Information-Analytical Systems of Thermo-Power Engineering

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Abstract. One of the main activities of the Institute of Automation and Control Processes FEB RAS is development, implementation and support (together with the service company LLC "Infovira") of information and analytical monitoring for both heat-and-power engineering objects (HPEO): thermo-power generation companies and consumers in the Russian Far East. The report highlights recent developments in this direction.

Keywords: information-analytical system, heat-and-power engineering objects, data acquisition, database system, metering devices (heat meters).

1 Introduction

In 2000, information-analytical system (IAS) "SONA" [1] was completed and since then was applied used for monitoring and management of thermo-energy (including thermo energy meters) by Administration of Vladivostok on the objects of education.

Since 2001, IAS equipped the boiler room of All-Russian Children's Center "Ocean" for monitoring and analysis of operation modes of heat sources "ISMA-ocean" [2].

The intensive applications of SCADA-systems enabled new development of IAS "AIST" [3] for heat sources, implementing function of the technological process monitoring using SCADA system Trace Mode 5, enriched by functions of retrospective data analysis. Requirement of analysis caused design of special subsystem with totally redesigned data structures and development of new processing modules for data visualization. System "AIST" designed and implemented in 2005 and operates in the boilers "Course" and "Southern", (both city of Arseniev). Further, in 2006, step-wise development of IAS with similar functions took place for boiler LLC Teploenergo "Bolshoi Kamen".

Well-known model of hydraulic and thermal systems are based on parameters reflected in the project documentation. However, using these relationships for analysis of functioning might be not possible due to difference between project and reality caused by the deviation from the project specifications during construction, aging of the object. That is why in vast majority of cases real information taken from measurement of the object becomes crucial and therefore essential to define technical

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state of the object and real dependencies, taking into account the actual technical state of the object. This information becomes useful for various real analysis. While volume of information is significant statistical methods including regression might be used. These methods became a foundation of information-analytical system "Scooter"

2 IAS "Scooter"

Stages of development associated with the introduction of a new technologies and measuring equipment. Monitoring functions in the system are implemented using SCADA platform Trace Mode 6 with built-in data analysis.

The next step in the development of this direction is associated with the new platform [4] (the universal framework) for creating systems to analyze modes of operation of HPEO.

The main pursued goals were:

- framework has to contain a database [5] and a reasonably complete set of software tools to analyze operations (using proposed database) and
- to allow efficient, with minimum time overheads assembling the system of analysis for specific applications.

The finalized version of the IAS Industrial "Scooter", was completed in 2006, mostly corresponding the mentioned above requirements. Figure 1 presents the structure of the standard IAS.

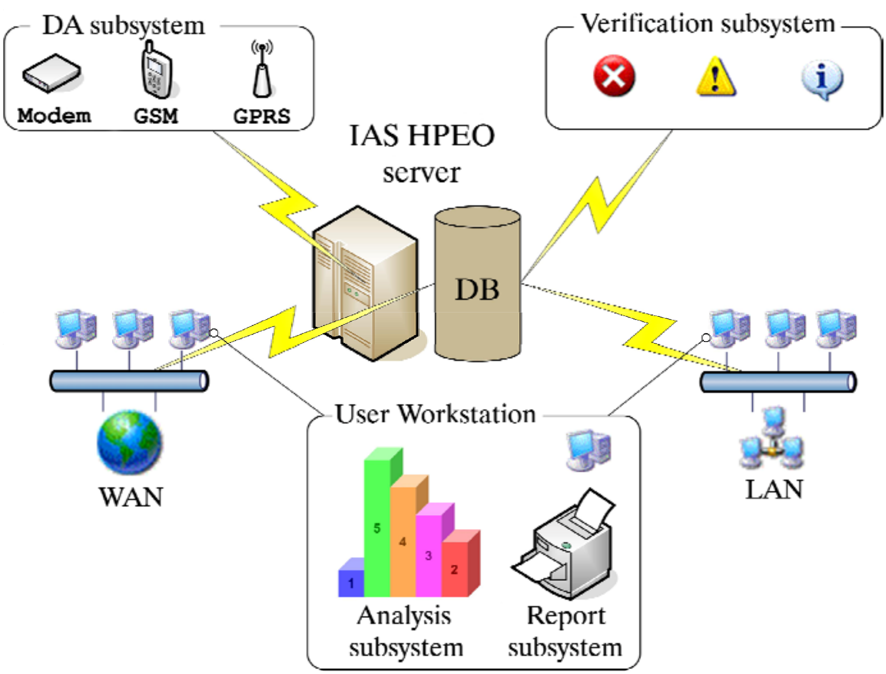

Fig. 1 Structure of the IAS

The information base of the system uses results of measurements of HPEO, as a result of the monitoring process using SCADA-system (mainly for heat sources), or includes application of archived data previously accumulated from heat meters (mainly for the objects of consuming heat).

The system includes a set of independent software modules that focused on the required applications and performed special functions required.

The main modules of the system are: "Data Acquisition", "Graphics", "Tables", "Reports", "Temperature schedule", "Heat Mode", "Recommendations", "Defects", "Diagrams", "Dependencies", "Configurator". Independent modules are interconnected by a data structure (which may be edited, recorded, accumulated and used by different modules). Data structure is stored one database, supported by *Windows* protocols formats of standard data exchange. The system implements a client-server architecture, using single database, accessible for client applications (modules) through a local area data network with TCP / IP protocol stack.

Modules of the system can be used autonomously (with its local copy of the database), for example, using aggregating module for manual data acquisition, followed up by synchronization of data within data base.

Another example of the use of separate databases is collecting of data from metering devices in a regional data accumulation centers (for example, through cellular links), transmission and synchronization of data in the overall data center for high-speed lines (TCP / IP). [4] presents the functionality of the main modules of the system.

2.1 Data Acquisition

The primary objective of IAS is to obtain the results of measuring basic parameters of operation of HPEO. This task consists of collection of archived data from metering devices (heat meters), the primary processing and storing in the database of measurement results, including retrospective ability to retrieve and use information. The list of devices supported by the system includes a set of heat meters, widespread in use. Other types of meters can be added by writing the appropriate driver.

The module supports different modes:

- Direct poll;
- Manual survey modem
- Automatic dial-up fee schedule;
- Distributed data acquisition via GSM / GPRS modems with the help of technology M2M;
- Monitoring current measurement results when connected metering devices via RS-232 converters in Ethernet.

Mode of direct check of parameters collects data from the heat meter archives. Mode is implemented using laptop for direct connected via a serial port (RS-232 or RS-485) or the optical head.

Manual poll allows connecting devices via a modem, using public switched telephone network (PSTN) or a network of mobile operators (GSM).

Automatic mode is used for the mass survey group of devices on a schedule of informational and analytical center. Communication equipment and communication channels are the same as the manual survey. The advantage of a distributed way of collecting data (GPRS) is the use of innovative hardware and software that allows to move from standard technology of switched access to the heat meter (CSD) at a certain time (scheduled) to asinc-driven data acquisition with a large number of heat meters without the need to increase the switching equipment at the DA server.

In addition, this method is more flexible, addressing the organization of data acquisition network and, significantly reducing communication costs.

For scheduling and management of large real scale of thermo-consuming heat infrastructures and for the possibility of connecting the heat meter to a local area network (LAN) or wide area network (WAN) a special adapter or interface cards, are required, allowing monitoring of the pseudo-real time and manipulate these objects from any point network through the Internet.

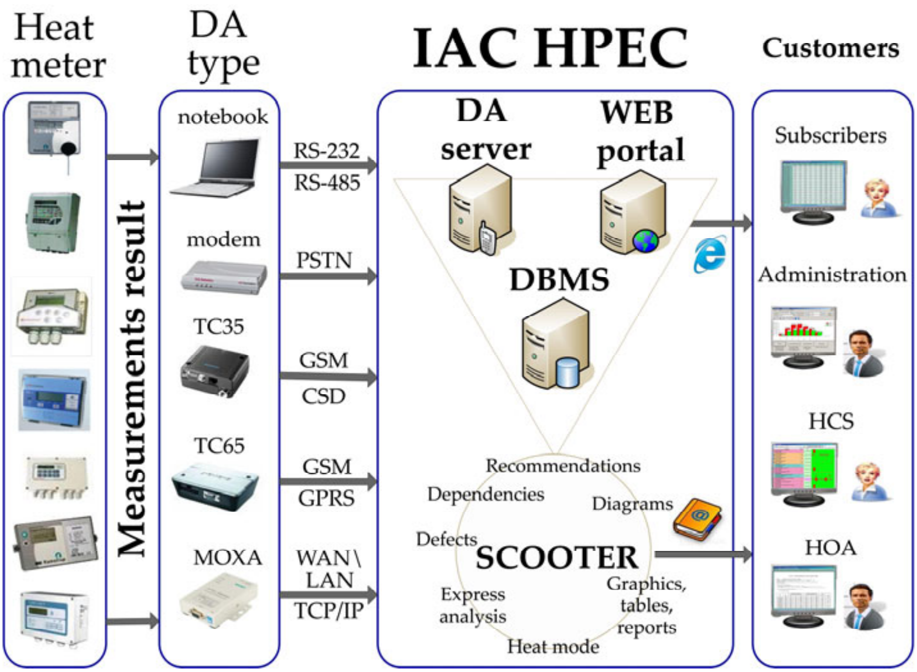

Fig. 2. Architecture of information-analytical center

Upon completion of reading data from the archives of the heat meter, the results of measurements are reduced to a unified structure and stored in the Database management system (DBMS) of thermal energy to heat facilities. Database process each item individually using service set static information (energy passport) and accumulated since the start of service retrospective information on the results of measurements. Currently, IAS "Scooter" services for more than five hundreds of consumers of thermal energy in Primorsky Krai, Russia. Among them individual subscribers, city administrations, housing and communal services (HCS), homeowners association (HOA).

In 2007-2009, IES "Scooter" adds on was performed by modules "Express-analysis" (verification of the results of measurements to determine their validity) and “Web-portal” (giving the user the results of measurements and data analysis in the Internet network). Below is a brief description of these modules.

2.2 Express-Analysis

To assess efficiency of the subsystem for data collection as an increasing number of serviced sites is impossible without the implementation of automated control and diagnostics at all stages of the process of data receiving: the connection with metering, reading of archive information, transfer data to server for accumulation, preliminary data processing and recording in the database.

Initially, the automatic collection of data provides journaling survey of storing a sequence of events occurring in the process of 24 hours date recording using substantial amount of meters. To display information from a journal of operation registration of thermal units a module plug-in "Express-analysis" [6] was developed. The module is displaying an operational data acquisition with heat meters for a group of objects heat supply for a given period of time.

Data acquisition also requires verification of data consistency and shows that it is important also to ensure adequate and reliable remote transmission of measurement results from the heat meters archives the database system. New data from metering devices need to be assessed in terms of reliability and validity of measurement results [7], as well as detection of abnormal situations on the thermal point and diagnosing defects measuring equipment [8].

Diagnostics tasks are performed by special module "Express-analysis”. On the basis of the developed methods and algorithms for diagnosis [9] created a subsystem of automatic verification of results. The inputs to the subsystem verification are the results of measurements coming from the heat meters and passport details of the thermal points: thermal load, temperature schedule, equipment specifications, the metrological characteristics of measuring tools and other information about the object.

The results of processing the input data after performing the verification process (the information about detected violations, deviations from the normal operation mode, the detected abnormal situations, etc.) are entered into the database. Accumulated diagnostic information is used later in other modules of IAS for the solution of various tasks: informing about the unreliability of data for a specific time interval, the recommendation to eliminate the defects on the thermal site, signaling the emergence of critical or emergency situations, etc.

Example of visualization of detected violations is shown in Fig. 3. Detailed information about discrepancies detected for a particular object can be accessed through the dialog box by clicking the appropriate cell in the table. To improve the perception of information and simplify analysis special filter was introduced that allows to display the relevant class of deviations.

Typically, the duration of violations shows the seriousness of the problem and the need for intervention. Using data from express analysis, maintenance engineer can quickly conduct a more thorough analysis of the situation and make a final decision on the causes of violations with the help of more powerful systems "Scooter". For example, estimation of the magnitude of error can be published for the allowable range, additionally changes of parameter over time can be presented as a graph or in tabular form using a system module "Graphs, Tables, Reports" [10].

Fig. 3. Visualization of diagnostic information

2.3 Web-Portal

The development of new technologies in the IT field makes periodically review the approaches of software development. Distributed systems became the most popular in recent years, due to ability to support remote operation via web-portals (using Internet, for example). This software works on web-server for information service providers, and users can view and access the information on the server anywhere in the world. In this connection there is need for a transition to a new platform for software development with a view to rapid and creating programs that run as a traditional way (on the user's computer) and on the web-server as a distributed system.

Clients web-portal have the opportunity to request data (collected, for example, with their own heat meters) from the central database of information service providers in the form of graphs, tables. In addition, it is possible to generate the report for the heat supply organization.

Modern web-technologies allow output data in the form of static (graphs, charts, tables) or in a dynamic, interactive format. In the latter case, the user, for example, using the mouse to perform certain actions: scale, move, hide unnecessary graphics, etc. Currently, the web-portal www.infovira.ru enables to access available dynamic graphics, tables and reports, having the core functionality as in the" Scooter " tool described above.

3 Implementation

The latest versions of IAS developed for the Radiopribor heating, Vladivostok (2008) and the MC Topolinaya Alley subscribers heating, Vladivostok (2010) are implemented with new functions of monitoring and analysis of process of control heating.

In 2006 there was a need in the development of IAS for the Radiopribor closed system of heating, Vladivostok (19 thermal units are installed on their meters and controls). In addition to traditional individual thermal units tasks of calculation and analysis were supplied by the customer other specific to the system object tasks: monitoring operating conditions (Fig. 4) with control of frequency and periods of reading of metering information, on request of the operation manager, analysis of cost balance and energy consumption for the whole factory, and its sectors, analysis of regulatory efficiency of thermal energy; control of butterfly valves with actuators on the thermal head node, determining the total heat consumption of the system.

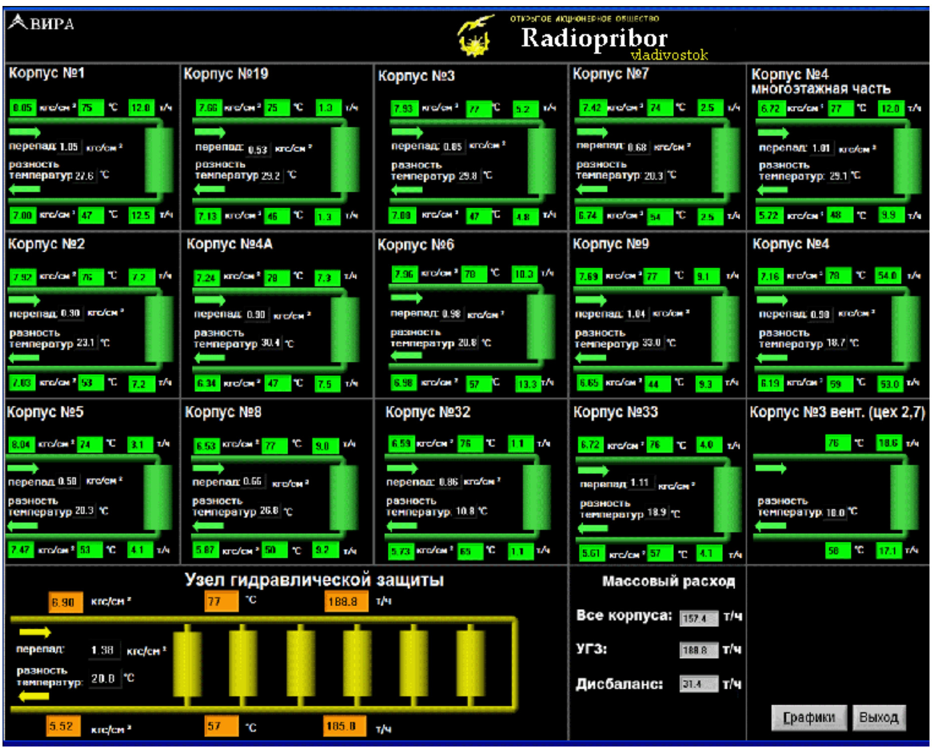

Fig. 4. The monitoring system of the Radiopribor heating

Valves are controlled electrically by AUMATIC AC 1.1. Made configuration of the control unit electrically improves regulation and de-risk hydraulic impact. For the organization of a remote control valve designed software and set up an individual communication channel with a control unit electrically independent from the existing data collection system with heat meters. Access to the control unit is performed using protocol MODBUS / RTU via converter ICP DAS RS232-RS485. The software allows monitoring the electric control unit and set the set point for opening / closing valves.

Recently, similar tasks of monitoring and analysis were initiated for the MC “Topolinaya alley" heating. Developed for this object IAS differs significantly from the previous in terms of implementation of the collection of measurement results. It also has a function of scheduling and remote management of the regulatory process for all thermal units of the system (Fig. 5)

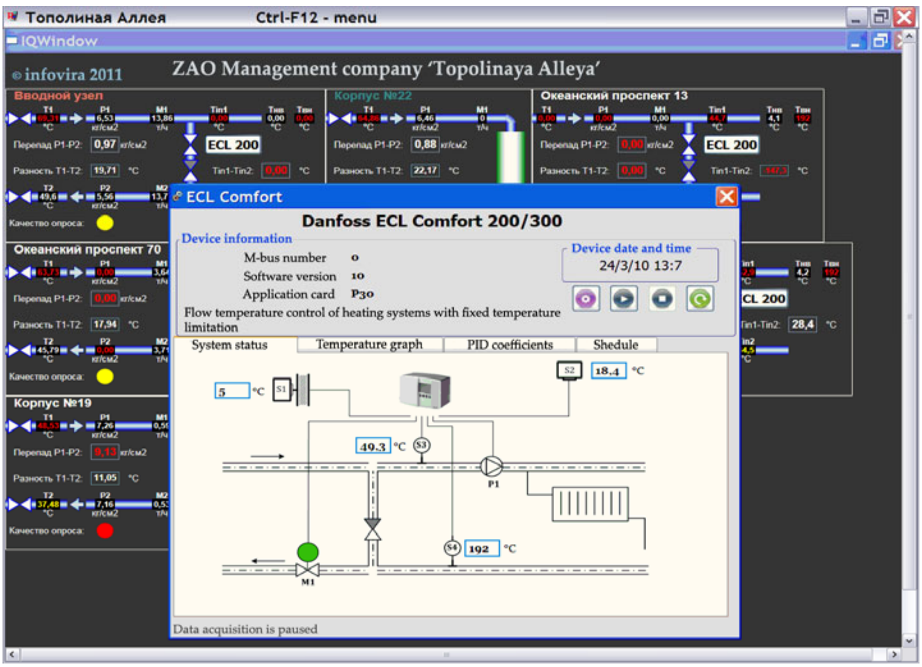

Fig. 5. The monitoring control system of the MC “Topolinaya alley" heating

The main effect of the introduction of emerging information and analytical systems defines new level of process control and monitoring of using of thermal resources: all supported by measuring equipment and a new generation of modern information technology.

Features of system ensure continuity and quality of heat supply, maintain optimal (energy efficient) operating conditions of objects, and achieve real economic effect and, consequently, control the growth of tariffs for heat and hot water.

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