УДК 004.056.5

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Design and Implementation Systems for Weather and Technology Process Monitoring

This work aims at building monitoring system that controls and collects data for weather parameters. A distinctive feature of the system is the use of the known solutions in its database structure, fully oriented to store large amounts of data with high time resolution. Another feature is the use of new approaches for data compression and extrapolation of the observed processes for timely detection and prediction of emergency situations.

Key words: weather monitoring systems, technology process monitoring systems, data compressing, emergency alarm, extrapolation algorithms.

Introduction

Weather monitoring plays an important role in human life, so the collection of information about the temporal dynamics of weather changes is very important. The collected data can be used to predict weather (forecasting) and can be used to improve the crops productivity, fishing, and other important human activities. As seen from the publications on weather forecasting, for example, [1, p.1203–1211, 2, p. 57–92, 3, p. 107–128], these forecasts are made by collecting huge amounts of data for the current state of the weather. The prediction accuracy depends on the collected data amount. Therefore, the development of various software engineering tools to implement up to date weather monitoring, and conduct associated with the monitoring and study of climate and atmospheric physics related research (eg, occurring in the atmosphere microturbulence), also devoted a large number of publications, such as [4, 5, p. 1125–1131, 6, 7, p. 403–408, 8].

However, the main focus of these papers is on the technique or method of experiment. Our paper proposes a variant construction of the system, aimed primarily at the opportunity to consolidate long-term synchronous data acquisition with a large number of sensors with high temporal resolution. Since the problem of collecting and storing large amounts of information are characteristic of technological monitoring systems, for example, used for operational control and energy accounting, the system can be successfully used for such purposes.

System description

The full system architecture is shown in Figure 1, has the typical structure of SCADA system and includes the following components:

— transducers;

— microcontrollers, which works as the primary data collection devices, and primary backup (PLC, programmable logical computer);

— Terminal Computer (TK), which works as a hub of data collection, storage backup and transfers data to a central database server (БД);

— Database server, designed for centralized storage of collected data;

— Web — server: allows web users to control the operation of the system and analyze the collected data.

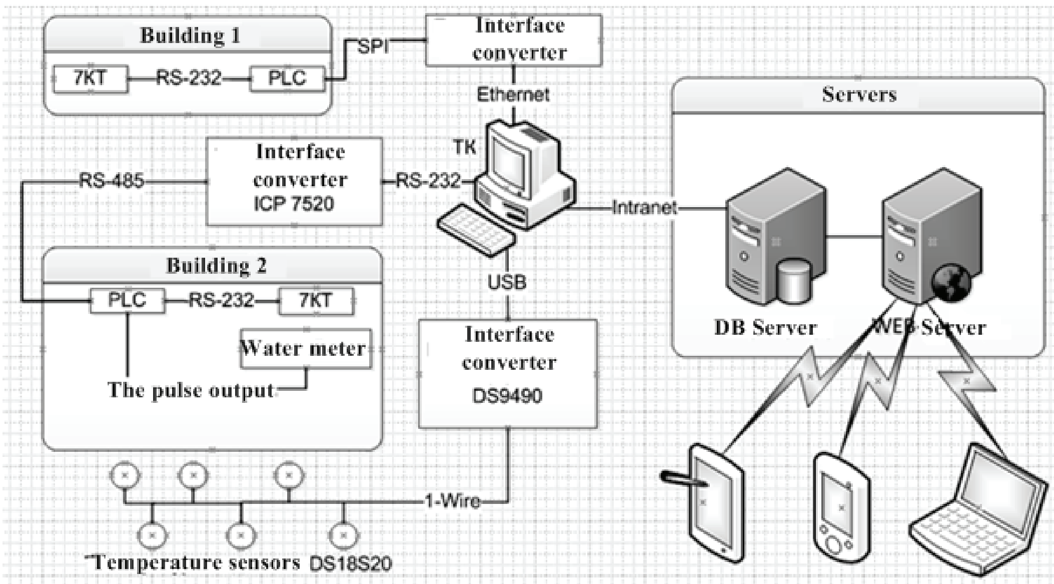

Figure 1. The architecture of the monitoring system

The system uses sensors firms Dallas Semiconductor (DS18S20 — to measure the temperature on the streets and indoors, and DS1923 to measure humidity), Texas Instruments (MPX5000 — to measure the atmospheric pressure), and also sensors of its own design [9, p. 134–138] on the basis of piezoelectric transducers T/R 40-18 U firms Audiowell Electronics [10] to measure the wind speed. To control the heat in the system, any recommended system utilities energy meter can be used. For transport information between TK and used industrial PLC interface RS485, which was consistent of the PC interface via interface converters 7120 firm ICP CON. To connect the sensor directly to the DS TC adapter uses DS9490R. In a PLC for this purpose 1-Wire bus signalsware software to emulate one of the pins of the microcontroller, which is used as a microcontroller Atmega64 from company ATMEL. To collect the data from water energy we use industrial controllers i7188D i7188XA firm ICP CON.

The power supply system of both types of PLC provides uninterrupted power for at least 24 hours. To avoid loss of data, PLC has an annular Flash — buffer that provides temporary storage for the duration of the absence of a stationary power or communication with the TC. In the TC is also possible to temporarily store data in a file in case you lose connection to the database server. These solutions significantly increase the robustness of the system and minimize the chance of data loss due to power failure or problems with communication between the various nodes.

The collected data from the sensors are concentrated initially in PLC and transferred first to the computer terminal and then — through the central highway network to a remote server in a single system-wide database MySQL. This configuration minimizes the data transport over local Ethernet — networks containing volatile switches and routers, and, consequently, improves the reliability of the system.

The interface between the TC and the remote database server, as well as the TC-PLC platform is implemented using Java jScada. Architecture subsystem data shown in Figure 2 and is based on the concept of multithreading to improve performance and stability of the system, depending on which kernel objects the application — it flows, the interaction between which the flow through the supervisor. The objects include the following core components.

— **Configurator.**, tunes the system, generates packet and the constructs logical links at the first run when the application starts. In the first phase of work, it builds a list of plug-ins and checks the files to specified requirements. Then searches for and reads the configuration files and settings, after they pass through the xml-parser, creates a plug-in for it, if it is in the list of modules, and builds a list of tags and packages. At the final stage of the configurator, object „Event Control“ is created and configured. That object is added to the list of packages.

— **Dispatcher**. Its main task is to organize data exchange between the performers. Data exchange between the kernel object is implemented with a blocking FIFO queue LinkedTransferQueue of collection of Java classes. The unit to exchange data between streams is a package that contains, in addition to numbers and the address part, the command tag for reading and writing, as well as a list of numbers of the following package transaction and the status of the package. The command determines which actions the recipient must perform. Tags directly contain sent or received data. The field „Recipient“ stores the recipient's name and a link to the object. The recipient may be a kernel object. This approach allows to build an extensive network of large data transfer and processing.

— **Implementer.** Their mission — to receive packets, extract data, send them to perform plug-ins and take tags with data. Via implementer, by the use of jScadaAPI, can be working with databases, organizing input — output, as well as organizing network devices. Packets can be directly transmitted from connected external modules to the dispatcher through the so-called listener PacketListener. This interface, methods that are implemented in the dispatcher, and the link is stored in the plug-in. Thus, the dispatcher signed for data reception and transmission module. This transfer occurs when the module automatically generates or receives data from the sources and packages them in a package. When such transfer is not known nor the packet but knowing the name of the tag and the sender, trace for the logical connections necessary package.

— **The event controller**.is a timer that initiates the time of requests for the transfer of packets.

— **The management console.** Object which manages the system. Management Console receives user requests, processes them, packs and bags in to the dispatcher. A query can be designed to provide information about the system, obtaining the connected list, their data request to stop or start objects. With the further development of the project is expected to expand the functionality available through the Management Console.

Implementer and plug-ins interact via the application programming interface developed jScadaAPI. jScadaAPI contains the necessary classes, interfaces, and tools for quickly creating new modules. Parents of all new modules is the class Basis.java, containing the tag table data, methods of work with a table, a reference to the listener, and how to work with it. Inherits Bases.java RTU.java DataBase.java and can also be used to create new modules. Class-based RTU implemented data acquisition modules with anemometer, temperature sensor DS18S20 and PLC. In this case, the data exchange between the TC and the database server using sockets, and the underlying data of the TC-PLC is the protocol ModBus.

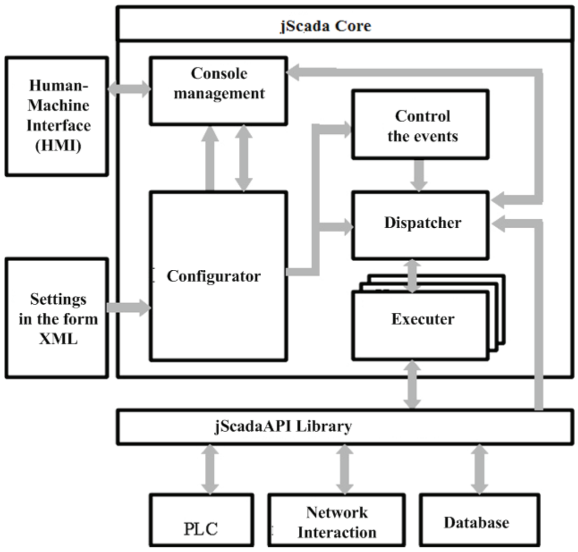

Figure 2. — The architecture of the subsystem data from the TK to the remote database server

The data structure and algorithmic software monitoring system

The collected data is stored in a database server running on the DBMS MySQL. The basis of the database table to store up Seconds, minute, hourly and monthly readings. They are based on the principle of building the replacement storage moments reading in absolute terms, the number of intervals from the start of the system, the duration of the intervals multiple of a fixed duration of the measure of the corresponding table [11, p.48–50]. All samples are stored in tables in a normalized integer values, calculated as Yi = (Xi + Xo)/k, where Xo — initial offset of reference to avoid negative values, and k — coefficient numerically equal to the minimum value of the quantity of distinguishable monitored parameter. Information on these factors, the location and type of sensors recorded data is stored in separate tables of properties of channels. To further seal the transformed data samples are recorded in the corresponding tables are not regularly, but only at times when the observed data are outside the boundaries of the segment, the opening angle is given by the E-layer model [12, p. 69–81]. The described approach allowed with a minimum computational effort to provide compression of the stored information is almost an order of magnitude without compromising its pragmatic value. The use of band approach allowed also to simplify extrapolation algorithms and to improve the reliability of identifying and forecasting of emergency situations [13, p. 72–74].

User Interface

Users of the system can follow the observed processes in real time via any web-browser from any device. Examples of information available to them are shown in Figures 3 and 4. For process visualization system offers two options based on AJAX and Flash technology as Flash — the technology in mobile devices is limited, though, provides great functionality.

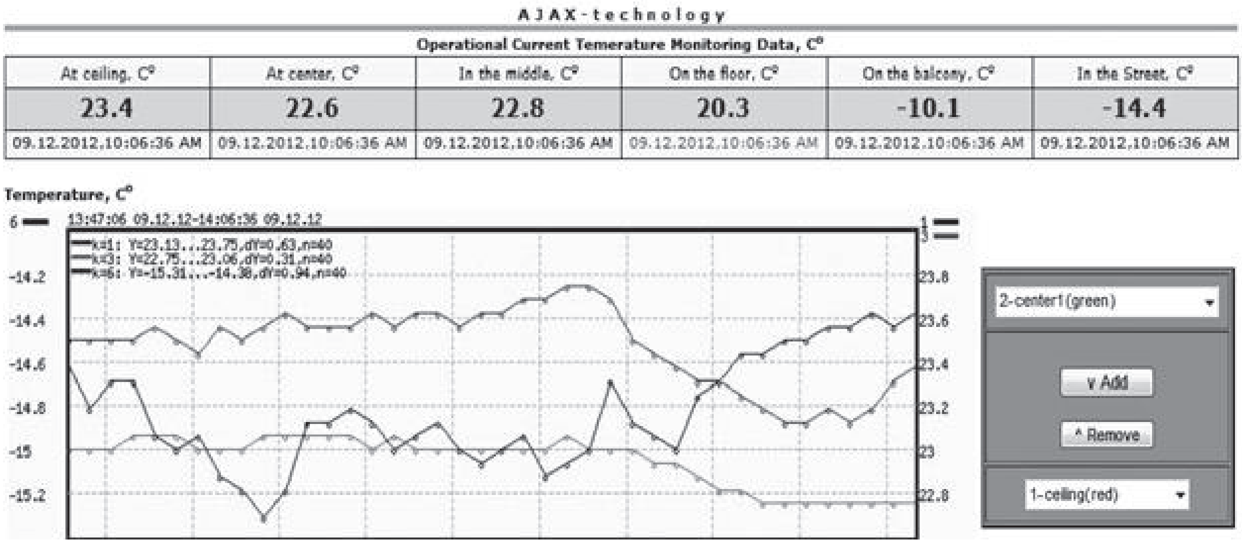

Figure 3. Graphical display for results of the monitoring system

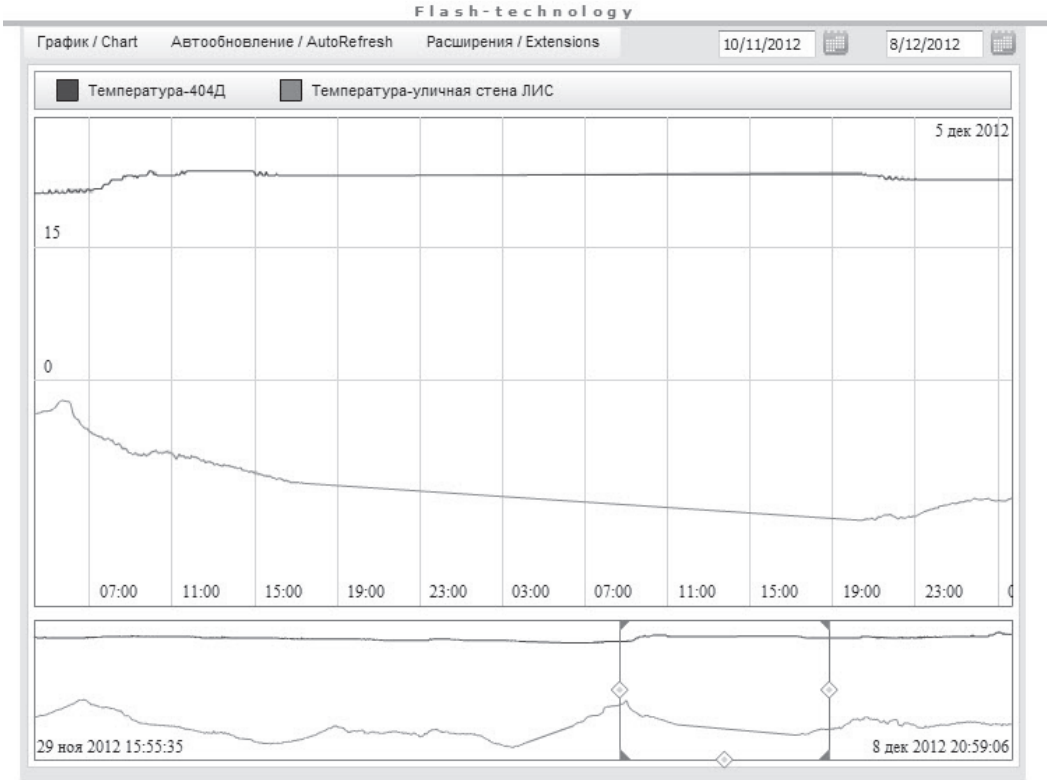

Figure 4. Flash-technology graphics

The results of implementation

The pilot project of the system has been implemented and tested in the university campus AltSTU (access to data available from the site http://abc.altstu.ru), which, along with meteorological parameters provides real-time monitoring of processes related to the consumption of energy resources. During the experiment, data were collected in the two buildings of the University for more than two years, providing collection and storage of such variables as temperature, pressure, humidity, speed of the air mass flow rate, heat flow and temperature of the coolant at the inlet and outlet of calculator. The time resolution of temperature channels is 30 s, which was enough to observe even the fastest processes in the atmosphere. In the future, further work will be work on a more compact storage and improvement and replacement algorithms of extrapolation.

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