

UDC 621.391

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ANALYSIS OF DEVELOPMENT ON CREATION OF DELIVERY ORGANIZATION SYSTEMS USING DRONES

Мороз Б.І., Покотиленко О.І. Аналіз розробок по створенню систем організації доставки з використанням дронів. В рамках даної статті розглянуті досягнення в сфері розробок, концепції та ідей по створенню систем доставки з використанням безпілотних літальних апаратів, що передбачає максимальну автоматизацію з мінімальною участю людини в процесі доставки товару або продукту до кінцевого споживача. Аналізується можливість поліпшення логістичної складової системи доставки з метою, поліпшити якість наданої послуги, також виключити втрати заявок та іншої інформації в роботі системи.

Ключові слова: дрон, система доставки, автоматизація, обробка інформації

Мороз Б.И., Покотиленко А.И. Анализ разработок по созданию систем организации доставки с использованием дронов. В рамках данной статьи рассмотрены достижения в сфере разработок, концепции и идей по созданию систем доставки с использованием беспилотных летательных аппаратов, предусматривающие максимальную автоматизацию с минимальным участием человека в процессе доставки товара или продукта до конечного потребителя. Анализируется возможность улучшения логистической составляющей системы доставки с целью, улучшить качество предоставляемой услуги, также исключить потери заявок и иной информации в работе системы.

Ключевые слова: дрон, система доставки, автоматизация, обработка информации

B. Moroz., O. Pokotylenko Analysis of development on creation of delivery organization systems using drones. Within this article we consider achievements in the field of development, concepts and ideas for creation of delivery systems using unmanned aerial vehicles (UAV), which provide for maximum automation with minimal human participation in the delivery of goods or products to the final consumer. We also analyze the possibility of improving of the delivery system logistics component in order to improve the quality of the service provided, as well as to eliminate the loss of applications and other information in the system operation.

Keywords: drone, delivery system, automation, information processing

Introduction and statement of the research problem. Technological progress does not stand still, more and more tabloid headlines describe new advances in science and technology, new concepts appear and existing technologies are improved. The idea, which even five years ago seemed practically useless because of the high cost of its implementation, now may well be realized with acceptable expenditure of resources. Electric vehicles [1] are a vivid example of this technology. Having appeared as an opposition to transport with combustible fuel, at first they were expensive and had an insufficient power reserve. With the development of energy storage technology, it got possible to reduce the cost of production and produce not a limited series available only to a few, but create a product designed for a wide consumer. For example, Tesla Model 3 [2] has a power reserve of 500 km, which is enough to get from Kiev to Odessa.

The same applies to drones. Now there are devices capable of expanding speed up to 17 m / s, which, combined with the ability to be in the air for 26 minutes, gives a flight range of more than 26 km.

Naturally, it was only a matter of time when someone should like to use drones to deliver goods. In addition to many independent companies and enthusiasts such corporations as Amazon, Google and DHL [3, 4, 5] got interested in such an application.

Despite the fact that the above-mentioned corporations have enough resources, they cannot boast of serious achievements yet. So, Amazon made only two deliveries [6], and Google froze its project after only one demonstration [7, 8], at DHL had better results, during a three-month experiment in the Alps in 2016, having delivered about 130 parcels [9].

Enthusiasts have things a little better. Zipline [10] delivers medicine and blood samples to Rwanda [11], and Matternet [12] performs a similar task in the Republic of Malawi [13]. Various projects for products delivery can be mentioned about only in passing, since many were only a PR move. However, subsequently, it's massive use of drones in delivery that is the ultimate goal and outcome of such research; and then it will be necessary to create a system that will effectively allocate the available resources for goods or products delivery.

Naturally, the construction of such a system is a complex task and one of its elements is the processing of incoming applications. One of the concepts for solving this problem is considered in this article.

Goal. It's to offer the concept creating of an automated subsystem for applications registering and processing for a product delivery system by drones to the end user.

Analysis of recent research and publications. Today, information about such researches is practical-ly non-existent since most of the projects aimed at creating and developing of the concept of cargo transportation using drones are in a state of controlled experiment and are not available to a wide circle of consumers.

Presentation of the main material. As mentioned above, cargo transportation by drones is not massive today, and therefore does not require specialized means and tools to manage the logistics of the delivery system using drones.

As an example, consider how Amazon sees the implementation of its Amazon Prime Air project [6]. First of all, it should be noted that the highlight of the project from Amazon is the use of airships as logistics centers for storing cargo and launching UAVs. According to Amazon, such application fulfillment centers will be able to respond to demand spikes even before they occur, but so far this development is only at the patent stage [14]. Figure 1 shows a diagram of how such a system can work. At the same time, it is proposed to use smaller airships to replenish stocks on such airships. And to reduce the cost of returning drones to flying logistics centers, airships are provided that will collect drones that have already completed their deliveries.

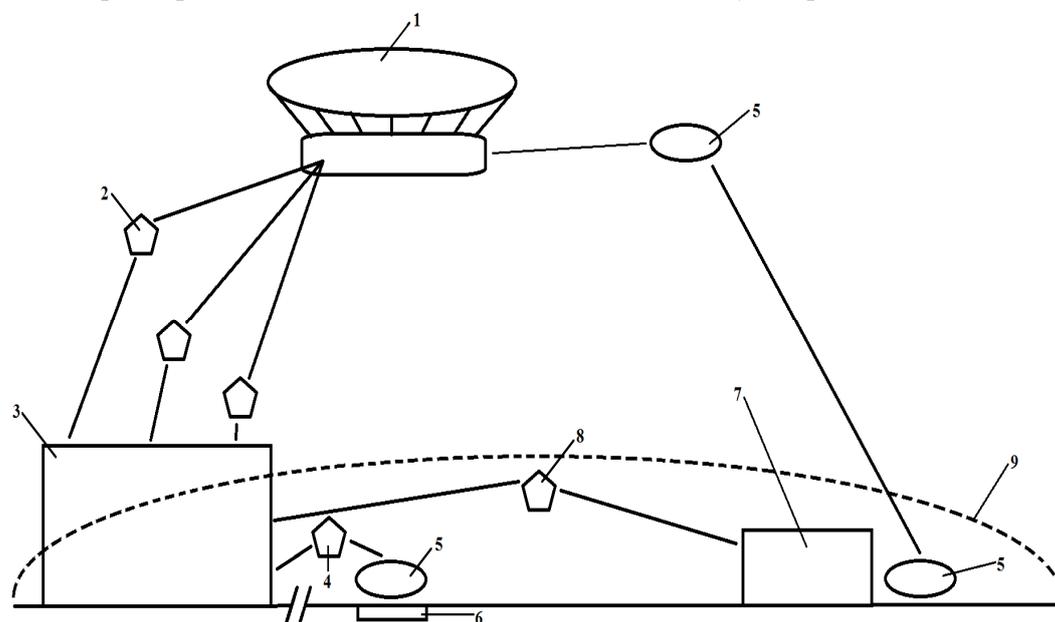


Fig. 1. Diagram of flying logistics centers from Amazon

As mentioned above, this diagram rearranges only a patent, but its implementation as shown in Figure 1 is worth considering. The diagram at figure 1 shows the so-called flying warehouse, which according to the project, acts as a mobile logistics center, the object at figure 2 displays the drone which delivers the goods from the flying warehouse to the consumer in region 3, while part of the descent is carried out by planning so that to save energy. Based on these considerations, the drone 4 does not rise back, but It is planned to use such small airships represented by figure 5, to replenish stocks of drones and goods at the flying warehouse. Such a supplying airship can be located not only at the special waiting area 6, but also near the ground logistic center 7, from which it also replenishes the stock new and goods before shipment to the flying warehouse. In the absence of a supplying airship at the waiting area, drone 8 performing the delivery can go to the ground logistics center 7; this approach will also save more energy than a simple return to the flying warehouse. The figure 9 schematically indicates the coverage area of the system using the flying warehouse.

It is also worth noting that this scheme was not described in the literature, calculations of its energy efficiency were also not presented, but exist at the concept stage and were adopted as such.

The system described above is still in the state of a patent and time and refinement are still required before a concrete implementation. At the moment, the actual implementation of the delivery system using drones by Amazon is as shown in Figure 2.

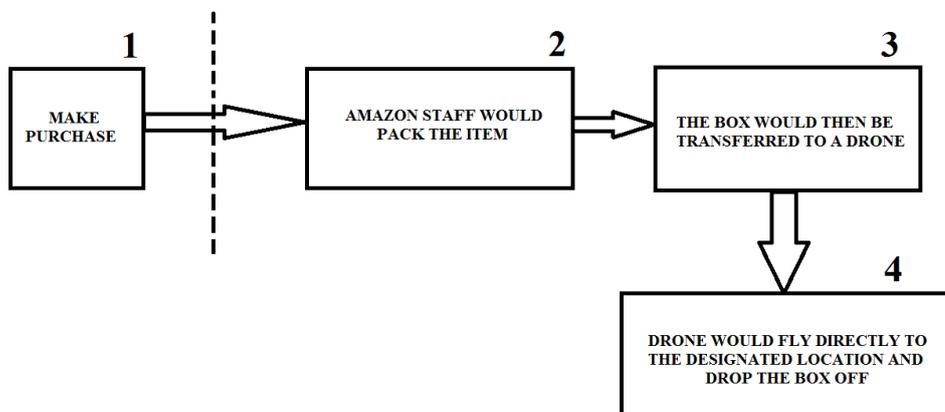


Fig. 2. The scheme of delivery by drones from Amazon

As it was mentioned, according to this scheme only two trial deliveries were made, therefore, when such a system enters the real market for mass service, it is inevitable that there will be a need for more detailed application processing and organization of the delivery of goods to the final consumer, which is indicated by the dotted line between items 1 and 2. The creation of such a subsystem is considered in this article.

At this stage, it is advisable to mention introduction of the user ability to choose two delivery options: as soon as possible or specify the exact date and time. Thus, the delivery system will have an additional effectiveness criterion.

Such a system must meet certain criteria:

- applications must be processed without loss (i.e. all must be delivered);
- must be met within the time constraints;
- must be met with minimal use of resources so that capital and operating costs are minimal.

Disciplines that are built on the basis of queuing theory are traditionally used to organize the service of requests, but the use of models allows organizing services according to criteria like service probability, average service time, etc. In this case, this is poorly applicable since it is necessary to provide service for each application within specific time limits (and not for the average time), and probabilistic criteria generally allow for the loss of a certain number of applications during maintenance.

The authors aim to develop such a system for organizing the service of requests that were not built on probabilistic and average service characteristics, but would allow determining these characteristics accurately. For this purpose, it is advisable to take advantage of the discipline named organization of information processing [15].

This discipline allows you to take into account the characteristics of aging and the value of information in the process of its transmission and processing, allows you to significantly increase the effectiveness of methods and means of data processing, their management and information services. The discipline allows us to take into account that during the operation of the system we will deal not with the average queue of requests, but with a specific queue at the current moment while taking into account the change of individual requests in time. In contrast to the statistical and dynamic disciplines used to solve such problems, the proposed discipline does not rely on such assessment criteria as:

- the maximum and average delay in the result issuance relative to the moments of their receipt;
- probability of the timing violation of the result issuance;

- allowable percentage of information loss during processing.

This is undoubtedly an advantage for the task.

Using such qualitative-quantitative characteristics as both aging and value of information, the proposed discipline allows organizing rational processing of information for two main cases:

- I. input streams are strictly regular or quasi-regular with varying degrees of intensity in different parts of the system;
- II. input message flows are random and are described by the Poisson law with different characteristics on individual sections of the system.

Using this discipline, you can create a system for processing of applications so that it should allow you to adjust the order of their processing depending on their intensity and characteristics.

For the case of strictly regular or quasi-regular input information flows processing process is as follows.

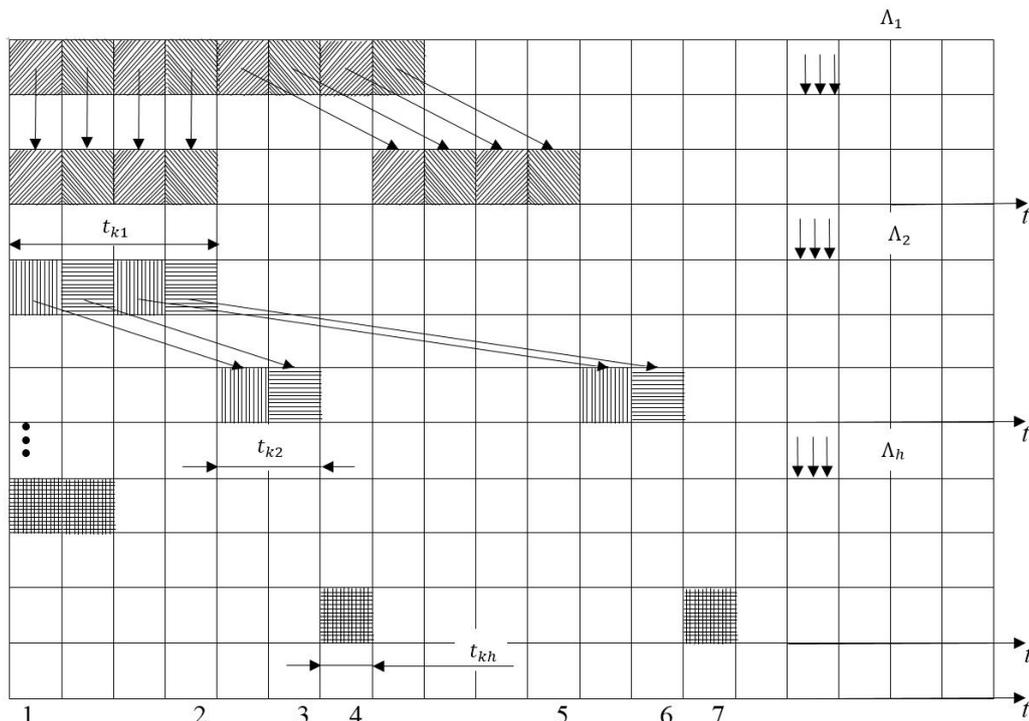


Fig. 3. Scheme of processing of regular input flows of applications in accordance with the managed discipline of maintenance

Flows of applications enter the system and get to the queue, depending on a certain threshold time for maintenance $T_{threshold, i}$, where i is an index of a membership of an application of an i -th type to $T_{threshold, i}$.

$$T_{threshold, i}(t) \geq W_i(t) + b_i, \quad (1)$$

where $W_i(t)$ is a function of waiting time for processing of an application of an i -th type, received at time t ; b_i is a time of processing of an application of an i -th type.

$$b_i = \int_0^{\infty} t d B_i(t), \quad (2)$$

where $B_i(t)$ is the function of distribution of processing time of an application of an i -th type.

The application is processed as follows (Fig. 3).

The system processes applications of each queue in turn, giving each i -th type of applications a time slice t_{ki} , during which 1, 2, 3 ... etc. applications i -th queue can be processed.

$$\frac{t_{ki}}{b_i} = 1, 2, 3 \dots \text{и т.д.} \quad (3)$$

Thus, the processing of applications can be made adjustable depending on changes in the intensity of application flows $\Lambda_i(t)$.

Vector T_k is used as the control vector

$$T_k = \{t_{k1}, t_{k2}, \dots, t_{ki}, \dots, t_{kn}\} \quad (4)$$

Conclusion. The information presented in the article allows to determine the direction of creation of delivery systems using drones, aimed at the mass consumer as a promising direction for research in the areas of robotics and the creation of software products and software. The proposed discipline of organization of applications processing process seems promising in terms of using to manage such a delivery system.

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