Application for the efficiency improvement of the work process in an energy company

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In modern society, electricity is necessary for the proper conduct of daily activities, becoming essential for life. All existing domains such as industry, transport, information technology, agriculture, economy, etc. requires energy resources to carry out the activities undertaken in optimal conditions. Thus, distribution companies invest enormously to transform networks into smart grids through a digitization effort that is constantly supported by modernization projects.
As an alternative with lower costs, an application can be implemented that helps consumers and employees regarding the the continuity of electricity supply, the quality of services provided to them and better communication between the consumer and the distribution operator.
Keywords*: electricity distribution company, consumer satisfaction , web application, prompt and quality services, automation of daily activities, easy reporting*

1 Introduction

Electricity is the most consumed source of energy in the world, becoming an essential part of modern life. According to the report made by A.N.R.E. in 2018 at national level, we can see the large number of consumers connected to the electricity network, more precisely 9.448.823, of which 5.170.629 are living in urban areas and 4.278.194 in rural areas. [1] Values have increased over the last few years.

The discovery of electricity led to the development of innovative technologies aimed to improve consumer satisfaction and companies efficiency from different domains of activity. Currently, the modernization of the energy domain involves the use of state-of-the-art technologies and equipment that can be controlled remotely: remote controlled separators, protection relays that allow the disconnection of the defective sector, smart meters which will benefit by the end of 2020 only 30% of the consumers. Due to the small percentage of beneficiaries and insufficient upgrades, there are still persistent problems such as: poor management of material stocks, long electricity outages, meticulous bureaucracy due to filling out paper forms, overloading telephone lines, significant waiting on a phone call to report an incorrect functioning of the electricity distribution network etc.

The main goal of this article is to present an alternative for electricity distribution companies, to which all users who have a device that allows internet connection have access. By using modern frameworks such as Laravel, Vue.js, the basic languages PHP, JS, CSS, HTML, the SASS preprocessor, the MySQL database but also the various APIs, I created an application that automates time and resource consuming physical operations by implementing features such as: online derangement reporting form, interactive map of derangements, digitized reports, prioritization of derangements, directions, calculation of travel distance, automatic sending of an SMS that notifies the consumer, calculation of monthly statistics at the company level etc. This innovation aims to improve the current level of the management system and increase performance at the company level.

2 Objectives

The developed application, digitizes within an electricity distribution company two areas: that of easy communication with consumers and the one of streamlining the work of network operators.

The first area developed will ensure the fulfillment of one of the objectives proposed by this type of companies more precisely, the customer loyalty and satisfaction.

Various surveys have shown that society is reluctant from various psycho-emotional reasons to call on strangers to report a problem, instead prefers to write a message on various applications or send an email. Another notable reason is the lack of time. The century of speed makes its presence felt and consumers do not have the patience to wait for the release of an operator to communicate the discomfort appeared.

To help these people and to increase their comfort, communication between consumers and distributors will be digitized through an online form with a series of standard questions to determine the type of inconvenience and whether certain measures have been taken before contacting the work team. For example, „Are there other consumers who do not have electricity?".

Before completing the form, the user can consult the map of existing derangements on the employees' work list. This will eliminate duplicate requests of fixing the derangement.

These functionalities do not only help consumers but also bring a benefit to dispatchers because during bad weather conditions or major electicity outages, they do not cope with the large number of consumers who want to report a problem. In those situations, consumers will choose to fill out the online form to reduce the waiting time. All this information from consumers will be transmitted in real time to the service team, without the need for a qualified person to inform employees by phone about the problems that have arisen.

The list of derangements to which the employee has access is ordered ascending according to the degree of importance (sick people, medium tension incidents, collective derangements, individual derangements), to their level of completion (available, taken over, started, completed), after the date of sending the report and depending on the distance of the service teams from the place where the derangement was reported.

Distribution operators may view additional consumer and derangement information and may request guidance to the location. An SMS notification system will be used to inform the person concerned that the derangement has been taken over and the intervention team is moving towards it, all this to eliminate the risk of her not being at home and also to make the work easier for employees because they no longer have to call her.

Completing a disturbance entails completing a questionnaire which, based on the answers, generates a report (observation note, movement report) which, by digitizing it, eliminates the large volume of handwritten documents and reduces the time to search or study them.

All the functionalities presented have methods behind which generate data for creating graphs and monthly statistics on working hours, employees performance, cost of materials, consumption of materials, time in which consumers ran out of electricity etc.

It can be seen that through all these automations brought to an electricity distribution company, the working time of the employees would be optimized, the derangements can be located more easily, the cost of traveling to them is reduced, the communication problems with the consumers are reduced, as well as those related to real-time inventory records would no longer exist.

All these economic problems will decrease significantly, and the company's profit may increase.

Although they are not visible in digital format, there are also improvements in the psycho-emotional level of the employees, the call center operators are not so overwhelmed and

the stress felt by them is considerably diminished, the work team no longer has so many manual tasks to do, being so much easier to view, complete and transmit data in the online environment .

3 Designing the Application

For designing the functionalities I used the relational database MySQL. Its logical schema is presented below, in **Fig. 1**.

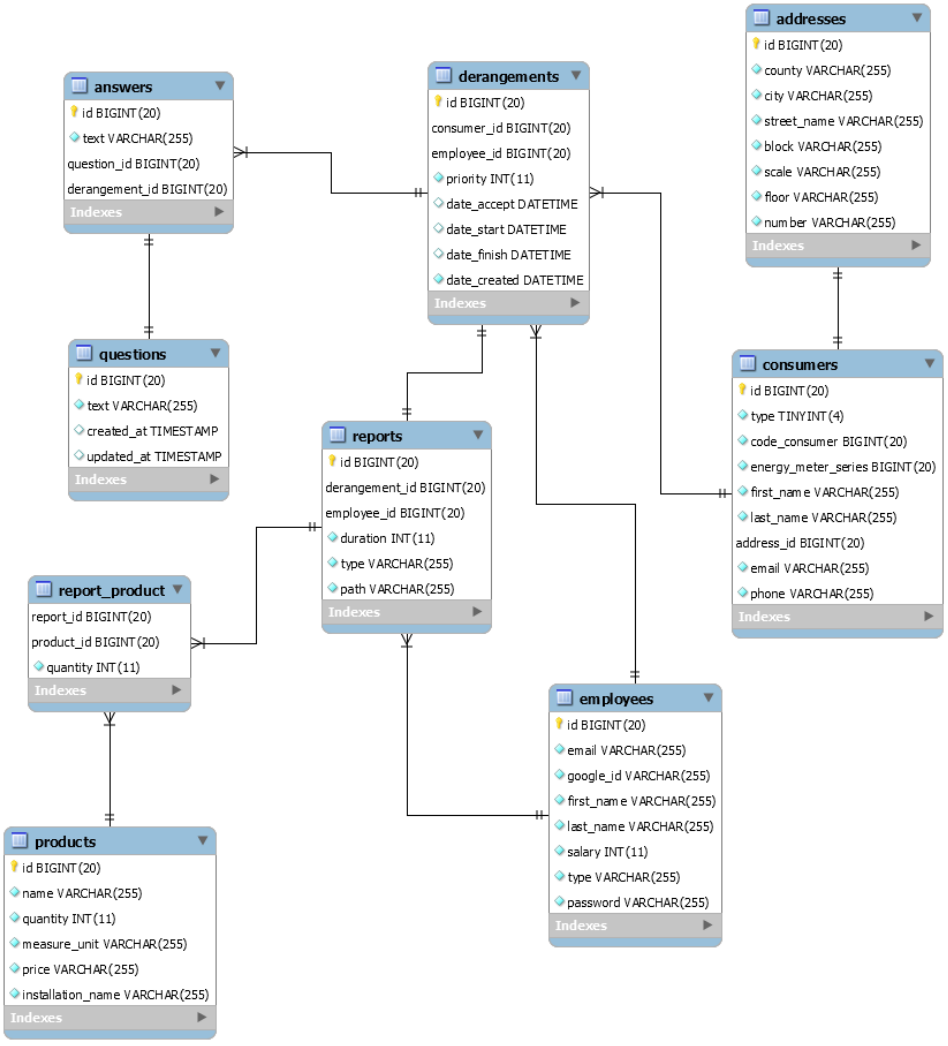


Fig. 1 Logical Schema of the Database

The communication with the database is done through the Model component that belongs to the architectural model MVC (Model-View-Controller), which I will talk about in the following sections.

The user interface is an important part, because for most users this interface is not just a visual part of the application, but the entire computing system. I considered that the design of an interface should be as suggestive as possible and easy to use, as we can see in **Fig 2**. The readability of the functionalities, the minimization of the complexity, the colors used, the pictorial realism can be a plus for the users who will definitely return in case of need.

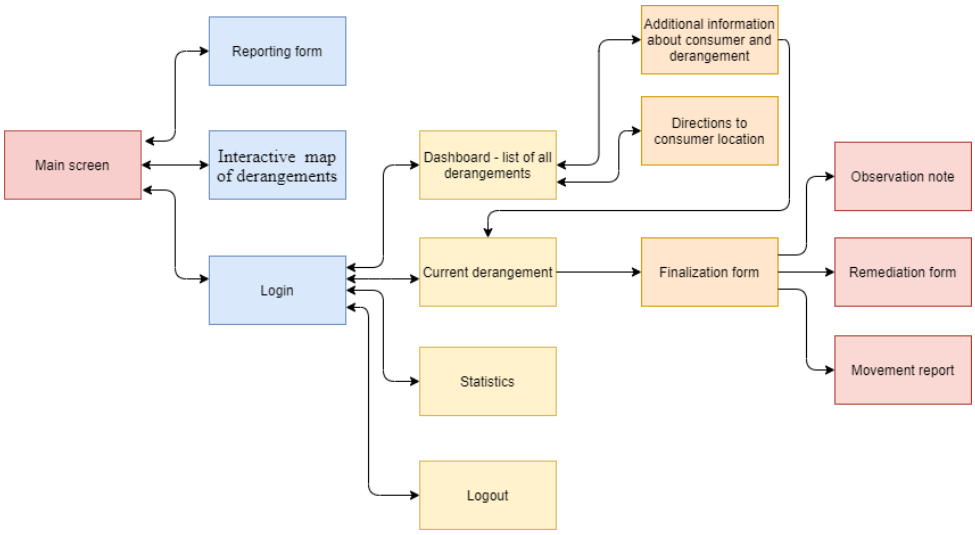


Fig. 2 User Interfaces Diagram

4 Software Technologies

For the implementation of the web application I used **PHP**, **JS**, **CSS** and **HTML** as basic languages. They blend seamlessly with popular frameworks, such as PHP-based **Laravel** for server-side work (used especially for web route control and interaction with the **MySQL** database),**Vue.js** for the interface part, JS-based framework for modeling the information received from the server, but also the **SASS** preprocessor for using CSS in a much more organized way, useful for complex applications.

The web pages were written in HTML and stylized through CSS,based on the SASS preprocessor. It allows the use of a much more efficient and organized language than the common CSS. Once the application is compiled, the CSS file that is normally used is generated.

The dynamism and interactivity of the application is given by the complex visual effects created by using the JavaScript object-oriented programming language. The scripting language, PHP is mainly used on the back end of the website and has facilities such as: generating dynamic content, encrypting data, performing operations on data retrieved from the database, controlling user access etc. [2]

Using the PHP framework, Laravel, involves the use of the architectural model **Model View Controller (MVC)** transforming the code into a well-organized and very easy to manage, thus respecting the principle of software development DRY (Don't Repeat Yourself). Considering that this application is a complex one, this type of model is very useful because it isolates the logical part from the design part.

In order to achieve the highest possible level of performance of the developed application, I chose to use a second framework, Vue.js, integrated with Laravel. This is a progressive framework used to build user interfaces. [3] It is based on the concept of **Single-Page Applications (SPA)** which involves dynamically rewriting the current web page with new data from the web server, instead of loading a new page.

For database management I used MySQL, being currently the most popular open-source DBMS. I chose this management system because it is widely used together with the PHP programming language, on which the presented application is based and can be used standard SQL commands already known by me.

Developing the functionality of visualizing the derangements on the map and providing guidance involves the use of the **HERE**

Maps API for JavaScript. This is a set of interfaces that allow programmers to include in web applications interactive maps that can be seen on both mobile and desktop devices and can transform a partial address into a complete one with the possibility of determining the geolocation (latitude and longitude).
The functionality of automatically sending the notification SMS to the consumer is created using the **Vonage communications API**, which has a reduced cost of only 0.06 eurocents per SMS.
One last API used is **Pusher**. It provides real-time communication between applications, more specifically, between the report form and the employee dashboard and between the dashboard and the current derangement page. When a report is sent, the dashboard page is updated, adding according to certain criteria a fault in the appropriate section. The dashboard is updated again when a derangement changes its status. I used the Visual Studio Code development environment to write the source code, and XAMPP to host the website on my personal computer.

5 Methodology

As I mentioned in the previous sections, I used for my application the architectural model MVC (Model-View-Controller). The components of the MVC model are:

- Model- has the role of performing operations related to the database
- View- contains the records taken from the database and presented to the user.
- Controller- has the role of controlling the actions of a website.

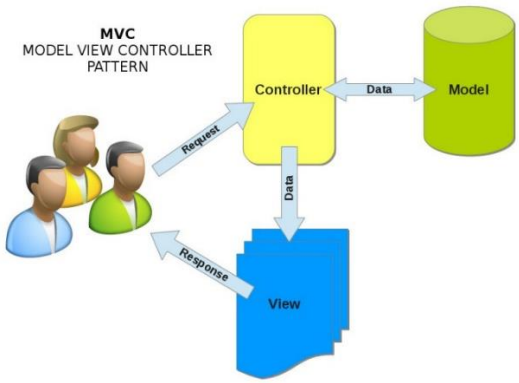


Fig. 3 MVC architectural model [4]

As we can see in **Fig.** 3, the MVC mode of operation is simple: a user initializes a request, and the controller takes the received data and converts it to the meaning of the Model and sends it to it. The model connects to the database and retrieves the necessary information and then sends it back to the controller.
The controller processes the data received from the model and sends it to the View component. The latter, by compiling the data, generates an interface adapted to the user's requirements, prepared by a new interaction. As can be seen, the Controller is the intermediate component between View and Model, the two do not communicate directly with each other.

6 Application Interface Depiction

When accessing the site we are greeted by a friendly interface which by the way the buttons are placed denotes a high degree of accessibility to all age categories. The first page is an informative one whose purpose is to inspire confidence in consumers regarding the company's performance and the safety of the derangement reporting platform. (**Fig. 4**)

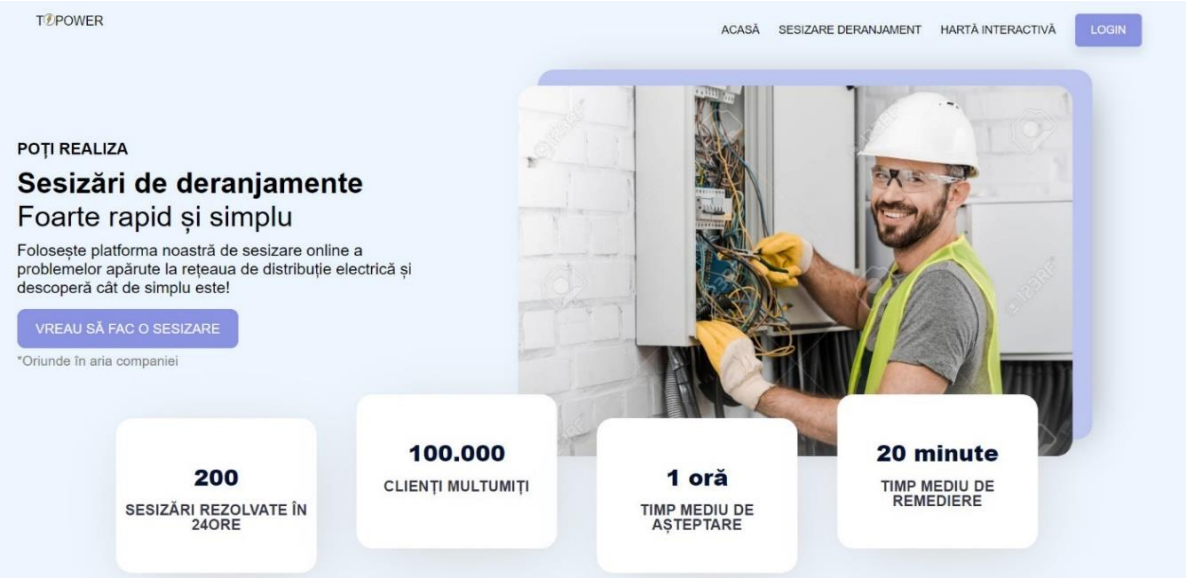


Fig. 4 Main Screen

A feature available to the consumer is represented by the interactive map in which the current derangements are displayed through pins.

It should be mentioned that in the database I have stored only the consumer's address, and in order to display exactly his report on the map, I use an HERE Map function of transforming the address into geolocation. Additional information about them is displayed individually by pressing the desired pin. (**Fig. 5**)

Fig. 5 Interactive map of derangements

The reporting form can be accessed through the central button "I want to make a report" or

from the navigation bar "Derangement reporting ". By pressing any button, a simplistic form will open, with 4 fields that have an average completion of approximately 2 minutes. (**Fig. 6**)

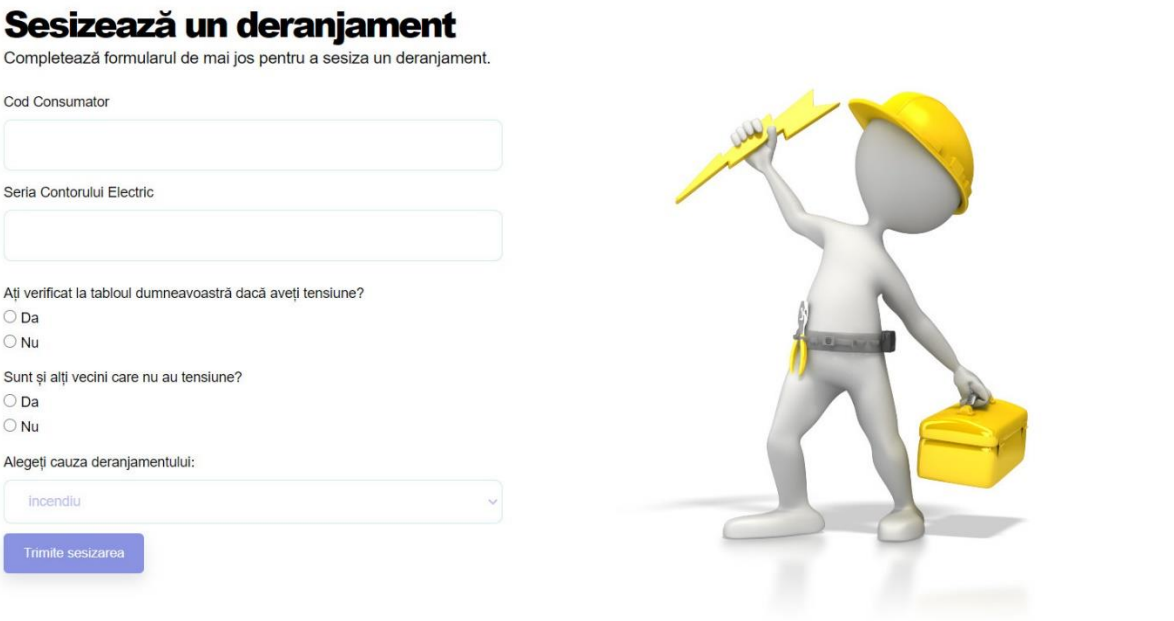


Fig. 6 Reporting form

To avoid frauds, the consumer's identity is automatically verified in the database by filling in the consumer code or the meter series. A second verification is the visual one by the consumer and is represented by the display from the database of the address that matches the written numerical code. If there is already a derangement on that street in the database, a message will be displayed to avoid redundant requests.

Simply press of the "Send report" button triggers the appearance of a modal window aimed at notifying the consumer that his request is sent for solving. **(Fig. 7)** He has the possibility to print the confirmation to facilitate the retention of the generated id as well as the details about the report, important information in case of irregularities.

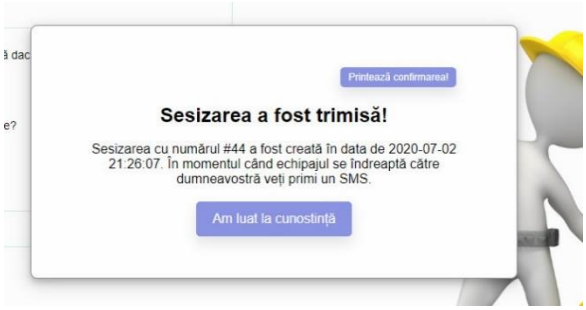


Fig. 7 " Successful sent" modal screen

Authentication to additional app features can be done using the existing username in the database or through Google authentication, with the condition that the e-mail address is listed in the database. After authentication, the dashboard page opens and can be seen all the derangements that are less than 3 days old. After 3 days, only the completed ones will be deleted from the dashboard.

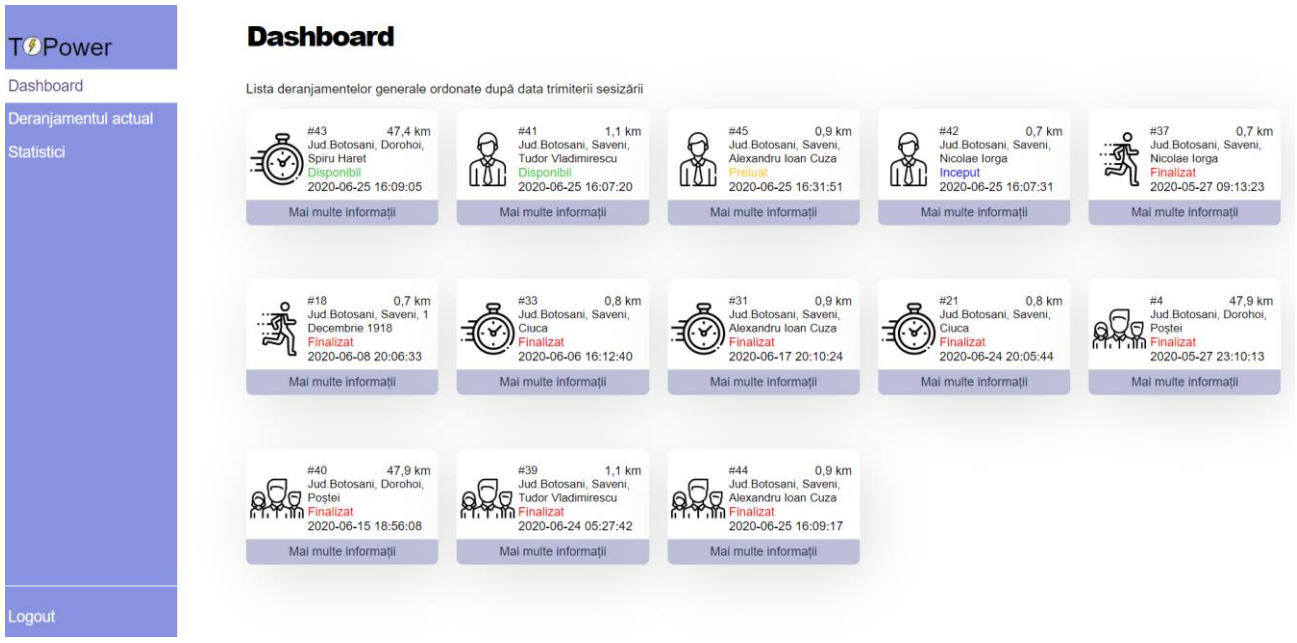


Fig. 8 Dashboard

The priority of a derangement is generated based on the answers given by the consumer and is visually represented by a specific picture. (**Fig. 8**) In this way we can exemplify 4 types of priorities in the order of importance that the employee must give:

Priority type 0 or sick people – people who are dependent on equipment that need a continuous supply of electricity. In the database there is a record of sick people by that attribute "type", so when a consumer sends the form a check will be made immediately to generate this priority degree.

Priority type 1 or medium voltage incidents – the answer to the last question generates this priority. Options such as "fires", "fallen conductors", "broken poles", "other situations that present a risk of electric shock" are processed and set the priority of the derangement. The other drop-down options are ignored and other form questions will be considered.

Priority type 2 or collective derangement – after the number of reports or after the answer to the question 2 it is determined whether there is a significant number of consumers who do not have electricity.

Priority type 3 sau individual derangement – the answer to the question number 2 also determines whether the problem is an individual one, which is placed last in the ranking in the employees' dashboard.

If two derangements have the same status and the same priority, the employee is free to choose between the criterion of distance to the location or the date of sending the report.

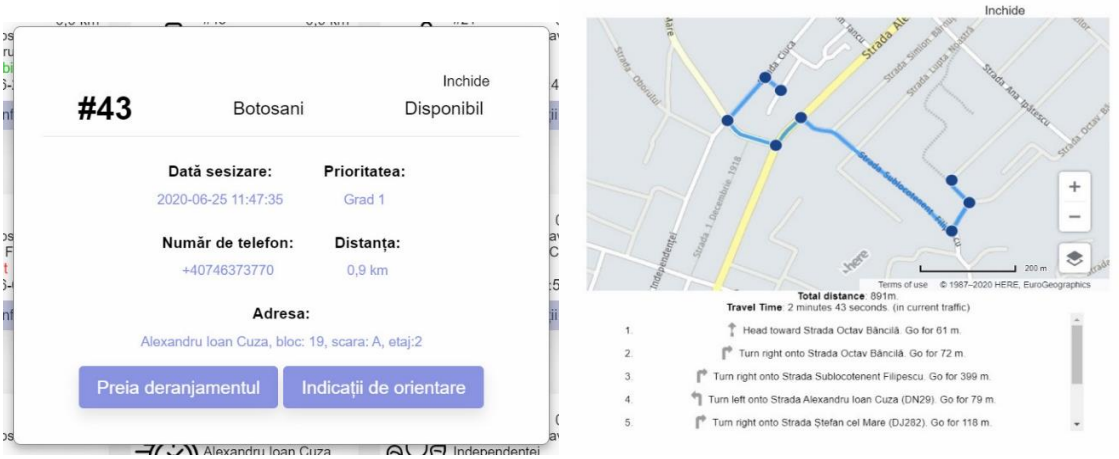


Fig. 9 Additional information, Directions to consumer location

The employee can view additional information about the derangement and can ask for guidance if the address is unknown. (**Fig. 9**) Taking over a derangement ends up sending an automatic SMS to the customer, as well as constantly changing the derangement status, and through the web socket the status is updated in real time and in the dashboard. (**Fig. 10**)

Fig. 10 Received SMS example

The completion of the derangement leads to a modal window represented in (**Fig. 11**), through which the employee answers to a maximum of 3 questions that establish what type of report he has to complete.

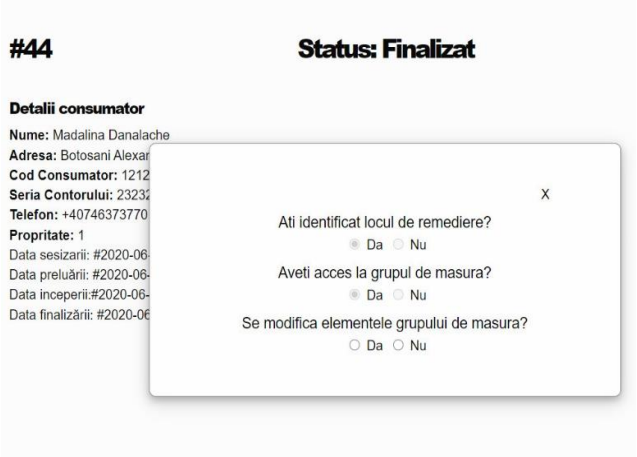


Fig. 11 Finalization form

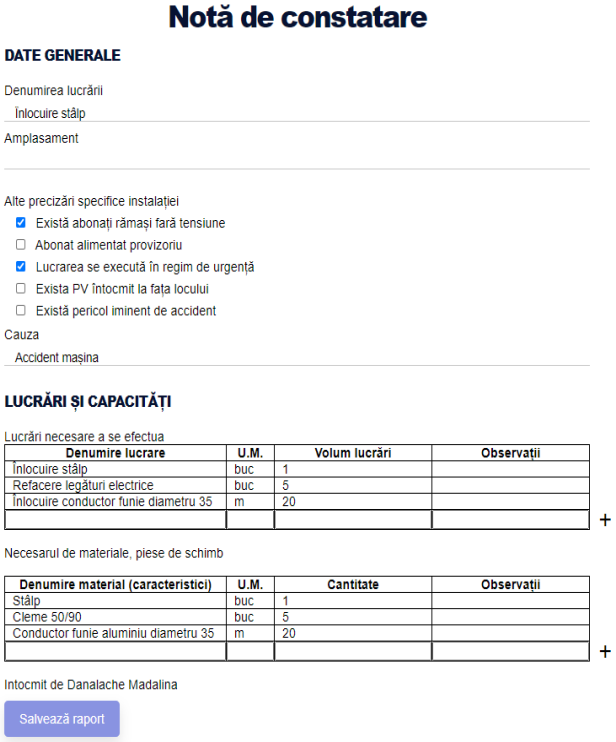
The 3 types of reports are:

Observation note – if the employee does not identify the place of remediation of the electricity network or does not have access to the measuring group, this type of report is completed with the works and materials necessary to complete the problem and will be sent to specialized teams. (**Fig. 12**)

Remediation form – the completion is determined by not modifying the elements of the measuring group, and through the database it will be possible to choose the name of the installation from a drop-down type element (LEA / LES / PT / FB / BMPM / BMPT) and the consumed materials corresponding to the

installation. These are dynamically subtracted from the database for a good management stocks.

Movement report – the change of the elements of the measuring group determines the completion of this type of report, to which are added, in addition to the previous report, two important tables: the characteristics of the meter and the elements of the sealed measuring group. They have inputs that can be easily filled in by employees. (**Fig. 12**)


Notă de constatare

DATE GENERALE

Denumirea lucrării

Înlocuire stâlp

Amplasament

Alte precizări specifice instalației

- [x] Există abonați rămași fară tensiune
- [ ] Abonat alimentat provizoriu
- [x] Lucrarea se execută în regim de urgență
- [ ] Exista PV întocmit la fața locului
- [ ] Există pericol iminent de accident

Cauza

Accident mașina

LUCRĂRI ȘI CAPACITĂȚI

Lucrări necesare a se efectua

Denumire lucrare	U.M.	Volum lucrări	Observații
Înlocuire stâlp	buc	1	
Refacere legături electrice	buc	5	
Înlocuire conductor funie diametru 35	m	20	

+

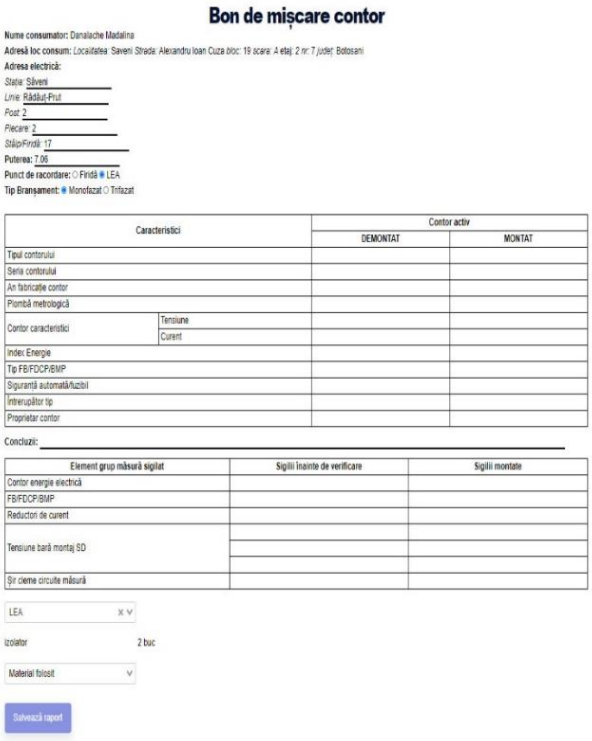
Necesarul de materiale, piese de schimb

Denumire material (caracteristici)	U.M.	Cantitate	Observații
Stâlp	buc	1	
Cleme 50/90	buc	5	
Conductor funie aluminiu diametru 35	m	20	

+

Intocmit de Danalache Madalina

Salvează raport


Bon de mișcare contor

Nume consumator: Danalache Madalina

Adresă loc consum: Localitatea: Saveni Strada: Alexandru Ioan Cuza bloc: 19 scara: A etaj: 2 nr: 7 județ: Botoșani

Adresa electrică:

Stația: Săveni

Linie: Rădăuți-Prut

Post: 2

Fiecare: 2

Stâlpi/Firidă: 17

Puterea: 7.06

Punct de racordare: ○ Firidă ◉ LEA

Tip Branșament: ◉ Monofazat ○ Trifazat

Caracteristici		Contor activ	
		DEMONTAT	MONTAT
Tipul contorului			
Seria contorului			
An fabricație contor			
Plombă metrologică			
Contor caracteristici	Tensiune		
	Curent		
Index Energie			
Tip FB/FDCP/BMP			
Siguranță automată/fuzibil			
Intrerupător tip			
Proprietar contor			

Concluzii: _____

Element grup măsură sigilat	Sigilii înainte de verificare	Sigilii montate
Contor energie electrică		
FB/FDCP/BMP		
Reductori de curent		
Tensiune bară montaj SD		
Șir cleme circuite măsură		

LEA

Izolator 2 buc

Material folosit

Salvează raport

Fig. 12 Observation note, Movement report

Compared to written reports, digital ones are much more accessible, some information coming automatically from the database.

The saving of each form is done by calling a PDF export function. The generated file is stored in the "Storage" folder within the application. After this last step, the employee can take over another derangement available in the dashboard.

By selecting the Statistics navigation link from the side menu, we will discover a page that is as visually appealing as it is simplistic in terms of access. The selection of a month determines the display of statistics that can be daily: the number of derangements resolved on that day, or monthly: the average time of electricity outage, the cost of used materials, the total cost of salaries, the number of derangements remedied in each type of priority, the average time to take over a derangement and the average travel time. All these statistics are represented by Pie, Bar, Line and Bubble charts. (**Fig. 13**)

Fig. 13 Statistics

7 Future work

One of the main benefits of this application is the possibility to improve existing functionalities as well as the development of completely new ones.

The complexity of the functionalities can be extended by the possibility of processing large volumes of data:

- the existence of several counties under the tutelage of the company, divided into work centers
- employees to be divided into specialized teams
- the database may contain the consumer's electrical address, the characteristics of the existing meter, seals, etc.
- several types of installations and materials etc.

Another improvement is the creation of a private administrator account that can check the performance of employees (real-time location, travel speed, working hours, etc.)

8 Conclusions

The web Application for the efficiency improvement of the work process in an energy company is accessible from any device, with an attractive interface that has ease of use, created with modern frameworks, popular programming languages and facilities offered by APIs.

The usefulness of the application presented in

this article comes from the fact that it helps consumers in finding and noticing much easier failures in the electricity distribution network, as well as employees by eliminating standard work procedures performed manually.

I believe that the implemented functionalities are perfectly in line with the current requirements of the company and bring an extra novelty in the energy field. The main goal was to automate actions that normally generated "dead" times, all in order to satisfy consumers by providing quality services, to increase the company's performance and to maintain the continuity of electricity supply.

9 Acknowledgment

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