building graphical user interfaces (GUI) on micro devices. XML methods and syntaxes were developed and used to design an application whereby the mobile devices receive an XML document and generate the GUI (for an input form, etc.). The following generalized steps describe how the Phase I prototype software functions.

- 1) User types login information into PDA (base application is already loaded on PDA). →
- 2) According to the user's preferences (stored in a database on the application server), two XML documents will be fetched from the database. One XML defines the GUI of the application. The other XML defines the initial data that appears in the application. →
- 3) User's micro device receives the XML documents →
- 4) PDA application parses those documents, generates GUI and fills in any initial values →
- 5) User then fills in all the forms in the report application. →
- 6) User clicks on submit →
- 7) The input values are updated in the XML document →
- 8) The XML document is sent back to application/web server →
- 9) On the server side, the data in the XML document are inserted into a database.
- 10) The data is used to generate storm spotter weather reports on the website.

Evaluation

A major problem was encountered during this phase of the project. For development purposes, the team used a MIDP emulator on a PC to develop and test the software programs. Theoretically what works on emulator will work on the real devices. However, in reality, it turned out that the Java MIDP network package did not work with the Palm PDA's internal wireless modem (Note: This may not be a problem for current/future models of the Palm PDAs.). As a result of this technical limitation, the team was only able to perform demonstrations in Phase I that did not include the wireless method of uploading the report data to the server. All of the other software components worked however, and, as will be described below, the MIDP network package works very well for cell phones.

The PDA vs. Cell Phone Issue. As a result of discussions associated with the Phase I prototype demonstrations (using the PDA and external GPS combo), it quickly became obvious that, although the PDA/GPS approach was certainly technically feasible, that the general consensus among potential users was that the PDA solution would not be as desirable to them as a solution using a cell phone. Obviously, the poor ergonomics associated with using an external GPS unit influenced their opinions (see Figure 1). However, everyone surveyed said that they would rather upgrade their cell phones and service contracts than purchase a PDA device with wireless and web capabilities (even if the GPS receiver was internally integrated). Cooperating storm spotters indicated that they would be willing to participate in an operational WSSMRS program that would require them to purchase a new phone with integrated (internal) GPS capability and subscribe to web access services since they would enjoy other benefits from the GPS capability and the web access service.

Phase II – Cell Phone-based Version of the Prototype WSSMRS

Hardware Issues

After researching several cell phones and service providers, it was determined that the Nextel phone network offered a series of devices and services that would enable implementation of a Phase II prototype system using a modified version of the software developed in Phase I of this project. Two Motorola Model i88 cell phones with Nextel service contracts were purchased and used to implement the cell phone-based version of the prototype system, and, during the testing and evaluation phase of this phase, the software was also loaded onto i88 Model phones personally owned by NWS staff. These particular cell phones, which became available in Fall 2003, were the first models to become commercially available that have an integrated (internal) GPS-receiver. These Nextel phones are also configured with 'J2ME' Java Virtual Machine software.

Other telecommunications service providers have announced new phones with integrated GPS and J2ME capabilities since this phase of the project was initiated. However, because of the necessity of using Motorola's proprietary application programming interface (API) in the development of the cell phone GPS component of the software, the current prototype system is limited to using Motorola's GPS-enabled cell phones. This draw back could be overcome by the adoption of a standard API for GPS-enabled phones, but that is another issue.

Software Development Approach

The software development approach for the cell-phone-based prototype uses several Java-based technologies to create network-centric prototype system. It significantly leverages and extends the software that was developed in Phase I of the project. Additionally the application uses the 'POSTGRESQL' database engine to store all of the weather report on the application/web server.

The open-source software technologies that were used to develop the prototype system include:

- Java Standard Development Kit version 1.4.2
- Motorola IDEN J2ME SDK
- Cocoon XML Web Development Framework
- Postgresql Database
- Debian GNU/Linux Operating System

The Motorola IDEN J2ME SDK application development software was used to develop the J2ME application that runs on storm spotter network enabled cell phones. This implies that the storm spotter must have the base application software installed on their phone. The J2ME framework was chosen because several cell phone manufacturers had begun to support the J2ME MIDP specification on their cell phones and, importantly, because Motorola provided a GPS API for developers to use. The phone-based application uses the phone network connection to communicate with a 'Cocoon'-enabled web server via the Http protocol. The 'Cocoon' web server is used as a bridge between the wireless application and the postgresql database, and generates dynamic web pages to display the reports using XML methods. The project's application/web server computer uses the Debian GNU/Linux operating system. By using an open-source approach, the prototype developed is a flexible system that can run on any application server computer using an operating system that supports a Java Virtual Machine and a relational database that allows for JDBC connections.

'Storm Spotter' Application Login Process



Step 1) The user selects the 'Storm Spotter' application from the phone's application menu. When 'RUN' is selected, the phone's built-in GPS receiver captures the lat/long coordinates to be submitted with the report.



Step 2) The user is then presented with the login screen. The application will authenticate this information with the 'Storm Spotter' application server to validate the user.



Step 3) A simple message screen let's the user know that the application server is being contacted. This process usually takes less than 30 seconds.



Step 4) Once logged in, this screen allows the user to select the type of report to submit. Currently the 'Storm Spotter' Application supports two types of reports.



Step 5) After a report type is selected the application downloads the appropriate template for that report and any default data, such as user info.

NOTE: At this point, the application has already captured the GPS location of the phone and the user has chosen to submit either a severe weather report or a marine weather report.

The screenshots below describe the step-by-step process of collecting the relevant observation data for each of these reports, and then submitting the report to the 'Storm Spotter' application server.

The server processes and then posts each submission on the prototype web site.

Marine Weather Report Submission Process



Step 1) A simple title screen is displayed for the type of report chosen. The user selects 'start' to begin entering data into the report.



Step 2) When a first-time user logs into the system, this screen appears and allows the new user to input personally descriptive data that will be stored on the 'Storm Spotter' application server. During subsequent logins, this user data will be automatically entered into each new report form.



Step 3) The date, time, and GPS coordinates are automatically loaded by the application into the report form.



Step 4) The user scrolls through the data input screens by selecting 'NEXT'. The 'shoreline reference' 'text input' screen is shown.



Step 5) A section of a weather observation input screen is shown to illustrate the use of 'radio buttons' to make selections.



Step 6) An input screen for weather observations related to rain and cyclonic activity.

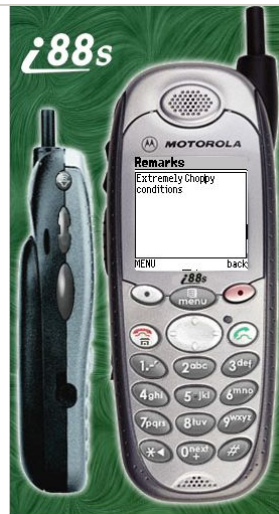
Marine Weather Report Submission Process (continued)



Step 7) An input screen for weather observations related to wind and rain.



Step 8) An input screen for observations related to swells and wave heights.



Step 9) A text input screen for adding other weather observation comments.



Step 10) When the report form has been completed, the user has the option to submit the report to the 'Storm Spotter' application server or cancel submission.



Step 11) The final step is for the user to verify his intent to submit the report.

Note: Upon submission, the weather observation report is immediately viewable on the prototype web site.

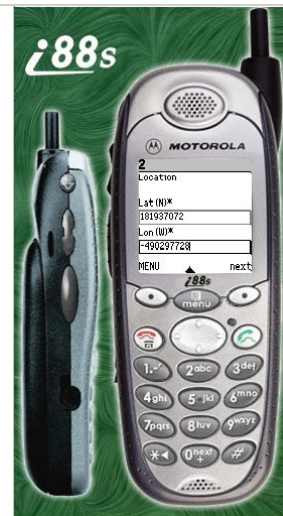
Severe Weather Report Submission Process



Step 1) A simple title screen is displayed for the type of report chosen. The user selects 'start' to begin entering data into the report.



Step 2) If this is not a first-time user, the 'Storm Spotter' application server automatically uploads the basic user information to the report form. (Note: This data was previously entered during the first login session.)



Step 3) The date, time, and GPS coordinates are automatically entered into the report form.



Step 4) The user enters data into the appropriate weather observation input screens. These screens make use of 'radio buttons' for selections.



Step 5) The various weather observation input screens also make use of text input fields and pull-down menus.

Step 6) To submit this report to the 'Storm Spotter' application server, repeat Step 10 and Step 11 as described above for the Marine Weather report.

1.3 Project Significance

This project is directly linked to the National Weather Service's Mission™, to provide weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy.

The project was developed and evolved with direct input from the NWS participants. The initial effort was to develop a PDA version as PDAs became popular, but both the difficulties encountered in the PDA network transmission of the data and the declining use of PDA devices made it desirable to switch to the cell phone approach as the cellular phone capability rapidly outpaced the PDA improvements. Both the NWS participants and the students viewed the shift as a positive improvement in the overall potential of the effort to improve severe weather reporting to the NWS WFOs. While few people on the nation's roadways would pull off the roadway to report sighting severe weather on their PDA, many individuals we talked to said they would report on their cell phone if the capability were there.

Section 2: Summary Of University/ NWS Exchanges

Team members (both students and faculty) visited the NWS JAX Office several times to observe operations and to discuss the office networks and server configurations with the NWS JAX. In addition they discussed future careers in the NWS as Information Technology specialists. Other topics included the use of multiple communications technologies and operating systems including Windows variants, several flavors of UNIX and Linux. These operating systems were discussed with the strengths and weaknesses of each from an operational perspective. The team members talked with the NWS JAX forecasters on duty, and how they used computer systems to facilitate forecasting. The team (six students and two faculty members) also became trained 'storm spotters' in order to understand the SKYWARN program and how weather warnings are issued. These visits were very helpful in guiding the student efforts to make the reporting of significant weather both easy and rapid, while fulfilling the NWS needs for verification. The WFO IT, Mr. Art Wildman, was a particularly valuable resource to the student investigators, and contributed significant off duty time and effort to assist.

Section 3: Presentations and Publications

The operational prototype was presented and a field demonstration was conducted at the May 14, 2004 Meeting of the North Florida Weather Association.

The UNF/NWS partners are currently preparing a paper for conference presentation.

Section 4: Summary Of Benefits And Problems Encountered

4.1 Benefits to the University

During the reporting period, and as a direct result of this and other UCAR-sponsored projects, a new lab was established at the University of North Florida dedicated to weather information system-related research and technology development. The new lab, called the Advanced Weather Information Systems Lab has established a very close working relationship with the Jacksonville NWS Forecast Office. Other weather-related research projects have been initiated as a result of this relationship including: Development of a Road Weather Information System for the State of Florida (a FDOT-funded project), and Development of the Master Plan for a Florida Weather Mesonet (a NOAA-funded project affiliated with the Florida Hurricane Research Alliance). Neither of these major projects would have been initiated without the prior relationships that were developed through previous UCAR/COMET funded projects.

This project has also provided an excellent opportunity for both undergraduate and graduate students at UNF to create prototype systems that serve a definite purpose. They have been able to directly relate and apply their coursework to a real-world application. These students have worked very closely with NWS Jax Office forecast staff (both in the lab and at the NWS Office) and other meteorologists (NAVY, TV, etc.) to develop, test, and demonstrate the prototype systems. The project has given them a chance to work directly with professionals to develop requirements, make compromises where necessary, and make a significant contribution.

4.2 Benefits to NWS

This project proves the concept that new models of commercially available PDA's and cell phones can be used by mariner's and trained storm spotters to provide the NWS Forecast Offices with a real-time weather verification feedback system that will enhance, improve and reinforce forecast products, advisories and warnings issued by NWS forecasters. While not a complete system in the sense of being used operationally over a wide area, it has been used to provide both severe weather test messages and marine test messages to the server, where they could be accessed by the WFO forecasters in near real-time, providing much faster feedback than is currently available by normal methods.

As the capability for this type of rapid reporting by ever more sophisticated cellular phone technology progresses, the option for Nationwide adoption of this reporting methodology in parallel with existing Ham radio, home telephones and marine radio relay becomes ever more promising.

Discussions with students on the operational use of 'open source software' technologies in the NWS computing architecture have benefited both parties. The students have learned that such software is robust and quite capable of becoming operational enterprise software with the added benefit of customization and increased utility for those in the production environment. The NWS personnel have benefited from learning through the students to anticipate future trends in computer system technology and software. In particular the ability to use wireless communication technology and networking supported by open source software in NWS routine operations is now a reality—with the promise of more applications to come.

4.3 Problems Encountered:

Several obstacles were encountered including:

- A problem (described above) with the Palm PDA internal modem having network software incompatibility issues that prevented demonstration of the wireless features for the PDA version of the prototype system.
- The original NWS Partner, Fred Johnson, transferred to another NWS Office early in the project. Dr. Pat Welsh stepped in to help with development at that point.
- The graduate student who initiated the software development approach in Phase I was not able to complete the project. Another graduate student had to be recruited and trained.
- The availability of the GPS-enabled phones was delayed until Fall 2003, creating a further delay in the project completion.