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Organizational and Economic Mechanism of Development and Promotion of IT Products in Ukraine

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ABSTRACT

Software development and the implementation of IT industry products are usually a very complicated and complex process. In recent years, software requirements' nature and complexity have changed dramatically, as have user demands for cost, performance, and quality. These three parameters can be considered key, and keeping them at an appropriate level for consumers is possible only through optimal design using well-established software development methodologies.

The search for ways to optimize labour and financial costs leads managers worldwide to the need to use in practice a variety of techniques and approaches. With this approach, the scientific and economic substantiation of the advisability of choosing one or another organizational and financial mechanism for organizing a team of developers and marketers becomes especially important.

The authors of the article studied Dynamics of export growth of Ukrainian IT products, the relationship between the IT product market elements, the main and auxiliary stages of creating an IT product. For the development and promotion of IT products, the authors proposed a methodology for iterative software development based on prototyping, using elements of the SCRUM system, which was tested at a private Ukrainian IT company. The modified version of the agile development system proposed in the article showed promising results in practice, both IT company managers and specialists positively assessed the experience of its use. Based on the already proven technology of agile development, this technique was able to add some mechanics that made it possible to neutralize several negative factors inherent in other approaches.

Keywords: Agile Development Methodology; IT Industry; Software Development; Software Product.

JEL Classification: M13, M15, L26

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Mecanismo Organizativo y Económico de Desarrollo y Promoción de Productos Informáticos en Ucrania

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RESUMEN

El desarrollo de software y la implantación de productos de la industria informática suelen ser un proceso muy complicado y complejo. En los últimos años, la naturaleza y la complejidad de los requisitos del software han cambiado drásticamente, al igual que las exigencias de los usuarios en cuanto a coste, rendimiento y calidad. Estos tres parámetros pueden considerarse clave, y mantenerlos en un nivel adecuado para los consumidores sólo es posible mediante un diseño óptimo que utilice metodologías de desarrollo de software bien establecidas.

La búsqueda de formas de optimizar los costes laborales y financieros lleva a los gestores de todo el mundo a la necesidad de utilizar en la práctica diversas técnicas y enfoques. Con este enfoque, cobra especial importancia la fundamentación científica y económica de la conveniencia de elegir uno u otro mecanismo organizativo y financiero para organizar un equipo de desarrolladores y comercializadores.

Los autores del artículo estudiaron la dinámica del crecimiento de las exportaciones de productos informáticos ucranianos, la relación entre los elementos del mercado de productos informáticos, las etapas principales y auxiliares de la creación de un producto informático. Para el desarrollo y la promoción de productos de TI, los autores propusieron una metodología de desarrollo iterativo de software basada en la creación de prototipos, utilizando elementos del sistema SCRUM, que se probó en una empresa privada de TI ucraniana. La versión modificada del sistema de desarrollo ágil propuesto en el artículo mostró resultados prometedores en la práctica, y tanto los directivos de la empresa de TI como los especialistas valoraron positivamente la experiencia de su uso. Basándose en la tecnología ya probada del desarrollo ágil, esta técnica fue capaz de añadir algunos mecanismos que permitieron neutralizar varios factores negativos inherentes a otros enfoques.

Palabras clave: Metodología de desarrollo ágil; Industria de las TI; Desarrollo de software; Producto de software.

Clasificación JEL: M13, M15, L26

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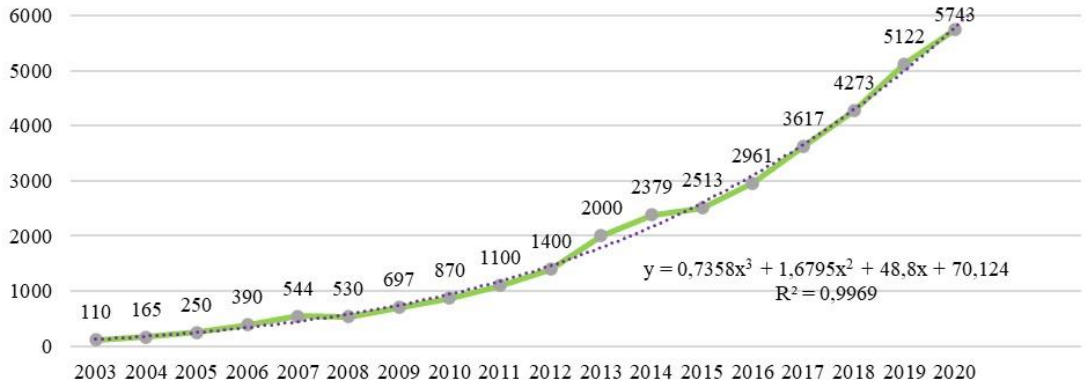
1. Introduction

At the present stage of development of the Ukrainian economy, strengthening the competitiveness of the national economy in the sector of IT products' world market has acquired significant importance (Halkiv et al, 2020). Within the framework of the national economy, the IT industry of Ukraine in terms of export volumes (in monetary terms) ranks third among export-oriented sectors of the economy, yielding in this respect only to the agricultural and metallurgical industries. The share of IT products in Ukraine's GDP is about 4%, and what is typical for the last 10 years, the export of IT products has grown almost annually by an average of 20%, this can be clearly seen in the graph shown in Fig. 1.

Figure 1. Dynamics of export growth of Ukrainian IT products



From an economic point of view, the development of the national IT-sphere for Ukraine can ensure the achievement of several macroeconomic effects that can positively impact the country's socio-economic development (Gryschenko & Goncharov, 2013; Melnikov et al, 2019). Moreover, in the long term, the effect of this industry's development can become a significant lever, pushing the development and modernization of other sectors of the national economy of Ukraine.

The following trends confirm the presence of the potential for the development of the IT-sphere of Ukraine:

- building up export potential;
- an increase in the number of business entities;
- growth in the number of people employed in the IT sector;
- formation of sufficient demand in the domestic market
- development of the financial sector (Melnykov & Ratushniak, 2019; Prokopenko, O. & Omelyanenko, 2020).

The IT product market itself is one of the segments of the information and telecommunication technologies market, a diagram of the interconnection of the elements of which is shown in Fig. 2.

On the other hand, the Ukrainian segment of the IT product market is at the stage of active development, the opportunities that open up for young Ukrainian specialists are endless (Zadorozhniuk, 2019). The fact that the IT sphere is actively developing and is in steady demand among young developers demonstrates the graph of the growth in the number of specialists involved in the IT industry is shown in Fig. 3.

The rapid growth in the number of employed specialists, which by 2023, according to our forecasts, will amount to more than 450 thousand people, together with an increase in the number of companies operating in the IT sector of Ukraine, raises the question of using the most optimal organizational and economic mechanism for development and promotion of IT products.

Figure 2. Segments of the global telecommunications technology market

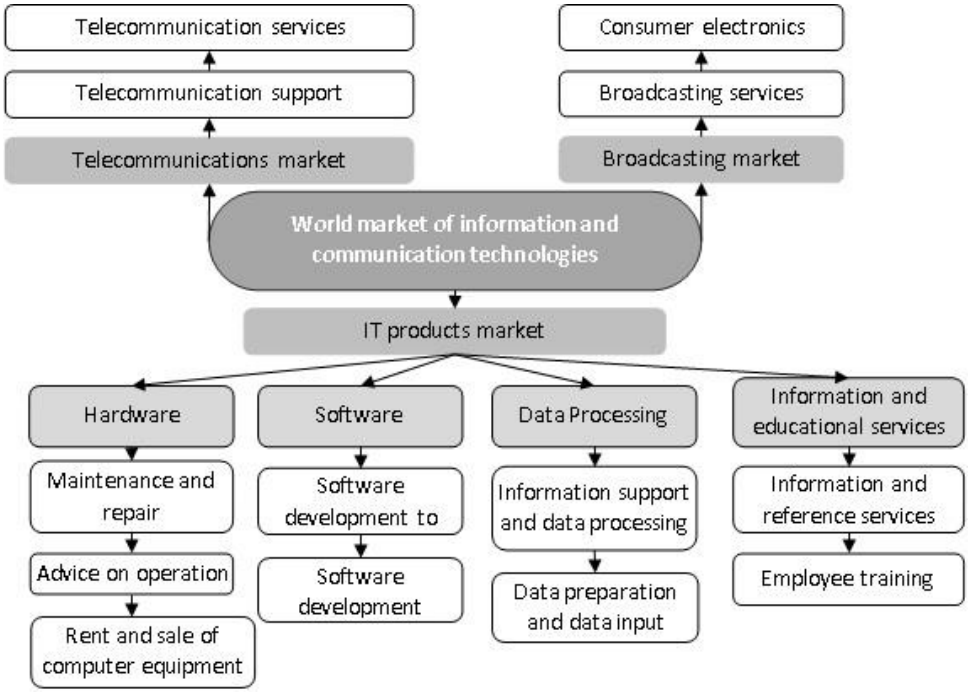
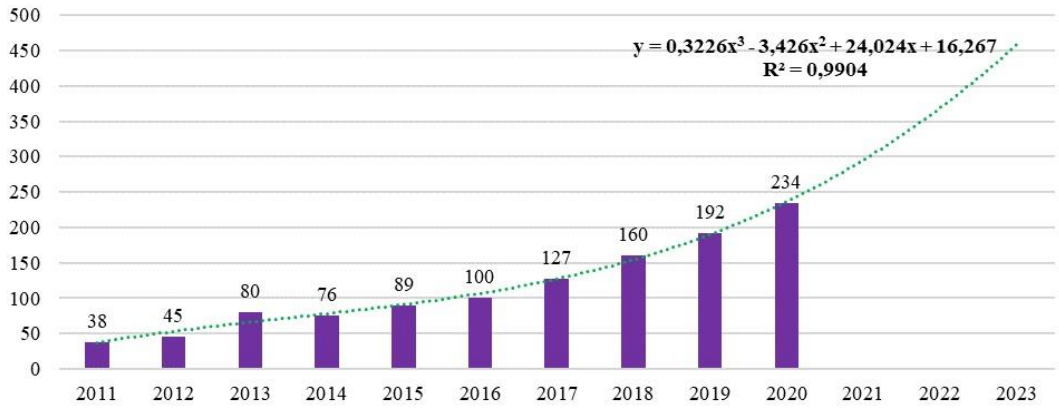


Figure 3. Forecast of changes in the number of specialists working in the IT industry of Ukraine (thousand people)



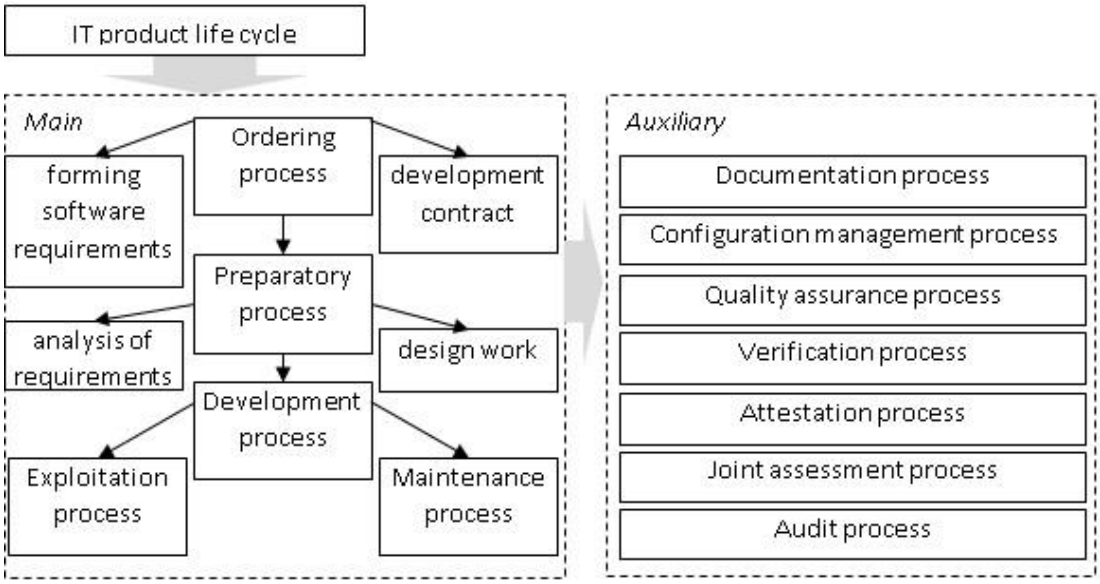
2. Literature Review

The technology for creating and implementing IT products, in particular software, is a complex system of measures not directed towards achieving the final result. The key concept here is the product life cycle, which includes several fundamental stages (Clista Elysia & Utama, 2020; Li et al, 2017).

The IT product life cycle model characterizes the team's approach to the software development process. It displays the accents and priorities at all stages of creating a software product, and most importantly, the order in which these stages are followed.

It should be noted that all stages can be divided into main and auxiliary ones; their role and interrelation are presented in Fig. 4.

Figure 4. IT product life cycle model



The main stages of the life cycle of software products include:

• The process of placing an order.

This stage is a preliminary stage of the customer's actions in need of a software product. At this stage, the customer forms a list of requirements for the final product, as well as a list of restrictions predetermined by the capabilities of the hardware on which this product will be used. In addition, this stage includes negotiations, formation and conclusion of a development contract and coordination of control and audit processes for the contractor's work.

• Preparation process.

At this stage, the contractor analyzes the customer's requirements, performs the design of the architecture and analysis of the upcoming work, decides the issue of distribution of labour resources, identifies the need to transfer part of the work to outsourcing and a list of potential subcontractors.

• The process of developing a software product.

A key stage at which creating a final product that meets the list of customer requirements takes place.

• Operation process.

This stage begins immediately after the end of the development process and the transfer of the finished product to the customer's specialists, at this stage the finished product is used in the working conditions for which it was created.

• Maintenance process.

The company-creator of the software product provides support and modernization of its product, this stage, by agreement with the customer, can be outsourced to another company, or performed by the customer. The process itself is in parallel with the operation process and is aimed at identifying and correcting possible errors in the source code of the product, as well as its timely updating (Korauš et al, 2020; Lei, 2020; Murphy, 2020).

The steps listed above are mandatory and determine the possibility of creating and promoting an abstract IT product. In addition, there is a whole group of projects that are classified as auxiliary for one reason or another (Murphy, 2020).

Supporting processes are the second part of a comprehensive model for creating an IT product. In terms of time frames, these processes can be performed in parallel with the main ones, and despite the name, they are by no means secondary. The role of supporting processes is vital, but their very essence relates to the supporting function.

Supporting processes within the software life cycle include:

• Documenting process.

Development of a software product is a complex and lengthy process, in order to ensure the ability to work with the source code of third-party companies and its employees, the executing company generates and updates technical documentation that provides an opportunity to understand the principles of the program for specialists, as well as user manuals.

• Configuration management process.

Creating a software product implies that it will go through a series of iterations, during which changes will be made to the source code. This process allows you to ensure the relationship of both different versions of the program and its individual components.

• Quality assurance process.

The complexity of creating a software product and various requirements for the quality of the final product predetermine the need to create a software product quality management system.

• Verification process.

This process ensures the identification and logging of errors made during the development of a software product.

• Certification process.

The process aims to confirm the compliance of the obtained values with the reference ones, that is, the data resulting from the operation of the software product must have an error that meets the requirements and established standards.

• Joint Assessment Process.

A process for monitoring personnel and checking the status of a software product being developed. Performed by both parties (customer and contractor) throughout the time of all work on the project.

• Audit process.

The process of providing an independent audit to assess current regulations, project status, documentation and reports. The audit compares it to the contract and standard-setting documents. Can also be performed by both sides.

It should be noted that regardless of what final product needs to be created, what technologies are supposed to be used, and how the workflow will be organized - the process of creating a software product will involve the implementation of all the indicated stages of the life cycle.

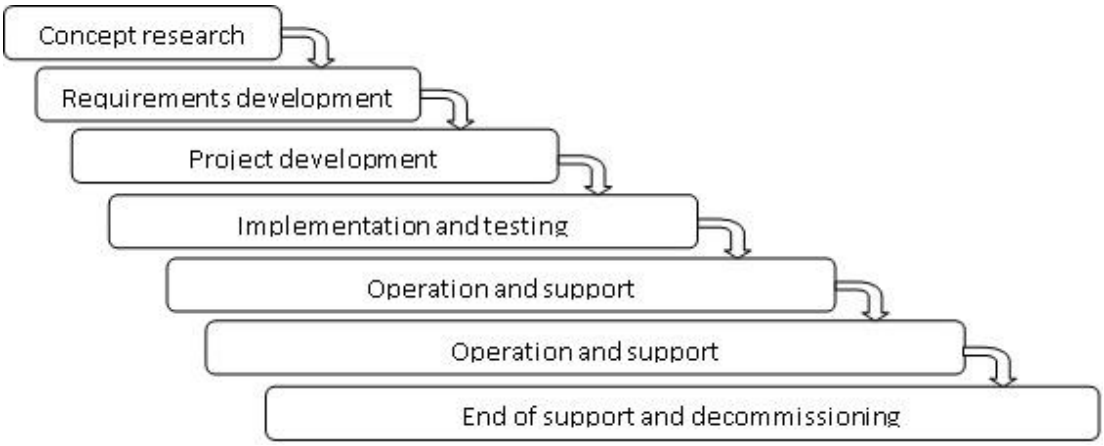
Nevertheless, the success of introducing a new IT product depends not so much on the innovation of the applied programming technologies, the efficiency of the frameworks used, and the number of highly qualified specialists, but on the competent approach to the process of organizing the work performed (Kotliarevskyy et al, 2016).

3. Methodology

Many companies' experience shows that the process of creating a modern IT product, and its successful introduction to the market, is primarily based on the use of an effective organizational scheme of work and a competent economic strategy for the involvement of labour and financial resources. It is no coincidence that statistical studies of software implementation success show that only 14% of developed software successfully enters the market (Robul et al, 2020).

At the dawn of the formation of the key processes of software development, even when the IT-sphere was just being formed, the so-called cascade model acted as an economic and organizational basis for software development, the diagram of which is shown in Fig. 5.

Figure 5. Waterfall model of software implementation and implementation



It is worth noting that despite its advantages such as transparent management of the development process, this approach has several significant disadvantages. As an example, it should be noted that the cascade approach does not imply high-quality management of the development time, the amount of financial resources spent is also poorly controlled, not to mention that this approach cannot provide the pledged level of quality. On the other hand, this technique ensures strict adherence to the given regulations, strictly consistently without returning to the previous stages. The consequence of this is the fact is completing the next stage.

In current conditions, the overwhelming majority of Ukraine companies that develop and promote IT products choose less formalized models as an organizational and economic model, which imply more flexibility in the development and implementation process.

The key approach in this matter is the use of agile development methods based on the philosophy of Agile, and the most popular of them is the SCRUM method, which is used by a significant number of Ukrainian IT companies.

The advantages of agile development methods include:

• By using an agile approach, the approach manages to effectively control timelines and adapt them to changes during the product creation process.

• Besides, the SCRUM methodology makes it possible to quickly launch a project with the highest priority functions and the lowest possible budget.

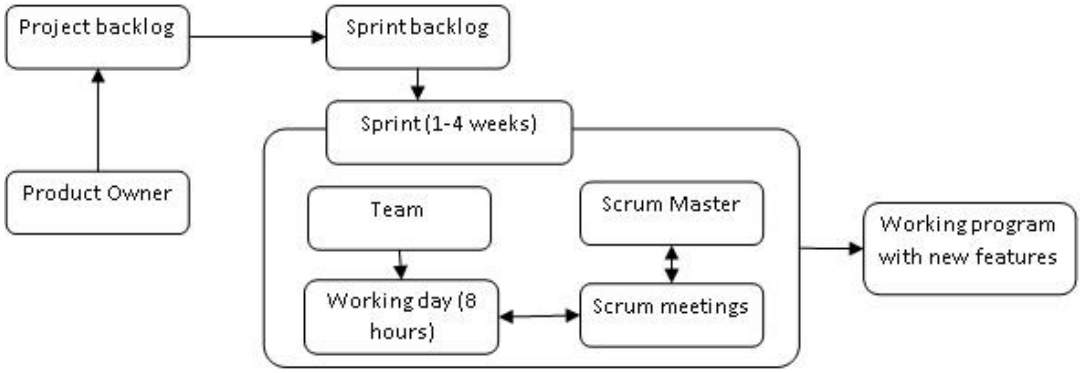
• Daily control over the progress of work, allows you to optimize budget costs for development.

• Application of this methodology assumes regular demonstration of a working software product to the customer, giving feedback quickly.

• The ability to make adjustments to the terms of reference in the project's course, which is an undoubted advantage for the customer.

The SCRUM methodology is based on iterations, fixed in time for production cycles (called Sprint), while at the end of the next process, the development team has a finished version of the program (with limited functionality defined at the beginning of this development cycle). The scheme of software product development using the SCRUM methodology is shown in Fig. 6.

Figure 6. Scheme of the team's work according to the method SCRUM



The roles of working according to the SCRUM method are distributed between the leader of the development team - Scrum Master), the customer's representative - Product Owner, and the software development team - Team.

Project backlog is the list of requirements for the functionality of the finished software product defined by the customer. The log requirements are sorted according to their importance in the implementation process.

Sprint backlog defines the list of functionality implemented by the development team at the end of the next cycle. Sprint's development cycle lasts from 1 to 4 weeks, at the end of which the team will have a working software product with new functionality. Then the cycle goes to a new iteration and continues until all the requirements for the product from the project log are met. At the end of each cycle, the software product's working version is demonstrated to the customer's representative and receives feedback from him.

During the next development cycle, the leader and the team hold daily working meetings - Scrum meetings, during which the progress of tasks in the process of work is determined.

The disadvantages of this approach include:

• Legal difficulties in formalizing contractual relations, since the SCRUM methodology does not imply a fixed budget and a fixed technical assignment.

• Frequent changes in the software product development process can create uncertainty about the exact result.

• Application of an agile development methodology to increase the project life cycle at the stage of its development, for all its participants.

• The need for daily team workshops and monthly customer meetings to demonstrate a software product increases labour costs.

All this leads to the need to search and optimize alternative options for developing IT products. Nonetheless, the common core of SCRUM based on the Agile philosophy will serve as the foundation for a modernized version of Agile. It should be noted that the list of principles of Agile philosophy, such as:

• the importance of the team,

• focus on product, not documentation,

• transparency of processes,

• continuous improvement,

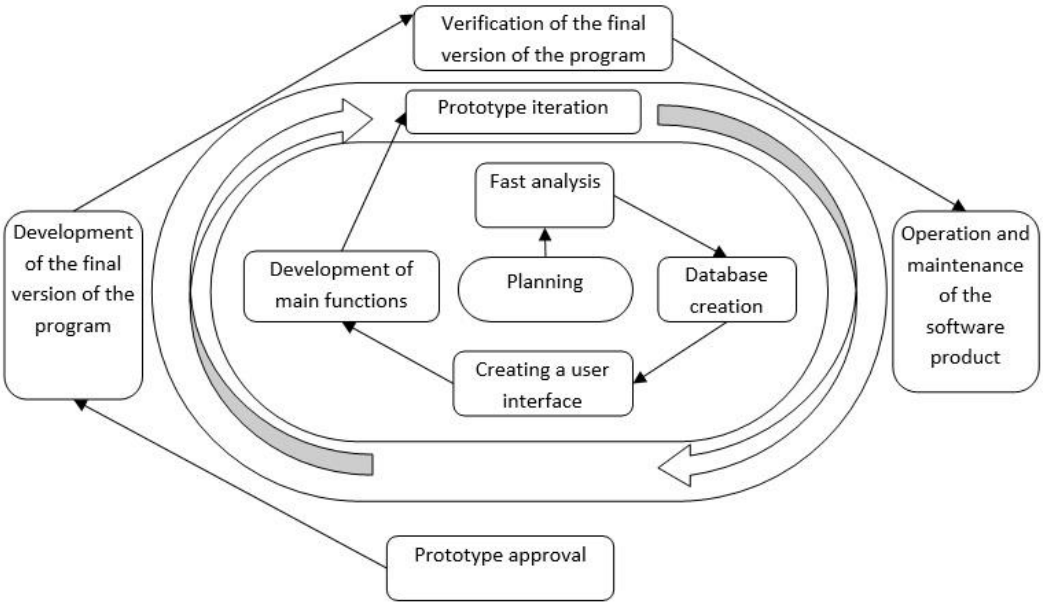
• quick result

significantly influence the success of the company that creates IT products from Ukraine. Together with the SCRUM methodology, these principles will be integrated into the practical methodology of the organizational and economic mechanism for creating a software product.

In particular, the first step in improvement is to combine agile development with prototyping-driven development. A diagram of the interconnection of the elements of the prototyping technique is shown in Fig. 7.

This approach involves creating several working versions of the program (prototypes) with incomplete functionality throughout the development process. Unlike a similar approach in the SCRUM methodology - prototyping is not limited to one development cycle, and most importantly, the prototype itself has more functionality than the working version at the end of the Sprint in Scrum.

Figure 7. Scheme of the relationship between the elements of the prototyping technique



Accordingly, the proposed methodology will inherit some of the features from the cascade model, thereby eliminating several SCRUM shortcomings, such as frequent working meetings and demonstrations of best practices to customers, and at the same time will retain the flexibility and adaptability of SCRUM, since the identified errors of the previous stage can be eliminated at the next iteration.

As noted above, the proposed SCRUM methodology has many shortcomings that are planned to be eliminated by modernizing it by borrowing effective practices from other approaches, particularly the iterative development model. This approach involves the iterative implementation of all major production stages of the software product life cycle. A schematic diagram of the production process, according to this principle, is shown in Fig. 8.

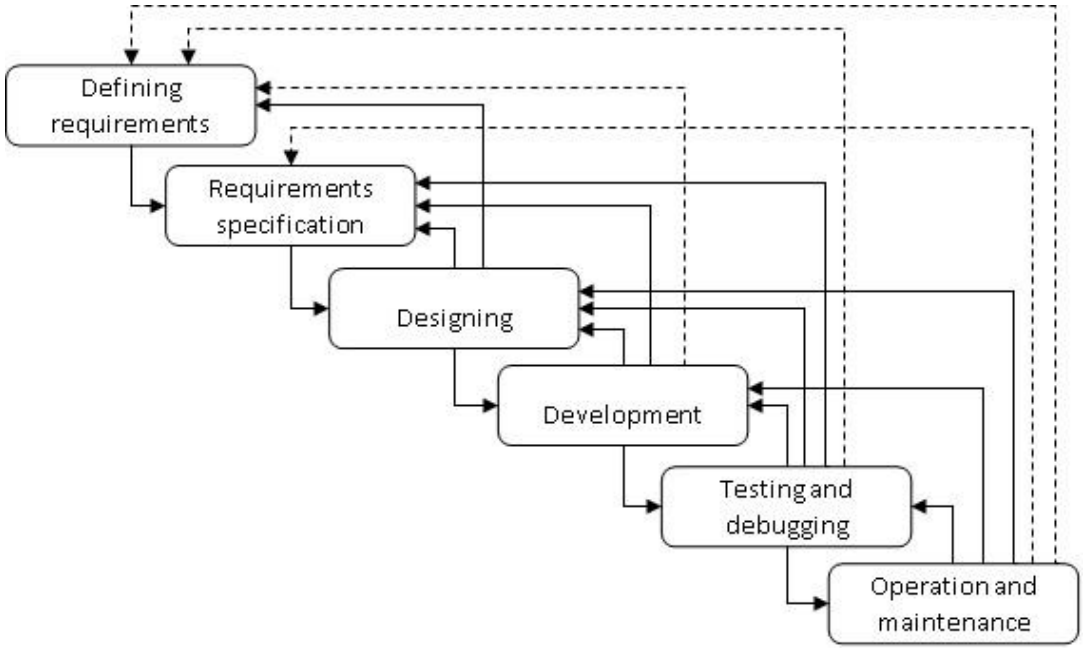
An iterative scheme, similar to a waterfall scheme, uses sequential execution of the main procedures of the software product life cycle, but unlike a waterfall scheme, it is not so rigidly tied to the main production sequence, that is, an iterative scheme allows you to return to previous stages of development and make the necessary adjustments.

Naturally, the difference between returning from the stage of designing a software product's architecture to refining the specification will spend fewer resources than returning to the same stage from the stage of final testing. In fig.5, returns that are suboptimal in terms of waste of resources (money and time) are indicated by dashed lines.

The very idea of returning and improving is reflected in the SCRUM methodology, but there is a significant difference in it, all the main stages of creating a working version are squeezed into the framework of a short development cycle (up to 4 weeks), many processes are parallelized. It should be noted that it becomes quite natural for small development teams to start developing a software product even before the final specification of the customer's technical specifications. Within the

SCRUM concept, this is explained quite naturally – be prepared for changes. Two factors facilitate this:

Figure 8. Iterative scheme of software product development



Firstly, the functionality of the future software product will still be revised, both based on the wishes of the customer and the results of its operation, which means that changes are inevitable.

Secondly, at the initial stages of creating a software product, developers have enough general requirements. Modern software has a similar structure, but the program's details and nuances will already emerge in the next cycles of the development process.

All this gives rise to a situation when, when developing according to the pure SCRUM method, despite daily working meetings, the process of creating a software product can generate hidden bottlenecks, the so-called bottlenecks, arising from a potential mismatch between the initial concept and the final version of the software product.

Adding iterative elements to the proposed software development scheme will bring several positive innovations to each life cycle stage. The result of work at each stage will be a clear set of documents (contract, terms of reference, project documentation), which will provide a complete understanding of the problem being solved, and the consistency of actions of all departments involved.

4. Results and Discussion

An IT company was chosen as an experimental base, the staff of which is 200 people (total number, including related divisions). This company was created during the period of the greatest turmoil in the Ukrainian IT market in 1998, during which time from a small company with a staff of 7 employees (including the director and chief engineer), it increased its staff to 200 employees.

The company's work's key feature was that throughout its life cycle, it mainly used a cascade (with some additions) model of organizing a business process. This approach ensured that the process and timing of software product development would be tightly controlled. In addition, senior managers had an understanding of both the actual development timeline and the potential cost of development.

On the other hand, the company's experience in the IT product market showed that the methodology of the organizational and economic model for implementing orders for IT products no longer meets market requirements.

The firm's work portfolio included two identical CNC software development contracts from Fagor Automation and Heidenhain, which we're updating their core industrial robot brands. Orders contracts in themselves:

• Creation of a test version of the program according to the specified characteristics.

• Development and transfer to the customer of the final version of the program and its source code.

• Final debugging and correction of possible errors on the customer's equipment.

• Creation of working documentation for this software product.

• Updating and maintenance of the software product in the first year of operation.

The contracts also included the extension of software product support for 3 years.

Both software products were to be developed by two independent development teams. The working groups included:

• 1 team leader (team lead);

• 1 system architect, who is also a senior developer;

• 4 software developers;

• 2 quality specialists;

• 1 leading systems engineer;

• 2 specialist engineers;

In total, the total number of each of the teams was 11 people.

The development of a software product for the first project was carried out based on traditional organizational concepts adopted in the company - a cascade method. In the second project, it was decided to use a modified agile development methodology.

The stages of creating software products were identical, but in the first project, the cascading methodology assumed no expected return to the previous stages. In both projects, the development included several stages:

1) Requirements analysis and preliminary sketches

2) Formation of program architecture and general design

3) Development of a working version

4) Testing for critical errors

5) Porting to hardware

6) Final debugging

7) Deployment on samples of customer equipment

8) Upgrades on demand, elimination of non-critical errors, product support.

The stages of development and testing were carried out in parallel, and in the future, for the testing stage, the time that was spent on tests, in addition to the development time, will be indicated.

It is also worth noting that both projects used the company's existing developments in this area; that is, the creation of a software product cannot be called "created from scratch".

In the second project, the iterative prototyping technique was used; during the development of the project, two prototypes of the software product and the final version were created. The prototypes were modified at the request of the customer.

In the course of work on both projects, customers periodically received adjustments to the initial parameters and limitations expected from the finished software product. Here it is worth making a remark and clarifying that the development of an IT product was carried out for the equipment being

designed whose parameters and performance characteristics changed in the course of work, this situation was provided for by the original contract with the customer.

The time and financial resources spent on the development and implementation of IT products for both projects are presented in the form of Table 1.

Table 1. Time and financial resources spent on the development and implementation of IT products

	First project – waterfall development	**Days**	**Financial resources (USD)**
1	Requirements analysis	3	45 493
2	Formation of architecture and general design	11	166 604
3	Development of a working version (total)	72	1 090 323
4	Testing for critical errors (total)	6	90 864
5	Porting to hardware	7	106 085
6	Final debugging	5	75 788
7	Deployment	7	106 037
	Total	111	1 681 194

	The second project – modified agile development	**Days**	**Financial resources (USD)**
1	Requirements analysis	2	30 296
2	Formation of architecture and general design	6	90 860
3.1	Development of the first prototype	14	212 087
4.1	Testing prototype	2	30 367
5.1	Porting to hardware	4	60 589
6.1	Final debugging	2	30 316
3.2	Development of the second prototype	16	242 283
4.2	Testing prototype	3	45 467
5.2	Porting to hardware	4	60 570
6.2	Final debugging	3	45 495
3.3	Development of a final version	21	318 005
4.3	Testing prototype	4	60 599
5.3	Porting to hardware	3	45 460
6.3	Final debugging	5	75 758
7	Deployment	6	90 878
	Total	95	1 439 030

The modified version of the agile development system proposed in the article showed good results in practice, both IT company managers and specialists positively assessed the experience of its use. Based on the already proven technology of agile development, this technique was able to add several mechanics that made it possible to neutralize many negative factors inherent in other approaches.

Analyzing the data in the table, it is worth noting that when developing a project with a waterfall approach, the need to make changes to a software product at different stages of development led to

the fact that the planned two-month cycle increased to 78 working days (taking into account the testing time).

Simultaneously, the project with a modified flexible development system saved not only 16 working days, but also more than 240 thousand US dollars. In addition, the customer for this project especially noted the positive fact of the opportunity to gain access to a working prototype, although without full functionality. This approach allowed already on the customer's side to revise some of the requirements for an IT product; as a result, the development team was able to implement it without the need to rework the finished software product.

5. Conclusion

Considering the approaches to organizing the development and promotion of IT products, it can be noted that Ukrainian companies, in addition to actively using world experience, can often apply both their own developments in this area and maintain organizational forms inherent in the Soviet economic system.

The SCRUM methodology in its purest form is used in many IT companies both in Ukraine and around the world. To a large extent, it, like the Agile philosophy, should be considered the industry standard in this area. The flexibility of the system, the ability to adapt to changing requirements, and control over the development time – all this refers to this approach's obvious advantages. Nevertheless, several criticisms of this system force us to look for ways to optimize it or replace it with other more effective approaches.

A specific feature of the Ukrainian approach to organizing work on the development of software products lies in the specifics of both national economic realities and Ukrainian specialists' mentality. It is worth noting that the IT-sphere's active development has left its mark on the approach to the development process - active development, constant readiness for change, the desire to learn and implement effective developments, have become a characteristic feature of Ukrainian companies.

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