Meteorology System for Nuclear Power Station Belene

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Abstract

This paper describes design and implementation of system for meteorological measurement in area around nuclear power station Belene. Measured parameters are written to database and some computations are made on this data.

1. Introduction

In the recent years energy consumption grows rapidly. All around the world people discuss the negative side of global warming from engines, factories, etc. One of the biggest polluters are the electric power stations. The cleanest power stations are the nuclear power stations, but they are very dangerous. Therefore around every power station many and different monitoring systems are mounted.

One of those systems is developed to measure the meteorology parameters in the area around Belene future nuclear power station. The system is particularly employed for monitoring wind speed, wind direction, temperature, rains, atmospheric pressure, atmospheric pressure trend, humidity, solar radiation, UV (ultra violet) index and forecast rule. Based on those measurements we compute in real time dew point and atmospheric stability.

2. System architecture

The automated measurement system has typical architecture. There are three base components – measurement system, database server and web server with user interface as it is presented on figure 1.

The utilized meteorology measurement system is **Vantage Pro2** Professional Series [1]. It measures the meteorology parameters and collects the information in its internal memory. Collect time interval is set and the data is read every day or the moment data is read every two seconds. The meteorology system measures the parameters listed above. It has RS232 communication interface and Davis software for connecting, collecting and visualization of the measured results. As shown the architecture is TCP/IP based network and three RS232 to TCP/IP converters are used to connect the stations to the network.

Another reason to write custom software are the requirements for user interface in Bulgarian language and possibility to see all measurements simultaneously, while with original software this is impossible.

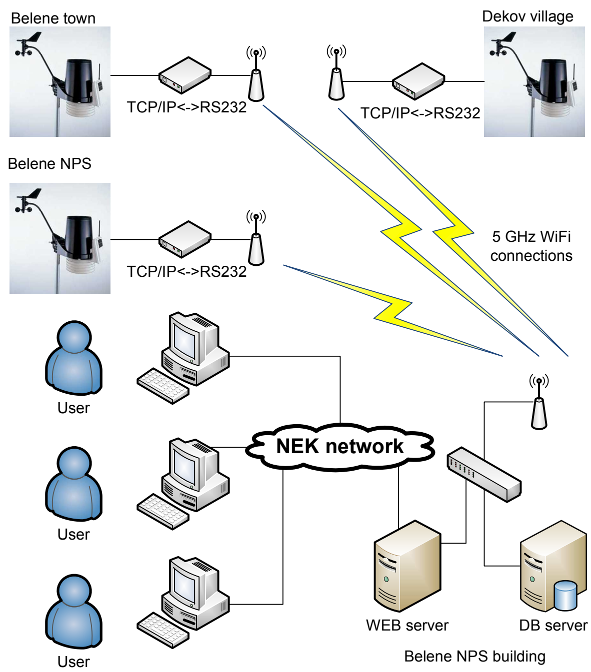

Fig. 1. System Architecture.

It is necessary the measured information to be converted and stored into database for further analysis, processing, archiving and proper visualization.

A web-based interface is developed and runs on the web server. The users access the system with their accounts to monitor the measurement results. They can also export data for desired time interval as coma separated values file (CSV) and use it in other statistical software.

3. Data transfer between meteorology systems and Data Base server

The meteorology software provided by Davis can only handle one station. It cannot store data to a database. Therefore the software is used to download data from stations in real time and collect archive data if the communications are broken for some time interval. At all the weather stations store average values of measured parameters for five minutes interval in internal memory. The meteorology system can work offline ten days. After that new data will overwrite the oldest one.

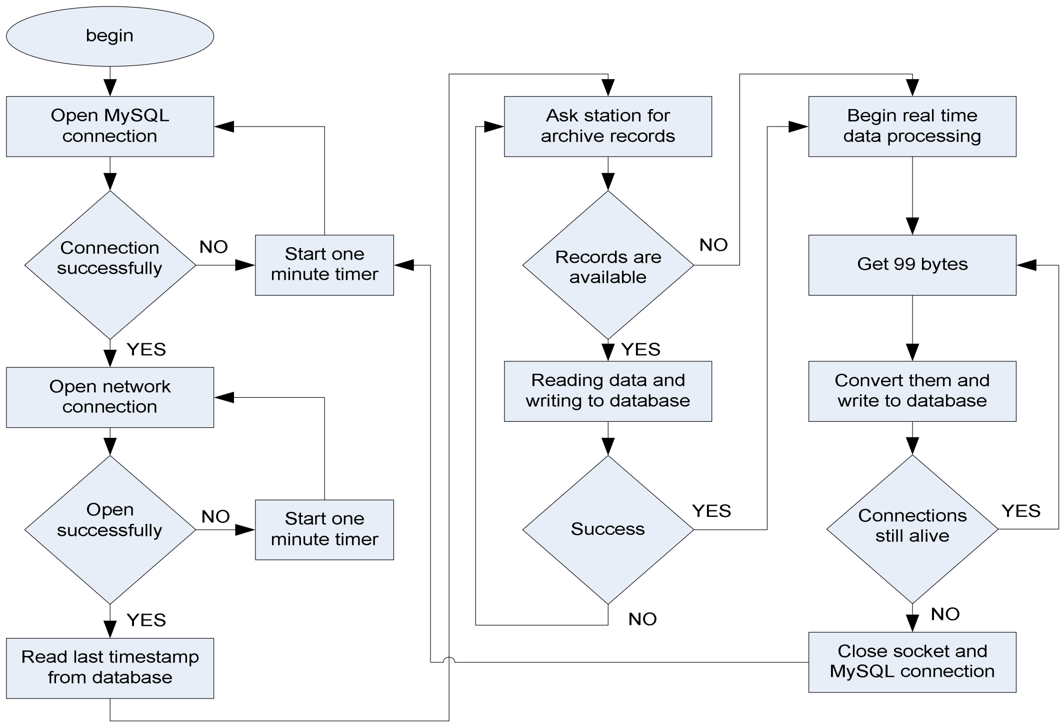

Fig. 2. Block diagram

To work properly server's software uses the following algorithm:

1. Connect to a database server.
2. Connect to a meteorology station.
3. Check the database for the last inserted data time stamp.
4. Ask the station for archive records from this time stamp.
5. If archive records are available – process them and continue with real time measurements, else continue with real time measurements.

The software was programmed in "C" and it is running under Ubuntu Linux. Figure 2 shows the algorithm of the program.

The real time measured data from the meteorology system is uploaded in a binary format. Davis provided a detailed documentation [2] that completely describes the binary data format. The software reads the packets from the network socket in binary mode and after conversion stores them to the database.

The data is presented in portions of 99 bytes [2] for real time measurements and 267 bytes for archive records. The below HEX code is one measured real time sample:

4c 4f 4f ec 00 f5 08 72 74 a4 04 0f 8a 03 0a 07 68 01 ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff 1c ff ff ff ff ff ff ff 00 00 2a ef 02 00 00 ff ff 00 00 79 01 d1 06 7e 00 34 02 92 06 ff ff ff ff ff ff ff 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 b5 03 06 2d f9 07 bd 03 0a 0d 12 98

The software converts this hexadecimal code into the proper format. The result of the conversion of this sample is presented with the following values:

Tab.1.

Measurement data

Date	31.08.2011
Time	15:31
Wind Speed	6.7 m/s
Wind Direction	281 degrees
Average wind speed	4.5 m/s
Temperature	29.5 C°
Rain Rate	0 mmHg
Day Rain	0 mmHg
Month Rain	81.03 mmHg
Year Rain	256.29 mmHg
Barometer	1005.3 hPa
Barometer trend	0
Humidity	36 %
Solar Radiation	221 W/m²
UV Index	2
Forecast Rule	192

This packet contains some more data for different parameters like transmitter battery level, time of sunrise and time of sunset. There are also empty bytes for information from sensors that are not attached to the meteorology station.

Archive records have similar schema. They consist of one byte sequence number, five data blocks of information (each 52 bytes long), four unused bytes and two bytes for CRC.

4. Database design

The data coming with every package was presented in previous chapter. Additional details describing the data could be found in [1]. It is about the time interval between two measurements for every parameter. The database is designed following this description. It has five different tables for storing data and one table for usernames and passwords of the web interface users. The table's models are shown on the next tree figures.

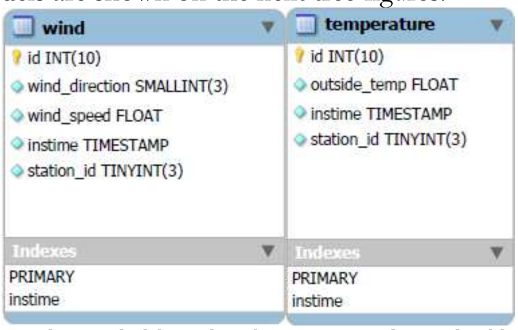

Fig. 3. Wind (2 sec) and temperature (10 sec) tables.

Wind speed and wind direction are measured on every two seconds, temperature on every ten seconds.

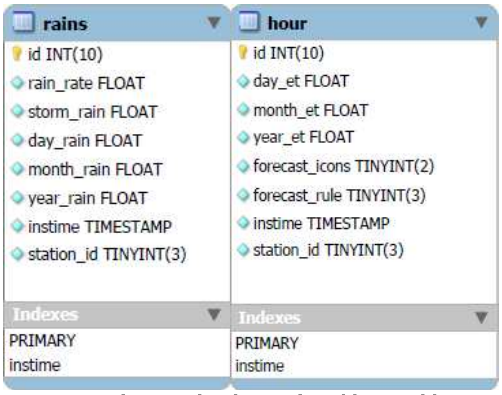

Fig. 4. Rains (20 sec) and hour tables.

Rain rates are measured on every twenty seconds, atmospheric pressure and forecast rule on every hour.

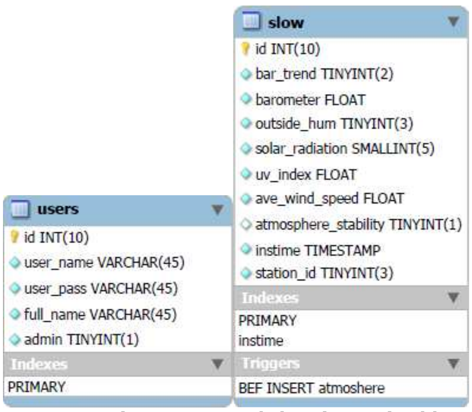

Fig. 5. Users and slow (50 sec) tables.

Atmospheric pressure trend, humidity, solar radiation, UV index and average wind speed are measured on every fifty seconds.

In the hour table some more fields appears: day_et, month_et and year_et. This is evaporation for day, month and year time interval respectively. The forecast icon is the number of an icon that represents the weather condition.

With this separation of the data in different tables, the data duplication is avoided. The available free space on the hard disk drive will be enough to store data for the next ten years.

Two algorithms are integrated in the database. The first one is for the calculation of dew point T_d. This is the temperature to which a given parcel of humid air must be cooled at constant barometric pressure for water vapor to condense into water. The condensed water is called dew. The dew point is a saturation temperature. After a very simple approximation T_d can be calculated with the following equation:

$$T_d = T - \frac{100 - RH}{5} \quad (1),$$

where T is current temperature and RH is relative humidity.

The second parameter is the atmospheric stability. It is very important in case of radiation leaks and shows how fast the radiation will spread around. The method developed by Pasquill is used. He categorized the atmospheric stability into six classes named A, B, C, D, E and F. They are described with more details in the next table.

Tab.2.

The Pasquill stability classes

Stability class	Definition
A	very unstable
B	unstable
C	slightly unstable
D	neutral
E	slightly stable
F	stable

In the database the users are stored with real names, usernames and passwords. In this system only two types of privileges exist. Administrators – they can create users and access data from the database and users – they can only work with the data.

5. User Interface and graphical visualization of measurements

User interface has tree basic functions: real time monitoring, reference graphics and data export.

For visualization and references Flot [4] graphical library is used. This is easy customizable software, where programmers can set just anything in the graphics. Flot is a pure Javascript plotting library for jQuery. It produces graphical plots of arbitrary datasets on-the-fly client-side. This part is intended for system operators. Very quickly they can see all changing trends. Base PHP functionality for working with text files [5] is used for the data exporting. The files are generated on the server and downloaded by the user.

Measurement results for wind speed, wind direction, average wind speed and current temperature are shown on figure 6.

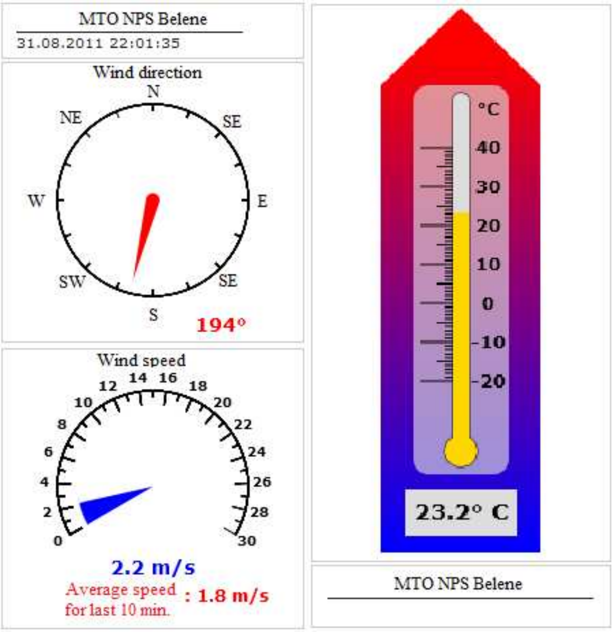

Fig. 6. Real time monitoring of the wind and temperature.

Wind direction is in degree: 0 - north, 90 - east, 180 - south and 270 - west. This is direction of the coming wind. At the above figure wind is coming from south and goes to north.

Temperature is shown in graphical thermometer, but the precise value is printed in small window at the bottom.

On the next figure is shown the temperature reference for the last three days.

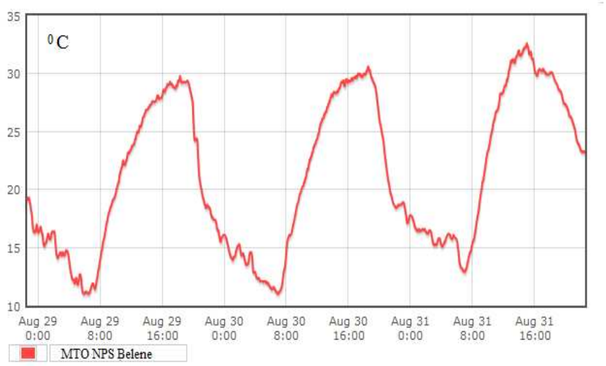

Fig. 7. Temperature reference for three days.

This reference can be obtained for every measured parameter and time interval.

Data exporting is simple. Operator can export parameters in two different modes. First is full data archive - all measured values for selected parameters in a time interval. Second is average mode – this will produce file with smaller size. The average interval can be set to 10, 15, 30 minutes, day, month and year.

If operator wants all temperatures for one hour, a file with 360 records will be downloaded, for 30 minutes average, the file would contain 120 records. The data export can combine different measured parameters. All combinations are allowed. The structure of a file with comma separated values depends on user.

6. Conclusion

The designed automated system is suitable for measurement of most significant weather parameters like: wind speed, wind direction, temperature, rains, atmospheric pressure and trend, humidity, solar radiation and UV index. This system is intended to be utilized for measurements in specific areas and for public monitoring as well. Thus developed the system gives the opportunity for measurement and monitoring in public buildings such as schools and kinder gardens.

The architecture is flexible and can work not only with Davis meteorology stations. With small changes in one of the modules, this system can work with any other meteorological station. The web interface makes all information available from every location with internet access. The export of data for different time intervals is perfect for analytical and statistical purposes.

Bibliography

[1] Davis Instruments, *Vantage Pro2 User's Manual*, Davis Instruments Corp. 2009

[2] Davis Instruments, *Vantage Pro and Vantage Pro2 Serial Communication Reference Manual rev. 2.3*, Davis Instruments Corp. 2009

[3] Kernighan Brian W.; Ritchie Dennis M. *The C Programming Language (2nd ed.)*, Prentice Hall, March 1988

[4] http://code.google.com/p/flot/

[5] http://php.net

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