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Call Rating based on Objective Data Extraction

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Abstract — **Interaction channels are special opportunities to improve customer satisfaction by offering a consistent problem-solving experience. Contact center employees are the link between the company and the customer. They are responsible for maintaining an appropriate relationship between the company and the customer. So, they are personally responsible for the customer experience. In this paper, we present an objective evaluation method for evaluating customer-agent interaction, i.e., evaluating the effectiveness of the realization of customer requests from calls. The evaluation method is automatic and does not depend on the relationship between the call center manager and the employees. The motivation for evaluating calls stems from the key performance characteristics of a contact center, of which we particularly emphasize service time, first call resolution, handling time, and others.**

Keywords — **contact center, agent, call rating, call routing.**

I. INTRODUCTION

THE goals of modern customer relationship management are to acquire new customers, improve connections with existing ones, and increase the competitiveness and profit of a business organization. A sure way to achieve these goals is to introduce business processes that create equal value for the company, employees, and customers. One of the ways to achieve such goals is a modern contact center with adaptive communication channels. Contact centers must provide superior service capacities (for example, a sufficient number of available agents, which will reduce the queue and service time) for customers so that they can see how much the company values their choice and time.

Customer Service Representatives (CSR), first-line employees, as they are often called, play a main role in

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determining the overall opinion of the service provided [1]. The customer and CSR, hereinafter agents, are the two main elements of the contact center system, and the success of the business largely depends on their interaction. Contact centers are service systems that differ from standard service models in several ways. One way is that contact center servers are human beings who differ from their co-workers in terms of abilities, skills, and productivity.

The basic characteristics of contact center service are heterogeneity and reliability. Each customer, through an incoming call, has their own expectations from the service system and has different characteristics that require different handling by agents. Precisely this unpredictability of the type of customers who call is a key challenge in the domain of services. Effective management of this unpredictability is crucial to building a sustainable competitive advantage for the company. Therefore, Quality of Service (QoS) is seen as a function of the customer's waiting time for the service, the value that the user attributes to the information he received and how he received it. Contact center performance depends on agent performance and call handling regulations.

The aim of our research is to propose an objective call evaluation method using several performance indicators. The rest of the paper is organized as follows: Section II presents related work, Section III presents the proposed call evaluation model, and Section IV presents the results of the evaluated calls and the discussion, followed by conclusions and guidelines for future research in Section V.

II. RELATED WORK

The legacy practice in contact centers is to evaluate agent performance monthly [2], based on metrics such as average call duration, number of calls offered per agent, working time after the call, adherence to the conversation schedule, etc. There are several approaches to scoring the outcome of a call. Multiple parallel scoring systems can be used at the same time, considering the way the scoring types are combined. For example, if an agent is selected to handle a call based on one paradigm, e.g., selling a service, the parallel scoring system must not be contradictory. A contradictory parallel system in this case can be service time, because the sale of the product will certainly require a longer service time.

The results of the call evaluation depend on the scoring method. In some cases, it is quite simple to rate the call. For example, for agents who sell one product, the call evaluation can be based on the number of units sold per unit of time or a pre-defined time required to close the sale. However, when selling various products and or services, the evaluation should include additional indicators, such as call duration, revenue per call or per unit of time, profit per call

or unit of time or similar. As the range of products and services increases, the open issues in evaluating agent performance grow.

There are two main approaches to evaluation: subjective and objective. Objective methods involve evaluating agent performance by simultaneously including multiple call metrics (such as average call duration, number of calls offered per agent, total work time, post-call work time, adherence to the call schedule, etc.) where the working conditions are the same for all agents. However, it is very difficult to measure productivity objectively, because the agent's greatest effect is the information he delivers to the user over the phone. The subjective evaluation of calls is the essence of the qualitative method. It is usually accomplished by monitoring and evaluating interactions between the customer and the agent based on the service experience of the evaluator [3]. This evaluation is performed by listening to a recorded call from an agent, listening to a live call, or placing a test call from a quality team member or an anonymous caller. The quality team listens to the recorded responses of the agents and uses pre-defined assessment forms [4]. The rating process has many drawbacks, because it evaluates agents based on their perceptions and previous experiences. Subjective assessment opens possibilities to favorize "social connections" [5]. Social connection implies a closer social bond between superiors and subordinates. The consequence of these connections is better performance ratings, in cases where there are no differences in actual performance between agents. Another disadvantage of subjective assessment is the limitation of resources for consistent and equal assessment of all agents over time. Some agents are evaluated on different shifts (day/night), which is inconsistent or unfair evaluation among agents. A standard challenge in agent effect evaluation studies is the unobservability of the actual effect, making it difficult to estimate the gap and detect estimation bias [5]. In other words, the subjective evaluation may underestimate the agent in situations where its performance could be higher or, on the contrary, the agent may be overestimated in the evaluation due to other indicators that may not be relevant to the true performance or service quality. Several studies are based on call evaluation by contact center managers, where each call is evaluated by listening to the call. Typical questions asked by managers when evaluating a call are: "did the agent provide accurate information to the customer", "did the agent use the correct system and documentation to provide answers to the customer", or did the agent use the correct protocol for talking to the customer.

The call evaluation is also usually accomplished by customers. After the conversation, a customer is asked to evaluate the work of the agent and the system overall with a rating in the range from 1 to 5.

Table 1. presents an overview of papers that used different ways of evaluating call outcomes in their respective call routing models. Authors in [6], [7], [8], [9], [10] use an objective approach to evaluate the performance of agents, using a maximum of three call metrics. Subjective method of evaluation, which is based on listening and evaluation of

calls by supervisors used in [2], [4], [9]. In the paper [4],[11], [12] the authors used a machine learning method to evaluate calls to monitor whether the agent adheres to a predefined order of calls or not, this is again an evaluation based on a single performance and does not include several metrics. Using a different call scoring method depends on what the same scoring process is trying to achieve, whether it is reducing call center operating costs, customer satisfaction, or both.

TABLE 1: OVERVIEW OF PAPERS INVESTIGATING CALL EVALUATION

Papers	Call evaluation parameters	Explanation
[6]	Sales outcome, Service time, Customer satisfaction	They represent talk time as a cost function, since agents have different salaries and service costs will be different.
[7]	Service time	Agent statistics for good, bad, average or great
[8], [9],[10]	Agent performance	Subjective evaluation of supervisors based on recent activities
[8]	Call outcome	With the return call, the customer rated the outcome of the call binary "good" or "bad"
[11], [12], [4],	Evaluation of customer and agent conversations	By applying the ML method, the call is evaluated based on adherence to the flow and topic of the conversation
[2], [4], [9]	Evaluation of overheard conversations	Subjective assessment by a supervisor (expert)

III. PROPOSED MODEL FOR CALL RATING BASED ON DATA EXTRACTION

The basis for evaluating calls in the proposed model are two quantitative measures, which are used to determine the productivity of agents and the quality of the service they provide to the customer. One of the measures is *Average Handling Time (AHT),* denoted as t_{aht} for further reference.

AHT is considered as the average time it takes an agent to process a call [13]. Another measure is *First Call Resolution* (*FCR*), which measures how many calls are resolved in the first contact without the need for further follow-up or a second call. t_{aht} is a quantitative measure and is much easier to measure than the FCR rate. Calculating the first call resolution rate requires the use of advanced data analysis techniques and tools. According to [7], these two are the main metrics for agent performance and the quality of the provided service.

A. Average Handling Time

AHT is used to evaluate the efficiency of the agent and the contact center in general. It can be an effective metric for establishing reference points that the contact center should build, and creating goals to trend for [13]. Since the duration of the conversation between the customer and the agent is considered as a cost, which should be minimized, each company individually sets a target value for t_{aht}.

Let $i, (i = 1,2,3, ..., n)$ denotes the agent that solves $j, (j = 1,2,3, ..., m)$ calls. If after the end of the conversation with the customer, the agent has no longer any obligations regarding the given call, then t_{aht} is equal to the average call service time:

$$t_{aht} = t_s \qquad (1)$$

However, the situation in practice is often the opposite, which could be described as follows. In the case of equality (1), it would mean that the call and all related obligations terminate at the same time, and that the agent is ready for the next call immediately after the end of the call. This means that the agent has the skill to quickly describe the problem, since every interaction between the customer and the agent is transcribed. Accordingly, the agent knows well the work in the system, or forwarding the problem to other departments, which will be coordinated by the agent. In order to consider the time spent talking to the customer and the time the agent spends on completing the job, the call handling time is expressed as:

$$t_{aht_{ij}} = t_{c_{ij}} + t_{s_{ij}} \qquad (2)$$

where:

- $t_{c_{ij}}$ – is the time required to close the call after being interrupted by the customer;
- $t_{s_{ij}}$ – is the service time, or the actual time of the conversation with the customer.

Therefore, the AHT call rate is expressed as:

$$AHT = \frac{1}{n_i} \sum_{j=1}^{n_i} t_{aht_{ij}} \qquad (3)$$

The call handling time depends on several values:

- Call type PR_p - more complex problems require a longer solution time compared to simpler problems;
- Number of customer/user questions the agent answers during the conversation - some users tend to ask more questions, therefore requires agent to spend more time talking;
- The level of knowledge and system skills of the agent - the more knowledge the agent has about systems and services, the faster he can provide answers to user inquiries. A more experienced agent with a lot of knowledge can immediately answer the customer's question.
- Communication skills of the agent - the better the agent is able to facilitate and successfully conduct the conversation, the shorter call is expected.
- Considering these values, the proposed method for call rating will take both the performance and personal characteristics of the agent, since the t_{aht} combines call types, system skills, level and quality of knowledge, and communication skills of the agent.

B. First Call Resolution

A call that is resolved in the customer's first contact with the contact center and does not require an additional call is called the resolution of the first call. The percentage of such calls for one agent represents the FCR rate [14]. It is a measure that helps to prevent abuse of the call handling time measure, because the goal is not only to solve the call in the shortest possible time, but also the quality of the call resolution. Therefore, combining these two measures indicates efficient and effective call resolution. Efficient because it tries to shorten the service time, as well as the

call handling time, and it is effective that the call is resolved in the first contact and that the customer is satisfied with the service provided. From the customer's perspective, the call resolution is focused from "how quickly the case was resolved" to "how well" the call was handled. With this understanding, FCR has a major influence on the level of customer satisfaction. Customer dissatisfaction grows exponentially with each bad experience and often results in a lost customer [15]. The authors in the paper [16] state that no KPI (K*ey Performance Indicator*) has a greater impact on customer satisfaction than the resolution of the first call. Increasing satisfaction with fewer calls from the same customer results in lower operating costs. After all, the reduced risk that the user may switch to a more competitive company reduces the risk of income. When employees work with happy customers, they are more satisfied with their work and are motivated to provide better quality service. If an agent has to deal with repeated calls from frustrated customers, agent morale and service quality decrease.

To determine the resolution rate of the first call, we introduce the value $I_j, j = 1,2 \dots m$ for each call j as:

$$I_j = \begin{cases} 1 & problem \ solved \ in \ the \ first \ contact \\ 0 & customer \ calls \ for \ the \ same \ problem \end{cases} \qquad (4)$$

After that, the FCR call rate is calculated as the percentage of calls that were resolved in the first contact in relation to the total number of inbound calls.

$$FCR = \frac{1}{n} \sum I_j \cdot 100\% \qquad (5)$$

The FCR rate can be calculated for each individual agent or for the entire service system. As we can see, this measure did not specify the period between reconnections. The callback evaluation is related to each individual customer. The value of I_j can also be defined at the company level. For this paper and the data set used, an assumption was made, as in the papers [17], [18] and [19]: if the customer calls within 24 hours after the previous call, and it is the same type of call PR_I, it's considered as a call back. If the customer calls after more than 24 hours, it is considered as a new call.

The consequent relationships between the rate AHT and FCR for agents could be reflected in the following [13]:

- High AHT and high FCR - the agent provides quality, but takes a long time to serve the customer. For example, when the agent has little knowledge about the given problem, but in the end the user gets the desired answer, i.e., the problem is solved.
- High AHT and low FCR - the agent does not provide quality and takes a long time to resolve the case. This is the case, for example, when the agent has limited knowledge but keeps the customer waiting for a long time without providing the correct answer at the end. This is a worst-case call for a single contact center. It creates high operating costs and customer dissatisfaction.
- Low AHT and high FCR - the agent processes the call quickly and efficiently. This is the case when the agent knows the answer or can quickly search internally in the system, because he has the experience to get the necessary answer. All call centers want this situation,

because it results in a higher number of received calls and a decrease in waiting time for the customer, which results in an increase in QoS.

C. Proposed Call Rating Scale

The call rating value (O_p) (7) is get by combining five parameters, namely:

- Type of reported problem (PR_p),
- Observed working day $(d = 1,2, ... ,365)$,
- Total average call handling time $(\overline{t_{aht_d}})$,
- Observed working day $(d = 1,2, ... ,365)$,
- Handling time of each individual call of the agent $(t_{aht_{ij}})$,
- Minimum service time t_{min},
- Indicator variables (I_j).

The call type PR_p (where $p = 1,2,3, ... ,k$) is the type of problem reported by the customer, i.e., the reason for his call. It can be a report of a technical problem, a financial problem, an inquiry about new services, or something else. Types of problems are defined by the call center. In the evaluation process, we assume all problems do not have the same serving time, as in [17], [18] and [19]. Therefore, the call handling time is different for different types of problems. For example, technical calls require a longer service time compared to short information-type calls, which can last up to a few seconds. It is assumed that the arrival of service requests is exponentially distributed, which implies that the arrivals are mutually independent and do not influence each other.

When evaluating calls, it is very important to consider working days separately because the intensity of call arrivals is not the same during the working week. Some days are significantly busier than others. Therefore, in our method, we add the day of observation to each parameter $d = 1,2, ... ,365$.

The total average call handling time $\overline{(t_{aht_d})}$ is the average time required for all agents to process a call on the observed day. The value $(\overline{t_{aht_d}})$ can be set as a desired value within the contact center, determined by the company's management. This is most often done by taking the value for which it is verified that the observed problem can be solved in that period with the ideal conversation with the customer. In this research, the total value $(\overline{t_{aht_d}})$ is obtained as the ratio of the average value of the handling time of all agents in the observed working day and the total number of calls that they all had together. In this way, the agent is evaluated as part of the team he works with, and together they influence the individual call evaluations of that working day.

$$\overline{t_{aht_d}} = \frac{1}{N}\sum_{\substack{i=1 \\ j=1}}^{\substack{m \\ n}} t_{aht_{ij}} \qquad (6)$$

where $t_{aht_{ij}}$ is handling time of each individual call of the agent and calculated by equation (2).

The limiting factor in our method is the minimum service time (t_{min}). That is the minimum time for which any problem can be solved. The t_{min} variable was introduced to prevent agent hang-ups, since some agents (especially new hires), in case they have a large volume of calls and cannot coordinate their management, hang up the call to the user before the call is finished [20]. The t_{min} size prevents agents from manipulating call handling time $t_{aht_{ij}}$.

Indicator variables (I_j) show whether the call was resolved in the first contact and is calculated according to the equation (4). This variable is the limiting factor for both t_{min} and $t_{aht_{ij}}$ because the agents will try to solve the call in the first contact but satisfying the other criteria.

By combining the equations (2), (4) and (6) we get the final equation (7) for the rating scale in the interval from 1 to 5.

$$O_p = \begin{cases} t_{aht_{ij}} < t_{min} & 1 \\ t_{aht_{ij}} \geq \overline{t_{aht_d}} \wedge I_k = 0 & 2 \\ t_{aht_{ij}} < \overline{t_{aht_d}} \wedge I_k = 0 & 3 \\ t_{aht_{ij}} \geq \overline{t_{aht_d}} \wedge I_k = 1 & 4 \\ t_{min} \leq t_{aht_{ij}} \leq \overline{t_{aht_d}} \wedge I_k = 1 & 5 \end{cases} \qquad (7)$$

With this method, time-continuous variables, such as call handling time, are mapped into a discrete space suitable for classification algorithms, such as KNN (*K-Nearest Neighbor*), logistic regression, SVM (*Support Vector Machine*). Discrete call ratings create conditions for intelligent call routing based on machine learning methods, which is in the research phase.

According to the proposed evaluation model, the analyzed contact center has opportunities for improvement in terms of key business parameters of the contact center, considering the parameters covered by this work. This way of evaluating calls has several effects for all actors in the contact center: users, agents, and the system in general (Fig. 1.). This evaluation method improves the FCR rate and shortens the service time, which are two of the main factors in customer satisfaction. Customers expect quick resolutions to problems because they don't enjoy reaching out to agent multiple times for the same queries. A low FCR rate means fewer callbacks for agents, and shorter service time directly affects shorter call handling time. All these parameters affect lower operational costs that are directly related to the KPI of the contact center.

Created call ratings are the basis for objective measurement of agent productivity. Objectively measuring the agent's productivity is a real challenge, since the real value of the work done by the agent is actually the information it has given to the user.

D. Data Collection

For this research, operational data of the bank's contact center were used, collected during twelve months of one year, at the level of individual phone calls. The database consists of 444,448 phone calls, with a complete history of call movement through the contact center. Only calls in which the user spoke to an agent were taken into account for rating the calls in the data set used, a total of 154, 441 calls.
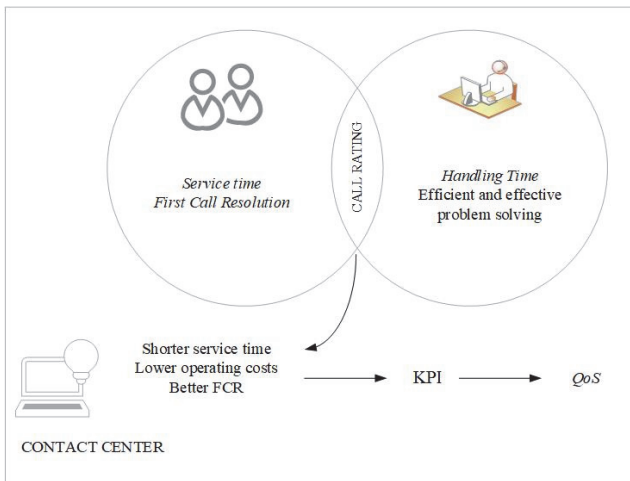
Fig. 1. Influence of the call rating on individual actors of the service system.

IV. Result and Discussion

All calls with a service time less than 25 seconds were rated with the worst rating of 1. In consultation with the management of the company that owns this data, it was concluded that in a given contact center there was a tendency for agents to terminate calls in order to have better handling times. After discovering that problem, they were able to reduce short calls with call control, which can be seen in Fig. 2. A service time less than 25 seconds is not enough to provide service or solve any of the problems. This means that on this data set it will be t_{min}= 25 seconds. Fig. 2 shows how much the call score proposed in this paper can reveal hidden behaviors in the system. It is sufficient for the company to adopt t_{min}, which it does not accept as sufficient service time, and to check which agents belong to that group. Every call center draws its own baseline that measures the overall performance objectively according to the ultimate call center objectives and strategies [21]. The schedule of calls by all grades on a monthly basis is shown in Fig. 3.
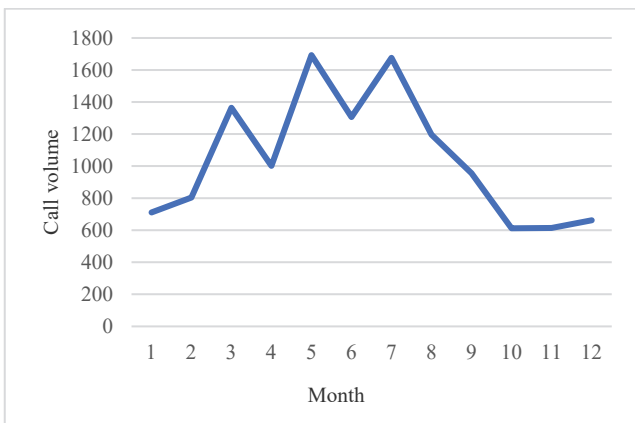

Fig. 2. Monthly display of the volume of short calls - rating 1.

Fig. 3. proves that the agent's productivity can be considered in this way, e.g., it is possible to look for a reason for the sharp increase in calls rated 2 and 3 in the tenth month. This means that agents started handling calls

with longer handling times by failing to resolve the call on first contact. A more detailed analysis of the data set, applying traditional methods of contact center analysis, while observing the individual calls of each agent by day and month, shows that in the eighth month there was a change of staff in the contact center. Some agents left the workplace, and new ones with less work experience came.
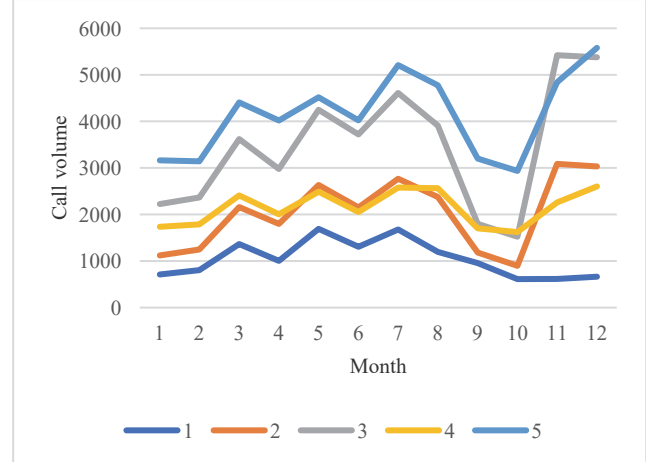

Fig. 3. Monthly presentation of the volume of calls according to assigned grades.

Objective evaluations show that this is a good measure for assessing the capabilities of the contact center as a whole, as well as the impact of staff turnover on service performance.

This evaluation method enables the comparison of agents according to the method of call performance. As we can see in Fig. 4. and Fig. 5., the agent (each agent is individually marked with code $An, n = (1,2,3 \ldots 24)$ with the highest call volume does not mean that he is the best in terms of the parameters included in O_p. For example, agent A22 has the highest call volume, but not 5-rated calls.
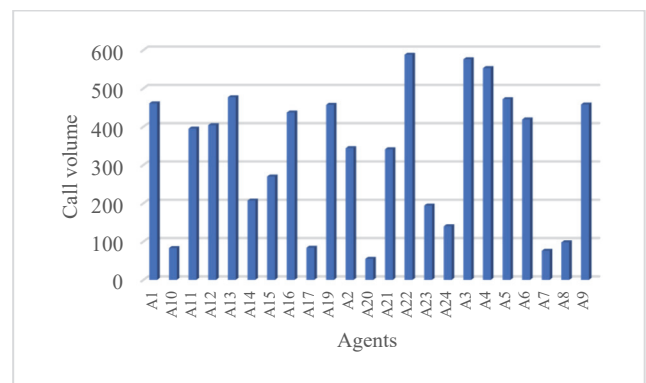

Fig. 4. Total number of calls in the 10th month per agent.

On the other hand, from Fig. 6., we can see the proportion of callbacks during the 10th month. These are calls rated 2 and 3. We can see that there were a total of 2418 callbacks in one month. In this way, companies can set goals for reducing callbacks in the following month, for example, by 30%. For example, if we compare, agent A5, who has the most calls during the 10th month and is only third in terms of the volume of calls rated 2 and 3, this means that the success of his calls rated 4 and 5 is very high and this agent has quite high-quality call performance.
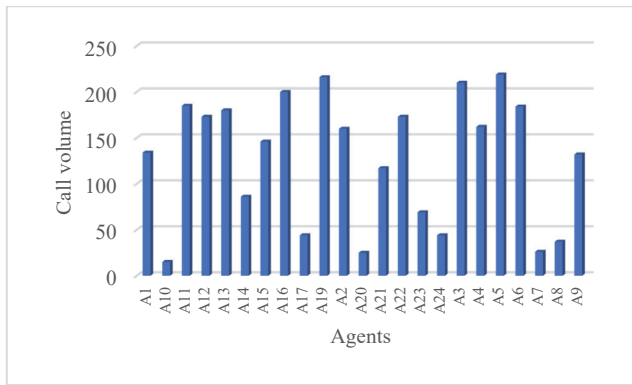
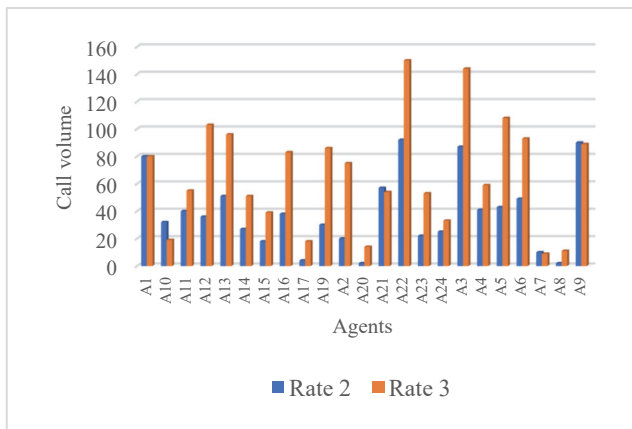Fig. 5. Total number of calls rated 5 in the 10th month per agent.

Fig. 6. Total number of calls rated with 2 and 3 in the 10th month per agent.

If a consequential connection is made between call handling time and first contact call resolution, inspired by [13], then the following conclusions are reached:

- Shorter call handling time ($t_{aht_{ij}}$) and resolved the call in the first contact - the agent processes the call quickly and efficiently. Such agents have absolute control over the conversation with the user, as well as the knowledge necessary to resolve the call in a quality way and so that the user no longer calls the contact center about the same. All call centers are interested in this situation, because it results in a higher number of received calls, reduced waiting time for the user, a higher FCR rate, which ultimately affects the increase of QoS [15], [16].
- Longer call handling time ($t_{aht_{ij}}$) and resolved the call in the first contact - the agent provides quality, but takes a long time to serve the customer. This outcome may be a consequence of the communication skills of the agent (asking the right questions that lead to a faster solution to the problem), his personal qualities in terms of directness and dexterity. This situation can also mean a lack of knowledge for a given problem, but also navigating the system to obtain the necessary knowledge, the ability to keep the customer patient on hold and, in the end, to provide a service that means a complete solution to the customer's problem. In short, it can be said that the agent effectively solves the problem from the QoS point of view, but the solution is not efficient from the point of view of operational costs of the contact center, since the

service time is actually an unavoidable cost that is tried to be minimized with every interaction, which has been repeatedly emphasized.

- Shorter call handling time ($t_{aht_{ij}}$) and an unresolved call in the first contact – the agent has a shorter conversation time, but does not resolve the call in the first contact. This means that the agent takes care of the service time, but in such situations gives superficial information about the customer's problem, which results in the customer calling the contact center again for the same problem, thus impairing the objective *Quality of Experience (QoE)*. This is an unacceptable case of calls for one contact center, because it creates high operating costs, unnecessary repeated calls, and user dissatisfaction.
- Longer call handling time ($t_{aht_{ij}}$) and an unresolved call in the first contact - the agent does not provide quality and takes a long time to solve the case. This means that the agent has limited knowledge, unnecessarily keeping the customer on hold for a long time without providing the correct answer to the query.

Since the given rating can only be created 24 hours after the call (because of the variable I_j), to create a rating call and to update the database, which stores that rating, is done at the end of the working day, as an offline process during the period when the contact center is not working. This significantly reduces the overall load on the system. The system monitors the call data and determines whether the call was successful or not, assigns a rating in the interval from 1 to 5. This significantly reduces the load on the system.

V. CONCLUSION AND FUTURE WORK

In this paper, an evaluation method for creating call ratings in a completely objective way is proposed. The proposed method is the basis for further call routing. From the customer's point of view, this method aims to shorten the service time and solve the problem in the first contact. Agents are evaluated objectively without subjective bias, taking care of the work team. The advantage of this service system is in the metrics used to obtain a given rating, which are key KPI indicators of successful contact center operations.

This way of evaluating calls is the basis of the framework for measuring the productivity of agents. A call is a combination of two sides, the customer and the agent. Based on the rating, the call can be classified, including the characteristics of the call and the interaction with the agent. It is suitable for the application of machine learning classification methods. On the other hand, the advantage of this call evaluation is that it can be the basis for creating a customer profile, so the customer will be directed to those agents who can achieve the minimum conversation time while best meeting the customer's requirements.

For future research, we suggest creating a new call routing model, which will contain introduced call rating parameters, because the discrete evaluation combines several different parameters that take on specific values.

Such call routing can be based on the principles of artificial intelligence. It would be interesting to compare call routing using machine learning versus traditional call routing methods. Also, we will try to compare the call evaluation presented in this research, with the evaluation that would be carried out by supervisors on the same calls, including experiments on such larger data samples. We are aware that manual commenting is quite demanding, from an organizational and economic point of view. This would really show the true effectiveness of this objective data extraction on call outcome.

REFERENCES

[1] J. A. Fitzsimmons and M. J. Fitzsimmons, *Service Management: Operations, Strategy, Information Technology*, Seventh Ed. 2001. [Online]. Available: https://industri.fatek.unpatti.ac.id/wp-content/uploads/2019/03/272-Service-Management-Operations-Strategy-Information-Technology-James-A.-Fitzsimmons-Mona-J.-Fitzsimmons-Edisi-7-2010.pdf

[2] M. Paprzycki, A. Abraham, R. Guo, and S. Mukkamala, "Data mining approach for analyzing call center performance," *Lect. Notes Artif. Intell. (Subseries Lect. Notes Comput. Sci.*, vol. 3029, no. Section 3, pp. 1092–1101, 2004, doi: 10.1007/978-3-540-24677-0_112.

[3] D. Sharp, *Call Center Operation Design, Operation, and Maintenance*. Digital Press, 2003.

[4] A. Ahmed, Y. Hifny, S. Toral, and K. Shaalan, "A call center agent productivity modeling using discriminative approaches," *Stud. Comput. Intell.*, vol. 740, no. January, pp. 501–520, 2018, doi: 10.1007/978-3-319-67056-0_24.

[5] K. Breuer, P. Nieken, and D. Sliwka, "Social ties and subjective performance evaluations: An empirical investigation," *Rev. Manag. Sci.*, vol. 7, no. 2, pp. 141–157, 2013, doi: 10.1007/s11846-011-0076-3.

[6] A. R. Ali, "Intelligent call routing: Optimizing contact center throughput," *Proc. 11th Int. Work. Multimed. Data Mining, MDMKDD'11 - Held Conjunction with SIGKDD'11*, pp. 34–43, 2011, doi: 10.1145/2237827.2237832.

[7] O. Rashid, A. M. Qamar, S. Khan, and S. Ambreen, "Intelligent decision making and planning for call center," *2019 Int. Conf. Comput. Inf. Sci. ICCIS 2019*, pp. 1–6, 2019, doi: 10.1109/ICCISci.2019.8716472.

[8] N. Mehrbod, A. Grilo, and A. Zutshi, "Caller-Agent Pairing in Call Centers Using Machine Learning Techniques with Imbalanced Data," *2018 IEEE Int. Conf. Eng. Technol. Innov. ICE/ITMC 2018 - Proc.*, 2018, doi: 10.1109/ICE.2018.8436314.

[9] R. A. Mohammed and P. Pang, "Agent personalized call center traffic prediction and call distribution," *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, vol. 7063 LNCS, no. PART 2, pp. 1–10, 2011, doi: 10.1007/978-3-642-24958-7_1.

[10] M. C. F. Pontes and C. O. B. Kelly, "The identification of inbound call center agents' competencies that are related to callers' repurchase intentions," *J. Interact. Mark.*, vol. 14, no. 3, pp. 41–49, 2000, doi: 10.1002/1520-6653(200022)14:3<41::AID-DIR3>3.0.CO;2-M.

[11] Y. Park and S. C. Gates, "Towards real-time measurement of customer satisfaction using automatically generated call transcripts," *Int. Conf. Inf. Knowl. Manag. Proc.*, pp. 1387–1396, 2009, doi: 10.1145/1645953.1646128.

[12] B. Karakus and G. Aydin, "Call center performance evaluation using big data analytics," *2016 Int. Symp. Networks, Comput. Commun. ISNCC 2016*, 2016, doi: 10.1109/ISNCC.2016.7746116.

[13] I. Brantevica, "Investigating the relation between First Call Resolution and Average Handling Time in a call center," *Res. Pap. Bus. Anal.*, no. 2595788, 2018.

[14] S. J. Willis and M. Bendixen, "A Review of Call Center Measurements," 2007, [Online]. Available: http://www.poms.org/conferences/cso2007/talks/30.pdf

[15] H. Singh, "The Importance of Customer Satisfaction in Relation to Customer Loyalty and Retention by Harkiranpal Singh May 2006 UCTI Working Paper," *UCTI Work. Pap.*, no. May, p. 6, 2006.

[16] Sumit Agarwal, Deepak Singh, and K S Thakur, "Performance indicators and customer satisfaction: with special reference to selected call centers of India," *Int. J. Arts Commer.*, vol. 2, no. 2, pp. 13–26, 2013.

[17] B. Legros, O. Jouini, and Y. Dallery, "A flexible architecture for call centers with skill-based routing," *Int. J. Prod. Econ.*, vol. 159, pp. 192–207, 2015, doi: 10.1016/j.ijpe.2014.09.025.

[18] J. Chen, J. Dong, and P. Shi, "A survey on skill-based routing with applications to service operations management," *Queueing Syst.*, vol. 96, no. 1–2, pp. 53–82, 2020, doi: 10.1007/s11134-020-09669-5.

[19] G. Koole and A. Pot, "An overview of routing and staffing algorithms in multi-skill customer contact centers," *Submitt. Publ.*, pp. 1–42, 2005, [Online]. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.97.1714&rep=rep1&type=pdf

[20] P. D. Feigin, "Analysis of Customer Patience in a Bank Call Center," 2006.

[21] J. C. Abbott, *The Executive Guide to Call Center Metrics*. Robert Houston Smith Publishers, 2004.

[22] E. Avdagić-Golub, N. Goran, B. Memić, M. Begović and B. Karahodža, "A New Evaluation Method for Call Rating in Contact Center," 2022 *30th Telecommunications Forum (TELFOR)*, Belgrade, Serbia, 2022.