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Applications of Blockchain in Supply chain Management

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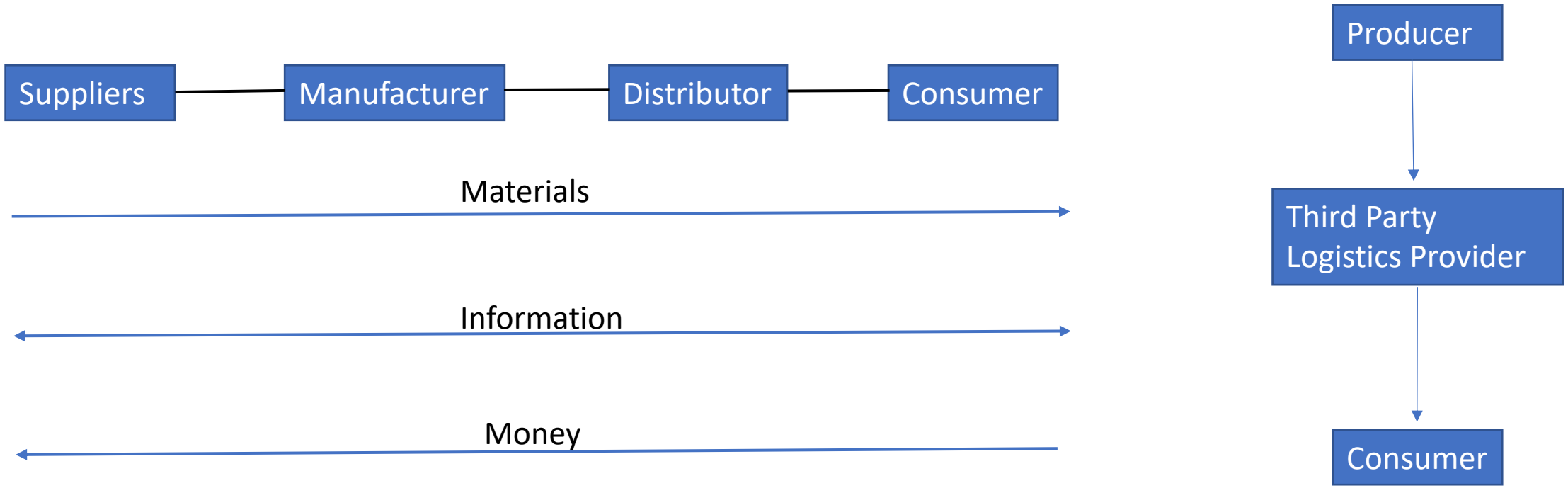
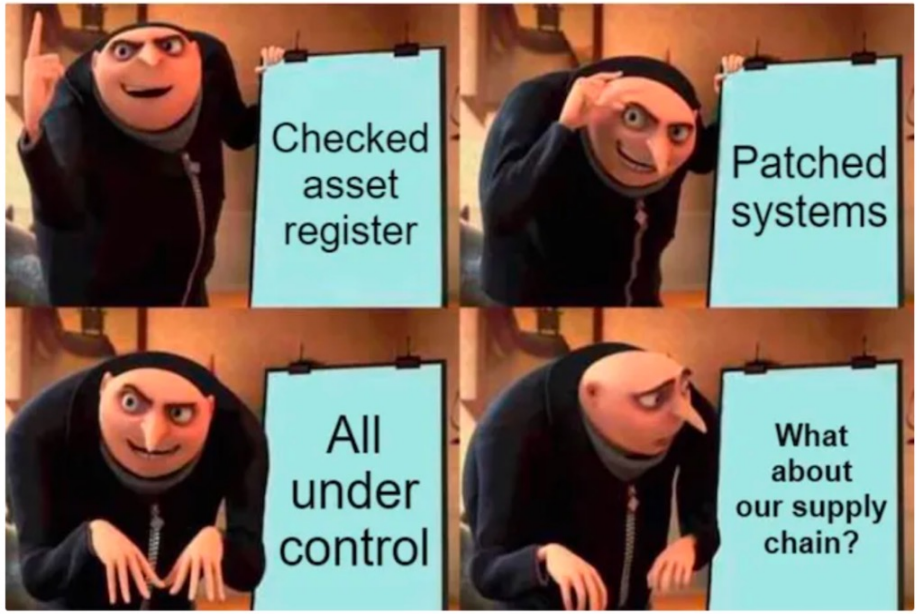
SUPPLY CHAIN BACKGROUND

Current Infrastructure (Workflow)



Research problem

- Asymmetric data at different stages in the supply chain.
- Huge growth in supply chain and difficulties in optimizing



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Motivation

- Limited knowledge on how blockchain can help supply chain
- Increased attacks on supply chain

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Research goals

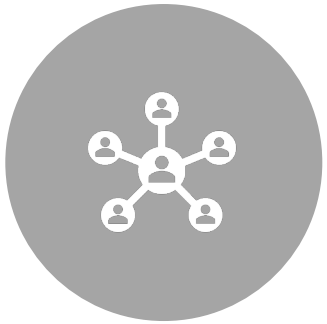
- Understanding how blockchain integration helps supply chain management.
- Exploring the threats and vulnerabilities that occur by integrating blockchain with supply chain.

Applications of blockchain in Supply chain

- Walmart's food traceability
- De Beers' Diamond Traceability
- Ford's Cobalt Supply Chain

Desirable Properties

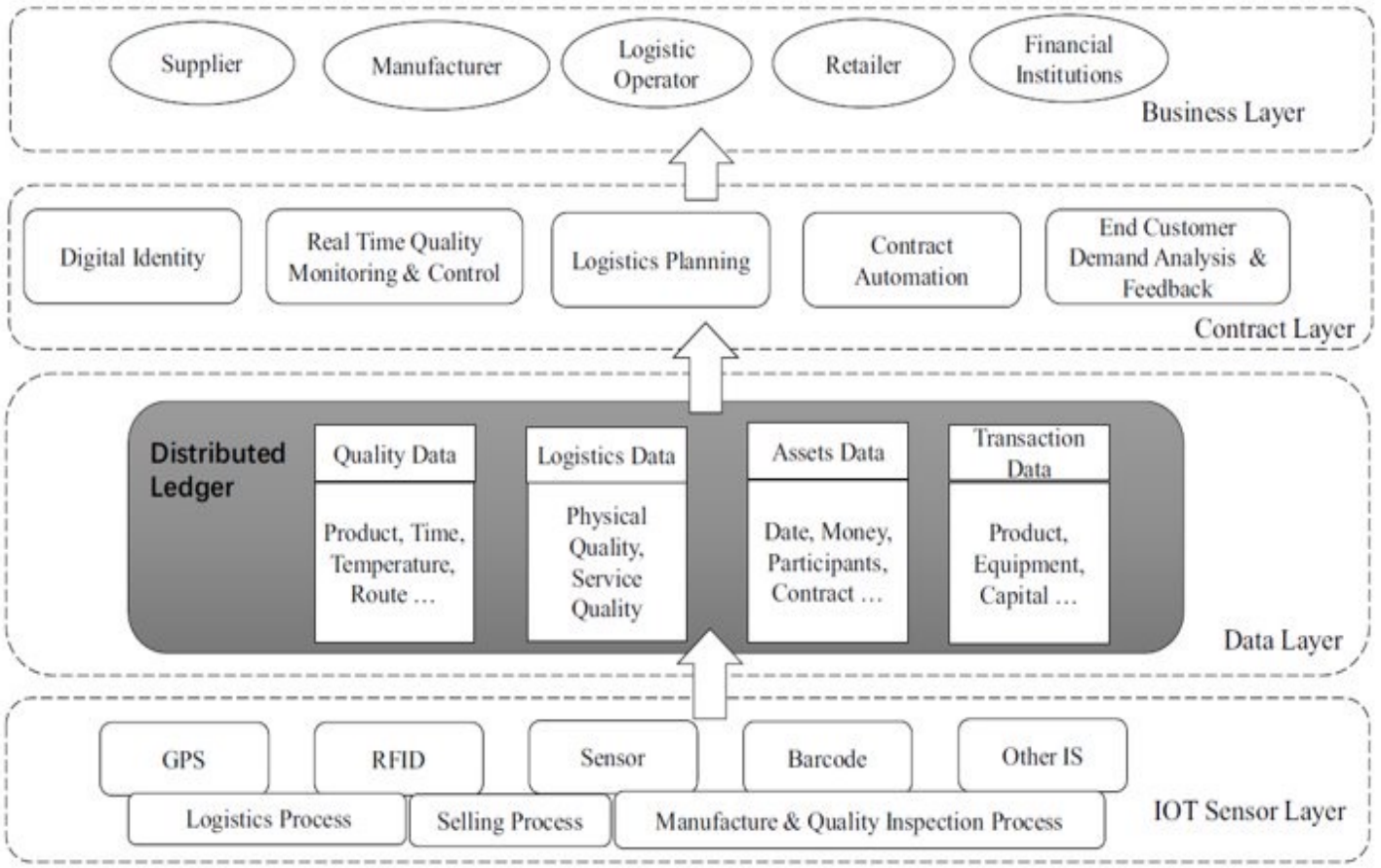
TRACEABILITY AND TRANSPARENCY IN THE SUPPLY CHAIN



DIGITALIZATION OF NETWORK

AVOIDING THIRD PARTIES AND ENHANCING DECENTRALIZATION IN THE SYSTEM

System Model



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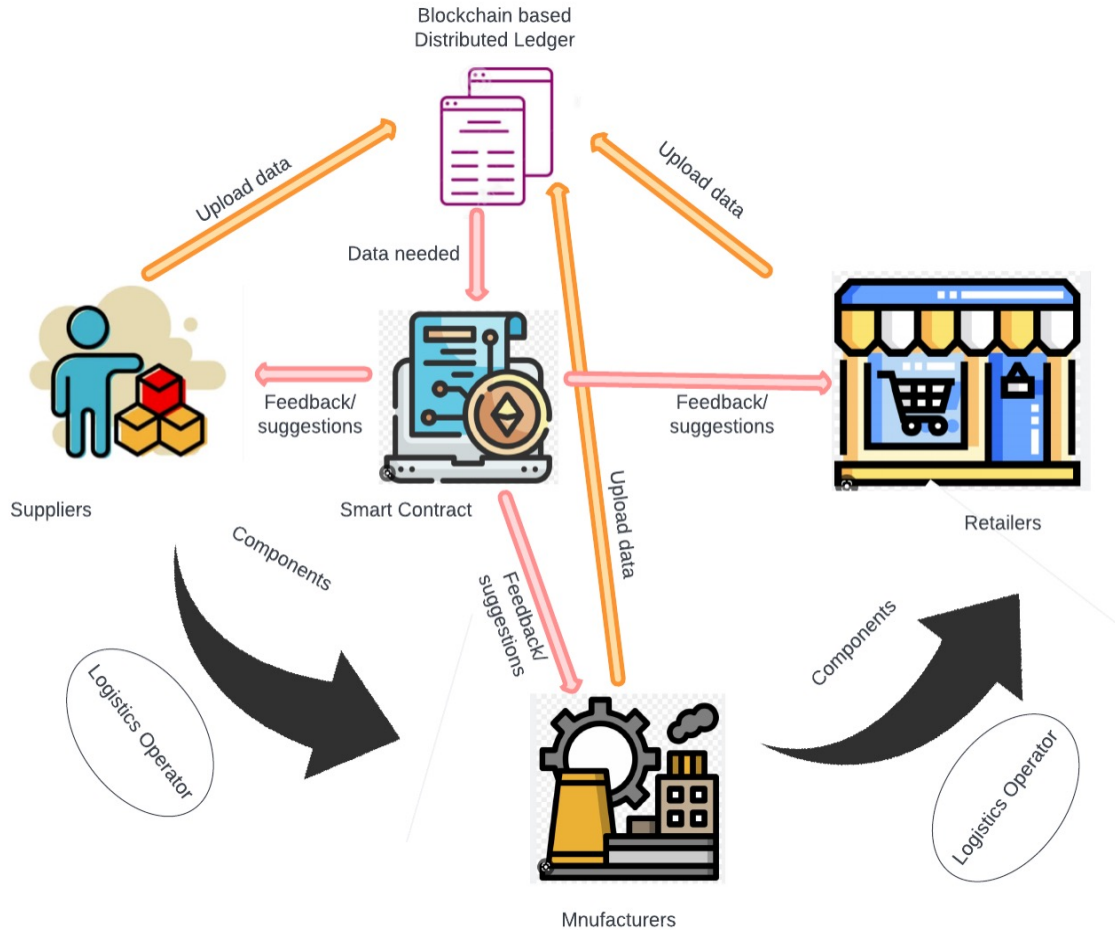
Network Model

- Data about quality in processes during production and inspection can be uploaded
- Process and product quality are evaluated in smart contracts
- Results/ Feedback are sent to Suppliers, Manufactures and retailers



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Security Model

Blockchain uses Private key or Digital Signature

Similarly, all the partners in Supply chain generates their own digital signature

Immutable transactions

Supplier can check the legitimacy of order from customer

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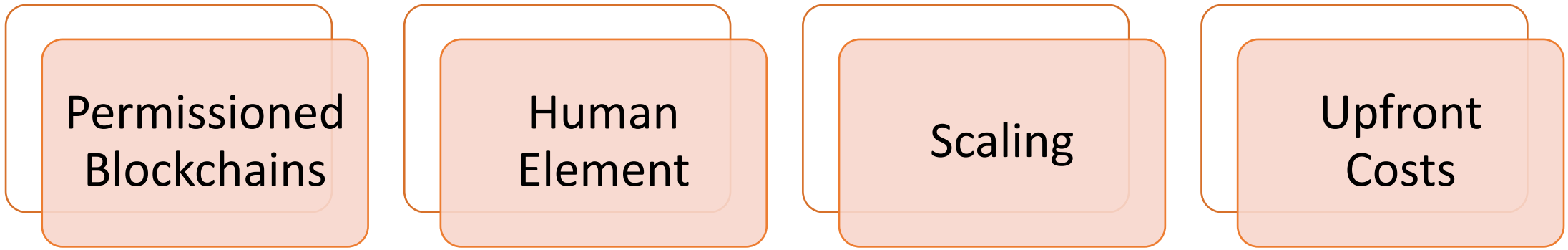
Threat Model



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Research Methodologies

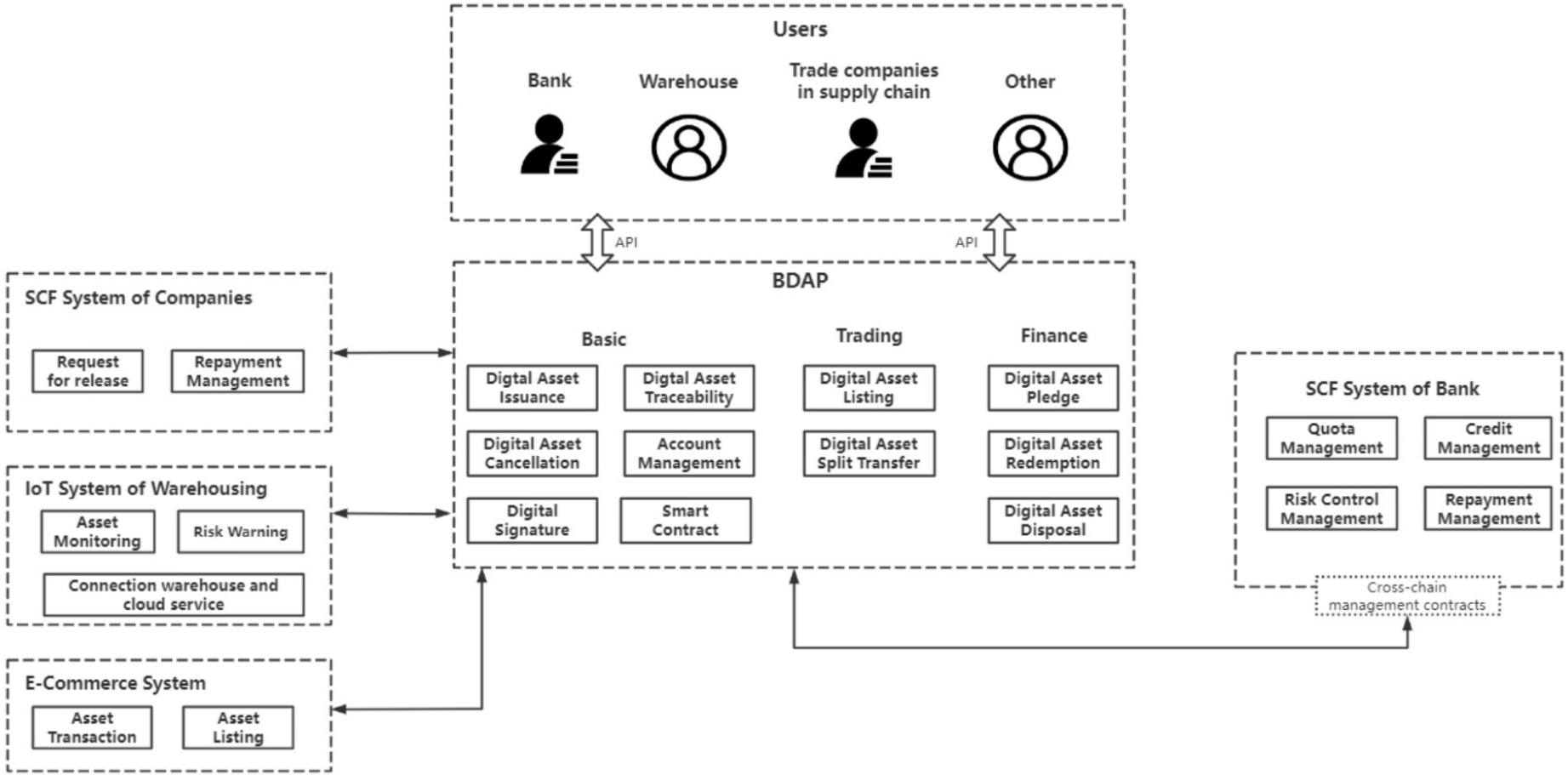
Different approaches to the problem are:

- Blockchain based payment collection and contract settlement
- Smart Contracts
- Cryptocurrency Payments

Implementing Digital Assets Platform with Blockchain

- Creating digital certificates for commodities, digital assets.
- These digital assets can be split and circulated for trading.
- Developing processes and applications based on various scenarios such as issuance, trading, financing, transfer, freezing, disposal, and cancellation of digital assets.
- Contains 3 main modules:
  - Basic Module
  - Transaction Module
  - Financial Module

Implementing Digital Assets Platform with Blockchain



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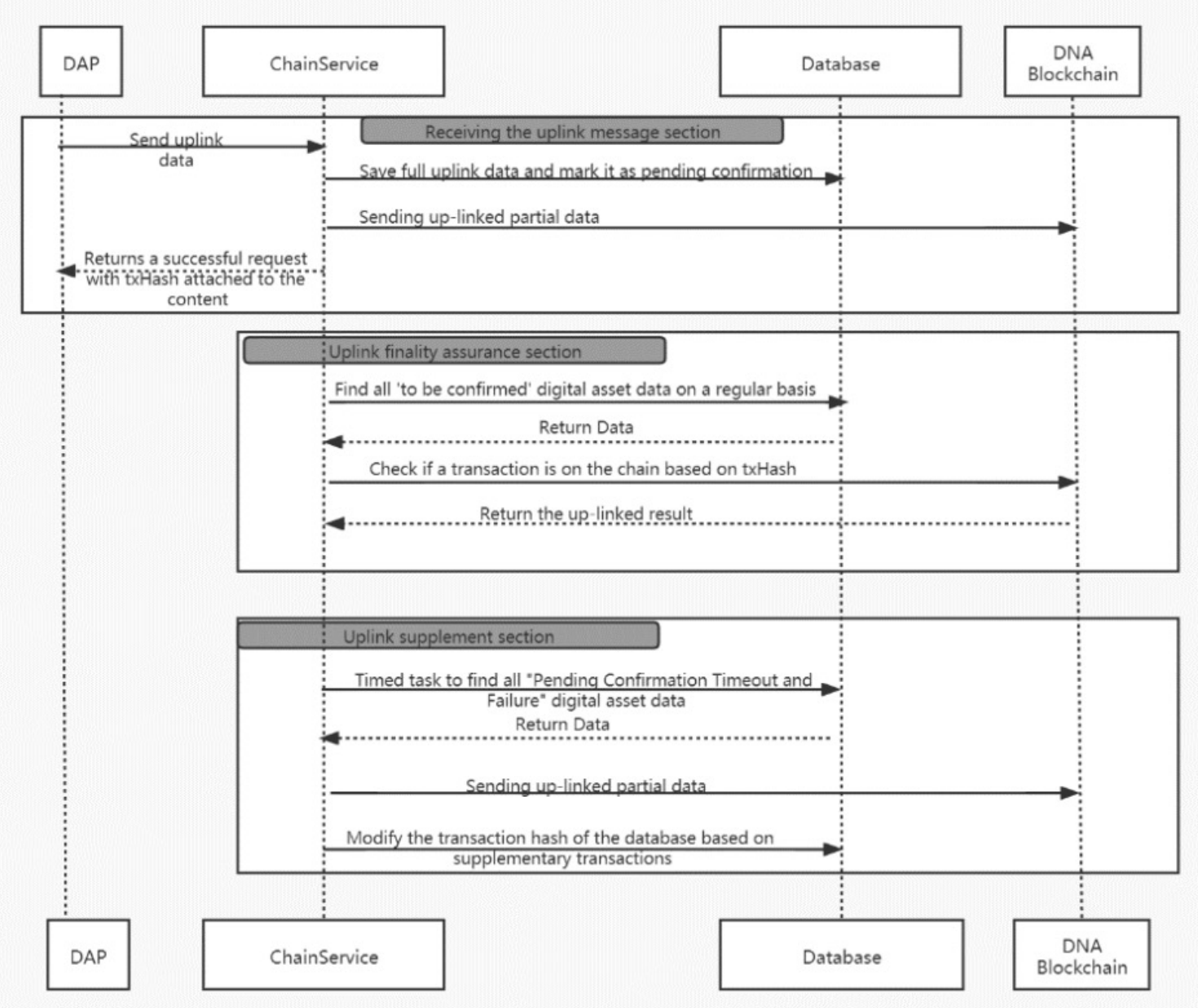
Implementing Digital Assets Platform with Blockchain

- The process of uploading data to the blockchain



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Experimental Results

- Results from the stress test conducted on the DAP.
- Test uses open-source test method of Apache, JMeter

Test items	Number of concurrency	Thread Group Increment	Response time	Success rate	CPU usage	Memory Usage
Website	10	Increase by 10 per second	0.373 S	100%	2%-5%	5%
	20	Increase by 10 per second	0.469 S	100%	2%-5%	5%
	100	Increase by 10 per second	1.441 S	99.95%	5%—10%	5%

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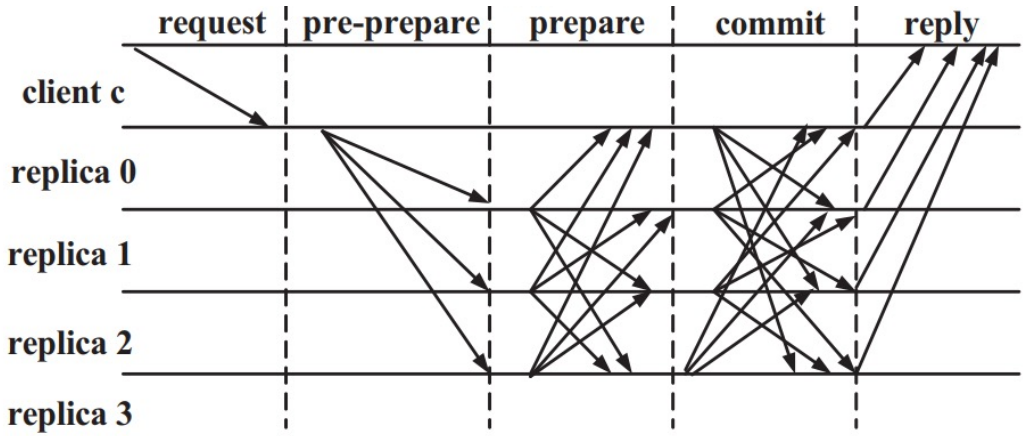
Machine Learning in Blockchain?

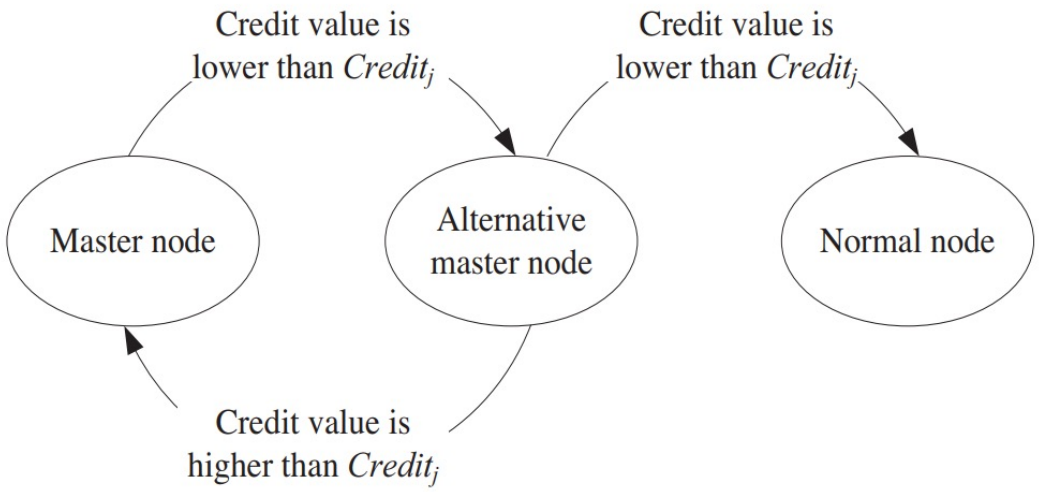
- PBFT consensus mechanism's drawbacks:
  - The master node that is chosen at random may be a byzantine node
  - No penalty mechanism for malicious nodes
- Use of classification algorithms can address these problems



PBFT consensus reaching process

Integrating SVM in PBFT Consensus Mechanism

- Credit value of each node
- Punishing or rewarding the node based on behavior
- Node downgrade mechanism



Node Degradation Relationship

Consensus Realization Process

Reward formula:

$$Credit_n = Credit_n + \log_{10} Credit_n$$

Penalty formula:

$$\begin{cases} Credit_n = Credit_n - Credit_1, \text{n master node} \\ Credit_n = Credit_n - Credit_2, \text{n is the replica node} \end{cases}$$

Input: Client request message<REQUEST, o, t, c>
Output: c The requested processing result
1. *p broadcast << PRE_PREPARE, v, n, d >, m > to all backup nodes;*
2. *while(v := 0)*
3. *for int k = 1,2,3, … , |R|-1 do*
4. *Node k delivery << PRE_PREPARE, v, n, d >, m > from p;*
5. *if((digest legal)&&(h ≤ n&&n ≤ H))*
6. *Node k broadcast < PREPARE, v, n, digest >;*
7. *else*
8. *Node k does nothing;*
9. *end for*
10. *Node k delivery other node preparation messages;*
11. *if (count ≥ 2f + 1)*
12. *Node k enters ready state;*
13. *Node k broadcast < COMMIT, v, n, D(m) >;*
14. *else*
15. *Node k broadcast < FAILURE, v, t, c, k, $Credit_k$ > to c;*
16. *end while*
17. *while(v := 0)*
18. *for k = 1 to |R|-1 do*
19. *Node k delivery other node preparation messages;*
20. *if (account ≥ 2f + 1)*
21. *Node k enters the commit state;*
22. *Execute client c request < REQUEST, o, t, c >;*
23. *Node k broadcast < SUCCESS, v, t, c, r, $Credit_k$ > to c*
24. *and $Credit_k = Credit_k + \log_{10} Credit_k$;*
25. *else*
26. *Node k broadcast < FAILURE, v, t, c, r, $Credit_k$ > to c*
27. *and $Credit_k$ = $Credit_k$-$Credit_1$ and other nodes $Credit_n$-$Credit_2$;*

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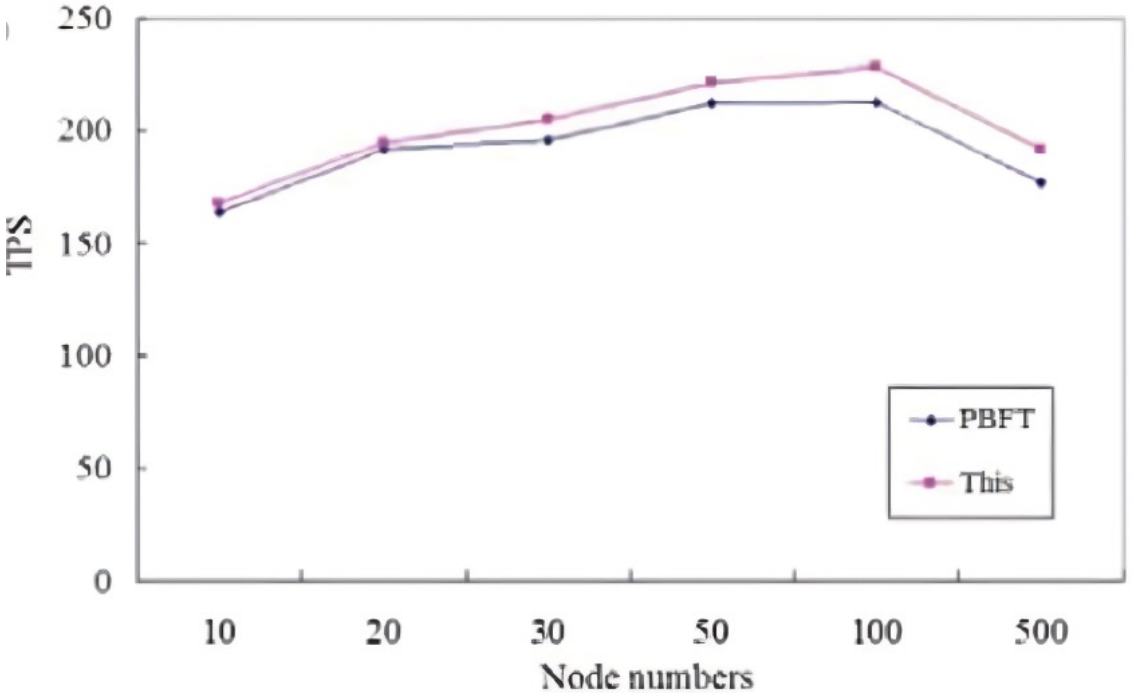
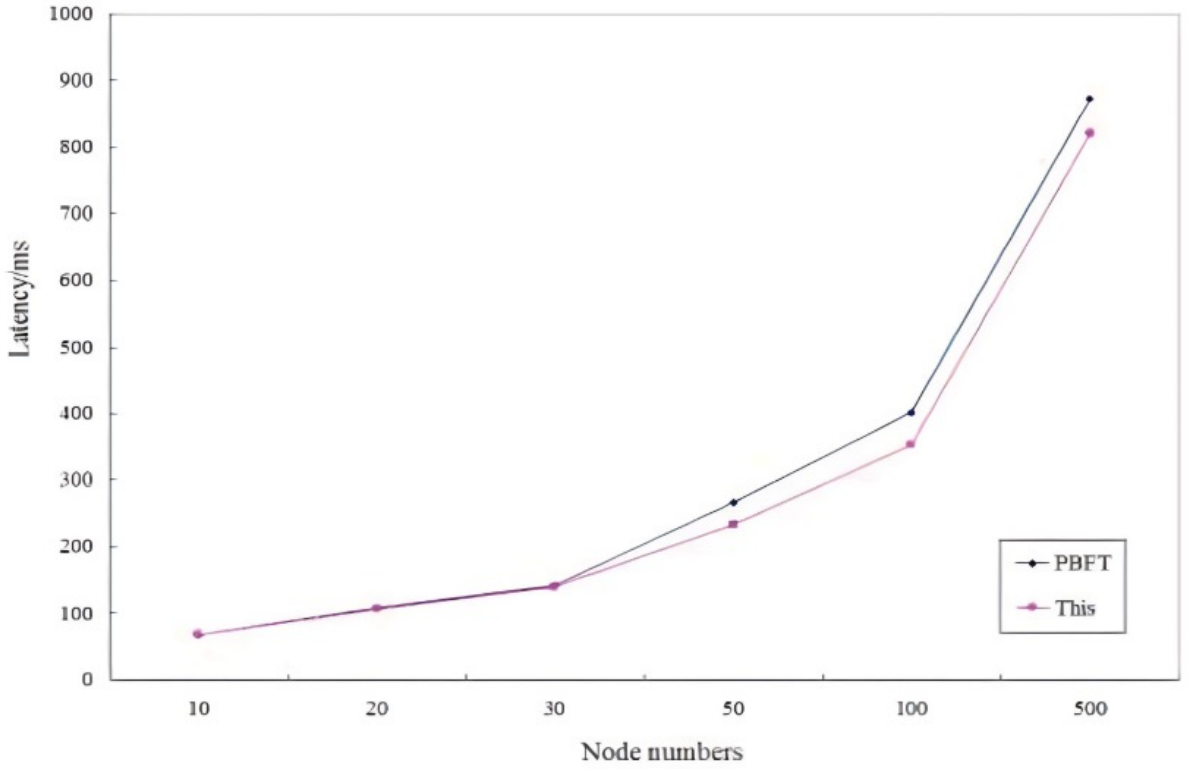
Experimental Results

- Algorithm TPS performance comparison before and after optimization.
- Algorithm delay comparison before and after optimization.





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Conclusion

- Blockchain can be integrated with various aspects of supply chain management, such as providing end-to-end traceability, improving access to financing, preventing counterfeit products, optimizing inventory management, and improving sustainability.
- Actively researched domain as there are many benefits to integrating BC and SCM.
- Integrating machine learning with consensus mechanisms, is very promising in improving the performance of the consensus mechanisms. These improvements and efficiency gains make it more viable for organizations to adapt this technology.

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Implementation References

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- N. Du, Z. Liang, Y. Huang, Z. Guo, H. Yang and S. Wang, "Performance optimisation Method of PBFT Consensus for Supply Chain Integration SVM," 2020 7th International Conference on Dependable Systems and Their Applications (DSA), Xi'an, China, 2020, pp. 371-377, doi: 10.1109/DSA51864.2020.00066.

Thank You!

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Q&A

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