

“Blockchain for AI: Review and Open Research Challenges”

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Outline of Presentation

1. Abstract
2. Introduction
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4. Blockchain Enabled AI Applications
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- Recently, AI and Blockchain are most trending and disruptive technologies.
- Blockchain has the ability to automate payment in the form of cryptocurrency (Bit-Coin, Ethereum etc.) from one person to another person.
- These transactions are decentralized, secure and trusted manner without use of third party.
- On the other hand, AI offers intelligence and decision making capabilities for machines to humans.
- In this paper, they present a detailed survey on blockchain application for AI and discuss open research challenges of utilizing blockchain technologies for AI.

I. Introduction

- In Blockchain, every transaction is cryptographically signed and verified by all mining nodes.
- Artificial Intelligence which allows a machine to have cognitive functions to learn, adapt based on data collections.
- The Decentralized AI has been recently emerging technology, **Decentralized AI is basically a combination of AI and Blockchain**[8].
- Decentralized AI enables to process and perform analytics or decision making on trusted, digitally signed, and secure shared data.
- This Share data has been store on the Block Chain, in distributive, decentralized fashion without the use of third party.
- Recent Market research predicts that AI market will grow up to 13 trillion USD by the year 2030.

Introduction (cont.)

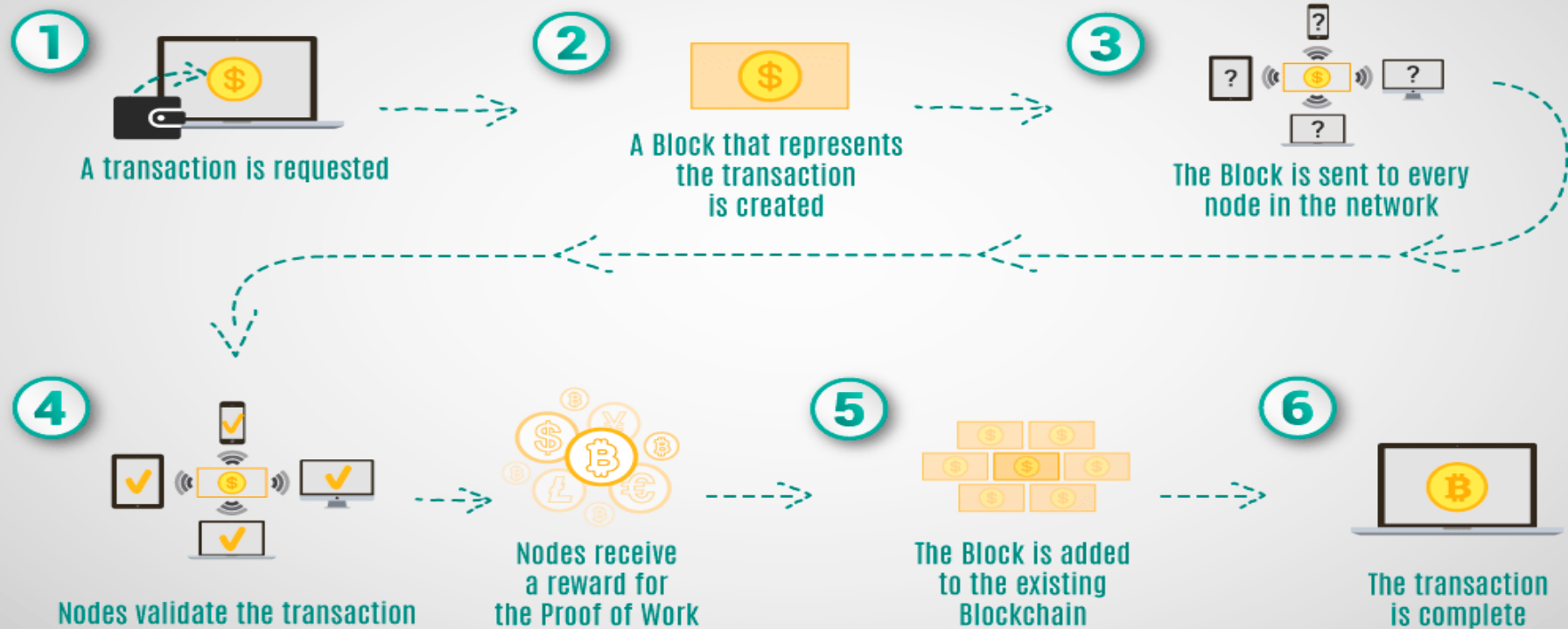
- The primary contribution of this paper summarized as follows:
 1. They give an **overview of blockchain basics and key features** and how these features can be use for AI.
 2. They discuss **how the integration of AI and Blockchain can help in developing a new ecosytem of decentralized economy** and key benefits.
 3. They present a **detailed taxonomy of blockchain platforms, architecture, infrastructure types and consensus protocols**, along with existing decentralized applications.
 4. They identify **open research challenges in adopting blockchain features for future AI applications**.

II. Background

A. Blockchain:

1. Basically Blockchain is a chain of blocks that make up the ledger, this ledger holds a permanent records of transactions and intercatons among participants accessing the distributed and decentralized blockchain networks.
2. Each block contains the details of transaction, asset exchanges(Bitcoin), current hash value and hash value of previous block.
3. Conventional blockchain is very expensive medium for storing large amout of data.
4. For solving this problem, a decentralized storage medium is used for storing such data and hashes of the data are linked with the blockchain blocks(Smart Contract Code)

HOW BLOCKCHAIN WORKS



Background (cont.)

B. Artificial Intelligence:

The field of AI research defines itself as the **study of Intelligent agents** (Any Device perceives environments or I/P and takes action or processing and give maximize its chance of success at some goal).

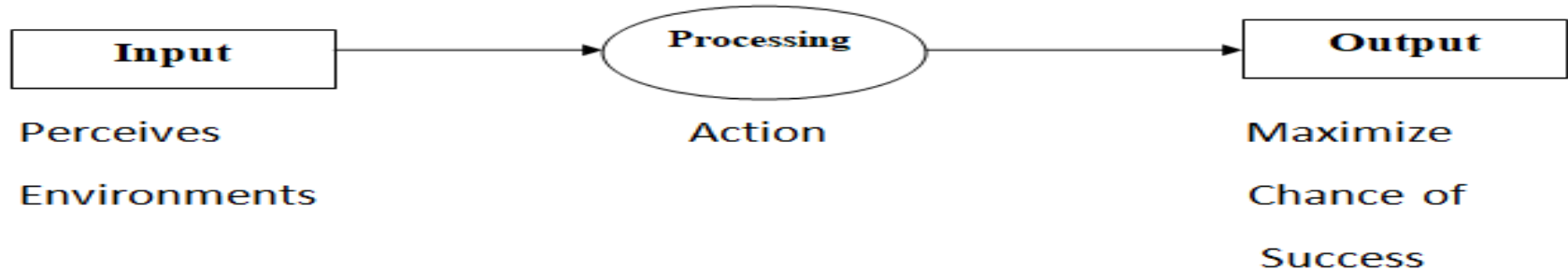


Table 1. Latest in trends AI Applications and Benefits of using Blockchain

Trends	Objective(s)	Applications	Blockchain Benefits
Explainable AI [9], [30]	Designing trustworthy and interpretable transparent AI algorithms to know why the algorithm is reaching a specific decision	- Healthcare - Military - Autonomous Vehicles	- Trust - Tracing Executions - Reliability
Digital Twins [31]	Translating data and intelligence from complex physical systems into applications and simulations in digital world	- Wind Turbines - Aircraft Engines - Offshore Vessels	- Trust - Provenance - Reliability
Automated Machine Learning [32]	Automating the whole process of machine learning from raw data acquisition to knowledge management in order to reduce manual work and faster application development	- Big Data Analytics - Industry 4.0 Systems - Massive Production of Intelligent Devices	- Permanence - Immutability
Hybrid Learning Models [33]	Combining different machine learning models to reach better informed decisions	- Real-time - Decision-agnostic - Data source-agnostic	- Trust - Provenance - Performance
Lean and Augmented Data Learning [34]	Enabling transfer learning among different AI applications to ensure high availability of relevant and accurate data	- Low data availability applications	- Trust - Provenance - Reliability

C. How Blockchain Can Transform AI

Table2: Key features and benefits of Blockchain integration with AI

Blockchain	AI	Integration Benefits
- Decentralized - Deterministic - Immutable - Data Integrity - Attacks Resilient	- Centralized - Changing - Probabilistic - Volatile - Data-, Knowledge-, and Decision-centric	- Enhanced Data Security - Improved Trust on Robotic Decisions - Collective Decision Making - Decentralized Intelligence - High Efficiency

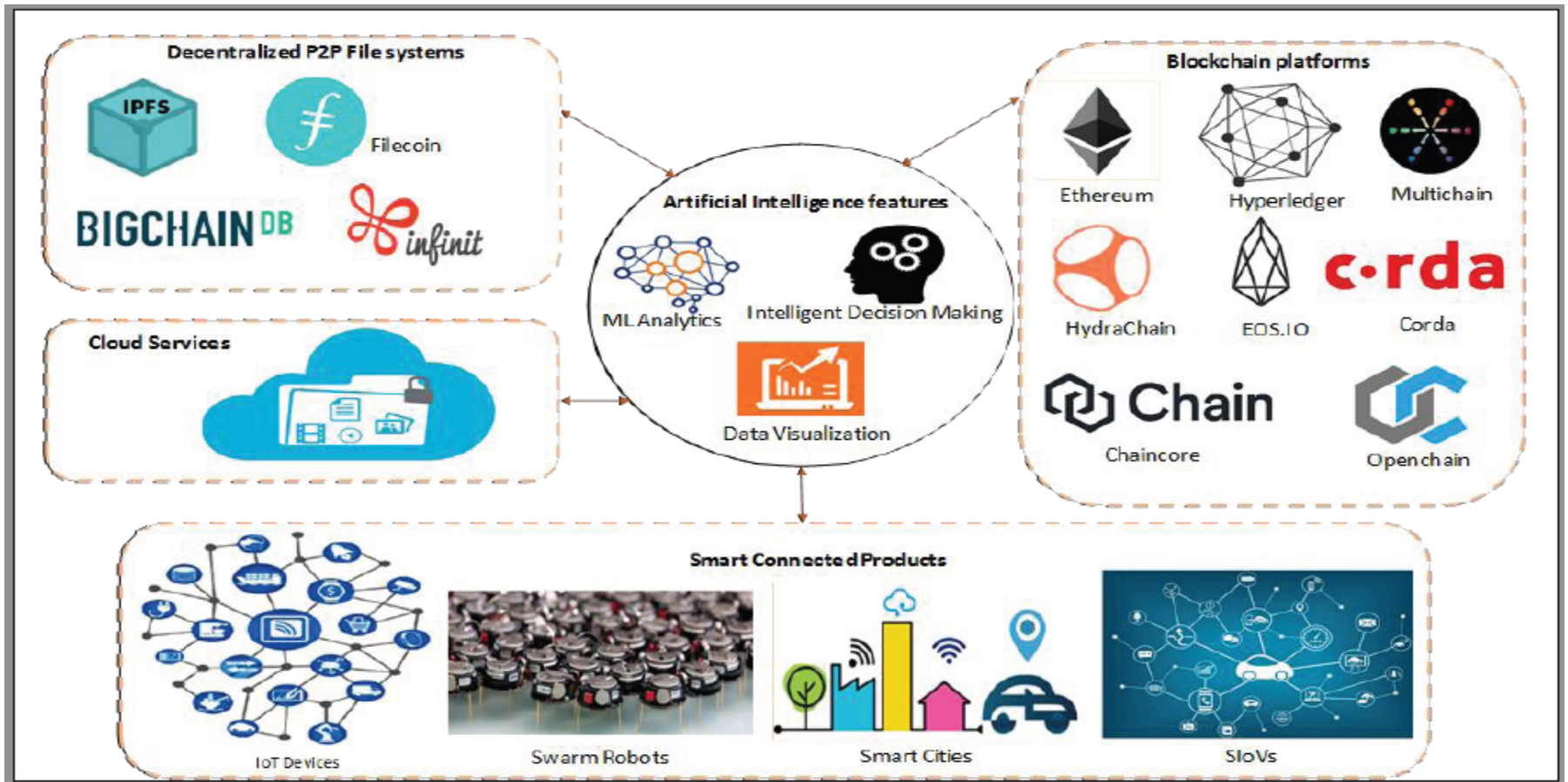
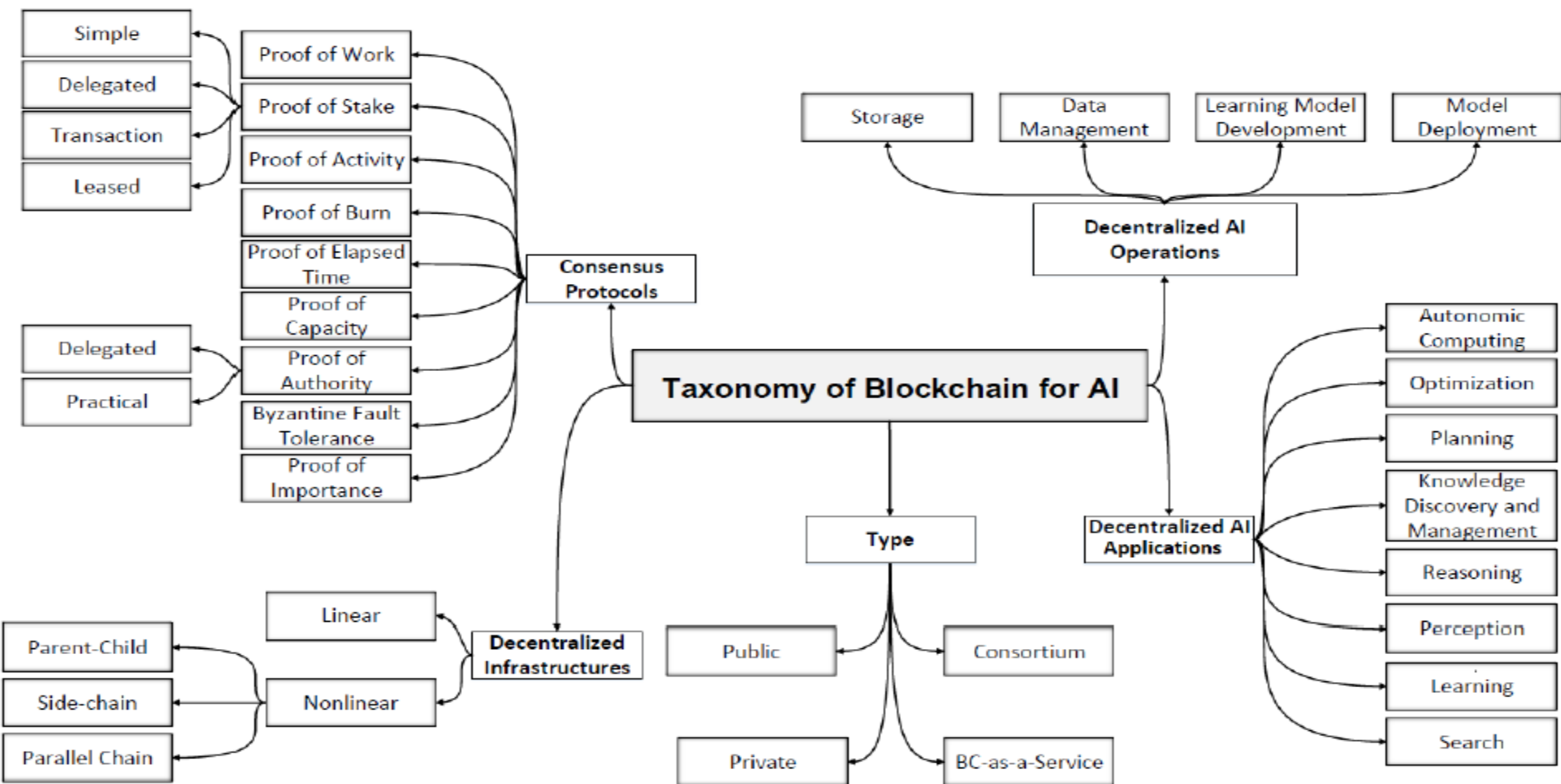


FIGURE 1. An overview of AI systems and features in relation to Blockchain and IoT-enabled ecosystems

III. Taxonomy of Blockchain for AI



A. Decentralized AI Applications

AI Applications operate autonomously in order to perform informed decision by different planning, search, optimization, learning, knowledge discovery and knowledge management strategies:

1. **Autonomic Computing** : provide fully or partially autonomous operations whereby multiple intelligent agents perceive their constituent environments, internal states and specified actions accordingly.
2. **Optimization**: Finding a set of best solutions from all possible solutions is one of the main features of AI enabled applications and systems.
3. **Planning**: help in operational efficiency and systems by taking current input state, use rule based algorithm to reach predefined goal.
4. **Knowledge Discovery and Knowledge Management**: support for centralizes big data processing systems
5. **Perception**: The decentralized perception strategies can facilitate the collcting of data frm different views.

6. **Learning:** The decentralized learning can help on achieving highly, distributed and autonomous learning systems.
7. **Searching:** The search strategies are designed by considering different factors such as completeness, complexity, optimality.
8. **Reasoning:** logic Programming is an essential component of AI applications that allow to develop inductive or deductive reasoning rules to reach decisions.

B. Decentralized AI Operations

1. **Decentralized Storage:** Storj, Swarm, Sia, Filecoin, IPFS(Interplanetary File System)
2. **Data Management:** Highly relevant, accurate, complete datasets are collected from reliable data source easily by Decentralized AI.
3. **Learning Model Development:** Understand the environment from current data and perform informed decision making based on new data.
4. **Model Deployment:** Model deployment in centralized systems is a straightforward iterative process., it is a challenge for this so we can use decentralized model deployment.

C.Blockchain Types for AI Applications

Table3. Key features and benefits of Blockchain platforms

Platform	Type	Architecture	PL
Achain [70]	Public	Parallel Chain	Glue
Ardor [71]	Public, Consortium	Parent-child Chain	Java
Azure Blockchain Workbench [72]	Consortium	BaaS	Java Script, Solidity
Bitcoin [4]	Public	Single Chain	C++
Blocko CoinStack [73]	Private	Single Chain	Java, Node.js, Rest API
Chain Core [74]	Private, Consortium	Single Chain	Java, Node.js, Ruby
ChainKit by Pencil Data [75]	Private, Public	BaaS	API
Corda [76]	Open Source	Single Chain	Java
Credits [77]	Public	Single Chain	Java
Elements [78]	Open Source	Sidechain	Python, C#
Eos.io [79]	Open Source	Single Chain	C++
Ethereum [11]	Public, Open Source	Single Chain	Solidity
HydraChain [80]	Private, Consortium	Parallel Chain	Python
Hyperleadger [81]	Private, Consortium	Single Chain	C++, Solidity
IOTA Tangle [82]	Public	Direct Acyclic Graph	Python, Node.js
Multichain [83]	Private	Mainchain, Off-chain	C++, API
Nxt Blockchain [71]	Public, Consortium	Single Chain	Java
Quorum [84]	Private, Consortium	Single Chain	-
SAP Leonardo [85]	Private, Consortium	BaaS	Java
Stratis [86]	Private, Consortium	Main Chain, Sidechain	C#

D. Decentralized Infrastructure for AI Applications

- **Linear Infrastructure**

Traditional blockchain architecture were designed as linear infrastructure based on the combination of linked list data structures and hashing strategies.

- **Nonlinear Infrastructure**

However , Nonlinear infrastructure based on graph theory and queue, it is used on real time applications and handle the big data.

E. Role of Consensus Protocols for AI Applications

1. PoW(Proof of Work)

- Pioneer consensus protocol proposed by Satoshi Nakamoto.
- For validating any transaction, at least 51% miners will solve a complex and random mathematical problems and break the hash code to read transaction on the blockchain.
- High energy consumption.
- Increase delay.

2. PoS(Proof of Stake)

- PoS protocols work by defining big stakeholders on blockchain networks and create new blocks.
- These protocol select the validators based on some criteria(random validators, delegated validators, validators holding coins for longer period).
- Solve high energy consumption issue.
- Useful for delay tolerant AI applications but not use for streaming data, real time informed decisions.

3. **BFT(Byzantine Fault Tolerance)(Majority Voting Algorithm)**

- Malicious nodes are already part of the blockchain but malicious intent code that can directly/indirectly lead to incorrect validations and corrupt the data stored on the blockchain.
- Handles fault tolerance by enforcing digital signatures and restricting communications between peer nodes.

4. **PoAc(Proof of Activity)(PoW + PoS)**

- Initially works on empty blockchains using PoW algorithm and solve 51% attack problem.
- PoAc solves complex mathematical problems and validators start receiving reward which increase their stack on blockchain.
- Provide more security, storage and data availability.

5. PoB (Proof of Burn)

- It allows the validators only if they can spend their coin by sending to public, verifiable, unspendable, invalid address.
- Once users burn their coin, they are create new blocks and get reward.
- Balance No. Of Coins by burning coin strategy.
- Solve energy consumption problem

6. PoET(Proof of Elapsed Time)

- Find leader who can create the new block on the chain.
- The leader node creates the new blocks and transmits its signature to the whole network.
- PoET protocols continuously execute the random leader selection algorithm and find new leader all the time.
- Solve energy consumption problem by random timer assignment.

7. PoC(Proof of Capacity)(Proof of Space)

- Discovery the hard drive space on the nodes of the blockchain network.

8. PoA(Proof of Authority)

- Suitable for Private Network, means use centralized authority.
- PoA Protocols solve the problem of dependency in PoS whereby validators must have monetary stack on the blockchain.

9. PoI(Proof of Importance) (Rank Wise)

- The validators with high frequency get more importance on the blockchain.
- It is used in public blockchain AI applications.

Table 4. Consensus Protocols used by Blockchain Platforms

Platform	PoW	PoS	BFT	PoAc	PoB	PoET	PoC	PoA	PoI
Achain [70]	✓	✓	✓	✗	✗	✗	✗	✗	✗
Alfa-Enzo [97]	✗	✗	✗	✓	✗	✗	✗	✗	✗
Ardor [71]	✗	✓	✗	✗	✗	✗	✗	✗	✗
Azure Blockchain Workbench [72]	✗	✗	✗	✗	✗	✗	✗	✓	✗
Bitcoin [4]	✓	✗	✗	✗	✗	✗	✗	✗	✗
Blocko CoinStack [73]	✓	✗	✗	✗	✗	✗	✗	✗	✗
BurstCoin [98]	✗	✗	✗	✗	✗	✗	✓	✗	✗
Chain Core [74]	✗	✗	✗	✗	✗	✗	✗	✓	✗
ChainKit by Pencil Data [75]	✓	✗	✗	✗	✗	✗	✗	✗	✗
Corda [76]	✗	✗	✓	✗	✗	✗	✗	✗	✗
Credits [77]	✗	✓	✓	✗	✗	✗	✗	✗	✗
Eos.io [79]	✗	✓	✓	✗	✗	✗	✗	✗	✗
Ethereum [11]	✓	✓	✗	✗	✗	✗	✗	✗	✗
HydraChain [80]	✗	✗	✓	✗	✗	✗	✗	✗	✓
Hyperledger [81]	✗	✗	✓	✗	✗	✓	✗	✗	✗
IOTA Tangle [82]	✓	✗	✗	✗	✗	✗	✗	✗	✗
Multichain [83]	✓	✗	✗	✗	✗	✗	✗	✗	✗
NEM [99]	✗	✗	✗	✗	✗	✗	✗	✗	✓
Nxt Blockchain [71]	✗	✓	✗	✗	✗	✗	✗	✗	✗
Quorum [84]	✗	✓	✓	✗	✗	✗	✗	✗	✗
SAP Leonardo [85]	✓	✗	✓	✗	✗	✓	✗	✗	✗
SlimCoin [94]	✗	✗	✗	✗	✓	✗	✗	✗	✗
Stratis [86]	✓	✓	✗	✗	✗	✗	✗	✗	✗

IV. Blockchain-Enabled AI Applications

A. Decentralized Data Storage and Management with AI

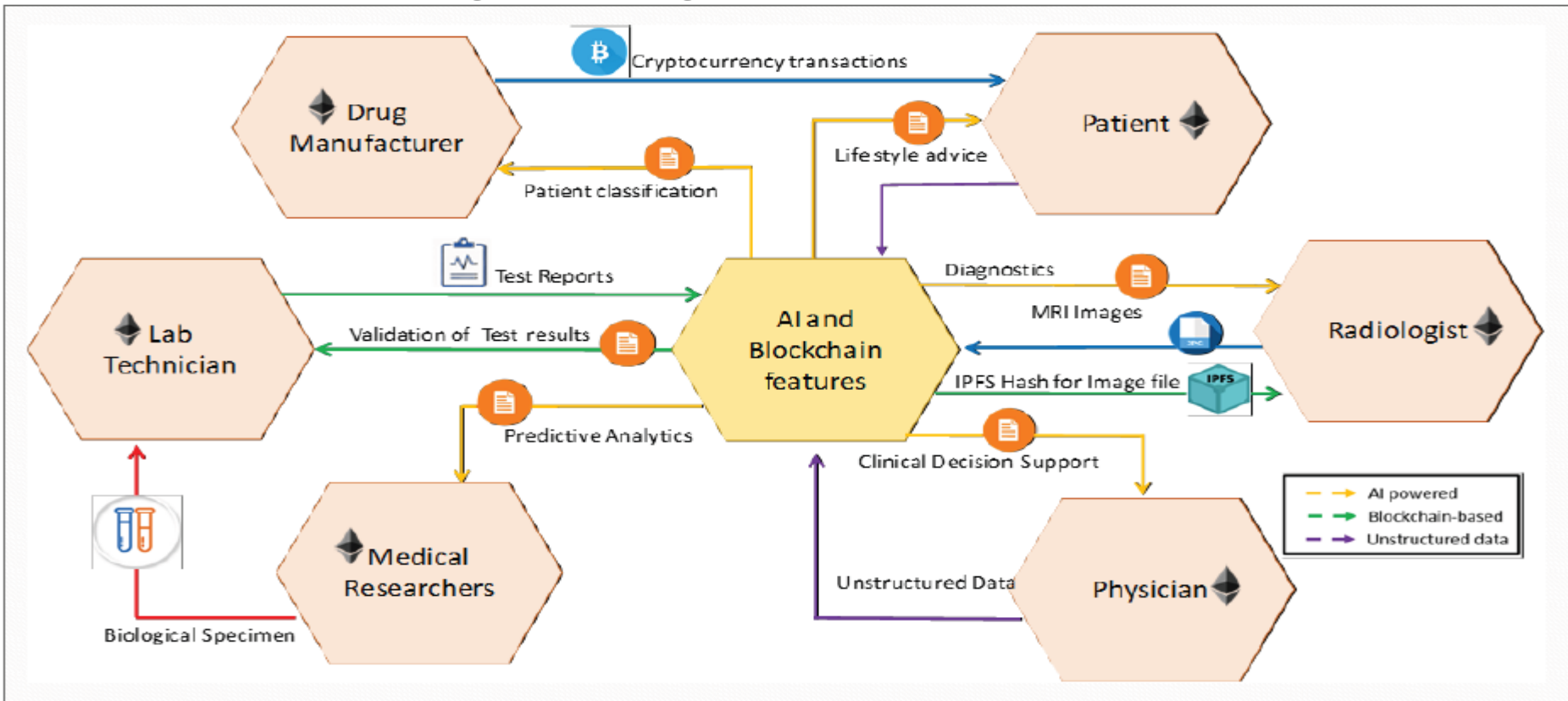


FIGURE 3. Collective intelligence for decentralized healthcare

B. Decentralized Infrastructure for AI

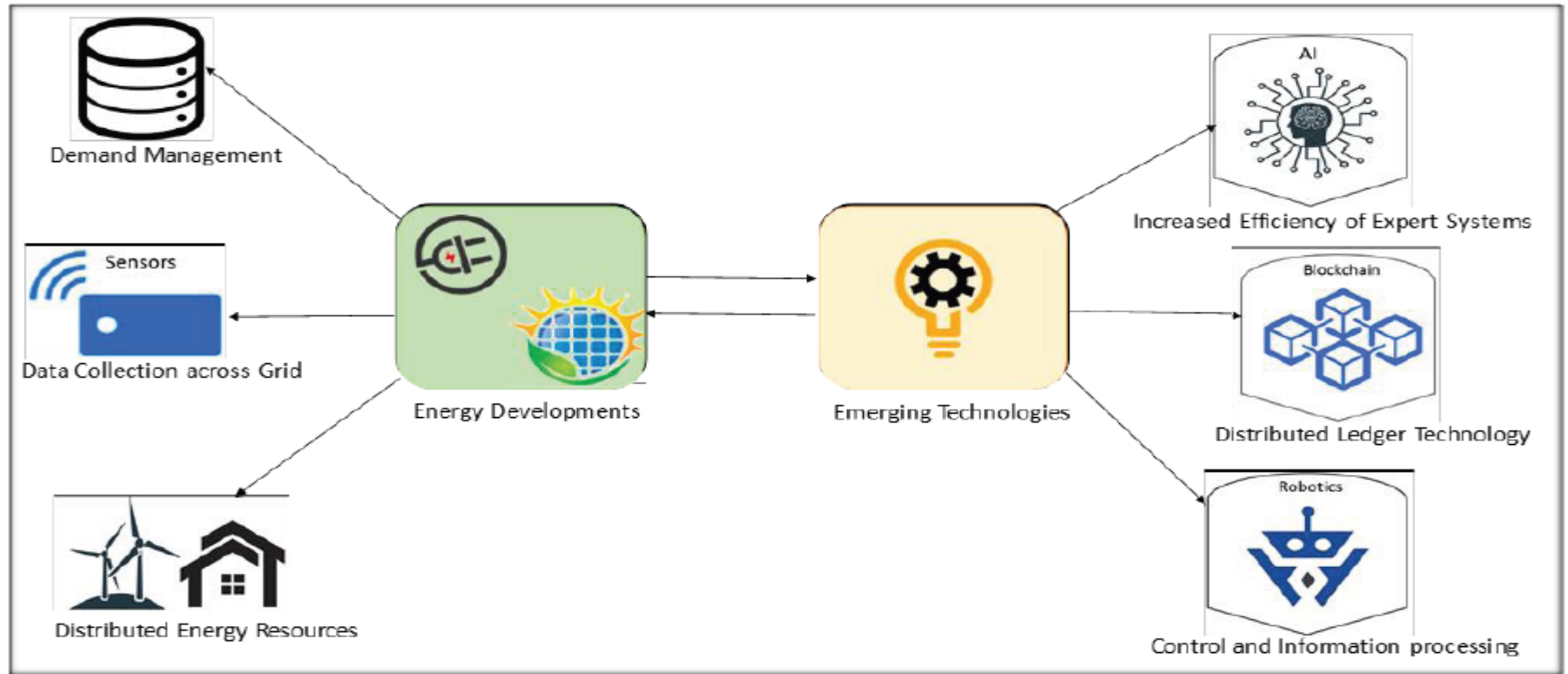


FIGURE 4. Future energy industry leveraging capabilities of blockchain and AI

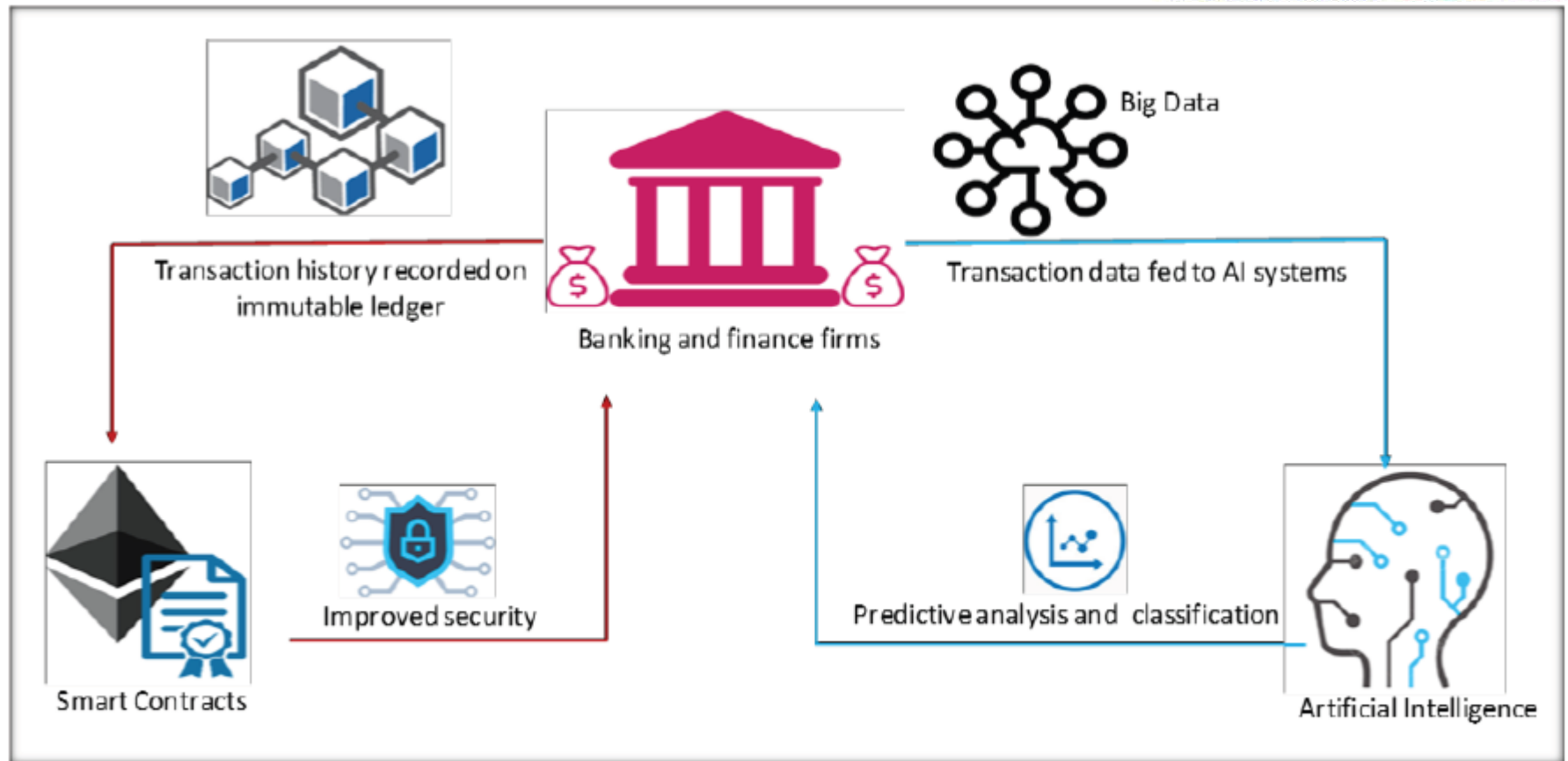


FIGURE 6. Combining AI and blockchain for banking and finance

V. Open Research Challenges

- Privacy
- Scalability and Side Chains
- Blockchain Security
- Smart Contracts vulnerabilities and Deterministic Execution
- Trusted Oracles
- Fog Computing Paradigm
- Lack of Standards, Interoperability and Regulations
- Quantum Computing
- Governance

- In this paper, they surveyed and reviewed the current state- of-the-art related to the use and applicability of blockchain features for AI.
- They gave an overview of blockchain and decentralized storage on how blockchain technology can enhance and solve key issues related to AI.
- They presented a detailed taxonomic discussion and comparisons of common block chain implementations in terms of decentralized AI operations, blockchain types and infrastructure, and consensus protocols.
- Various features of AI for Blockchain applications are also summarized.

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- [12] K. SALAH, M. H. REHMAN, N. NIZAMUDDIN, and A. Al-Fuqaha, “ Blockchain for AI Review and Open Research and Challenges” IEEE Access in 2019.

Opinion and Suggestions

It is a two different concepts

1. Blockchain for AI
2. AI for Blockchain

In this paper, they present detailed survey on Blockchain Application for AI.

But Blockchain have also some issues

- Security measurement
- Attacks
- Accuracy
- Smart Contract Vulnerability
- Scalability

So we can survey on AI for Blockchain and Blockchain for AI in IoT.

Research work	Year	Technological Aspects	Blockchain for AI	AI for Blockchain	Open research issues
Kshetri et al.[4]	2017	Blockchain + IoT	Yes	No	Limited
Banarjee et al.[5]	2017	Blockchain + IoT	Yes	No	No
Li et al. [6]	2017	Blockchain	No	No	Yes
Zheng et al. [7]	2017	Blockchain	Limited	Limited	Yes
Atlam et al. [8]	2018	IoT + AI	Limited	Yes	Limited
Reyna et al. [9]	2018	Blockchain + IoT	Limited	No	Yes
Qian et al.[10]	2018	Blockchain + IoT	Yes	Limited	Limited
Swan et al. [11]	2018	Blockchain + AI	Limited	Yes	Limited
Lin et al. [12]	2018	Blockchain + IoT	Limited	Limited	No
Wright et al. [13]	2018	Blockchain + IoT + Edge Computing	Limited	Limited	No
Lu et al. [14]	2018	Blockchain	No	No	Yes
Salah et al. [15]	2019	Blockchain + AI	Yes	No	Limited
Ours	-	Blockchain + AI + IoT	Yes	Yes	Yes

Thanks

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