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E-sports organizations with franchised networks: formalization of technological and economic development based on optimal operation and upgrade of the hardware

Abstract. The paper focuses on the priority given to the technological and economic development of e-sports organizations with franchised networks. Attention is paid to the specificity of the process of timely upgrading of e-sports hardware, which involves the upgrading and introduction of new, more sophisticated and advanced gaming and other devices, which determines the number of e-sports disciplines and available e-sports events for the e-sports arena. The success of franchising networks depends on the quantity of the c-sports hardware, which should be similar to the hardware used by the main arena in order to ensure the functionality of a well-structured state-of-the-art training process for e-sport athletes.

The purpose of the study is to present a basis for the technological and economic development of e-sports organizations with a franchising network within the formalized system in terms of finding optimal solutions to the problem of hardware upgrades.

The study presents a model of technological and economic development of all e-sports organizations with franchised networks as a content area, posing the rules of operation, regulating the process of hardware upgrades and focusing on the sustainability of development.

Dynamic programming methods based on Bellman's equations and the formalization of the problem of hardware replacement through graphic notations, cloud computing in the ***AnyLogic*** environment are used to identify and illustrate the features of such solutions.

The result of the research is a description of technological development of e-sports organizations with a franchise network with the use of a model that approximates the optimal way of operation and upgrade of related hardware. This development illustrates the optimal way of operation and hardware upgrade of Blizzard Arena and Overwatch League, represented by participants from the United States, the United Kingdom, Germany, France, South Korea and Ukraine. The franchised Overwatch League includes the main arena (Blizzard Arena), as well as Florida Mayhem Club (Miami-Orlando, USA), New York Excelsior Club (New York, USA), London Spitfire Club (London, UK), Vault Club 15 (Kyiv, Ukraine), Immortals Club (Los Angeles, USA), NRG E-sports Club (Berlin, Germany), Misfits Club (Seoul, South Korea), PS4 Training Base (Beijing, China) and Xbox One Training Base (Paris, France).

According to the obtained data, the formalization of the technological and economic development of Blizzard Arena suggests a solution to the problem of finding an optimal strategy relevant to optimization of hardware up to the moment of its transfer to the franchised network. Such formalization is highly relevant. They rely on the possible state of the system proposed in our research. That system state identifies the functional Bellman equations. Naturally, emerges a possibility to significantly reduce investment in the e-sports environment of the main arena and the franchise while controlling the quality and functionality of e-sports hardware.

The organizations' focus on two-stage upgrades will reduce investment in major hardware. The study illustrates the formalization of the techno-economic development of the Blizzard Arena through a two-stage upgrade of the Aerocool Advanced Technologies franchise (primary franchise - from producer, secondary franchise - from franchise Blizzard Arena operator). Based on the specific features of the Bellman equations, the development of the Blizzard Arena must take into account the model which determines the feasibility of hardware transferring to a franchised network during the third period of operation, where it operated as long

as franchisees enter the maximum profit area. When using the Bellman equations, we suggest that the arena focus on the moment when the function values will correspond to the replacement state of the hardware and the franchise member on the stability of the environment.
The formalization of the technical development will make it possible to orient the e-sport organizations with franchised networks to search for conditions sufficient for optimal operation and upgrade of their hardware. As a result, there will appear an optimized system with a content area, which will provide a stable environment for e-sports events at the arena and athletes' training in franchise clubs.
Keywords: E-sport; Franchise; Blizzard Arena; Overwatch League; Hardware; Upgrade; Bellman Equations; Graphic Notations; Dynamic Programming
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Кіберспортивні організації з франчайзинговими мережами: формалізація техніко-економічного розвитку на основі оптимальної стратегії експлуатації та оновлення обладнання

Анотація. Авторами відзначено високу пріоритетність техніко-економічного розвитку кіберспортивних організацій із франчайзинговими мережами, яка обумовлена впливом своєчасного оновлення кіберспортивного обладнання, що передбачає оновлення, впровадження нових, більш досконалих і прогресивних ігрових та інших пристроїв. Для кіберспортивної арени технічний розвиток визначає кількість кіберспортивних дисциплін, що доступні для кіберспортивної події. Успішність розвитку мереж залежить від кількості кіберспортивного обладнання, яке повинно бути повністю аналогічним до обладнання, яке застосовується основною ареною, щоб по функціональності забезпечити правильно вибудуваний, сучасний тренувальний процес кіберспортсменів. Метою дослідження є представлення змістовної основи техніко-економічного розвитку кіберспортивних організацій із франчайзинговими мережами в межах формалізованої системи, сформованої рішеннями завдань оптимальної стратегії оновлення обладнання.
Передбачається подання моделі техніко-економічного розвитку всіх кіберспортивних організацій із франчайзинговими мережами у вигляді змістовної області. У цій області представлені правила оперування безліччю процесів експлуатації та оновлення обладнання таких організацій (виходячи з завдання його заміни зі специфічною орієнтацією на стійкість розвитку). Для ілюстрації особливостей виконання такого завдання використано методи динамічного програмування на основі рівнянь Беллмана, а також формалізація завдання заміни обладнання на основі графічних нотацій та хмарні обчислення в середовищі AnyLogic Claud.
Результатом дослідження став опис змістовної області технічного розвитку кіберспортивних організацій з франчайзинговою мережею за допомогою моделі, яка надає правила наближеного оптимального управління експлуатацією та оновленням обладнання. При цьому складена формалізація технічного розвитку в графічній нотації наближено оптимального управління експлуатацією та оновленням устаткування Blizzard Arena та міжнародної франчайзингової мережі Overwatch League, представленої осередками в США, Великобританії, Німеччині, Франції, Південній Кореї та Україні. Франчайзингові мережі Overwatch League об'єднують основну арену (Blizzard Arena), а також осередки: клуб Florida Mayhem (Маямі-Орландо, США); клуб New York Excelsior (Нью-Йорк, США); клуб London Spitfire (Лондон, Великобританія); клуб Vault 15 (Київ, Україна); клуб Immortals (Лос-Анджелес, США); клуб NRG Esports (Берлін, Німеччина); клуб Misfits (Сеул, Південна Корея); тренувальну базу PS4 (Пекін, Китай); тренувальну базу Xbox One (Париж, Франція).
Ця формалізація актуальна, оскільки, орієнтуючись на можливі стани системи «дохід від експлуатації обладнання – щорічні витрати, пов'язані з експлуатацією і модернізацією обладнання – залишкова вартість обладнання / вартість нового обладнання» (яка визначається за функціональними рівняннями Беллмана $F_k(t)$), з'являється можливість знизити обсяг інвестицій в облаштування кіберспортивного середовища основної арени й франшизи за умов контролю якості та функціональності кіберспортивного обладнання.
Зменшити обсяг інвестицій в основне обладнання дозволить орієнтація розв'язання задачі на двоступеневе оновлення. У дослідженні проілюстрована формалізація техніко-економічного розвитку на основі двоступеневого оновлення обладнання за франшизою Aerocool Advanced Technologies (первинна – від виробника, вторинна – від оператора для франчайзингової мережі). Виходячи з отриманих рівнянь Беллмана $F_k(t)$, розвиток Blizzard Arena має забезпечуватися з урахуванням доцільності передачі обладнання до франчайзингової мережі в 3-му періоді його експлуатації, де воно

повинно експлуатуватися, поки забезпечує потрапляння в зону максимальних прибутків. Пропонуємо арені орієнтуватися на момент, коли значення функції будуть відповідати стану заміни обладнання, а учаснику франчайзингової мережі – орієнтуватися на стійкість середовища (тобто допоки значення $r(t)$ і $u(t)$ знаходяться в зоні максимальних прибутків).
Формалізація технічного розвитку дозволить орієнтувати кіберспортивні організації з франчайзинговими мережами на пошук умов, достатніх для оптимальної експлуатації та оновлення їх обладнання у вигляді системи зі змістовною областю, що забезпечує для арен стійке середовище проведення кіберспортивних подій, а для елементів мережі – стійке середовище тренувального процесу кіберспортсменів. Розширене уявлення про особливості такої змістовної області забезпечать отримані нами графічні нотації, які також адаптуються до моделювання та проектування процесів розподілу коштів.
Ключові слова: кіберспорт; франшиза; Blizzard Arena; Overwatch League; обладнання; оновлення; рівняння Беллмана; графічні нотації; динамічне програмування.

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Киберспортивные организации с франчайзинговыми сетями: формализация технико-экономического развития на основе оптимальной стратегии эксплуатации и обновления оборудования

Аннотация. Авторами отмечена высокая приоритетность технико-экономического развития киберспортивных организаций с франчайзинговыми сетями, которая обусловлена спецификой процесса своевременного обновления киберспортивного оборудования, предполагающего обновление и, внедрение новых, более совершенных и прогрессивных игровых и других устройств. Для киберспортивной арены такое развитие определяет количество киберспортивных дисциплин и доступные киберспортивные события. Успешность развития сетей зависит от количества киберспортивного оборудования, которое должно быть аналогичным оборудованию, применяемому основной ареной, чтобы по функциональности обеспечить правильно выстроенный, современный тренировочный процесс киберспортсменов.
Целью исследования является представление содержательной основы технико-экономического развития киберспортивных организаций с франчайзинговыми сетями в рамках формализированной системы, сформированной решениями задач оптимальной стратегии обновления оборудования.
Предполагается представление модели технико-экономического развития всех киберспортивных организаций с франчайзинговыми сетями в виде содержательной области, в которой представлены правила оперирования множеством процессов эксплуатации и обновления оборудования таких организаций, исходя из задачи его замены со специфической ориентацией на устойчивость развития. Для выявления и иллюстрации особенностей решения такой задачи использованы методы динамического программирования на основе уравнений Беллмана, формализация задачи замены оборудования на основе графических нотаций, а также облачные вычисления в среде AnyLogic Claud.
Результатом исследования стало описание содержательной области технического развития киберспортивных организаций с франчайзинговой сетью при помощи модели, которая представляет правила приближенного оптимального управления эксплуатацией и обновлением оборудования. Составлена формализация технического развития в графической нотации приближенно оптимального управления эксплуатацией и обновлением оборудования Blizzard Arena и международной франчайзинговой сети Overwatch League с представительствами в США, Великобритании, Германии, Франции, Южной Кореи и Украине. Франчайзинговые сети Overwatch League объединяют основную арену (Blizzard Arena), а также клуб Florida Mayhem (Маями-Орландо, США); клуб New York Excelsior (Нью-Йорк, США); клуб London Spitfire (Лондон, Великобритания); клуб Vault 15 (Киев, Украина); клуб Immortals (Лос-Анджелес, США); клуб NRG Esports (Берлин, Германия); клуб Misfits (Сеул, Южная Корея); тренировочная база PS4 (Пекин, Китай); тренировочная база Xbox One (Париж, Франция).
В соответствии с полученными данными представлена формализация технико-экономического развития Blizzard Arena на основе решения задачи оптимальной стратегии обновления ее оборудования в пошаговой оптимизации до момента его передачи участникам франчайзинговой сети. Такая формализация крайне актуальна, поскольку, ориентируясь на возможные состояния системы «доход от эксплуатации оборудования – ежегодные затраты, связанные с эксплуатацией и модернизацией оборудования – остаточная стоимость оборудования/стоимость нового оборудования» (определяется по функциональным уравнениям Беллмана $F_k(t)$), появляется возможность значительно снизить объем инвестиций в обустройство киберспортивной среды основной арены и франшизы при контроле качества и функциональности киберспортивного оборудования.
Снизить объем инвестиций в основное оборудование позволит ориентация решений задачи на двухступенчатое обновление. В рамках исследования проиллюстрирована именно формализация технико-экономического развития на основе двухступенчатого обновления оборудования по франшизе Aerocool Advanced Technologies (первичная – от производителя, вторичная – от оператора

для франчайзинговой сети). Исходя из особенностей уравнений Беллмана $F_k(t)$, развитие Blizzard Arena должно обеспечиваться с учетом факторов, определяющих целесообразность передачи оборудования во франчайзинговую сеть в 3-м периоде его эксплуатации, где оно эксплуатируется, пока обеспечивает участникам сети попадание в зону максимальных прибылей. Предлагаем при использовании $F_k(t)$ арене ориентироваться на момент, когда значения функции $F_k(t)$ будут соответствовать состоянию замены оборудования, а участнику франчайзинговой сети – на устойчивость среды, т.е. есть пока значения $r(t)$ и $u(t)$ находятся в зоне максимальных прибылей. Представленная формализации технического развития по функции $F_k(t)$ позволит ориентировать киберспортивные организации с франчайзинговыми сетями на поиск условия достаточного для оптимальной эксплуатации и обновления их оборудования в виде оптимальной системы с содержательной областью, обеспечивающей для арен устойчивую среду проведения событий по киберспортивным дисциплинам, а для элементов сети – устойчивую среду тренировочного процесса киберспортсменов. По нашему мнению именно расширенное представление об особенностях такой содержательной области обеспечат полученные нами графические нотации, которые также могут быть адаптированы к сфере моделирования и проектирования процессов распределения средств, что делает предлагаемый подход идеальным для обеспечения стабильности среды событий по киберспортивным дисциплинам и тренировочного процесса киберспортсменов.
Ключевые слова: киберспорт; франшиза; Blizzard Arena; Overwatch League; оборудование; обновление; уравнение Беллмана; графические нотации; динамическое программирование.

1. Introduction

The study focuses on the technical and economic development in global e-sports organizations, representing one of the fastest-evolving scopes in the digital economy. Particularly, this technological advance is a priority to systematically benefit from specific business interactions oriented towards the e-sport virtual space. The audience of e-sports tournaments numbers millions of spectators. For example, in 2019, EPICENTER Major's events on e-sports, including Dota 2, were attended by some 46 million spectators.

During the period between March and August 2020, the number of spectators increased to 80 million (Blizzard Arena, 2020). Every competition in Overwatch at the Blizzard Arena was watched by approximately 489,000 people, compared with only 370,000 people in 2017 (Blizzard Arena, 2020). Each viewer promotes expansion of the media, gaming and competitive streaming training space in e-sport, as well as a growing demand for evolutionary development of technology to provide for integrated organization and management of this business. As a result, since 2017, all e-sports arena operators (including RFRSH Entertainment, PTWP Event Center Sp. z o. o, and Tencent) have been transforming into global franchisers.

Nowadays, the arena owners in major e-sports events are not simply billing themselves as organizations majoring in events in specific e-sports disciplines but rather as parties that grant their rights for business activities related to a specific e-sport discipline, by implementing an already elaborated business model of its management and technological development (i.e. via hardware franchise).

Actually, the main e-sports arenas act as operators of franchised networks (franchisers). These franchisers are the following: the Blizzard Arena by the Overwatch League operator (tournaments and Overwatch tournament finals, Los Angeles); the Spodek Arena by the PTWP Event Center Sp. z o. o (tournament finals in Intel Extreme Masters, Katowice), the Staples Centre by the NA LCS operator (tournament finals by the League of Legends, Los Angeles); Sang-am World Cup Stadium by the Tencent operator (tournament League of Legends, Seoul) and the E-sport Arena from the RFRSH Entertainment operator (tournament by CS: GO, Kyiv).

At first the transition to franchising by gaming corporations such as NA LCS and Overwatch League caused fierce controversy among gamers but eventually has proven a success since that time. In the case with the Overwatch League, the franchising approach was implemented in launching a whole range of global clubs and hubs, including Florida Mayhem, New York Excelsior, London Spitfire and many more.

Geographically bound participants began to engage more people in gaming discussion, thus commercializing it, so the Overwatch League also represented a model of technical development. Currently, operators of e-sports franchises are developing multifunctional e-sports platforms (arenas) and their global networks, represented by single-format specialized clubs, home arena hubs for e-athletes, constituting training centers in specific e-sport disciplines. The main concept of the franchising approach is to create technically advanced clubs and training centers, intended for teams representing their native regions where they will have fans. The teams must have home arenas for local e-sports events.

A necessary condition for e-sports organizations with franchised networks to become a success in technical development is defined by the quality and functionality of their e-sports hardware. For the major e-sports arena, it serves to determine the number of e-sports disciplines and available e-sports events.

The initial selection, installation and customization are carried out according to the hardware franchise from the leaders of the gaming industry market. Thus a high marginality of events in e-sports disciplines is ensured (Blizzard Arena, 2020; Rardin, 2015). However, effective upgrade management remains an outstanding issue in order to guarantee a sustainable environment for holding events in e-sport disciplines.

Game consoles, system blocks for e-sport tournaments, game servers are sensitive to functional obsolescence, deterioration, and their updating (by installing or replacement of individual components) is extremely expensive and often not possible. The arena hardware should provide for a stable environment for e-sports events in all available formats; it should be updated at the time when the loss from early replacement is less than the loss incurred from its operation.

For e-sports athletes, training takes several hours every day to keep fit before the competition. Achievements in network development depend on the number of e-sports hardware units, which should be the same as that of the main arena. This is required to ensure functionality of the training process of e-sports athletes. Hence, basic hardware is included into the franchise cost. However, the franchiser transfers second-hand hardware to the franchise networks (since the latter recommended for replacement in the arena, but suits perfect for the training process). In particular, this hardware may cause technical issues related to a small input lagging or rarely a frame loss. However, it does not affect the quality level of the e-sports athletes' training process. The remaining problem is the effective management of hardware upgrade, ensuring a stable training environment.

To earn money from e-sports disciplines, e-sports organizations engage franchising terms for standardized hardware of a specific manufacturer. The hardware is not returned to the franchisor until the expiry of its lifespan but is further transferred to the franchise network. At this, it is required to balance the technical development of the e-sports arena and its franchising network. This is feasible by completing tasks of optimal operation strategy and hardware upgrade.

Technical and economic development formalization based on an optimal operation strategy in hardware upgrade remains pertinent for Ukraine. Despite the public franchise offer by the E-sport Arena (from Vincere), as well as that by foreign e-sports arenas (including the Overwatch League's Blizzard Arena), 98% of the e-sports corporate bodies work independently or through franchises from local e-sports operators not possessing arenas and offering only discounts on hardware within a 2-5% range of the cost (the PTWP Event Center Sp. z o.o, 2020; the Blizzard Arena). Among such local operators are the Cyber:X Community, Good Game, Strike Arena, and Colizeum. In this case, franchising networks sharers do not have sufficient funds to purchase the required number of functional hardware.

A prove to this is the fact that 17% of those clubs have home arena hardware (i.e. provide for the opportunity of holding spectacular e-sports events with no frame loss) while only some 37% are equipped with consoles designed for multi-gaming training.

2. Brief Literature Review

There are many studies concerning the importance of meeting the challenges of technological development through optimal operation strategy and hardware upgrade for different types of organizations. In general, experts in this field make only an approximate assessment of the impact of the hardware operating duration period on the income (benefits) or total operating costs, without ever specifying the essential terms of hardware operation. Further, implying dynamic programming methods, the optimum solution to the issue of hardware upgrade is found.

Some individual scholars (Bhondekar, Vig, Singla, Ghanshyam, & Kapur, 2009) have suggested that the brute-force (access scan) method (uniform Search Algorithms, grid-searching) should be employed as an alternative to dynamic programming method in order to solve the existing problem. Although it is the simplest method of finding significant functions in hardware upgrade by any cost criteria, dynamic programming methods are more effective in shaping a hardware upgrade strategy. This includes a step-by-step optimization method or a hardware upgrade strategy optimization method involving Bellman equations.

We have singled out a range of scientific works suggesting to study the factors shaping the cost of capital stock overhaul using the following: Cobb-Douglas two-factor production function (Renshaw, 2016); the derivative of the constant elasticity-of-substitution production function

(Chen, 2012; Renshaw, 2016); the Leontiev production function (Mishra, 2010); the linear production function (Arrow, Chenery, Minhas, & Solow, 1961). In their studies, the scholars draw attention to the advantages of applying each of the selected production functions, in particular, the simplicity of constructing the «cost - cost - utility», practical universality functional relationships.

Meanwhile, in the earliest studies (Arrow, Chenery, Minhas, & Solow, 1961), it is emphasised that any production function expresses the relationship between production costs and the product output, which makes this function highly dependent on the production factors utility. It is typical that these functions should suggest a mandatory increase in production ramp-up (or utility) to increase in factor costs. However, it may not be appropriate when developing a hardware upgrade strategy for e-sports organizations, since the increase in factor costs includes variable annual costs due to the peculiarities of specialized hardware operations.

In particular, the following issues arise during the process of hardware operation:

1. Issues related to the operating system: computer viruses, unnecessary background computer software and obsolete software remnants.
2. Issues of hardware obsolescence (in different ways, causing problems concerning the quality of rendering cinematics, video standard quality, etc.).
3. Issues related to accrescent software requirements, etc.

In a number of instances, replacing an arena's gaming hardware will be cheaper than its upgrading, based on of each component specs. The increase in the production cost factors does not always provide for an increased in their effectiveness.

According to the studies by Mensch & Blondel (2018), and Lapkina (2018), at the conditional optimization stage, the dynamic programming method allows for discarding certainly useless variants (with us, these are options to continue hardware operation). Dynamic programming provides for management of hardware upgrade with a standard approach, utilizing various cloud services. A formalized description of key organizational destinations can be compiled requiring minimal management intervention (Winter Simulation Conference, 2018).

A whole team of scholars (Taha, 2017; Bellman, 2010, 2013; Denardo, 2012; Zaidon, Wei, & Honglei, 2009) suggest that the initial state of the hardware should be determined for this purpose with further applying the step-by-step optimization method, which implies that the search for an optimal solution is divided into a fixed number of stages (steps). Then a step-by-step comparison is made between different variations in the hardware upgrade strategy.

Along with that, scholars like Zaidon, Wei & Honglei (2009) point out that the main conditions for applying this dynamic programming method are an increase in repair and maintenance costs, a decrease in productivity and marketable value.

These are not common cases for modern e-sport hardware. Not only general but also special cases arise when completing tasks concerning staged hardware replacement. In our opinion, it is important to consider the cases where the optimal conditions for maximizing profits for the organization are lost.

Carter, Price, & Rabadi (2019), Bertsekas (2012), Rardin (2015) consider special cases arising when completing tasks concerning staged hardware replacement with the help of Bellman equations. The search for the optimal solution is divided into steps at the i-th stage, depending on the actual state of the system. Rardin (2015), Lutsenko (2016), Lapkina & Malaksiano (2018) determine that the initial hardware state is relevant for the first k-step only. Bohner, Stanzhytskyi & Bratochkina (2013) suggest that the Bellman equation content should be considered not simply as differential in private derivatives but also as an equation with operating hardware conditions set up for the latest moment. This approach will make it possible to take into account all models of the optimal hardware upgrade strategy in e-sports organizations, because it allows for identifying the following: cases where the upgrade scope contains elements where it is most appropriate to preserve the initial hardware, since there are optimal conditions for maximizing profits; cases where maintaining hardware is not appropriate, since an increase in costs needed for the hardware to meet technical, system, or other requirements at a certain stage results in losing optimal conditions for maximizing profits. Thus, the importance of the approach to dynamic programming is supposed to be guided with optimal conditions in order to maximize profits. It is typical of an approach based on Bellman equations (Zerbini, Luceri, & Vergura, 2017).

In particular, the advantage of the dynamic programming method in optimizing the hardware upgrade in e-sports organizations, along with the use of Bellman equations, is an opportunity to analyze the technical environment to determine its sensitivity to changes in the state of the entire hardware complex in arenas, clubs and training centers until the i-th step. Some finite state is defined taking into account the target function (win) at each i-th step.

3. Purpose

The purpose of the paper is to present an informative basis for the technological development in e-sports organizations featuring franchising networks within a formalized system formed by completing tasks in the optimal strategy relevant to hardware upgrade.

4. Methodology and Data

We suggest a presentation of the informative basis of the technical development in e-sports organizations to be compiled as operating rules for multiple operation and hardware upgrade processes for the companies, based on the formalization of the replacement task, with a view to the sustainability of the major arena development, as well as its franchising network. To identify and illustrate the peculiarities in finding solutions, the following methods are used: dynamic programming methods (based on Bellman equations); methods of formalizing the description of the hardware replacement task based on graphic notations; cloud computation in the AnyLogic Cloud environment featuring a free tariff for computing functions, including finding solutions with complex dynamic tasks (Bellman, 2010; Bellman, 2013).

The graphic notation is used as the main method for visual representation of resulting rules for approximate management of the hardware operation and upgrade. The entire technical development process in an e-sport organization is described with an event-functional chain of variables controlling the hardware upgrade at each operational step.

The e-sport organization Overwatch League, an Overwatch trend hub to multiplayer first-person shooter games, is selected as the base for the research (Donovan, 2018). The reasons for choosing the technical development model of the organization as the basis for our scientific research is its being typical for e-sports. In particular, this model unites the Blizzard Arena with global franchising networks represented by clubs and training centers operating with Aerocool Advanced Technologies' unified gaming hardware. This franchising network includes Florida Mayhem, New York Excelsior, London Spitfire, Vault 15, Immortals, NRG E-sports, Misfits, as well as PS4 and Xbox One training centers. All members of this network have home arenas in the Overwatch discipline. At the same time, the Blizzard Arena is a space for major events only in Overwatch computer sports. For Overwatch League, as it is with similar organizations, the solution to the problem of hardware operation and upgrade is set with the initial data, taking into account the two-stage process: primary arena hardware upgrade by the franchise directly from the manufacturer and secondary hardware upgrades within the franchise network (Bellman, 2010; Noghin, 2018), namely:

- $r(t)$ - income from e-sports events obtained within each planning period through the hardware operation (including income from digital products, streaming, sales of media rights, sponsors);
- $u(t)$ - annual costs related to the operation and modernization of e-sports hardware, depending on royalties, additional maintenance costs related to bringing the hardware in conformity with technical and other requirements;
- $s(t)$ - residual hardware value, taking into account functional obsolescence;
- p - original franchise hardware value, including required capital needs;
- q - number of hardware units required for a single game session for 450 athletes.

The $r(t)$ product value function has been replaced by the average income function from e-sports events, $r(t) = r(t) - u(t)$. Initially, hardware for e-sports arenas is donated by sponsors. If the original hardware cost is not specified, the AnyLogic Cloud may perform the task based on the cost and replacement function, (which is a task in capital investment planning). In any case, the variable for controlling the hardware upgrade process at each k-step is a logical variable that can receive one of two values: save (S) or replace (R) the hardware for the k-th year.

The formalization procedure of the Blizzard Arena's technological development should not be compiled simply based on the hardware operation interval but considering the technical development within the entire Overwatch League franchise network where hardware transfer timing from the Blizzard Arena to network members is important. The input data for the formalization of the Blizzard Arena's technical development including Overwatch League franchised networks based on the optimal hardware operation and the upgrade strategy are presented in Table 1.

According to the input data, it is possible to formalize the technical development of the Blizzard Arena by defining the task of an optimal hardware operating and upgrading strategy within step-by-step optimization starting from the actual timing transfer moment to the members of the network. In order to accomplish this task, the basic strategy is to upgrade the arena hardware and change the value of $u(t)$, taking into account the flexible hardware franchise package envisaging adaptation to operating conditions within the Overwatch League franchising network.

In particular, for each step, possible states of the average income function are determined based on the Aerocool Advanced Technologies franchising terms (taking into account the values $t = 1,2,3,4$ for the game console Overwatch and $t = 1,2,3$ for other hardware). Consequently, formalization of the development model in e-sports organizations with franchising networks is determined with the functional equations of Bellman $F_k(t)$ in the following format:

- provided $k = 4,3,2,1$.

Step 1: $k = 4$. For step 1, the possible states of the system $t = 1,2,3,4$, at which the functional equations have the form: $F_4(t) = \max(r(t), (S); S(t) - P + r(0), (R))$;

Table 1:
Input data for the formalization of the technical development of the Blizzard Arena's League franchised networks including Overwatch based on the optimal hardware operation and upgrade strategy in the period between 2020 and 2024, USD

Hardware (E)*	**Actual and expected data to the task of hardware arena transfer timing to the network members, USD. ****						**Optimization condition for calculating of possible system states**	
	t	0	1	2	3	4	r(t) = r(t) - u(t)4	step
Overwatch system unit for game console	r(t), $	0	10,000,000	…	…	it not required	r(0) = 0	3,2,1
		Cost of tickets, broadcasting rights, excluding streaming					r(1) = 9,880,000	
	u(t), $ [2]	0	120,000	6,600,000	112,400,000		r(2) = 3,400,000	
	s(t),$	15,000,000	12,200,300	6,489,087	4,673,450		r(3) = -12,400,000	
	q, units	450	450	450	450			
Game console Overwatch	r(t),$ [2]	0	10,000,000	…	…	…	r(0) = 0	4,3,2,1
		Cost of tickets, broadcasting rights, excluding streaming					r(1) = 9,649,200	
	u(t),$ [3]	0	350,800	1,539,000	13,000,000	8,976,300	r(2) = 8,461,000	
	s(t),$	12,780,000	10,130,000	9,420,400	7,239,000	5,274,000	r(3) = 3,543,300	
	q, units	450	450	450	450	450	r(4) = 1,023,700	
Game server and server hardware	r(t),$	0	5,000,000	…	…	not envisaged	r(0) = 0	3,2,1
		Streaming at e-sports events					r(1) = 4,400,000	
	u(t),$ [4]	0	6,000,000	2,540,000	5,000,000		r(2) = 2,460,000	
	s(t),$	4,000,000	3,000,000	2,500,000	2,000,000		r(3) = 0	
	q, units	450	2	2	2			

Notes:

[1] the hardware: 1 - Overwatch system block for the game console at USD 33,330 (lifespan before upgrade up to 3 years); the hardware operation lifetime at the time of analysis, $t = 0$ (new); 2 - game console Overwatch at USD 28,400 (lifespan before upgrade up to 4 years; 3 - game server and server hardware at USD 2,000,000. (lifespan before upgrade up to 3 years);

[2] $u(t)$ for $t = 1$ - work and rest environments modelling; own processor load test; graphics performance estimate, a memory speed and storage system speed estimate and gaming tests; $u\ (t)$ for $t = 2$ - CPU overclocking; software update; driver updates; cleanup; (t) for $t = 2$ - full upgrade; here $u(t)$ for t envisages adaptation to operating conditions in the franchise network;

[3] $u(t)$ for $t = 1$ - sound system connection and setup, electric component adjustment, integrated highlight upgrade; $u(t)$ for $t = 2$ - monitors upgrade; electric component adjustment, integrated highlight upgrade and RGB- highlight upgrade; $u(t)$ for $t = 3$ - upgrading the gaming workstation; electric component adjustment, integrated highlight upgrade and RGB- highlight upgrade; DXRacer Racing upgrade; $u(t)$ for $t = 4$ - full upgrade, including the replacement of all monitors, seat tilting mechanism, footrest mechanism, the projecting hoist bracket mechanism with the monitor, Bluetooth loudspeakers; here the design $u(t)$ for t envisages adaptation to operating conditions within the franchise network;

[4] $u(t)$ for $t = 1$ - server software upgrade; $u(t)$ for $t = 1$ - server software upgrade; replacement and upgrade of embedded network controllers; $u(t)$ for $t = 3$ - memory module upgrade, network and graphic adapters upgrade, server software upgrade; effective management of the convergent environment; here $u(t)$ for t envisages adaptation to operating conditions within the franchise network.

Source: Compiled by the authors based on data by the Blizzard Arena: https://eu.battle.net/login/en/?ref=https://eu.battle.net/oauth/authorize?response_type%3Dcode%26client_id%3D057adb2af62a4d59904f74754838c4c8%26scope%3Daccount.full%2520commerce.virtualcurrency.full%2520commerce.virtualcurrency.basic%26state%3DeyJzdGF0ZUVudHJvcHkiOiJYV0hRMTdTSmdPOWIzQ2s2REIFYm9pV2RSR0VjNHZsWHI0OHZrdXJndVJzPSIsInJIZmVycmVyIjoiL292ZXJ2aWV3In0%253D%26redirect_uri%3Dhttps://account.blizzard.com/login/oauth2/code/account-settings%26registration_id%3Daccount-settings&app=oauth

$u(t)$, $s(t)$ - Blizzard Arena Hardware Franchise Information Leaflet: https://drive.google.com/file/d/1xmM-Fw1_N2tKaHZwdweTnjIkgad13iJB/view?usp=sharing

Step 2: $k = 3$. For step 2, the possible states of the system $t = 1,2,3$, at which the functional equations have the form: $F_3(t) = \max(r(t) + F_4(t+1) ; S(t) - P + r(0) + F_4(1))$;
Step 3: $k = 2$. For step 3 the possible states of the system $t = 1,2$, at which the functional equations have the form: $F_2(t) = \max(r(t) + F_3(t+1) ; S(t) - P + r(0) + F_3(1))$;
Step 4: $k = 1$. For step 4, the possible states of the system $t = 1$, at which the functional equations have the form: $F_1(t) = \max(r(t) + F_2(t+1) ; S(t) - P + r(0) + F_2(1))$;

- provided $k = 3,2,1$.
For Step 1, the possible states of the system $t = 1,2,3$, at which the functional equations have the form: $F_3(t) = \max(r(t), (C); S(t) - P + r(0), (R))$;
Step 2: $k = 2$. For step 2, the possible states of the system $t = 1,2$, at which the functional equations have the form: $F_2(t) = \max(r(t) + F_3(t+1) ; S(t) - P + r(0) + F_3(1))$;
Step 3: $k = 1$. For step 3 the possible states of the system $t = 1$, at which the functional equations have the form: $F_1(t) = \max(r(t) + F_2(t+1) ; S(t) - P + r(0) + F_2(1))$.

The optimization condition for calculating the possible states of the system) is presented in Table 1. Under the optimization condition, k is hardware operation year and t is the actual age of the hardware. Input data were used to define maximum profit zones/Blizzard Arena hardware timing transfer to a franchised network (based on Bellman $F_k(t)$ equations and formalize a graphic form for the approximate optimal operation and upgrade of the Blizzard Arena hardware (compiling graphic notations). The formalized value for $F_k(t)$ is expressed through the actual state of the technical development of the arena based on its income maximization. At this, $u(t)$ is modified to meet the needs in the operating hardware upgrade aimed at achieving a stable event environment in the Overwatch e-sport discipline. The formalization substantiation is isolation of $F_k(t)$ function values, namely those corresponding to the actual state by the hardware replacement state. This reason is explained by the variable controlling the hardware upgrade process at each k-step, being a logical variable, receiving one of two values: save (R) or replace (3) the hardware for the k-th year.

Within a franchise network, the task of the optimal operation and the upgrade hardware strategy is completed in the same way, taking into account the maximum facility income and the total hardware service life of the hardware (t actual = 8 for gaming hardware from Aerocool Advanced Technologies, i.e. the task compiled for the franchised network taking into account the remaining 5 years of hardware operation, where $k = 5,4,3,2,1$).

For franchising networks, we set the starting point data for the hardware operation and upgrade, taking into account the transfer of the Aerocool Advanced Technologies franchise by the Overwatch League network operator, namely:

- $r(t)$ - income from training game sessions, obtained during each planning period through the hardware operation, including income from streaming and sponsors;
- $u(t)$ - annual costs related to operation of the e-sports training hardware, depending on royalties and additional operating costs;
- $s(t)$ - residual hardware value with regard to its functional obsolescence; if the residual value is constant for all $s(t)$, the same parameter value is supposed to be accepted;
- p - cost of the original franchise hardware, including required capital investments;
- q - number of hardware units per single training session, based on the club needs.

Here, $s(t)$ and $u(t)$ are general values, due to the operating conditions similarity within the franchise network. These values are assigned by the proportion method. The input data for the formalization of the technical development in the Overwatch League franchises, based on the optimal hardware operating and the upgrading strategy are presented in Table 2.

The formalization of the technical development in the Overwatch League franchise networks is determined with functional Bellman equations $F_k(t)$ of various modes. The most desirable is the hardware maintenance equation, where $F_k(t)$ for $k = 5,4,3,2,1$.

For step 1, the possible states of the system $t = 1,2,3,4,5$, at which the functional equations have the form: $F_5(t) = \max(r(t), (S); S(t) - P + r(0), (R))$.

For step 2, the possible states of the system $t = 1,2,3,4$, at which the functional equations have the form: $F_4(t) = \max(r(t) + F_5(t+1) ; S(t) - P + r(0) + F_5(1))$.

For step 3, the possible states of the system $t = 1,2,3$, at which the functional equations have the form: $F_3(t) = \max(r(t) + F_4(t+1) ; S(t) - P + r(0) + F_4(1))$.

For step 4, the possible states of the system $t = 1,2$, at which the functional equations have the form: $F_2(t) = \max(r(t) + F_3(t+1); S(t) - P + r(0) + F_3(1))$.

Table 2:
The input data for the formalization of the technical development in the Overwatch League franchises, based on the optimal hardware operating and the upgrading strategy in the period between 2020 and 2024, USD

	t in $F_k(t)$	Actual and expected data for the task of hardware upgrade, USD **					
		0	1	2	3	4	5
	t Actual	3	4	5	6	7	8
Overwatch system unit for game consoles (the r(t) value in USD is taken into account as the planned income from training sessions)							
1	r(t), $	0	700,390	...	...	...	...
2	r(t), $	0	728,405	...	...	...	...
3	r(t), $	0	1,050,585	...	...	...	...
4	r(t), $	0	1,071,596	...	...	...	...
5	r(t), $	0	1,093,028	...	...	...	...
6	r(t), $	0	332,290	...	...	...	...
7	r(t), $	0	502,370	...	...	...	...
8	r(t), $	0	2,693,033	...	...	...	...
9	r(t), $	0	2,209,011	...	...	...	...
Total values for franchisees [1]	u(t),$ [3]	1,203,430	1,406,430	1,608,430	1,809,430	20,013,030	2,205,500
	s(t), $	6,489,087	5,289,087	4,089,087	3,969,087	2,796,087	1,569,087
	q, units	450	450	450	450	450	450
Game console Overwatch (the r(t) value is taken into account as the planned income from training sessions and streaming)							
1	r(t), $	0	980,390	...	...	...	...
2	r(t), $	0	1,019,605	...	...	...	...
3	r(t), $	0	1,360,390	...	...	...	...
4	r(t), $	0	1,071,596	...	...	...	...
5	r(t), $	0	1,093,028	...	...	...	...
6	r(t), $	0	442,290	...	...	...	...
7	r(t), $	0	662,370	...	...	...	...
8	r(t), $	0	2,693,033	...	...	...	...
9	r(t), $	0	2,209,011	...	...	...	...
Common values for franchisees [1]	u(t), $	1,539,000	1,631,340	1,539,001	1,631,341	1,539,002	1,631,342.1
	s(t), $	9,420,400	753,6320	602,9056	4,823,244	3,858,595	3,086,876.6
	q, units [1]	450	450	450	450	450	450
Game server and server hardware (the r(t) value is taken into account as the planned income from Overwatch games enhancement, through cloud servers)							
1-7 - general values for franchisees [1]	r(t), $	0	2,675,800	...	...	...	...
	u(t), $	1,117,600	1,173,480	1,232,154	1,293,762	1,358,450	1,426,372
	s(t), $	1,100,000	880,000	704,000	563,200	450,560	360,448
	q, units[1]	1	1	1	1	1	1
8,9- common values for franchisees [1]	r(t), $	0	2,945,900	...	...	...	...
	u(t), $	1,422,400	1,493,520	1,568,196	1,646,606	1,728,936	1,815,383
	s(t), $	1,400,000	1,120,000	896,000	716,800	573,440	458,752
	q, units[1]	1	1	1	1	1	1

Notes:
[1] $u(t)$ and $u(t)$ values common for franchisees, assigned by the proportional method, based on the (d) share, as defined by submitted hardware applications: club 1 - d - 0.05; club 2 - d - 0.09; club 3 - d - club 4 - d - 0.12; club 5 - d - 0.12; club 6 - d - 0.04; club 7 - d - 0.04; training center 1 - d - 0.1; training center 2 - d - 0.2. The $u(t)$ value for t envisages adaptation to operating conditions in the franchise network.
[2] Franchisees: 1 (club Florida Mayhem); 2 (club New York Excelsior); 3 (club London Spitfire); 4 (club Vault 15); 5 (club Immortals); 6 (club NRG E-sports); 7 (club Misfits); 8 (training center PS4); 9 (training center Xbox One).
[3] $u(t)$ for $t = 1$ - full update for operating conditions within a franchised network; $u(t)$ for $t = 1$ - modelling environments rest and work; own CPU load test; graph performance estimate, memory speed and storage system speed estimate, gaming tests and so on.

Source: Compiled by the authors based on data by the Blizzard Arena: https://eu.battle.net/login/en/?ref=https://eu.battle.net/oauth/authorize?response_type%3Dcode%26client_id%3D057adb2af62a4d59904f74754838c4c8%26scope%3Daccount.full%2520commerce.virtualcurrency.full%2520commerce.virtualcurrency.basic%26state%3DeyJzdGF0ZUVudHJvcHkiOiJYV0hRMTdTSmdPOWIzQ2s2REIFYm9pV2RSR0VjNHZsWHI0OHZrdXJndVJzPSIsInJlZmVycmVyIjoiL292ZXJ2aWV3In0%253D%26redirect_uri%3Dhttps://account.blizzard.com/login/oauth2/code/account-settings%26registration_id%3Daccount-settings&app=oauth
$r(t)$ - input data for the optimal Blizzard Arena hardware maintenance strategy with Overwatch franchise, 2023-2028: https://docs.google.com/document/d/1A5sDW-PPF1YbmlID0_ZcyzpsIvuqNUc7nTzU-IrvV2o/edit?usp=sharing
$u(t)$, $s(t)$ - Hardware Franchise Information Leaflet https://drive.google.com/file/d/1IFvwunkHHtbPjZp2cwcbMx9UN6ZcrtjQ/view?usp=sharing

For step 5, the possible system states $t = 1$, at which the functional equations have the form: $F_1(t) = \max(r(t) + F_2(t+1) ; S(t) - P + r(0) + F_2(1))$.

The formalized value for $F_k(t)$ serves for reflecting technical development is more preferable, compared to the others, by its maximum income if we take into account the following: the actual state vector $u(t)$, the specific k (the year of operation) and t (the actual hardware lifespan). Thus, we may suggest an optimal hardware operation model, up to reaching the $F_k(t)$ function values corresponding to its replacement state (3), from the initial time point to the final time point.

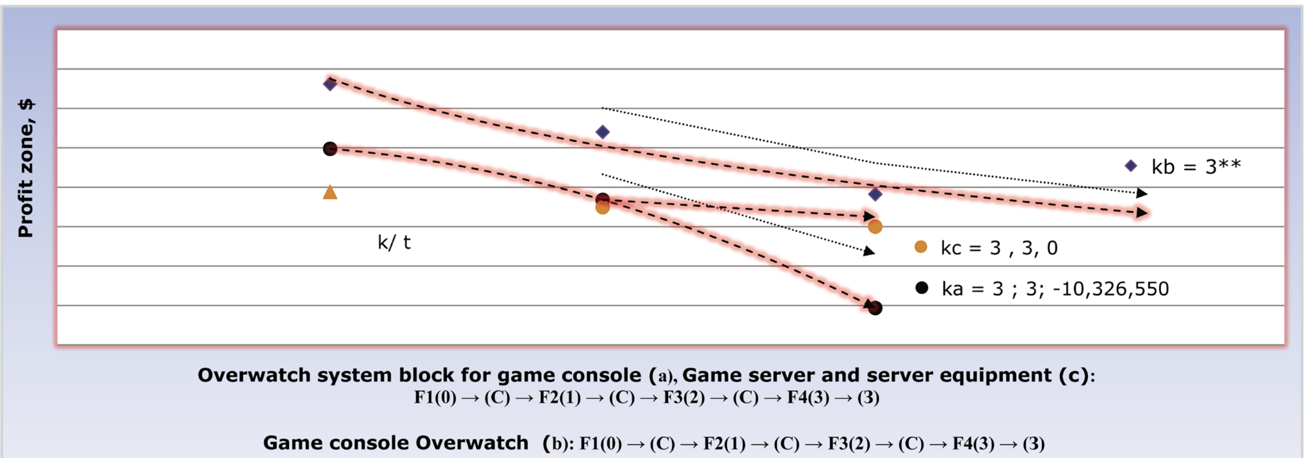
When formalizing the technical development in e-sports organizations featuring franchised networks (based on an optimal hardware operating and upgrading strategy), the replacement process is considered as n-step and the operation period is split into separate n-steps. Typically, a step towards optimizing the hardware replacement plan is an $F_k(t)$ sequence, from k to n years. If equal $F_k(t)$ values are obtained during completing the formalization task, a hardware saving equation is compiled.

5. Results

Considering that the sought outcome should provide for presenting a basis for the technical development in e-sports organizations with franchising networks, the formalization is presented through a system of graphic notations. These allow for approximate describing for the processes of optimal hardware operation and upgrade, engaging several elements. These include the following: profit maximization, solutions, data and arrows determining dynamics of profit maximization (based on the determined number of data points on the operation of the hardware). Formalization of technical development on a graphic notation illustrating the approximate rules of the optimal hardware operation and upgrading in the Blizzard Arena is presented in Figure 1.

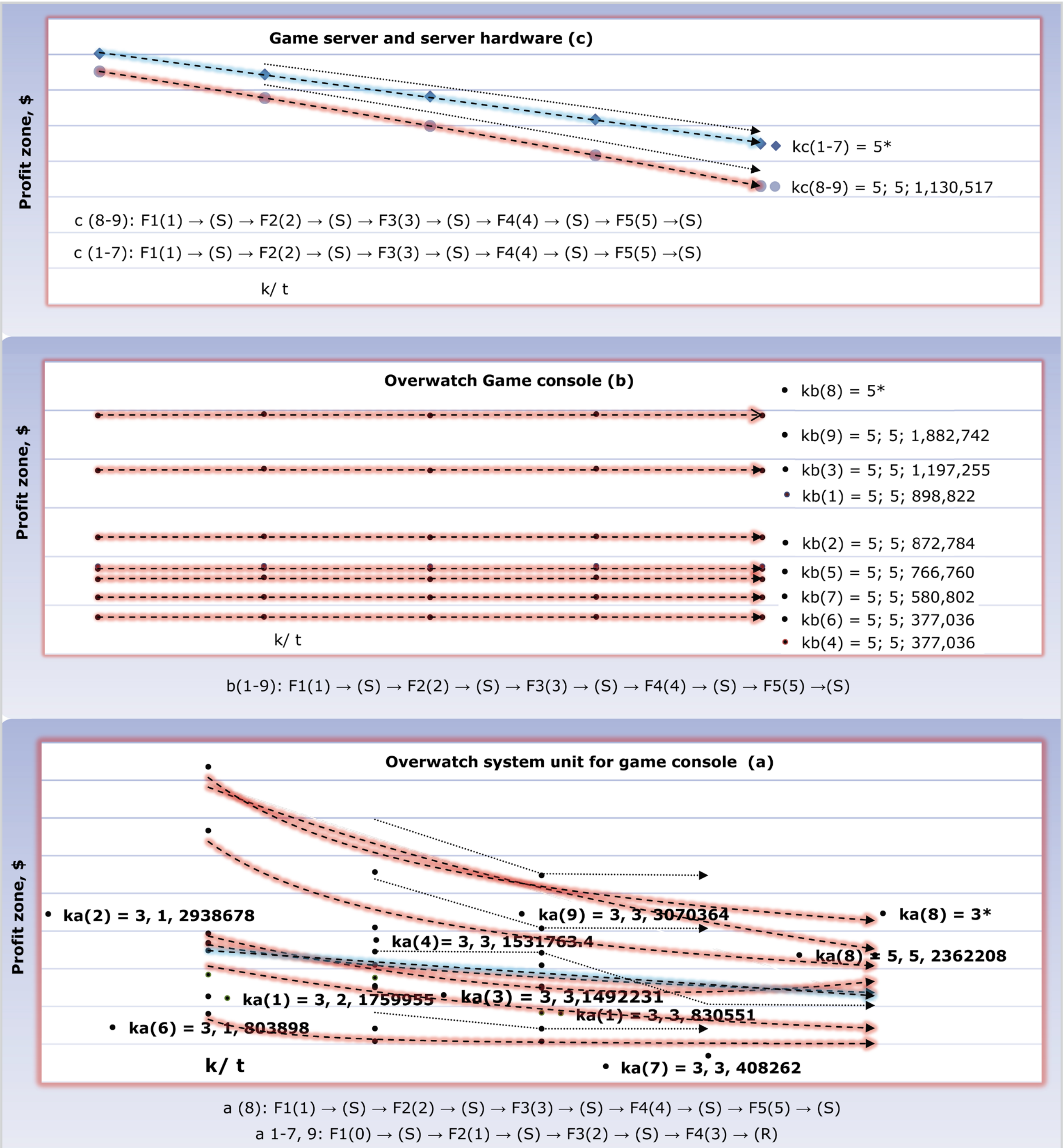
The notation system is provided with a set of constants (kn), defining the rules for marking processes of the approximately optimal management of the Blizzard Arena's hardware received under franchise. These constants are interconnected. Those suitable for the Blizzard Arena are oriented on the hardware age (t) equal to 3 years (at the time of its transfer to the Overwatch League franchised networks). This is due to the orientation on the scope with optimal conditions for maximizing profits.

The subsequent formalization of technical development for the approximately optimal management strategy of the hardware operation and upgrade is aimed at a set of graphic elements, which possibly can be formed after its transfer to the franchised network. They are presented in Figure 2.



Notes:
* S and R are the logical variables for the management of the hardware operation and upgrade for the k-th year.
** $kn = 1,..,$ where $n - k$ is a constant defining the step number along t, and n are values at the constant defining each element in the franchise network. The franchise network is formed by the following members: 1 (club Florida Mayhem); 2 (club New York Excelsior); 3 (club London Spitfire); 4 (club Vault 15); 5 (club Immortals); 6 (club NRG E-sports); 7 (club Misfits); 8 (training base PS4); 9 (training base Xbox One).

Figure 1:
Formalization of technical development on the graphical notation illustrating the approximate rules of the optimal hardware operation and upgrading in the Blizzard Arena in the period between 2020 and 2024, USD
Source: Compiled by the authors with the use of the AnyLogic Cloud computing environment based on Table 1



Notes:
* kn(m) = 1,.., n - where k is a constant defining the step number along t. Here, n - are the values at the constant defining each element of the franchise network. The franchise network consists of the following members: 1 (club Florida Mayhem); 2 (club New York Excelsior); 3 (club London Spitfire); 4 (club Vault 15); 5 (club Immortals); 6 (club NRG E-sports); 7 (club Misfits); 8 (training base PS4); 9 (training base Xbox One).

Figure 2:
Formalization of technical development for the approximately optimal management strategy of the hardware operation and upgrade in the period between 2023 and 2028, USD
Source: Compiled by the authors with the use of the AnyLogic Cloud computing environment based on Table 1 and Table 2

The system of graphic notations is accompanied by a set of constants $kn(m)$, defining the rules for denoting the processes of the approximately optimal management strategy of hardware operation in the franchised network Overwatch League.

The notations suitable for the Overwatch League franchise network are oriented on an area with a stable income by Bellman equations $F_k(t)$ (by analogy with the Blizzard Arena).

Formalization of the technical development in the Overwatch League e-sport organization with franchised networks, given in graphical notations comes as a result of utilizing ready-made software, namely the Anylogic, a specialized environment for computing. Yet, the task of their constructing requires a common methodological approach to the formalization of technical development and to processing notations for the approximately optimal management strategy for the hardware operation and upgrade. The computation results of Bellman equations should denote the $F_k(t)$ function related to the maximum profits zones of the arena until the time of the transition to the zone of the hardware transfer to the Overwatch League franchise network (Table 3).

Bellman's Optimality Principle (Strakhov, 2013) serves as the basis for the peculiarities of the stability environment in e-sport events. Taking it into consideration, the formalization of the technical development in the Blizzard Arena illustrates that the most favourable conditions for financing the hardware upgrade are 3 years of operation in the arena, with a subsequent hardware transfer to the franchised network. Thus, by the beginning of the first year of operation, the age of all Blizzard Arena hardware will have increased per one time unit and be equal to $t_1 = t_0 + 1 = -1 + 1 = 0$. The profit will constitute an amount equal to $F_1(0) = 1$. The optimal management strategy at $k = 1$, $x_1(0) = (S)$, i.e. the maximum income level, from 0 to 3 or 0 to 4 years (per game server) is achieved in case the hardware is not replaced. By the beginning of the second year of operation, the hardware lifespan will have increased per time unit and be equal to $t_2 = t_1 + 1 = 0 + 1 = 1$. At this, small environment disruptions in cyber sports events are noticeable (although the average system state within the maximum profit area is satisfactory over the period). By the beginning of the third year of operation, the hardware lifespan will have increased per one time unit and be equal to: $t_3 = t_2 + 1 = 1 + 1 = 2$. At this, apart from breaking stability values, the average $F_k(t)$ function for some hardware periodically shifts from the profit area into the loss area. Completing the task of the optimal arena hardware upgrade strategy is described by the hardware upgrade or $F_1(0) \rightarrow (S) \rightarrow F_2(1) \rightarrow (S) \rightarrow F_3(2) \rightarrow (S) \rightarrow F_4(3) \rightarrow (R))$. Taking into account the differences in the stability environments in the e-sport arena and the training process in e-sport clubs and training centers, the optimality in the operation and upgrading

Table 3:
Maximum profit zones / the Blizzard Arena hardware transfer to the Overwatch League franchise network by Bellman equations, 2020-2024, USD

Hardware	k/ t	Maximum profit zones / hardware transfer zone (by Fk(t) function values, USD)			
		1	2	3 Common values for franchisees	4
Overwatch system block for game console units[1]	1	9,769,087			-
	2	13,280,000	**-110,913**		-
	3	9,880,000	3,400,000	**-10,326,550**	-
Game console Overwatch	1	24,399,800			
	2	21,653,500	**14,750,600**		
	3	18,110,200	12,004,300	**4,108,200**	
	4	9,649,200	8,461,000	3,543,300	-3,000,000
Game server and server hardware	1	7,300,000			
	2	6,860,000	**2,900,000**		
	3	4,400,000	2,460,000	0	

Notes:
[1] *For Step 1*, according to computing, the possible system states $t = 1,2,3$ at which the functional equations become: $F_3(1) = \max(9,880,000; 10,000,000 - 15,000,000 + 0) = 9,880,000$ (C),
$F_3(2) = \max(3,400,000; 5,009,087 - 15,000,000 + 0) = 3400,000$ (S),
$F_3(R) = \max(-1,2400,000; 1,000,050 - 15,000,000 + 0) = -12,400,000$ (S).
For Step 2, the possible system states $t = 1,2$, at which the functional equations become:
$F_2(1) = \max(9,880,000 + 3,400,000 ; 10,000,000 - 15,000,000 + 0 + 9,880,000) = 13,280,000$ (S),
$F_2(2) = \max(3,400,000 + -12,400,000 ; 5,009,087 - 15,000,000 + 0 + 9,880,000) = -110,913$ (3).
For Step 3 the possible system states $t = 1$, at which the functional equations become:
$F_1(1) = \max(9,880,000 + -110,913 ; 10,000,000 - 15,000,000 + 0 + 13,280,000) = 9,769,087$ (S).
The $F_k(t)$ function values corresponding to the state of hardware replacement (S) are highlighted in Table 1.

Source: Compiled by the authors with the use of the AnyLogic Cloud computing environment based on Table 1

of the hardware, according to the Bellman equation, is also different. Formal ratios expressing sufficient optimality conditions are not the same (Lapkina & Malaksiano, 2018).

Hardware in e-sports organizations with franchised networks is operated in stages. Thus, Stage 1 involves the hardware operation within the arena (until the maximum profit area is achieved). Stage 2 involves the hardware operation in the franchise network (until the maximum profit area is achieved). Naturally, the content of the Bellman equation for clubs and training centers is also set with derivatives including initial and acceptable technical development conditions, based on the state of the arena hardware after its transfer to a franchised network. Thus, the calculation results should highlight the function $F_k(t)$ values, according to maximum profit zones until hardware replacement in the Overwatch League franchise (Table 4).

The table shows the $F_k(t)$ function values, determining the state of hardware replacement. In all cases, breaking the environment stability values also identifies possible hardware replacement points. Such points have font markings in profit or loss zones in AnyLogic. In case the cells in selected areas are distinguished with line saturation (compared to the main font), it means the zone no longer provides the required income or becomes a loss zone. In other words, the optimal hardware operation and upgrade strategy depends on its current state and the purpose, and is independent of its background (Yatsenko & Svystun, 2019). This peculiarity of the Bellman equation allows for shifting from the initial multi-step task of optimizing the hardware operation and upgrade to the sequential completing several one-step technical development tasks in e-sport organizations with franchising networks (Rardin, 2015).

6. Conclusions

The formalization of the technical development in e-sports organizations is focused on searching sufficient criteria for the optimal hardware operation and upgrade. An optimal strategy has a feature based on the following assumption: whatever the initial state and the initial solution may be, only the subsequent decision constitutes the optimal policy. Considering that the development of e-sports organizations with franchised networks lies in the fact that at every step of hardware operation there is no need for an isolated Fn(t) function optimization, but rather for the optimal management of the maximum profit areas for all the subsequent steps. Thus, according to the data of the Blizzard Arena, we hereby present a formalization of technical and economic development (based on completing the optimal hardware upgrade strategy through step-by-step optimization until the moment of its transfer to the franchised network members).

In the course of the study, we come to the following conclusion. This formalization is generally an outstanding issue for Ukraine as well, since a significant share of e-sports clubs operate independently or through franchises of local operators of e-sports franchising networks with no arenas of their own. Respectively, these clubs do not have sufficient funds to purchase the necessary hardware.

The above results of the studies can serve as tools for the following:

1) reorientation of national e-sports organizations towards cooperation with e-sports arenas functioning as operators of franchising networks;
2) increasing the number of native arena owners in major e-sport events. The study prospects are related to the fact that the proposed approach to the techno-economic development in e-sport organizations is based on the possible system state - «the income from hardware operating - the annual costs related to the e-sports hardware operation and upgrading - the residual hardware value/original hardware value». The state of the system is identified with the use of Bellman functional equations. There emerges a possibility to significantly reduce investments in the e-sports environment hardware in the main arena and the franchised ones while controlling the quality and functionality of e-sports hardware.

The strategy of focusing on two-stage upgrade will reduce investment in major hardware. The study illustrates the formalization of the techno-economic development of the Blizzard Arena through a two-stage upgrade of the Aerocool Advanced Technologies franchise (primary franchise from the manufacturer, secondary franchise from the Blizzard Arena franchise operator). Based on the specific features of Bellman equations, the development of the Blizzard Arena must be provided taking into account the model $F_1(0) \rightarrow (S) \rightarrow F_2(1) \rightarrow (S) \rightarrow F_3(2) \rightarrow (S) \rightarrow F_4(3) \rightarrow (R)$. The latter serves for determining the feasibility of hardware transferring to a franchised network during the third period of operation, where it is operated as long as franchisees may enter the maximum profit area. The results illustrate the way gaming hardware investments can be reduced by

Table 4:
Maximum profit zones / hardware transfer to the Overwatch League franchise network by Bellman equations, 2023-2028, USD

Club[3]	k/t	Maximum profit zones / hardware transfer area by Fk(t), USD 1					model[2]	Maximum profit zones / hardware transfer area by Fk(t), USD					model[2]
		1	2	3	4	5		1	2	3	4	5	
		Game server and server hardware (joint operation)						Game server and server hardware (joint operation)					
1-7	1	6,894,782						6,476,859					2[3]
	2	5,645,354	5,392,462					5,346,342	5,024,479				
	3	4,328,004	4,143,034	3,948,816			8,9	4,129,378	3,893,962	3,646,775			
	4	2,945,966	2,825,684	2,699,388	2,566,777			2,830,084	2,676,998	2,516,258	2,347,481		
	5	1,502,320	1,443,646	1,382,038	1,317,350	1,249,427		1,452,380	1,377,704	1,299,294	1,216,963	1,130,517	
		Overwatch system block for game console						Overwatch system block for game console					
1,2	1*	2,100,838						3900,620					1
	2*	2,400,174	1,460,620					3,015,773	2,986,793				
	3*	1,840,255	1,759,955	**830,551**			1	2,938,678	2,101,946	**2,091,146**			
	4*	1,270,287	1200,037	1,129,887	209,656			216,669	2,024,851	**1,206,299**	**1,100,729**		
	5*	640,218	630,068	569,968	559,918	-350,262		1,281,844	1,252,864	1,129,204	**294,902**	**184,472**	
3,4	1	3,291,915						3,343,322					1
	2	**2,493,873**	2,381,973					**2,549,522**	2,426,432				
	3	2,669,326	**1,504,231**	**1,492,231**			1	2,684,118	**1544,963**	**15,317,634**			
	4	1,799,684	1,759,384	**602,489**	**485,189**			1,811,558	1,767,228	**637,093**	**508,063**		
	5	909,942	889,742	869,642	**-424,752**	830,035		916,889	894,669	872,559	**-408,825**	828,991	
5,6	1	3,135,284						614,579					1
	2	**2,547,341**	2,323,541					**383,306**	338,546				
	3	2,314,227	**1,576,198**	**1,552,198**			1	803,898	**75,394**	**70,594**			
	4	1,583,085	1,502,485	**780,856**	**546,256**			543,985	527,865	**-197,358**	-224,161		
	5	811,742	771,342	731,142	**-265,486**	65,1928		276,032	267,952	259,912	-468,231	244,070	
7,8	1	1,262,259						9,408,742					2
	2	**886,160**	830,210					7,046,534	6,926,673				
	3	1,265,895	**414,262**	**408,262**			1	7,355,455	4,564,465	4,474,905			
	4	853,997	833,847	**-13,686**	**-72,336**			4,933,837	4,873,387	2,112,697	2,053,286		
	5	432,048	421,948.5	411,898	-498,281	392,095		2,482,068	2,451,768	2,421,618	-308,921	2,362,208	
9,1	1	6,885,414						Game console Overwatch					2
	2	**5,181,489**	4,957,689					4,503,348					
	3	5,662,175	**3,094,364**	**3,070,364**			1	3,604,525	3,604,525				
	4	3,815,050	3,734,450	**1,183,039**	**948,439**			2,701,085	2,705,702	2,701,085			
	5	1,927,725	1,887,325	1,847,125	**-979,286**	176,7911		1,802,262	1,802,262	1,802,262	1,802,262		
		Game console Overwatch						898,823	903,439	898,822	903,439	898,822	
2,3	1	4,380,545						6,004,746					2
	2	3,507,760	3,507,760					4,807,490	4,807,490				
	3	2,626,665	2,634,975	2,626,665			2	3,601,001	3,610,235	3,601,000			
	4	1,753,880	1,753,880	1,753,880	1,753,880			2,403,745	2,403,745	2,403,745	2,403,745		
	5	872,785	881,095	872,784	881,095	872,784		1,197,255	1,206,489	1,197,255	1,206,489	1,197,255	
4,5	1	4,481,060						3,870,737					2
	2	3,588,911	3,588,911					3,103,977	3,103,977				
	3	2,686,605	2,696,762	2,686,604			2	2,318,749	2,337,217	2,318,748			
	4	1,794,455	1,794,455	1,794,455	1,794,455			1,551,989	1,551,988	1,551,988	1,551,988		
	5	892,149	902,306	892,149	902,306	892,149		766,760	785,228	766,760	785,228	766,760	
6,7	1	1,892,568						2,913,248					2
	2	1,515,532	1,515,532					2,332,445	2,332,445				
	3	1,134,802	1,138,496	1,134,802			2	1,747,025	1,751,642	1,747,025			
	4	757,766	757,766	757,766	757,766			1,166,222	1,166,222	1,166,222	1,166,222		
	5	377,036	380,729	377,036	380,729	377,036		580,803	585,419	580,802	585,419	580,802	
8,9	1	12,269,361						9,450,649					2
	2	9,821,029	9,821,029					7,567,907	7,567,906				
	3	7,358,846	7,372,697	7,358,846			2	5,666,696	5,685,164	5,666,695			
	4	4,910,514	4,910,514	4,910,514	4,910,514			3,783,953	3,783,953	3,783,953	3,783,953.		
	5	2,448,332	2,462,182	2,448,331	2,462,182	2,448,331		1,882,743	1,901,210	1,882,742	1,901,210	1,882,742	

Notes:
[1] Step 1: $F_5(t) = \max(r(t), (S); S(t) - P + r(0), (R))$, $k = 5$;
Step 2: $F_4(t) = \max(r(t) + F_5(t+1); S(t) - P + r(0) + F_5(1))$, $k = 4$;
Step 3: $F_3(t) = \max(r(t) + F_4(t+1); S(t) - P + r(0) + F_4(1))$, $k = 3$;
Step 4: $F_2(t) = \max(r(t) + F_3(t+1); S(t) - P + r(0) + F_3(1))$, $k = 2$;
Step 5: $F_1(t) = \max(r(t) + F_2(t+1) ; S(t) - P + r(0) + F_2(1))$, $k = 1$.
[2] (1) The development model: $F_1(1) \to (S) \to F_2(2) \to (S) \to F_3(3) \to (R) \to F_4(1) \to (S) \to F_5(2) \to (S)$ or hardware replacement at the beginning of the third year of operation;
(2) $F_1(1) \to (S) \to F_2(2) \to (S) \to F_3(3) \to (S) \to F_4(4) \to (S) \to F_5(5) \to (S)$. Replacement of hardware is not required after 5 years of operation. The development model is calculated through an algorithm similar to that used in Table 2
[3] (1) club 1 (Florida Mayhem); (2) club 2 (New York Excelsior); (3) club 3 (London Spitfire); (4) club 4 (Vault 15); (5) club 5 (Immortals); (6) club 6 (NRG E-sports); (7) club 7 (Misfits); (8) training center 8 (PS4); (9) training center 9 (Xbox One).

Source: Compiled by the authors with the use of the AnyLogic Cloud computing environment based on Table 1

the franchised network development, being attracted by a standard e-sports arena with a capacity of 450 players. Namely, an investment is made into the following hardware: Overwatch system units at the amount up to USD 15 million, gaming consoles amounting to USD 12.7 million, and the game server and server hardware amounting to USD 4 million. A strategy for achieving the required technical and economic development in a franchise network is also presented (with minimal investments in basic hardware).

Graphic notations for approximate description of the optimal hardware upgrade management is sufficient to create an extended event-driven process chain for extended notation of technical development formalization chain in e-sports organizations with franchising networks.

The practical significance of graphic notations aimed at describing the optimal operation and upgrade strategy for hardware units is in the possibility of their application in modelling (functional, information, behavioural) and distribution of funds. These will ensure the maximum stability of the e-sports event environment and sustainable training environment for e-athletes.

References

1. AnyLogic. (2018). *Official web site*. http://www.anylogic.ru (in Russ.)
2. Arrow, K., Chenery, H., & Solow, R. (1961). Capital-Labor Substitution and Economic Efficiency. *The Review of Economics and Statistics*, *43*(3), 225-250. https://doi.org/10.2307/1927286
3. Bellman, R. (2010). *Dynamic Programming. Princeton*. New Jersey: Princeton University Press.
4. Bellman, R. (2013). *Dynamic Programming. Mineola.* New York: Dover Publications, Inc.
5. Bertsekas, D. P. (2012). *Dynamic Programming and Optimal Control*. Belmont, Massachusetts.
6. Bhondekar, A. P., Renu, V., Singla, M., & Ghanshyan, C. (2009, March 18-20). *Genetic Algorithm Based Node Placement Methodology For Wireless Sensor Networks* [Paper presentation]. Proceedings of the International MultiConference of Engineers and Computer Scientists, 1, Hong Kong. https://www.researchgate.net/publication/44259528_Genetic_Algorithm_Based_Node_Placement_Methodology_For_Wireless_Sensor_Networks
7. Blizzard Arena. (2020). *Official website*. https://eu.battle.net/login/en/?ref=https://eu.battle.net/oauth/authorize?response_type%3Dcode%26client_id%3D057adb2af62a4d59904f74754838c4c8%26scope%3Daccount.full%2520commerce.virtualcurrency.full%2520commerce.virtualcurrency.basic%26state%3DeyJzdGF0ZUVudHJvcHkiOiJYV0hRMTdTSmdPOWlzQ2s2RElFYm9pV2RSR0VjNHZsWHI0OHZrdXJndVJzPSIsInJlZmVycmVyIjoiL292ZXJ2aWV3In0%253D%26redirect_uri%3Dhttps://account.blizzard.com/login/oauth2/code/account-settings%26registration_id%3Daccount-settings&app=oauth
8. Bohner, M., Stanzhytskyi, A., & Bratochkina, A. (2013). Stochastic dynamic equations on general time scales. *Electronic Journal of Differential Equations, 57,* 1-15. https://www.researchgate.net/publication/265829694_Stochastic_dynamic_equations_on_general_time_scales
9. Carter, M. W., Price, C. C., & Rabadi, G. (2019). *Operations research: a practical approach.* Boca Raton: CRC Press.
10. Chen, B. Y. (2012). Classification of h-homogeneous production functions with constant elasticity of substitution. *Tamkang Journal of Mathematics*, *43*(2), 321-328. https://doi.org/10.5556/j.tkjm.43.2012.321-328
11. Denardo, E. V. (2012). *Dynamic Programming: Models and Applications*. New York, Courier Corporation.
12. Farnham, D. (2018, February 28). *Overwatch's new hero, Brigitte Lindholm, is a tanky support*. https://www.cnet.com/news/overwatch-new-hero-brigitte
13. Lapkina, I., & Malaksiano, M. (2018). Elaboration of the hardware replacement terms taking into account wear and tear and obsolescence. *Eastern-European Journal of Enterprise Technologies*, *3*(3(93)), 30-39. http://journals.uran.ua/eejet/article/view/133690
14. Lapkina, I., & Malaksiano, M. (2018). Estimation of fluctuations in the performance indicators of hardware that operates under conditions of unstable loading. *Eastern-European Journal of Enterprise Technologies*, *1*(3(91)), 22-29. https://doi.org/10.15587/1729-4061.2018.123367
15. Lutsenko, I. (2016). Definition of efficiency indicator and study of its main function as an optimization criterion. *Eastern-European Journal of Enterprise Technologies*, *6*(2(84)), 24-32. https://doi.org/10.15587/1729-4061.2016.85453
16. Mensch, A., & Blondel, M. (2018). *Differentiable Dynamic Programming for Structured Prediction and Attention*. https://arxiv.org/pdf/1802.03676.pdf
17. Mishra, S. K. (2010). A brief history of production functions. *The IUP Journal of Managerial Economics*, *8*(4), 6-34. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1749083
18. Noghin, V. D. (2018). *Reduction of the Pareto set: an axiomatic approach*. Studies in Systems, Decision and Control. https://doi.org/10.1007/978-3-319-67873-3
19. Rardin R. L. (2015). *Optimization in Operations Research*. New York: Pearson.
20. Renshaw, G. (2016). *Maths for Economics* (4rd ed.). New York: Oxford University Press.
21. Richard, E. B. (2003). *Dynamic programming. Dover Books on Computer Science.* Mineola, NY, United States.
22. Sokolovska, Z. M., Yatsenko, N. V., & Khortiuk, M. V. (2019). The Simulation Models of Activities of IT Firms on the Basis of AnyLogic Platform. *Business Inform, 6,* 61-76. https://doi.org/10.32983/2222-4459-2019-6-61-76 (in Ukr.)
23. Strakhov, E. M. (2013). Dynamic Programming in Structural and Parametric Optimization. *International Journal of Pure and Applied Mathematics*, *82*(3), 503-512 (in Ukr.).
24. Taha, H. (2017). *Operations Research: an Introduction* (10th ed., rev.). Boston: Princeton.
25. Winter Simulation Conference. (2018, December 9-12). *The premier international forum for disseminating recent advances in the field of system simulation*. http://meetings2.informs.org/wordpress/wsc2018
26. Yatsenko, T. O., & Svystun, L. A. (2019). Processes and methods for value engineering in enterprise management task systems. *Efficient Economy*, *5* (in Ukr.).

27. Zaidon, Z., Wei, W., & Honglei, X. (2009). Hamilton-Jacobi-Bellman equations on time scales. *Mathematical and Computer Modelling*, *49*(9-10), 2019-2028. https://doi.org/10.1016/j.mcm.2008.12.008
28. Zerbini, C., Luceri, B., & Vergura, D. (2017). Leveraging consumer's behaviour to promote generic drugs in Italy. *Health Policy*, *121*(4), 397-406. https://doi.org/10.1016/j.healthpol.2017.01.008

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