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Statistical methodology of developing services for mobile communication companies in the trend of m-government

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***Abstract*— This article examines measures to extend the service life of devices by implementing a comprehensive preventive maintenance plan. The aim is to ensure the reliability and usability of devices to provide high-quality services to users of mobile communication infrastructure within the "M-Government" environment of mobile communication companies. Additionally, it explores ways to increase customer numbers and support service-providing companies by studying customer relationships based on an analysis of customer satisfaction, retention, loyalty, acquisition, and attrition criteria. The article also emphasizes the importance of providing analytical information to mobile company management about each of the key indicators influencing customer relationships.**

***Keywords*—** *communication, mobile communication, infrastructure, management.*

1. INTRODUCTION

In recent years, the global communication network has become an extremely important sector of the economy. A mobile communication company consists of a system of devices and personnel that provide services to various clients. To gain a greater market advantage and maximize profits, mobile communication industry managers strive to offer a wide range of high-standard services in accordance with customer needs. Therefore, it is advisable to focus on the network structure, the reliability of devices, the level of success in customer-supplier relationships, and to understand potential problems that may arise in the mobile communication system from various perspectives. Today, it is emphasized that the "Global System for Mobile Communications (GSM)" is centered on two main components, namely the "Base Station Subsystem (BSS)" and the "Network Subsystem (NSS)," each of which includes separate components related to mobile communication infrastructure.

2. RELATED WORKS

Mobile communication infrastructure consists of various types of devices operating under the supervision of specialists to provide services to users. As a result, two objectives are pursued: firstly, to extend the operational life of the equipment by implementing a comprehensive preventive maintenance plan to ensure device reliability and usability; secondly, to increase and maintain the customer base of service providers by studying customer relationships based on analysis of customer satisfaction, retention, loyalty, acquisition, and churn criteria. This dual approach strengthens service quality while fostering trust and loyalty among mobile communication users. These objectives align with the broader goal of optimizing service quality while enhancing customer experience.

Research conducted to improve the efficiency of services provided by mobile communication companies requires identifying sources for determining device performance indicators, as well as key indicators of customer relationship management. For this purpose, various statistical methods were identified and utilized in this research work, such as mean time between failures, reliability analysis, regression, K-means clustering, and classification using decision trees. It is substantiated that these methods can be tested in the field using applications for predictive maintenance, customer relationship analysis, and customer churn analysis.

As a result of this analysis, four procedures were proposed that complement service provider management systems and help implement various strategies aimed at improving their efficiency:

The first procedure is aimed at improving the reliability of devices and conducting preventive maintenance of telecommunication equipment to notify mobile communication companies providing services about anticipated future malfunctions.

The second procedure involves analyzing a single indicator of customer relationships to identify influencing factors.

The third procedure is focused on performing an intersection analysis of two indicators and forming customer groups using the K-means clustering method.

The fourth procedure incorporates the concept of customer churn analysis, where user classification is carried out using a binary logistic regression model and a decision tree-based classification approach.

The economic efficiency of a communication device is determined by numerous variables, including energy consumption, cooling costs, base station activation/deactivation, utilization of hybrid energy systems, and integration of new technologies. "It has been observed that nearly 50% of energy consumption is attributed to the operation of mobile communication networks" [1]. "70% of mobile towers in India experience power outages lasting more

than 8 hours per day" [2]. Consequently, a mobile base station must be equipped with a generator and/or battery for support, depending on the number of existing base stations it has.

According to researchers, it has been determined that currently more than 80% of mobile communication power is consumed at base stations [3]. It is also noted that turning off power amplifiers is often more convenient than keeping them in standby mode [4]. "Nearest distance" and "Efficiency priority" are two strategies used for turning base stations on and off. Other strategies can be used to reduce switching costs - by turning off a base station (BS) with zero load or by transferring a BS that can be switched to another base station. Other strategies can be used to reduce switching costs - by switching off a base station (BS) with zero load or a BS that can be switched to another base station. The base station is equipped with a diesel generator, batteries, and an environmentally friendly energy network that includes wind turbines and solar panels. By utilizing a solar hybrid system, the diesel generator (DG) can reduce fuel consumption by 40-90%, as well as decrease operating and maintenance costs by up to 90%. [5]. The optimal solution for powering the BS (Base Station) may involve using different energy sources at different times. "Many companies are adjusting their strategies due to a significant reduction in costs associated with cloud services" [6]. It is also known that the costs of storing spare parts contribute significantly to overall operational expenses [7].

Comprehensive technical maintenance is designed to improve the productivity and reliability of production facilities and serves as a central function of the quality management system. Efficiency can be enhanced through proper maintenance to reduce losses such as equipment malfunctions, short downtimes, and decreased productivity levels that affect the usability and reliability of the equipment. "Maintenance has a direct impact on component and system reliability" [9]. "TPM strives to achieve and secure 100% operator involvement for zero defects and zero accidents" [8]. This includes various types of maintenance services, such as breakdown maintenance, periodic maintenance, predictive maintenance, preventive maintenance, and corrective maintenance.

• Emergency maintenance is a type of technical service that begins after equipment has completely broken down.

• Regular maintenance is a time-based technical service, where maintenance is carried out according to a predetermined schedule and does not depend on the condition of the equipment.

• Predictive maintenance is a method used by enterprises to reduce operational costs and ensure high-quality service without interruptions.

• Preventive maintenance is used to prevent or delay the occurrence of faults. Critical devices are serviced during the operational stage.

• Corrective maintenance is a type of system maintenance that is performed when a failure or problem occurs in the system.

3. METHODS.

Each of these types of maintenance can be applied in various situations and for different purposes, with the ultimate goal of improving device reliability.

This chapter demonstrates numerous forms of maintenance used in mobile communication companies' operations, as well as the economic efficiency of communication devices. As a result, equipment reliability through the use of predictive maintenance is generally considered the most critical factor that needs to be measured to extend the device's service life. This approach helps increase equipment reliability, improve service quality, and meet customer needs.

The mobile communications industry is one of the service-based sectors where both devices and customer relationships are considered integral parts of the organization. The success of such an organization is rooted in its ability to maintain excellent relationships with its customers. According to Montgomery and Ranger, statistics is a field that aids in decision-making and drawing conclusions in the presence of variability [10]. Various types of statistical data are available for use, depending on the specific situation being studied.

To improve the quality of service in the mobile communications sector and thereby meet customer needs, we can focus on the reliability, maintenance, and usability of equipment. Additionally, another application of statistics is identifying key variables that play a crucial role in understanding customer behavior and analyzing customer relationships. This is accomplished using powerful analytical and statistical tools and methods such as exploratory and confirmatory factor analysis, regression and analysis of variance (ANOVA), cluster analysis, and classification analysis.

In mobile communication companies, business engineers typically use statistics to develop and propose new services and make important decisions. This research paper describes the statistical approaches used to improve the reliability of mobile communication companies' devices and manage relationships between service providers and customers. The initial sections of the research work examine the statistical stages that form the basis for conducting any statistical analysis, namely data collection, data visualization, data analysis, and conclusion stages. In the data analysis stage, the following statistical methods are applied in this field:

• The reliability function is expressed as follows [11]:

$R(t) = 1 - F(t) \quad for\ t > 0$

here, F (t) is the distribution function, t is the operating time of the device.

• A widely used technical indicator in mobile communication networks is "MTBF (Mean Time Between Failures), MTTR (Mean Time To Repair), or MDT (Mean Down Time) " [12]. Usability is described as "a measure of the degree to which an element of a mobile communication system or the system itself is in a state suitable for use" [13]. The usability value is calculated as follows:

$$A_i = \frac{MTBF}{MTBF + MTTR}$$

here, MTBF is the average time between failures, MTTR is the average time for repair.

4. RESULTS

Data reliability. It provides information about whether there is a uniformity in respondents' answers to the questions. The use of statistical packages allows users to easily measure the Cronbach alpha value, as it is known that if the value of

the given attribute is greater than 0,7, the result is a positive indicator of internal consistency as a result of good association [14].

Data validity: this checks whether independent variables are measuring what they are intended to measure. This can be determined by examining the significance of the correlation coefficient between variables. Different types of correlation coefficients can be used, such as Pearson and Spearman correlation coefficients. In this context, Schober demonstrated that the values of all correlation coefficients should range from -1 to +1 [15]. If the p-value of the test result is small, specifically less than 0.05, a significant correlation is observed, in which case it is possible to infer the reliability of the data.

Principal Component Analysis (PCA): This is a method of reducing the number of components under study by determining the type of correlation between identified independent variables. Additionally, PCA can identify differences in the direction of variables, i.e., it can highlight variables measured on a different scale. PCA provides a table showing the number of factors that can represent the input factors. After determining the number of given coefficients, it is necessary to examine the rotated component matrix to compare which variables correspond to each other. This can be determined by looking at the highest value for each factor in the component matrix output and then checking which component it belongs to.

Confirmatory Factor Analysis (CFA). CFA helps determine which of the factors under study is more effective than each of the aforementioned hidden factors of satisfaction and retention. "In the CFA, researchers can determine which measurement variable is associated with which hidden variable" (CFA, 2020). The CFA model uses maximum probability estimation, the performance of which can be tested using the AMOS program. When CFA is triggered, there will be a trial and error stage to find the correct combination of variables to use in the analysis. Various statistical models are used to calculate the effectiveness of CFA, and typical statistical models are CMIN/DF, RMR, SRMR, CFI, RSMEA, GFI, and NFI. Some examples of statistical software that can use AMOS, R, Stata CFA.

Regression analysis: A set of statistical tools used to model and study the relationships between non-deterministically linked variables is called regression analysis. Regression analysis is used for prediction: "Logistic regression is used to predict a categorical variable based on a set of predictive variables" [16]. Regression analysis is also used to improve the company's operational efficiency and highlights important factors in each industry. The general equation obtained by regression analysis can be summarized as follows:

$$y = a + b_1x_1 + b_2x_2 + \cdots + b_bx_n$$

Dependent variable in binary logistic regression $y = (\log(\frac{p}{1-p}))$

- this is the probability that the dependent variables have a value equal to 1. The result of the regression analysis includes the coefficient of determination R^2, the value of which represents the percentage change in the dependent variable.

• Cluster analysis: Researchers in this field, Liu and Zhang, have demonstrated in their scientific works that the main objective of clustering is to divide the data set into K classes [17]. There are numerous clustering methods, and the K-Means clustering algorithm is one of the most popular among them. K-Means operates using a centralized approach; it first randomly generates centers for each cluster, then calculates the distance from each point to these centers and forms groups. Averages for each group are calculated to create new centers, and this process is repeated until the centers of the clusters stabilize. The distances calculated in the clustering algorithm can be Euclidean distance, Manhattan distance, Chebyshev distance, and so on, depending on the type of data and analysis being performed.

• Classification analysis. In the telecommunications sector, classification analysis can be used to analyze customer churn. Various statistical methodologies can be employed for analyzing customer attrition, with the most commonly used being binary logistic regression and decision tree classification algorithms. The results of classification can be verified and compared using indicators such as classification accuracy, sensitivity, and specificity. It is advisable for mobile operators to implement models with high sensitivity. [18].

$$Accuracy = \frac{TP + TN}{TP + FN + FP + TN}$$

$$Sensitivity = \frac{TP}{TP + FN}$$

$$Specificity = \frac{TN}{TN + FP}$$

5. CONCLUSION

For classification using binary logistic regression: the process of binary logistic regression utilizes the model significance table, model summary, classification table variables, and coefficient tables. The classification table consists of two parts: false positive and false negative. A false positive occurs when an event is predicted to happen but does not actually occur in reality. A false negative is the opposite situation, where an event is not predicted to occur, but it actually takes place in reality.

Decision tree classification model: A decision tree is a well-defined classification system consisting of a set of nodes arranged in a hierarchical structure.

Various algorithms are used to create a decision tree, with J48 being the most commonly used. Decision trees can be easily obtained using statistical software such as SPSS and WEKA.

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