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DECENTRALIZED AUTONOMOUS ORGANIZATIONS:

UNLOCKING THE FULL POTENTIAL OF BLOCKCHAIN TECHNOLOGY FOR THE REAL PHYSICAL WORLD BY EXPLORING SELF-ORGANIZING AND SELF-REGULATING DECENTRALIZED SYSTEMS BY APPLYING SMART CONTRACTS AND FIRST ATTEMPTS OF APPLYING AI

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ABSTRACT

This paper explores the potential of DAOs (Decentralized Autonomous Organizations) built on blockchain technology, which are expected to revolutionize our computing and transaction infrastructures This paper will focus on the legal classification of DAOs, with an emphasis on the mechanisms of raising capital through ICOs and NFTs as alternative financing options for easier access to capital. The potential of linking DAOs and AI is also briefly addressed. Corporate law must keep pace with this rapid change, and the question arises whether it is "sufficiently flexible to make room for the new technical possibilities" and to cover completely "new forms of organization" based on software code that may be inadequately reflected in existing regulations. Overall, this paper highlights the potential of DAOs and their impact on the future of business models, organizational structures, and financing options.

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1. INTRODUCTION

The development of blockchain technology or DLT (distributed ledger technology) is being followed with great interest around the world, as it enables major changes in numerous economic fields due to its "revolutionary but also disruptive properties" (Appendix No. 1) [34]. Similar to the Internet in the 1990s, this technology will completely transform society and revolutionize our computing and transaction infrastructures.

What started with the first decentralized cryptocurrency, Nakamoto's Bitcoin protocol, in the midst of the financial crisis in 2008 as a reaction to an unstable international financial and banking system, was only the starting point of a much more massive development. For the real innovation is the data structure underlying this cryptocurrency, namely the blockchain, which on the one hand enables decentralized structures and the hosting of decentralized applications, so-called D-Apps (see Appendix No. 2) [7] and on the other hand drastically reduces the need for middlemen in many sectors of the economy [7].

This has triggered the automation of many business processes in Industry 4.0 [1] while significantly reducing any transaction costs. That’s because blockchain technology is not just a "tamper-proof cashbook for storing transactions or cryptocurrencies" [12], but it is the basis for supercomputer networks such as the IPFS (Inter-Planetary File System) [42] or the Turing-complete/Turing-powerful EVM (Ethereum Virtual Machine) [9]. Alan Turing's thought that a machine might one day be empowered to learn and "in the process become its own independent steward of itself" is becoming a reality by combining Blockchain technology with Artificial Intelligence (AI) and creating self-operating electronic systems from "Cyberdyne Skynet" fiction.

The technical networks created in this way no longer serve only as a substitute for payment, but can autonomously control almost any "process," [17] making them elementary foundations for processing, coordinating, incentivizing, and financing IoT applications and the basis for the next generation of robotics. Blockchain technology is accelerating such developments and may one day be the starting point for a company without employees, as it already enables robotic process automation (RPA) in ways never before possible [31]. The "self-owning company" that is controlled by a "strong" artificial intelligence and buys back all its shares, thus becoming free and ownerless, as already presented in 1986 by Meir Dan-Cohen in his book "Rights, Persons and Organizations", is no longer pure utopia [7].

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So-called DAOs (Decentralized Autonomous Organizations) play a prominent role in this because they can prepare completely new business models of autonomous AI systems as a basis for AI applications. In the meantime, it is no longer a problem, even for non-experts, to set up their own DAO within a very short time, e.g., using modular systems such as the Aragon project or DAOStack [35]. Thus, with the Aragon Project, up to 5,000 DAOs have been founded to date (cf. Appendix No. 3). Some people would like to talk about a "DO-ocracy" or even a "DAOcracy" [15], focusing on the completely new forms of collaboration that DAOs enable and that give individuals a variety of unprecedented new creative freedoms [25]. DAOs are "profoundly changing the way humanity organizes its work."[25]. The ability to retain control over one's digital identity and emancipate oneself from centralized platforms and surveillance capitalism while co-creating and co-owning one's digital identity is very attractive to millions of users [14].

There is also the possibility of capturing any value digitally using blockchain technology (e.g., in the form of NFTs, ERC 721 tokens, etc.) and exchanging it digitally and in a decentralized manner. Thus, a blockchain can also serve as a central repository for security by "tokenizing" a company's stock, a government bond, a syndicated loan, or other securities and trading the token quickly and transparently in the market like a bitcoin. Corporate law must keep pace with this rapid change, and the question is whether it is "sufficiently flexible to allow room for the new technological possibilities" and to capture entirely "new forms of organization" built on software code that may be inadequately reflected in existing rules [39].

This paper will deal primarily with DAOs. It will attempt to delve into the concept of Decentralized Autonomous Organizations (DAOs). The history of DAOs is presented, tracing the origin of the concept and its development over time. Next, the essay examines the functioning and structuring of DAOs, including general information about their operation and the tokens that comprise them. Additionally, the decision-making process of DAOs and how members can join via NFTs is explored. The crucial role of smart contracts in the functioning of DAOs is also discussed. The essay then moves on to explore oracles and their relationship with the physical world, examining how they enable blockchains to connect with real-world data. Furthermore, the essay analyzes how DAOs can be used as financing instruments through Initial Coin Offerings (ICOs) and Non-Fungible Tokens (NFTs). Blockchain technologies are enabling a new form of crowd- or mass-capitalism that gives the public an immediate stake in the success and emergence of autonomously operating organizations that are self-powered and not only realize entirely

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new P2P (peer-to-peer) markets that can be collectively owned, but also "drive digital upheaval." Assets coordinated by DAOs have increased tenfold from 2021 to 2022, growing to over $14.5 billion as of August 2022 [25]. It also briefly discusses the potential of combining DAOs and AI to enable not only a purely decentralized organization, but one that will operate completely autonomously for the foreseeable future as well as the possibilities to use DAOs to fight the climate change.

2. HISTORY OF THE DAO

The concept of a DAO is not entirely new. For example, even before DAOs, there were so-called chaordic organizations, such as the VISA company, which can be understood as a precursor to DAOs [4]. Of course, VISA's organizational model has changed over the years, leaving behind the initial structures from the 1970s. The first functionally operating DAO to attract greater attention was "The DAO" project. This project is the most well-known, well-documented, and consequential blockchain hack to date. The fact that the venture behind this project had its starting point in 2016 in Germany, Saxony [39], is at least as surprising as the far-reaching consequences of the hack for the second largest Blockchain network Ethereum, which was split into two different networks (Ethereum and Ethereum Classic) in a hard fork as a consequence (see Appendix No. 4).

In April 2016, programmer Christopher Jentzsch published a whitepaper (*Teichmann*, 2017), which further specified the project "The DAO". "The DAO" makes one think of a venture capital company or a decentralized investment fund [25], which collects funds from its members in exchange for governance tokens. Tokens are a type of token to which a specific right is securitized. A governance token allows the holder to participate in digital voting processes [25]. The governance tokens of "The DAO" were fungible (freely transferable) and could be traded anonymously [25]. The DAO was about deciding collectively, through a simple majority vote, how to invest the money collected in the most profitable way [39]. The ostensible aim was to subsequently profit from agreed repayments.

Although the original goal of the German programmers was to finance their own company (Slock.It UG) by means of a vote of the governance token holders, each governance token holder also had the opportunity to submit their own proposals to the vote, provided these could have been paid for using Ethereum [25]. Upon reaching the required quorum, the underlying smart contract should have orchestrated the governance of the capital flows in an automated manner after a successful vote [37]. In doing so, "The DAO" had taken two security measures. First, there was a kind of curator (reviewer) who

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managed a list of potential investment projects and could be voted out by members at any time. Secondly, the invested Ether with a minimum holding period of about 28 days was parked in a Sog. Child-DAO temporarily parked and could not be used immediately [39].

Since the legal situation was not entirely clear even to the programmers, it was agreed that they would simply make the code freely available to the public and the organization could then be activated by third parties on the Ethereum Blockchain [24]. Eventually, the programmers selected one of the DAOs created in this way by third parties, invested in it, and promoted it heavily using their German Slock.it UG [24]. After "The DAO" - which consisted of just 900 lines of programmed code - was initialized, the project quickly collected 11,994,260.98 ETH (which was about 14% of the total cryptocurrency holdings of the Ethereum platform), worth more than $160 million at the time. The "largest crowdfunding project of all time" to the present day had been created [24].

A "digital bank robber" managed to steal about3,689,577 ETH from this already huge amount on June 17, 2016, which was about 30% of the total amount collected. The market value at the time was about $50 million [24]. This would have been more than 14 billion US dollars at the peak of ETH in 2022. The hacker had cleverly exploited a flaw in the source code of "The DAO" and was thus able to fork over the money [17]. The smart contract allowed deposited money to be withdrawn again, which led to the hacker appropriating other users' money as well [39]. This was a so-called replay attack. The hacker could not be identified at times due to the anonymized data structure of the blockchain, although there is increasing evidence that the hacker(s) could be located in Austria (*Shin*, 2022). This hacking had an immense impact on the Ethereum blockchain, as about one seventh (14%) of the total ETH holdings had gone into "The DAO" (see above). However, since the money could only be paid out after a lock-up period of one month, the Ethereum community had time to work out a solution in a lively, transparent discussion that could be tracked by everyone on the Internet [24].

In the process, the developers of Ethereum around Vitalik Buterin worked towards a hard fork, which allowed the affected users to reverse the purchase of their shares (*Willcke*, 2016). A hard fork always occurs when new functions are introduced into a blockchain network that were considered invalid in previous versions. The nodes or miners that do not then upgrade to the current software version can then no longer join the longer, existing blockchain chain, so the ledger splits and there are two cryptocurrencies side by side (see Appendix No. 4). Since the hard fork comprehensively rewrites the protocol, users had to decide whether they wanted to belong to the old now "flawed" blockchain or to the new network [37].

It was a matter of "drying up the bad guy...in a dead corner of the blockchain" by starting a "new fork in the chain." Since the vast majority of node operators (nearly 99%) agreed to a so-called hard fork - by installing a software update [37] - that recorded the preceding creation of "The DAO" and the theft of the money as undone, it was possible to undo the hack.While the money was now temporarily parked on a child DAO, the hard fork could be successfully carried out [37], which in turn led to the fact that a large part of the funds could be secured and returned to the investors [17].

The immutability of the blockchain was removed for this one very specific individual case by the retroactive rewrite, which was seen as an imposition, especially by part of the community, as it undermined the trust of the users [39]. In particular, the principle of "code is law"[39] was invoked, and it was felt that the code would be compromised by a "vigilante justice system supported by a majority of participants"[17]. Furthermore, the opponents of the hard fork argued that there was precisely no attack on the system or criminal act, but that the hackers had merely exploited a vulnerability in the code [17]. Therefore, there were also some node operators (about 1% - including the hackers) who chose to continue the old blockchain under the name "Ethereum Classic", which in turn were excluded from the new Ethereum network for lack of installation of the update [37].

Conversely, the updated clients were no longer compatible with the consensus rules of "Ethereum Classic" and were in turn excluded from this network. Without a doubt, the hack of "The DAO" can be classified as disloyal, as it clearly violated the purpose of the company [37] and the error of the smart contract was not intended in this way. If one were to come to a different conclusion, one could also say - to illustrate the absurdity of this discussion - that it would be legitimate to collect other people's cats in the city and to claim that they were running around freely and could therefore be accessed by anyone and that all social rules would have to be suspended in such a case, even if the majority of society would classify this as theft in the sense of § 242 StGB ivm § 90a BGB. It seems absurd that participants in a DAO would also want to subordinate themselves to the rules in the software in the event of a hack and would also want to accept malfunctions of the software in advance. At least as absurd is the justification of the cat thief that the cat was attracted to him because he discovered that cats have an error programmed into their DNA and like to change owners for a bowl of milk and that this genetic programming and the feelings of the animal triggered by it should therefore be placed above the applicable law.

Of course, participants can deviate from the content of the code if it now seems nonsensical or an existing loophole has been abused as in the case of "The DAO". The case of "The DAO" has once again

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impressively shown how important increased security is for trust in blockchain systems, because such systems are particularly at risk of falling victim to hacker attacks and even small security gaps in the smart contract can have a significant impact [37].

Even though the project "The DAO" failed, media attention was drawn to DAOs and the Ethereum Blockchain despite this incident or perhaps because of it. In retrospect, this development has even been quite instrumental in popularizing the idea of independently operating organizations - i.e. DAOs [26]. As a result, there are now a wide variety of DAO projects with a wide variety of focuses. Baur has attempted to classify DAOs according to their basic function and has defined four main DAO types. Thus, he distinguishes between management DAOs (a project as a whole is operated by the DAO and services are offered to third parties), financing/investment DAOs (voting-based investment associations such as "The DAO"), the donation DAOs (charitable purposes are pursued here) and control DAOs (coordination of software - important in the IoT field). While these concepts have overlaps, they are very different in their respective market interactions (see Appendix No. 5). Following this classification, this thesis will largely focus on financing/investment DAOs, management DAOs and control DAOs. This classification makes it possible to take a generalized look at DAOs and not get lost in looking at individual projects (such as the Collector DAO, Flamingo DAO, MakerDAO, Uniswap or building block DAO systems like Aragon) - all of which have specific character traits.

3. FUNCTIONING AND STRUCTURING OF A DAO

The following part explains the general functioning of a DAO. In doing so, the design and structure are highlighted as well as the question of how joining a DAO can be done, what belongs to the participants of a DAO and how they can control the DAO.

3.1. General information on the functioning and structure of a DAO

A DAO is composed of a large number of smart contracts, which - upon the occurrence of certain events - can execute themselves [23]. The DLT (blockchain) is only the basis for the DAO, which is set up on this infrastructure like an app or application. In principle, a DAO can run on any blockchain that provides a suitable infrastructure. Probably the most common infrastructure of the 2020s is currently provided by the Ethereum blockchain, but there are also other blockchains that could be considered just as well and [26], purely theoretically, it would be possible to set up a blockchain of one's own, on which

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the DAO would then in turn be set up. Nevertheless, a large number of smart contracts are usually programmed, which then make up the DAO, and are subsequently stored on an existing blockchain to initiate the DAO [23].

3.2 The tokens of a DAO - Who owns the DAO, how to join it and how the decision making is done

Those who wish to have a "share" in the DAO can acquire so-called tokens (which can be thought of as value coupons on which certain rights are securitized - see above) in the DAO. This can be done in two ways: Either by the user contributing intangible services (services, creative activities or the like) and being paid for them in tokens, or by exchanging an accepted currency (e.g. ETH or BTC) for a token [16]. For the latter, the user only has to send the accepted currency to the smart contract address of the DAO and in return receives tokens transferred to his wallet [23], which are generated directly during the period of an ICO (Initial Coin Offerings) or come directly from the wallet of the DAO in the later course.

A wallet or wallet address is a "public key" (PuK) to which anyone can send cryptocurrencies or NFTs and which can also be viewed by anyone, but which only the owner can dispose of by means of a private key (PrK). For example, tokens on the Ethereum Blockchain are created using the ERC-20 standard (Ethereum request for comments-20), which defines 6 mandatory functions (total token balance, balance, transfer, transfer from, approve, allowance) and includes three optional functions, such as name, symbol, and the number of decimal places after the decimal point.[1] Since the various token types are very diverse and can be securitized with a wide variety of rights, only the tokens most relevant to DAOs, namely the simple tokens without voting rights (investment tokens) and those with voting rights (governance tokens, more rarely also equity tokens or governance certificates), will be examined in more detail below [7].

Here, too, it must be noted that the dividing lines cannot be drawn so easily and vary from project to project. However, this approach may suffice for a general consideration. An ordinary token (e.g. in the form of an investment token) would, for example, participate in profit distributions and would have an intrinsic value that could be sold later on the market with an increase in value, if necessary [24]. The comparison with different share classes suggests itself (A-shares with voting rights, B-shares with less voting rights, C-shares without voting rights, etc.), which, for example, have different voting rights or

[1] *The Ethereum Foundation*, ERC-20 TOKEN STANDARD, accessible at: https://ethereum.org/en/developers/docs/standards/tokens/erc-20/,[Last time retrieved on March 10th, 2023].

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profit participation. A governance token is an entitlement certificate and, in addition to the basic properties of an investment token, also gives holders the opportunity to participate in voting processes regarding the direction of a DAO (Cf. Appendix No. 6) [16].

It is by no means an exaggeration to say that the "heart of every DAO" is the "software-driven voting mechanism". It is then the members of the DAO who - depending on the design of the DAO - ideally steer the organization in the desired direction and extend or adapt the underlying self-executing program code of the smart contracts through voting procedures [16]. In doing so, all participants can "interact with the software within the constraints set by the software using their wallet address." The problem here - as with any member-dependent organization - is that participation in voting is idR low, and it is common for less than 10% of those eligible to vote to participate in voting (*Greilich* 2022).

In general, governance tokens are also fungible, i.e. freely transferable, and can be traded anonymously. Problematic for the voting processes is that individuals can acquire multiple governance tokens. Even if this were excluded in the protocol, it would not be possible to control how many wallet addresses with then one governance token each an individual person owns due to the anonymity. As a rule, a small group therefore holds a large proportion of the governance tokens [32]. It can therefore happen that so-called "whales" (designation for investors who hold a particularly large number of governance tokens) can enforce their decisions on the basis of their token majority [15].

The governance token holders can submit proposals within the DAO, whereby an overloading of the system by mass requests or not seriously meant fun proposals is prevented by paying a deposit for each submitted proposal, as well as in some projects by prior review by so-called reviewers (curators). However, the concrete design varies from DAO to DAO. Financing or investment DAOs will be projects into which collected capital is to flow in the form of a shareholding. Governance token holders can then vote on proposals; if a quorum previously set in the code is reached, the DAO's code will independently execute the desired transaction and any subsequent steps (*Mann*, 2022).

In this way, unlike traditional organizations, this form of decision-making is not left to the top management but is stored in the DAO's code. Decision-making and decision-making can be implemented much more cost effectively and quickly with greater transparency and traceability [26]. In addition, governance token holders can form an "association will" and pursue the advancement of a "common purpose" by providing capital and participating in voting.

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3.3 Smart Contracts as the Basis for DAOs

As we understand smart contracts today, they were already conceived in the 1990s by Nick Szabo [29], although the discussion about automatically executing programs certainly goes much further back in time [29]. Depending on how you look at it - if you also want to understand the first commodity vending machines as "simplified versions" of modern smart contracts [13] - they were "in use long before the German Civil Code came into force."[29]. In this context, the Ethereum blockchain was the first platform to enable smart contracts and D-apps, explaining the dominant position of this blockchain (see Appendix No. 7) [10]. Thanks to the "Turing-completeness of the smart contract architecture", the possibilities of designing a DAO are almost unlimited [4]. This then also ensures that people and machines can be coordinated autonomously by means of a DAO through specifically adapted smart contracts - without the connection to classic business entities [26].

3.3.1 How smart contracts work.

In a sense, the smart contract works like an autonomous agent in that it automatically responds to input it receives from external accounts or other smart contract programs running on the network [7]. Thus, based on an "if" operation or "if...else-statement" known in the programmer's language, an "if-then" logic is programmed in that triggers or omits a certain operation when a certain pre-defined event occurs (e.g., paying out an amount of money to a certain wallet address) [16]. The smart contract also has a wallet address to receive payments in cryptocurrencies [3]. The Smart Contract virtually executes itself based on its set of rules [39].

A Smart Contract can consist of as little as a few hundred lines of code and can therefore be used in any country and by anyone with an internet connection, thanks to the transnational nature of a Blockchain [7]. Smart contracts have many advantages: they offer companies and organizations entirely new ways to protect themselves from misappropriation, misuse of their assets, self-dealing, and opportunistic behavior by enabling much better internal control, automating many mundane processes [7], and coordinating an increasing number of market and non-market activities [7].

In addition, smart contracts can be used over and over again, perform very small-scale operations (especially important in the IoT space where micro payments are involved), and map so-called D-apps through them. Finally, they are also the basis for DAOs, which are composed of a large number of smart

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contracts [7]. Furthermore, they can be used to map areas without central intermediaries (which slow down processes) even if they are of such small scale that previous structures (e.g., a notary) would not take them on for reasons of time and cost (especially e.g., micro-payments to sensors) [7].

Through smart contracts, many processes can be negotiated in an automated manner, entire production processes can be freely initiated and executed by intermediaries, and finally, payment transactions can be handled automatically [1]. At the same time, the whole thing takes place at such high speed that they are also suitable for "time-sensitive applications" [17]. Smart contracts create trust because the parties know that the code - provided it correctly reflects their intentions and the circumstances underlying them occur - will be executed fully automatically on the blockchain [17]. And because this execution occurs identically and almost simultaneously on all nodes worldwide in a decentralized manner (see Appendix No. 8), there is no need for additional entities to subsequently enforce the execution (e.g., a court) [23].

In this sense, smart contracts are the backbone of DAOs. They are also DeFi applications, which can be understood as small, tamper-proof, highly transparent (the internal logic of the deterministic program code can be understood by anyone) computer programs that are stored and executed on the blockchain [32]. Contractual agreements can also be mapped in these programs, enabling the automatic exchange of services and the immediate enforcement by execution of the contracts. The word "smart" does not stand for "clever" or "smart," but is equated in programming jargon with "uniquely identifiable" and "forgery-proof". The comparison with a vending machine is often used to describe smart contracts: The customer can select a product, is shown a price, deposits the money and then - depending on the filling status of the vending machine - receives either the product or his money back in a fully automated manner, since the contract, which is transparent to the customer, fulfills itself [34].

3.3.2. Smart contract - a contract or just code?

The parties using a smart contract must have negotiated the underlying conditions of the smart contract in advance and agree that they want to have this contract executed automatically by means of a smart contract on the blockchain. The contractual agreements are recorded in software code and then processed and executed in a decentralized manner by all nodes supporting the underlying blockchain network [7]. However, the concept of a contract is misleading, as the smart contract is not a contract but merely a program code that can at most still mirror a contract from the real physical world, but executes

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it in a fully automated manner [39], which, however, does not lead to the smart contract becoming a contract in the legal sense [29].

According to the prevailing opinion, the concurring declarations of intent [39] and the will to be legally bound (Rechtsbindungswille) are missing. In addition, the initiator of the smart contract also takes a back seat to it and can no longer change it independently [39]. In most cases, smart contracts are used to "fulfill or control already existing debt relationships."[12] Smart contracts are merely to be seen as "automated business processes and legal transactions, which, however, would already have existed longer than the German Civil Code (BGB)" [29]. *Baur* would therefore even like to see the name Smart Contract replaced with the term "controlling software code". Only the supporters of the "code is law" principle see a smart contract as a "new legal institution" that can no longer be interfered with by the legislature [see in this paper: Section 4].

3.3.3. Problem of immutability and reversals of smart contracts

A repeatedly cited disadvantage of smart contracts is that - unlike centralized institutions with intermediaries - an erroneous or unauthorized transaction cannot be reversed after the network of nodes on the blockchain has validated it [7]. And, of course, there is always the risk of a programming error occurring with a smart contract (see "The DAO") [32]. Since no party controls the blockchain on which the smart contract has been placed, and the smart contract executes itself, it cannot be stopped after it has been activated, and the conditions contained in the code are executed. Subsequent correction is then generally no longer possible unless the entire network is reset, as in the case of "The DAO" (see above) [17]. This can only be counteracted if the parties have already programmed the possibility of stopping the program into the smart contract in advance [7]. Thus, one can also integrate withdrawal agreements into a smart contract or the possibility to call an arbitration court to decide the dispute [7].

The concern that smart contracts can no longer be changed is unfounded, however, because there are now enough functionally adequate "workarounds" to counteract the consequences of a smart contract once it has been executed by means of anticipatory behavior. It is therefore possible - something that is often overlooked in the discussion - to limit the executive character of smart contracts without this being particularly difficult. There are various approaches here that do not collide with the basic principles of blockchain technology. Anticipating every conceivable case in advance and storing possible contract violations and their resolution in the code seems unrealistic; but one can at least make regulations on how

to deal with a reversal situation (possibly also in the real physical world) [12]. *Freidank* also correctly recognizes that possible problems "can be solved well with the current law, however, if the possibilities and limits of the technology used are always kept in mind and appropriate contractual provisions are made"[12].

If it is recognized that any undesirable developments cannot be anticipated in the code, a smart contract can be programmed in such a way that part of the code draws on an external source, such as an external library (this is referred to as modifiable libraries). In this way, one can build in a "back door" to adapt the Smart Contract in parts later on, if both sides agree or a judge should order this. A back-reference function (in German: Rückverweisfunktion) is also conceivable, in which an existing smart contract refers to another smart contract that is later initiated in an optimized manner if essential elements of the agreement change.

In other words, smart contracts could of course be modified retrospectively if they were programmed intelligently and with foresight. So-called "reverse transactions" protocols, which either require the cooperation of the repayment debtor or aim to withdraw certain assigned legal positions that are still tied to the blockchain (e.g., computing capacities, usage rights, licenses, etc.), are also being tested [12].

Other possible solutions involve a smart contract only implementing certain transactions after a certain grace period and recording them on the blockchain [12], which is what made reversal possible in the first place in the case of "The DAO" project [12]. Viewed in this way, the smart contract would then retain financial assets or other benefits like a "trustee" until the other party has confirmed receipt of its performance or an objection period has expired or a waiver of revocation has been declared [29]. Recently, so-called "Chameleo Hash Functions" on so-called "Redactable Blockchains" have also been discussed, which make it possible to change the entries on a Blockchain after the fact without immediately triggering a hard fork [12].

Despite all these approaches, there is no question that smart contracts will not be able to take into account all the legal intricacies, at least not in the near future, especially if these are difficult to anticipate and it is therefore not possible to transfer these specifics into the "strict logic of the code" [7]. This may possibly change due to "Strong AI", i.e. "strong artificial intelligence" (which can perform several

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specialized operations simultaneously) in connection with DAOs, the development of which is expected in the near future [33].

4. ORACLES AND HOW BLOCKCHAINS CONNECT TO THE REAL PHYSICAL WORLD

Smart contracts and DAOs stored on the blockchain can connect and interact with external systems (such as programs, sensors, RFID chips) or with individuals and legal entities through interfaces to the real world - so-called oracles - which allows them to incorporate information from the real physical world (off-chain) into their processes [7]. This allows a DAO to respond to changing conditions in near real-time and verify events from the real world [7]. An example of such a process would be the fully automated matching of the shipping status of an online order by an Oracle that can access the API of the shipping company's website, and automatically pass a confirmation to the smart contract when the package has been shipped. The confirmation then distributes a specific token to the contract partner [17].

A real-world independent person could also function as an Oracle and reflect information back to the blockchain or smart contract or DAO. For example, an arbitration judge/arbitrator previously appointed by the parties who analyzes the facts of the case and communicates his or her decision (see Appendix No. 9) [29]. Or the farmer who detects certain stress factors in the field (e.g. pest infestation) and enters it manually into a database using a suitable input device [1]. Currently, the largest and still fastest growing application field for Oracles is crypto-derivatives. That is, betting on the market performance of specific asset classes (e.g., cryptocurrencies, stocks, commodities, etc.) via blockchain-based derivatives protocols that align smart contract-driven monetary distributions with real external market developments and therefore require real-time information from the real world [32]. Using Oracles, it is also possible to capture performance disruptions in the real world and - if these performance disruptions have been anticipated - address them using smart contract programming (e.g., temporarily shutting down resources or locking a smart lock, etc.) [29].

This definitely also poses dangers because the "exclusion of external data sources typical of blockchain is partially removed" [12] and dependencies on external information arise [32]. This can lead, for example, to data sources connected to the Oracles being manipulated. Examples include a website that is hacked and transmits false data, or a human Oracle that can be corrupted and willingly and knowingly provides false information, which in turn leads to incorrect operation of the connected smart contract or DAO (so-called Oracle Problem) [32]. Such a danger can be reduced if several independent data sources

are used, which is now already practiced in many projects that rely on decentralized Oracle networks with a large variety of data sources [32].

Especially in the area of automation Oracles play an important role, because they connect the digital with the analog world [29]. The importance of Oracles is particularly exciting in view of IoT and robotics. Should a DAO have a "physical existence," such as a robot, it could also use this very directly as an Oracle in the real-physical world and then interact even more directly with the real environment. The prerequisites for this are already in place today. Just take a look at fully automated corporate organizations and the use of merchandise robots [31]. It is possible that the involvement of humans will no longer be necessary in this area and that the intermediary replacement, which currently operates only digitally, will become part of the real physical world [31].

5. THE COMBINATION DAO WITH ARTIFICIAL INTELLIGENCE (AI): THE FULLY AUTOMATED DAO

Humans have been dreaming of creating artificial humans, robots and self-managing companies for a very long time, i.e. a company without humans, the "No Man Society". The concept of Artificial Intelligence and self-governing organizations has accompanied mankind for centuries. For example, the first philosophical attempts to formalize thinking can be found in the 13th century with the Mallorcan philosopher *Ramon Llull*. *Gottfried Wilhelm Leibniz* also dealt with the "algebra of the mind", with the help of which one should arrive at a result "as it were by the action of a machine". And finally, *Alan Turing* developed the decisive thoughts on the functioning of an artificial intelligence and the question of whether machines would one day be able to think for themselves. Although *Schwemmer* already assumes that an "autonomously acting artificial intelligence" will be used at least partially in the DAO [35], this is not the case.

At the present, we do not yet have a "strong AI", i.e. an artificial intelligence that would be largely self-determined and comparable to human intelligence, and that can perform several operations in parallel (see above) [33]. However, some scientists, such as *Kurzweil*, believe that we will soon reach the technological singularity where a strong AI can operate at a human level. In particular, the connection of the DAO with an AI could play a crucial role in this. Strictly speaking, the name "DAO" is not correctly chosen for today's decentralized organizations because, although the DAO can automate certain processes, we are not currently at the point where the Decentralized Autonomous Organization can operate truly

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autonomously from humans by means of "Strong AI" because this "Strong AI" does not currently exist [17]. Actually, one should therefore correctly speak of a DO (Decentralized Organization) [35].

At this moment, DAOs merely serve as a "virtual framework" which, at best, helps to "structure the activities of the participating members and to channel their will formation" [16]. In any case, no DAO that is completely devoid of human control can be expected in the foreseeable future. Apart from that, an AI cannot be a contracting party due to the lack of appropriate legislation, since it cannot be a natural person, a legal entity or a partnership [17] and cannot be granted any personal rights. Recent developments, such as Google's LaMDA AI, which claims personality rights [17], are promising, and it has already been proven that AI is capable of creating things that exceed the expectations or the knowledge of its programmers provided in the Deep Learning process. It is likely that, much like legislators have given legal personality to companies in the past, these developments will soon require a new legal framework to properly capture the rights and responsibilities of DAOs that will be autonomously controlled by AI in the foreseeable future [7].

For the discussion in this paper, however, actual autonomously operating AI-controlled DAOs can be disregarded for the time being, as no project has yet become known in which a "Strong AI" and a DAO have been combined. Especially interesting might this discussion furthermore become if we think about even more sophisticated developments in the DLT field such as for example but not only limited to DAGs (Directed Acyclic Graphs) and how they might be brought together with AI.

6. THE DAO AS A FINANCING INSTRUMENT VIA ICOs AND NFTs

In addition to its structure-giving function and its function for the proportionally autonomous orchestration of processes, a DAO also has the function of an alternative financing option for easier access to capital. By means of the blockchain, shares in companies can be "tokenized", i.e. converted into virtual shares recorded on the blockchain (see above) [7]. It is not uncommon for DAOs to issue other tokens (often in the form of crypto-coins or as NFTs) in addition to certificates in the form of governance tokens.

Thus, a DAO itself can become a kind of Bitcoin as its tokens become more valuable over time. NFTs in particular have become increasingly popular in this regard in recent years, as they allow for individualization in addition to a granted right, e.g., a voting right (Cf. Appendix No. 10). Investors can also individualize, even personalize these tokens - unlike shares - with very different added values (such

as utility functions, property rights, license fees, participation rights, convertible loans, etc.) and acquire them directly from the DAO, the company or the projects [10].

This issuance of coins is called an Initial Coin Offering (ICO). ICOs are comparable to the issuance of shares, the Initial Public Offering (IPO). In order to be able to offer a classic security (IPO), companies must - for the protection of investors - idR create numerous documents and fulfill verification requirements, which is not only costly and time-consuming, but above all also very complicated, which is why most public markets remain closed to startups and small companies [7]. Unlike IPOs, ICOs hardly have to submit to any regulations - at least at the moment - due to their novelty and decentralization [7]. Even though they are now recorded as securities in the U.S., for example.[2]

Thus, with just a few lines of code, a DAO can conduct an ICO, not only bypassing existing financial regulations, but also launching a global public offering to anyone. This makes it easier for the DAO to collect money from private investors without routing it through government agencies or centralized intermediaries. One is rightly reminded of popular crowdfunding platforms (such as Kickstarter, Betterplace, GoFundMe or IndiGoGo) [7]. The similarities between crowdfunding projects, investment DAOs, ICOs and IPOs are also evident in the communication with potential investors, whom one tries to animate to invest in the project, which is why documentation of the project is made available (in the case of DAOs and ICOs so-called whitepapers, in the case of IPOs a "securities prospectus" in the sense of § 32 III No.2 BörsG).

The whitepapers (mostly published on a website of the project) then contain a description of the technical details of the project, basic biographical information about the project founders and advisors as well as goals and hopes, which are roughly outlined [7]. In most cases, the tokens are implemented on the Ethereum blockchain (using an ERC-20 protocol), but they can also be created on their own blockchain. Many DAO project also issue Non-Fungible Tokens (NFTs) instead of crypto coins (see above). These are also mostly implemented on the Ethereum blockchain (using an ERC-721 protocol).

Such issuance of coins is also very secure due to the verification and validation capabilities, transparent, tamper-proof, and time-based recording of each transaction on the blockchain [7]. This form of raising capital is an interesting alternative to risky venture capital (VC) contracts, convertible loans,

[2] ICOs are classified as securities transactions in the United States, relying on the U.S. Supreme Court case 'SEC v. Howey Co' from 1946 and applying the so-called 'Howey Test'. Further details can be found in: *Burniske/Tatar*, Cryptoassets, p. 258.

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loans (credit agreement), debentures, etc., especially for startups and small companies, because, on the one hand, they are easy to implement, and the initiators retain control over their companies [22].

This also explains the popularity of ICOs (cf. Appendix No. 11). However, there are still many ambiguities due to the lack of regulation, which has advantages and disadvantages in equal measure [22]. Issues discussed include regulatory issues, related prospectus and permission requirements [22], compatibility with the "strict requirements of the German Civil Code (BGB)", tax issues, and how to deal with international buyers and sellers [22]. The "technology-neutral approach" pursued by BaFin is encouraging, which at least puts any licensing obligations of financial instruments with regard to ICOs and tokens in the background.[3]

7. CONCLUSION

In conclusion, the Decentralized Autonomous Organization (DAO) is a rapidly growing phenomenon that is transforming the way we think about organizational structures and decision-making processes. This essay has explored the history of DAOs, their functioning and structure, the role of smart contracts and oracles in DAOs, and the potential for combining DAOs with artificial intelligence. We have also examined how DAOs can be used as financing instruments through Initial Coin Offerings (ICOs) and Non-Fungible Tokens (NFTs). The emergence of DAOs is part of a broader trend towards decentralized and democratized systems, enabled by blockchain technology. DAOs offer a new way of organizing and managing resources that is transparent, democratic, and more equitable. They allow for a high level of automation, reducing costs and increasing efficiency. While DAOs are still in their early stages, there is no doubt that they hold great promise for the future of organizational structures and decision-making processes. As the technology continues to evolve, we can expect to see even more advanced forms of DAOs that incorporate AI, DAGs and other cutting-edge technologies. However, as with any new technology, there are also risks and challenges associated with DAOs. For example, there are questions around governance, legal forms, regulation ingeneral, and security that need to be addressed. Nevertheless, it is clear that the benefits of DAOs outweigh the risks, and we can expect to see their continued growth and adoption in the years to come.

[3] *BaFin*, Second notification regarding prospectus and permit obligations related to the issuance of so-called crypto tokens (Zweites Hinweisschreiben zu Prospekt- und Erlaubnispflichten im Zusammenhang mit der Ausgabe sogenannter Krypto-Token), accessible at: https://www.bafin.de/SharedDocs/Downloads/DE/Merkblatt/WA/dl_wa_merkblatt_ICOs.html, [Last time retrieved on March 10th, 2023].

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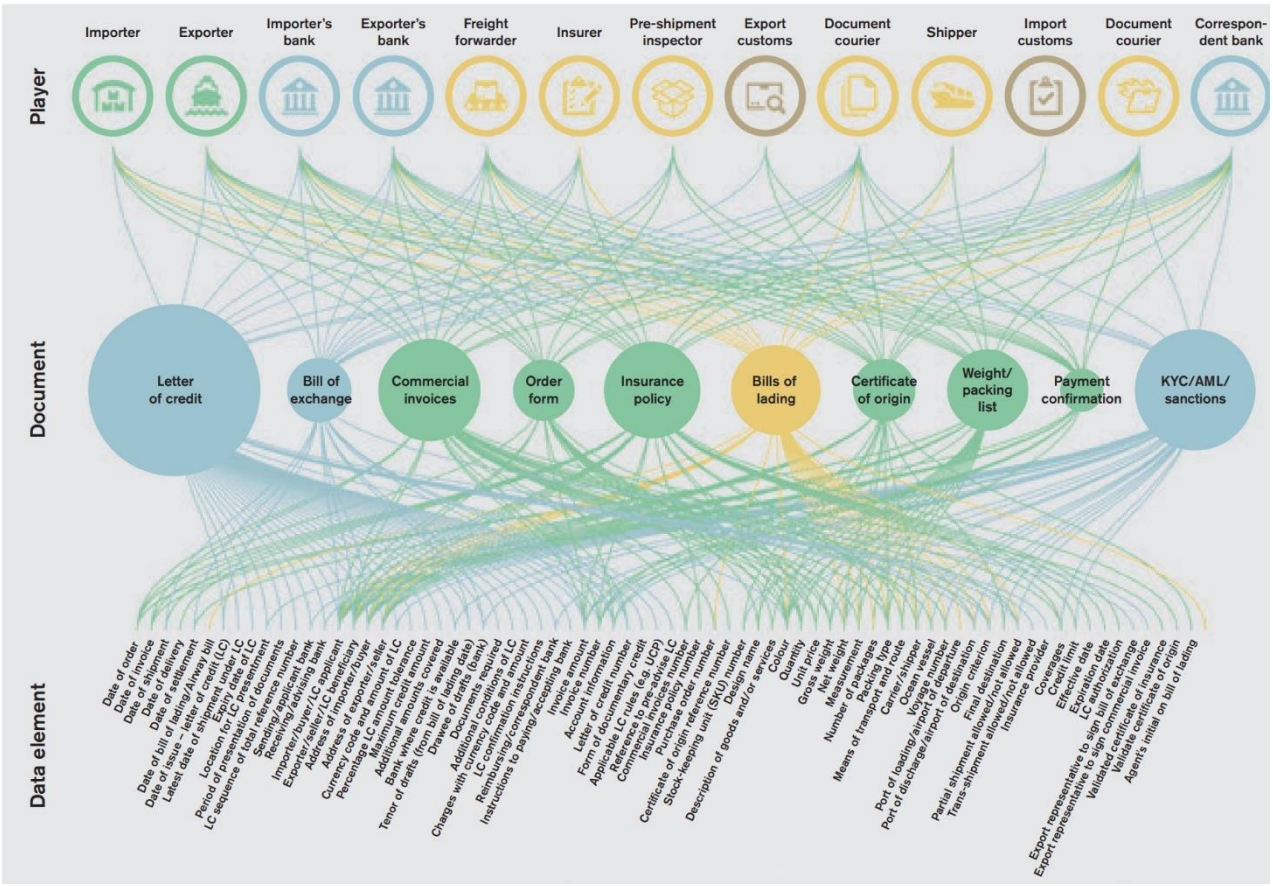
APPENDIX

Appendix No. 1 - The various transaction partners that blockchain technology makes obsolete



The diagram shows the necessary transaction partners that can be involved in a financial transaction. Many of these transaction partners are made redundant by blockchain technology and protocols such as Bitcoin.

Source: *Ganne*, World Trade Organization – Can Blockchain revolutionize international trade?, p. 22 mwN.

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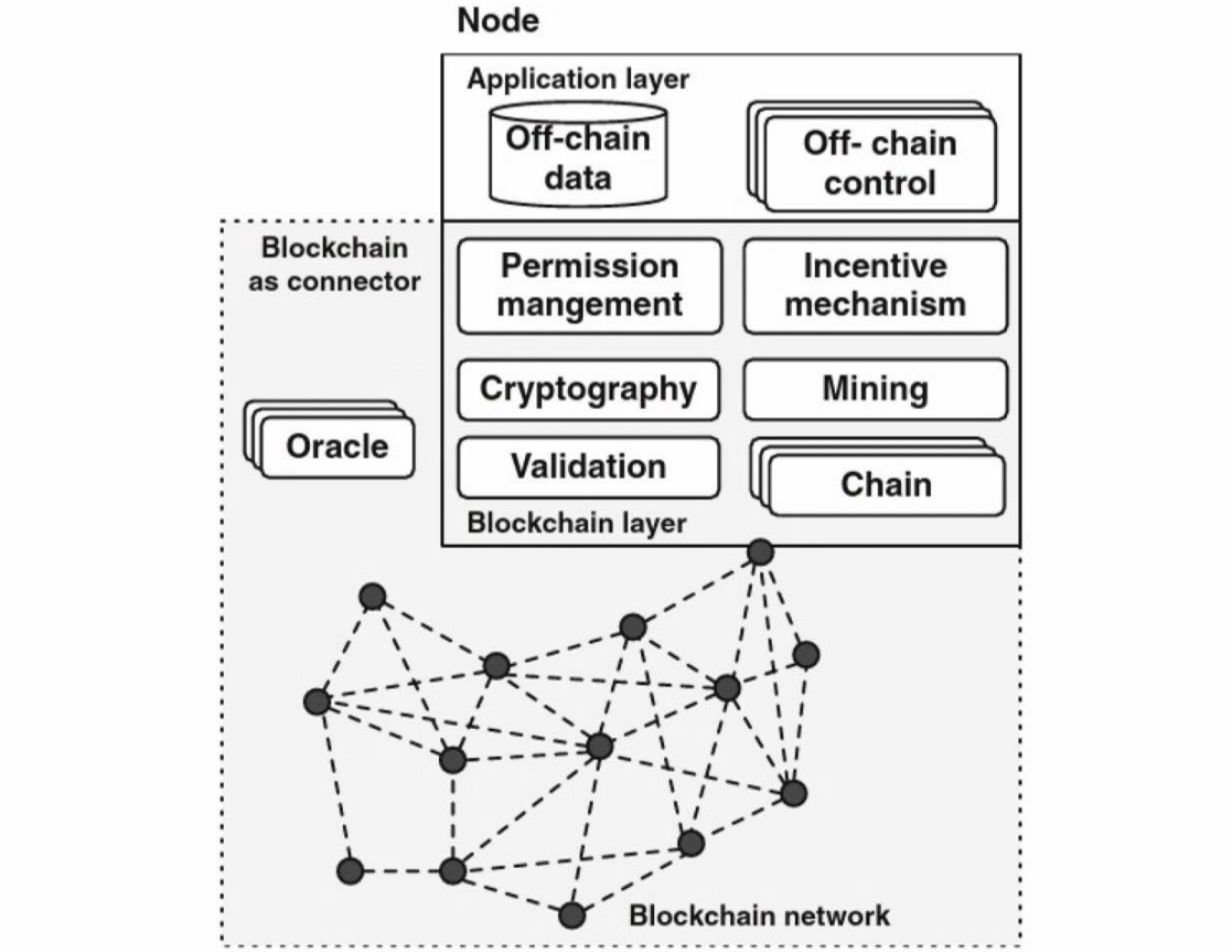
Appendix No. 2 - Overview of the functionality, and the different layers of a blockchain.

Appendix No. 2.1 - Basic Chemical Overview of the Functionality of the Layers of a Blockchain.

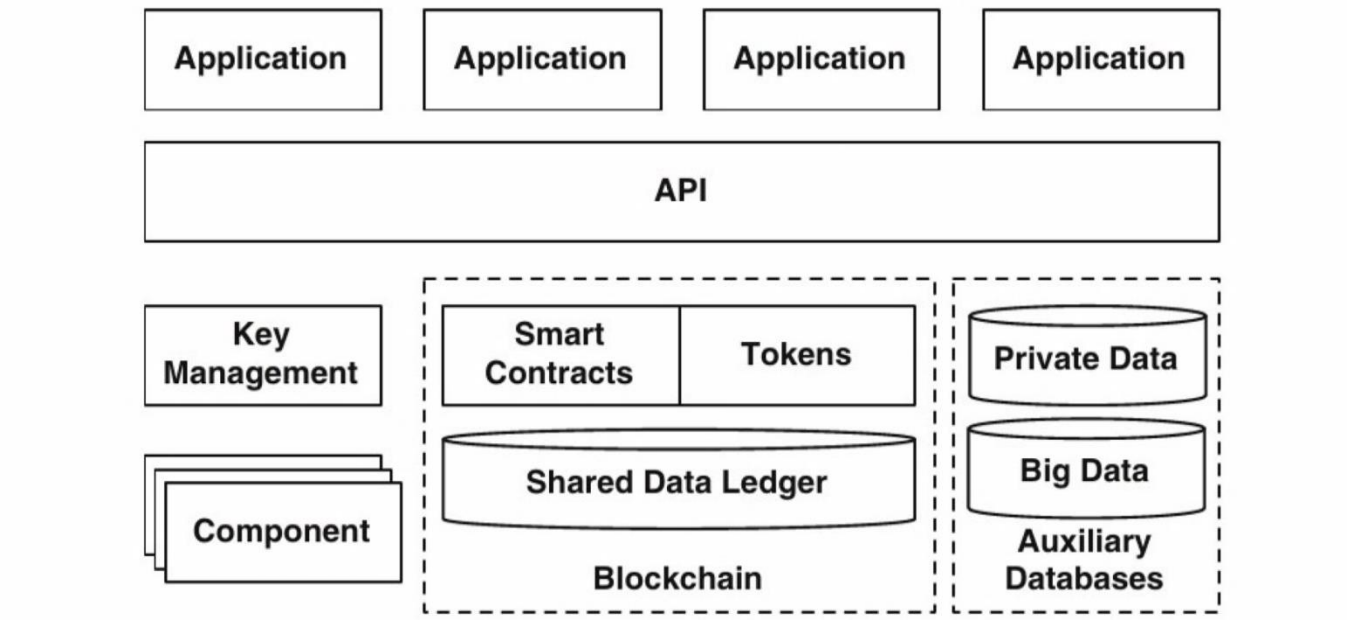


The blockchain first requires a network of nodes (here: blockchain network), which keeps the blockchain decentralized operational. The various layers are then built on top of this network. The whole thing starts with the first layer, which maps the basic functions (here: Chain, Validation, Mining, Cryptography, Incentive mechanism, Permission management). Finally, there is a layer on which certain programs can be executed (here: application layer), oracles can be connected via the API of the blockchain and bridges can be built into the real-physical world.

Source: *Xiwei Xu/ Ingo Weber/ Mark Staples*, Architecture for Blockchain Applications, 1. Auflage 2019 Springer Verlag, Schweiz, P. 14 mwN.

https://doi.org/10.54934/ijlcw.v2i3.xx

Appendix No. 2.2 - Overview of the "Applications" built on top of the Blockchain in the Layer Model.



In the diagram, you can once again see schematically how the blockchain architecture is structured for the integration of third-party applications and for mapping a DAO. The blockchain and the data ledger form the basis on which everything else (e.g., the smart contracts or tokens) is built. An API can then be used to create interfaces in the real physical world (so-called oracles) or to integrate applications and other programs from third parties. In this way, it is also possible to build a communication channel to a wrapper via the API.

Source: This overview builds on an earlier work: Vgl. *Xiwei Xu/ Ingo Weber/ Mark Staples*, Architecture for Blockchain Applications, 1. Auflage 2019 Springer Verlag, Schweiz, P. 84 mwN.

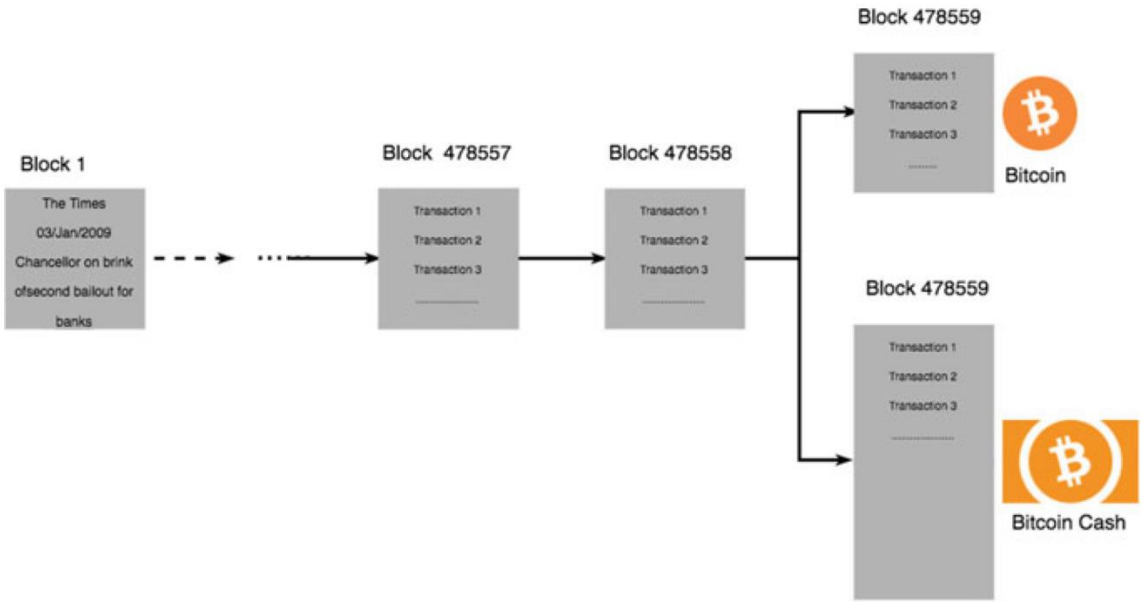
https://doi.org/10.54934/ijlcw.v2i3.xx

Appendix No. 3 – Development of the Aragon initiative to establish DAOs

Through the Aragon DAO Initiative, close to 5,000 DAOs have already been realized using the building block system provided. At the same time, the market capitalization rate is 16.9 billion US dollars.

Source: *Juliette Chevalier*, The Smart Contracts Behind DAOs, Vortrag auf der EthCC [5], vom 19. - 21. Julie 2022, accessible at: https://www.youtube.com/watch?v=ezhY4DDtCoU&t=5s, [Last time retrieved on March 10th, 2023].

Appendix No. 4 - Process of a hard fork using the example of the split of Bitcoin into Bitcoin and Bitcoin Cash



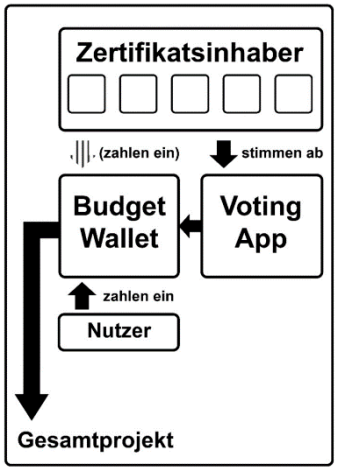
This graphic can be applied to the Ethereum project. It shows how the Bitcoin network split into Bitcoin and Bitcoin Cash in a hard fork on 01 August 2017. The users who carried out the Bitcoin hard fork did so in order to increase the transaction speed of Bitcoin Cash.

Source: Maria Grazia Vigliotti/ Haydn Jones, The Executive Guide to Blockchain – Using *Smart Contracts* and Digital Currencies in your Business, 1. Auflage 2020, Springer Nature Switzerland, P. 59

https://doi.org/10.54934/ijlcw.v2i3.xx

Appendix No. 5 - Functioning of different DAOs according to *Baur*

Appendix No. 5.1 - Functioning of the Management DAO

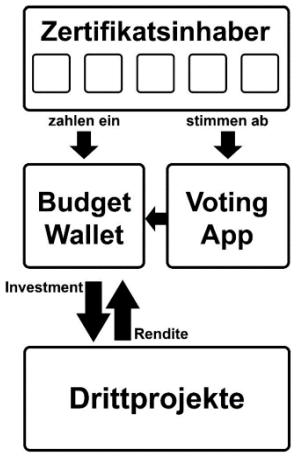


First, interested parties pay money into the DAO's budget wallet. In this way, they become "certificate holders", i.e. governance token holders. Subsequently, the governance token holders can vote on the use of the funds from the Budget Wallet by means of a voting app (which is already a basic element of the DAO). The DAO then organises the disbursement of the funds independently and offers third parties ("users") e.g. services. The "users" then in turn pay money to the DAO's Budget Wallet in order to be able to use certain services.

Source: *Baur*, Die gesellschaftsrechtliche Außenhaftung für die Verbindlichkeiten von Decentralized Autonomous Organizations, P. 57.

https://doi.org/10.54934/ijlcw.v2i3.xx

Appendix No. 5.2 - Functioning of the Investment DAO

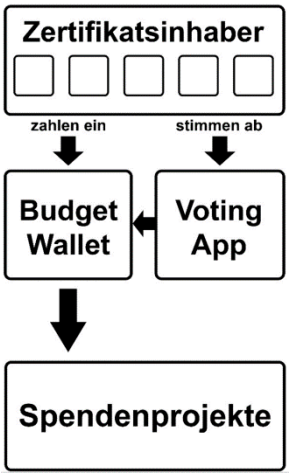


First, interested parties pay money into the DAO's budget wallet. In this way, they become "certificate holders", i.e. governance token holders. Afterwards, the governance token holders can vote on the DAO's investment goal using a voting app (which is already a basic element of the DAO). The DAO then automatically invests the Budget Wallet funds in third-party projects. The third-party projects pay a return to the DAO's Budget Wallet. The governance token holders can then vote whether the third-party funds are retained, reinvested or paid out to the governance token holders.

Source: *Baur*, Die gesellschaftsrechtliche Außenhaftung für die Verbindlichkeiten von Decentralized Autonomous Organizations, P. 60.

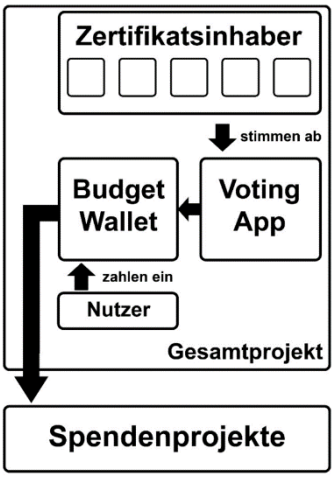
https://doi.org/10.54934/ijlcw.v2i3.xx

Appendix No. 5.3 - Functioning of the Donations DAO



The donation DAO works like the investment DAO (see above), with the only difference that no returns are expected from the donation project and the money only flows in one direction (namely to the donation project).

Source: *Baur*, Die gesellschaftsrechtliche Außenhaftung für die Verbindlichkeiten von Decentralized Autonomous Organizations, P. 63.

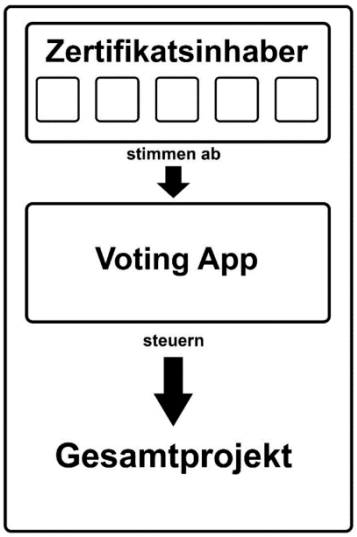


The only exception to this would be a so-called donation-annex DAO, where the DAO offers a service in addition to the funding goal of the donation project and raises money for the donation project through this.

Source: *Baur*, Die gesellschaftsrechtliche Außenhaftung für die Verbindlichkeiten von Decentralized Autonomous Organizations, P. 65.

https://doi.org/10.54934/ijlcw.v2i3.xx

Appendix No. 5.4 - Functioning of the Control DAO



With the governance DAO, the "certificate holders", i.e. governance token holders, can vote directly on the overall project. Such a DAO could be used, for example, to coordinate software processes in the IoT area.

Source: *Baur*, Die gesellschaftsrechtliche Außenhaftung für die Verbindlichkeiten von Decentralized Autonomous Organizations, P. 67.

https://doi.org/10.54934/ijlcw.v2i3.xx

Appendix No. 6 - Procedure for voting by means of governance tokens

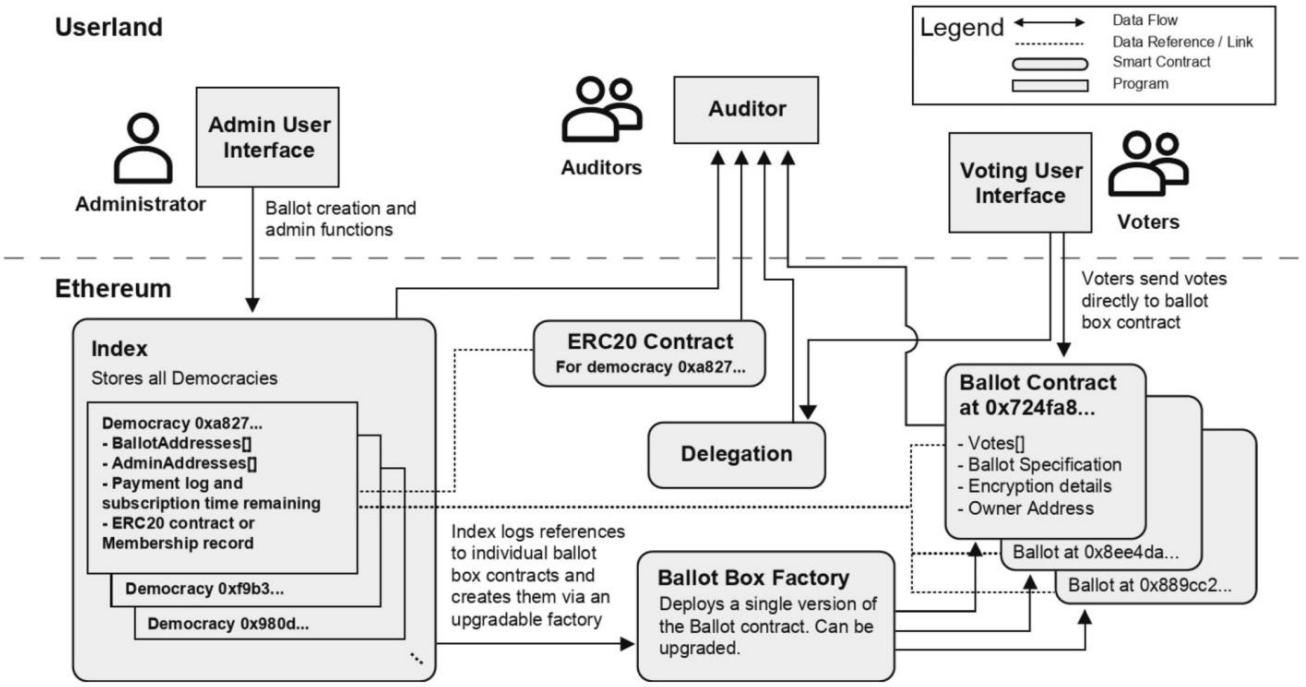


Fig. 13.1 Planned architecture for Tokenvote before development

The graphic shows the voting process with governance tokens. The Ethereum blockchain was taken as the basis here. It should be noted that smart contracts on other blockchain systems are sometimes executed quite differently than on Ethereum. However, since Ethereum currently serves as the benchmark for smart contract operations and most DAOs are currently based on the Ethereum blockchain, this graphic was deliberately chosen for further explanation.

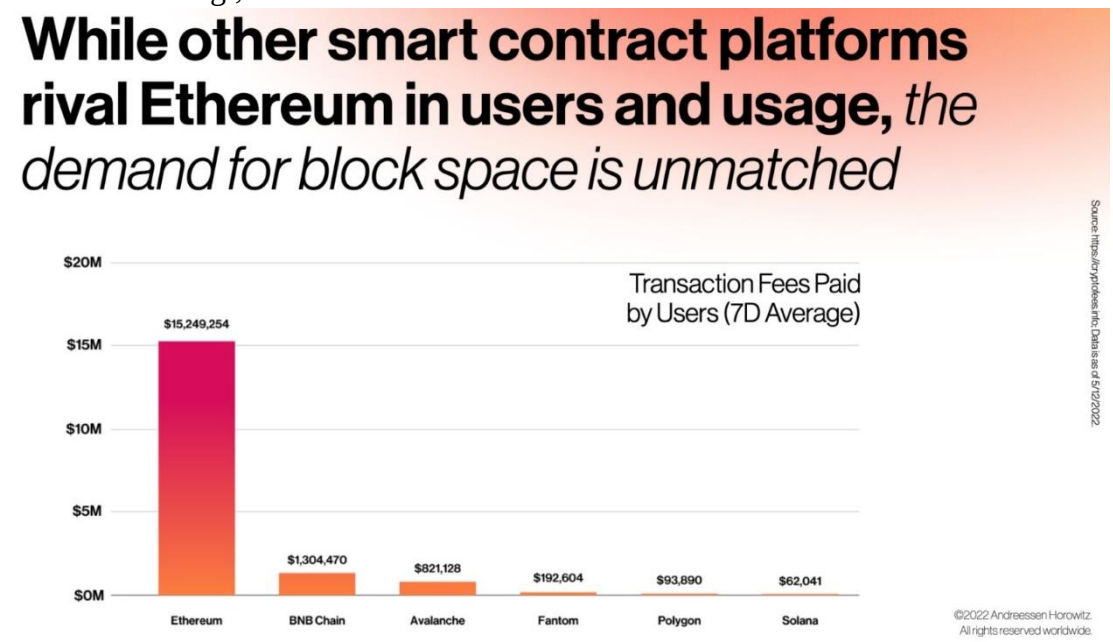
It should also be taken into account that each governance token can have different basic requirements and that the voting processes also vary. In the diagram shown here, however, it becomes clear how the mechanism works in general. For example, certain issues are first made available to the auditors. After they have validated the voting content, the governance token certificate holders can vote on it. No longer visible on the diagram is how a smart contract implements the proposal in the event of a positive vote, which is often done by releasing cryptocurrencies or tokens to one or more wallet addresses.

Source: *Xiwei Xu/ Ingo Weber/ Mark Staples*, Architecture for Blockchain Applications, 1. Auflage 2019 Springer Verlag, Schweiz, P. 263.

https://doi.org/10.54934/ijlcw.v2i3.xx

Appendix No. 7 - Ethereum Smart Contracts

Diese Grafik zeigt, dass



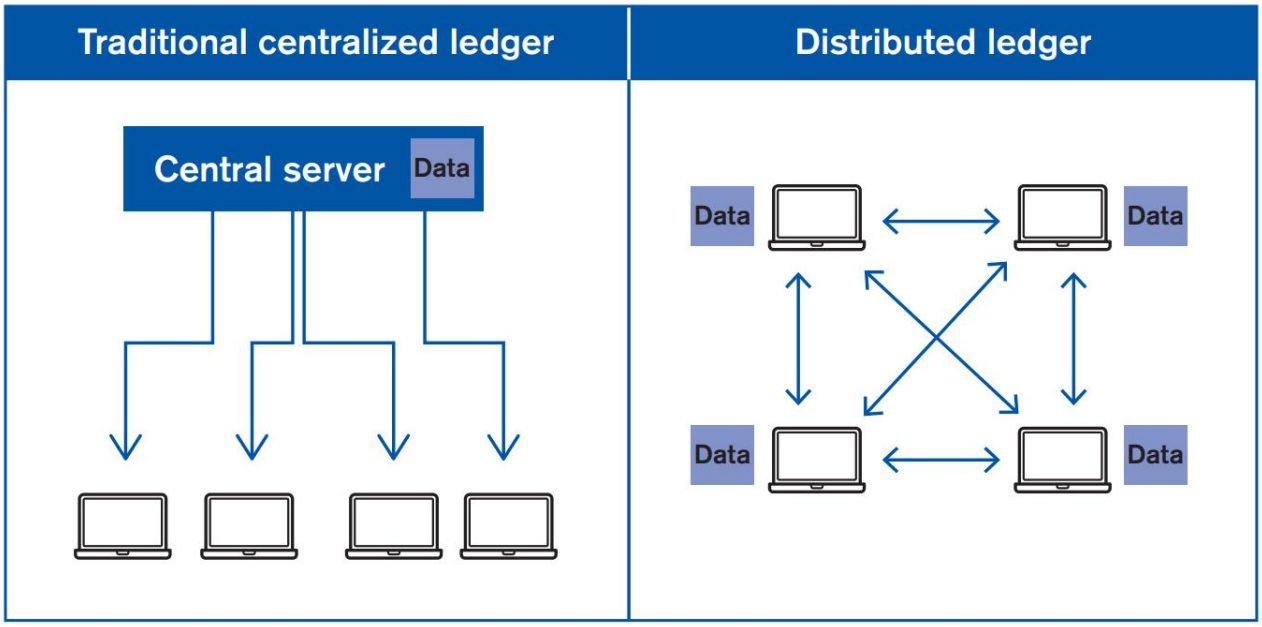
Ethereum in particular continues to dominate the market.

Source: *Andreessen Horowitz*, While other smart contract platforms rival Ethereum in users and usage, the demand for block space is unmatched, vom 12. May 2022, accessible at: Cryptofees.info;dataisasof5/12/2022, [Last time retrieved on March 10th, 2023].

https://doi.org/10.54934/ijlcw.v2i3.xx

Appendix No. 8 - Nodes as the basis of decentralized systems

Appendix No. 8.1 - Centralised system compared to decentralised systems with nodes



The graphic shows the difference between centralised systems (left) and decentralised systems (right).

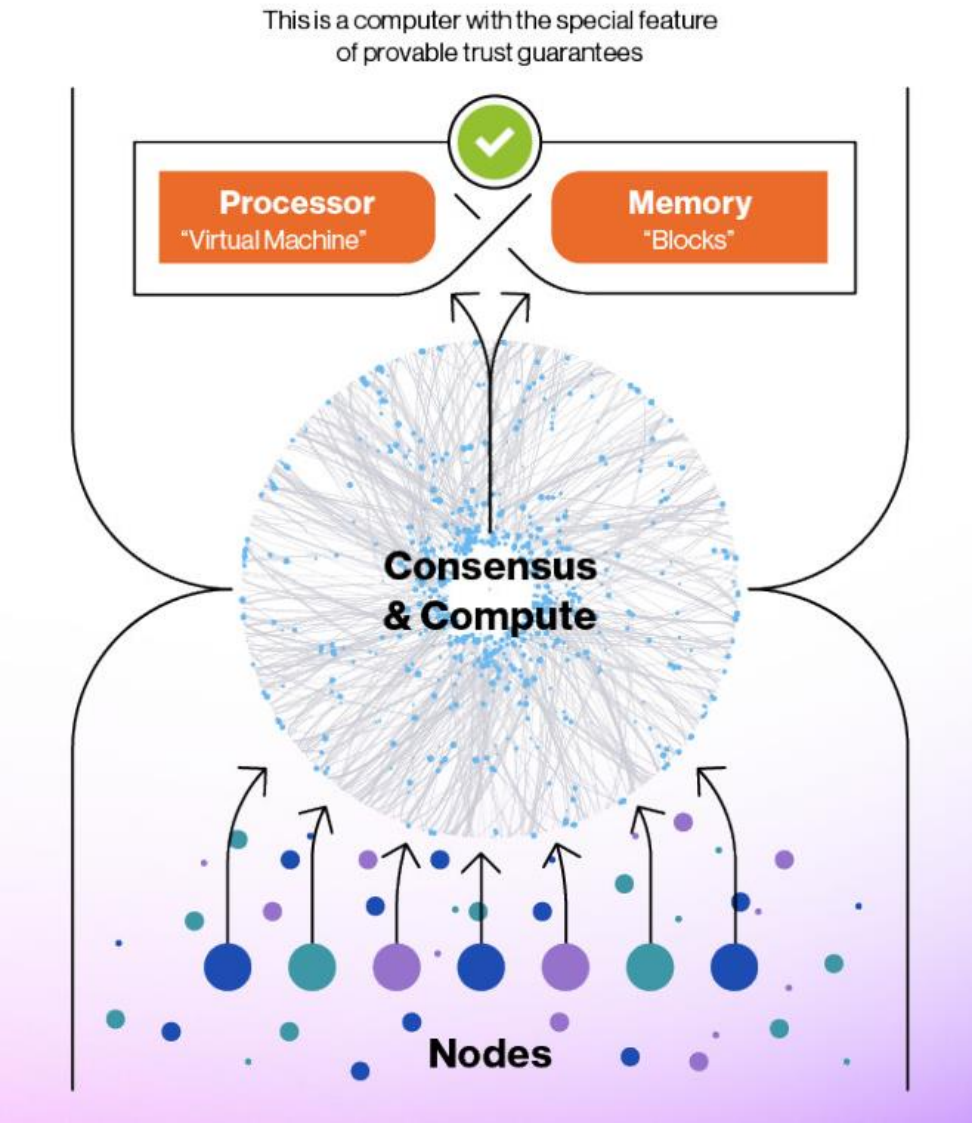
In centralised systems (left), all data is located on a central server. If this server is hacked or damaged, the entire data system is affected. Of course, there are security measures such as server mirroring and backup copies to prevent this.

In the decentralised system (right), all data is on different nodes. Depending on the design, all nodes have all the data or it is split up. In any case, the data is mirrored several times and well protected against loss or hacker attacks.

Source: *Ganne*, World Trade Organization – Can Blockchain revolutionize international trade?, P. 6.

https://doi.org/10.54934/ijlcw.v2i3.xx

Appendix No. 8.2 - Functioning of nodes in connection with a virtual machine via a blockchain

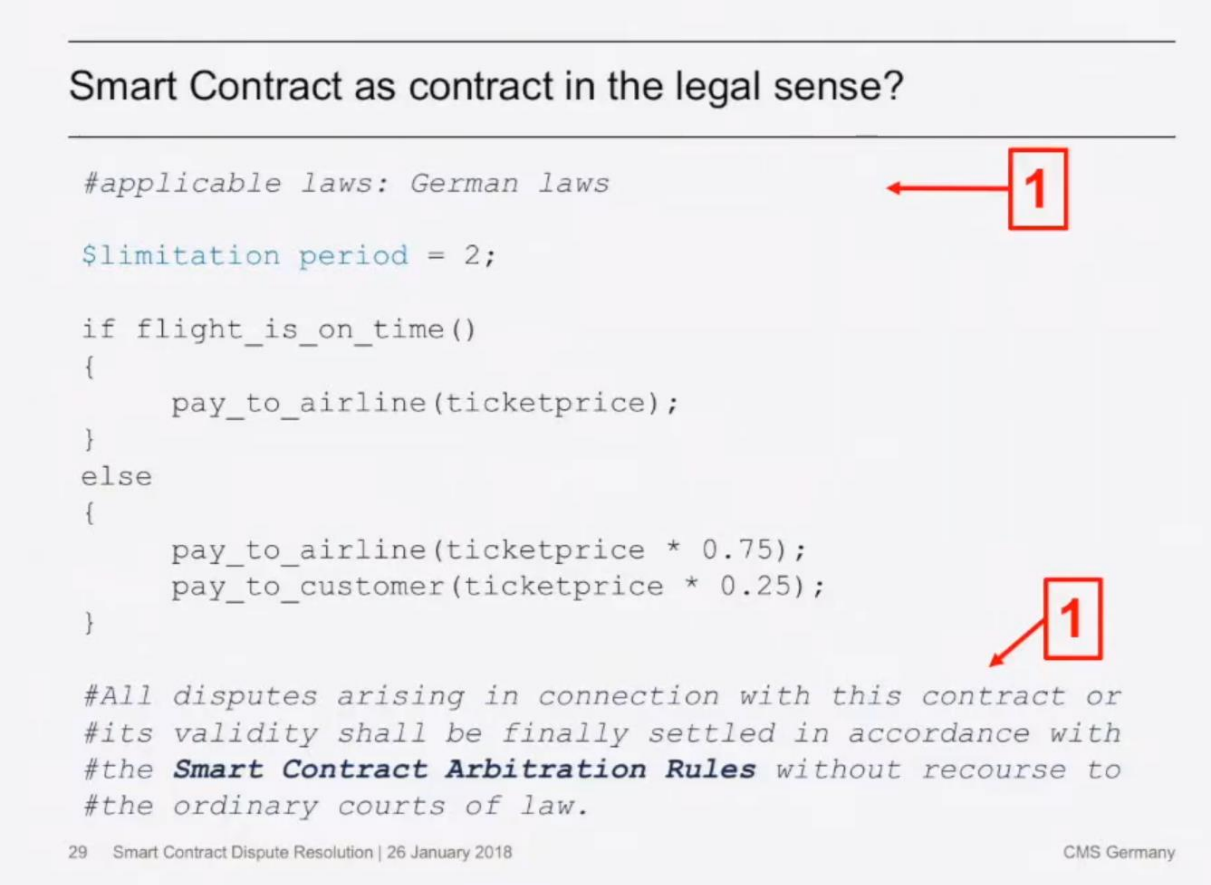


The nodes are physical computers or computing units that are connected to each other and jointly adjust the consensus mechanism. It is obvious to use them later for more intensive computing operations such as AI operations (comparable to the time sharing concept of the 1960s).

Source: *Andreessen Horowitz*, While other smart contract platforms rival Ethereum in users and usage, the demand for block space is unmatched, vom 12. May 2022, accessible at: Cryptofees.info;dataisasof5/12/2022, [Last time retrieved on March 10th, 2023].

https://doi.org/10.54934/ijlcw.v2i3.xx

Appendix No. 9 - Example of a smart contract with a dispute resolution clause in the code

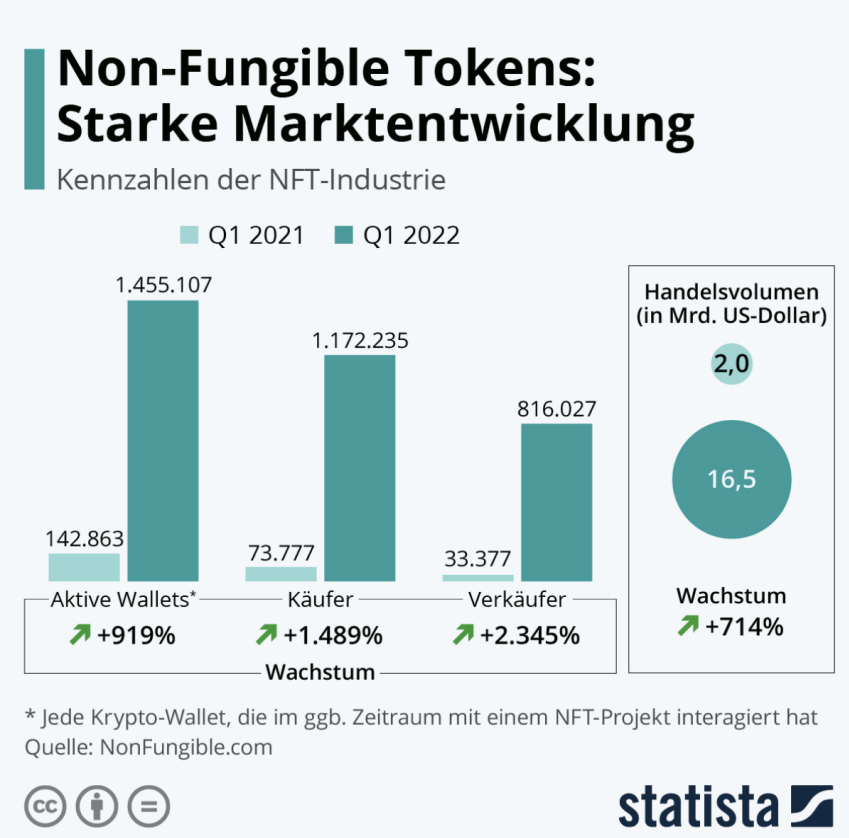


The Smart Contract states that German law is to be applied first and that an arbitration judge is to arbitrate in the event of a dispute.

Source: *Markus Kaulartz (CMS Hasche Sigle)*, on Blockchain Arbitration, Auf der Konferenz "blockchain, law, blockchainlaw?" an der *Humboldt-University* Berlin am 25.02.2018.

https://doi.org/10.54934/ijlcw.v2i3.xx

Appendix No. 10 - Market Development of NFTs



Source: Statista

Appendix No. 11 - ICOs as a financing model

The number of ICOs has grown significantly. Every DAO usually also has an ICO, as the governance tokens are issued in the course of an ICO. This can be used to raise money for the operation of the DAO as well as for the actual operations of the DAO.

The chart shows the capital raised via ICOs and the exponential growth of projects each from 2014 - 2018. What it does not show is the sharp drop in 2018 and the subsequent recovery phase.

Source: Maria Grazia Vigliotti/ Haydn Jones, The Executive Guide to Blockchain – Using *Smart Contracts* and Digital Currencies in your Business, 1. Auflage 2020, Springer Nature Switzerland, P. 20

https://doi.org/10.54934/ijlcw.v2i3.xx

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ABOUT THIS ARTICLE

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