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DATA COLLECTION OF HIGH RESOLUTION 3D SONIC ANEMOMETER MEASUREMENTS

Edward Vidal, Jr* and Young Yee

US Army Research Laboratory
Computational and Information Sciences Directorate
Battlefield Environment Division
White Sands Missile Range, NM

The recent emphasis on urban warfare will require high-resolution meteorological measurements in complex urban environments. A methodology for the collection and management of a distributed array of 3 Dimensional sonic anemometers is proposed. Issues that need to be addressed are sensor interface, data basing, scalability of measurements (number of sonic instruments), distributed processing of loosely coupled systems, and performance of the data acquisition system(s). One of the major issues in the management and handling of enormous quantities of micro-met measurements is the time tagging of the data and location information of each instrument in a micro size grid. Scalability and integration of multiple sonic sensors are accomplished using loosely coupled Jini/Java Spaces. Solutions to these problems will be discussed in this paper.

1. Introduction

Increased concerns of urban warfare have accelerated efforts to characterize meteorological conditions at major cities that may be targets. The central business districts of large homeland cities can be very complex in nature and may require high spatial and temporal resolution meteorological measurements. 3D sonic anemometers are well suited for these type of measurements because of their robustness and fast response. Large number of sensors to well characterize the complex urban environment will require efficient and scalable data collection architecture.

Use of data loggers and multi-port boards for PC's have the following disadvantages:

- Limited by the number of physical serial COM ports that a PC can handle
- Software is usually specific to the data loggers.
- Data distribution and data processing during data collection is restricted by the data logger software.

This paper discusses a data acquisition architecture that is flexible and robust enough for remote site operation. The advantages and disadvantages of this approach versus other measurement systems will be summarized.

2. The Atmospheric Boundary Layer Exploitation Facility

These measurements are an integral part of the Atmospheric Boundary Layer Exploitation project.

Edward Vidal, Jr, Army Research Laboratory, White Sands Missile Range, NM 88002-5501; e-mail: evidal@arl.army.mil

The primary objective of the Army Research Laboratory's initiative is to develop a unique research and development facility for addressing relevant Army atmospheric boundary layer problems. Cogan et al (1998) presented early concepts for mobile met measurement capability. The ABLE consists of two fixed experimental sites and a mobile unit. One site is located at Blossom Point, Maryland with a secondary site at the White Sands Missile Range, New Mexico. The Blossom Point site is located near the Potomac River, south of Washington, DC in a grassy, wooded area. The White Sands Missile Range site is located in a desert region on the Tularosa Basin with the Sacramento Mountains to the east and the Organ Mountains to the west. These two sites provide climatic variability to develop and experiment with innovative meteorological instrumentation and measurement techniques. The facility is capable of providing continuous view of processes in the lower atmosphere over a highly instrumented domain.

The ARL facility at Blossom Point, Maryland comprises 4 individual 30-meter meteorological walk-up towers. Figure 1 is a photograph of one of the instrumented towers in which wireless communications will be installed.

3. Sonic Sensor Interface

The traditional methodology for collecting meteorological data from a typical sonic anemometer as shown in figure 2 is through an RS232 communication output. The output from the sensor can then be connected to a serial COM port on a PC computer or laptop PC. Longer transmission can be achieved by converting the RS232 output to RS485 output via line drivers.

Early configurations for utilizing Java and networking applications were presented by Vidal and Measure (2001).

Figure 1. Photograph of the ARL 30meter met tower at Blossom Point, MD. 3D sonic anemometers are mounted on the tower

Figure 2. RM Young 3D ultrasonic anemometer (no moving parts)

The approach taken in this paper's architecture involves a RS232 to Ethernet interface as shown in figure 3.

4. Sonic Anemometer Measurements

The experimental collection of sonic measurements consists of several steps outlined as follows:

1. Select specific locations to place sonic sensors for representative characterization
2. Calculate GPS coordinates including the height above the surface for each sensor.
3. Determine optimum sampling rate.
4. Set the IP network address for each met sensor.
5. Setup wireless LAN bridge connection.
6. Synchronize data collection with the central data acquisition system.
7. Screen for bad data lines and either delete it or process a correction.

5. Database collection

The RS-232 serial data is converted to a socket, which is transmitted over the Ethernet. This data (u v w speed of sound and air temperature) is put into an object, which is temporally held in the Java Space (fig4).   A loosely coupled application scans the Java Space (Torres, 2001) for new objects and the elements of the object are inserted into the fields of a rational database. The ACQ table in the database contains location information (latitude, longitude, elevation, & x, y, z, and time tagging sonic ID with a key field, which is the acquisition number. This key field relates series of meteorological wind (u v w) readings and temperature with speed of sound measurements.   This key field is only update when a new data collection process is started. Screen for bad data lines and either delete it or process a correction.

6. Conclusions

The retrieval of sonic anemometer measurements in urban type settings requires specialized methodologies to handle the data ingestion of large quantities of data.   To accomplish this task requires the leveraging of current technologies including wireless communications, microchip developments, Java-based distributed databases, and compression algorithms.

Urban measurements rely on simultaneous measurements in order to assemble meaningful data sets for modeling. The goal is to assemble high quality, near simultaneous sonic anemometer measurements for turbulence and dispersion modeling in complex environments and to characterize flows above and below the urban canopy.

Using microchip technology to collect and process data at the sensor level, the data from individual sensors are networked together. Assembled data from each local network of sensors is then transmitted wirelessly over a network bridge to a central node. Data (wind speed and direction, speed of sound, temperature) from each sensor are uniquely tagged with sensor identification, GPS location, and time stamps. Data at the central node is quality checked for corrupted data entries before being saved in a relational data base system. Implementation of a Java Spaces environment allows multiple accesses to the data for distributed applications such as real-time displays, data compression, sorting, and statistical analysis. This architecture is not limited to the collection of sonic anemometer measurements. It can be used to collect other types of met instrumentation that output serial information such as pressure readings, rain gauge measurements, radiation measurements, etc. Scalability features and loosely coupled distributed data processing are the key highlights of this architecture.

7. Acknowledgements

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8. References

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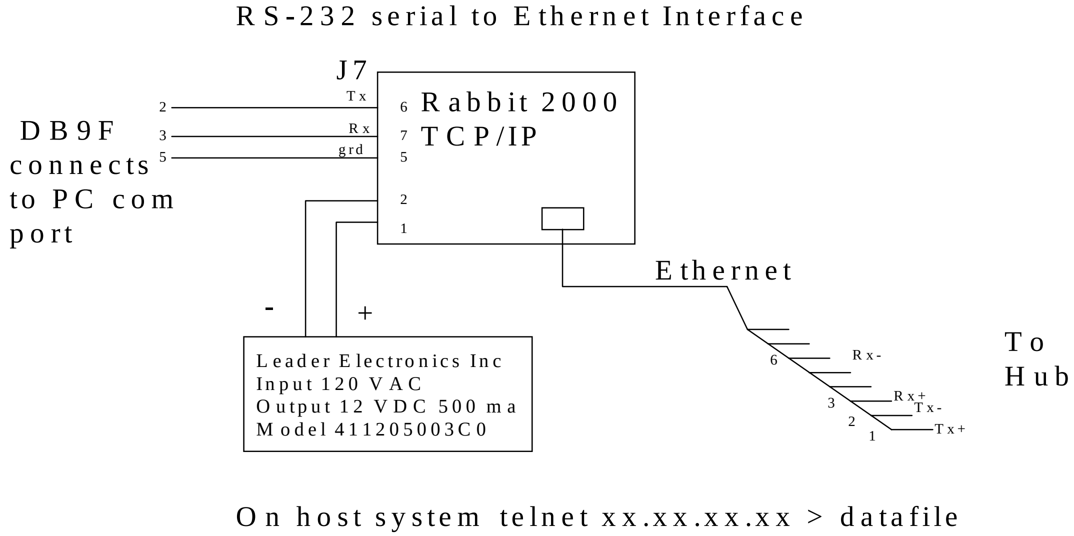

Figure 3. RS232 to Ethernet sonic sensor interface.

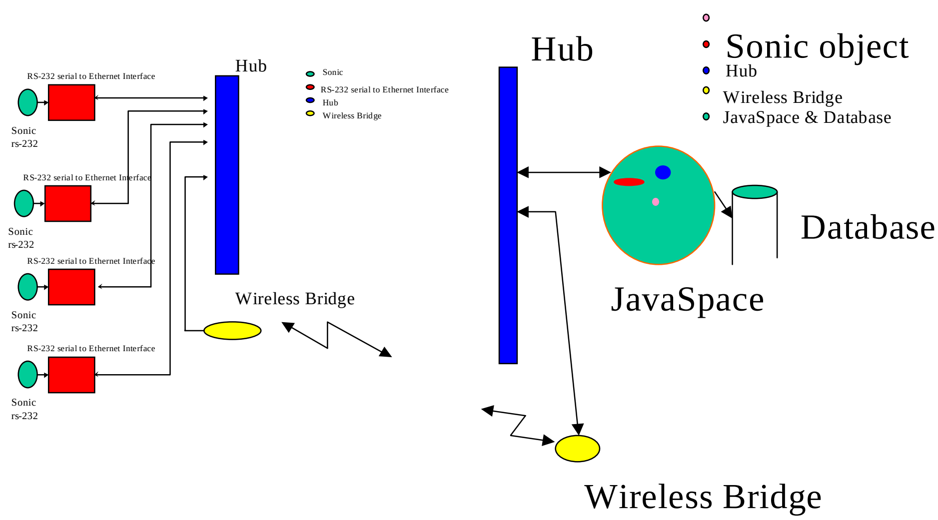

Figure 4. Java Space and Database