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Algorithm for ranking applications in QS with priorities in the agro-industrial sector

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Abstract: The study delves into the queuing process for warranty or post-warranty service requests in companies specializing in repairing electronic devices within the agro-industrial sector. The research also investigates the environmental implications of such operations and the environmental challenges related to servicing electronic devices in agricultural production. To streamline maintenance operations and cut costs, a logistic allocation approach for requests is proposed based on queuing systems theory principles. By analyzing workshop operations, a repair work performance scheme is developed, aligning with the specifics of agricultural production and environmental considerations in device maintenance. This has helped outline the primary requirements for the information system, creating diagrams that detail the sequence of processes for order addition, diagnostics, repair, spare parts ordering, and waste disposal. Using terminology from mass service systems, the workshop process is described, and an algorithm for preliminary time parameter calculations has been formulated to predict service completion dates. This methodology not only enables timely updates for customers regarding service completion times and the optimization of order routing through various channels, but it also contributes to addressing the adverse environmental impacts, a critical aspect in the organization of activities within the agricultural sector.

1 Introduction

The process of global informatization, which began at the end of the twentieth century and made humanity hostage to electronic media, was marked by a new approach to organizing data storage. Increased requirements for service quality based on information technology have led to the rapid growth of quality management systems, which make it possible to regulate the flow of service requests and manage the system in such a way as to achieve the required quality indicators. Hence the high requirements for the types of systems support, especially mathematical and software. Of particular relevance is the problem of optimal distribution of requests for service and forecasting such parameters as service speed, service end time and other parameters of the service system necessary for optimal decision making.

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Modeling, as a generally accepted method for studying system parameters, allows one to interpret the problems of analyzing the time parameters of a service system using mathematical models. The theory of queuing systems (QS) and probability theory serve as a classical mathematical apparatus for modeling systems whose functioning processes are stochastic in nature.

Dynamic planning uses a classic approach to organizational architecture, which implies that the system represents a set of performers subordinate to general management. The approach under consideration is that a static schedule is constructed at the beginning of the control period using classical planning methods. Once the execution of orders begins in accordance with the schedule constructed in this way, unforeseen situations may arise that disrupt the stable process. In these cases, the schedule is adjusted taking into account Pareto optimality. One of the methods of dynamic planning theory is the use of the following heuristics [1,2]:

– at the time of receiving the task (FIFO rule);
– by the number of operations (the task runs the fastest, has a higher priority);
– by cost (high priority are tasks whose completion on time entails the greatest financial losses);
– by deadlines (with high priority are the most urgent tasks, the implementation of which is urgent).

The advantage of this approach is organizational systematization, strict control over execution and transparency of the application execution process.

At the same time, the approach is focused on large projects in team implementation and requires complex information support.

Distribution logistics is a set of interrelated functions implemented in the process of distributing material flow between various wholesale buyers, i.e. in the process of wholesale sales of goods.

The main goal of distribution logistics is to ensure that the right goods are delivered to the right place, at the right time, at minimal cost.

Unlike marketing, which is engaged in identifying and stimulating demand, distribution logistics is designed to satisfy the demand generated by marketing at minimal cost. In this case, it is necessary to proceed from the tasks of satisfying the basic needs of the consumer of the product, which include the following: timely delivery of goods, the ability to satisfy emergency needs of the customer, careful handling of goods during loading and unloading operations, the manufacturer's readiness to quickly replace defective products and maintain a certain level of inventories [3].

Areas of application of distribution logistics

There are two approaches to defining distribution logistics functions. The first covers a set of operations for the shipment of finished products from the supplier's warehouse. The second one is wider. In this case, it is considered that distribution logistics implements the entire process of circulation of material products, starting from the moment when it leaves the production line until the moment when it reaches the consumer's warehouse. It should be borne in mind that distribution problems are solved at the level of micro- and macro-logistics.

The following tasks are solved at the micro level:

– planning the implementation process;
– selection of product packaging, packaging and canning;
– organization of product shipment;
– control over transportation to the place of consumption and delivery of products to the consumer;
– organization of post-sales service.

At the macro level, the tasks of distribution logistics include:

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– selection of a material flow distribution scheme;
– formation of distribution channels;
– placement of distribution centers.

The approach to generating applications based on distribution logistics has a pronounced product orientation, i.e., it is used in complex production systems where there are a large number of resources at the input and a lot of results at the output and it is necessary to ensure the relationship between the input and output of the system.

The theory of queuing systems is widely used in the field of servicing various requests, has well-developed mathematical tools and can be applied to the subject area under study. It is the QS theory that we will use to solve the problems of generating service requests.

2 Materials and Methods

We will consider the implementation of systems for distributing the priority of requests for service using the example of an electronic device repair company that carries out its activities on its warranty or post-warranty service.

The process of providing a repair service begins with a request from a client who comes along with his faulty device. The acceptance/issuance manager first finds out the reason for the request from the client and checks the device for completeness and external damage. If the device is in critical condition and cannot be repaired, the manager has the right to refuse such a client and this ends the process of terminating the service. If the device is repairable, then the manager begins to fill out an acceptance certificate and enters information about the client and the device into the database, after which he transfers the device to the workshop.

In the workshop, a modular diagnostics technician diagnoses the device and begins repairs; if any spare parts are required that are not available, he sends a request to the spare parts supplier, after which work begins with the supplier [4].

A request for the required spare parts is sent to the supplier. The supplier's process begins with receiving this request, then the supplier checks its parts database and sends a response form to the workshop about the availability of the necessary parts and their cost. The workshop receives this form and gives consent to the supplier to pack the order. The supplier collects and packages spare parts and hands them over to the courier, this is where work with the supplier ends [5].

After receiving the spare parts, the technicians carry out repairs and send the device to the reception desk for delivery; as soon as the device appears at the delivery point, the manager must immediately notify the client about this by calling him and upon the client’s arrival, he must take payment and issue the device, and that’s it for the repair service finished. Figure 1 shows a diagram of repair work, taking into account the fact that the activity is carried out using an information system for recording requests for service.

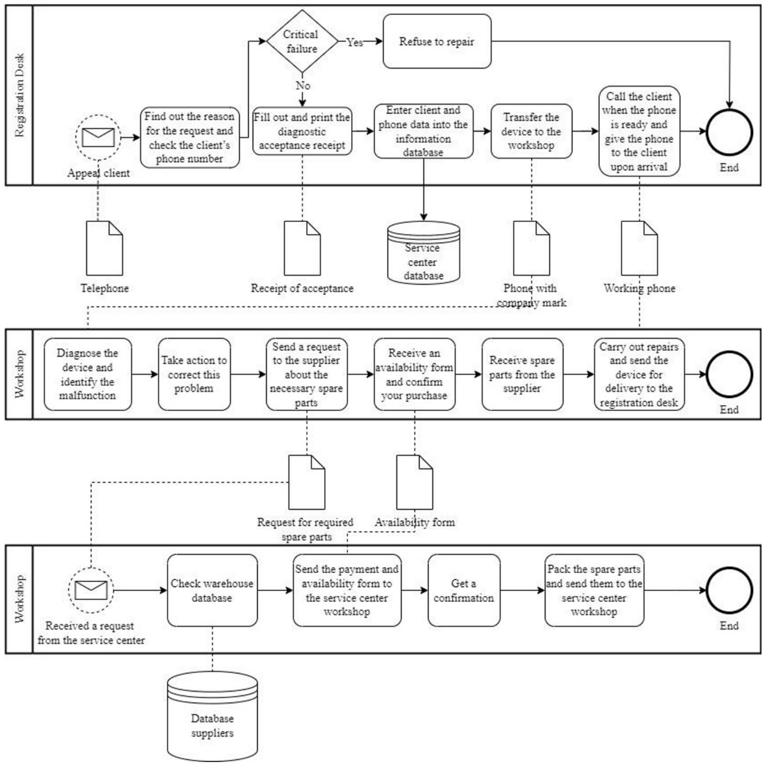

Fig. 1. Process of repair work

Information exchange between all departments of the organization occurs quickly not only due to a well-functioning information structure, but thanks to an organized file server that will store a database [6].

Figure 2 shows a diagram of use cases for the information system.

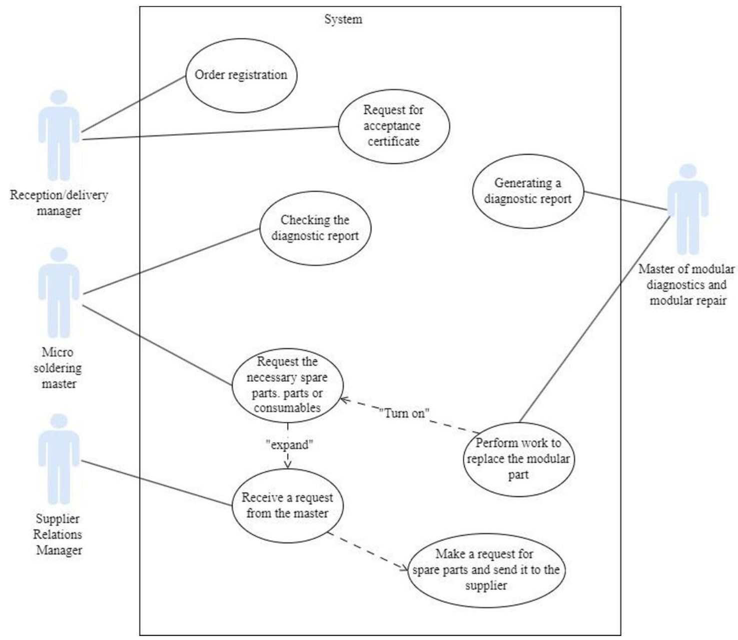

Fig. 2. Use case diagram

When organizing work in this way, the human factor plays a significant role, and therefore there is a possibility of low quality of work performed and increased labor intensity, which negatively affects the work of the company.

In connection with these problems, there is a need to use an information system (IS) for systematic and continuous recording of work performed [7].

The IS performs the main tasks, namely, it monitors customer orders in real time, enters an order and, based on the entered information, prints an acceptance certificate, and also stores a list of the most required spare parts that are in stock and that are required order.

IS perform these functions:

– entering order data;
– constant monitoring of ongoing orders;
– viewing information about the order and changes in its status;
– search for various information on orders, product lists, spare parts;
– stamp of the acceptance certificate.

The purpose of the IS is to increase the efficiency of the company and facilitate control over all orders carried out with minimal costs and on existing equipment.

Basic parameters of the application functional model:

– System environment (Actors)
– Reception Manager
– Micro-soldering master
– Supplier Relations Manager
– Master of modular diagnostics and modular repair
– System precedents (Use Case).
– Order registration
– Request for acceptance certificate
– Checking the diagnostic report
– Generate diagnostic report

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– Request for necessary spare parts or consumables

Figure 3 shows the sequence diagram for adding a new order.

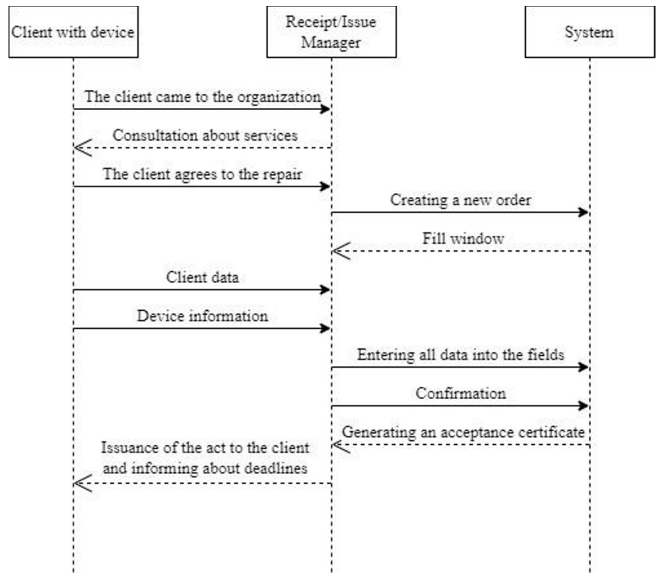

Fig. 3. Sequence diagram for the process of adding a new order

Figure 4 shows the sequence of the device diagnostic process.

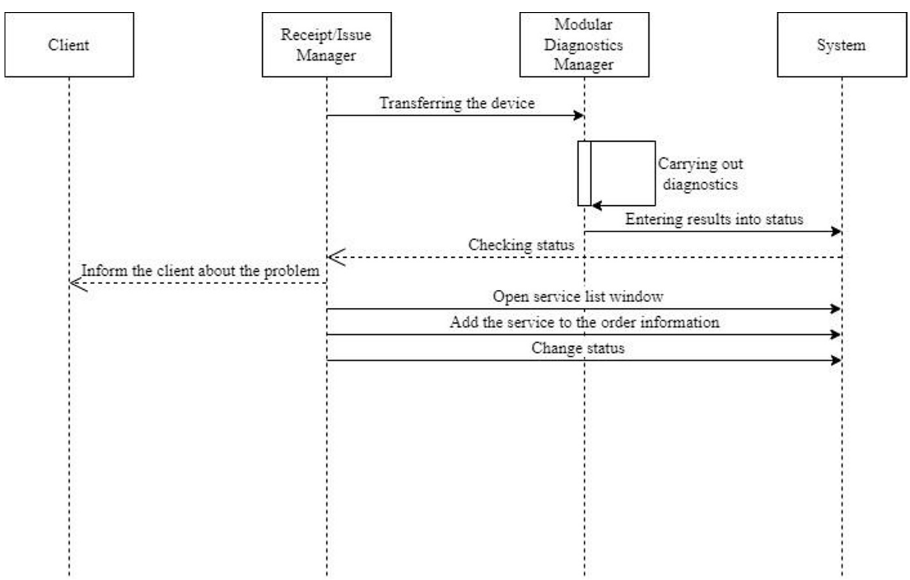

Fig. 4. Sequence diagram for the diagnostic process

When performing repairs, the master checks the status of the device and the malfunction in the system, then the master carries out repairs and if he needs spare parts, he draws up a report on the necessary spare parts. The manager logs into the system and sees the report from the workshop in the system and sends the report to the supplier. The supplier returns a

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report on the availability of spare parts, and the manager agrees to delivery, after which the supplier sends the components. After receiving the spare parts, the manager adds them to the system, after which the technician can carry out repairs and change the status of the order after the repair is completed [8,9].

Figure 5 shows the sequence of the process of diagnosing repairs and ordering components.

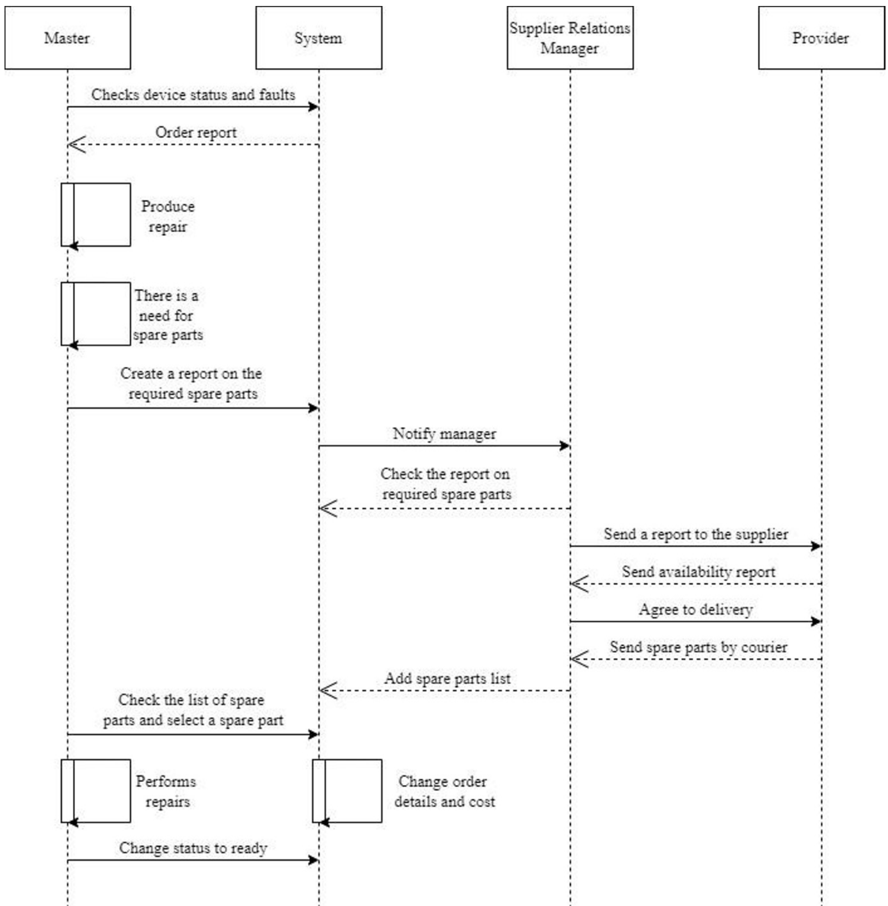

Fig. 5. Sequence diagram for the repair process and ordering spare parts

To increase the efficiency of customer service and improve the quality of service, it is necessary to develop an IS software module for calculating the priority of requests for service in order to optimize the use of the working time of craftsmen and inform customers about the timing of orders. To solve the problem, an approach based on the theory of queuing systems is used [10].

3 Research and results

Figure 6 shows the workshop process in terms of a queuing system.

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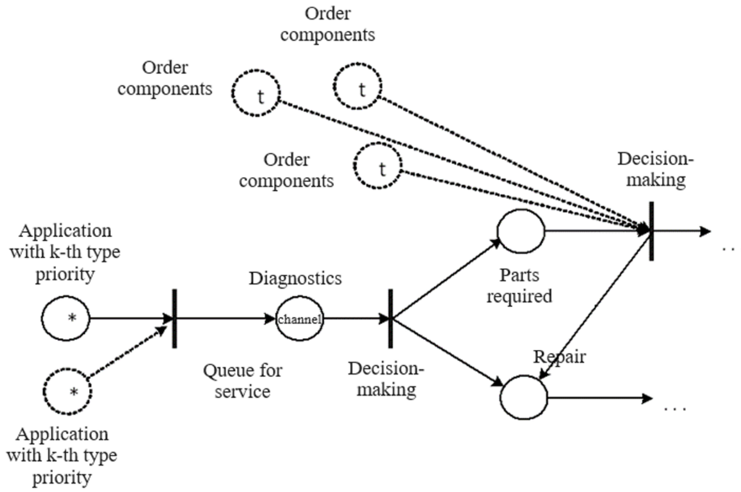

Fig. 6. Workshop process in terms of a queuing system

There is a set of typical faults that we will consider services or typical applications. Applications are received at the input of the system after documentation, when the receiver places an order, enters information into the database using the IS interface and issues a document confirming the acceptance of the order.

At the stage of placing an order, it is necessary to determine the complexity of the work.

Labor intensity of work is the time to complete a service (application), measured in hours.

The labor intensity of each service is different, the basic labor intensity varies, calculated as the average value for the provision of a service, obtained by timing the performance of the service by craftsmen. In addition to the basic service, it is possible to assign additional time to complete the work. This is due to a situation where the service cannot be completed within a given time due to a lack of components or the need to perform additional work [11-13].

Labor intensity affects the time it takes to complete the work and notify the client about the finished order. In the existing information system that is used in the company, all requests are executed in order of priority and time is calculated based on the fact that until the first request is completed, the second request cannot be executed by this master. This leads to lost working time and incorrect accounting. In fact, it turns out that the master takes the next order, but its execution is postponed until the previous one is completed. Given that the wait for components can last for days and weeks, this accounting option is unsatisfactory.

Applications must be prioritized depending on the complexity and load of the system. It is necessary to take into account the situation that if the master has a lot of work, then the application goes to another master [14-16].

To calculate the priority of service requests, it is proposed to introduce the concept of additional labor intensity t_n, which affects the service time in the system and the time spent in the system.

Thus, in accordance with the above and the workshop work flow diagram shown in Figure 6, an algorithm for preliminary calculation of the time parameters of the queuing system was developed, shown in Figure 7.

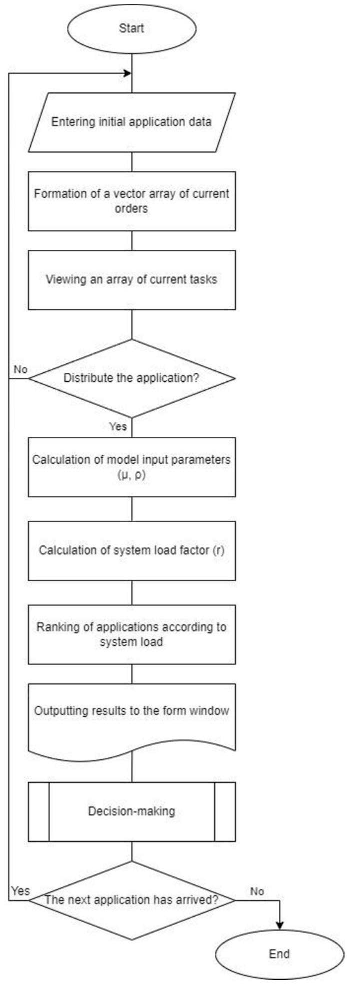

Fig. 7. Algorithm for preliminary calculation of time parameters of the queuing system μρ

According to the proposed algorithm, the service flow can be calculated in the service system and the moment when the service will be completed can be predicted. This is necessary in order to inform the customer about the completion time of service and take into account the nature of routing requests for service for different channels [17-20].

4 Conclusion

An algorithm for ranking applications has been proposed, which differs from existing ones in that the priority of an application is determined by the system load factor, calculated as the ratio of the time in the system to the waiting time for the order to be processed. Orders with the lowest coefficient are executed first, i.e., have the highest priority. An important circumstance is that the reduced intensity in the queuing model is a parameter that is recalculated for each new request, since the intensity of the service flow is determined by the complexity of the request, and the complexity consists of the basic labor intensity, which has a model value, and additional labor intensity, determined at the stage of selecting a service to order.

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