Simulation With Arena: Optimization Of Delivery Times In Quick Commerce Of A Company In The Building Materials Sector

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Abstract:

Background: E-commerce is a business model that has been gaining a lot of ground in recent years because it offers customers greater convenience, making it possible to make a purchase from anywhere using an electronic device connected to the internet. Despite offering benefits not only to the customer, but also to companies, along with these advantages come problems related to the time it takes from purchase to delivery. The purpose of this article is to indicate the main complications faced in the process of preparing and delivering orders to meet the lead time proposed for the market and to present a solution to the bottleneck.

Materials and Methods: The research used experimental and quantitative methodology, using the Arena platform to manipulate numerical data and test variable hypotheses by measuring the resulting effects.

Results: In the end, we concluded that it is possible to meet the customer's expected preparation time without facing bottlenecks during the process.

Conclusion: In this way, the Arena software contributes to the process optimization method, showing the bottlenecks and achieving the process objective, given that the company's goal was to reduce the total time it took for the order to pass through the system.

Key Word: E-Commerce; Logistics Process; Simulation; Arena.

I. Introduction

In 1999, a year of great importance for e-commerce in Brazil, the big players in the domestic market emerged, such as Americanas and Mercado Livre, companies that are still the biggest names in Latin America today. Among the definitions of e-commerce is the buying and selling of products, information and services via the computer network, explains (NAKAMURA. 2011, p.14). The big turning point in e-commerce came in 2020, during the COVID-19 pandemic, when people were forced to remain isolated and traditional, face-to-face commerce was unable to function. Many people turned to online shopping and, as a result, Brazilian e-commerce grew by 47% in the first half of 2020, its highest growth in 20 years (SCHNAIDER, 2020)

Over the last few years, companies have done everything they can to stand out in the ecommerce market, where all their competitors are operating and increasingly offering differentiated services, and so the concept of Quick Commerce emerged. Also known as Q-commerce, this model has its origins in food delivery systems, but has been adapted to deliver other types of products. According to SEBRAE - Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (2023), literally translated as "quick commerce", the term represents a type of sale that involves an immediate delivery strategy, which can be within hours or minutes of the purchase being made remotely.

With this new scenario also comes a new challenge. Companies are trying to adapt to this current demand without affecting the quality of their deliveries. For this reason, the purpose of this article is to present real data from a company in the building materials and DIY sector, carry out an analysis using Arena software, raising hypotheses that solve specific problems in the operation to avoid bottlenecks in its stages. The article will use exploratory research to gather data on the phenomenon and then formulate more precise hypotheses. From there, it will adopt the experimental research methodology, making changes to the variables and testing the data collected on the Arena software platform to arrive at the expected result.

After simulating a few hypotheses, it was possible to see a 41% improvement in order preparation time, or lead time, which includes starting with the purchase of the product, sorting, invoicing, packaging and transportation until delivery to the customer, completing the cycle. As a secondary result, it was possible to equalize and better manage the use of human resources that were previously employed in product picking, where they had the biggest bottlenecks, to meet peaks at specific times, resulting in greater productivity for the entire operation.

In conclusion, the use of Arena software proved to be an important simulation tool even in a new environment such as Quick Commerce, adapted to a specific operation such as the building materials trade, and even so, it brought excellent results and can serve as a basis for future studies related to the area.

II. Theoretical Background
The following are the main topics that will guide the concepts covered in the article.

Simulation
Nowadays, with technological progress, the use of methods such as simulation has become quite common, facilitating and helping with difficult and risky decisions, as it offers confidence and greater certainty. According to Michaelis (2016), to simulate is to reproduce a procedure or situation as accurately as possible.

Paragon (2005) points out that, due to increased competitiveness in the market, simulation has become a powerful and indispensable tool, helping with planning, projects and systems control. It is considered one of the most widely used tools for analyzing projects, operations and processes, as this technique is a highly reliable quantitative tool for the systems under study.

Arena Software
There are currently a number of software programs that carry out simulations, largely due to the high demand at the moment. Companies are increasingly looking for these resources. Among these is Arena, from Rockwell Software. It is used to carry out simulations in a logical and highly dynamic way, identifying improvements in operating conditions, such as bottlenecks, queue visualization, waiting times, resource occupation and system behavior.

Arena software is one of the most widely used in the design of computer simulators with an integrated graphical environment. The software has resources for statistical analysis, process modeling, animation and analysis of results (PARAGON, 2019). According to Silva (2017), Arena is a program used to model the most varied environments, simulating a set of processes used in manufacturing, services and others. Like other computer simulation software, Arena is used to visualize the system to be modeled, consisting of a set of workstations that provide services to customers. It is used to simulate the most diverse environments, from production lines to the flow of customers queuing in stores or banks.

According to Paragon (2005), Arena has templates, which are models that make up the chosen formula. These are groupings that help to illustrate the procedures by means of flowcharts that stage the probabilities. According to Paragon (2005), the templates are made up of the following modules:
- Create module : Where the entities for simulation are created;
- Process Module : The entities are maintained during the execution of the activities;
- Decide module: This is applied when there are multiple continuation options at a flow point;
- Dispose   module : Where entities are removed from the system.

Figure 1: Arena platform model
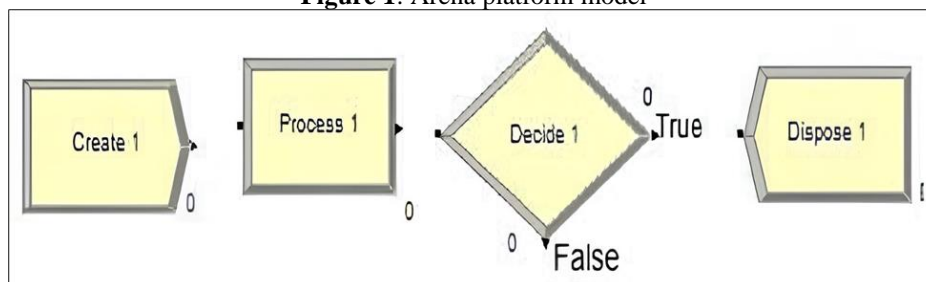
Source: Authors

According to Prado (2014), each designer must check each report with its due relevance to contribute to decision-making.

E-Commerce

According to SEBRAE (2016), online commerce or e-commerce is an essential part of digital business. It is the commercial activity that establishes the electronic link between the company and the customer for the sale of products or services, following the strategy defined by the digital business. According to SEBRAE (2016), there are four types of commercial transactions:

- B2B - which stands for "Business to Business '' or business to business: This is the term used for commercial transactions between companies. Many companies use this type of e-commerce to relate to their suppliers, placing orders, receiving and paying invoices, exchanging information and finding new partners, among other things;

- B2C - stands for "Business to Consumer": In this category, the company sells directly to the consumer. A particular consumer goes to the company's website in search of a product; looks for information about the product, such as the technical manual, how it works, price, delivery time, technical assistance; makes the purchase and pays by bank deposit, bank slip, credit card or internet banking.

- B2G - stands for "Business to Government", which refers to commercial relations between companies and government: It covers all transactions between companies and government organizations. Some state governments have already started to implement electronic invoicing, which in addition to reducing the use of paper has also made it possible to increase tax collection;

- C2G - also known as "Citizen to Government", i.e. interactions between citizens and the government: with the growth of the business-to-consumer and business-to-government categories, governments can expand their electronic interactions with the consumer, as is the case with online tax returns.

Quick Commerce

According to SEBRAE (2023), Quick Commerce is an extremely relevant trend for traders, as it implies speed and excellence in delivery. Literally translated as "quick purchase", the term describes a sales method that involves agile delivery. In this format, there is more than just simple shipping. Customers place an order remotely and receive their purchases within a few minutes or hours.

Building materials store

According to SEBRAE (2021), a building materials store is a commercial establishment dedicated to the sale of tools, utensils, parts and raw materials necessary for the construction and renovation of homes, apartments and residential or commercial buildings. Thus, both essential materials, such as blocks, tiles and cement, and more refined finishing materials, such as light bulbs, wires, paint, light fittings, flooring and showers, are sold in building materials stores. The main difference between small/medium-sized building materials stores and large ones is that the former focus on "essential" materials such as lime, cement, wood, nails, electrical material and lighting, while large stores are considered generalists and offer a wider variety of products, including even decorative pieces and household appliances. Today, materials can be simple or composite, obtained directly from nature or manufactured industrially. There are several options for different uses, as well as different properties and varieties of the same material.

III. Material And Methods

In the article in question, the experimental and quantitative method was applied, using the Arena platform to manage numerical data, test variable hypotheses and measure the effects of the results.

The following materials and methods were used to apply simulation with Arena to optimize delivery times in Quick Commerce:

Materials:
1. Historical delivery data from Quick Commerce, including information on orders delivered after the deadline.
2. Arena software, a widely used tool for modeling and simulating processes.
3. maps and geographical information of Quick Commerce's delivery areas.

Methods:
1. Collection and analysis of historical order data to understand the current process and identify possible bottlenecks or areas for improvement.
2. Definition of simulation parameters, such as processing time, product separation, delivery times, among others.
3. Analysis of the results obtained in each scenario to identify the best strategies for optimizing delivery times.
4. Drawing up conclusions and recommendations based on the simulation results.

Following the flowchart
The order entry and exit operation of the company studied takes place within 5 processes, as shown in Figure 2.

Figure 2: Flowchart of the e-commerce order process
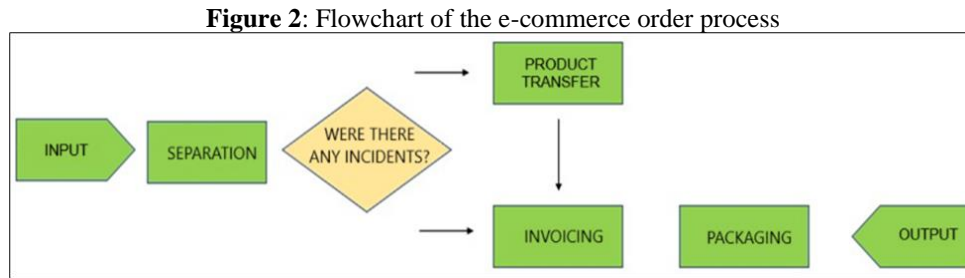
Source: Authors

To collect the times, we used the report from the company's picking department and randomly selected 70 orders with different processing times given in minutes.
The times were entered into the Input Analyzer to run the process in Arena.
The times (given in minutes) were:
- Order entry into the system: between 1 and 60 minutes;
- Separation: between 1 and 46 minutes;
- Product transfer: between 61 and 180 minutes; - Billing: between 1 and 7 minutes;
- Packaging: between 1 and 5 minutes.

Table 1 shows the table with the 70 random times. From this table, it was possible to extract the numerical expressions that are used within the Arena platform. The data was processed and transformed into minutes.

Table 1: Processing times for each process in minutes

Interval between orders							Separation time						
5	10	20	40	10	20	20	2	26	26	46	46	1	7
30	10	10	10	30	16	1	2	3	8	15	6	1	16
3	10	10	15	5	10	10	4	5	8	18	8	12	39
10	20	10	10	10	10	10	4	7	28	24	27	2	4
10	10	40	20	10	30	20	6	4	2	3	1	7	7
20	10	10	10	10	10	10	1	3	17	15	9	1	9
10	10	10	10	10	10	10	5	4	3	15	16	17	1
10	10	10	10	20	30	20	1	1	8	3	7	12	15
10	10	10	10	10	10	20	15	1	1	1	6	1	1
10	20	1	9	60	10	30	23	36	9	6	3	1	15
Tempo de Transferência de produtos							Billing time (invoice issuance)						
117	87	71	147	136	61	73	7	3	7	4	4	2	6
94	134	171	122	148	119	98	7	4	2	6	6	5	3
172	91	166	150	180	176	61	5	7	5	2	7	2	4
94	139	101	143	105	76	177	6	6	5	4	7	3	5
151	123	91	119	78	87	136	7	2	4	4	3	5	5
94	134	139	75	98	118	102	7	6	2	3	4	4	7
173	119	110	120	86	107	61	5	3	7	4	4	3	3
142	146	61	143	146	152	118	4	4	6	4	2	5	6
109	171	112	156	76	171	122	7	4	2	6	5	6	2
91	142	129	140	161	150	154	6	7	5	6	2	7	4
Packaging time													
4	2	5	2	5	3	3							
4	1	4	4	5	4	4							
1	5	3	3	2	2	3							
1	5	2	2	4	4	3							
5	3	2	3	2	1	1							
3	5	5	2	5	3	2							
2	2	3	2	2	4	4							
5	4	3	1	3	2	3							
1	3	3	3	2	3	5							
4	3	3	5	5	1	1							

Source: Authors

Processing incoming orders

Orders are created via electronic platforms such as a website, application or telephone. From then on, the order generated is recorded in the company's own system, and can be consulted by any employee using their LDAP - Lightweight Directory Access Protocol. It is an application protocol used to access and manage information in a network directory, such as a user directory. At this point, the application is waiting for payment before moving on to the next steps. With a variation from 1 to 60 minutes, the expression generated was: TRIA (0.5, 10, 30.5), as illustrated in the Figure 3, which shows the graph of variations and the expression given by the system immediately afterwards:

Figure 3: Order entry times in the system
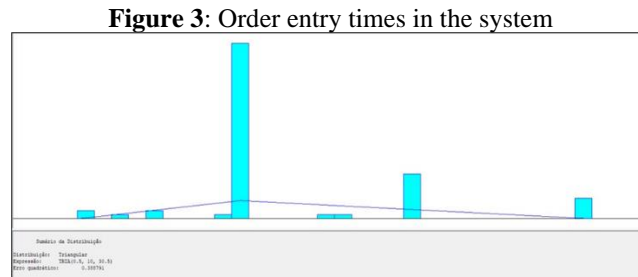
Source: Authors

Picking processing

In this second stage, the NEXP system, an inventory management platform, organizes orders into waves, and these waves can have more than one order or not. To optimize the picker's productivity, the system always suggests picking items from the same group and avoids unnecessary movements and wasted time.

Time in the picking process is extremely variable, as each order has a different complexity. These include items that are out of stock quantitatively, when comparing the values of physical and virtual stock. If there is not enough product to fulfill the order, a "stock hole" occurs, i.e. the product is no longer available for sale. Therefore, an incident is opened and the order remains pending. In the flowchart shown in Figure 2, this phenomenon is represented by the triangular figure symbol, indicating the decision stage. With a range from 1 to 46 minutes, the expression generated was: $0.5 + 28 * BETA(0.477, 1.26)$, as illustrated in the Figure 4:

Figure 4: Separation time
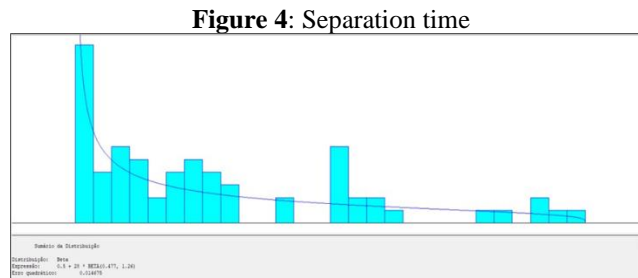
Source: Authors

Product transfer processing

This stage only takes place when the product is out of stock. In this case, the picking process is completed and the order is prevented from proceeding to the invoicing stage. For the missing product, availability is checked at another branch in the same region and a transfer is requested in order to fulfill the order. After authorization from the supervisor in charge, a third-party carrier collects the product, evaluates it and makes it available in stock for invoicing. This process can take up to 3 hours, ranging from 60 to 180 minutes. The expression generated was: $61 + 119 * BETA(1.12, 1.07)$, as shown in Figure 5.

Figure 5: Product transfer
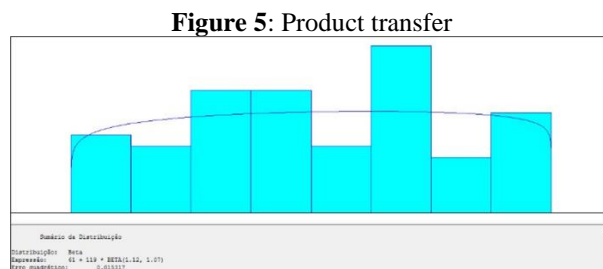
Source: Authors

Billing processing

Once the order has been closed without any outstanding issues, it goes to the billing stage. At this point, the process also works as a check to avoid shipping errors, as in this process the items are once again passed one by one through the data collector. Once this process is complete and the invoice has been issued, the organization moves on to the next stage. For the invoicing process, a variation of between 2 and 7 minutes was evident, the expression generated was: $1.5 + 6 * BETA(1.16, 1.04)$, as illustrated in the Figure 6.

Figure 6: Billing process (invoice process)
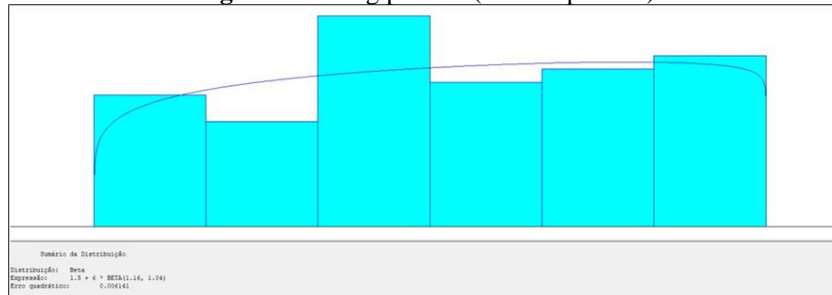
Source: Authors

Packaging processing

Once invoicing is complete, the order is packed immediately to avoid possible shipping errors with items missing from the package. When finished, the assistant responsible for the flow creates the Transport Document (DT) and the order is immediately dispatched to the carrier who will make the delivery. For the packaging process, there was a variation of 1 to 5 minutes, generating the expression:
$0.5 + 5 * BETA(1.39, 1.33$, as illustrated in the Figure 7.
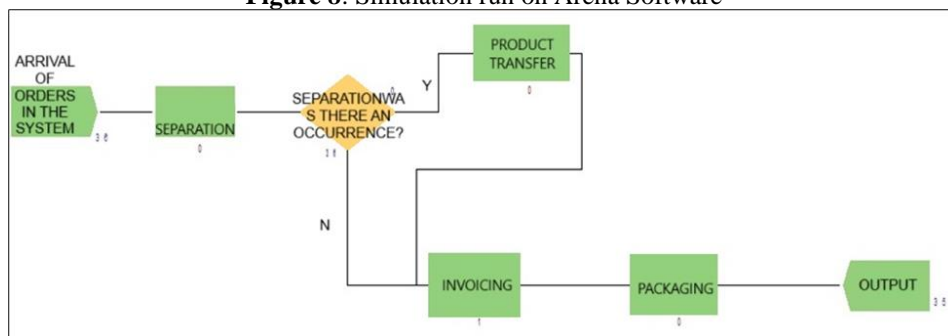
Figure 7: Packaging processing
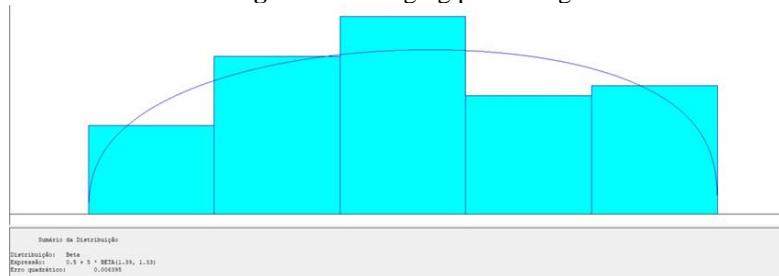
Source: Authors

IV. Discussion

After running the simulation in Arena Software using the expressions presented as a basis, the following layout was obtained, shown in Figure 8:

Figure 8: Simulation run on Arena Software

Source: Authors

Figure 9 shows the results of the report generated in Arena for random orders, showing the queue in the Sorting, Transfer, Billing and Packaging processes, with Sorting being the sector where the longest waiting times occurred. It is clear that the longest waiting times are related to the separation and transfer of goods

Figure 9: Queue Report

Name	Source	Average Of Replication Averages
PACKAGING.Queue	Queue	0,122086051
INVOLCING.Queue	Queue	0,730089257
SEPARATION.Queue	Queue	4,078175051
PRODUCT TRANSFER.Queue	Queue	12,72783307

Source: Authors

Figure 10 shows that 37 orders were registered in the system, but there was a bottleneck of 1 order during the invoicing process.

Figure 10: Number Out

| Name	T ype	Source	Average Across Replications	Half-Width
PEDIDO.NumberIn	Number In	Entity	37	1,849691497
PEDIDO.NumberOut	Number Out	Entity	35,42857143	2,25692583

Source: Authors

Based on the data in Figure 11, it can be concluded that the bottleneck in the process is in the separation area. This is evidenced by the fact that the time used by the separator was the greatest among the four areas, representing 59% of the total time, or 0.59%, as indicated in the resources report in Figure 11.

Figure 11: Resources

Name	Type	Average Of Replication Averages	Half-Width
ATENDENTE	Instantaneous Utilization	0,346273794	0,027147021
EMBALADOR	Instantaneous Utilization	0,231555724	0,018742855
FILIAL	Instantaneous Utilization	0,284388265	0,156156803
SEPARADOR	Instantaneous Utilization	0,590271559	0,093074495

Based on the results of the report, it is proposed to increase the number of sorters, as it is disproportionate to the number of orders generated per hour. Therefore, two more tabs will be added to the Arena simulation to eliminate the current bottleneck as Figure 12 shows.

Figure 12: Improvement simulation into Arena Software
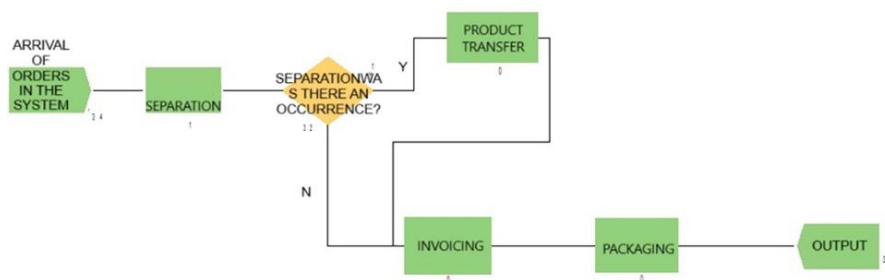
Source: Authors

By using 3 separators in the Separation stage, the waiting time in the queue was reduced to 0, increasing the efficiency of the process. On the other hand, in the Transfer queue, there was an increase of 4 minutes, as shown in Figure 13. However, it is not necessary to adjust the area, since only 2% of orders are directed there.

Figure 13: Queue report (with improvement)

Name	Source	Average Of Replication Averages
EMBALAGEM.Queue	Queue	0,090187296
FATURAMENTO.Queue	Queue	0,594690477
SEPARAÇÃO.Queue	Queue	0
TRANSFERENCIA DE PRODUTO	Queue	16,83633875

Source: Authors

V. Conclusion

It can be concluded that considering the scenario, using the Arena software, it is possible to identify the bottlenecks in the billing and sorting processes. Therefore, the solution found was to hire 2 more sorters to optimize the processes with the longest queues and reduce the bottleneck. Despite this, the addition of two sorters (2 sorting employees) resulted in an increase of 4 minutes in the queue time for the transfer process.

However, as already mentioned in Results and Discussions, it is not necessary to make adjustments in the area, as only 2% of orders go to this sector. In this way, the Arena software contributed to the process optimization process, showing the bottlenecks and achieving the goal of the process, since the company's objective was to reduce the total time taken for the order to pass through the system.

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