Functional Differences of Neo and Ethereum as Smart Contract Platforms

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Abstract. While Ethereum is currently the most popular smart contract platform, there are interesting alternatives like Neo. However, Neo only rarely appears in scientific literature. Moreover, comparisons of smart contract platforms hardly employ a structured approach, but rather apply different criteria to each platform.

This work performs an in-depth comparison between Ethereum and Neo in a structured manner. We derive a catalogue of criteria from related work and use it to identify differences and similarities worthy of discussion. We show how Ethereum and Neo differ in key aspects, ranging from the general goal to technical issues like the execution and fee model and practical aspects like the maturity of its features and documentation.

Keywords: Evaluation · Criteria · Smart contract · Platform

1 Introduction

While Ethereum has been widely used as a platform for smart contracts (SCs), alternatives keep appearing. When a company decides on a SC platform for its business case, several aspects have to be considered. Since blockchain interoperability is still an issue, migrating applications from one platform to another can be expensive and time-consuming. Furthermore, when targeting the Asian market, the stance of China on this technology is an important factor.

One promising alternative to Ethereum is Neo, sometimes referred to as Chinese Ethereum, which at first glance indeed appears to be quite similar to Ethereum. An immediate difference emerges when looking for documentation. While documents about Ethereum are abundant and readily available, detailed information about Neo is sparse. Regarding comparisons, technical reviews tend to list the features of platforms individually instead of using a structured list of criteria as common reference. In particular, there is no rigorous comparison of Ethereum and Neo in terms of functionality and mechanics.

This paper is a condensed version of the comparison described in [2].

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Contribution. This work elaborates in a structured manner the differences between Ethereum and Neo as SC platforms. Our contribution consists in (i) a catalogue of criteria relevant for the comparison of platforms, (ii) a comparative evaluation of Ethereum and Neo as SC platforms based on these criteria, and (iii) a discussion about the effects of the differences on the development of SCs.

Benefits and Audience. The catalogue provides a structured scheme for comparing SC platforms, which may serve as the basis for further well-founded comparative studies. Our work provides a guideline for companies and developers that have to choose between Ethereum and Neo.

Roadmap. Section 2 presents the criteria used for the comparison in Sect. 3. We discuss the differences in Sect. 4 and conclude in Sect. 5.

2 Catalogue of Criteria

After reviewing related work, we will specify the criteria for our comparison. They are highlighted in bold face and grouped into the categories *project*, *blockchain*, *platform*, and *operation*. We employed the following five-step approach to arrive at criteria relevant for comparing the functionality of SC platforms.

1. Collect descriptions and comparisons of blockchains or SC platforms,
2. extract terms used as criteria,
3. remove criteria not relevant for the functionality of SC platforms,
4. add criteria for features specific to Neo to avoid bias, and
5. merge similar terms.

2.1 Related Work

Early comparisons like [3,4] concentrate on Bitcoin and Ethereum. The survey [17] aims at breadth and describes 17 SC platforms, including Ethereum and Neo. A more recent one, [31], compares five platforms, among them Ethereum. Other publications focus on particular aspects: [24] compares the languages Solidity, Pact and Liquidity, while [30] is devoted to blockchain-based applications in general, highlighting Bitcoin, Ethereum and Hyperledger Fabric as SC platforms. [19] discusses scalability, interoperability and sustainability in general without referring to specific blockchains, while [1] compares consensus algorithms. [5] interviewed the developers of numerous blockchain projects on a broad variety of platforms. We used all mentioned publications, and some more, to develop our catalogue of critera. Moreover, we scanned [20] for Neo-specific criteria, as none of the papers but one relates to Neo.

2.2 Project

Objectives of a platform include specific use cases or application domains as well as general goals like decentralization. It also includes the possibility of integrating third-parties or government bodies. **Maturity** mainly refers to three

aspects: (i) the platform is sufficiently mature for hosting applications in productive use [3], (ii) quality of documentation and (iii) status of specification. Developers of DAPPs need reliable information on the chosen platform and its mechanics. **Origin and Organization.** The country of origin and the organization behind a platform are relevant factors, when having to deal with legal regulations. **Governance** determines who can propose changes and who finally decides which changes will be implemented. Blockchain governance can be achieved by a variety of rules that are usually classified as on-chain or off-chain.

2.3 Blockchain

Chain and Dependencies includes the availability of a live mainnet and testnets as well as "whether the platform has its own blockchain, or if it just piggybacks on an already existing one" [3]. **Deployment Types** commonly divide networks into public, private and permissioned. To qualify as public (or permissionless), a chain must be accessible without special permission by anyone following the respective protocol [4]. **Consensus Protocol** is the most commonly mentioned criterion. It strongly influences key parameters like transaction volume, energy consumption and operation costs. It is crucial to the operation of a blockchain as it ensures reliability in a network of unreliable nodes; it guarantees the integrity and consistency of the blockchain.

2.4 Platform

Language Support means the availability of languages for writing SCs and the maturity of compilers and corresponding documentation. **Community** refers to the size and activity of the group of developers that is usually the first address to ask for help. **Execution Model.** The underlying mechanics need to guarantee three essential properties of SCs: determinism, isolation and termination [16]. Determinism is usually ensured by simply not offering non-deterministic functions or data sources and limiting or prohibiting dynamic calls. Isolation means that the executed SC is sandboxed, so that it cannot influence other contracts or the system itself. Finally, termination in Turing-complete SC platforms is usually achieved by limiting fees, the number of computation steps or time. **Interoperability** between SC platforms is achieved either when two or more platforms agree on a trusted third-party to transfer information and digital assets, or when the platforms share information directly with each other leveraging trust generated by SCs [19]. **Identity Management.** One of the key characteristics of existing blockchain platforms is pseudo-anonymity provided by addresses not linked to real identities. However, some applications require accountability and transparency in terms of user identity and therefore a secure association with real-life identities. **Tool Support** is crucial for an effective development process [24]. As most current tools are not tuned for SC development, the need for specialized tools like customized IDEs, debuggers and testing tools arises [5]. **Application Standards** improve interoperability, re-usability and security.

2.5 Operation

Block Time is the time between the creation of two subsequent blocks. **Block Confirmation Time** is the latency between submission and confirmation of a block. **Throughput** is the number of transactions processed per second. **Execution Costs.** Platforms employ a fee model to compensate nodes for the resources (computation and storage) used by SCs. Furthermore, fees prevent applications from consuming too many resources of a network.

3 Comparison

Based on the criteria from Sect. 2, we evaluate the available documents about the two platforms Ethereum and Neo. Some aspects need verification using actual SCs on the respective test chains. We also checked the Neo website and forum in Chinese with Google Translate to make sure nothing essential is overlooked.

3.1 Project

Objectives. Ethereum aims at a featureless generic platform that does not censor anything, supports the creation of decentralized applications or organizations [28,30], and is not dependent on a single country or its government.

Neo on the other side sets the 'smart economy' as its primary goal, and thus intends to incorporate features for identity management and cross-chain compatibility [20]. Smart economies need to work with government bodies, which Neo acknowledges by incorporating digital identity standards [25]. However, most of the features for supporting the smart economy are not yet finished.

Maturity. Ethereum has been live since July 2015, and provides a main net and test nets. Although not in its final form and subject to changes, it is the most used platform with thousands of DAPPs. Above all, Ethereum is well documented [12,28] has a formal description [29] and resources (like [12,13]).

Neo also provides a production network. However, it is not as widely used as Ethereum and most of the key features are still missing. Moreover, the platform is poorly documented. The whitepaper [20] is a mix of features of the current version (Neo 2.0) and the future version (Neo 3.0) and contains contradictory information. Furthermore, as of January 2020, Neo's yellow paper [7], that aims to define the technology formally, is mainly blank except for one section.

Origin and Organization. The development of Ethereum was funded using a crowdsale in 2015. Of this, 12 million Ether were retained for the Ethereum Foundation [11] with the mission to "promote and support Ethereum platform and base layer research, development and education to bring decentralized protocols and tools to the world that empower developers to produce next generation decentralized applications (DAPPs)" [13]. As such, they sign responsible for the

development of the Ethereum client *Geth*, the SC scripting language Solidity and widely used development tools like Remix.

The Ethereum ecosystems consists of many different companies that participate in the development of Ethereum, infrastructure projects and DAPPs. Two organization with a high impact on Ethereum are ConsenSys [8] and the Enterprise Ethereum Alliance [10]. ConsenSys acts as an incubator for Ethereum related projects like MetaMask and facilitates communication and knowledge transfer between developers while allowing them to work autonomously [15]. Moreover, it acts as a venture capital company by financially supporting projects and provides services for companies who intend to incorporate Ethereum or create private Ethereum networks [15]. The importance of ConsenSys to Ethereum goes well beyond providing infrastructure tools. Because it ties to decentralized projects and companies implementing Ethereum, ConsenSys strongly influences the Ethereum project itself. Furthermore, it maintains close relationships to government bodies (like the European Commission).

Antshares (now Neo 1.0) was started by CEO Da Hongfei and CTO Erik Zhang, who already founded the blockchain company OnChain [27]. A crowdsale in 2015 raised funds to develop the platform. Antshares was rebranded to Neo in 2017 with a focus on the 'smart economy' [20]. The development of the Neo protocol is steered by the Neo Foundation, a Chinese non-profit organization, in which Hongfei and Zhang have executive authority [21]. In 2018, the companies Neo Global Development (NGD) and Neo Global Capital (NGC) were founded. NGD is a sub organization of the Neo Foundation and focuses on research & development, marketing, and community development [21]. NGC is a Singapore-based organization licensed for fund management.

The company most associated with Neo is OnChain. Da Hongfei even needed to clarify publicly that Neo and OnChain are in fact separate companies [23]. OnChain has its own blockchain product called Distributed Network Architecture (DNA), which helps other companies to set up blockchains. DNA is highly similar to Neo and therefore profits from its ongoing development. Da Hongfei even mentions that interoperability between Neo and DNA-based chains will be possible in the future [23]. OnChain closely cooperates with the Chinese government [26] with unclear impact.

Governance. Ethereum uses an off-chain governance process, which means that the rules are not encoded in the platform but applied on a social level. The governance process is based on the Ethereum Improvement Proposals (EIPs). EIPs are design documents that either present information to the community or describe a new feature of Ethereum or its surrounding processes. Although the process involves the Ethereum community, the core developers eventually determine which changes are implemented in the core protocol.

Neo utilizes off-chain and on-chain governance. Neo provides two types of native tokens: NEO and NeoGas. The indivisible token NEO represents the right to manage the network and participate in the on-chain governance process. Neither the whitepaper nor the yellow paper specify the concrete network

parameters, on which the token holders can vote [20]. New ideas can be discussed in Neo Enhancement Proposals (NEP) [22], which work similar to EIPs in Ethereum. The final decision on proposals for the protocol is made by Hongfei and Zhang [9].

3.2 Blockchain Properties

Regarding the blockchain, Ethereum and Neo mainly differ in the **consensus protocol**. Ethereum uses Proof-of-Work (PoW) – with sustainability and scalability issues. With Ethereum 2.0, the switch to Proof-of-Stake (PoS) is planned, where anybody (with sufficient stake) can propose and validate blocks. Variants of PoS with incentives to facilitate decentralization are being discussed [6].

Neo puts a focus on scalability at the cost of a low degree of decentralization by using the Delegated Byzantine Fault Tolerant (dBFT) algorithm [20]. In fact, seven bookkeeping nodes propose and validate new blocks, of which cureently five (to six) nodes are under the control of the Neo Foundation (the two-third majority needed to accept or reject blocks on their own). All other nodes can indirectly influence the block creation by voting for one of the bookkeeping nodes. The founders of Neo intend to change this with Neo 3.0 [9].

3.3 Platform and Development

Language Support. Ethereum currently supports two programing languages actively in use, Solidity and Vyper. With Ethereum 2.0, plans are to add the Ethereum flavored WebAssembly (eWASM) as a second assembly platform [8] that inherits a wider range of languages and tools.

Neo supports common languages like Java or C# [20]. Being able to use the same programing languages for on- and off-chain parts eases development. However, some of the languages listed are not fully supported yet [20]. Moreover, documentation for the compilers (and their status) is lacking.

Community. Ethereum has an active community that provides help in many cases. Neo's community is much smaller and partly interacts in Chinese.

Execution Model. Both platforms execute SCs in a stack-based virtual machine that only offers deterministic functions. Isolation is achieved by sandboxing, while termination is guaranteed through a fee model (gas).

Platform Interoperability and Identity Management. Ethereum hosts DAPPs for both, with uPort being the most popular DAPP for identity management. Neo hosts a DAPP for identity management from the telecom provider Swisscom. It is planned to integrate both functionalities into the platform.

Tool Support. For Ethereum, ConsensSys and the large community provide tools, like the specialized IDE Remix, IDE add-ons and numerous further tools. Neo focuses on plug-ins for existing environments.

Application Standards. Ethereum offers a wide range of ERCs for tokens, identity management, proxy contracts and more. Neo offers a small number of application standards focusing on tokens.

3.4 Operation

Both platforms have a **block time** of around 15 s, but this is likely to change in future versions.

The **block confirmation time** for Ethereum is around six minutes, while the consensus protocol of Neo provides instant finality.

Ethereum achieves a **throughput** near 10 transactions per second, while Neo's promise of 10 000 transactions per second has not yet been verified.

Execution costs differ significantly. In Ethereum, everyone can deploy a contract for a few US Dollars. In contrast to that, in Neo one has to spend several thousand US Dollars per SC deployment. Thus, Neo is used by well-funded projects only. SC users encounter high fees as well. Neo's approach to compensate the high costs with grants further diminishes its decentralization.

3.5 Summary

Although both platforms look similar on a superficial level, the structured comparison revealed noteworthy differences. In Table 1, we marked those criteria in bold face where the platforms show notable differences.

4 Discussion

Both Ethereum and Neo are blockchain-based smart contract platforms featuring a Turing-complete virtual machine. This allows them to support all kinds of smart contract applications, and indeed both platforms host live applications.

The preference for a platform also depends on the market your application targets. If China is a main target for you DAPP, Neo might be a good choice. Furthermore, OnChain already creates blockchains for the Chinese government and Chinese companies. Those chains will eventually become compatible with Neo. Therefore, an entire blockchain ecosystem might emerge with Neo being the backbone of OnChain's blockchain concept. The plan is that Neo provides a public chain while OnChain provides private chains for enterprises, and the ultimate goal is to link both worlds together [27]. If the plan succeeds, Neo is likely to play a major role in the Chinese blockchain market. For developers focusing on the Chinese or Asian market, this is a strong argument in favor of Neo. China's interest in Neo may go hand in hand with stricter rules and higher demands. For example, when the Chinese government banned western social media platforms, they encouraged its population to use WeChat (developed by Tencent) [18]. Tencent on the other hand had to employ people close to the communist party. At least in theory, Neo currently outperforms Ethereum regarding scalability and language support. On the other hand, Ethereum is an established platform with an active community and quite likely will improve its performance and language support. Then again, Neo may become a globally successful blockchain as envisioned by its CEO Hongfei. The cooperation with Swisscom is a noteworthy step in that direction.

Ethereum's PoW results in a high power consumption [14] that will change with the planned switch to PoS. Neo's power consumption is low already due to its consensus mechanism and the small network consisting of only seven validating nodes and a comparably small total number of participating nodes.

Table 1. Summarized comparison of Ethereum and Neo

Criterion	Ethereum	Neo
Objectives	General purpose	Smart economy
Maturity	Live applications plentiful documentation formally specified VM	Live applications varying documentation no formal specification
Origin, organization	Ethereum foundation Switzerland company ConsenSys fairly independent	Neo foundation China company OnChain links to Chinese government
Governance	Off-chain core developers EIP	Off- and on-chain founders NEP
Chain	Mainnet and testnets	Mainnet and testnets
Deployment types	Permissionless	Permissionless
Consensus protocol	PoW (PoS), decentralized	dBFT, 7 validators
Language support	Domain specific languages, mature compiler and docs	Common general purpose Languages, almost mature compiler and docs
Community	Large and highly active	Small and active
Execution model	Deterministic, sand-boxed, resource pricing	Deterministic, sand-boxed, resource pricing
Platform interoperability	Not planned as built-in by means of SCs	Planned as built-in by means of SCs
Identity management	Not planned as built-in by means of SCs	Planned as built-in by means of SCs
Tool support	Plentiful in various stages of maturity IDE and add-ons	Inherited from common languages plug-ins
Application standards	ERCs for diverse areas	for tokens
Block time	15 s	15 s
Block confirmation	6 min	Instant (one block)
Throughput	10 tps	33 tps effectively (10 000 tps claimed)
Execution costs	Low to moderate (few $)	High (several thousand $)

Regarding the sustainability of the project, both projects depend on an active ecosystem of developers and other contributors to succeed [19]. The community

of Ethereum is much larger, more international and exists for a longer time than Neo's. Both projects are well funded through ICOs [13,25].

Concerning dependence on companies or governments, Ethereum is fairly independent. The core developers eventually decide about the development. Neo has a similar dependency on its founders. The relationship between the Neo Foundation, OnChain and the Chinese government has never been clarified.

5 Conclusion

Our comparison showed, that Neo is a viable choice when (i) targeting the Chinese and related markets, (ii) energy consumption is a concern, (iii) dependence on the Chinese government is no concern, (iv) centralization is no concern, and (v) use cases are limited to the 'smart economy'. Its poor documentation and high execution costs make it virtually indispensable to cooperate with the Neo foundation.

Ethereum is a comparatively mature and decentralized general purpose solution without preference for any country or markets, albeit with a high energy footprint. The switch to Ethereum 2.0 may be a game changer.

Limitations. We took aspects of a platform as cryptocurrency into account only to the extent that they are relevant for the execution of SCs. Moreover, we did not aim at an in-depth performance test, but focused on functionality.

Future work. Regarding Neo, the claimed performance has not yet been confirmed due to the high costs of operation. Moreover, its relationship to the government of China should be reassessed. As both platforms are evolving, evaluating future versions seems worthwhile.

References

1. Alsunaidi, S.J., Alhaidari, F.A.: A survey of consensus algorithms for blockchain technology. In: International Conference Computer and Information Sciences (ICCIS). IEEE (2019)
2. Bareis, M.: Comparison of Ethereum and NEO as smart contract platforms. Master's thesis, TU Wien (2020)
3. Bartoletti, M., Pompianu, L.: An empirical analysis of smart contracts: platforms, applications, and design patterns. In: Brenner, M., et al. (eds.) Financial Cryptography and Data Security. LNCS, vol. 10323, pp. 494–509. Springer, Cham (2017)
4. Bocek, T., Stiller, B.: Smart contracts - blockchains in the wings. In: Linnhoff-Popien, C., Schneider, R., Zaddach, M. (eds.) Digital Marketplaces Unleashed, pp. 169–184. Springer, Heidelberg (2018)
5. Bosu, A., Iqbal, A., Shahriyar, R., Chakraborty, P.: Understanding the motivations, challenges and needs of blockchain software developers: a survey. Empirical Softw. Eng. **24**(4), 2636–2673 (2019)
6. Buterin, V.: Ethereum Proof-of-Stake FAQs. https://github.com/ethereum/wiki/wiki/Proof-of-Stake-FAQ. Accessed 29 Sept 2019

7. Coelho, I., Coelho, V., Lin, P., Zhang, E.: Community Yellow Paper: A Technical Specification for NEO Blockchain. https://neoresearch.io/assets/yellowpaper/yellow_paper.pdf. Accessed 07 Jan 2020
8. ConsenSys: Homepage. https://media.consensys.net. Accessed 05 Dec 2019
9. Cuen, L.: Neo relaunch. https://www.coindesk.com/neo-releases-detailed-financials-ahead-of-cryptocurrency-relaunch. Accessed 19 Aug 2019
10. Enterprise Ethereum Alliance. https://entethalliance.org. Accessed 11 Nov 2019
11. Ethereum Foundation. https://www.ethereum.org/. Accessed 15 Aug 2019
12. Ethereum Wiki. https://github.com/ethereum/wiki/wiki. Accessed 15 Aug 2019
13. EthHub. https://docs.ethhub.io. Accessed 8 Nov 2019
14. Fairley, P.: Ethereum plans to cut its absurd energy consumption by 99 percent. IEEE Spectr. **56**(1), 29–32 (2019). https://doi.org/10.1109/MSPEC.2019.8594790
15. FlatOutCrypto: ConsenSys: understanding one of the most important firms in crypto. https://hackernoon.com/consensys-understanding-one-of-the-most-important-firms-in-crypto-7e1d66533d4a. Accessed 28 Aug 2019
16. Harris, C.G.: The risks and challenges of implementing ethereum smart contracts. In: International Conference on Blockchain and Cryptocurrency (ICBC), pp. 104–107. IEEE (2019)
17. ICO Rating: Smart Contract Platforms Review. https://icorating.com/pdf/56/1//Bd40ljAOmjaCFAXmkCj9NAKZAIUj1Dwb9v75AAZe.pdf. Accessed 10 Dec 2018
18. Levenson, N.: NEO versus Ethereum. https://hackernoon.com/neo-versus-ethereum-why-neo-might-be-2018s-strongest-cryptocurrency-79956138bea3. Accessed 19 Aug 2019
19. Lyons, T., Courcelas, L., Timsit, K.: Scalability, interoperability and sustainability of blockchains. Technical report, European Union Blockchain Observatory & Forum (2019)
20. NEO Docs. https://docs.neo.org/docs/en-us/index.html. Accessed 02 Dec 2019
21. NEO release statement. https://neonewstoday.com/general/neo-release-statement-on-organisation-restructure/. Accessed 28 Aug 2019
22. NEP. https://github.com/neo-project/proposals. Accessed 04 Aug 2019
23. OnChain: Interview with Da Hongfei. https://www.youtube.com/watch?v=BcmoSp7bL7g. Accessed 28 Aug 2019
24. Parizi, R.M., Amritraj, A.D.: Smart contract programming languages on blockchains: an empirical evaluation of usability and security. In: Chen, S., Wang, H., Zhang, L.J. (eds.) International Conference on Blockchain, pp. 75–91. Springer, Cham (2018)
25. Rosic, A.: What is NEO Blockchain? https://blockgeeks.com/guides/neo-blockchain/. Accessed 18 Aug 2019
26. See, R.: The company behind Neo. https://hackernoon.com/neo-onchain-and-its-ultimate-plan-dna-4c33e9b6bfaa. Accessed 28 Aug 2019
27. Seth, S.: Why NEO Can Do What No Other Cryptocurrency Can Do. https://www.investopedia.com/tech/china-neo-cryptocurrency/. Accessed 15 Aug 2019
28. Ethereum: A Next-Generation Smart Contract and Decentralized Application Platform. https://github.com/ethereum/wiki/wiki/White-Paper. Accessed 15 Aug 2019

29. Wood, G.: Ethereum: a secure decentralised generalised transaction ledger. https://ethereum.github.io/yellowpaper/paper.pdf. Accessed 15 Aug 2019
30. Xu, X., Weber, I., Staples, M.: Architecture for Blockchain Applications. Springer, Heidelberg (2019)
31. Zheng, Z., Xie, S., Dai, H.N., Chen, W., Chen, X., Weng, J., Imran, M.: An overview on smart contracts: challenges, advances and platforms. Future Gener. Comput. Syst. **105**, 475–491 (2020)