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BLOCKCHAIN-DRIVEN APPROACHES FOR SUSTAINABLE DIGITAL MARKETING

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Abstract: Digital marketing, as a dynamic and rapidly evolving field, closely follows the development of technique and technology and changes in market requirements, facing constant turbulence. This inherent dynamism brings forth certain challenges that digital marketing addresses with varying degrees of success and adaptability. In such an environment, it is not easy to effectively confront these challenges and overcome the limitations that arise in daily implementation. One potential solution to these limitations has been identified in modern and emerging technologies. This paper demonstrates the transformative impact of blockchain technology on digital marketing, and maps its contribution to both business and environmental sustainability, demonstrating how innovative blockchain-driven approaches can foster a more efficient, secure, and sustainable digital marketing ecosystem.

Key words: *digital marketing, blockchain technology, sustainability, sustainable business, consensus mechanism.*

INTRODUCTION

Digital marketing is an integral part of the process of digital business transformation [1]. The question is no longer whether the company will have a digital marketing strategy, rather when management will recognize the necessity of introduce digital marketing into the business. In addition to the numerous advantages of applying

digital marketing in business, which are reflected in the ability to interact with users 24/7 [2], a high level of interaction [1], [3], overcoming geographical barriers [1], [3], more precise targeting and market segmentation [1], personalization of content [1], monitoring and analysis of analytics [1], [3], in digital marketing, as a very dynamic area, there are also certain limitations. As the development of technique and technology affects almost all spheres of business, with the aim of improving the process, the development of modern technologies can also be applied to the aim of improving digital marketing [4]. The modern business context requires that all spheres of business, including digital marketing, be aligned with the principles of sustainability, both business and environmental sustainability.

The modern technology that is being increasingly utilized for e-business [5] and digital marketing is blockchain technology. In the next few chapters, digital marketing will be further defined, with a focus on current limitations, blockchain technology will be discussed in more detail, as well as the impact of blockchain technology on digital marketing, in order to overcome the limitations. Subsequently, the impact of blockchain on digital marketing sustainability was mapped out, focusing on its use. Therefore, this paper highlights blockchain not only as a driver of digital marketing transformation, but also as a technology that can contribute to achieving sustainable business and environmental goals.

DIGITAL MARKETING

As a dynamic field, an official definition of digital marketing does not exist. One of the definitions of digital marketing is that it is the process of adopting promotional activities on the Internet, using information technologies, for the purpose of selling goods and services [6]. It includes numerous channels and methods, thus enabling the message to reach a wider audience, as well as effective communication with consumers.

Digital marketing is a field that changes according to a number of different factors, such as the development of techniques and technology [7], changing user requirements, legal regulations, competition, changes in algorithms, market changes [8], etc. Therefore, digital marketing is a very challenging field that requires constant learning and adapting to new trends. This dynamism dictates a rapid response, which sometimes does not result in the best solutions.

Some of the disadvantages and challenges of digital marketing, which are recognized in practice, are high level of competition, staff expertise, algorithm change, data security, overcrowding of information on the Internet, limited attention of users, rapidly changing trends, etc. It is a fact that some existing shortcomings are being overcome, but also that new ones are appearing. It is precisely such challenges that require the application of new technology such as blockchain.

BLOCKCHAIN TECHNOLOGY

According to [9] Blockchain represents a technology that enables immutability, and integrity of data in which a record of transactions made in a system are maintained across several distributed nodes that are linked in a peer-to-peer network.

It represents a distributed transaction record database, and which is validated and maintained by a network of computers around the world. Instead of a single central authority such as a bank, the records are supervised by a large community and no individual person has control over it and no one can go back and change or erase a transaction history [10].

The role of blockchain is to enable secure, transparent and decentralized data storage with simpler transaction tracking and identity verification. The way the blockchain works is shown in Figure 1.

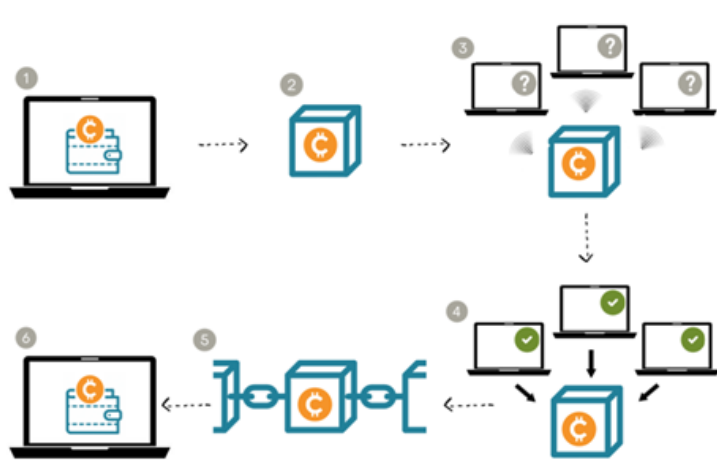


Figure 1. How a blockchain works

The first step in the process is the requested transaction. The following is the creation of a block that represents a group of transactions. The block is sent to each node in the network, after which the nodes validate the transaction. The next step is to create a block of data and add the block to the existing blockchain, after which the transaction is completed. The basic blockchain structure is shown in Figure 2.

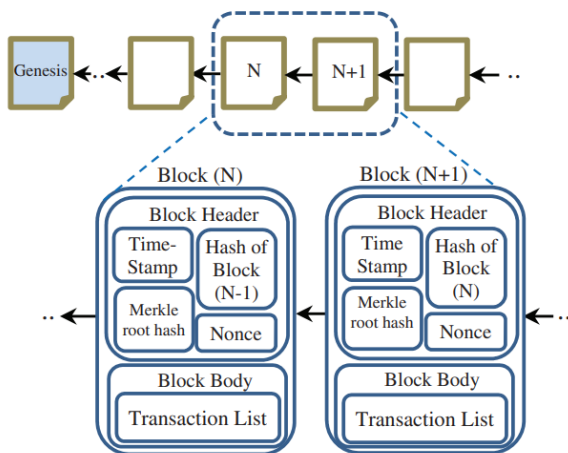


Figure 2. Basic structure of blockchain [11]

Types of blockchain

All types of blockchain can be categorized as Permissionless, Permissioned and as a combination of the two. Permissionless are those that have open access, i.e. access does not require permission, while Permissioned is not publicly available and requires access permission [12]. The types of blockchain according to permission, as well as their advantages and disadvantages, are shown in Table 1.

Table 1. Types of blockchain

Permissionless		Permissioned	
Public	Hybrid	Consortium	Private
No central authority	Controlled by one authority with some permissionless process	Controlled by a consortium	Controlled by one authority
Advantages			
open access, transparent, trust, security	access control, performance, scalability, flexibility	access control, scalability, fast transactions, privacy	access control, performance, security
Disadvantages			
performance, scalability, privacy, energy consumption	trust, auditability, complexity, more technical expertise is needed	transparency, upgrading, trust, security, dependence on members	transparency, less innovation, centralization

Consensus mechanisms

As a data structure that stores in chronological order, blockchain can support different consensus [13]. Consensus mechanisms have been incorporated into blockchains as a fault-tolerant mechanism for transaction verification [14]. There are many different consensus mechanisms, and their number is constantly increasing. Consensus mechanisms may considerably affect the performance and energy consumption of a Blockchain network. However, the most well-known are Proof of Work (PoW) and Proof of Stake (PoS), and there are also hybrid models like Hybrid PoW/PoS. Table 2 presents a comparative analysis of consensus mechanisms.

Table 2. Consensus mechanisms comparisons [15]

	PoW	PoS	Hybrid
Leader selection	Based on hash rate	Based on stake	Depends on variant
Energy consumption	Significant	Negligible	Medium to negligible
Hardware requirement	High	None	Medium to none
Block generation speed	Slow	Fast	Medium to high
Transaction confirmation speed	Slow	Fast	Medium to high

THE IMPACT OF BLOCKCHAIN ON DIGITAL MARKETING

Blockchain technology has attracted attention from academia and industry sectors [16]. The reason for this is the benefits of applying blockchain technology in different spheres. Figure 3 shows some of the impacts of blockchain technologies on digital marketing, in terms of the possibility of solving existing limitations.

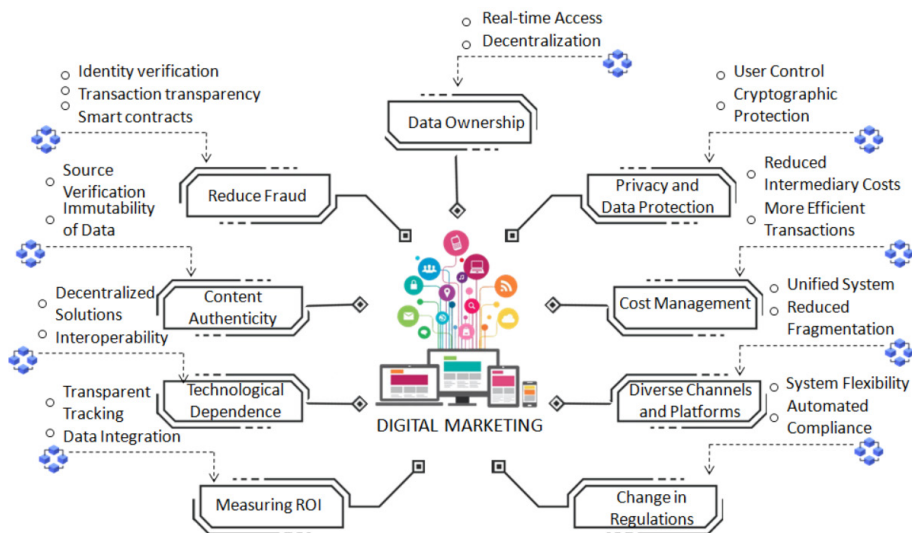


Figure 3. Transformation of Digital Marketing through Blockchain

One of the biggest disadvantages of digital marketing is the occurrence of fraud, which can be significantly reduced due to the transparency of transactions provided by the blockchain. Also, the use of smart contracts enables the automatic execution of the agreed conditions, thus reducing the possibility of fraud using fake orders. In addition, smart contracts, through automated compliance, provide the ability to adapt to new laws and regulations.

The fact that blockchain allows users to take control of their data and determine who has access to information also contributes to privacy protection. Decentralization provides access to data in real time, without downtime, and with transparent monitoring of all activities, allows better measurement of return on investment.

Today, in addition to efficiency and transparency, increasing attention is being paid to sustainability, both business and environmental. Therefore, the following chapter maps the specific impact of blockchain on the sustainability of digital marketing.

MAPPING THE IMPACT OF BLOCKCHAIN ON THE SUSTAINABILITY OF DIGITAL MARKETING

As mentioned, the impact of blockchain implementation in digital marketing is multiple. The segment that this paper pays special attention to is the impact of blockchain on the sustainability of digital marketing. In order to more clearly see the effects that this technology has on the sustainability of digital marketing, a mapping of these impacts was performed. In the following table, through the impacts presented in Figure 3, the integrated contribution of blockchain implementation in digital marketing is defined.

Table 3. The impact of blockchain on digital marketing sustainability

Blockchain Impact on Digital Marketing	Functionality	Business Sustainability	Environmental Sustainability
Data ownership	Decentralized data storage [17]; allowing users to control their data	Reduces the need for central servers	Potential reduction of resource use; depends on underlying consensus mechanism
Privacy and data protection	Security and proof of content origin [18]; User control, cryptographic protection	Reduces energy costs of centralized servers; protects user privacy	Can contribute to more sustainable infrastructures with PoS/green blockchain solutions
Cost management	Payment automation and campaigns [14]; transparent contract execution; reduction of intermediary costs, optimization of transactions	More efficient use of budget and resources	Reduction of CO ₂ emissions using energy-efficient blockchain models; reduces resource wastage
Diverse channels and platforms	Decentralized networks, interoperability [15]; unified systems, reduced fragmentation	Reduces redundant servers and infrastructure	More energy efficient when implemented with sustainable blockchain technologies
Change in regulation	Automated regulatory compliance and campaign ROI tracking	Reduces errors and duplicates in campaigns	Less wastage of resources; facilitates sustainable practice in accordance with legislation; environmental impact varies by blockchain model
Measuring ROI	Data integration and transparent monitoring of campaign performance	Enables optimization of campaigns	Less resource wastage and more efficient energy consumption with green blockchain implementations
Technical dependence	Decentralized solutions and interoperability between platforms	Reduces the need for redundant servers	More energy efficient and sustainable technical infrastructures with PoS-based networks
Content authenticity	Security and proof of content origin, immutability [15]; source verification and data immutability	Ensures the authenticity of the content	Reduces ineffective campaigns and unnecessary consumption of resources
Reduce fraud	Campaign monitoring, ad fraud prevention, smart contracts [14]; identity verification, transaction transparency, smart contracts	Reduces fake campaigns and unnecessary spending of the budget	More energetically and financially efficient if implemented with low-energy consensus mechanisms

In order to achieve the above-mentioned contributions related to environmental sustainability, it is necessary to emphasize the underlying consensus mechanism of blockchain technology. Unlike traditional Proof-of-Work (PoW) models that are energy-intensive, newer Proof-of-Stake (PoS) can significantly reduce energy consumption, while maintaining basic transparency and other system features. The table shows the specific application of blockchain and its contribution to two levels of sustainability, business and environmental. Business sustainability is reflected in increasing business efficiency and building consumer trust. Environmental sustainability considered through the application of PoS is reflected in reducing resource waste, increasing energy efficiency, reducing CO₂ emissions, and reducing redundant infrastructure. In this way, in addition to its impact on digital marketing, the application of blockchain technology in this area also contributes to the goals of sustainable business and environmental protection.

CONCLUSION

Digital marketing is one of the most dynamic segments of business. Despite its dynamism and adaptability, it still faces various limitations. This paper presents a way to overcome the observed limitations by applying blockchain technology. Since blockchain technology is an innovative solution that finds its application in various areas of business, special attention should be paid to the specifics of examples in various segments.

The paper presents the deeper application of blockchain technologies in digital marketing and the new advantages it brings, such as improved efficiency, enhanced data privacy, and increased user empowerment. The contribution of blockchain to sustainability, both through business and economic efficiency, is particularly emphasized, resulting in resource optimization, reducing energy consumption with the use of energy-efficient consensus mechanisms. Through decentralized data management, transparent processes, and the use of energy-efficient consensus mechanisms, such as Proof-of-Stake, blockchain can contribute to both business sustainability, by reducing costs and building consumer trust, and environmental sustainability, by reducing energy consumption, CO₂ emissions, and resource waste.

At this level of application, blockchain can undeniably solve a number of issues and shortcomings, making digital marketing more efficient, secure, and customer-oriented. However, it is important to emphasize that blockchain is not a perfect solution either. Just as digital marketing is not without its flaws, so is blockchain and its application in this field. That is why a balanced and realistic approach is necessary when integrating such technologies, with constant evaluation and adaptation to market and technological changes. The application of blockchain in digital marketing can contribute to the broader goals of responsible and ethical business, which is one of the key challenges of the modern market.

Due to the complexity of the solution, the subject of future research should be focused on improving the integration of blockchain technology and digital marketing, with the aim of achieving long-term sustainability, ethical business and greater end-user satisfaction. It is a multidisciplinary approach that is key to successful implementation and maximizing the benefits that such innovative solutions can bring.

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