Improving the software engineering algorithm for business

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Abstract. The changes that have occurred in the business landscape due to COVID-19 present marketologists and entrepreneurs with new problems. The forced trend of a sharp increase in online interaction with consumers should be used. Such global shifts give rise to innovative tools for evaluating commercial results and transform old techniques to correspond to the new reality of the market. This is the basic condition for a business to sustain in any industry. This paper focuses on developing a theoretical description of the multi-stage interaction with the customer base. In order to solve this problem, a mathematical model was developed at the base of which is a digital information interaction, starting with identifying the target audience and finishing with a completed commercial transaction. Unlike the classical sales funnel, the algorithms presented allow a multi-dimensional conversion funnel to be used for more than just evaluating the results of business for the accounting period. Thanks to a stream of arguments for the model in real time, it is becoming possible to optimize the commercial process by moving to the concept of leading economic indicators.

1. Introduction
The retail audit of the first half of 2020 showed that new processes are developing in the field of e-commerce [1]. If earlier this channel served for the purchase of large durable goods and online purchases on the global Internet sites of large aggregators, now the processes of a shift in the center of gravity of consumer interest towards the purchase of everyday goods are clearly observed. The sharp increase in purchasing activity in the FMCG [2] segment was noted in the Nielsen survey and defined as a long-term trend. Among the cardinal changes in the structure of consumer demand [3], the growth of purchases from mobile devices, cross border, and work on the D2C (direct to customer) model also stand out. It was also noted that if in 2019 the entire e-commerce segment of the Russian Federation amounted to 4172 billion rubles, then in the first half of 2020, under the influence of COVID19, the growth in online purchases [4] will be significantly higher than the level of the same period of the previous period. This is primarily due to the influence of the new reality caused by the pandemic. At the same time, these difficulties gave impetus to the expansion of online trade, and this process continues even after the weakening of quarantine measures, since the population appreciated the advantage of such purchases. Changing consumer behavior is also reflected in Nielsen's review, as 4.2% growth in Internet coverage.
It is noted that the segment of the mobile Internet has also grown, which is used by 86.2 million people, which is 70.5% of the population of Russia. For mobile apps [5] to be effective, science-based algorithms [6] are needed that use real-time feedback on consumer activity data.

2. Statement of the research problem
Forecasting required for effective business operations [7] must consider many stages of interaction with the consumer pool. The sales funnel [8] view of the process used in analytics is widely used for measuring sales results [9]. However, such a tool is designed for offline sales and is nothing more than a convenient abstraction. In addition, the results of using the sales funnel are limited by the fact that lagging indicators appear in this model [10]. The processes taking place in online trade allow radically transforming the use of sales funnel and turning it into a powerful business forecasting tool with the ability to objectively assess all stages of commercial interaction. For such a transition, it is necessary to formulate the fundamental differences in its application at the present stage. Since the initial and final stages, respectively: prospecting, unqualified leads and deliver the product represent basically the same set of consumers, but the sources of awareness and loyalty are completely different. If the sales funnel uses cold call interaction methods, then in online mode these will be landing page, targeted page, blog posts and online order tracking, deliveries and invoicing, online tracing, respectively. You can also interpret transitions [11] from offline modes for the discovery, evaluation, intent, purchase stages. This will be, respectively: qualifying leads, initial meeting, define prospects needs will be transformed into content, marketing, inbound marketing, online ads, opportunity size; make an offer will be a set of SEO (search engine optimization), SEM (Search Engine Marketing), viral campaigns, social media, IFO (Irresistible Free Offer); negotiation, finalize proposal turns into site registration, subscription options of supply stages [12]. Separately, we note the transition from closing the deal, which now looks like: system for making orders, online payment. The task of this study is to formally describe the stages of online interaction, to draw up a mathematical model and to find methods for optimizing the commercial process in this paradigm.

3. Mathematical model
Since the process of interaction with consumers of goods [13] and services is divided into a number of stages, we introduce the corresponding axis $X$. The client moves along this axis, moving between the stages of the commercial process from the initiation of his interest to the final transfer of money. For a quantitative description of the situation in dynamics, at each stage along $X$, we will postpone a value $Q$ numerically equal to such commercial indicators [15] as customer requests, offers made, contracts concluded, etc [16]. A decreasing number of potential consumers goes to each next stage. Thus, we have a functional dependence $Q(x,t)$ not only along the axis of the stages $X$, but also on time $t$. Such formalism reflects the level of demand of potential consumers who are at the moment $t$ at the stage $x \in X$ for the proposed product or service. If we determine the virtual shift of the consumer starting from $t = t'$ along $X$ starting from a certain stage $x_1$ to the next $x_2$, then the following expression can be written to estimate the losses $W$ of potential customers [17]:

$$W = \frac{Q(x_2, t') - Q(x_1, t')}{x_2 - x_1}.$$  

This indicator is called the bounce rate and is used to determine the efficiency of commercial services [18] at this stage. The limiting values during the transition $x_1 \rightarrow x_2$ give an instantaneous value $W$ numerically equal to the partial derivative: $\lim_{x_2 \rightarrow x_1} W = -\frac{\partial Q}{\partial x}$. Thus, the bounce rate level changes along the axis $X$ and the essence of the variable $W$ is the degree [19] of narrowing of the sales funnel. Physically [20], this means the ratio of the number $-\frac{\partial Q}{\partial x} \Delta t$ of potential customers who have passed to the stage $x_i$
over the period $\Delta t$ of time to the reduced number of them $-\frac{\partial Q}{\partial x_{i}} \bigg|_{x_{i}=x_{i-1}} \Delta t$ at the exit from $x_{i}$. This is expressed [21] by the ratio: $(W(x_{i}) - W(x_{i})) \Delta t = -\frac{\partial Q}{\partial x_{i}} \bigg|_{x_{i}=x_{i-1}} \Delta t - \left(-\frac{\partial Q}{\partial x_{i}} \bigg|_{x_{i}=x_{i-1}} \Delta t \right)$.

4. The business quality model

The obtained mathematical description [22] must be associated with indicators of the quality of doing business. To do this, we will introduce a function $g(x)$ to take into account the KPI index, which determines the efficiency of organizing a commercial process [23] at a stage $x = x_{1}, x_{2}, ..., x_{N}$, where $N$ is the number of interaction stages. Such an integral indicator reflects both the degree of interest of potential customers, and the professionalism of developers of business schemes, mobile applications and the level of use of technological opportunities of online trading. The quality of work [24] at the stage $x$ is the higher, the more it matters $g(x)$. Moving on to the concept of conversion at a stage $x$, its level is determined from the formula: $g(x)^{-1}\Delta x (Q(x,t_{1}) - Q(x,t_{1})) = g(x)^{-1}\Delta x \Delta Q$. For formalized accounting [25] of the adverse impact of the competitive environment on the bounce rate level $W$, it is also necessary to introduce a function $D(x,t)$. This integral indicator takes into account the activities of competitors that distract part of the client pool, changes in legislation, and the influence of other market factors. The general equation of dynamics in this case has the form:

$$-\frac{\partial Q}{\partial x_{i}} \bigg|_{x_{i}=x_{i-1}} \Delta t - \left(-\frac{\partial Q}{\partial x_{i}} \bigg|_{x_{i}=x_{i-1}} \Delta t \right) = g^{-1}(\Delta x (\Delta Q - D(x,t)) \Delta t),$$

which allows using the Lagrange theorem to write down the dynamic model [26] of the process in the form: $g \frac{\partial^{2} Q}{\partial t^{2}} + D(x,t) = \frac{\partial Q}{\partial t}$. Next, let's link the KPIs. For this, the performance of the means of interaction [27] with consumers is denoted as $\mu_{i}$, where $n$ is the number of the stage along the axis $X$. The density of requests at the entrance $x_{i}$ will be denoted as $\lambda_{i}$, the number of interaction channels [28] available for clients is equal $m$ (for example, software-implemented mobile applications). We calculate the conversion using the formula:

$$g_{n} = 1 - \frac{\lambda_{n}^{m+i}}{m^{i} \mu_{n}^{m+i+m}} \left[\sum_{k=0}^{m} \frac{\lambda_{n}^{k}}{m! \mu_{n}^{k}} + \frac{\lambda_{n}^{m+i}}{m! \mu_{n}^{m+i}} \left(1 - \frac{\lambda_{n}}{m \mu_{n}}\right)^{m-i}\right].$$

In this case, the impact of the competitive environment $D(x,t)$ is taken into account by the losses $v(t)$ of potential consumers calculated by:

$$D(x,t) = 1 - \frac{v(t)}{\lambda} \left[\sum_{k=0}^{m} \frac{\alpha_{n}^{k}}{k! \mu_{n}^{k}} + \frac{\alpha_{n}^{m}}{m! \mu_{n}^{m}}\right] \frac{\alpha_{n}}{m!} Y,$$

where it is accepted: $\alpha_{n} = \lambda_{n} / \mu_{n}$; $Y = \sum_{k=1}^{\infty} \frac{\alpha_{n}^{k}}{(m+k) \mu_{n}} v(t)$.

5. Calculation

To calculate the dynamics of the business process, we calculate the input flow of potential customers using the Verhulst equation. In this case, we will take $Q_{0}(t)$ the volume of potential consumers at the beginning of the promotion, $\Omega$ - the supporting capacity of the market, $\theta$ - the dynamics of consumer preferences. We use the ratio: $\frac{dQ_{0}(t)}{dt} = \theta Q_{0}(t) \left(1 - \frac{Q_{0}(t)}{\Omega}\right)$. Online interaction process Fig. 1 is calculated using the presented model. Fig. 2 shows the result of calculating the optimal business
interaction. For this, when calculating by the mathematical model, the exponential regression decrement indicator was used [29]. The calculation results allow us to summarize data on the quality of the organization of the commercial process, convenient for practical use (table 1).

![Figure 1. General process modeling.](image1.png)  
![Figure 2. Finding the optimal solution.](image2.png)

**Table 1.** Degree of commercial service quality.

| The level of the commercial service                              | Decrement at N=8 | Decrement at N=12 |
|-----------------------------------------------------------------|------------------|-------------------|
| Optimal interaction at all stages                               | 0.1              | 0.08              |
| Well-organized business process                                 | 0.14             | 0.12              |
| There are reserves for improving the quality of interaction     | 0.21             | 0.18              |
| There is a loss of potential customers                          | 0.3              | 0.22              |
| Weakly organized commercial service                             | 0.42             | 0.27              |
| Poor customer service, most consumers refuse goods and services| 0.5              | 0.32              |

6. Conclusion

The sales funnel came about as a method for evaluating a company’s work with customers. At the same time, this tool is effectively used for businesses which characteristically have a long sales process and for which a high level of interaction with potential consumers of goods and services is important and which also actively attract new costumers. In this type of offline trade, the use of a sales funnel is acceptable in the B2B and B2C segments. A qualitative leap in the level of online commerce over recent months has been accompanied by a transition of the interaction process to internet resources as well as by an expansion of the spectrum of D2C interaction. The conversion rate of potential consumers depends specifically on the development quality of sites, trade portals, platforms, and integration with other services when moving from one stage of the interaction to another. Thus, the process is transformed into a conversion funnel. Despite the similarity in the purpose of the processes within these two tools for promoting goods and services, they are fundamentally different. First, it is a transition to a digital virtual interaction and real-time work. Second, the wide popularity of the aggregator sites gives greater opportunities to reach the client base. Finally, and most importantly, it opens up the possibility for commercial businesses to adjust their strategy of market interaction and to optimize all stages of the business process using algorithms based on leading economic indicators.

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