Portable data collection terminal in the automated power consumption measurement system

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Abstract. Aim of efficiency increasing, automation process of electric energy data collection and processing is very important at present time. High cost of classic electric energy billing systems prevent from its mass application. Udmurtenenergo Branch of IDGC of Center and Volga Region developed electronic automated system called “Mobile Energy Billing” based on data collection terminals. System joins electronic components based on service-oriented architecture, WCF services. At present time all parts of Udmurtenenergo Branch electric network are connected to “Mobile Energy Billing” project. System capabilities are expanded due to flexible architecture.

1. Introduction

Control over electric energy consumption is very important at present time. Application of different Automated intellectual measuring systems of automated informative electric power accounting system solves a number of tasks, existing in case of manual data collection of electric energy consumption. Automation of data collection eliminates “human factor” from billing process, allowing getting exact information on electric energy consumption. Automation of data collection and processing reduces operation costs [1].

Prior to using Automated informative electric power accounting system it is necessary to complete a number of tasks: installation of measuring device bundled with PLC-modem, switches and GSM-gates installation, setting software to collect data and process it. Completion of all tasks to apply Automated informative electric power accounting system requires high financial expenses. High cost of such systems is a great issue for its application [2].

Application of Data Collection Terminals (DCT) used to automate the process of data collection for electric energy billing is alternative to Automated informative electric power accounting system. Development and application of electronic information analytic system of electric energy billing is performed by Udmurtenenergo Branch of IDGC of Center and Volga Region (referred to as Udmurtenenergo) in cooperation with Kalashnikov Izhevsk State Technical University.

The purpose of development of an information system is to Optimize the business processes of the formation of productive electricity supply by reducing operating costs labor production personnel,
increasing data quality and speed of their processing, with the use of geo information systems and DCT.

2. Task description
Mobile system for electric energy billing based on Data Collection Terminals solves a number of tasks:
- Paper workflow reduction.
- Elimination of human Inspector errors of data collection and its registration in database.
- Reduction of data collection time.
- Data collection and transfer in real time.
- Data receiving from DCT.
- DCT workflow control.
- Control over data access from remote location.
- Estimation of staff personal productivity based on operation data of the system.

“Mobile Energy Billing” is the software installed in DCT should perform:
- Collection and storage of data from measurement devices.
- Data transfer to Regional Information Center (RIC) based on GSM Technologies.
- Location of Measurement device based on GPS.
- Service control over energy consumption.
- Mobile reports printing based on Wi-Fi technology.

Information system of Regional Information Center should comply with:
- DCT operation.
- Analytic processing of data transferred from DCT.
- Monitoring of Electric energy consumption based on GIS module (geo information system).
- Management solution development to increase efficiency of electric energy consumption.

Equipment and technologies of automated informative electric power accounting system is shown on Figure 1.

![Equipment and technologies of automated informative electric power accounting system.](image)

Figure 1. Equipment and technologies of automated informative electric power accounting system.

3. Theory
Prior to the introduction of DCT, the business process is a "tool check" began with the fact that the controller from the group of electricity metering produces the search for the necessary user and
relevant information about metering device (date of verification, the seals, the coefficients of the transformation, the names and types of instruments) in the database of the branch, and then prints the act of conducting instrumental inspections. Further advances to the customer and carries out the relevant work, which involves the process.

For data taken with transformers and metering device manually calculated and taken into account the consumed power. Calculated instrument error. If the error is within acceptable limits, then the conclusion of the suitability of the metering device.

All records are maintained manually, which implies that mistakes and errors (the human factor). The process takes about 20-30 minutes per user, if there are errors or unexplained results (too large values), then this time can take about 50-60 minutes. At the end of the day all statements are logged and dealt technician RES. Replication to a Central database every 10 days. Further sending data in OAO Energosbyt Plus occurs 2-3 times per month.

With the exception of the intermediate step — the registration act — a test reference on the performed inspection/replacement/installation PU, decreases the probability of an erroneous entry operator data in the database. This increases the speed of all operations.

Also DCT is a basic photo/video camera for the implementation of fixation of readings, revealed the facts of non-contracted/non-contracted consumption of electric power; a GPS receiver to monitor the movements of the controllers. Based on the data obtained with the GPS receiver, you can schedule crawls of consumers for the efficient operation of the controllers.

After receipt of the information in the database, with GIS you can display all the information according to the data obtained from DCT and place them on the map. For each indication you can see (value, time of removal, the data consumer controller who directed the reading, etc.). The continued collection coordinates with a GPS receiver gives you the ability to overlay routes and closely monitor the work of the controller. All data remains in the database, which gives the opportunity to use the route history for any date and display on the map.

Data can be collected from any type of measurement device, so there is no additional expenses for high cost equipment. Mobile system concept is shown on Figure 2.

![Figure 2. Mobile system concept.](image)

DCT – high technology electronic device, mobile computer made in dust and moisture protected case (protection class IP54 and higher). Terminal includes:
- Built in barcode scanner.
- Wireless interfaces (Bluetooth, Wi-Fi).
- GPRS/GSM modules.
- GPS receiver.
- Base terminal software.

Data collection takes place on consumer’s side. While first visit data collection department inspector finds consumer in DCT Database (referred to as DB) by input consumer data such as account number, address, measurement device code, barcode etc. Terminal DB contains information over the measurement device type, last inspection date and previous measurement data. Next, inspector checks all data, inputs measurement data for present date, sets unique barcode, puts barcode on measurement device case.

In case consumer is not found in DB or in case of non–authorized independent wire connection beyond the balance border (consumption without contract) takes place inspector should draw up a report. In case of electric energy theft inspector should draw up a non-registered consumption report using data from DB and mobile printer. Changes of DCT DB data are transferred to DB of a Branch through GPRS channel or through specially designed interface cable in the end of inspector working day. While next visit inspector reads barcode set on measurement device using barcode scanner of DCT first, then checks all data within DB and inputs changes if necessary.

First terminal reads measuring device barcode, then measurement device data are put into DCT. DCT estimates data are correct comparing it with previous data input. Data are transferred to Udmurtenergo RIC by GSM connection. Besides, terminal transfers to RIC its location data which is then used by GIS module (Geo Information system) to show it on the map.

Data send by terminal are received by DCT control module on the RIC side which commands and tasks are accepted by terminals. Here system and operational data are processed. Data processed are stored in database (DB). Further processing is executed by other modules of system, such as GIS-module, intellectual data processing modules (image recognition, prediction). Each module executes its own task.

Image recognition task is carried out by intellectual processing module. Facing part image of measuring device is the object to recognize which contains following data:
- Measuring device readings.
- Measuring device model (type).
- Factory number.
- Barcode.
- Seals of Electric Energy Supplier.

Image recognition allows to compare data put by inspector with recognition module results, thus verify data in integrated processing center [3].

Data collected can be shown on the map by GIS module. Value of electric energy consumption, date and time of readings, consumer data, inspector data can be restored for each reading. Frequent collection of GPS location data allows making routes and control inspector job in detail. All the data is stored in DB allowing to use routes history at any period of time and show it on the map.

Modules of system are connected directly to database. Access to the data stored in database is carried out by procedures and functions specially designed in each module. Over time, databases size increases, their architecture changes which require existing methods change of each module and decrease the efficiency of developers.

Realization of single way to operate with database server significantly simplifies developer task. This way includes system modules universal rules development allowing interaction with databases. These rules can be developed in additionally designed module based on services. Thus system has service-oriented architecture (SOA) [4].
Applying SOA gives following advantages to software developers:

- Elimination of the same software program code usage in different system modules.
- Applying WCF services (configuration allowing access to WCF service functions) for modules, developed in different platforms.
- Scalability increase of software developed by combining existing services in new solutions.
- Applying of functionality already been designed on the side of a service.

Software service development is based on WCF technology designed to create distributed information systems. WCF technology is the program framework being a part of the .NET platform. WCF is used for data exchange between applications. Configuration of technology allows creation of flexible operation between system modules [5].

Clients, system modules apply different WCF service functions by multiple endpoints created. Client sending message in definite format to endpoints is able to use service functions. Contract between client and service defines format of the message send by client. After message has been delivered to endpoint, service starts operation sending its result to client (Figure 3).

![Figure 3. Client and WCF service interaction.](image)

4. Results
Mobile Energy Billing Project has become a winner of two Russian contests [6]. At present time all 27 regions of Udmurtenergo brunch electric network are connected to Mobile Energy Billing Project. Developed Information system allows to process analyze and store data transferred from terminals with minimum investments [2].

Application of WCF services differentiates rights and responsibilities for system modules. Demand for system functionality increases over time and new services can be developed to solve a definite task. This application can help to increase system functionality with minimum time lost.

Implemented and planned tasks:

- Data Collection and transmission in real time (subject to availability of communication channels) is successfully implemented.
- The Daily formation of the productive supply of electric power was successfully implemented.
- Dynamic management of production process – in the process of implementation.
- Automated data validation is successfully implemented.
- Reducing the time of receipt of the data object to an operator from several days to several minutes – is successfully implemented.
- Geographic information the binding of objects of customers and network organization, data access control on the ground – has been successfully implemented.
- Installation of the rules execution of works with an automated control performance – in the process of implementation.
• Execution of pending queries and processes – planned implementation.
• Performance Evaluation of the personnel according to operational data of the system – is successfully implemented.
• A system of prompt notification of emergency situations – in the process of implementation.
• Energy Prediction using artificial neural networks – planned implementation.
• Establishment of a monitoring and management process being – implemented at the moment.

The expected results from the implementation of the program complex are:

• A significant reduction in operating costs for the readings of meters.
• Automation of process of removal of indications of conducting instrumental inspections and other actions with the electricity metering devices, as well as with the data consumer.
• Reducing the number of operator errors when introducing data.
• A significant decrease in the volume of paperwork, or complete failure of clearance of works on paper.
• Visualization of spatial data.
• Improving the reliability of the accounting system as a whole.
• Reduced influence of human factor on the functioning of the system.

5. Conclusions
Programs developers are confident that complete implementation of system allows to eliminate divisions with electric energy supplier. Objective and operation data transfer to database is the main functions of the project. In case of success startup of Mobile Energy Billing project it will be replicated in other regional branches of IDGC of Center and Volga Region.

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