Washington and Lee Law Review

Volume 80 | Issue 3 Article 6

Summer 2023

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Abstract

Tantamount with the increasing application of blockchain technologies around the world, the use of blockchain-based smart contracts has rapidly risen. In a "smart contract," computer protocols automatically facilitate, verify, and enforce arrangements made between parties on a blockchain. Such smart contracts offer a variety of commercial benefits, notably immutability and increased efficiency facilitated by removing the need for a trusted intermediary. However, as discussed in recent legal scholarship, it is difficult for smart contracts to uphold certain fundamental principles of contract law. Translating concepts of individual intention and responsibility into the decentralized space of blockchain is problematic. Aggregating such individual intention into the combined will and intention of the blockchain entity is at best challenging, and at worst unfeasible. Further, while traditional contracts accommodate change and allow for the amendment of terms in response to evolving circumstances, blockchain smart contracts do not. As the difficulties of blockchain smart contracts become apparent, attention is turning to hybrid smart contracts.

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"Hybrid" smart contracts are commonly described in legal discourse as arrangements that consist of both a traditional contract (natural language) and a blockchain-based smart contract (formal computer code) component. In comparison, computer science scholarship provides a more complex and nuanced articulation, framing hybrid smart contracts as arrangements that combine code running inside the blockchain (on-chain) with data and computations from outside the blockchain (off-chain). The link between these on-chain and off-chain operations is created through a decentralized oracle network. Such hybrid contracts maintain the immutability of blockchain, and the trustless contracting this facilitates, with the flexibility that comes from connecting to real-world, real-time data sources.

In such a context, the objective of this Essay is to examine the nature and operation of hybrid smart contracts, integrating both legal and computer science discourse, and to critically analyze whether such arrangements have the potential to mitigate some of the legal challenges that have been identified with respect to fully on-chain smart contracts.

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INTRODUCTION

As blockchain technologies are increasingly deployed around the world, reliance on blockchain-based smart contracts has correspondingly risen.[1] A "smart contract" consists of computer protocols that automatically facilitate, verify, and enforce agreements made between parties on a blockchain, based on a set of predetermined factors.[2] Agreements are embedded in software code and automatically executed on the blockchain, giving rise to the autonomous and self-executing characteristics of smart contracts.[3] The commercial benefits of smart contracts have been well-documented.[4] Smart contracts can help the traditionally ponderous and slow machinery of contract law keep pace with the far more rapid transactions enabled by contemporary technologies.[5] Removing the need for protracted negotiations between individuals, as well as

1. *See* SHUBHANI AGGARWAL ET AL., ADVANCES IN COMPUTERS: THE BLOCKCHAIN TECHNOLOGY FOR SECURE AND SMART APPLICATIONS ACROSS INDUSTRY VERTICALS 5 (Ali Hurson eds., 1st ed. 2021) ("Governments and corporates all over [the] world are slowly and steadily realizing the value in blockchain, which is a new kid on the block."). "Blockchain" is one type of distributed ledger technology (DLT) where transactions are recorded using immutable cryptographic signatures. *See What is Blockchain Technology?*, INT'L BUS. MACHS., https://perma.cc/62MS-JQV4. It refers to a distributed database that maintains a ledger of records, termed "blocks," which are linked using cryptography. *Id.* If a particular user on a blockchain desires to perform a transaction, the request is recorded on the ledger in a node and a copy is then made available to all the users on that chain. *Id.* If the users verify the transaction in the node and reach a consensus, the transaction is authenticated. *Id.*

2. Shuai Wang et al., *Blockchain-Enabled Smart Contracts: Architecture, Applications, and Future Trends,* 49 IEEE TRANSACTIONS ON SYS., MAN & CYBERNETICS: SYS. 2266, 2266 (2019).

3. *Id.*

4. *See* Somboun Tern, *Survey of Smart Contract Technology and Application Based on Blockchain*, 11 OPEN J. APPLIED SCIS. 1135, 1135 (2021) ("[Contract technology] . . . is widely used in digital payment, financial asset disposal, multi-signature contracts, cloud computing, Internet of Things, sharing economy and other fields."); Marco Iansiti & Karim R. Lakhani, *The Truth About Blockchain*, HARV. BUS. REV., Jan.–Feb. 2017, at 7.

5. *See infra* Part III.

removing the need for trusted intermediaries, increases efficiency and facilitates the rapid formation of large-scale, multi-party, multi-sector, multi-jurisdiction contracts.[6] The automation of performance and enforcement advances efficiency and reduces cost. However, as the operation of blockchain-based smart contracts comes under greater legal scrutiny, concerns are emerging about the extent to which they can uphold established principles of contract law.[7] A contract is in essence an agreement between identified individuals, reflective of their unique will, wishes and intentions.[8] Translating this concept of individual intention and responsibility into the decentralized space of blockchain is problematic.[9] Aggregating such individual intentions into a combined will and intention is also challenging.[10] Further, while contractual principles allow for negotiation and amendment of terms in response to evolving circumstances, blockchain smart contracts do not support such commercial agility.[11] The contractual doctrine of frustration

6. *See* Primavera De Filippi et al., *Block Chain as a Confidence Machine: The Problem of Trust & Challenges of Governance*, TECH. SOC'Y, 2020, at 1 ("Blockchain technology . . . has emerged as a potential solution to the erosion of trust in traditional institutions and online intermediaries more generally, as it allegedly eliminates the need for trust between parties.").

7. *See* Joshua Fairfield & Niloufer Selvadurai, *Governing the Interface Between Natural and Formal Language in Smart Contracts*, 27 UCLA J.L. & TECH. 79, 111–17 (2022) (discussing the issues that arise when applying current contract law to smart contracts); Alexander Savelyev, *Contract Law 2.0: 'Smart' Contracts as the Beginning of the End of Classic Contract Law*, 26 INFO. & COMMC'NS TECH. L. 116, 128–33 (2017) (listing the issues and challenges of "[s]mart contracts in the context of the present contract law").

8. *See generally* Guido Governatori et al., *On Legal Contracts, Imperative and Declarative Smart Contracts, and Blockchain Systems*, 26 ARTIFICIAL INTEL. & L. 377 (2018).

9. *See* Gabriel Olivier Benjamin Jaccard, *Smart Contracts and the Role of Law*, JUSLETTER IT, Nov. 2017, at 8 (Switz.) ("[A] computer code won't take into account the possible nullity of a legal contract unless taught to. Instead, its system is based on its own norms and will execute the agreement according to its given design only.").

10. *See* Stuart D. Levi et al., *An Introduction to Smart Contracts and Their Potential and Inherent Limitations*, HARV. L. SCH. F. ON CORP. GOVERNANCE, (May 26, 2018), https://perma.cc/6V46-4DFH ("The objectivity and automation required of smart contracts can run contrary to how . . . parties actually negotiate agreements.").

11. *See id.* ("[Parties] may determine that if an unanticipated event actually occurs, they will figure out a resolution at that time. . . . This approach to contracting is rendered more difficult with smart contracts where

enables obligations to be revised in light of external circumstances outside the control of parties.[12] In marked contrast, the immutability of blockchain platforms hinders such nuanced response to circumstances.[13] Finally, it remains unclear whether and to what extent blockchain-based smart contracts can be enforced in courts and arbitration centers around the world.[14]

So, how can we harness the commercial potential of blockchain-based smart contracts while also upholding established principles of contract law which protect human agency and wider societal interests? One option is to use hybrid smart contracts. However, the notion of hybrid smart contracts in legal and technical discourse displays some interesting variances. Legal discourse typically defines a hybrid smart contract as one in which some legal obligations are expressed in natural language and others are expressed in the formal code of a computer program.[15] In comparison, technical discourse focuses on the capacity of hybrid smart contracts to combine code running inside the blockchain (on-chain) with data and computations from outside the blockchain (off-chain).[16] A decentralized oracle network creates links between these on-chain and off-chain operations.[17] Such hybrid contracts maintain the immutability of blockchain, and the trustless contracting this facilitates, with the flexibility that comes from

computer code demands an exactitude not found in the negotiation of text-based contracts.").

12. *See* RESTATEMENT (SECOND) OF CONTRACTS § 265 (AM. L. INST. 1981).

13. *See supra* note 11 and accompanying text.

14. *See* Jaccard, *supra* note 9, at 22.

15. *See* LAW COMMISSION, SMART LEGAL CONTRACTS, ADVICE TO GOVERNMENT, 2021, HL 401, at vi (UK), https://perma.cc/J9WU-3VPA (PDF) (defining on-chain and off-chain).

16. *See* LORENZ BREIDENBACH ET AL., CHAINLINK 2.0: NEXT STEPS IN THE EVOLUTION OF DECENTRALIZED ORACLE NETWORKS 2 (2021) (describing hybrid smart contracts as "[o]ffering a powerful, general framework for augmenting existing smart contract capabilities by securely composing on-chain and off-chain computing resources").

17. *See id.* at 6–7 ("[DONs] goal is to enable secure and flexible hybrid smart contracts, which combine on-chain and off-chain computation with connection to external resources.").

connecting to real-world, real-time data sources.[18] It is suggested that in order to mitigate the legal problems associated with fully on-chain smart contracts through the use of hybrid smart contracts, it is necessary to bring together these legal and technical understandings.[19] These understandings are not inconsistent. Rather they differ in their focus and the varying degrees of attention paid to contractual principles and logistics of operation.

In such a context, the objective of the present paper is to provide a preliminary exploration of the benefits of hybrid smart contracts, integrating legal and technical discourse, and consider whether such arrangements have the potential to mitigate some of the legal challenges that have been identified with fully on-chain smart contracts. There has been a sophisticated discourse on the capacity of code to operate as law,[20] and conversely, the ability of law to operate through code.[21] This scholarship has been extended through a

18. *See id.*

19. *See* Joshua Gacutan & Niloufer Selvadurai, *The Relevance of Internet Architecture to Law: The Liability of Internet Service Providers for Harmful User-Generated Content*, 3 AUSTL. NAT'L U. J.L. & TECH. 55, 72–73 (2022) ("An understanding of Internet structure is . . . critical . . . because, as discussed, each layer of the Internet's architecture has very different economic and technological attributes.").

20. *See* LAWRENCE LESSIG, CODE AND OTHER LAWS OF CYBERSPACE 6 (1999) ("[T]he argument of this book is that the invisible hand of cyberspace is building an architecture . . . that perfects control—an architecture that makes possible highly efficient regulation."); Lawrence Lessig, *Code Is Law: On Liberty in Cyberspace*, HARV. MAG., Jan. 1, 2000, https://perma.cc/3YB9-Q9VT. For differing perspectives see Jan Oster, *Code is Code and Law is Law—The Law of Digitalization and the Digitalization of Law*, 29 INT'L J.L. & INFO. TECH. 101, 101 (2021) (arguing for a "sharp analytical distinction between the realms of technology and of law"); Tim Wu, *When Code Isn't Law*, 89 VA. L. REV. 679, 682 (2003) (discussing the "interesting and complicated effects" that using code to "minimize the burden of laws" has on the legal and political system).

21. *See* Primavera De Filippi & Samer Hassan, *Blockchain Technology as a Regulatory Technology: From Code is Law to Law is Code*, FIRST MONDAY (Dec. 5, 2016), https://perma.cc/2NFF-LMEP (discussing "a new approach to regulation, the code-ification of law, which entails an increasing reliance on code not only to enforce legal rules, but also to draft and elaborate these rules"); PRIMAVERA DE FILIPPI & AARON WRIGHT, BLOCKCHAIN AND THE LAW: THE RULE OF CODE 6 (2018) (explaining that "blockchain-based networks run the risk of creating discrete risks that could destabilize central banking, financial markets, and the administration of commercial agreements"); Wessel Reijers et al., *Now the Code Runs Itself: On-Chain and Off-Chain Governance*

comparison of the on-chain versus off-chain arrangements, and it has been suggested that the former displays striking similarities to Kelsen's notion of a positivist legal order.[22] Hybrid smart contracts, with their combination of on-chain and off-chain elements, present an additional dimension for consideration.[23] Can law and code work together, not merely at a theoretical level but at a pragmatic logistical level, to advance contractual efficacy? This Essay seeks to provide an initial analysis of whether and to what extent hybrid smart contracts can harness the socio-economic benefits of smart contracts while also upholding fundamental principles of contract law.

I. THE NATURE AND OPERATION OF SMART CONTRACTS

A. *Phases of Creation*

It is useful to begin by considering the various phases of creation of a smart contract.[24] This will form a useful foundation for the subsequent analysis of the operation of hybrid smart contracts. In the blockchain structure of smart contracts, each of the blocks contain hash values of the present and previous blocks, as well as a timestamp.[25] The creation of blockchain smart contracts can be delineated into three distinct phases.[26] The initial phase consists of multiple users participating in the development of the contractual terms by using their respective private keys.[27] This agreement is then programmed into code.[28] Once all the participants sign off using their private keys, the

of Blockchain Technologies, TOPOI: INT'L REV. PHIL., Dec. 17, 2018, at 1, 8 ("The legal discourse on the state of exception focuses on the conflict between the integrity of the legal order and the effectiveness of a government in a state of emergency.").

22. *See* Reijers et al., *supra* note 21, at 1.

23. *See* Governatori et al., *supra* note 8, at 399–402 (comparing imperative and declarative smart contracts).

24. *See* Wang et al., *supra* note 2, at 2268 (using Ethereum and Hyperledger Fabric as examples to introduce the operational mechanisms of smart contracts).

25. *See* Somboun, *supra* note 4, at 1140.

26. *Id.* at 1138.

27. *Id.* at 1139.

28. *Id.*

contract is transmitted into the blockchain network.[29] Phase two involves the transmission of the contract into each node in the blockchain network through a peer-to-peer platform ("P2P").[30] The verification node stores and packages the contract.[31] When consensus is reached, the contract is verified and written into the blockchain.[32]

B. *Means of Verification*

The primary means of verification is by ensuring that the private key signature of the various participants matches the account.[33] During phase three, the smart contract will execute the contract when the predetermined trigger conditions have been satisfied.[34] The automation will continue until the contract has been fully executed.[35] It is relevant to note that while a smart contract is created and executed on the graphical interface, the principles of deployment will differ depending on the platform used. Common platforms include Ethereum, Hyperledger Fabric, and EOSIO.[36]

C. *Immutability*

When formed, smart contracts are immutable as the program code is recorded on a blockchain. Further, such contracts are decentralized as the execution of the contract is

29. *Id.*

30. *Id.*

31. *Id.*

32. *Id.* at 1140.

33. *See id.* ("The validity of the verified contract will be successfully executed after consensus.").

34. *See id.* ("The state machine and trigger condition of each contract will push the contract that meets the trigger condition to the queue to be verified.").

35. *Id.*

36. A comparative analysis of blockchain platforms is outside the scope of this paper. For such an analysis, see Xiaoqi Li et al., *A Survey on the Security of Blockchain Systems*, 107 FUTURE GENERATION COMPUT. SYS. 841, 844–50 (2020); Daniel Macrinici et al., *Smart Contract Applications within Blockchain Technology: A Systematic Mapping Study*, 35 TELEMATICS & INFORMATICS 2337, 2338, 2347–52 (2018); Qi-Feng Shao et al., *Survey of Enterprise Blockchains*, 30 J. SOFTWARE 2571 (2019); Yun Gao & Han Yan, *Middleware Design in Hyperledger Fabric Blockchain Software Architecture*, 48 COMPUT. & DIGIT. ENG'G 2195 (2020).

through trustless anonymous individual nodes on the blockchain, with contractual actions, such as transfer of digital assets, triggered when predetermined conditions occur.[37]

II. LEGAL AND TECHNICAL ARTICULATIONS OF HYBRID SMART CONTRACTS

A. *The Legal Discourse*

As intimated, legal and technical scholarship diverge in the way that they describe smart contracts. The law commonly classifies smart contracts into three forms.[38] At one end of the smart contract spectrum are contracts that are primarily expressed in natural language but have automated performance of minor terms, such as mode of delivery.[39] In such an arrangement, the code of the computer program falls outside the legally binding contractual arrangement.[40] The code is merely a technological tool utilized by one or both parties to execute the obligations that are articulated by the natural language contract.[41] At the opposite end of the spectrum are contracts which are wholly articulated in code.[42] These arrangements are the most difficult to reconcile with traditional contractual law principles. As such arrangements do not have an accompanying natural language contract, it can be difficult to discern the intention of the parties and determine when the elements of

37. *See* Josh Stark, *Making Sense of Blockchain Smart Contracts*, COINDESK (June 4, 2016, 1:39 PM), https://perma.cc/8WBL-SNAP ("These transactions still require a minimum level of trust to be commercially viable, but are ill-suited for legal contracts, which are comparatively expensive and require the involvement of legal persons like a corporation or human.").

38. *See* LAW COMMISSION, *supra* note 15, at vii ("There are essentially three forms a smart legal contract can take, depending on the role played by the code. These are: natural language contract with automated performance; hybrid contract; or solely code contract."); *see also* Max Raskin, *The Law and Legality of Smart Contracts*, 1 GEO. L. TECH. REV. 305, 310 (2017) (providing an analysis of the spectrum of "strong" and "weak" smart contracts).

39. LAW COMMISSION, *supra* note 15, at 1.

40. *See id.* at 22 ("This type of smart legal contract can also be referred to as an 'external' contract, as the code falls outside the scope of the parties' legally binding agreement.").

41. *See id*.

42. *Id.* at 1.

offer and acceptance have been satisfied.[43] Even if formation can be established, it is also difficult to determine which terms have been incorporated into a contract.[44] If the terms can be established, interpretation of such terms is also fraught, as what is being interpreted is not natural language but the algorithmic expression of contractual rights and liabilities.[45]

Somewhere in the middle of this spectrum are hybrid contracts. These are contracts that have some rights and liabilities written in natural language and others written in the code of a computer program.[46] It is relevant to note that even within such hybrid contracts, the degree of automation differs.[47] On one side of the contractual spectrum reside hybrid contracts that are principally articulated in code, with a few terms articulated in natural language.[48] The terms articulated in natural language are commonly overarching terms, such as those relating to choice of jurisdiction or governing law.[49] Contractual negotiations may be carried out in natural language, and the contractual terms articulated in natural language, with contractual performance undertaken by code.[50] Another form of hybrid smart contracts involves repeating all the terms in both the natural and code components.[51] This could be done by articulating the terms in the contract and also

43. *See id.* at 56 ("A more novel situation may arise where the parties enter into an agreement on a DLT system, or smart contract platform, without any natural language documents or communications passing between them.").

44. *See id.* at 77.

45. *Id.* at 78.

46. *See id.* at 28.

47. *See id.* at 27 ("Consultees said that the nature and degree of the interaction between natural language and code in a hybrid smart legal contract varies depending on (amongst others) the intention and sophistication of the parties, and the smart contract platform.").

48. *See id.* at 22.

49. *Id.*

50. *See id.* ("At one end of the spectrum, the terms of a hybrid contract could be primarily written in code with a few natural language terms setting out, for example, the governing law and jurisdiction.").

51. *See id.* at 22–23 ("[T]he same contractual term(s) can be written in both natural language and in code. The natural language terms can be incorporated in an accompanying natural language agreement, or in natural language comments included in the code.").

repeating them as comments to the code in the computer system.[52]

B. *Technical Framings*

In contrast to the legal framings discussed above, computer science articulations of hybrid smart contracts understandably focus on the logistics of operation. Hybrid smart contracts are framed as arrangements that combine code running inside the blockchain (on-chain) with data and computations from outside the blockchain (off-chain).[53] The link between these on-chain and off-chain operations is created through a DON.[54] This hybrid system enables the on-chain code to be automatically augmented to address new scenarios in real-time.[55] The on-chain element, the blockchain, operates to maintain the ledger and provide authoritative custody of the assets of users and interact with relevant private keys.[56] The on-chain blockchain also operates to execute final settlement by processing irreversible transactions and transferring value between parties.[57] In contrast, the off-chain element, the DON, can interact with external data sources, fetching, validating, securing and delivering real-time data.[58]

Ultimately, these differences in description and emphasis between legal and technical discourse are more logistical than substantive. Still, they are useful to note as we progress towards

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52. *Id.* at 23.

53. *See supra* note 16 and accompanying text.

54. *See* BREIDENBACH ET AL., *supra* note 16, at 10 ("A hybrid smart contract consists of . . . . on-chain component . . . . and an off-chain component. The DON serves as a bridge between the two components as well as connecting the hybrid contract with off-chain resources such as web services, other blockchains, decentralized storage, etc.").

55. *See id.* at 19 ("A DON is designed primarily to augment the capabilities of a smart contract on a main chain with oracle reports and other services, but it can provide those same supporting services to other non-blockchain systems, and thus need not be associated with a particular main chain.").

56. *See id.* at 20 (defining a ledger as data that "once added, cannot be removed or modified").

57. *Id.*

58. *Id.*

considering whether and to what extent hybrid smart contracts can mitigate the legal challenges of using smart contracts.

III. THE CAPACITY OF HYBRID SMART CONTRACTS TO MITIGATE LEGAL CONCERNS ASSOCIATED WITH SMART CONTRACTS

A. *Formation—Greater Certainty*

Hybrid smart contracts can help support greater certainty in establishing that a contract has been validly formed. A foundational principle of contract law is that in order for a contract to be valid it must demonstrate a common intention by parties to enter legal relations.[59] Dissenting in *Rose & Frank Co v. JR Crompton & Bros Ltd.*,[60] Lord Justice Atkin L.J. noted that this common intention must be objectively determined and "communicated expressly or impliedly."[61] *Edington v. Board of Trustees of the State Public Sector Superannuation Scheme*[62] further held that intention can be discerned from conduct—even solely from conduct.[63] In *Western Export Services Inc v. Jireh International Pty Limited*,[64] Justice Hammerschlag noted that "[i]n ascertaining the intention of the parties . . . regard can be had to the commercial circumstances in which the parties exchanged their communications."[65] In *Banque Brussels Lambert SA v. Australian National Industries Ltd*,[66] the court further held that such a principle is necessary to recognize the "business reality" of parties' agreements,[67] with Chief Justice Rogers noting, "The whole thrust of the law today is to attempt to give proper effect to commercial transactions."[68]

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59. *See* Governatori et al., *supra* note 8, at 382.

60. [1923] 2 K.B. 261 (Eng.).

61. *Id.* at 293.

62. [2016] QCA 247.

63. *See id.* at [80] ("Whether there is such an intention in particular circumstances is to be determined objectively from the outward manifestations of the parties' intentions." (internal quotation omitted)).

64. [2010] NSWSC 622.

65. *Id.* at [197].

66. (1989) 21 NSWLR 502.

67. *Id.*

68. *Id.* at 523.

Based on these contractual principles, participating on a commercial blockchain arguably demonstrates an intention to enter legal relations with respect to the transactions carried out on that blockchain.[69] It can be further argued that agreeing to transact on the blockchain platform satisfies the elements of offer and acceptance in relation to the transactions carried out on the platform.[70] However, as has been noted in the legal scholarship, there remains the problem of transitioning such an aggregated will to all individuals in the blockchain.[71] Adopting the legal definition of smart contacts, a code-based contract accompanied by a natural language contract can enable substantive legal rights and liabilities to be articulated in the latter, with the coded component essentially functioning as a mode of operation clause.[72] Such an arrangement can help mitigate some of the uncertainties relating to smart contract formation.

B. *Interpretation—Greater Clarity*

Hybrid smart contracts can also support greater clarity in interpreting contract terms. Legal scholarship has examined the difficulty of identifying, and then interpreting, the terms of an agreement where the contractual terms were generated through

69. *See* Morgan N. Temte, *Blockchain Challenges Traditional Contract Law: Just How Smart Are Smart Contracts*, 19 WYO. L. REV. 87, 104 (2019) ("Through this lens, a smart contract fulfills the offer requirement through a posting on the blockchain ledger which occurs in an effort to elicit acceptance. Acceptance and consideration are both confirmed through the act of performance of the self-executing smart contract.").

70. *See* John Salmon & Gordon Myers, *Blockchain and Associated Legal Issues for Emerging Markets*, 63 INT'L FIN. CORP.: THOUGHT LEADERSHIP 5 (2019), https://perma.cc/WFY6-45XX (PDF) ("Contract law will likely apply to the underlying transactions between the parties using smart contracts, assuming that the arrangement between the participants otherwise fulfils [sic] the requirements for contract formation.").

71. *See* Fairfield & Selvadurai, *supra* note 7, at 86 (illustrating the discrepancies between individuals who contract for the same product through a website versus directly from a smart contract, and exploitation of human to computer contracting).

72. *See* Megan Ma, *Writing in Sign: Code as the Next Contract Language*, MIT COMPUTATIONAL L. REP., Aug. 14, 2020, at 2, 5–20, https://perma.cc/4JGL-WGST (PDF) (discussing how various coding programs translate into natural language clauses).

interaction on a distributed ledger.[73] A central problem to be addressed is the gap that sometimes arises between what the code was intended to say and what it actually does when it is executed. This can be described as a "gap between intended meaning and unintended effect." Applying the legal definition of hybrid smart contacts, the blockchain contract can potentially be connected to natural language aids to interpret coded terms.[74] As it is part of the one contract, it can be used to interpret the scope and operation of the on-chain code.[75] Applying computer science formulations of hybrid smart contracts, off-chain data can aid the interpretation of the on-chain terms.[76] In contrast to traditional smart contracts, hybrid smart contracts are formed and executed by two distinct decentralized networks, a blockchain network and also a DON.[77] While smart contracts also utilize the oracle gateway to connect to data sources, leveraging off-chain computations which are not accessible on the blockchain, a hybrid smart contract additionally utilizes DON to create contracts using off-chain data.[78] This unique structure of hybrid smart contracts can, hence, potentially advance legal certainty by connecting the contract to off-blockchain data. This would aid such legal matters as

73. *See* Temte, *supra* note 69, at 98–99 ("[T]he decentralized nature of [smart contract's] transactional ledger is a strong advantage of blockchain. But this decentralization also has drawbacks—the largest being the lack of opportunity for parties to modify once the smart contract executes."); Maren Woebbeking, *The Impact of Smart Contracts on Traditional Concepts of Contract Law*, 10 JIPITEC 106, 111 (2019), https://perma.cc/6Q5K-5QMX ("Particularly precarious, however, remains the interaction between the interpretation of the smart contract code and a respective underlying written contract . . . . [I]t will be crucial that the parties stipulate explicitly to what extent the smart contract code should serve for interpretation.").

74. *See* Woebbeking, *supra* note 73, at 110 ("[I]f there is a need to use ambiguous clauses in a smart contract, it is likely that interpretational difficulties will be resolved by assigning them to a human-based oracle.").

75. *See* LAW COMMISSION, *supra* note 15, at 88 ("Natural language can be used in various ways to aid the court in understanding and interpreting the coded terms of a smart legal contract.").

76. *See Hybrid Smart Contracts*, CHAINLINK, https://perma.cc/85XU-ALMX (last updated May 24, 2023) ("DONs can be used to bridge various types of external data to and from blockchains, enabling hybrid smart contracts to be written around those specific pieces of data.").

77. BREIDENBACH ET AL., *supra* note 16, at 9.

78. *See id.* at 6.

determining which terms have been properly incorporated into the contract and interpreting those incorporated terms.

C. *Performance – Greater Flexibility*

Arguably, the greatest potential benefit of hybrid smart contracts relates to contractual performance. Hybrid smart contracts have the potential to address one of the greatest problems of traditional smart contracts, inflexibility, while also maintaining their greatest strength, immutability.[79] As Lin, Zhang, Li, Ji, and Sun note, "Tamper proof is the most remarkable feature in the blockchain, and its specific performance in that once the smart contract is successfully deployed, then it cannot be changed."[80] However, this strength also creates one of the most significant problems relating to fully on-chain smart contracts, inflexibility.[81] "Purely on-chain contract code is slow, expensive, and insular, unable to benefit from real-world data and a variety of functionalities that are inherently unachievable on-chain, including various forms of confidential computation, generation of (pseudo) randomness secure against miner/validator manipulation."[82]

In a traditional blockchain smart contract, the data that delineates the terms and conditions is based solely on the blockchain.[83] That is, the smart contract is based solely on the data that is housed in the formal language of the blockchain programming.[84] The smart contract is not able to read programs and protocols that exist outside of the blockchain.[85] The use of oracles, middleware that translates outside data onto the

79. *See* Jeremy M. Sklaroff, *Smart Contracts and the Cost of Inflexibility*, 166 U. PA. L. REV. 263, 291 (2017) ("Computer code must be precisely and completely defined . . . . A smart contract cannot contain a term that has one meaning at the time of execution and takes on another meaning later.").

80. Shi-Yi Lin et al., *A Survey of Application Research Based on Blockchain Smart Contract*, 28 WIRELESS NETWORKS 635, 640 (2022).

81. *See supra* note 79 and accompanying text.

82. BREIDENBACH ET AL., *supra* note 16, at 9.

83. *See* Shi-Yi Lin et al., *supra* note 80, at 636 ("Smart contract is an embedded programming contract that can be built into any blockchain data, transaction or asset to form systems . . . .").

84. *Id.*

85. *Id.*

blockchain, can help mitigate this problem.[86] As the authors of *Chainlink 2.0: Next Steps in the Evolution of Decentralized Oracle Networks* note,

> For smart contracts to realize their full potential therefore requires smart contracts to be architected with two parts: an on-chain part (which we typically denote by SC) and an off-chain part, an executable running on a DON (which we typically denote by exec). The goal is to achieve a secure composition of on-chain functionality with the multiplicity of off-chain services that DONs aim to provide. Together, the two parts make up a hybrid contract.[87]

The hybrid smart contract system can hence enable the on-chain code to be automatically augmented to address new scenarios in real-time. Notable present examples include: geolocation data that can be used to monitor the flow of goods through a supply chain, capital market data relating to tokenized assets and securities benchmarks reference data, such as interest rate data relating to smart financial derivatives, and meteorological data used for a variety of purposes, including insurance.[88] Such off-chain data can include changing information as to the price of assets, updated information as to reserve balances supporting tokenized assets, and other data from application programming interfaces.[89] This latter category can cover a wide range of data including agricultural harvests and mining information.[90] It is conceivable that such off-chain data could include legal repositories of material relating to contractual terms and their intended operation, as well as data relating to external events such as those relevant to the application of the doctrine of frustration.

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86. *See* LAW COMMISSION, *supra* note 15, at vii (defining a smart contract as computer code that "is capable of running automatically according to pre-specified conditions").

87. BREIDENBACH ET AL., *supra* note 16, at 9.

88. *See* Woebbeking, *supra* note 73, at 108 ("The fields of application of smart contracts are numerous. They can be used, at least in theory, wherever economic assets show interfaces to the internet and certain events can be verified digitally.").

89. *See* BREIDENBACH ET AL., *supra* note 16, at 8, 27 (discussing DONs' asset access).

90. *See Hybrid Smart Contracts*, *supra* note 76 (describing how hybrid smart contracts can benefit different global industries).

The on-chain element, the blockchain, continues to operate to maintain the ledger and provides "authoritative custody of users' assets and interacts with private keys."[91] Final settlement is executed by the blockchain through the processing of irreversible transactions and the transferring of value between parties.[92] Finally, the on-chain blockchain can also provide appropriate guardrails to ensure the secure functioning of the off-chain activities executed by the DON.[93]

CONCLUSION

At present, the most prevalent form of automated contracts are natural language contracts with automated performance.[94] Such contracts do not offer the full benefits of smart contracts, most notably their features of ease of formation and trustless contracting through the removal of the need for intermediaries.[95] However, the transition to smart contracts is discernable and accelerating.[96] The United Kingdom Law Reform Commission's 2021 report, *Smart Legal Contracts: Advice to Government*, notes that the prevalence of contracts recorded solely in code "might increase over time as the underlying technology becomes progressively sophisticated."[97] While developments in blockchain technologies have led to a new "crypto-economy," the next generation of decentralized applications will be facilitated by the increasing use of smart contracts.[98]

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91. *Id.*

92. *Id.*

93. *Id.*

94. *See* LAW COMMISSION, *supra* note 15, at 26 ("Of the 22 consultees who answered this question, 11 said natural language contracts with automated performance are most commonly used in practice.").

95. *See id.* at 22 ("The code itself does not define any contractual obligations, but is merely a tool employed by one or both of the parties to perform those obligations.").

96. *See id.* at 26.

97. *Id.* at 30.

98. *See* Shafaq Naheed Khan et al., *Blockchain Smart Contracts: Applications, Challenges, and Future Trends*, 14 PEER-TO-PEER NETWORKING & APPLICATIONS 2901, 2920 (2021) ("Thus, smart contracts are expected to

Despite this growing commercial interest in the use of smart contracts, there is an increasing legal concern as to the capacity of smart contracts to uphold fundamental principles of contract law.[99] In such a context, it is suggested that hybrid smart contracts can offer many of the benefits of fully automated smart contracts while also mitigating some of the primary concerns.[100]

This Essay has provided a preliminary exploration of hybrid smart contracts' potential to mitigate problems relating to uncertainty, lack of clarity, and inflexibility. It is relevant to note that this is merely an initial scoping analysis. For this analysis to progress, it will be necessary for lawyers to formally collaborate with computer engineers and data scientists to connect legal and technical understandings. Lawyers are well-versed in the contractual principles that need to be maintained, but are less familiar with how blockchain infrastructure and smart contracts can be designed to uphold these principles.[101] Conversely, technical experts understand the logistical operations of smart contracts but are not familiar with the substantive law to be upheld.[102] As in many other fields of technology law, it is only in the coming together of disparate disciplines that meaningful progress can be made.[103] The use of DONs to mitigate the inflexibility of a fully smart contract has not been the subject of legal analysis. Yet, this unresearched arrangement could form a key to overcoming some of the most significant contractual challenges identified in the legal literature on smart contacts.

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revolutionize many traditional industries, such as financial, healthcare, energy, etc.").

99. *See supra* Part III.

100. *See supra* Part III.

101. *See* LAW COMMISSION, *supra* note 15, at 25 ("Many consultees emphasized [sic] the importance of coders in the formation of a smart legal contract. The parties may contract with a computer coder to draft the code based on instructions provided jointly to the computer coder by the parties.").

102. *See id.*

103. *See* Gacutan & Selvadurai, *supra* note 15, at 72 ("An understanding of Internet structure is thus critical to the design of effective laws to restrain the sharing of harmful user-generated content.").