ABSOLUTDATA
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BRAINWAVE

DATA SCIENCE DIGEST

5TH EDITION

Q1 2021

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"If Big Data is the quantity, Blockchain is the quality." – Maria Weinberger

Dear folks

Warm greetings from the Data Sciences team for the novel beginning of 2021!

Due to the unanticipated rise in remote collaboration like never before (thanks to the unfortunate pandemic), most of the professionals feel the need of a technological enablement which ensures transparency, efficiency, real-time collaboration and optimal trade-off between decentralization & centralization in terms of data access. Now, owing to the work-from-home flexibility, the workplace (permanent or otherwise) of each digital nomad has metaphorically become a branch of their organization, which reinforces the need of such enabler all the more significantly.

Technological disruptions like Big Data and Blockchain are going to redefine the best practices for the business we do now. Blockchain technology shot to distinction with the growing popularity of digital currencies (e.g. bitcoin). However, today it has found relevance not only in recording cryptocurrency transactions, but also recording anything of interest.

Blockchain is simply a chain of blocks, where digital information ('block') is stored in a public database ('chain'). The numerous blocks store information about transactions, users with unique proxy IDs (e.g. digital signature), and the cryptographic codes that differentiate between any two distinct blocks. Besides, the network of these blocks also checks for the verity of the information intended to be stored. Each computer in the blockchain network has its own copy of the blockchain, which means there are numerous copies of the same blockchain. Thus, with blockchain, there is not a single definitive account of events that can be mutated or manipulated. Instead, a hacker would need to manipulate every copy of the blockchain on the network, which is nearly impossible due to the huge amount of computing power that will be required. If a block is changed, it will have implications on all the subsequent blocks as well, making it impossible for the change to go unnoticed [1]. Thus, a **Blockchain is a secured, transparent, distributed, decentralized, and immutable digital ledger.**

Now, here are some relevant questions for us:

- Why is Blockchain touted to be the future of Data Science?
- What are the use cases for which these technologies can be brought under one roof?
- What will be synergistic output, if Blockchain and Data Science are used on the same corpus of information?

Big Data, Blockchain and Data Sciences may seem to have different use cases, but their relevance and applications do find a substantial intersection. Blockchain has already established evidence and confidence in the fields like fintech (e.g. federated fraud analytics), legal studies (e.g. land deeds), healthcare (e.g. medical records), and supply chain for its utility, while the rest of the industries are catching up and exploring ways to marry these three disciplines. The potential of synergy of these technologies is poised to manifest itself big time. As and when various other industries come of age and explore, more concrete use cases are likely to crop up and pave the way for data science to reap the lion's share of the windfall.

With the aid of blockchain, data sciences can be applied in a fragmented fashion. **Federated Learning is one of the adaptations of blockchain technology in data science.** Federated learning (also known as collaborative learning) is a decentralized machine learning approach that trains an algorithm across the multiple decentralized edge devices or servers holding local data samples, without exchanging their data samples. This approach stands in contrast to the traditional centralized machine learning techniques, where all data samples are uploaded to one server, as well as to more classical decentralized approaches which assume that local data samples are identically distributed [2].

The prime advantage of using federated approaches to machine learning is to ensure data privacy. Indeed, no local data is uploaded externally, concatenated, or exchanged. Since the entire database is segmented into local bits, this makes it more difficult to hack into it. With federated learning, only machine learning parameters are exchanged. In addition, such parameters can be encrypted before sharing between learning rounds to extend privacy [3].

However, the applications of Blockchain may turn out to be an expensive affair, due to the cost of storing big data in blocks. It will be interesting to observe how the evolution of blockchain pans out and overcomes such drawbacks. In the meanwhile, let us be party to this paradigm shift and contribute to the community, through conducting and broadcasting POCs, small-scale implementations etc. within our specializations!

Hope you find this edition of BrainWave informative and inspiring too!

Abhimanyu Saraf
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[2] Federated Learning – Wikipedia

[3] Sattler, Felix; Müller, Klaus-Robert; Samek, Wojciech (4 October 2019). "Clustered Federated Learning: Model-Agnostic Distributed Multi-Task Optimization under Privacy Constraints"

Contents

Blockchain Security

Statistictionary

Introduction

Blockchain technology was first described in the 1990s; the aim was to timestamp digital documents so that it was not possible to backdate them. However, the technology gained popularity with its application in Bitcoin in 2009.

Blockchain is a distributed, decentralized, public ledger; it's the record-keeping technology behind the Bitcoin network. As the name indicates, a blockchain is a chain of information-containing blocks. Once data has been stored inside a blockchain, it becomes very difficult to make unauthorized changes to it. Blockchain's distributed and decentralized nature have made it a very popular technology, although it still faces the same main issues as any technology, namely usability, security, and trustworthiness.[1]

Is Blockchain Secure?

Each new user transaction creates a new block in the chain and the blockchain is updated in its network of thousands (or millions) of computers. This distribution of information across such a large network makes it very hard to manipulate. If someone wishes to alter a particular transaction in a block, they will need to manipulate copies of the blockchain in more than 50% of the network's computers. This defines the "distributed" ledger property of blockchain.

Public-Key Cryptography

Despite all the transaction information on a blockchain being public, personal information for any user is limited to their digital signature or username. Each participant has a "wallet" through which they run all their transactions, and each wallet is equipped with two different cryptographic keys: a public key and a private key. The public key is what appears in the transaction ledger, tagging the transaction to the user. However, the user needs the private key to withdraw their bitcoins. The public key is derived from the private key using complex algorithms, and the process is almost irreversible – i.e. you cannot generate a user's private key from his public key, hence ensuring the safety of the user's wallet.[2]

The mathematics behind blockchain is highly complex and relies on Elliptical curve cryptography to ensure that a transaction is secure. The members make use of the **Elliptic curve digital signature algorithm (ECDSA)** each time they make a transaction.

General Equation [3]

Elliptic curve: $y^2 = x^3+ax+b$

For Bitcoin: $y^2 = x^3+7$ (a=0 and b=7)

One of the properties of the elliptic curve is that a non-vertical line passing through two points on the curve would also intersect on a third point.

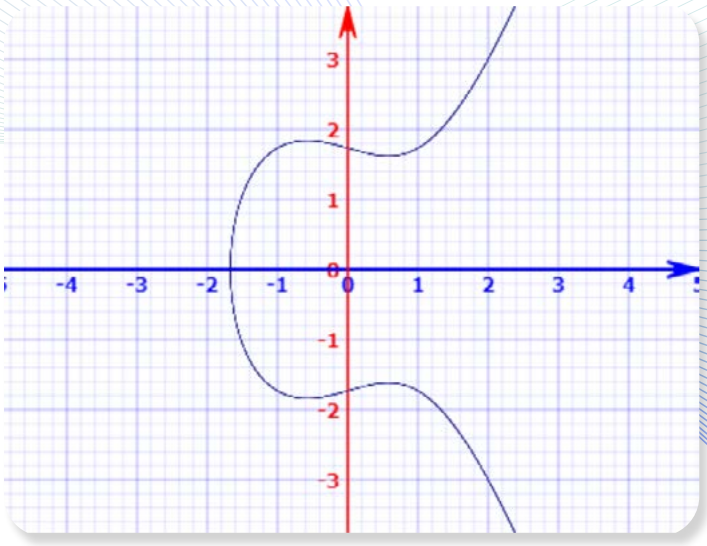

Figure 1: Elliptic Curve [3]

- If you want to add two points on an elliptic curve, you first draw a line through the two points. When you find the point where the line intersects the curve for the third time, you reflect the third point on the x-axis; this will give you the addition of the first two points.

  Therefore, P+Q = R.

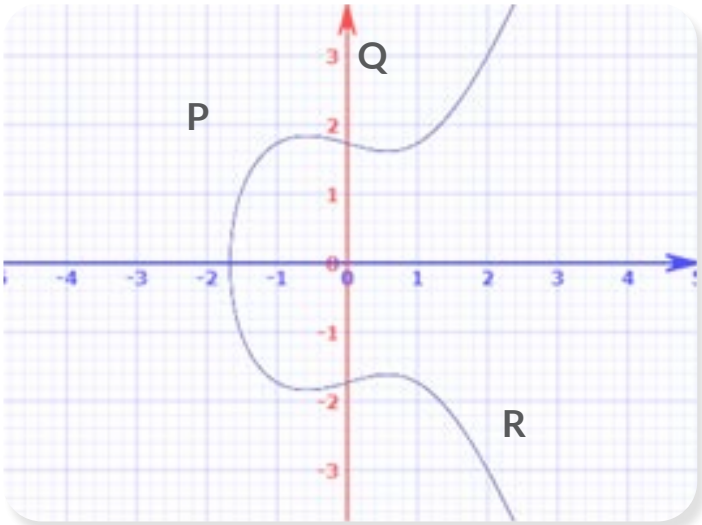

Figure 2: Elliptic Curve – Addition of two points [3]

- To do Elliptic curve cryptography efficiently, rather than the aforementioned addition of random points, we specify a base point on the curve and only add that point to itself.
  - If we have an initial point P, the reflected point will be 2P. We can continue to compute 3P, 4P, and so on. If we think about it, how many steps will it take to compute 10P?
  - In general, 10P = P+P+P+P+P+P+P+P+P+P, i.e. a 9-step operation.
  - However, since the property nP+rP = (n+r)P holds, we can also compute 10P in this manner:

$$\left.\begin{array}{l} 1P+1P = 2P \\ 2P+2P = 4P \\ 4P+4P = 8P \\ 2P+8P = 10P \end{array}\right\} \textbf{4 steps}$$

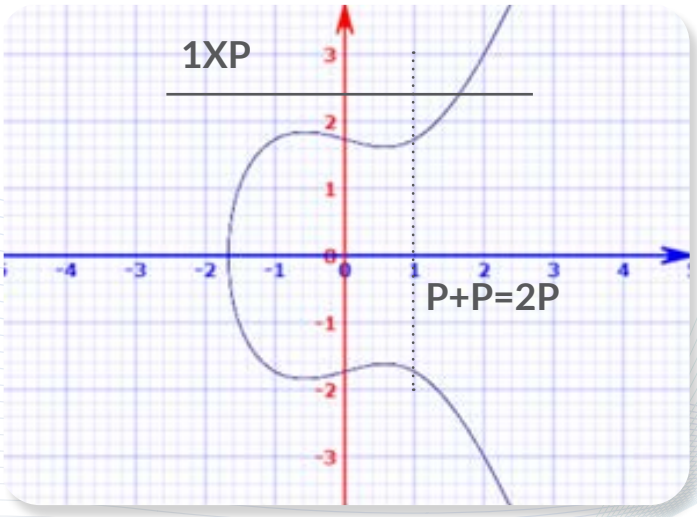

Figure 3: Elliptic Curve – Addition of base point [3]

Accordingly, how many steps would be required to compute xP, where 'x' is a random 256-bit integer that ranges from 0 to a very high integer?

It turns out computing xP would never require more than 510 step operations.

Since elliptic curve cryptography does not support a 'division' function, in the equation X = xP we cannot calculate 'x' given 'X'. It makes sense to assign 'x' to be a private key and 'X' to be a public key. Your private key would then be a 256-bit integer, whereas your public key would be the x and y coordinates on the elliptic curve. It would then be computationally impossible to arrive at your private key from your public key.

Conclusion

We can safely say that the mathematics involved in the generation of security keys is very complex and is not trivial. We have also seen that it is easier to arrive at a user's public key from their private key than vice-versa. ECDSA is the underlying essence of how all blockchain applications work. [3]

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Building Blocks of Blockchain in Python

Coder's Cauldron

Background

Blockchain has found application in numerous fields, including cryptocurrency, banking, supply chain management, and healthcare. Simplistically speaking, blockchain enables data to be embedded in a digital code and stored in transparent and shared databases in a way that is secure and cannot be tampered with, deleted, or revised.[1]

Let us assume that we have been asked to create a blockchain that can store cross-border transactional data. Donning your coder's hat, you could start with the following five building blocks to implement a blockchain in Python:

1. Storing data in blocks

The data inside a blockchain is stored in the JSON format. This data is often referred to as "transactions"; these transactions are stored in blocks, where a block might contain more than one transaction.

```
class Blck:
    def __init__(self, ind, transacts, timestmp):
        self.ind = ind
        self.transacts = transacts
        self.timestmp = timestmp
```

Every block would have a unique block ID (index in the above code).

2. Hashing the blocks

The purpose of a hash function in blockchain is to ensure that the data in the chain cannot be meddled with. This function takes data as input and produces another piece of data (also called "hash") of a fixed size as output. The hash is produced in a way that it becomes impossible for someone to detect the input from the hash.[2] One of the hash functions in Python is sha224(). Its implementation is as follows:

```
import hashlib
strr = 'blockchn'
res = hashlib.sha224(strr.encode())
print(res.hexdigest())
```

This hash function can be kept inside the existing Block object to ensure that the data inside the block is secure.

3. Linking the blocks together – Step 1

Since a blockchain is meant to be a collection of blocks, we must ensure that blocks are linked in a specific order and this order cannot be compromised. To achieve this, every block is associated with a "previous hash" – i.e. the hash of the previous block. Since the first block does not have any preceding block, it is called a "genesis block". [3]

```
class Blckchn:
 def __init__(self):
     self.chn = []
     self.create_gen_blck()
   def create_gen_blck(self):
     gen_blck = Block(0, [], time.time(), "0")
     gen_blck.hash = gen_blck.compute_hash()
     self.chain.append(gen_blck)
```

4. Adding a nonce variable – Step 2

A nonce is a variable that can be changed until we get a hash with some pre-defined constraint. This would make the task of calculating the hash from the input difficult and random.[3] A simple implementation could be:

```
blck =123
  nonce = 0
  df ='SAM'
  prevHash = pp
  fnd =0
   while fnd ==0:
       zz = str(blck) + str(nonce) + df + prevHash
       newHash = hashlib.sha256(zz.encode()).hexdigest()
      if newHash[:3]='000':
           fnd =1
      nonce+=1
```

5. Putting additional blocks in the chain – Step 3

To add a block to the chain, we first keep a function to verify the integrity of the data present. The next step is to make sure that the previous hash field of the added block is the last block that was present in our blockchain.[3]

```
class Blckchn:
  def add_blck(self, blck, prf):
    prev_hash = self.last_blck.hash
    if prev_hash != blck.prev_hash:
      return False
    if not Blckchn.is_valid_prf(blck, prf):
      return False
   blck.hash = prf

self.chain.append(blck)
return True

 def is_valid_prf(self, blck, blck_hash):
    return (blck_hash.startswith('0' * Blckchn.difficulty) and
          blck_hash == blok.compute_hash())
```

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[1] The truth about Blockchain

[2] Develop a blockchain application from scratch in Python

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Visualizing the Blockchain Network

Vivid Visualization

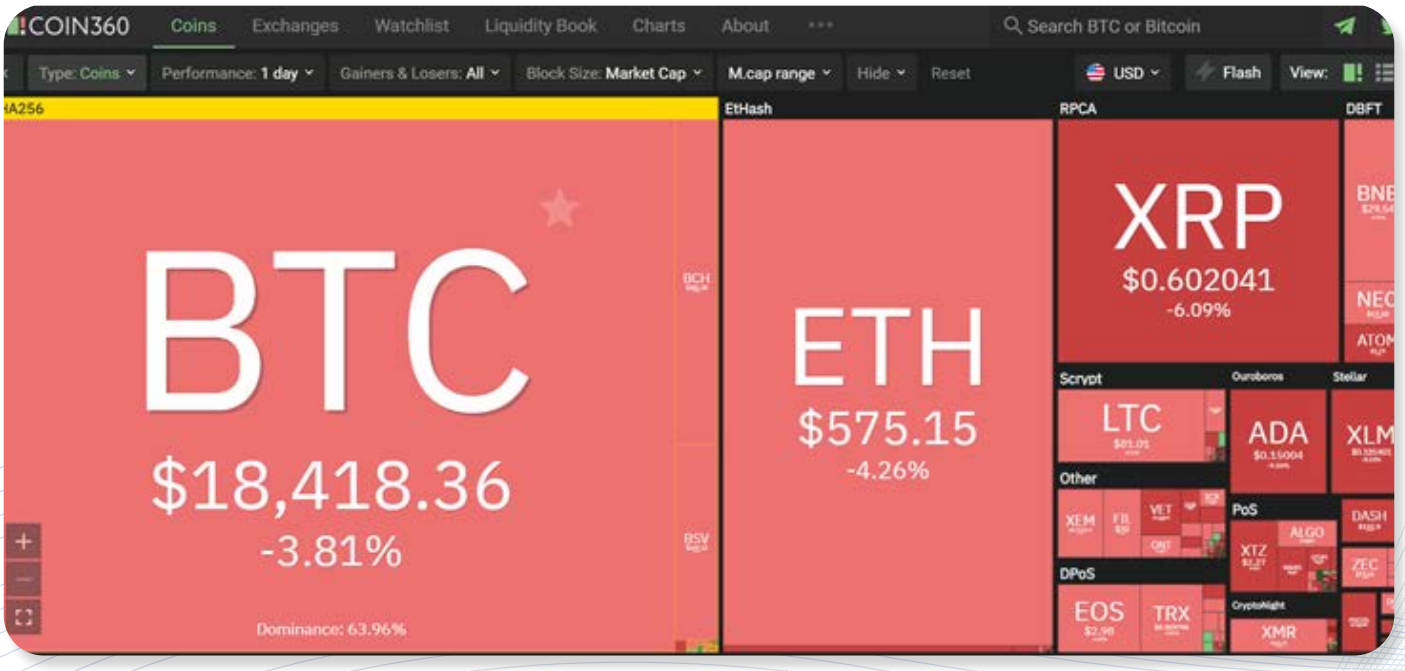
Background

One of the fundamental pillars of blockchain is transparency, and this transparency allows us to access a whole range of data about the blockchain network to create vivid data visualizations.

Bitcoin and Ethereum are the biggest applications of blockchain technology. Thus, most of the interesting visualizations we will talk about here make use of their networks; however, most of these visualizations can be ported to other blockchain applications as well.

Market Capitalization and Volume

The main page of the website coin360.com has a live heatmap of different cryptocurrencies' market capitalizations. The colors of the blocks signify market movement: red for price decline, green for price rise, and gray for price stagnation. The size of the block corresponds to the market capitalization of each currency. The heatmap gives us an interesting perspective of the data generated by cryptocurrencies and shows us which currencies dominate the cryptocurrency ecosystem. [1]



Recent History

Given that blockchain technology is completely transparent, we can view all the transactions in real-time. The site ethviewer.live takes this real-time data and visualizes the 24 most recent blocks of the Ethereum blockchain. The multiple transactions that make up each block are represented as circles inside the block. The circles behind the blocks are the transactions that are waiting to be included into the block.

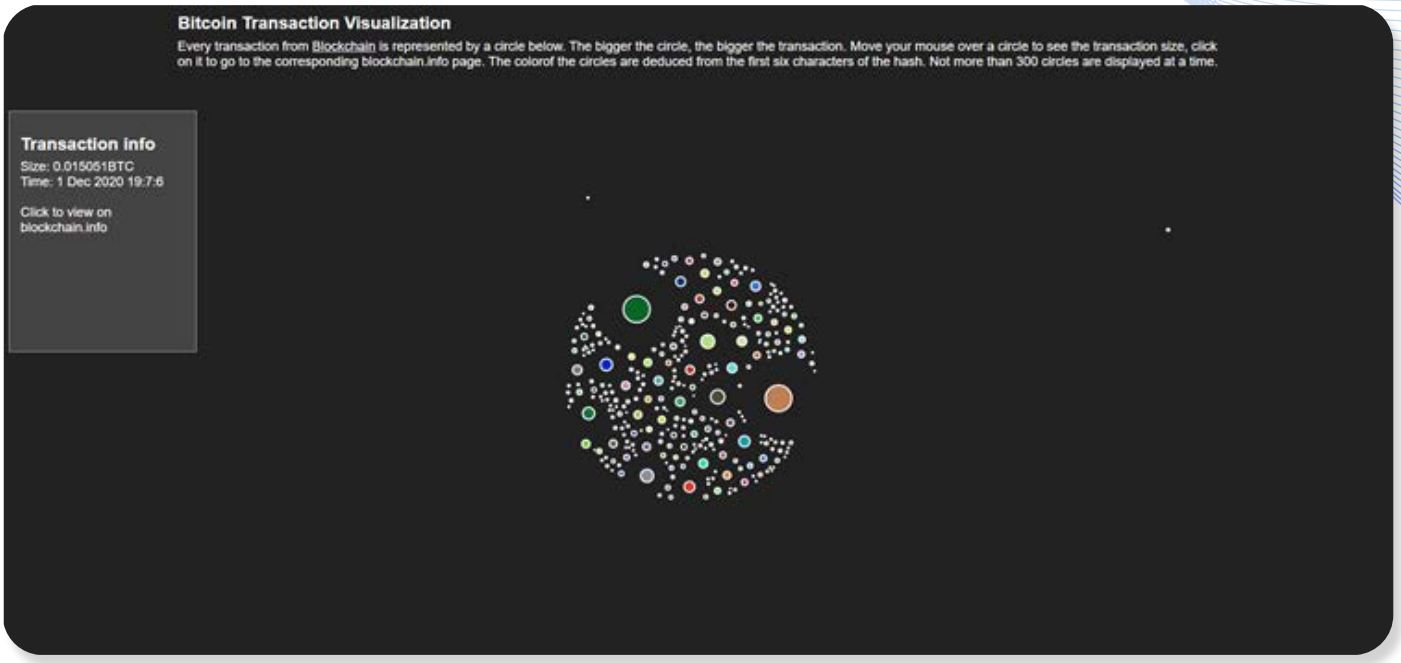
Ethviewer shows an animation whenever a waiting transaction is assigned to a block. By clicking on any transaction, you will be directed to the relevant etherscan.io page, where you can view more information about that transaction.[2]

Network Maps

In the Bitcoin network, a node is any program or computer that fully validates transactions and blocks. Bitnodes.io finds all these nodes in the network and estimates the size of the Bitcoin network. This website shows a live map of all the reachable nodes, which allows us to get a high-level view of where most transactions are being validated. [3]

Live Transactions

The website bitcoin.interaqt.nl, like ethviewer, visualizes Bitcoin transactions, but here the size of each circle represents the size of the transaction. Again like ethviewer, you can click on a transaction to open the relevant blockchain.info page and view additional information about it. [4]



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[1] https://coin360.com/

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[3] https://bitnodes.io/nodes/live-map/

[4] http://bitcoin.interaqt.nl/

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Adaptation of Blockchain in New Domains

Thriving Traction

Introduction

Blockchain has disrupted the world since it was first practically recognized in its Bitcoin implementation, and it continues to be adapted to a number of industries. In the bigger scheme of things, the idea is undemanding; it makes use of simple computing powers to secure communications through systems in a decentralized network. It follows a peer-to-peer network, so that some important information remains strictly between the entities that maintain and contribute to that information.

Using Blockchain has its fair share of advantages that would appeal to business executives; these include:

- Reducing the involvement of third-party companies.
- Less reliance on third-party companies to secure the technical infrastructure.
- An auditable, cost-effective mechanism that that resists changes to previously maintained digital records; this virtually ensures that documents/information are not tampered with.

If there is one obstacle in the way of blockchain's mass recognition and appreciation, that would be its scalability. Sectors like finance and banking have made blockchain part of their daily process. As one would imagine, these industries have a whole lot of data that needs to be processed each day. While blockchain resolves the security issue, processing large amounts of data is also a must for its wide acceptance. But just like all technologies, Blockchain is evolving to overcome the challenges that it currently faces.

The Emerging Technological Trend – Blockchain

Personally identifiable information, notarized documents, financial and medical records, tax collection, cross-border payments … wherever you need transparency and safety in dealing with sensitive information, blockchain is an efficient one-stop solution. That may sound like a sales pitch, but it pretty much speaks for itself. Let's briefly explore some of the emerging and adapted applications of blockchain.

Artificial Intelligence integrations with Blockchain

The introduction of AI into blockchain will significantly improve the development process of any AI-integrated decision-making application. By storing the computation process and the computed variable in its ledger system, blockchain will give the ability to record and trace why certain decisions are made by a Machine Learning model. [1]

We touched upon the scalability of blockchain and how it can be a hurdle when dealing with a large amount of data, but AI can improve the efficiency with which a blockchain is executed and maintained. Needless to say, this will be a happy marriage.

Blockchain as a Service (BAAS)

BAAS provides the technological infrastructure to create a blockchain application in the Cloud. [2] Just as Salesforce provides all the tools and functionality needed for marketing, BAAS allows the user to create smart applications that leverage blockchain without having to deal with its setup process. Amazon is one of the technical giants providing Blockchain as a Service.

Blockchain and the Internet of Things (IoT)

IoT works on the principal of devices communicating within a network. In other words, it is a centralized, unsecured system with a single point of failure. [3] The emergence of IoT into homes and workplaces can thus pose a serious cybersecurity threat. Network hacking is becoming more commonplace; using blockchain to hold pertinent information such as sensory trigger data between devices, decentralized network protection and mine-proof record maintenance will be of prime importance for IoT deployments.

References

[1] Blockchain and AI

[2] Top Emerging Blockchain Trends

[3] Blockchain technology in 2020

Authored by

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Can We 'Trust the Process'?

Folk-Wisdom's Fallacy

The Blockchain Revolution

The revolution in technology consists of massive developments in the IT space that are leveraging the advancements made in electronic and digital architecture to showcase their actual capabilities. There are some that even say that the biggest leap in this revolution has been made by blockchain – that this is even beyond that of Big Data, machine learning, IoT, drones, and robotics. [1]

Blockchain is being considered as the second generation of the 'Internet of Information'. However, it's the general utility of blockchain that piques interest among critics, particularly in the way it addresses the most common misconceptions of day-to-day users. What misconceptions?

- Our mobile phones are private devices.
- To develop trust in the economy, intermediaries (e.g. banks, recordkeepers, etc.) hold the utmost importance in registering the day-to-day activities of all citizens.
- Large government expenses that are claimed to go towards the welfare of the country cannot be scrutinized.

Understanding or Undermining?

Every intermediary that may be serving a pivotal role towards the growth of our economy also has an underlying problem – one that is becoming very evident through re-targeting/re-marketing tactics. Think about sales calls that establish direct contact with potential customers on a regular basis; all of this is due to the data that is being captured and employed by the systems that record intermediary transactions. Our privacy is being undermined, and we are unsure of the extent of it.

Hack at the Highest Level

When, as customers, we use a software service or a mobile/web application, we generally assume that the software developers have put encryption mechanisms in place. We assume that they're safe from cyber-attacks.

This is true for the most part, but to manage a massive number of users from all over the world, companies often use a centralized server; all the information is saved in one place only. Companies such as Home Depot, LinkedIn, and JP Morgan (among others) suffered the consequences of this in the worst way possible, when their users/clientele were badly impacted due to the general information storage architecture they employed. [2]

In Blockchain, such information would only float from one peer to the next, with different systems storing different sets of transaction information. Thus, information potentially is spread all across the world, with each system/block having its own specific encryption.

How Safe Are We?

We all cannot be tech gurus, but we can't ignore the simple fact that the economy is the health status of a country that is heavily reliant on the information gathered through keeping exhaustive tabs on its people. We can only hope that this information is kept and distributed safely. And this is the conquest that is trying to be achieved by blockchain.

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[1] The Blockchain Revolution

[2] Data Breaches

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Blockchain into Action

Experience Extended

What does a future with Blockchain look like?

Bitcoin is one of many Blockchain applications. Blockchain technology has made its way through financial services, and many other industries are starting to benefit from it. Tracking products and legal documents, attributing media files, and verifying user identities have all been listed as Blockchain applications.[1]

The wide range of possible Blockchain applications have the potential to bring some transformative changes to society. Let's look at several key areas.

Electronic Voting Systems

Many electronic voting systems have inherent design issues; for example, a centralized design that means one supplier oversees the code base, the database, and the monitoring tools. Given today's political climate, it is very important to build and maintain voters' trust. This is where Blockchain can make a difference; it can function as a secure transaction database, giving visibility to the logging and auditing of votes.[2]

Follow My Vote is one initiative that uses Blockchain technology. Its goal is to "build a secure mobile voting platform that will allow for greater election transparency and increase accessibility to the polls on Election Day". [3]

Cybersecurity

Today, our lives almost seem dependent on digital devices; from making a bank transaction to ordering a pizza, we spend most of our time surrounded by our smartphones. This has brought a lot of comfort and ease to our lives, but at the same time it exposes us to much larger security risks. Thus, strong cybersecurity systems are the demand of the hour.

Blockchain can very efficiently fill the gap by providing us the perfect system to protect our digital lives from external threats. It could create an impenetrable wall between legit users and hackers. Transparent ledgers can store user biometrics, which could ultimately provide password-free data access. Since data will be stored in a decentralized format, it will be present in the form of small blocks, which leave very little vulnerable to hackers. Since all the data entries are visible to every member in the chain, any misadventure can be easily tracked. A cluster of all these features make Blockchain an indispensable technology for cybersecurity.

Preventing Piracy

It has been observed that one of the biggest villains for the entertainment industry is piracy. In the Internet era, a single copy of a movie can be distributed to the entire world with just a click. Blockchain can put an end to this. To draw an analogy, think of Bitcoin; no one can use your bitcoin balance but you, and similarly Blockchain can be leveraged to ensure only the right people get access to the right content. [4] This would be a great milestone for the entertainment industry.

Real Estate

In real estate, land records that date back more than 10-20 years have to be found in massive public logs that are stored in government buildings; this makes finding and tracing land deeds a very complex process. Moreover, it is very inefficient and prone to human error. Blockchain can be a great blessing in this sector, due to its transparent and distributed log system. Any errors that a person made 50 years ago can be easily traced in the Blockchain system.

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[2] Using the Bitcoin Blockchain for secure, independently verifiable, electronic votes by Pierre Noizat

[3] Follow My Vote - A secure mobile voting platform that will allow for greater election transparency and increase accessibility to the polls on Election Day.

[4] 5 Future Uses for Blockchain by Eric Reed

Authored by

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Privacy and Computational Control Through Blockchain

Food for Thought Experiment

Blockchain's capabilities find their implementations and applications in multiple domains, including (but not limited to) finance, tourism, social media, digital technology, and healthcare. Blockchain also enables data scientists to get more reliable data and use the capabilities of distributed computing. [1] Additionally, open-source communities like OpenMined provide the capabilities to run experiments on a blockchain environment.

Data Reliability

Blockchain improves the end-to-end process of data handling, including collecting data, enabling data traceability, and supporting real-time data analysis. It helps guarantee data quality, as this technology can bypass intermediate sources of data error.

Distributed Computing

When analyzing huge amounts of data, individuals rely on Cloud computing options (e.g. GCP and Azure services). However, decentralized computing through blockchain would reduce the computation cost and would eliminate the need for third-party vendors. [2] The Ethereum-based Golem project is one such experiment that would give users the power to purchase computing resources from people with idle computers.

OpenMined – Data Science Project

OpenMined's goal is to make the world's data more private and secure. Specifically, this open-source community is lowering AI's entry barriers by allowing persons and companies to host private datasets that data scientists can use for training or querying but cannot access.

OpenMined uses extended PyTorch, Tensorflow, and Keras capabilities in its two libraries: [3]

- PYSYFT, which enables Python-based machine learning with remote execution, federated learning, and encryption.
- PYGRID, which allows entities to host their data in the Cloud.

Traditionally, data science is limited to centralized computation, usually on a single cluster. OpenMined enables us to create a machine learning model that can be governed by multiple users and trained on an unseen dataset. This allows data scientists to train their models remotely, without actually having access to the data, by using Federated learning and on-device prediction. [3] Encrypted computations enable secure computations on foreign environments, and a differential policy helps control the level of access that you may need in the final predictions; these could be statistical results or predictions of the model.

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[2] Blockchain projects on Github

[2] PYSYFT and PYGRID Library Code Documentation

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Data Science Competitions/ Seminars / Fora / Courses

Online Courses:

1. Blockchain Essentials v2

Platform: Cognitive Class

Fees: Free

Time to Complete: 3 hours

2. Blockchain and Deep Learning: Future of AI

Platform: Udemy

Fees: Free

Time to Complete: 1 hour 21 minutes

3. Blockchain A-Z™: Learn How To Build Your First Blockchain

Platform: Udemy

Fees: 6 USD (can vary)

Time to Complete: 14 hours 42 minutes

4. Digital Transformation: From AI and IoT to Cloud, Blockchain, and Cybersecurity

Platform: MIT, USA

Fees: 2300 USD

Time to Complete: 6 Weeks

5. Coursera Courses on Blockchain

Conferences/Events:

1. AI and Blockchain Summit

Organiser: Convergence India 2021

Location: Pragati Maidan, New Delhi, India

Dates: 24-26th March 2021

Agenda: Exhibition, Conference

2. AIBC Manila Summit

Organiser: AIBC

Location: SMX Convention Centre, Manila

Dates: 27th-28th May 2021

Agenda: Conferencers and Workshops,

Emerging Tech Startup Pitch,

AI & Blockchain Awards

3. World Crypto: Bitcoin, Blockchain & Cybersecurity 2021

Organiser: STAR conferences LLC

Location: Virtual conference from Toronto, Canada

Dates: 4th March to 5th March 2021

Agenda: Conference on future impacts of Bitcoin and Blockchain

4. EAI International Conference on Safety and Security in Internet of Things

Organiser: EAI SaSeIoT

Location: Pragati Maidan, New Delhi, India

Dates: 25th April 2021

Agenda: Conference on Safety and Security in IoT

Paper Submission Deadline - 30 November 2020

Competitions:

1. Blockchain and AI Hackathon

Host: TH.0

Date: November 21

Location: Virtual

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Thank You

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