Forecasting the Impact of Artificial Intelligence

Part 4 of 5: Blockchain (BC) Technology, the Integration of BC and AI, and the Road to Intelligence Augmentation (IA)

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Editor's Note: This fourth part of Spyros' article on forecasting the effects of AI over the near and distant future was originally meant to be the concluding installment. When we received the manuscript, however, it was clear that *Foresight* wouldn't be able to accommodate everything Spyros had to say in just this issue. We've decided instead to extend the article to five parts, with the fifth installment comprising an assessment of the emerging and long-term future of AI's impact on culture, business, and commerce.

"Change is the essential process of all existence." —Mr. Spock, from the *Star Trek* original series episode "Let That Be Your Last Battlefield"

INTRODUCTION

It has been less than nine months since the publication of part one of my *Foresight* article (Fall 2017 issue) "Forecasting the Impact of Artificial Intelligence," and I am already amazed by the enormity of the technological changes occurring in this brief span. Some of these developments, like the AlphaGO Zero AI program (part 2, Winter 2018, p. 7), would have been hard to predict even when the first part was written. However, it's much more difficult to imagine what's coming next, following Amara's Law (see part 1, p. 13) to neither overestimate technology's impact in the short term nor underestimate it in the long run.

This will be a major objective of these concluding two parts, with the current installment encompassing blockchain (BC) and its unique breakthrough advantages; BC's integration with AI and the considerable benefits bound to come from such a marriage; and the drive towards Intelligence Augmentation (IA), an essential point if we humans are to stay ahead of AI and avoid its negative consequences.

BLOCKCHAIN TECHNOLOGY

Artificial intelligence requires massive amounts of high-quality data that needs to be obtained/transmitted safely and reliably; blockchain's major competence is to make such data available. This makes BC a complementary AI partner, resulting in extensive benefits from the possible integration of the two that may speed up and heighten the AI revolution by combining the advantages of both while avoiding or minimizing their disadvantages. Such benefits will be considered in some examples below once I've described the unique value of BC.

The Unique Value of Blockchain

In their new book, *The Truth Machine: The Blockchain and the Future of Everything*, Michael Casey and Paul Vigna (2018) talk about the power of blockchain to revolutionize transactions without the need of entrusting the recordkeeping process to central intermediaries who profit from the process. The authors suggest, for instance, that BC could permit neighboring households that both produce and consume power using rooftop solar panels to trade energy among themselves, bypassing utility companies that set rates and acquire monopolistic profits.

Similarly, they say that property owners, buyers, and mortgage lenders would not be forced to place their trust in government registries when a more secure and cheaper alternative could be built that is less vulnerable to corruption, human failure, and theft. These authors and others

are deliberating BC's many advantages and value when applied on a grand scale, offering a parallel between BC at present and the Internet in its mid-1990s infancy. They point out BC's great potential not only to complement but also to further revolutionize the Internet as we know it today.

Blockchain is a decentralized or distributed ledger (in contrast to the centralized ones kept by banks to record transactions and keep customer balances) of trustworthy digital records shared by a network of participants. As such, it expands the traditional Internet of information and communications (e-mails, sending/receiving/searching for information, exchanging files, participating in social media, etc.) to a new category that might be called the "Internet of Value." This includes sending/receiving money between two parties without the need for financial intermediaries, buying and selling stocks, keeping/issuing certificates or real-estate titles, improving supply chains, and more.

- **Disintermediation** The ledger (database) is not maintained by any single person, company, or government, but by all participating computers located around the world. This means that two parties are able to generate an exchange without the need for an intermediary to authenticate transactions or verify records.

Additionally, BC can result at times in substantial cost savings and greater speed when transferring money or other assets, as transactions are possible 24/7 and do not require an intermediary who works only during "regular" business hours.

Blockchain provides a fundamental shift from the Internet of information/communications to the Internet of Value. While the traditional Internet has created the likes of Amazon, Google, Facebook, and Alibaba as well as Uber and Airbnb, it also has produced huge monopolies/oligopolies that have come to dominate the marketplace and suppress both competition and personal privacy. The

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Blockchain's uniqueness comes from three special capabilities:

- **Trust** New information can be added only when the majority of computers in the network give approval, after seeing satisfactory proof that the information, transmitted cryptographically, is truthful. The authentication of information is done in short intervals of time and the updated information is stored on (appended to) all participating computers.

- **Immutability and Transparency** Information can be appended only to previous data and, once entered, cannot be changed, modified, or lost, providing an incorruptible historical record that stays permanently in the system. Moreover, changes to the public blockchains can be seen by all parties in the network, thus ensuring transparency.

recent Facebook scandal of selling personal information for profit speaks for itself. Additionally, information transmitted through traditional Internet can be copied, thus making it impossible to guarantee its trustworthiness without the approval of an intermediary such as a bank verifying an account balance prior to a money transfer.

The major advantage of the Internet of Value is the establishment of trust between strangers through the application of blockchain technology. With trust built into the systems, assets can be exchanged instantly and efficiently without intermediaries. This advantage is bound to bring about even more profound changes than those brought by the traditional Internet. Trusted peer-to-peer transactions will encourage the formation of decentralized structures, diminishing the monopolistic/oligopolistic power of

intermediaries such as banks or firms like Amazon. New players would exploit the blockchain-based platforms of decentralized networks, creating a more efficient and sustainable economic system.

About a decade ago, Estonia started implementing BC technologies in governmental operations with now 99% of public services being available online 24/7, saving 800 years of working time in this small nation (*https://e-estonia.com/*). Its BC technology includes an "eHealth" record system that covers any one of its citizens who had ever visited a doctor, with 95% of the data and 99% of the prescriptions being digital, and 100% of the billing done electronically. Estonia has proven that BC technology can be applied successfully, resulting in vast efficiencies and savings.

Hangzhou in China's Zhejiang Province plans to introduce BC technology, constituting the largest application not only in China but in the entire world (Zhou, 2018). With continuous improvements in BC as well as development of cheaper and faster computers, other countries/regions will follow, even though implementing BC technologies in larger countries may be a greater challenge.

Two Innovative BC Applications

There are two innovative BC applications standing out, with huge potential to affect the legal profession and the management of organizations, including peer-to-peer and machine-to-machine transactions:

Smart Contracts Smart contracts can diminish the role of lawyers in drafting legal documents, This is probably the

technology with the greatest potential to affect legal transactions, from the execution of wills to the Internet of Things (IoT). Consider the executor of a will who approves how inheritance money will be allocated according to the directives of the deceased. A programmable, legally binding smart contract, using blockchain technology, could achieve the same results without requiring an executor, thus reducing costs, minimizing fraud, and improving efficiency.

Decentralized Autonomous Organizations (DAOs)

A DAO is a company without a CEO, managers, employees, or office buildings. It is created and run by computer code included in a smart contract. For example, funds that invest solely in market indexes would have no need to pay executives, employ personnel, or occupy offices when they can be run 24/7 as a DAO. Cost reductions and more efficient operations are possible because DAOs, once perfected, are not prone to human error, enabling peer-to-peer and machine-to-machine transactions (e.g., an autonomous vehicle [AV] paying for charging its batteries or for using toll roads) that eliminate human involvement.

Since 2016, the number of BC applications developed by start-ups is growing, providing innovative solutions that cover a large number of areas that are going to change the economic and business landscape, turning BC into a momentous technological player

COMBINING BLOCKCHAIN AND AI

As discussed, blockchain is a groundbreaking technology permitting the safe and reliable storage and transmission of data, among other advantages. AI, on the other hand, is a revolutionary technology that can learn on its own, by analyzing and discovering patterns in massive amounts of data.

As depicted in **Figure 1**, there is a natural complementarity between the two, since BC safely stores/transmits trustworthy data while AI requires huge amounts of

Figure 1. Integrating BC and AI
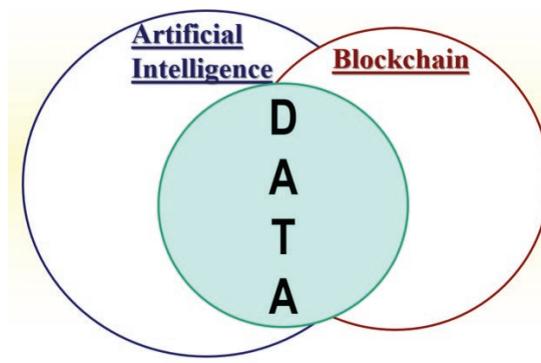
such data to discover patterns and learn. In this section, I discuss the complementarity between the two technologies and consider the breakthroughs that could result from their marriage. The potential benefits will be felt in medicine, autonomous vehicles, the Internet of Things (IoT), smart contracts, DAOs, and additional applications—many not yet conceived.

Once operational, each AV will be issued a unique number recording its position and enabling **rich interconnections** among all other AVs in the vicinity. These connections carry the potential to reduce or avoid traffic jams, and they determine the optimal means to reach desired destinations. Novel ways to encourage ride sharing will also become available: the position and destination of every AV will

Eventually, AVs equipped with smart BC contracts will be fully autonomous, receiving payments, disbursing funds for recharging their batteries, paying toll-road fees and whatever other expenses are required, while also distributing their remaining profits to their owners.

Autonomous Vehicles (AVs)

AVs are probably the most advanced AI application to date and may have the greatest potential for disruptive change. Waymo, Google's driverless-car company, is now running its autonomous minivans around Phoenix, Arizona with no human to grab the wheel if things go bad. According to Waymo's CEO John Krafcik, it took Google a mere eight years to go from its experimental AVs to a "fully driverless car interacting with the world, all of the other human-driven cars, pedestrians, and cyclists and other things that are on the road at the same time." Waymo plans to expand its AVs to other cities and eventually the world.

The advantages of integrating blockchain and AI for AVs are threefold: improved *security*, assurance of rich network *interconnections* among all AVs on the road, and *autonomous function* with minimal human interference.

Security is an issue for all network applications. For AVs, breaks in security can mean vehicle theft, sabotage of operations, or even loss of control resulting in terrorist attacks against pedestrians. If AVs are to be utilized on a grand scale, these serious problems must be eliminated. BC technology can minimize the possibility of hacking and, through sophisticated encryption, will eventually eliminate the dangers of malicious interference.

be viewable on the devices of potential passengers, maximizing usage and reducing traffic jams and pollution.

Eventually, AVs equipped with smart BC contracts will be fully autonomous, receiving payments, disbursing funds for recharging their batteries, paying toll-road fees and whatever other expenses are required, while also distributing their remaining profits to their owners. Plausibly, AVfleets (owned by firms or individuals) will be organized and operated as DAOs, minimizing expenses and reducing the usage costs, conceivably revolutionizing transportation, car ownership, and energy costs while mitigating pollution. Owning an AV may well be a source of income in addition to its owner's transportation.

Internet of Things (IoT)

Using blockchain, the IoT can interconnect devices embedded in everyday objects so they can send and receive data rapidly and automatically. However, it will generate massive amounts of data, which must then be utilized to optimize some desired parameter or objective.

Optimization can be done using big data and machine learning (the subject of two other articles in this issue of *Foresight*). The current number of applications is limited, but the possibilities are endless. Venture capital is being invested in numerous new start-ups, particularly in the areas of smart homes, cities, grids, and structures where "smart" implies some

way of utilizing the information from the IoT devices to optimize a desired end. Further down the road, IoT utilization will expand to the Virtual Environment of Things (VEoT), which would incorporate virtual and augmented reality to sense and enhance the environment of users.

The revenues for IoT are expected to pass the $3 trillion mark by 2025 and reach $12 trillion by 2030, with more than 125 billion connected devices by this time. Thus, there will be many future IoT applications involving start-ups, as well as established firms like Amazon, hoping to capture part of the pie.

Supply Chain

Supply-chain applications can profit from the marriage of blockchain and AI. BC is currently used to reduce paperwork, diminish bureaucracy, eliminate fraud, and speed up inspections in order to save money and effort in the process. The need for letters of credit is removed, as BC ensures the physical existence of goods.

AI is utilized to optimize scheduling and improve the planning of supply-chain activities. New AI applications are envisioned to enable automatic ordering of raw material and parts as well as their authentication and tracking within the supply chain.

Utilization of smart contracts can further extend BC's value by specifying how things should be implemented once certain conditions have been satisfied, including the timing of payments. Smart Contracts can implement AI's contribution by enacting modifications when permanent changes in the environment have been confirmed. Similarly, there are significant improvements that can be made using AI for optimizing scheduling, reducing transportation costs, and minimizing inventory levels.

INTELLIGENCE AUGMENTATION

AI effectively outsources intellectual tasks to machines, while the goal of intelligence augmentation (IA) – also called

intelligence amplification – is to develop systems in which machines work collaboratively with humans to improve human capabilities. "Instead of just fretting about how robots and AI will eliminate jobs, we should explore new ways for humans and machines to collaborate," says Daniela Rus (2017), the director of MIT's Computer Science and Artificial Intelligence Lab. Moreover, she refers to a study by Harvard researchers that compares the ability of expert doctors and AI algorithms to diagnose cancer: while doctors performed such diagnoses better than algorithms, the expertise of doctors using AI was better still.

The value of IA is easily seen in games like chess where the "centaur" concept—half human, half computer—is being advanced. Like the mythical centaur (half human and half horse) the world chess champion was neither a computer nor a human but a human using a computer. In such play, the human is in charge of strategy and the computer responsible for the tactics as well as verifying the correctness of possible moves. The centaur played by Steve Crampton and Zackary Stephen won the chess championship in 2005, beating both grand masters and sophisticated computer programs.

Chess and Go programs sometimes make highly creative moves, initially surprising grand masters. But after due study, the masters can incorporate such moves into their own games, increasing their power and creating more exciting tournaments.

By harnessing the speed and memory of computers, there is nothing to prevent people from being able to beat the most advanced chess/Go program. The centaur idea is supported by *Moravec's Paradox*, which states that "it is comparatively easy to make computers exhibit adult-level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility."

The same is true for strategy, where humans excel, and tactics, where computers possess a great advantage. IA can naturally amplify human intelligence by exploiting AI's considerable tactical benefits and people's strategic intelligence.

Future developments should focus on finding innovative ways to turn AI into IA, working toward a symbiosis of humans and machines rather than an adversarial face-off in a lose/lose competition. This symbiosis will reduce the perceived danger that one day AI will end human supremacy. We have little reason to doubt that humans will learn to tap the power of computers to augment their own intelligence.

Voice commands that request information and eventually direct brain-to-computer links will likely make the keyboard obsolete and, more important, have the potential to make us smarter than any human who's ever lived. Three steps would be required for this to happen, according to Michael Anissimov (*https://io9.gizmodo. com/humans-with-amplified-intelligence- could-be-more-powerf-509309984*).

- Creation of a direct neural link to all available information stored in the computer—the equivalent of a "telepathic" Google—that would tell us whatever we would want to know but also process this information at lightning speed.
- Building of a Brain-Computer Interface (BCI) that would augment our visual cortex, the best-understood part of our brain.
- Genuine augmentation of our prefrontal cortex, enhancing the way we combine perceptual data into concepts, thus achieving hitherto impossible intellectual feats.

This vision of intelligence augmentation may seem impossible at present, but could become reality, maybe by the end of this century or sooner.

Another "science fiction" application with the potential to infinitely expand our intelligence involves Brain Emulation (or Em), which aims to upload a human brain into a computer where it will live forever on its own or be transferred into a robot. *https://www.ibc.org/tech-advances/ dr-hanson-super-intelligent-machines-will- make-the-world-a-better-place/2347.article*

I will write about more of these speculative/fantastical technological developments in the final part of this article. If IA progresses at the same or even faster pace than AI, we will experience a new world of unlimited possibilities, incredible advances, and no fear that we will become the pets of robots. Instead, we will turn into the kind of super-intelligent beings we have seen in *Star Trek*.

In the fifth and final installment. I'll present 10 emerging technological trends and extrapolate them to consider their impact on our lives, work and organizations. Some long-term predictions may seem like science fiction today, but they have a chance of becoming reality down the road.

With the passage of time, science fiction, it seems, is becoming reality at a faster and faster rate.

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