Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
Make Harmony Between Technology and Nature, and Your Mind will Fly Free as a Bird
Annals of DAAAM International

APPROACH FOR GREEN ENERGY POTENTIAL EVALUATION USING REAL-TIME DATA ACQUISITION DEVICES

CROITORU, B[ogdan] S[ergiu] M[ihai]; BOCA, M[aria] L[oredana]; JOLDES, R[emus] & CABULEA, L[ucia]

Abstract: *The present paper describes a complex monitoring process of few environment parameters for evaluating green energy potential of a relatively small geographical area. The monitoring approach presented here consists in: a real-time data acquisition process using two real-time data acquisition devices (DAQ); a wireless network used for long distance data transmission; LabVIEW applications used for controlling data acquisition devices; a network protocol analyzer used for a detailed analysis of the communication protocols and data packets; the management of the huge volume of sensor data by using a high level software applications; long term sensor monitoring by using a complex graphic software application.*
Key words: *data acquisition, sensors, software, wireless*

1. INTRODUCTION

In the last ten years the field of real-time data acquisition evolved spectacular. Also the field of real-time data processing evolved in the same manner. Technical progress in these fields determined great progresses in many industries. Nowadays, smart sensors have real-time data acquisition capabilities, powerful microprocessors and powerful network capable application processors (NCAP) with routing capabilities ready to be used wherever are needed.

Usually, a smart sensor board is able to measure up to five or six different environmental parameters. This is possible due to great improvements of manufacturing technologies, where dimensions of components are constantly diminished. Smart sensor boards have low power consumption and they are equipped with power supplies based on batteries which assure long periods of activity.

The presence of Field Programmable Gate Arrays (FPGA) inside a real-time DAQ device gives an extra bonus to real-time data acquisition process and improves radically data processing (Wang et al., 2006).

Many of today's DAQ devices use a powerful real-time microprocessor and one powerful FPGA circuit. Such devices accept, simultaneously, as inputs tens, hundreds of heterogeneous sensor signals (analogical and digital signals). These benefits are doubled by using new technologies and communication protocols in wireless data communication.

The present paper is focused on describing a complex monitoring process of five environment parameters for evaluating green energy potential of a small geographical area surrounding a small city.

A foreign team planted (on a hill) an 86 meters steel pylon and deployed few sensors for measuring five different environmental parameters: wind speed, wind direction, temperature, vibrations and solar power (sun intensity).

The monitoring process approach presented in this paper consists in: a real-time data acquisition process using two real-time DAQ devices and one data logger; a wireless network used for long distance data transmission; three LabVIEW applications used to control data acquisition devices; a network protocol analyzer used for a detailed analysis of the communication protocols and data packets; the management of huge volume sensor data files using a high level software applications; long term sensor monitoring by using graphic software application.

2. RELATED WORK

In the field of data acquisition a lot of work and research has been done in the last decade. Technical progress intensified the work on designing and building sophisticated smart sensor boards with advanced data acquisition techniques and advanced network communication modules (Popescu & Szekely, 2008).

Bluetooth, WI-Fi, Zig-Bee standards are commonly used for data transmission in smart sensor wireless networks and, generally, for short / medium / long distance multiple-hop data transmission (Popescu & Szekely, 2008).

For example, a large number of smart sensor boards with powerful data acquisition capabilities can work together in a "mesh network". Every node of the network has routing capabilities and efficient neighbour discovering algorithms. Each node will detect the best path to nearest master coordinator to send data to it (Jamil et al., 2009).

But, stationary FPGA – based DAQ devices, like Compact RIO - 9004 (Reconfigurable I/O Real-Time Embedded Controller – product of National Instruments Company), have the capability to collect data from external heterogeneous sensors. The device mentioned above has attached to its chassis eight DAQ modules; each module is capable to acquire data from one to eight external sensors, depending on hardware configuration (Wang et al., 2006).

Many prototypes of wireless DAQ devices were implemented to test and improve few important aspects like: sampling rates, power consumption, autonomy, efficient data collecting process and transmission process, higher speeds for data transmission, "dead-time" issues in wireless networks, immunity to external EMI, routing capabilities for each smart sensor board, and other (Das et al., 2009).

Also, a consistent number of embedded DAQ devices were designed in order to be able to acquire data from tens, hundreds of heterogeneous sensors. These DAQ devices contain, besides real-time micro-controllers, FPGA circuits which extend the borders of real-time data acquisition processes. FPGA circuits bring an extra power to parallel real-time data processing.

3. IMPLEMENTATION

As it was mentioned above, the present paper describes a complex process of green energy potential evaluation by using sensors, DAQ devices and software applications.

A foreign team planted on a hill an 86 meters steel pylon and deployed, on different heights, few sensors and equipments for measuring the following parameters: wind speed (two anemometers); wind direction (one wind direction sensor); temperature (one temperature sensor); steel pylon vibrations (two accelerometers on 3-axes); solar energy (three photovoltaic panels used for supplying with energy all the equipments and, also, to measure the sun energy potential).

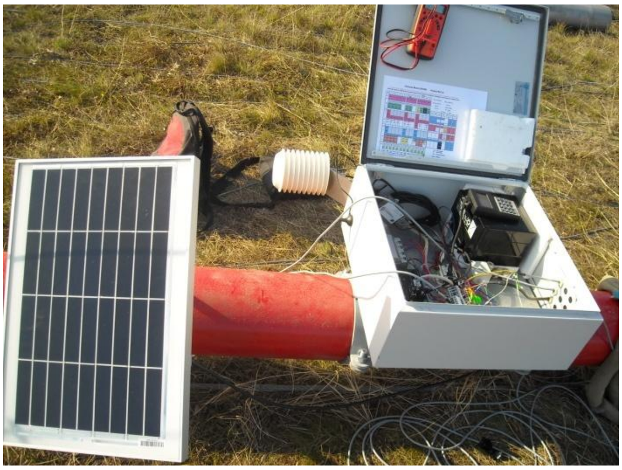

Fig. 1. A photovoltaic panel, a temperature sensor and a steel box containing other auxiliary equipments - all of them attached to the steel pylon

Figure 1 show a few equipments attached to the steel pylon by the team. It can be depicted: a photovoltaic panel used to provide energy for the equipments; a 3-axes accelerometer inside the box used for pylon vibrations; a temperature sensor and other auxiliary equipments that were necessary.

For data acquisition processes we used three different DAQ devices to be able to do some detailed tests: one Compact RIO – 9004 Real-Time Embedded Controller (provided by National Instruments); three NI WLS-9163 Real-Time Wireless DAQ Carriers (provided by National Instruments); and a relatively chip data logger - DaqPRO (Kalyanramu, 2005).

We created four LabVIEW applications in order to use the DAQ devices for real-time data acquisition processes. These applications were created in order to use the entire computing power of the FPGA circuits inside DAQ devices.

The best data acquisition performances as well as the best high speed data processing were achieved with Compact RIO – 9004 Real-Time Embedded Controller. Best performances were assured by a powerful XILINX FPGA circuit that was carefully programmed using LabVIEW platform. A cheaper solution for real-time data acquisition was NI WLS – 9163, which is a DAQ device with a wireless transmitter and one DAQ module (C – series modules NI 9221 or NI 9215). This DAQ device has a pre-programmed FPGA circuit.

For data processing the NI WLS 9163 DAQ device used is relative slow. The power consumption of this device is low, and because of the local power constraints we were forced to use it. The third option was a cheap data logger (Wang et al., 2006).

We also implemented a high speed secured wireless network (IEEE 802.11 b/g standard) to be able to transmit all gathered data to a remote location about 7 km distance. As a backup solution we used a VODAFONE line to send data remotely. Two access points and two routers were used with three 20 dB 2.4 Ghz Omni-directional antennas. All DAQ devices were connected by Ethernet cables to the Routers. The radio link was good. Maximum radio signal was achieved in both directions. We were reading final acquired data on two different remote locations (Lu & Krishnamachari, 2007).

We made also tests for measuring the quality and integrity of data packets and were realized using a network protocol analyzer. The results were: few data packets are lost and we needed to improve the wireless network as well as to secure it against external electromagnetic interference and other sources of parasite radio waves which may affect the network. The network protocol analyzer used in the experiments is free license, open source software, which is called Ethereal.

One sensor is storing approximately 100 000 values in a month. Values are stored in Comma Separated Values (CSV) files and Excel files. The sampling rate we chose was one measurement / one minute (0.017 Hz). We built two high level software applications in order manage the high volume of sensor data. The goal of building these applications was to monitor the evolution of each sensor in time, and to make relative good predictions of the measured parameters on a period of one year. The green energy potential is being evaluated by analyzing these recorded values.

First application is performing some extractions of the relevant data from the CSV and Excel (.XLS files) files and creates new Access Databases (.MDB files) with these extracted data. Each database contains five relevant fields.

The second application was designed to load one database (database previously created by the first application) at a time, and gives the possibility to display a 2D graphic (with zooming capabilities) for each sensor values on a period of time. When application starts few querying parameters must be set: starting date; ending date; starting time; ending time; the name of the sensor. Using this graphic some predictions could be made.

4. CONCLUSIONS

The green energy potential of a specific geographic area can be well evaluated by using complex software applications that are capable to manipulate large sensor data files. A good monitoring process of all sensors was achieved by implementing a graphic software application, which is able to plot every measured sensor value on each moment of time. The results were helpful for analysing green energy potential.

5. FUTURE WORK

As a future work we propose to reduce the sampling rates of DAQ devices in order to reduce the number of recorded values (where is possible). Also we propose to upgrade both software applications in order decrease data processing time (~ 1 hour / 1 file) and to realize more accurate real-time predictions and measurements regarding green energy potential evaluation. This research will lead on attracting investments in green energy field to help local economy.

6. REFERENCES

Das, A.; Popa D.; Ballal P. & Lewis F. (2009). Data-logging and Supervisory Control in Wireless Sensor Networks, *Available from:* http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.103.559&rep=rep1&type=pdf *Accessed:* 2010-05-17

Jamil, M.; Zain M. F. M.; Krishnamurthy V. & Sazonov E. (2009). Scientific Data Acquisition for Structural Health Monitoring by Using Wireless Intelligent Sensor, *European Journal of Scientific Research*, Vol. 33, No.4, pp.585-593, ISSN 1450-216X, Euro Journals Publishing

Kalyanramu, V. (2005). Embedded Wireless Data Acquisition System, *Available from:* http://scholar.lib.vt.edu/theses/available/etd-12202005-005049/unrestricted/Kalyan_Grad_Thesis_Final.pdf *Accessed:* 2010-05-27

Lu, G.; Krishnamachari B. (2007). Minimum latency joint scheduling and routing in wireless sensor networks, *Ad Hoc Networks*, Science Direct, Vol. 5, pp. 832–843

Popescu, V. & Szekely I. (2008). Wireless Data Acquisition System Using Bluetooth, *Available from:* http://vega.unitbv.ro/~popescu/REV%20Paper.pdf *Accessed:* 2010-05-24

Wang, X.; Lu Y. & Zhang L. (2006). Design and implementation of high-speed real-time data acquisition system based on FPGA, The Journal of China Universities of Posts and Telecommunications, Volume 13, Issue 4, Pages 61-66, Published by Elsevier B.V., Science Direct, doi:10.1016/S1005-8885(07)60035-1.