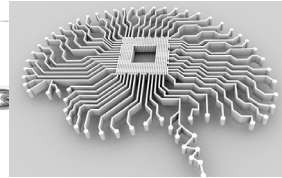# Extending Blockchains with AI for Risk Management

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Distinguished Global Indian Speaker Series talk at Amity University, India

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Slides and Video Recording of this talk are at:

http://www.cse.wustl.edu/~jain/talks/pbc_amity.htm

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Overview

1. Strength of Blockchains

2. Weaknesses of the blockchains

3. Extending Blockchains: Converting data to knowledge

4. Applications of Knowledge Chains

What is a Blockchain?

1. Satoshi Nakamoto invented Bitcoin

2. He used blockchains to make it decentralized

3. Since then blockchains have found numerous other applications

4. Blockchains allow two complete strangers to enter into a smart contract without a trusted third party.

5. This talk is about blockchains <u>not</u> about Bitcoin.

Example of a Contract: Wedding

http://www.cse.wustl.edu/~jain/talks/pbc_amity.htm
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Wedding (Cont)

❑ **Centralized**

❑ Decentralized

❑ Centralized registry

❑ Single point of failure

❑ Easy to hack

❑ Decentralized

❑ No single point of failure

⇒ Fault Tolerant, No Monopoly

❑ Very difficult to hack

Examples of Centralized Systems

❑ **Banks**: Allow money transfer between two accounts

❑ **City Records**: Wedding registers, Property ownership

❑ **Networks**: Certificate Authorities, DNS

❑ In all cases:
  ➤ There is a central third party to be trusted
  ➤ Central party maintains a large database ⇒ Attracts Hackers
  ➤ Central party may be hacked ⇒ Affects millions
  ➤ Central party is a single point of failure.
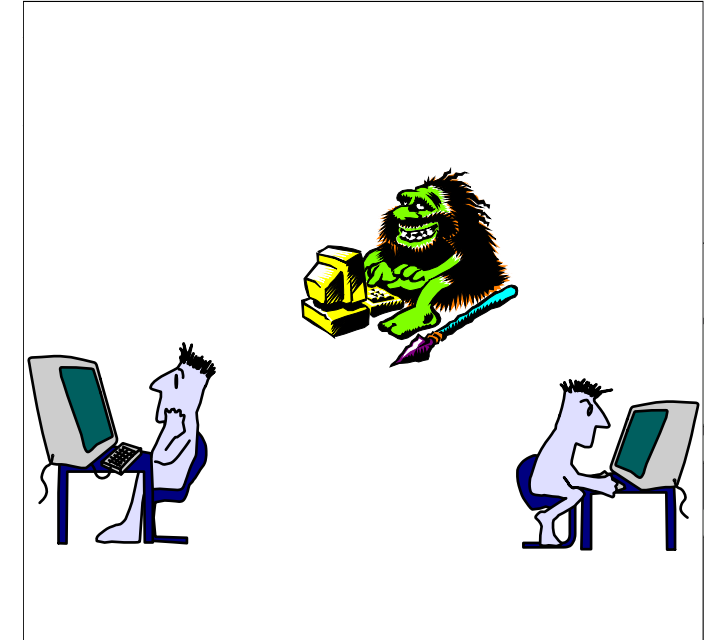   Can malfunction or be bribed

Trend: Decentralized ⟹ Centralized ⟹ Decentralized

Decentralized

Industrialization ⟹ Centralized   COVID ⟹ Decentralized

Time is a cycle: Decentralized vs. Centralized debate

Key Strengths of Blockchains

1. **Distributed**: No single point of failure

2. **Decentralized Consensus**: Transactions valid only if agreed by majority

3. **Trustless**: Transacting or processing parties do not need to trust

4. **Cryptographic Security**: Elliptic Curve Cryptography

5. **Non-Repudiation Guarantee**: All transactions are signed

# Can the Blockchains be Enhanced?

Limitation 1: Only facts are recorded

❑ Alice is married to Bob

❑ Alice gave 20 coins to Bob

❑ Alice signed a contract with Bob to pay 10 coins for 1 kg of xx.

Limitation 2: Binary Validity

❑ All transactions recorded on the blocks that are committed are valid

❑ Those not on the committed blocks and old are invalid

❑ So the recording is binary: only 0 or 1.

0
False
Invalid

1
True
Valid

Limitation 3: Deterministic Events only

❑ Can not record that I am only 90% sure that Alice gave 20 coins to Bob.
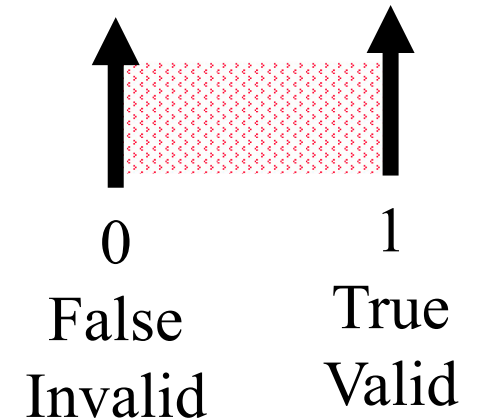
Ideas to Enhance Blockchains

❑ Blockchain is just a distributed **data storage** of valid transactions

❑ All transactions are *deterministic*

❑ What's Wrong?

  ➢ Need to convert data to knowledge

  ➢ We are in big data and machine learning age

  ➢ Real life is probabilistic

  ➢ Most to the decisions we make are probabilistic
    ⇒ All decisions have some risk
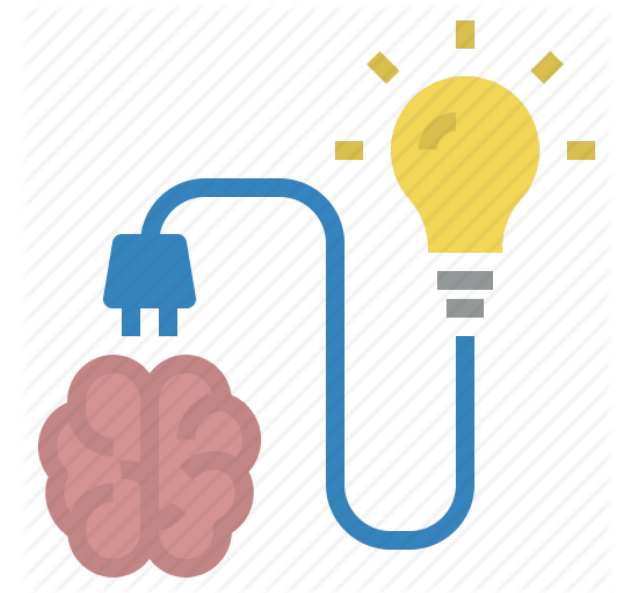
Decisions with Risk

❑ Sell insurance

❑ Buy insurance

❑ Sell a stock

❑ Buy a stock

❑ Download a software application on your computer
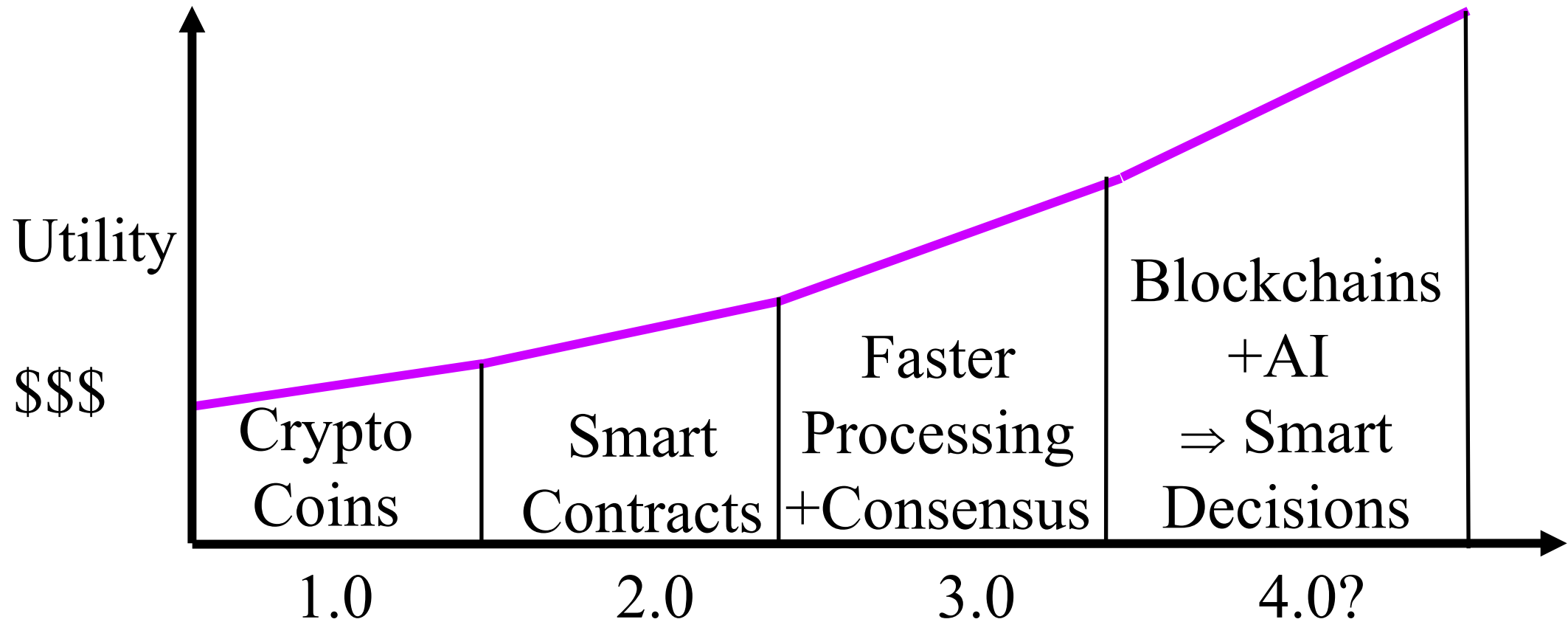
❑ Update your computer

❑ Marry someone

Our Goal

❑ Moving the chain from deterministic to **probabilistic**

❑ Moving the chain from storage to **computation**

❑ Moving the chain from data to **knowledge**

❑ Moving the chain from information to **decision making**

❑ Google is moving from "Search" to "Suggest" using AI

❑ A blockchain that provides knowledge
  – A **knowledge chain** would be more useful

Blockchain Generations

Utility $$$

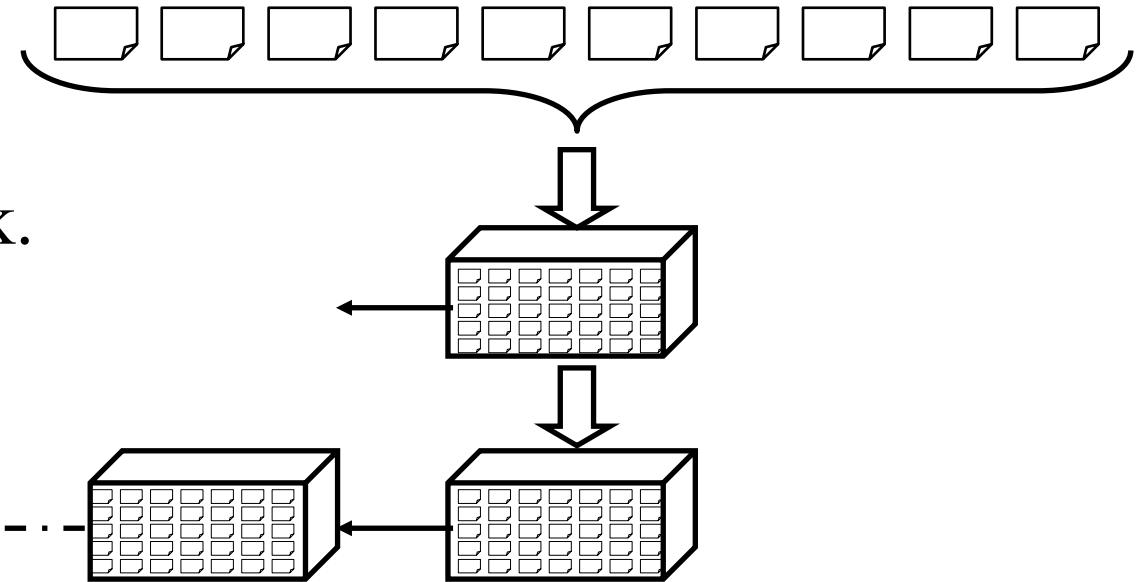| Crypto Coins | Smart Contracts | Faster Processing +Consensus | Blockchains +AI ⇒ Smart Decisions |

1.0   2.0   3.0   4.0?

Blockchain Process

1. **Users** broadcast signed transactions
   or smart contracts

2. **Mining nodes** validate transactions
   and create blocks. Point to previous block.

3. **Blockchain nodes** validate blocks
   and construct a chain

❑ There are many users, many mining nodes, and many blockchain nodes.
   More nodes ⇒ Better. Less ⇒ Blockchain not required/useful.

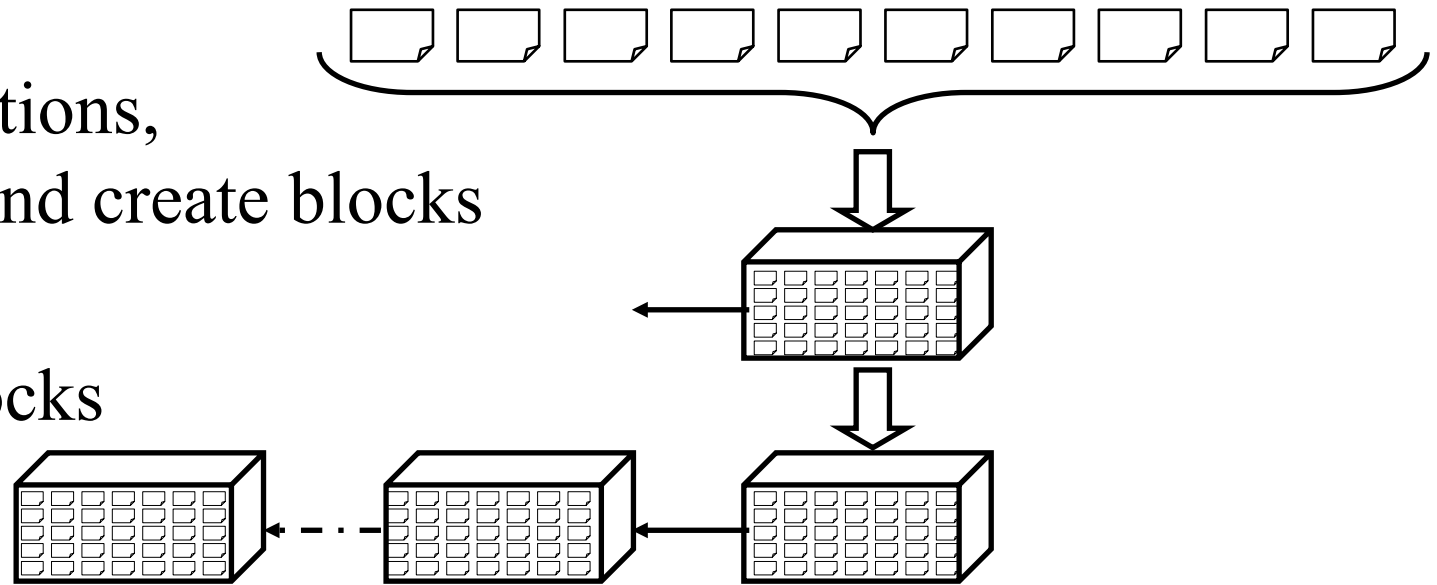# Knowledge Chain /Probabilistic Blockchain

1. **Agents** broadcast transactions,
   Transactions = Opinions/decisions

2. **Mining nodes** validate transactions,
   create a knowledge summary and create blocks

3. **Blockchain nodes** validate blocks
   and construct a chain

❑ Two types of users:

➢ **Agent nodes** provide their probabilistic opinions/decisions

➢ **Management nodes** that inquire the blockchain and use it for group decisions

Knowledge Chain Example

❑ **Issue**: Whether Cisco stock will go up tomorrow?

❑ i^{th} Agent says that the probability that it will go up is p_i

❑ Summary of all opinions related to this issue is:

$$\text{P[Stock will rise]} = G(\{p_1, p_2, \ldots, p_n\})$$

Here, G = Machine Learning Algorithm = Summarizing function

Ref: T. Salman, R. Jain, and L. Gupta, **"Probabilistic Blockchains: A Blockchain Paradigm for Collaborative Decision-Making**," 9th IEEE Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON 2018), New York, NY, Nov. 8-10, 2018, 9 pp.,
http://www.cse.wustl.edu/~jain/papers/pbc_uem.htm

Generalizing the Summary Function

❑ Summary can be any other reasonable function of individual decisions:
   ➢ 90-percentile
   ➢ Median
   ➢ Mode
   ➢ 2nd Moment

❑ Summary can be a vector: {1^{st} moment, 2nd moment, …, n^{th} moment}

❑ Summary can be the result of any **statistical** algorithm

❑ Summary can be the result of a **data mining** algorithm

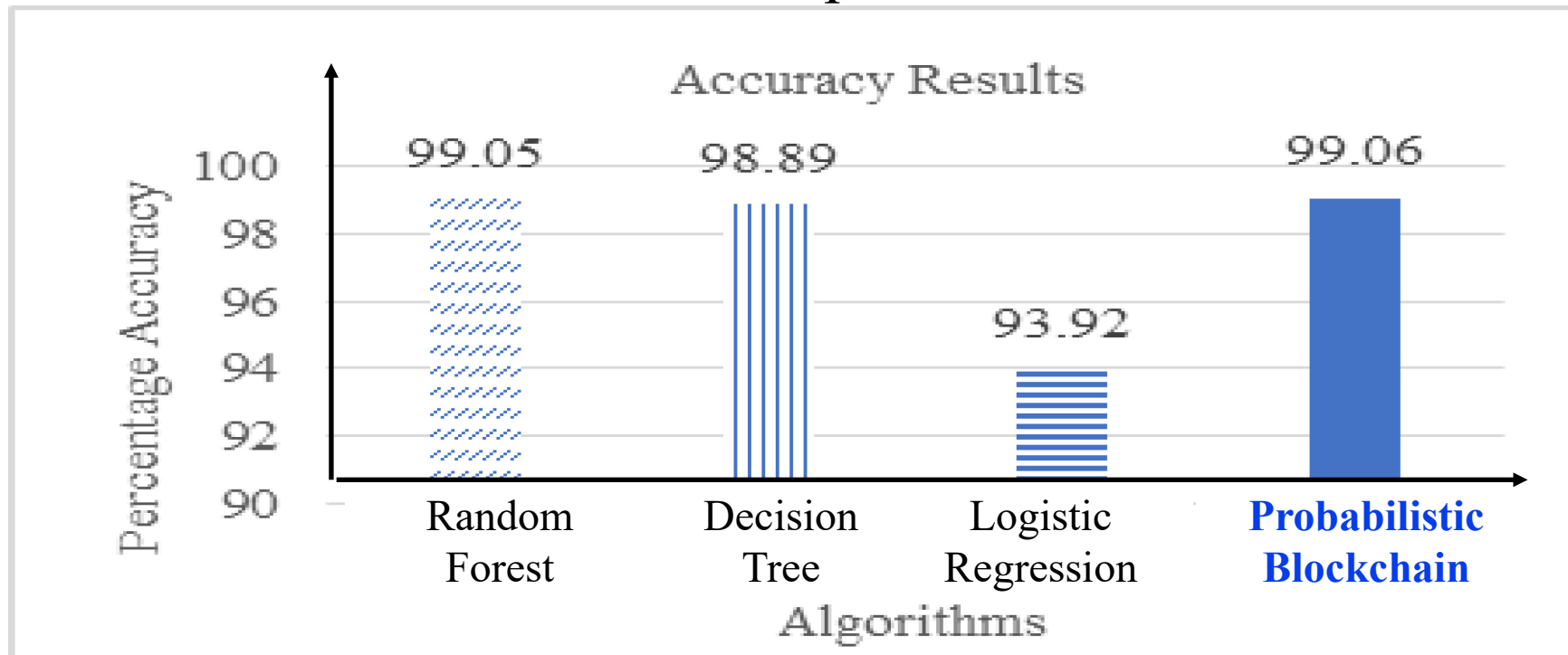❑ Summary can be the result of a **machine learning algorithm**

Empirical Validation

❏ Issue: Whether a network traffic pattern represents intrusion

❏ 1000 Agents* using different machine learning algorithms give their decisions: Yes or No

❏ Mining nodes summarize these decisions using the majority function

$$P = \frac{1}{n} \sum p_i$$

*In our simulation, agent modules randomly pick one of the 3 algorithms: Random Forest, Decision Tree, Logistic Regression

Results

$$\text{Accuracy} = \frac{\text{Correct Predictions}}{\text{Overall Samples}} \times 100\%$$

Accuracy Results

Random Forest: 99.05
Decision Tree: 98.89
Logistic Regression: 93.92
Probabilistic Blockchain: 99.06

Distributed decision making is better than any individual decision

Blockchain 4.0: Database to Knowledge Base

❑ Blockchain = Distributed ledger/database

❑ Probabilistic blockchain = Knowledge + database

❑ **Database**: Who bought, who sold,
what quantity, what price, what time

❑ **Knowledge**:

➢ Where the market is going?

➢ Whether we should buy, sell, or hold?

➢ Is this a fake news? Spam? Fraud?
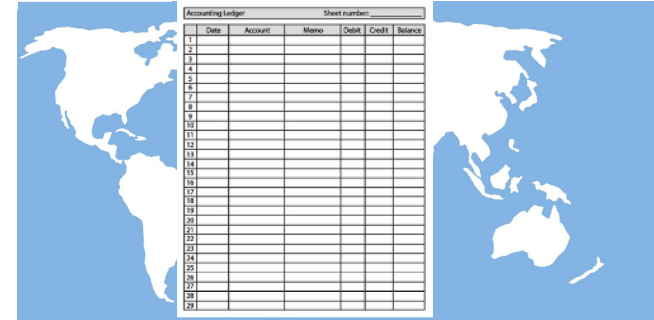
Knowledge Chain

❑ Customer query to blockchain network:
How is the Cisco stock doing today?

❑ Blockchain to Customer: With 60% confidence, the probability of stock rising is 90%, …

❑ Ideal for **large** distributed systems with **no national boundaries**, no exchange limitations, no brokers in between

❑ **Crowd-sourced knowledge**, crowd-sourced decisions

Application Examples

1. Spam from Email/IP Addresses/Cloud providers/source/public IP

2. Intrusions/attacks from IP Addresses. Anonymously share attack information.

3. Gray domains: Share gray list among agents.

4. Reliability/Issues with recent software updates

5. Error/reliability statistics of network/IoT devices

6. Virus in software

Issues to Resolve

1. **Summary functions**

2. **Overhead of consensus mechanisms**: Proof of Work, Proof of Stake, …

3. **Reputation of Experts and Bad Actors**:

   ➢ Some agents are better than others

   ➢ Group decisions should give more weight to them

   ➢ How to incentivize better agents

   ➢ How to penalize bad actors

Summary
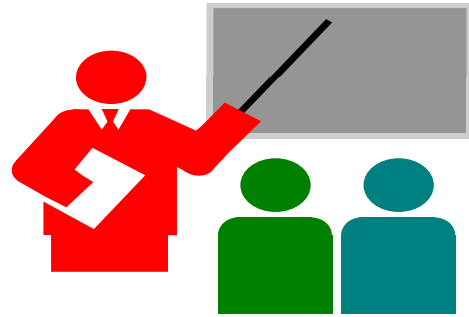
1. Blockchains provide an immutable, secure, distributed database

2. Three generations: Crypto currency, Smart contract, faster performance

3. All three generations are deterministic and **only provide storage**

4. The next generation needs to **connect computation and AI** to make knowledge/decisions in addition to data storage

5. Consensus can be probabilistic result of any statistical algorithm, data mining, or machine learning $\Rightarrow$ **Knowledge Chain**

Related Papers

❑ Tara Salman, Raj Jain, and Lav Gupta, "**Probabilistic Blockchains: A Blockchain Paradigm for Collaborative Decision-Making**," 9th IEEE Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON 2018), New York, NY, November 8-10, 2018, 9 pp., http://www.cse.wustl.edu/~jain/papers/pbc_uem.htm

❑ Tara Salman, Maede Zolanvari, Aiman Erbad, Raj Jain, and Mohammed Samaka, "**Security Services Using Blockchains: A State of the Art Survey**" IEEE Communications Surveys and Tutorials, Accepted September 2018, 28 pp., http://www.cse.wustl.edu/~jain/papers/bcs.htm

❑ T. Salman, R. Jain, and L. Gupta, "**A Reputation Management Framework for Knowledge-Based and Probabilistic Blockchains**," 2019 IEEE International Conference on Blockchain, Atlanta, July 14, 2019, http://www.cse.wustl.edu/~jain/papers/rpmcewa.htm

List of Acronyms

- AI   Artificial Intelligence
- DNS   Domain Name Service
- IEEE   Institution of Electrical and Electronics Engineers
- IoT   Internet of Things
- IP   Internet Protocol
- PKI   Public Key Infrastructure
- SSL   Secure Socket Layer

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THANK YOU

Raj Jain

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http://www.cse.wustl.edu/~jain/talks/pbc_amity.htm