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DARQ Technology as a Digital Transformation Strategy in Terms of Global Crises

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Abstract

Purpose: The aim of the paper is (1) to analyze the DARQ (Distributed ledger, Artificial Intelligence, Extended Reality, Quantum Computing) technology in terms of its implementations and (2) to compare these technologies with the SMAC technology (Social, Mobile, Analytics, Cloud). We present the thesis that DARQ technologies can help in building information systems aimed at both predicting and monitoring global crises. We argue that the DARQ technology will support the management of network organizations in the first period of development.

Design/methodology/approach: The research procedure consists of the following steps: literature analysis, conducting qualitative research and its presentation, obtaining expert opinions and recommendations for further research.

Findings: The results of work on the DARQ technology that supports management systems allowed for the evaluation of usability both in terms of the expected effects and the areas of risk of application.

Research limitations/implications: Due to the lack of practical applications of all the elements that make up the DARQ technology, the analysis of such components as Extended Reality (Virtual Reality), Quantum Computing (Virtual Computing Technology) is not complete and requires complementary research and a more complete analysis of its applications. We consider the presented work as an introduction to broader research.

Originality/value: The thesis has been substantiated that the transition from SMAC to DARQ technology can be done gradually. Both of these technologies are compatible. This may result in gradual and collision-free changes in the quality of the management system. Elements of the new DARQ technology,

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such as Distributed ledger, Artificial Intelligence, Extended Reality and Quantum computing, allow for abrupt changes in both the management system and the functioning of the organization. Already today, each component of the DARQ technology has a significant impact on various sectors of the economy. However, it should be noted that apart from the positives, the DARQ technology also poses some threats. The article contains conclusions from the research and indicates a recommendation for further work, which concerns extending the application of DARQ technology to predict and monitor disasters and unpredictable events. To this end, we analyze the Black Swan theory (based on the COVID-19 pandemic case study) as the theoretical framework for the use of DARQ technology as a tool to reduce the occurrence of unpredictable events.
Keywords: DARQ, SMAC, Black Swan Theory, COVID-19, digital transformation strategy.
JEL: M15, H12, O32, O33

Technologia DARQ jako strategia transformacji cyfrowej w warunkach globalnych kryzysów

Streszczenie

Cel: celem artykułu jest: (1) analiza technologii DARQ (Distributed ledger, Artificial Intelligence, Extended Reality, Quantum Computing) pod kątem jej zastosowań; (2) przeprowadzenie porównania tej technologiami z technologią SMAC (Social, Mobile, Analytics, Cloud). W artykule stawiamy tezę, że technologie DARQ mogą być pomocne do budowy systemów informatycznych mających na celu zarówno przewidywanie, jak i monitorowanie globalnych kryzysów. Uważamy, że zastosowanie technologii DARQ będzie w pierwszym okresie rozwoju wspomagać zarządzanie organizacjami sieciowymi.
Metodologia: procedura badawcza składa się z następujących etapów: analizy literatury, przeprowadzenia badań jakościowych i ich prezentacji, uzyskanie opinii ekspertów oraz propozycje dalszych badań.
Wyniki: efekty prac nad technologią DARQ wspomagającą systemy zarządzanie pozwoliły na ocenę jej użyteczności ze względu na spodziewane zarówno efekty, jak i sfery ryzyka zastosowania.
Ograniczenia/implikacje badawcze: z powodu braku zastosowań praktycznych wszystkich elementów składających się na technologię DARQ analiza takich części składowych, jak Extended Reality (rzeczywistość wirtualna), Quantum Computing (technologia obliczeń wirtualnych) nie jest pełna i wymaga badań uzupełniających i pełniejszej analizy jej zastosowań. Artykuł traktujemy jako wstęp do szerszych badań.
Oryginalność/wartość: uzasadniono tezę, iż przechodzenia z technologii SMAC do DARQ może odbywać się stopniowo. Obie te technologie są kompatybilne. Skutkować to może stopniowymi i bezkolizyjnym zmianami w jakości systemu zarządzania. Elementy nowej technologii DARQ, takie jak Distributed Ledger, Artificial Intelligence, Extended Reality, Quantum Computing pozwalają na skokowe zmiany zarówno w systemie zarządzania, jak i funkcjonowania organizacji. Już dziś poszczególne technologie DARQ silnie oddziałują na różne branże gospodarki. Należy jednak zwrócić uwagę, że obok pozytywów technologia DARQ stanowi również pewne zagrożenie. W artykule zawarto najważniejsze konkluzje płynące z badań oraz wskazano dalsze kierunki realizacji prac badawczych w tym zakresie.
Słowa kluczowe: DARQ, SMAC, teoria czarnego łabędzia, COVID-19, strategia transformacji cyfrowej.

1. Introduction

The 21st century is the age of innovation and rapid multilateral development of the economy. It is a period of changes, both positive ones as well as those resulting from global crises. The digital economy changes modern management fundamentally. In this paper, we would like to present

and focus on these changes, which result from the progress made in the digital technology. New technological solutions directly affect the tools that support modern management.

The main objective is to present and analyze the application opportunities arising from the newly emerging digital technology, which is abbreviated as DARQ (Distributed ledger, Artificial Intelligence, Extended Reality, Quantum). We present the digital technology development process perspective in the context of comparing it with the currently existing technology known as SMAC (Social, Mobile, Analytics, Cloud). The DARQ technology is a significant stage in the evolution of ICT (Information and Communication Technology). We analyze its applications as a tool supporting the construction of IT systems used in both forecasting and monitoring global crises. We also treat the DARQ technology as an innovative element in creating breakthrough solutions in economic progress. According to the Accenture report (2019), approximately 89% of organizations use at least one element of the DARQ technology[1].

In the usability research of the DARQ technology, special emphasis was placed on the analysis of the expected effects and risk of its use. They were presented in the context of the analysis of the effects and risks of SMAC technology.

The article was inspired by the Accenture report (2019) on the expected trends in digitization. The following research procedure has been used: the first stage of presented study is the analysis of the literature and published research reports. Then, based on our own research of the digital technology domain, we extended the analysis of risks presented by Benhayoun-Sadafiyine and Boughzal (2020).

Our research on management support systems allowed both for the evaluation of the risk sphere and for the determination of the expected effects of using DARQ technologies (Kisielnicki, 2012, 2013, 2017; Olszak & Kisielnicki, 2018; Kisielnicki & Sobolewska, 2019). The conducted research has been complemented by the opinions of digital technology experts that represented various industries. The analysis covered the development plans of software companies operating in Poland, such as IBM, SPA, Comarch, IFS, or Asseco. These analyses resulted in a synthetic Table 1 that presents the expected effects and threats of using SMAC and DARQ components. Table 2 summarizes synergistic effects and threats for described technologies. The final stage presents the possibilities of application of the DARQ technology during the COVID-19 pandemic and building a protection system against "Black Swan". The term "Black Swan" is an allegory for determining unexpected dangers. In the summary of the paper, the main conclusions of the studies were formulated and further directions of the research indicated. While writing the article, we used mainly the research methods such as critical analysis of the literature, the deduction method and the experience and results of research on the implementation of

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the aforementioned projects on computer-aided management, but expert opinions were also used.

The key four components of DARQ technology used individually are a very useful and powerful tool employed in practice to improve the management system. Individual effects are obtained from a standalone application such as Distributed ledger, Artificial Intelligence, Extended Reality, Quantum computing. As a result of the integration of the described technologies, they are enhanced by the synergy effect. This effect allows for achieving a new quality in management. As the article demonstrates, the DARQ technology also introduces new requirements. It can be argued that applications of the DARQ technology will support the management of network organizations in the first phase of development. This is due to their nature that requires technological connections between the management infrastructure of individual organizational entities. Such conclusions could be drawn as a result of the analysis of the effectiveness of building an interoperability platform for the ORLEN Corporation[2].

We consider the presented article as an introduction to broader research. Many of the issues raised are initially indicated and have to be developed in further research.

2. DARQ Technology as a Drive of Innovation in Formulating a New Management Strategy

The literature highlights the evolution of digital technology. It is often stated that we are on the threshold of the post-digital age. Currently, management is supported by the SMAC technology, which consists of the following components: Social, Mobile, Analytics and Cloud. Applications focus on solutions aimed at:

- building an information society,
- mobile solutions, described by the formula "my office is where my laptop is",
- development of various types of decision support systems, i.e. systems known as Decision Super Systems and Expert Systems,
- handling large sets/data files that are stored outside the facility where they were produced, i.e. in the so-called cloud.

The transition from SMAC technology to more advanced technology such as DARQ requires significant financial resources. Therefore, only large corporations and previously mentioned network organizations can opt for such solutions. However, there is a risk that SMEs (Small and Medium-sized Enterprises), under the influence of the ongoing changes, will increasingly (in terms of the management infrastructure) deviate from large organizations. Both of these technologies are compatible. This may result in gradual and collision-free changes in the quality of the management system. Elements of the new DARQ technology, such as Distributed ledger,

Artificial Intelligence, Extended Reality, and Quantum Computing allow for abrupt changes in both the management system and the functioning of the organization. Already today, each component of the DARQ technology has a significant impact on various sectors of the economy. However, it should be noted that apart from the positives, the DARQ technology also poses some threats. A description of these threats has been discussed in the following paragraphs.

The DARQ technology can be characterized by defining its components, features and applications:

Distributed ledger (DLT) has a more general meaning than blockchain technology (Arslanian & Fischer, 2019). It refers to databases stored on multiple digital devices, called system nodes. A key feature of distributed ledger is that recorded data is shared within the network without any central administration. Updates of the entire database are performed automatically and independently in each node while ensuring integrity through consensus-based validation protocols. The benefits mainly concern the simplification of the coordination of entries made in various public institutions – tax offices, banks, notary's offices, regulatory offices – and they substantially increase the confidence in the data included in the database. The implementation of this technology has proved itself in logistics, which allows for the simplification, acceleration of the preparation and execution of specific transactions (Hackius & Petersen, 2017).

Artificial intelligence (AI) is a branch of computer science, the ability of a computer to operate in a way to mimic human intelligence (Minsky, 1968). For its application, the digital system that is used should have an enormous amount of information and appropriate procedures. The latter is modeled on the characteristics of human intelligence, which leads to the ability to process data independently, learn from the collected data, solve decision-making problems of varying complexity. Numerous applications of AI as a standalone module allow us to assess its high efficiency and great potential in decision-making processes (Chen et al., 2018; Edwards et al., 2000).

Extended Reality (XR) is a general term that includes Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR). Figure 1 shows the relationship between technologies from the real environment and those form the virtual environment based on the work of Milgram (Milgram & Kishino, 1994). Extended Reality (XR) refers to a combination of real and virtual reality using digital technology (Doolani et al., 2020). Depending on the virtual part of the application, it can contain a small or significant part. For instance, a small part is a tool for modifying simulation models of the real situation (the so-called augmented reality). An example of a significant part can be the construction of a complete virtual environment, which is based on data collected through our senses and various types of sensors. The effectiveness of this technology has been demonstrated by its applications in

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the training of employees and in the modeling of the economy as a whole as well as in its respective industries. The technology is currently used in computer simulation of various real phenomena and processes. Recently, for instance, Volkswagen has been using quantum computing to simulate the chemical structure of batteries to improve and increase battery longevity (Koolwal & Khandelwal, 2020). Volkswagen has partnered with Nvidia to add AI features to future car models. The DML is also tested to protect cars from hacker attacks, facilitate automatic payments at gas stations, create secure mileage counters and so on. What is more, Volkswagen provides service in cars repairs through the XR.

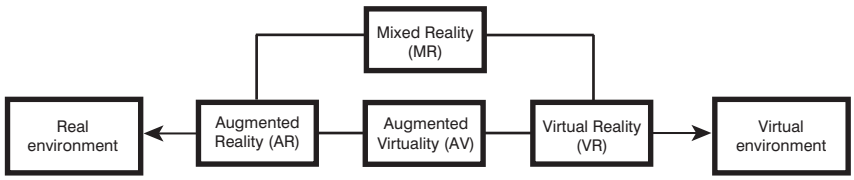

Fig. 1. Relation between Extended Reality (XR) technologies. Source: Adapted from Milgram and Kishino, 1994.

Milgram and Kishino define the concepts of Extended Reality by placing it on a scale whose extremes are the real environment (left side) and the virtual environment (right side). As you move to the right, the degree of stimulus generated by the computer increases.

Quantum computing, which is a quantum computing technology (Gruska, 1999), refers to the quantum computer that performs specific operations. Quantum computing uses quantum mechanics principles and quantum algorithms (Ying, 2010). To solve specific computational problems, these algorithms use basic quantum unit of information – qubit. Quantum computers differ from classical computers in that, in addition to values 0 or 1, they can hold a full range of all possible states. Thus, the qubit is capable of storing and carrying much more information than a bit, thanks to which its efficiency is many times higher[3]. At the time of formulation of this paper, i.e. the beginning of 2021, the technology is not ready for widespread use. The intensity of the work carried out, the amount of funds spent and the involvement of scientific institutions are the announcement that in the near future quantum computers will process big data/data files. An example of the changes offered by this technology is the acceleration of calculations. Quantum computing is expected to drive new innovations in the coming years.

The last element of the DARQ technology, Quantum, is now the element that makes the DARQ technology possible to use to a limited extent. The complexity of the world requires very complex calculations. Therefore, the development of DARQ technology depends both on the interconnection of

the four elements of technology as well as on the technology of quantum computing.

Two stages can be distinguished in the application of DARQ technology:

The first stage is a present state, in which the architecture is represented in Figure 2, and refers to the independent development of individual elements. They function side by side and realize their development independently. They are closely related to the existing digital SMAC technology.

The second stage presents the target architecture image. Figure 3 demonstrates the DARQ technology as one system.

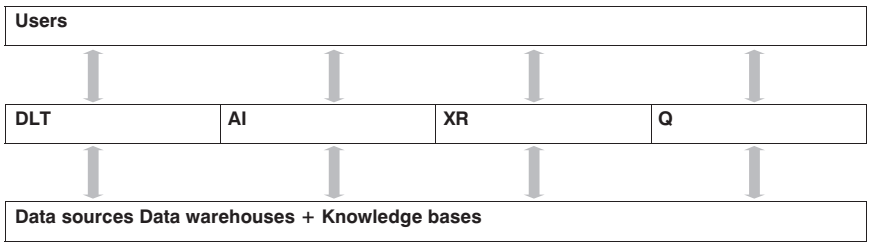

Fig. 2. Current architecture of DARQ technology (as element platform). Source: Own work.

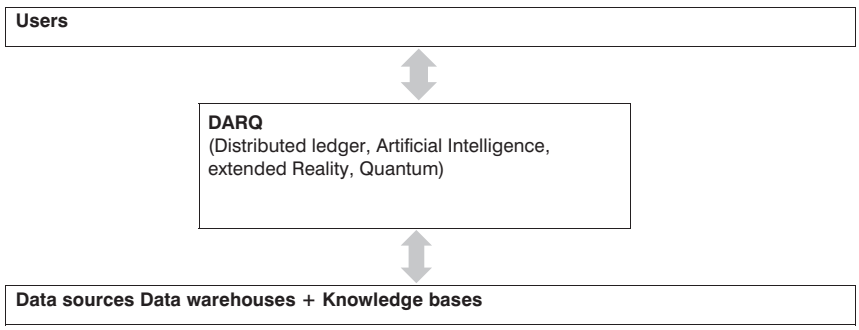

Fig. 3. Target architecture of DARQ technology. Source: Own work.

Figure 2 represents a situation where each of the four DARQ technologies is used by an organization individually to differentiate its products and services from competitors. Figure 3 presents the interrelationships of these four partial technologies.

Based on interviews, correspondence and literature analysis, it can be concluded that it would be difficult to select an organization that fully uses the DARQ technology. However, in many cases, we are dealing with the use of combined technologies. This is particularly true of the relationship

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between AI and XR in a domain such as medicine or education. Already now, in many financial solutions, AI and DLT offer organizations an advantage over their competitors. For example, VOLVO is working to merge DLT and AI. It can be assumed that quantum solutions – quantum computers will inspire new innovations in the coming years.

3. Effects and Risks of SMAC and DARQ Technologies in Literature and Own Research

Qualitative studies on the effects and risks on SMARC and DARQ technologies were aimed at answering the following research questions:

1. What effects and risks can we expect in in the application of SMAC and DARQ technologies?
2. What effects and risks will we receive as a result of the combination of SMARC and DARQ technology components, what are the benefits and threats in the overall implementation of both technologies – synergy effect?

The current research is a continuation of previous analyses on the effectiveness of ICT applications conducted by J. Kisielnicki (1981, 2012, 2017). The benefits and risks presented in Tables 1 and 2 usually have a business dimension. Their materialization results both from the SMARC and DARQ technology itself, but also from its application. The effects and risks that we expect while implementing new technologies are mostly economic and business-related. Without calculations, it would be unprofitable to invest time and funds in a new technology. The following assumptions were made in the conducted research. The obtained effects and risks related to the application of each digital technology depend not only on the hardware and software used but also on the applications and qualifications of the people who use them. In the process of organizational transformation, we have to be aware that the use of SMAC and DARQ technologies bring benefits to the organization, but they also carry risks. This risk has an economic, ethical and technical dimension. Due to the synergy effect, the overall use of SMAC and DARQ technologies will result in significantly greater effects than in the case of individual components. We observe new opportunities of combined technologies especially in medicine (Dugstad et al., 2019). It is emphasized in the literature that the DARQ technology in particular initiated a new era in medicine[4]. Significant effects in human treatment have been achieved by using the Quantum module in conjunction with AI. DARQ is a revolution in computing thanks to its fast processing as well as advances in the functioning of the internet and data encryption[5]. The performed preliminary analyses are intended to prepare assumptions for in-depth research. The issue of analyzing the effects and risks of the modern digital era and the current post-digitization period is presented, inter alia, in the Accenture report (2019).

3.1. Research Procedure

The following research procedure was implemented:

Step I – Literature research in terms of the effects and risks of digitization. In this step, there was no problem with the discernment of SMAC technology (Sitarska-Buba, 2017; Dewan & Jena, 2014; Cornelius, 2013), while in the field of DARQ technology, we had limited access to information. In response to an inquiry sent to large software companies, only IBM-Poland stated that it intended to intensify work on the DARQ technology. The issue of the risk of SMAC and DARQ technology is dealt with in the paper of L. Benhayoun-Sadafiyine and I. Boughzal (2020). This publication demonstrated the opinion of five experts on the risk of unpredictable situations in the use of both technologies.

Step II – Qualitative research in the focus group. A group discussion focused on the effects and risks of SMAC and DARQ technologies was conducted. Research on both the SMAC technology and one element of the DARQ technology, namely AI applications, was conducted in April 2018. At that time, information about the DARQ technology as a whole was still very scarce. The focus group was about 30 people. The discussion was conducted during the classes in the subject of Computer Science in Management at the MBA studies at the Lazarski University[6] The participants of the group were people with higher education, where 6 people worked directly in the IT department. Most of the participants (25 people) were at the middle management level. As a result of the work, synthetic tables on the effects and risks of individual SMAC and AI technologies were developed. The participants did not know the other elements of the DARQ technology.

Step III – Elaboration of synthetic tables based on literature, a risk table of SMAC and DARQ technology elements developed by L. Benhayoun-Sadafiyine and I. Boughzal (2020) and the results of the qualitative study in the focus group.

Step IV – Selection of experts to evaluate the developed preliminary synthetic tables and propose their modification. Nine experts were selected: five with doctoral degrees in management and four with advanced doctoral dissertation in management. Five people had technical education (graduates of polytechnics). The experts had at least 10 years of experience in the IT sector.

Step V – Forms distributed to experts, asking for evaluation and modification. Elaboration of results and their presentation in Table 1 and Table 2.

Step VI – Elaboration of a schedule of further work and preparation of an application for a research grant to the NCBiR.

3.2. Findings

The results of the study are demonstrated in Tables 1 and 2.

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Technology	Elements	Effects. What effects can we expect?	Risks. What risks can we expect?
SMAC			
	Social	Development of information society. New marketing channels. New opportunities to reach and interact with a customer.	Negative publicity (damage in terms of image). Harassment, mobbing. Development of harm measures (including filter bubble, fake news).
	Mobile	Improving the communication system between individuals of society. Improving the quality of functioning: government, banks, etc. Increase in labour mobility. Easier access to information systems (e.g. by synchronizing a smartphone with a computer) Reach the customer more effectively.	Access to private data. Cyber attack. Identity theft. Personal data theft.
	Analytics	Objectivization of decision making. Analysis of development trends of various objects such as industries. Analysis of market behavior.	Measurement errors. Non-compliance with the GDPR. Data manipulation (fingerprints, genomes, etc.). Risk related to the sensitivity of the shared data.
	Cloud	The ability to operate large data sets. Reduction of data storage and data sharing costs. Overcoming geographical barriers.	Data security / leakage. Personal data protection. Threat to the sovereignty of the country. Loss of property.

Table cont.

Technology	Elements	Effects. What effects can we expect?	Risks. What risks can we expect?
DARQ			
	Distributed ledger including blockchain.	Increased security of the transactions. Expanding financial transaction networks. Elimination of trusted third parties.	Financial fraud. Useless investment. No legal regulations.
	Artificial Intelligence	Plays a key role in process optimization and decision-making at various management levels. Replacing labor in various positions. Advisory function, i.e. legal, financial.	Algorithms have not been mastered. Self-learning algorithms can take control of some processes. Misuse. Usage scam. Conditions for opportunistic behavior.
	Extended Reality	New ways of experiencing the surrounding reality Visualization and 3D simulation as a way to learn and improve skills. Reducing the need for movement. High commitment.	Unnecessary investment decision. The risk of using unmastered technology. Limited availability of broadband internet. Privacy protection. An immersive environment may pose a threat to the user's health.
	Quantum computing	Innovative ways to solve the most difficult computational problems.	Excessive capacity to oversize to react to trivial problems. The risk of using unmastered technology.

Tab. 1. Expected effects and threats from the use of technology elements: SMAC [Social, Mobile, Analytics, Cloud] and DARQ [Distributed ledger DLT, Artificial Intelligence AI, Extended Reality XR, Quantum computing]. Source: Own work and a part of risk identification based on L. Benhayoun-Sadafiyine and I. Boughzala (2020).

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Effects. What effects can we expect?		Risks. What risks can we expect?	
SMAC	**DARQ**	**SMAC**	**DARQ**
The emergence of new business models*. Building relations with clients (i.e. contact anywhere, anytime). Improving the decision-making process* (i.e. by better understanding customer needs). Faster access to and flow of information. Increase in the efficiency of organization* (e.g. by managing product flows). Lower information processing costs.	Reduction in financial outlays*. Obtaining an effective tool for crisis monitoring. Higher quality of the management system. Eliminating burdensome and time-consuming activities. Opportunities of using dedicated dashboards. Simulation of the effects and risk evaluation of various development strategies. Customization (personalization) of products and services.	Greater dependence on external suppliers*. Lack of confidence in new technologies.* May lead to user addictions. The need to use specialized personal data protection systems. The need for highly qualified technical and operational staff. Dependence of the management system on technological solutions*.	The risk of system failure is greater than that of individual components of technology*. Changing the development strategy may lead to personnel and financial problems. High entry barrier. Promoting: negative patterns, unethical behavior, nationalist ideas, etc.

* observed in both SMAC and DARQ technology

Tab. 2. Expected synergistic effects and risks from the SMAC and DARQ technologies. Source: Own work and a part of risk identification based on L. Benhayoun-Sadafiyine and I.Boughzala (2020).

By analyzing the characteristics of both technologies listed in Tables 1 and 2, we would like to draw attention to the following:

1. The characteristics of both effects and risks are qualitative and the description of both technologies has no classification features (uniqueness and completeness) and in the future, after a full analysis, and not as a pilot one, the fuzzy set theories should be applied.
2. The SMAC technology can be implemented by almost every company in Poland. SMAC was an opportunity for small businesses. Small, family-run or small-town businesses can, with the relatively low financial outlay and through the use of social media, reach customers from all over Poland. This way, they can gain a competitive advantage. The analytics of this data in basic form is provided free of charge and is relatively

inexpensive. Thanks to improved, direct communication, small companies can conduct effective marketing activities, building their credibility and loyalty among customers. For instance, a small family sewing plant sewing children's clothes, thanks to social media, was able to obtain orders for its products throughout the country from individual customers, and then analyze the profile of the buyer or visitor to its store.

3. The DARQ technology is currently not fully used. It is difficult to assess both in terms of effects and threats. Its use is costly and with the introduction of Quantum computing solutions, it will require fundamental changes in the management infrastructure. The technologies in question are capital-intensive investments.
4. It can be argued that all SMAC effects (results) will become, in a qualitative sense, the results of the DARQ implementation. The exception is "lower information processing costs". The issue of risk is similar. The relationship between the risk of using SMAC technology and the risk of DARQ technology is one-way. This means that SMAC risks are DARQ risks simultaneously, but DARQ risks are not SMAC risks. The exemplification is the entry barrier, where it is low in SMAC, and high in DARQ. It can be hypothesized that the relations of development trends are one-sided, which may result in significant transformation costs that will arise under new, unpredictable threats.
5. SMAC and DARQ technologies should not be viewed as competing with each other. This means that SMAC technologies will not be completely replaced by DARQ technologies in the future, but only enriched with DARQ achievements.
6. The research results in this section of the paper should be continued in terms of the quantification of both technologies. This mostly relates to effects and costs. Such studies will be recommendations for organizations as to the legitimacy of spending on hardware, software and training of users of the described technologies.

Black Swan Theory and the Experiences of Occurrence the COVID-19 Pandemic. Recommendation of Elaborated Research on the DARQ Technology and Implementation to Predict and Monitor Disasters and Unpredictable Events

The theoretical framework of the „Black Swan" is presented in the book titled *The Black Swan: The Impact of the Highly Improbable* written by American scholar Nassim Taleb. The Sunday Times recognized it as one of the most important books written since the Second World War (Appleyard, 2009). Taleb describes the Black Swan phenomenon as a rare, unpredictable event that meets three conditions: firstly, it is unexpected and subjectively very unlikely; secondly, it has a huge impact on reality; thirdly, after its occurrence, it seems that the event was predictable and explainable, and thus becomes rationalized in retrospect (Taleb, 2014). Taleb concludes that examples of Black Swan events can be considered as the rise of the

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internet, the outbreak of World War I, the collapse of the Soviet Union, or the terrorist attacks on 11 September 2001. As Kisielnicki notes, the consequence of the presence of the Black Swan is that what we do not know is more important than what we already know (Kisielnicki, 2021).

We argue that DARQ technologies could become a useful tool for predicting, monitoring and counteracting Black Swans. We also claim that DARQ technologies can be used to effectively counter the negative effects of the COVID-19 pandemic.

The coronavirus pandemic spread in a short time from Wuhan, the capital city of Hubei Province in China (Li et al., 2020), is certainly a rare event with unpredictable consequences, although it should be noted that historically, epidemics have occurred repeatedly. Giving the example of the pandemic of Spanish flu, lasting from 1918 to 1920, the death toll is estimated at 39 million people. It is estimated that the number of deaths then constituted up to 2.0% of the global population at that time (Barro et al., 2020).

Some scholars refer to the Gray Rhino metaphor (Lindhouta & Reniers 2020) in the context of the COVID-19 pandemic. Compared to Taleb's metaphor, it reflects a probable but ignored threat (Wucker, 2016). This sentence seems to be confirmed by Taleb himself, who calls the SARS-COV-2 pandemic a white swan due to the lack of an element of unpredictability (Swango, 2020). Although epidemics themselves, as well as wars or collapses of superpowers, are not something unknown or new, it should be considered whether in such a globalized world it was possible to predict the scale of the consequences caused by the coronavirus pandemic, i.e. the outbreak of a social, economic or health crisis (McKee & Stuckler, 2020). Thus, we argue that the COVID-19 pandemic and its unpredictable effects should be considered a Black Swan. We would like to highlight that in this paper, it was not our intention to start an academic discussion on this issue. Regardless of the metaphor or the nature of a catastrophe, we are talking not only about learning from the current pandemic, but above all about the current ICT risk management practice in the 21st century, especially in the context of growing uncertainties, i.e. new diseases, natural disasters, economic crises, etc., events that are difficult to predict, but have a similar disproportionate impact on reality. It is important to do a retrospective analysis of events in order to be better prepared for them in the future.

When building models to protect against the effects of the Black Swan, two assumptions should be taken into consideration: (1) the future cannot be predicted; therefore, it is not worth relying on experience and historical data; (2) the processes taking place in the world are too complex to fully understand and quantify them. Therefore, when building predictions, even the most unlikely scenarios should be analyzed. For this purpose, it might be advisable to construct a computer system using Quantum computing (Q) and Artificial Intelligence (I) technologies to build simulation models.

Most blockchain projects are currently in the proposal phase (Abd-alrazaq et al., 2020), but have several potential implementations that may contribute to a faster end of the coronavirus crisis. Applications include simplification of vaccine and drug clinical trials and data tracking. The benefits of blockchain technology, i.e. maintaining confidentiality and trust in collecting and reporting data, will affect the level of security of the collected information (Marbouh et al., 2020).

Big data and Artificial Intelligence (AI). These technologies are used by countries such as China, Singapore and Taiwan to track people and thus limit the spread of infection. Tools such as migration maps, mobile payment apps, payment card usage, and social media activity are used to collect real-time data about the location of people (Whitelaw et al., 2020). Based on this data, machine learning models were developed to predict the regional transmission dynamics of coronavirus COVID-19 as well as to maintain movement restrictions. South Korea has implemented additional tools using surveillance footage, facial recognition technology and GPS to get the most detailed information on people's movements. Leaving aside ethical and legal aspects, such as the mortality rate per million inhabitants, as well as the total number of cases, the country ranks among the least affected among highly developed countries[7]. A research team from the University of Oxford concludes that tracking people can slow down or completely stop the spread of COVID-19 (University of Oxford, 2020). In addition, Artificial Intelligence is used for patient diagnostics, i.e. diagnosis based on a chest radiograph (Rosebrock, 2020), epidemiological modeling, infodemiology or better understanding the nature of the coronavirus (Mohammad & Tayarani, 2020, Abd-Alrazaq et al., 2020).

The role of augmented reality is emphasized in the literature. Technology was successfully implemented to study biomolecular structures through 3D visualization, which enables a better understanding of the virus mechanism of action and accelerates the process of drug discovery (Calvelo et al., 2020). It is expected that the emerging tools will be permanently introduced by scholars to drug development processes. The quantum computing technology has been committed to fighting the effects of the pandemic. In March 2020, the White House Office of Science and Technology Policy and the US Department of Energy formed the COVID-19 HPC consortium consisting of research departments and IT industry leaders such as IBM, Google Cloud, Microsoft, NVIDIA and Intel (the full list can be found on the consortium's official website[8]), as well as the US federal government to provide computing power at the level of 600 petaflops[9] to research teams working on issues related to the coronavirus pandemic. It was possible to perform a molecular simulation on the SARS-CoV-2 protein, which allowed the identification of several potential drugs that may interact intracellularly with this viral protein. For researchers who will have access to the consortium's computing

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capabilities, it is expected that after carrying out the research, they will publish their results in the open scientific literature.

The described theory of the Black Swan is valuable for an explanation of the mechanisms of unexpected events. We claim that ICT tools are extremely useful, especially mathematical modeling systems and fuzzy sets. The paper demonstrated the theoretical framework and justification for the building of an IT system for predicting and monitoring the Black Swan event. As shown in the given examples, currently DARQ technologies can largely be used against the Black Swan, which in our opinion is the COVID-19 pandemic. We recommend continuing research work on the development of assumptions for the implementation of a prediction and monitoring system.

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Endnotes

1 Likely refers to large organizations with revenues in excess of $ 250 million (accessed on 19.01.2021).

2 Kisielnicki 2018 – Management Expertise – typescript.

3 Komputery kwantowe zmienią świat biznesu. Jak przygotować firmę? MIT Sloan Management Review Polska (accessed on 9 August 2019).

4 Kavita Sharma and Padmavat Manchikanti (2020), *Regulation of Artificial Intelligence in Drug Discovery and Health Care,* Published Online:7 Oct 2020.

5 Yash, Vishakha Sehdev, Ankit Verma: Issue 10, pp. 62–68.

6 At that time, J. Kisielnicki was the director of the Postgraduate Education Center and a lecturer.

7 Basesd on: https://www.statista.com/statistics/1104709/coronavirus-deaths-worldwide-per-million-inhabitants/, accessed on 14 January 2021.

8 https://covid19-hpc-consortium.org/, accessed on 12 January 2021.

9 PFLOPS is a computer system capable of performing one quadrillion (10^{15}) floating-point operations per second.

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