Problems and Prospects of Billing Systems in the Housing and Utilities Sector of Russia

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Abstract. The article deals with the problems and prospects of using billing systems on SaaS (software as a service) software complex in the housing and utilities sector and civil engineering. As consumers are considered both individuals and construction companies. The construction also uses utilities. These utilities also need to be paid. Currently, “thin billing” is predominantly used in Russia, where each service provider applies its own metering system. The supplier independently performs calculations, and then transfers the information to the Financial Settlement Center in the established format, where after a billing document is drawn up and sent to the consumer of utilities. This format has an advantage only for suppliers, as they can change the tariff corridor and set flexible conditions. From the point of view of the consumer, such a format does not allow tracing all settlement schemes. And in the event of failures or technical errors, the consumer will have to find out the reasons in all instances as before. In order to eliminate bureaucratic processes, it is proposed to implement turnkey billing systems in a “one window” format, where all operations of the housing and utilities industry are consolidated into one platform. Despite proven reliability, billing systems in Russia require large financial investments to ensure complete information security.

1. Introduction

The billing system in the housing and utilities sector and civil engineering is software that is capable of supporting and managing business processes without direct human involvement. Before the advent of automated computing systems, all complex calculations were performed manually by operators and cashiers using a pen, a sheet of paper, and a calculator. It often happens, and it’s not surprising that there were mistakes in the utility bills. The situation was changed by box billing systems, where all the calculations were performed by computers based on the submitted information from consumers and established tariffs. However, it was also difficult to call such systems to be fully automated, since human involvement was still required [1, 2].

In the realities of the tempo of modern living, such systems, having no time to be widely deployed, became outdated. Despite the fact that the information systems market is large, information products related to the housing and utilities sector have a very scanty range. The most popular information systems are SAPUtilities (SAPIS - U) and Oracle Utilities Customer Care & Billing (CC & B), and they are foreign products. Our most well-known modern domestic products are the operational information complex SBYT and the settlement and analytical system Billing-Online.
The first utility settlement centres (SC) appeared in Russia in the mid-90s, but there is no unified name of these enterprises so far. In different cities one can find the names - Settlement Cener, Information and Settlement Center, Settlement and Cash Center, etc. At the same time, regardless of the name, all these organizations perform the same function — drawing up and invoicing housing and utility bills. And they all use special software, either developed by them or purchased, since utility billing is technically impossible without a billing system [3].

The widespread promotion of the Internet and the development of information technology and SaaS (software as a service) software have replaced box systems. Their advantage mainly lies in the lack of permanent maintenance. All the equipment is in the possession of a developer who guarantees 100% uptime during the entire lease term of the software shell. The access to tenants is provided through online services. The system calculates the payment for housing and utilities services, receives payment data, as well as issues receipts by means of the web interface. Due to billing, the tenants do not wonder how and why they charged the indicated amount: the calculation is transparent. Calculations for each personal account are made automatically, the data can be directly received from metering devices. Of course, provided that the metering devices have the corresponding digital platforms of the calculators, and the metrological parameters of the dynamic range of the flow meters are broad and commercial metering does not stop every time, as it was before.

The billing systems on SaaS software complex are flexible and productive. The developer is constantly improving his product, adding new capacity, which allows working with large streams of data and taking into account historical data. Utility companies do not require special high-performance computers and servers, which require strict maintenance of temperature and humidity conditions for uninterrupted operation, as well as constant RAID (Redundant Array of Independent Disks) - copying and duplication of power supplies [6-10].

Another advantage of billing systems on SaaS software is the constant access of consumers of housing and utilities services to their personal accounts. The personal account functionality of a typical automated system includes a range of options from online payment to statistical archive data analysis and payment receipts generation [3].

Some systems may include another set of functionality. The most important thing is that both representatives of the utility companies and ordinary consumers, as well as the representatives of municipalities can work on the same platform. Under the conditions of proper coordination of work, some bureaucratic procedures can really be avoided and speed up the time for consideration of applications and discounts on housing and utilities services for pensioners and people with disabilities. Nowadays, in Russia, far from all the regions of our country use billing systems and modern digital technologies based on SaaS software complex. However, according to the plan for the development of the digital economy until 2025, all the regions will be forced to switch to modern information technologies. Experts estimate such a transition at 4.1–8.9 trillion rubles of increasing the country’s GDP (Gross Domestic Product) [5].

The purpose of this work is to analyze the existing information systems of power supply companies and propose an optimal scheme for the implementation or optimization of the billing system.

2. Materials and methods
Consider an example of the implementation of subscriber accounting and billing systems based on Oracle Utilities Customer Care and Billing software (hereinafter - CC&B). CC&B software consists of the main characteristics of the data model of the system designed to conduct transactions with entities, services and financial transactions.

The application kernel provides the main administration spreadsheet in the system. CC & B is a fully managed spreadsheet application that allows each customer to customize the rules and behavior of the system. Several distinctive features of the system and features of the administration parameters are presented below:
Multiservice can invoice for an unlimited number of services - not only for utilities of different standards (electricity, gas, water, sewage, garbage collection, etc.), but also bills for third parties and other services such as insurance, rent or sale of equipment and devices. The services that will be offered depend on how the system is configured, and new services can be offered at any time without resorting to reprogramming.

Multi-language software - user interface configuration is available, which allows displaying information in the language selected by the operator. Thus, two users who are nearby and are using the same system, can see different languages in all menus, pages and tags descriptions, as well as in error or warning messages in the process of system using [6,7]. The software can generate client bills and letters for clients in the language that the client selects. Such information as line-by-line bill description, bill notification, and other subject-specific tags can be entered in different languages.

Multiregional software supports multiple jurisdictions, allowing the definition of different business rules for each jurisdiction, including different products, prices and tariffs, taxes, billing and payment options, market rules, as well as loan and charging rules. CC&B also supports aggregation of cross jurisdiction and taxes.

Multicurrency covers all options of currencies and prices related to the current monetary system. The user interface displays the currency symbol, code or description in the format preferred by the operator, as specified in the currency data management spreadsheet.

According to the classical goal tree of the utility companies, the introduction of an automated subscriber accounting and billing system leads to cost saving, which, in its turn, leads to the achievement of the highest level of profit for the company. This fact proves the expediency of introducing or optimizing the accounting and billing system for power supply and utility companies [8, 9]. Here is a description of the information architecture at various abstraction levels, when the company implements the system:

Conceptual level. Data is exchanged between departments and external organizations at the conceptual level of an information architecture in order to support a business process:
- Accounting Department;
- Economic Department;
- External System Relations and Electricity Transport Monitoring Department;
- Monitoring and Energy Sales Analysis Department;
- Network organizations.

Logical level. The logic layer includes all the information about the available data and provides interprocess communication. The logical diagram of connections in the V-model form is presented in figure 1.

![Figure 1. V-model of subscriber accounting and billing system](image-url)
If before the introduction of this model for one subscriber, there were several applications including the subject, then in case of introduction of the information system, everything is in a single application. There was created a common data repository, a common database.

The software under consideration can be operated with the following types of service providers:

- Energy resources (energy suppliers, retail companies)
- Measurement services (measurement service providers and measurement service agents)
- Taking readings from metering devices (measurement data management agencies and service providers for taking readings from metering devices)
- Billing agents (maintain the relationship between the service provider, the subject and the company, ensuring that all financial transactions are related to the correct service provider).

The main entities of the system are:

- Subject. This is the subscriber, the information contained in this subject such demographic data as Name, Postal address, Phone numbers, E-mail address.
- Personal accounts are objects at the level of which the process of charging and billing for services is performed. At least one personal account is created for each subject. There is a possibility to have several personal accounts. As one subject can be both a consumer of the supplied electricity, and a grid organization.
- SAS (service agreement section) for electricity - SAS is an agreement between the service company and the subscriber. SAS contains conditions that determine how the system calculates charges for certain services provided to the subscriber. SAS acts like an agreement.
- Service object. The service object in the system is the location for which the power supply service is provided. This object contains such data as the address, the tax jurisdiction characteristics, as well as the description of non-standard situations that are possible at the property.
- Metering points are the specific location for the services provision at the facility. The metering point contains data describing the type of service, as well as ways to measure its parameters.

Physical level. Let’s visualize the main database spreadsheets:

- CI_ACCT  – personal account;
- CI_ADJ – adjustment;
- CI_ADJ_CALC_LN – amount of adjustment;
- CI_BILL – service bill;
- CI_BSEG – service bill segment;
- CI_MR – meter readings;
- CI_MTR – metering device;
- CI_MTR_CONFIG – metering device configuration;
- CI_MTR_TYPE – metering device type;
- CI_PAY_SEG – payment segment;
- CI_PER – subject;
- CI_PREM – service object;
- CI_REG – metering device register;
- CI_REG_READ – metering device register readings;
- CI_SA – SAS;
- CI_SA_SP – metering points related to SAS.

Security and protection. CC&B Security & Protection integrates users into groups with a certain access level to the system. Users can belong to a group that has extended access rights, they automatically receive the highest degree of access in this case that only can be offered to user groups for a particular service.

The system keeps security and protection at the following levels:

Action level allows data protection administrators to determine which actions user groups can perform with respect to each transaction;
Field level – uses system security spreadsheets to define and to enter field-level permissions for specific user groups and transactions. Users are assigned codes that are tracked when a user enters a transaction. The software automatically rejects invalid updates for certain fields.

Account level – restricts access to certain personal accounts. This is very useful when protecting important personal accounts from accidental updates by unauthorized users and in convergent billing applications where companies want to restrict access to third parties for which they provide billing services. This protection level is in addition to other security levels.

The software complex operates and manages all types of interval data, including raw consumption data, aggregated load data, standard load profiles, tariffs and other factors. There is a set of functionality for processing this data, including validation, modification and evaluation (VME), differentiation, aggregation, display of usage time and interval billing.

Data management Managing meter readings data offers options for uploading or writing interval data to the system. The raw time data can be directly linked to the Metering Point via interval data channels. Interval data storage can store many forms of interval data, and with any interval lengths. This includes raw and aggregated data, consumption values, standard load profiles, charts showing consumption time, tariffs, agreement terms and other interval factors. Multiple data versions are supported at each data storage level. This allows you to upload new or corrected data without damaging existing data. A history of data uploading in support of comparison with parameters and calculations of the previous period is supported. Validation, modification and evaluation allows you to perform calculations and manage interval data, which allows you to perform many functions. Validation, modification and evaluation (VME) processes can be performed with raw data in order to prepare it for aggregation or other calculations. The aggregation processes summarize data streams of the data link layer at the agreement level. Differentiation algorithms provide such calculation parameters as measurement unit conversion, time period conversion, and other settings carried out in accordance with the agreement requirements specific to a given subject before the moment of tariff application. Tariff zone parameters can be applied to interval data in order to reduce the number of data entry points to a more convenient control set of accounting intervals. As soon as data becomes available, the software complex allows processing interval data. Thus, activities similar to the summation of the raw data of the data link layer and the application of the chart showing the tariff zones, to the summed results are carried out during the month as data becomes available, reducing the system load when drawing actual bills. The software complex supports time zones and daylight saving time. Interval data spreadsheets, including interval parameters, interval values and interval data reflecting the tariff zone, store information in accordance with the local time of the main time zone.

Interval billing. Interval billing in the system is carried out after the interval data processing and is associated with the appropriate type of Service Agreement. Aggregation and differentiation of interval data is the data collection from multiple sources into a single stream. This usually occurs when there is one Service Agreement for multiple Metering Points or metering devices. The data, which is once aggregated and related to the Service Agreement, can be used directly or the additional “differentiation” processes can be applied. Characteristics and functionality, Differentiation algorithms base their calculations on data from other profiles, chart showing time of use, registers, account parameters, etc. The result of differentiation - “derived data” is usually supported in the context of the agreement, and becomes input data for a set of the calculated algorithms. The software complex records and tracks modifications to this data, and the algorithms provided by the base can detect any such changes, triggering the re-differentiation process. We draw your attention to the fact that differentiation may depend on other system data, the modifications of which are not monitored in the same way. In these cases, the derived data, however, can be recalculated manually, initiating a differentiation process [9-11].

Tariff zone charts showing consumption periods, which group identical intervals and classify them into specific periods, usually according to a tariff plan are required for the billing process on the basis of interval data. For example, a typical monthly period of 720 hours can be displayed as a specific number of periods showing tariff zones, such as peak, off-peak and intermediate ones. There are no
restrictions on the number of types of zones showing consumption intervals. The software complex provides a toolkit that helps users upload data, install standard reusable templates, and generate charts showing tariff zones. Algorithms for pricing and billing modules use a user-defined chart showing consumption time for their current interval data. The use of the chart contributes to the effective creation of a smaller number of calculated values based on the consumption time. These values can be estimated and included into the bill in any form using the Charges Calculation Module.

The charges calculation based on interval data provides storage of information related to prices based on both interval data and tariff zones data. This means that when calculating charges, the system is able to apply prices in a format appropriate to the calculated data (for example, tariffs based on a tariff zone, or tariffs based on 10-minute intervals, as applied to consumption values over a 10-minute interval). Numerous tariffs based on interval data can be stored and modified, for example, for different tariff zones or subscriber indices. Tariffs based on interval data also support versioning [12].

3. Results and discussions

A conceptual diagram of a technical architecture is presented in figure 2-3. The network infrastructure is planned with the provision of communication channels duplication both between the components of the Data Processing Center (DPC) and communication channels with remote offices.

![Figure 2. Technical architecture of the main data center CC&B](image)

![Figure 3. Technical architecture of the local computer center CC&B](image)

The communication channels between the DPC software and hardware complex with the local network of the general use of the power supply company should ensure the transfer rate of 1 Gbps.
Channels for the organization of a Wide-Area Network, which is a geographically distributed network of the organization, provided by the provider for the communication of the DPC hardware and software complex with geographically dispersed platforms should ensure the transfer rate of:

- 100 Mbps for the DPC hardware and software complex
- The minimum bandwidth requirements of the local network for the end-user connections, which are: 32 kbps per a workstation, but not less than 512 kbps per a division, provided that there is no other activity in the considered network section, except for those related to the operation of Oracle CC&B. If the considered network section is used by other services and applications, then it is necessary to calculate the required bandwidth taking into account the requirements of all such services and applications as well.

Network equipment designed to provide communication channels between DPC components: DBMS (database management system) servers, applications, administrative server, storage system, load balancing servers, active network equipment should ensure the transfer rate of 1 Gbps.

A Storage Area Network (SAN) ensuring data transfer rate of at least 4 Gbps should be arranged between the database level servers, the administrative server, the storage server, the development servers and the storage system.

In order to optimize metering and billing business processes, graphical models are presented, as well as the data and connections stream is shown (figure 4-5). IDEF0 technologies were used to model business processes.

![Figure 4. General view of the process of subscriber accounting and billing](image)

The complexity of implementing fully automated billing systems lies in the actions and interests of all participants in the housing and utilities sector. On the one hand, they are suppliers of utility services and so-called management companies, on the other hand, they act as Settlement Centers. In fact, we are talking about the outsourcing of the charging function: calculating amounts due for payment on the basis of tariff rates, standards or actual consumption figures and consumer databases.

It should be noted that SCs (settlement centre) assume the function of charging far from everywhere, as “thin billing” is very common, when the supplier performs the calculations on its own, and then transmits the information to the SC in the prescribed format. Such a scheme is now used in Moscow and Novosibirsk. There are two problems with “thin billing”: The first one is organizational and technical problem, the second one is a system-wide problem, creating a whole chain of social and economic problems [10, 11].

The organizational and technical problem is the need to harmonize data formats. “Thin billing” means that each supplier applies its own metering system. Naturally, he can change it at his discretion.
But when operating through any SC, dozens or even hundreds of participants are involved in the exchange system, and if at least a few of them change their data formats, add or delete new metering analytics articles, this will immediately require introducing modifications to the SC automated system.

Figure 5. Decomposition of the process of subscriber accounting and billing
The system-wide problem is that the SC in this case does not take responsibility for the correctness of the charges, and if the payer has questions or objections, it is immediately sent “to the address” - to the supplier who performed these calculations. With this procedure, it is impossible to create a “single window” regime, and citizens are forced to go from place to place in order to get clarifications or to challenge the amount presented for payment.

Nevertheless, it can be assumed that the “thin billing” will exist for an indefinite time. It is understandable as the suppliers are afraid to outsource such a responsible activity as calculations: what if the SC incorrectly calculates current consumption, forgives debts to those whom it should not, or, what is even worse, it will use its monopoly position [12-14].

4. Conclusions
The transition to a digital settlement system for construction companies gives a new impetus to optimize the construction industry. Optimization occurs due to the abolition of the processes associated with the continuous monitoring of expended energy resources. In addition, modern billing systems can process archived resource consumption data. That allows you to more accurately plan all costs.

From the point of view of geographic location and reference to the infrastructure, a modern billing system should have a flexible topology, providing the ability to freely change the geographical location of the system elements, their reference to equipment and communication lines directly during operation, depending on the automation area geographical conditions and the current state of the communication lines.

From the point of view of the metering model integrity, it is optimal to use a “virtual metering machine” - a mechanism for converting data coming from outside into information system data (into the uniform management chart of accounts and then into the reports based on the uniform metering principles).

Very few Russian software developers can currently guarantee the delivery of their software on a turnkey basis in accordance with all these requirements. And this means that the market of software for utility billing is still at the very beginning of its development.

Unconditional positive and beneficial aspects have risks, primarily related to energy security. A complete transition to the digital management of the housing and utilities industry will require significant material and financial investments for information protection [15-18].

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