



## Internet-accessible Real-time Weather Information System

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### Abstract

We have developed an internet-accessible real-time weather information system. This system provides real-time accessibility to weather information from a multitude of spatially distributed weather stations. The Internet connectivity also offers multiple features such as platform-independence, remote configuration and control of the weather stations, data base queries, graphical displays and multi-media presentation capability. The weather information is presented in user-selectable formats such as Text and Graphics. Thus, real-time weather data can be accessed by various user agencies including regional meteorological organizations, airport authorities and the World Meteorological Organization (WMO). The Internet-accessible real-time weather information system described here promises a new level of flexibility and sophistication in the acquisition and use of weather information for a number of diverse applications ranging from meteorological training and research to a multitude of operational usage.

### Introduction

Knowledge of wind field and perturbations of other meteorological parameters such as pressure, temperature etc is important to a wide range of meteorological and a number of diverse engineering applications. These include boundary layer research, weather forecasting, hazard warning, air pollution modeling and prediction of its dispersal, air traffic control, rocket launching, and engineering design such as airport and so forth. Wind data have also been used in the field of agriculture for effective spraying of pesticides and soil erosion modeling [1]. The wind field plays an important role in controlling the environment through transport of heat and moisture. Determination of the spatial and temporal variability of meteorological conditions is essential to understand and model the formation, movement, and modification of moisture and air masses, and other atmospheric and oceanic phenomena. In India and its neighbouring countries, a good knowledge of wind characteristics is important to understand the features of monsoon circulation. In some regions (e.g., California), intrusion of marine air into the land and the extended sea breeze circulation is an interesting phenomenon with important implications to the transport of air pollutants and to local micro climates [2]. For oceanographers, knowledge of winds is important for sea state assessment and circulation

modeling. The ocean circulation develops and varies according to wind stress and heat fluxes between ocean and atmosphere, at various time and space scales. In the tropical oceans, the ocean circulation adjusts quickly to the fluctuating trade winds. Spatially distributed meteorological stations, capable of real-time or near real-time data communication capability, form part of the infrastructure necessary for providing operational applications. The integrated weather data from such stations are useful to provide effective and timely storm-surge forecast and warning to fishermen at sea, guidance to rescue operators and planners, and so forth.

In the past, attempts have been made to network several meteorological stations. For example, remotely located weather stations have been connected to standard telephone lines, wherein on-site computer capabilities allowed rapid generation of a variety of up-to-date integrated and analyzed real-time meteorological products to meet the requirements of forecasting and operational purposes. Ochs et al., [3], Smith et al., [4] have reported a network of weather radars for observation of wind field, which could be directly input into diagnostic and predictive models of local wind flows. Subsequently, geo-stationary environmental satellites have also been employed for networking geographically remote autonomous weather stations, wherein the stations transmitted averaged meteorological variables at regularly timed intervals to the satellites, and the weather data have been received by satellite ground stations [5]. In recent development, Brown [6], has reported a meteorological system having voice synthesizing and recognition apparatus, and a radio receiver for communicating with global weather reporting communications systems utilizing cellular communications. A limitation of this system is that it is merely a radio communication system wherein its data is accessible to only selected predetermine stations.

## **Description**

We describe a networking system, which enables remote access to one or more weather stations via Internet. Fig. 1 represents a block schematic of the above Internet-accessible real-time weather information system. This consists primarily of communicating weather data through several central servers, referred to as weather servers (WSRs), located at several geographical regions from one or more remote weather stations in a given region. The WSRs are connected to Internet through a hub and bridge. These WSRs can be connected to the weather stations via RS-232 / RS485 direct cable connection, conventional telephone connection, UHF / VHF wireless communication and so forth. Real-time weather data is transmitted by the autonomous weather stations to the respective WSRs either continuously or on request. Except in the case of telephone connectivity, the data flow is continuous. The WSRs are in turn programmed to retransmit the data to the client computers, which establish a communication link with the servers using standard network socket protocols. This scheme thereby provides for platform-independent global accessibility to weather information from a network of spatially distributed weather data platforms from one or more geographically remote locations to Internet users, using Internet browser. The user may include regional, national or international meteorological offices (e.g., World Meteorological Organization), thus providing a means for dissemination of weather information for real-time or near real-time use on a global scale, a capability which was hitherto unavailable.

The weather station implemented by us ( Fig. 2) comprises of a suit of meteorological sensors such as wind speed & direction, air temperature, solar radiation, relative humidity and

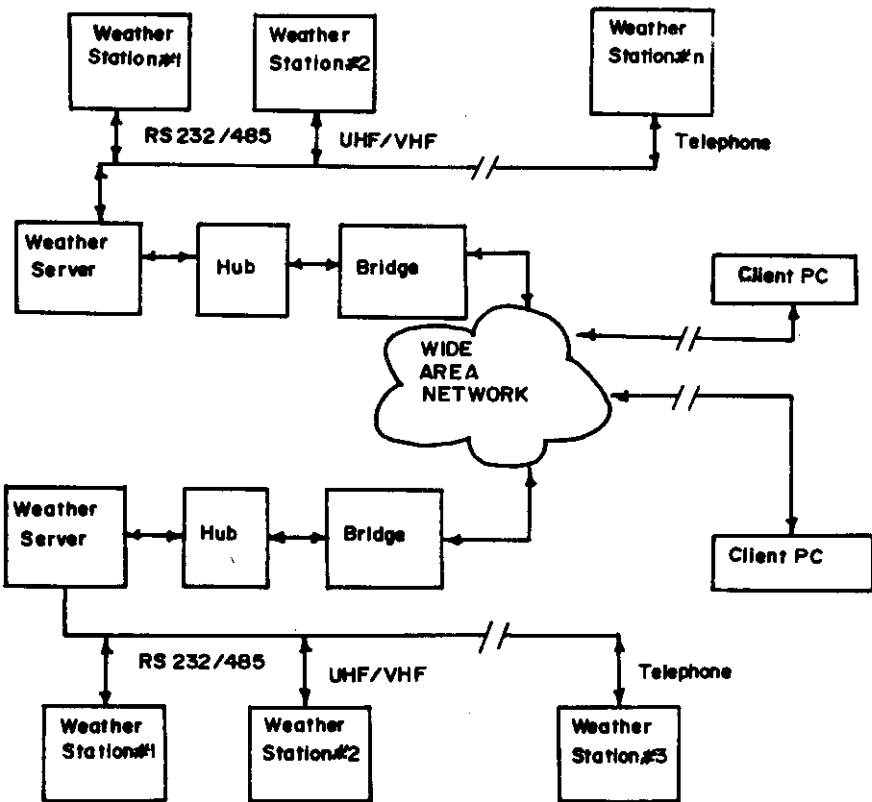


Fig.1 Block schematic of the Internet-accessible real-time weather information system

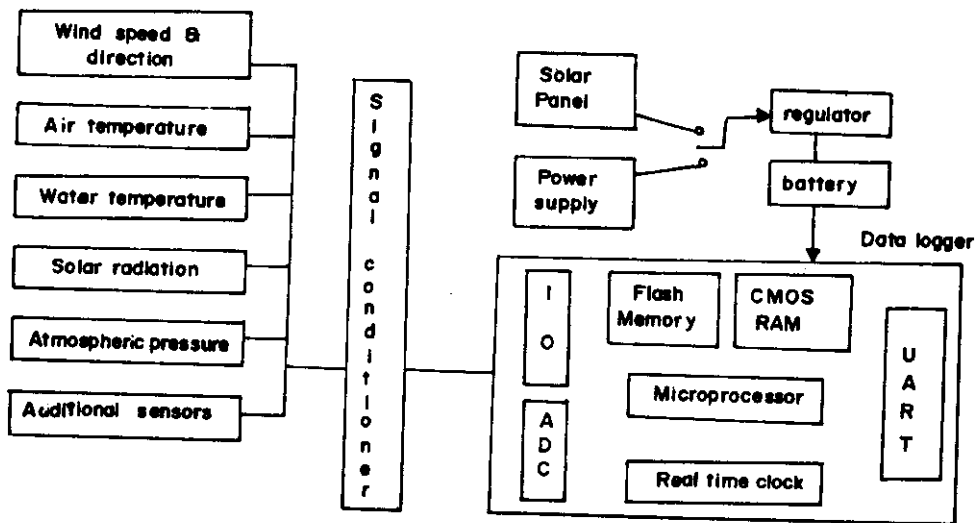


Fig.2 Block schematic of weather station

atmospheric pressure, and has flexibility to interface to additional sensors. The sensor outputs are suitably conditioned using a signal-conditioner, and are interfaced to a data logger, which consists of a low power embedded microprocessor, on-board flash memory, CMOS RAM, digital input / output ports, an analog-to-digital converter, a real-time-clock (RTC), and an UART. The FLASH memory is used to store the data acquisition program. The acquired time-tagged meteorological data is stored in CMOS RAM memory. The microprocessor is put into low-power (sleep) mode between successive measurements, and the RTC is used to wake-up the microprocessor from sleep-mode. The weather station can be powered from a battery, which is charged either through solar panels or through mains power supply via a regulator, depending on the facilities available at the site. Presently the weather station is connected to the WSR through the data-logger's serial port via direct cable using RS-232 or RS-485 type line drivers. However, alternate communication links such as telephone connectivity, wireless UHF / VHF link etc., are also possible using compatible modems.

The weather station is normally initialized (i.e. configured) after power-on. The initialization parameters include date & time, sensor warm-up time, sampling interval, recording interval, and other relevant user-information. The data logger, which normally remains in sleep-mode, is interrupted by either a wake-up signal from preprogrammed RTC or in response to commands received on the serial port from WSR. In case of an RTC interrupt, the sensor's outputs are sampled, processed, locally stored in the logger's internal CMOS RAM memory, and sent to the WSR. Wind vector components are resolved to vector-average the wind data. In response to the external client-commands received on the serial port, the data logger allows display of available storage space, down-loading of data, change in current configuration, updating of the firmware etc.

In the present system, the WSR is based on Microsoft Windows NT platform, which hosts world-wide-web (W W W) services using Internet Information Server (IIS). The server also takes care of periodic downloading of data, which has been locally stored at each weather station and also the maintenance of a database system. The client software is embedded within the HTTP (Hyper Text Transfer Protocol) document on the server.

Figure 3 shows the various activities performed by the WSRs. Here the WSR communicates with the weather stations via a weather-station server-interface (WSSI), and with clients via a client-server-interface (CSI). The WSR continually looks for data on its serial communication port from different weather stations within the WSSI, wherein the in-coming data (in the form of ASCII character strings) are read by the server.

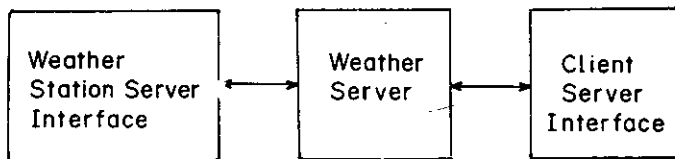


Fig.3 Functions of the weather server

The WSSI performs functions such as reading of real time weather data, checking data integrity, issuing warning messages, performing periodic download and handling client-commands. The data integrity check essentially detects the outliers in the data set, and inspects various system parameters which determine the health of the weather station such as battery voltage, internal temperature, reference voltages etc. If the data integrity check reports the presence of any outliers or out-of-bound system parameters, then the server issues warning messages in the form of email messages through Internet connectivity and in the form of voice messages through telephone connectivity to the personnel responsible for management of weather information.

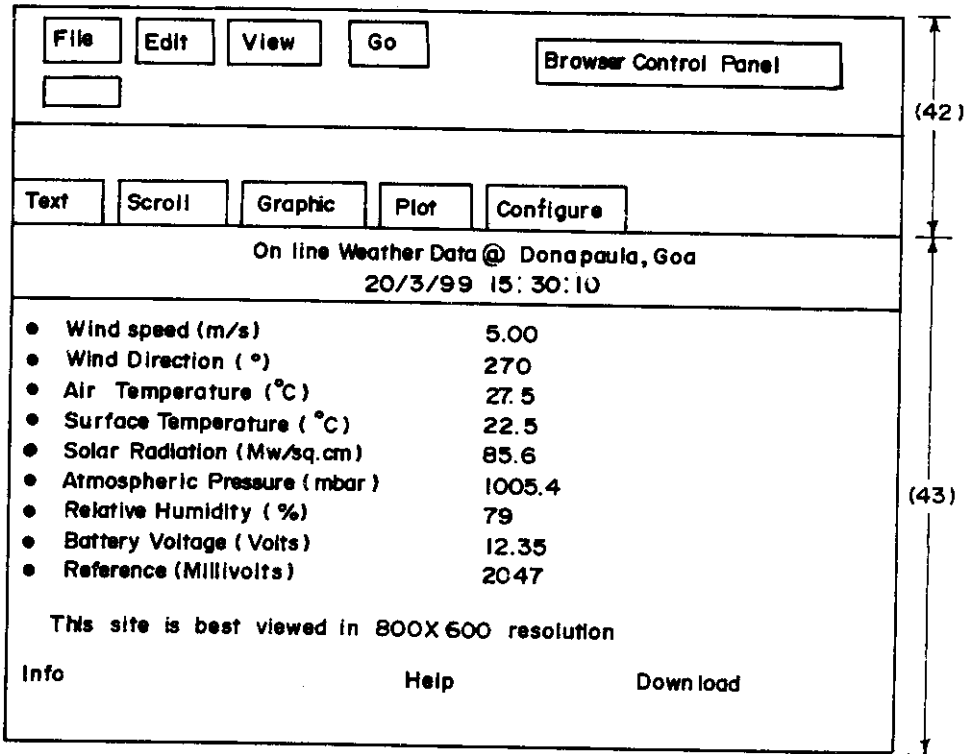


Fig.4 Screen display of a typical sample of weather data

The client-server-interface enables access to services such as HTTP, FTP (File Transfer Protocol) database access, network socket connectivity, forwarding of real time weather data and reception of client commands by the weather servers. With the use of the CSI, the clients are allowed to login into the WSR and select the desired weather station site from the available list and monitor the real time data. The CSI also allows the clients to send queries to local database, which is maintained on the WSR and to retrieve the desired results in the form of formatted HTML (Hyper Text Markup Language) documents or alternatively to download

data files using standard FTP protocols. These queries provide for various options to retrieve information on one or more parameters acquired during any given period of interest, occurrence of parameters within defined limits and so forth. The Java Applet embedded within the HTML page performs the following functions:

- Execution of the client program, which handles communication with the WSR
- Display of real time data on the client-computer's screen
- User-interaction that allows selection of various options

The real time data can be viewed in various formats such as **Text**, **Scroll**, **Graphic**, or **Plot** by selection of different menu options. Fig. 4 shows a screen display of a typical sample of the weather data in **Text** format as an HTML web page, which is viewed using Internet Browser. Here the upper segment of the screen display indicates standard browser control panel. The next segment of the screen display shows real-time meteorological data, with menu at the top. This segment provides for the choice of different options. The weather data are updated on the screen at every sampling interval. In the Graphic mode, the data is represented on screen in the form of dials and gauges.

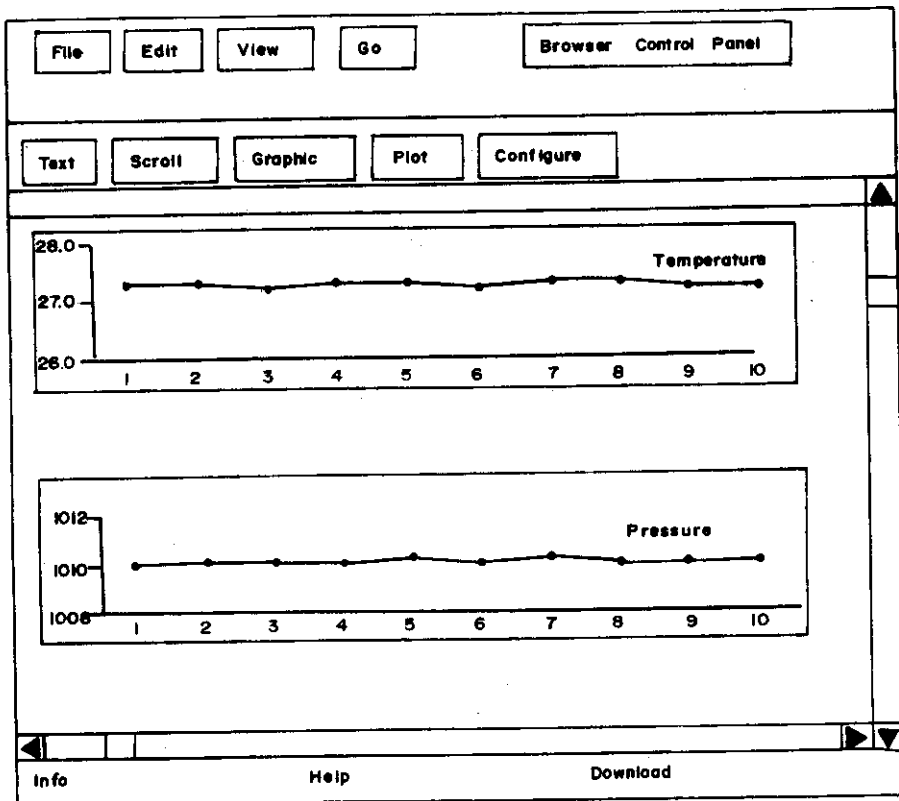


Fig.5 A typical plot of Internet-accessed air pressure and temperature

In the Plot mode, real-time plots of different parameters of the incoming data can be seen on the screen. Fig. 5 shows a typical plot of air pressure and temperature. The other parameters can be similarly viewed on the screen by using the mouse-driven vertical scroll bar on the right hand side of the screen display.

The **Configure** option permits the privileged client to remotely configure the selected weather station, under password protection, with the desired initialization parameters such as date & time, sampling interval, recording interval, etc.

The bottom of this page contains HTTP / FTP links, to web pages, such as **Info**, **Help**, and **Download**. The **Info** option provides additional information on the weather information system, including sensor specification, technical documentation, etc. The **Help** option provides information on setup required for browser environment on the client computer. The **Download** option enables downloading of data files onto the client computer using the FTP protocol.

## Conclusions

We have described an Internet-accessible real-time weather information system. The main advantages of this system are:

1. It functions as a local, regional, and global scale observation network wherein the weather data from different geographically remote and spatially distributed weather stations can be archived at many regional or world data banks.
2. It permits real-time monitoring and tracking of large scale meteorological disturbances, thereby allowing a reliable prediction of their probable trajectory, and issuing of early warnings for safety & rescue operations.
3. It enables monitoring the health of any weather station in the network, because any failure is immediately reported by the weather-server via email and voice call. This feature is particularly useful for taking swift action to prevent loss of data - a feature very important for remote sites.
4. It allows, through password protected features, an authorized Internet client to remotely configure the weather station, thereby avoiding distant site visits.
5. It permits, through the use of Internet Browser and client access software based on Java, platform-independent access for an Internet-client, irrespective of hardware and operating system of the client-computer.

The Internet-accessible real-time weather information system described here (patent filed) promises a new level of flexibility and sophistication in the acquisition and use of weather information for meteorological training, research, and a multitude of operational applications.

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