

Fusionistic Convergence of AI to Blockchain TechStack - Turning Opportunities into Realities

Abstract

Integration of two or more technologies is not a new phenomenon. Robots are created by integrating four technologies collectively called mechatronics and then made intelligent by adding AI tools. However, the fusionistic convergence of the two titans of the digital world, viz., Blockchain and AI, is not a reality in many cases. New opportunities to maximise value creation and minimise value destruction can be created with the collaborative fusion of the two technologies under the strict drive and supervision of the Smart Contract embedded in any blockchain platform's digital systems. The author has tried to ideate and narrate several such probable application use cases that can be experimented to generate more value with a total focus on ESG and DEI. Specific findings, conclusions, and recommendations of research scholars have also been cited in support of the ideated propositions.

Introduction

Thousands of zettabytes of digital space and thousands of kilometers of physical paper space have already been consumed and stored with writings on Blockchain technology-based platforms, Artificial Intelligence, and their applications. As these two technologies evolve and advance with more capabilities, more applications-oriented knowledge continues to be added, and breakthrough solutions are being created. The latest three are Generative AI, Spatial Computing, and Quantum AI. AI and blockchain continue to sustain with ever-enhancing power and capabilities for intelligent, advanced, and innovative applications for digital transformation and value creation.

There are some anxieties amongst users and even solution builders about AI's specific far-reaching adverse impacts. However, most technology experts believe exercising appropriate care and caution while building solutions, complying with regulatory codes of standards with universal altruism and oversights, and complying



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with country-specific legal compliance can minimize the effects. AI is also emerging as an indispensable technology for specific applications like healthcare. Blockchain is predicted to move forward from a transformative to a foundational technology of this century because of its potential to qualitatively improve any country's societal and economic foundation with more diversity, equity, and inclusivity (DEI).

The author has also written about these two technologies and their multivarious and multisectoral applications in the second enlarged edition of his Book¹ and other research-based papers which are readily available. Therefore, given the shortage of space, various features and utilities of Blockchain and AI as digital technologies are not being repeated in this paper. Anyone with some knowledge of what can be done by separately using blockchain and AI can contemplate what great tasks can be performed if a cluster of AI tools collectively is added to a Blockchain platform to become an added layer to the Blockchain platforms technology stack.

Objective

After briefly narrating a blockchain technology platform's functional and data management system, this paper will examine the justifications for adding a layer of the artificial intelligence technology stack to the blockchain platform. The cardinal principle for combining two objects is that the combined unit must generate additional value and more opportunities/avenues for generating values. For a merger and acquisition transaction, investment bankers adopt a simple formula to justify the acquiring company's (AC) investment to bring the target company (TC) under its ownership. The formula is that the value of the combined company/group should be more than the mathematically

added individual values of AC and TC or $\text{Value}_{AC+TC} > \text{Value}_{AC} + \text{Value}_{TC}$.

This paper aims to similarly appreciate whether new opportunities for more value generation can be created by adding a layer of AI Technology Stack (AI TechStack) to a blockchain technology platform. According to the author, this is possible, albeit to be validated by real-life case studies. Efforts will be made to understand and justify this claim from the perspective of blockchain and AI technology users. Certain complex propositions of digital solution builders will be briefly explained, and a few new ones will be added as the author ideates and perceives the same to be possible. In the end, the conclusions and recommendations of certain research scholars will be reviewed to support the propositions in this paper.

Blockchain TechStack and Data Management

Any blockchain platform's technology stack (TechStack) is an integrated set of intricate digital technologies that work in unison following the designed principles of a no-trust decentralised environment, including encryption and data storage facilities. The functional domain across all TechStack layers is auto-driven by all-pervasive provisions of smart contracts without any human interventions by any central controller/administrator. This is what is at the central software system of the platform. The smart contracts are scripted into the software to cover business processes and compulsively ensure compliance with all applicable legal and regulatory requirements. Thus, the transactional data provided by such a system is always free from any bias or distortion and is reliable, relevant, traceable, and auditable.

The typical technology stack of any blockchain platform can be broken down into several tiers. Appendix 1, at the end of this paper, provides a graphical display of the technology layers of a typical blockchain. Readers may observe a data layer of transactions towards the bottom of the graphic. The transactional layer of any blockchain platform for financial and non-financial events, identity management, tokenization, etc., generates as much transactional data with underlying documentary evidence for as many events it records.

Any transaction can sequentially get added to the chain of transactional blocks of previous transactions only after the designated participant grants consent identified with a public key. Each such transactional data is added to the chain chronologically and logically, following a pre-defined data structure. There can be the following two scenarios of data storage:

- ⊙ **On-Chain Storage:** All transactional data and underlying digitised documentary evidence are stored on the blockchain platform itself, and
- ⊙ **Off-Chain Storage:** All transactional data are stored in an integrated database, and underlying documents are stored in a separate document library with all related transactional references for easy tracking and

retrieval. Only the metadata for the transactions are stored in the blockchain platform itself,

But in both types of storage systems, the following are done for security, safety, and trackability:

- ⊙ **Reference Tagging:** All data and documents are duly tagged with the related transactional references for easy constant surveillance, tracking and retrieval,
- ⊙ **Encryption:** All data and documents are encrypted with complex algorithms for safety and security,
- ⊙ **Immutability:** Changes of any data and document of any type for any reason can only be made by passing another transaction, with tagged reference to the earlier one, after due consent from the concerned parties to nullify or modify the previous ones as appropriate. This process ensures the immutability and reliability of all data and documentary evidence, including for acceptability in the court of law in the event of any litigation and
- ⊙ **Data Sharing:** Related quantitative and financial data along with related digitised documents are transferred to the wallet at the node of each of the concerned participants of the blockchain platform in any transaction for onward transfer and recording into their respective books of accounts.

Thus, the data layer in the TechStack of any blockchain platform is designed to auto-administer and conduct storage management of all transactional information and digitised documents. The system also includes structuring data before storage with 'Merkle Tree,' Hash Tagging, and Hash Chain. All these provide facilities for tracking, monitoring, and retrieving the data following an appropriate logic for any individual participant during a given period. For example, the data can be for Letters of Credit (L/Cs) or their usage for bill discounting during a given period, or L/Cs issued by a particular bank during a defined period, for which the related export-import transactions are performed in a blockchain platform.

Why to Add AI TechStack to Blockchain TechStack

Accuracy, reliability, relevance, currency, traceability, immutability, and auditability of data are essential for success in any AI application that draws meaningful insights from those data. If the data is provided from the database of a blockchain platform, data scientists can remain peaceful and anxiety-free about all these aspects. From the perspective of participating parties, data will always remain available for all transactions performed through blockchain platforms.

The data of any blockchain system will further reinforce the power of AI-based tools for self-learning and creativity. This would render the system acceptable and adaptable for multi-dimensional purposes. According to the author, over time, the solution builders will also be able to provide

participants with access to process their respective wallet's data using the 'AI Layer' various data processing facilities added to the blockchain platform. All these can be done without disturbing the data of other participants in any manner whatsoever.

Kamales Lardi, Forbes Council Member², believes that "In the current digital economy, data is produced exponentially by people, channels, platforms, and devices. AI models used for decision making provide little transparency, where large data sets are pumped into systems, and results are produced in the form of analysis, reports or recommendations. This can create an issue of trust and raises questions about the system's credibility However, combined with blockchain technology that offers clear data provenance and audit trails, transparency and traceability of data and potential interoperability across various platforms, I believe the result could produce more trustworthy AI-based systems for analysis and decision-making".

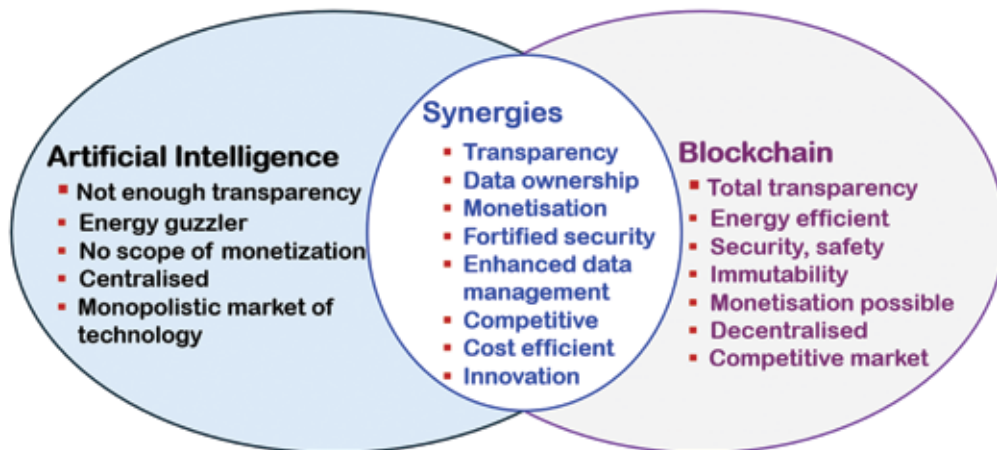
The above powerful statement, recorded in a Forbes Council publication, evokes confidence in Blockchain. One can look forward to a situation in which organisations will increasingly prefer only those systems that provide

more safety and security to the most valuable assets in the ongoing digital economy, which is data, metaphorically called the digital gold of the current Industry 4.0 era. All these will enhance the power of the user organisation to explore all opportunities and potentials. The path to success for the same can be charted using the insights drawn from pervasive analyses of data drawn from the repository of blockchain platforms.

Opportunities for Synergistic Benefits from Convergence and Fusion

Although artificial intelligence is a centralised system, it can effectively function in a decentralised environment with the help of an extracting, transforming, and loading (ETL) tool. These tools can be made functional for drawing data from one or more computing systems, curating, and preparing the same for meaningful applications of AI tools. Those AI tools can be Deep Dive Analytics (DDA), Machine Learning (ML), Deep Learning (DL), Neural Networks (NN), and Generative AI. On the other hand, in a Blockchain environment, the added AI layer to the Blockchain TechStack does not need to perform much prior exercise to prepare the data before applying the AI tools.

Illustrative Synergies from the Fusion of AI and Blockchain



Source: Graphic created by the author

According to a publication in Appinventiv³, "The fusion of AI and Blockchain can potentially revolutionize supply chain logistics, healthcare, and cybersecurity, among other areas. the advancements backed by their intersection are truly unparalleled. AI and Blockchain are now converging to unleash incredible possibilities. Together, they are poised to revolutionize various industries and unlock unprecedented potential. The combination of AI and Blockchain is not just the sum of their strengths but rather a multiplication of their impact."

Thus, the fusion of AI into blockchain TechStack cobbles up a strong and healthy alliance that can create much more impact than the simple summation of benefits from the

two technologies. The above graphic is self-explanatory regarding the synergies generated from the fusion of AI into Blockchain TechStack. The multiplication of the impacts arising from the synergistic integration of the two systems can generate many more perceivable benefits than what can be narrated in words. Given the space limitation, readers may extend their thoughts to visualise all those synergistic benefits, taking the above graphic as the basis.

The following graphic illustrates some of the significant components of the digital technology stack of Artificial Intelligence. Two of the substantial investment and revenue cost savings that will arise from the fusion of AI into Blockchain TechStack can be visualised from the first two

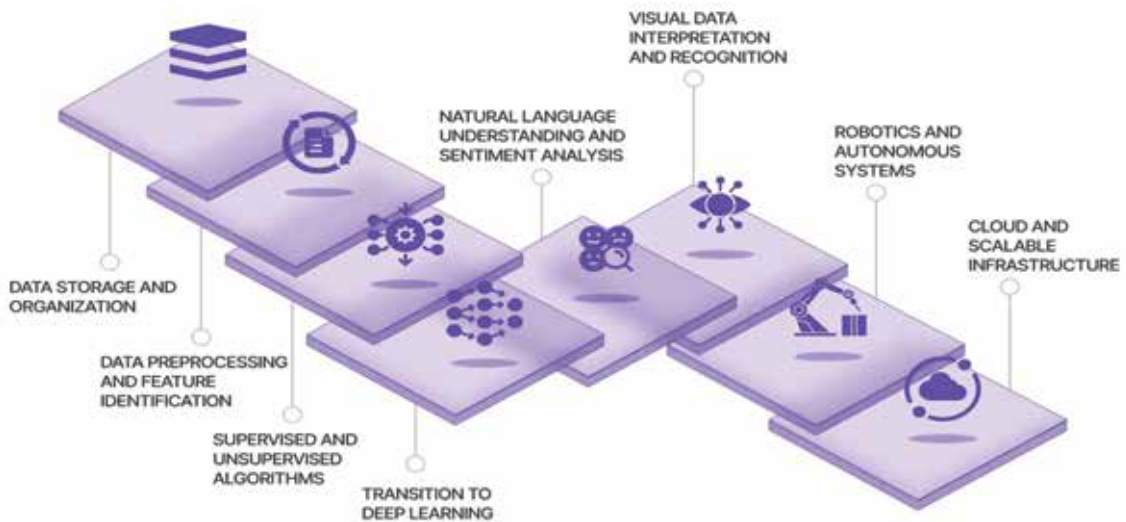
blocks of the following graphic:

- The avoidance of additional storage space and security measures for keeping the second set of data created with the application of ETL and
- Reduced efforts, electricity consumption, and costs for data pre-processing and identifying features to prepare it for the application of AI tools.

Another significant advantage of such fusion is the need-based integration of the Internet of Things (IoT)

and artificially intelligent IoTs or AIoTs into this network. This is possible because blockchain technology can accommodate IoTs in the P2P network of Participants, for which IoTs are also considered another set of event-based information providers. Such applications are mostly seen in blockchain-based solutions for Healthcare, Smart Cities, Life Science, and Supply Chain Management, including track and trace facilities. Combining the three technologies also helps protect IoTs and AIoTs from cyber-attacks and securely preserves the information collected through the IoTs in the encrypted blockchain database.

Illustrative Components of AI Technology Stack



Source: <https://markovate.com/blog/ai-tech-stack/>

RPA for KYP Process

Completing the process for 'Know Your Participant' before admitting any new individual or organisation as a participant of the blockchain platform for conducting transactions is a must for any private, public, and hybrid blockchain. For this, any new entrant, like in the case of completing KYC for Banks, must provide certain predefined and structured information and upload certain documents in support of the same. Robotic process automation (RPA) of this KYP system as the first layer of technology for the blockchain platform is possible with the help of the AI TechStack integrated into the Blockchain. The tools like OCR, NLP, Image Recognition, etc., of the AI TechStack can help automate the process and validate the documents by accessing data.

Smart Contract to Activate Tools of AI TechStack

According to the author, another set of benefits that can be generated by combining AI and Blockchain TechStacks is operating the AI tools more effectively. The database is readily available without any need to curate, transform, and prepare the data for the application of AI tools. Hence,

the tool can be run at programmed intervals to meet the specific and unique requirements of individual participants of the blockchain platform and outcomes sent to the participant's wallet. Such a process can also be effective for supervised and unsupervised ML, DL, BDA, Neural Networks, Generative AI, etc. Appropriate provisions can be scripted in the Smart Contract, enabling individual participants to activate and run the Tools in the above AI TechStack.

Use of Generative AI Tools

Generative AI Tools like Chat GPT of Open AI, Gemini of Google, etc., are now used by ordinary people. Readers may be aware that the success of such GenAI tools depends upon two factors. The first one is framing the query for the task to be performed by the tool and the data and information base to be used. Readers must have experienced that errors, gaps, and distortions creep in when tasks are prompted to any Generative AI tool through any browser like Chrome, and the tool uses data and information from the open source.

The outputs from an in-built Generative AI tool into the AI TechStack, integrated into any Blockchain TechStack,

will, in all probability, not provide such erroneous and substandard outputs. The apparent reason is that the transactional database, other information to be used, and documents to be analysed are from the repository of the Blockchain Platform. At the point of the related transaction, such data gets generated, and documents are loaded under strict supervision and surveillance power built into the Smart Contracts that auto-administer the blockchain platform in compliance with all related legal and regulatory requirements.

Therefore, any strategic decision in a blockchain environment based on the output of any in-built AI tools will always be based on the purposeful and reliable inference drawn from the proper data, information, and document analysis. Readers may know that fifteen Indian banks have incorporated a company to run a blockchain platform for Trade finance transactions. Let it be assumed that, ten years later, RBI would want to frame any macroeconomic policy on any aspect of trade finance-related issues; it can base its decisions on the inferences drawn from analyses of all transactional data from that blockchain. Similarly, each participant bank can also use such built-in GenAI tools to make strategic decisions specific to their banks on various functional aspects of trade finance operations.

Blockchain for IoT and Drone Networks

In an earlier paragraph, the proposition for including IoTs and AIoTs was explained for various purposes. Any network of IoTs can be handled with the help of a blockchain as an added cluster of participants like that of individual or organisational participants in a P2P network. The inputs received from that IoT network can be administered through a blockchain, and the information and data inputs can further be processed in the AI TechStack for various strategic purposes.

Similar to P2P network IoTs, Drones can also be handled and administered by a Blockchain platform for multivarious usage in agriculture, surveillance of sovereign borders, supply chain management, etc. The drones can be added with edge computers, and the functional data and images collected by the drone can be channelised through the blockchain TechStack and information processed by the AI TechStack for various strategic and decision-making purposes.

Technology Fusion to Enhance Security and Safety

The intended benefits of any individual technology tool can further be affirmatively impacted if AI TechStack and Blockchain TechStack collaborate to create agile tools for surveillance of the combined TechStack-based system. It is accepted that cyber criminals and hackers use AI-based tools for hacking and spawning ransomware

post penetration into the target's computing system. It is accepted that hacking any blockchain platform is the rarest of rare events. In that situation, the fusion of AI into Blockchain TechStack can create collaborative systems for further securing the combined platforms and the database by positing AI-based agile software gatekeepers and anti-malware and ransomware spawning abilities to block attacks. Such digital gatekeepers can effectively be deployed at the API points to ensure interoperability between two blockchain platforms.

Spatial Computing

The fusion of Blockchain TechStack and AI TechStack can facilitate the implementation of spatial computing relatively easily and open up various new possibilities for digital transformation. A spatial computing system (SCS) embraces all immersive technologies, viz., augmented reality (AR), virtual reality (VR), and mixed reality (MR). According to a World Economic Forum⁸ (2024) publication, an SCS permits users to transcend “.....*traditional two-dimensional interactions and engage with a dynamic three-dimensional world. This shift is more than technological — it's a redefinition of experience, turning passive viewers into active participants in blended physical and digital experiences.*” If a Blockchain platform is made the central administrator of all the technologies and the user participants, the author believes that the implementation of SCS will become much more manageable. One should keep in mind that the metaverse's digital technologies include blockchain. However, this proposition needs to be tried and tested with real-life use cases

Synergistic Integration of AI and Blockchain – Literature Review

Scholars' conclusions supporting the convergence and fusion of AI into Blockchain are evident from many published research papers. Mohammad (2024)³ studied the impacts of synergistic integration of Blockchain and AI based on case studies in finance, healthcare, and supply management. His paper highlighted that “.... *AI-driven optimization can overcome traditional blockchain limitations, such as scalability and energy efficiency, while also enhancing the security and functionality of blockchain networks.*”

Girija et al. (2023)⁴ concluded that various dimensional aspects of the integration of three technologies, viz., Blockchain, AI, and IoT, are being empirically investigated in greater detail by researchers for more privacy of data and safety benefits by securing the IoTs. In the research paper, Guergove and Radwan (2021)⁵ concluded that “.... *successful and effective integration will enhance the development of new business models as well as the digital*

transformation of market corporations. Accordingly, new approaches to convergence should ensure that executives address the demands of new technology to obtain significant gains in efficiency.” They have hastened to add that integrating blockchain platforms and AI would pose many challenges, including scalability, that must be resolved to attain success.

In their research paper, Singh et al. (2022) concluded that the combined use of blockchain and AI technology can bridge the existing gaps in transportation systems management and can fruitfully handle the existing challenges. According to them, “The convergence of both technologies is likely to yield significant advantages and provide a common distributed platform for data sharing, reliability, and decision-making.” Odeyemi et al.⁷ (2024) concluded that immense potential can be generated by combining blockchain and AI technologies. When systematically harnessed, the combined capabilities of the two will open up vast possibilities, e.g., detecting fraudulent activities, reinforcing systems for identity verification and authentication, and further streamlining systems and processes, including legal and regulatory compliances. Their work has highlighted the transformative impacts that can be generated by a fusion of the two technologies towards creating a trusted financial ecosystem. More research-based conclusions and recommendations could have been added had there been no limitation of writing space.

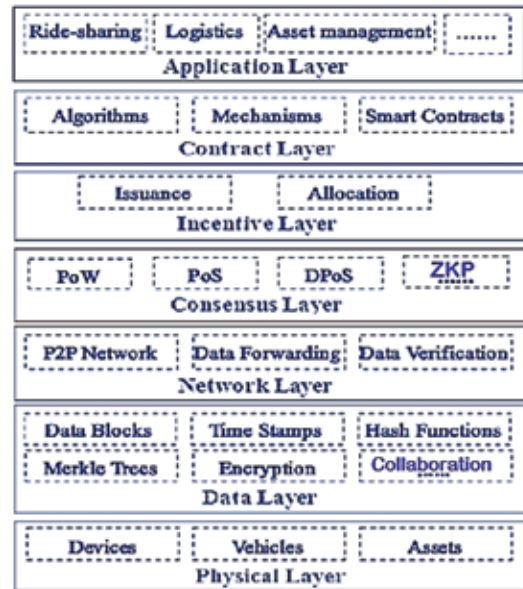
Readers, by now, may be convinced that the author’s claims in this paper that many opportunities can be created and turned into realised possibilities to derive significant synergistic benefits from the fusionistic combination of AI TechStack with the blockchain TechStack. This convergence and combination can facilitate the resolution of many problems while designing digital solutions and positioning agile and critical safety measures and digital gatekeepers. Such a fusion holds immense potential and promises to create enormous beneficial impacts and generate more value in tangible terms by maximisation of value creation and minimisation of value destruction.

Recommendation for Research

This paper contains many propositions and probabilities that can be converted to realised realities. However, each proposition should be subject to more empirical study and validation through case study-based applications. Industry, corporations, and startups are requested to help researchers collaborate and take up new projects for each proposition. Their project work must include issues related to inter alia scalability, maximisation of value creation, and minimisation of costs with a specific focus on ESG and DEI-related objectives to be achieved.

Appendix – I

Standard Layers of a Blockchain Platform



Source: https://www.researchgate.net/figure/An-ITS-Oriented-Blockchain-Model_fig4_332320425

The author has added ZKP and Collaboration in Incentive and Network Layer. MA

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