‘A Multicriteria Evaluation of Blockchain Technologies in the Healthcare System'

Nicolò De Sandre | Rome, November 28th, 2018

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The Netherlands

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Presentation's Agenda

1. Healthcare System's Problems
2. Blockchain Technology
3. Solution Properties
4. Use Case
5. Conclusion

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1) Healthcare System's Problems

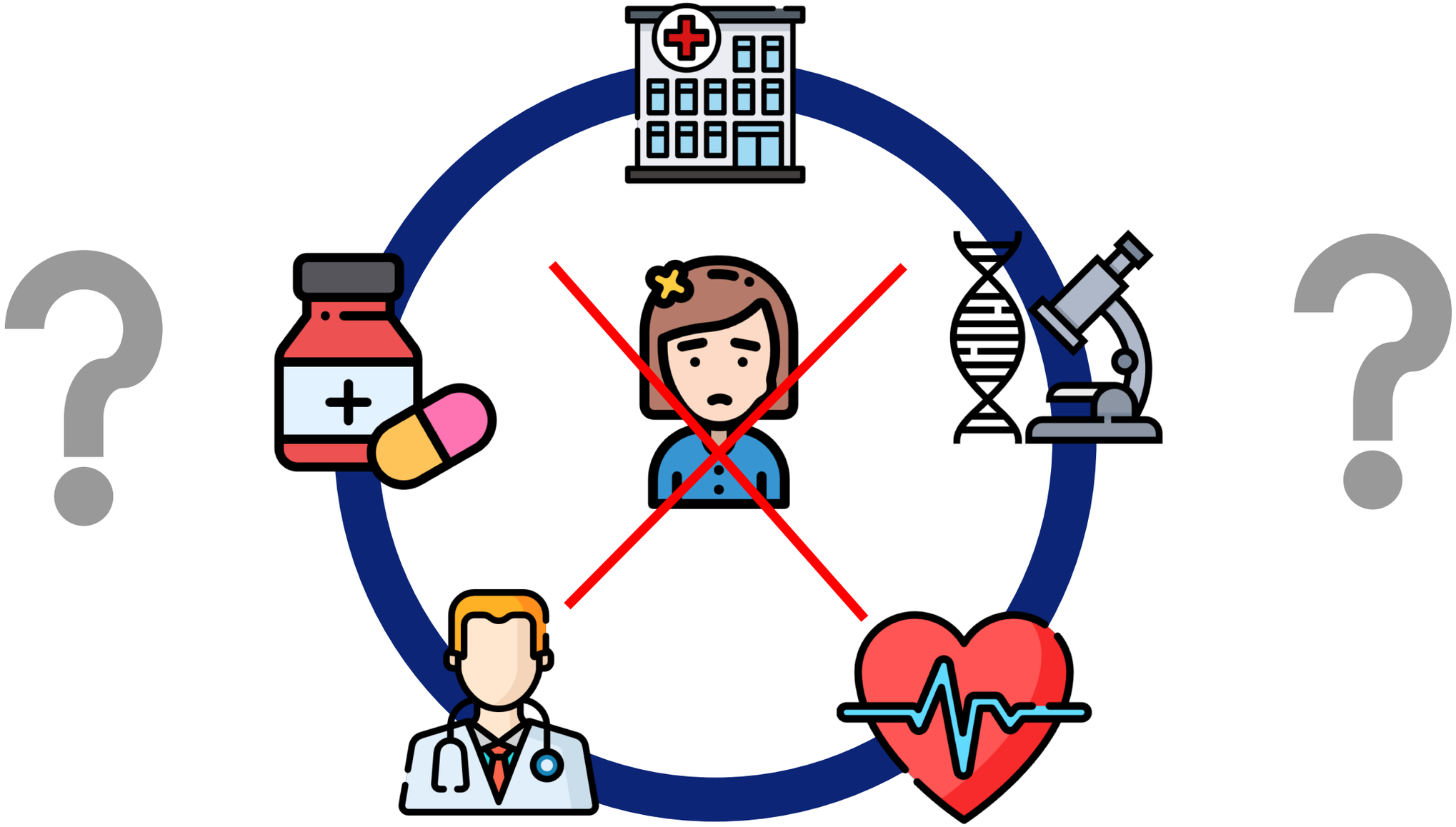
1. MEDICAL ERRORS
2. MEDICAL DATA OWNERSHIP
3. INFORMATION BLOCKING

NON PATIENT-CENTERED SYSTEM

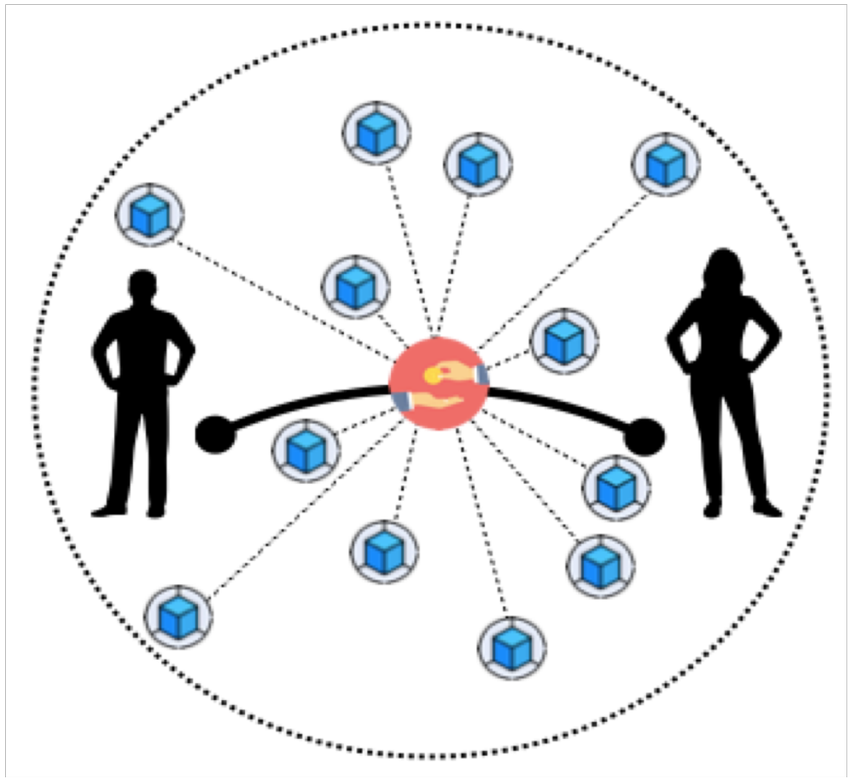
1) Healthcare IT Problems

Healthcare System Problems	Impact	Source
Different IT Systems	*Interoperability, Scalability*	1-2-3-4-5-7-9-10-11-12-13-15-16
Information Blocking	*Interoperability*	5-7-9-10-16
Incomplete, Incorrect Medical Data	*Interoperability, Patients' Data Management*	1-4-5-8-9-16
Health Data Privacy	*Patients' Data Management*	1-5-8-11-12-14
Health Data Security	*Patients' Data Management*	1-4-8-11-12-14
Health Data Accessibility	*Patients' Data Management*	1-4-5-8-9-16
Data Silos	*Interoperability*	2-5-16
Data Complexity	*Interoperability*	1-6-13-16
Claim Process Complexity	*Patients' Data Management*	3-11-14-15-16
High Care Costs	*Patients' Data Management*	3-5-7-13-15-16

1) Healthcare System's Problems



1) Healthcare System's Problems



1) Healthcare System's Problems

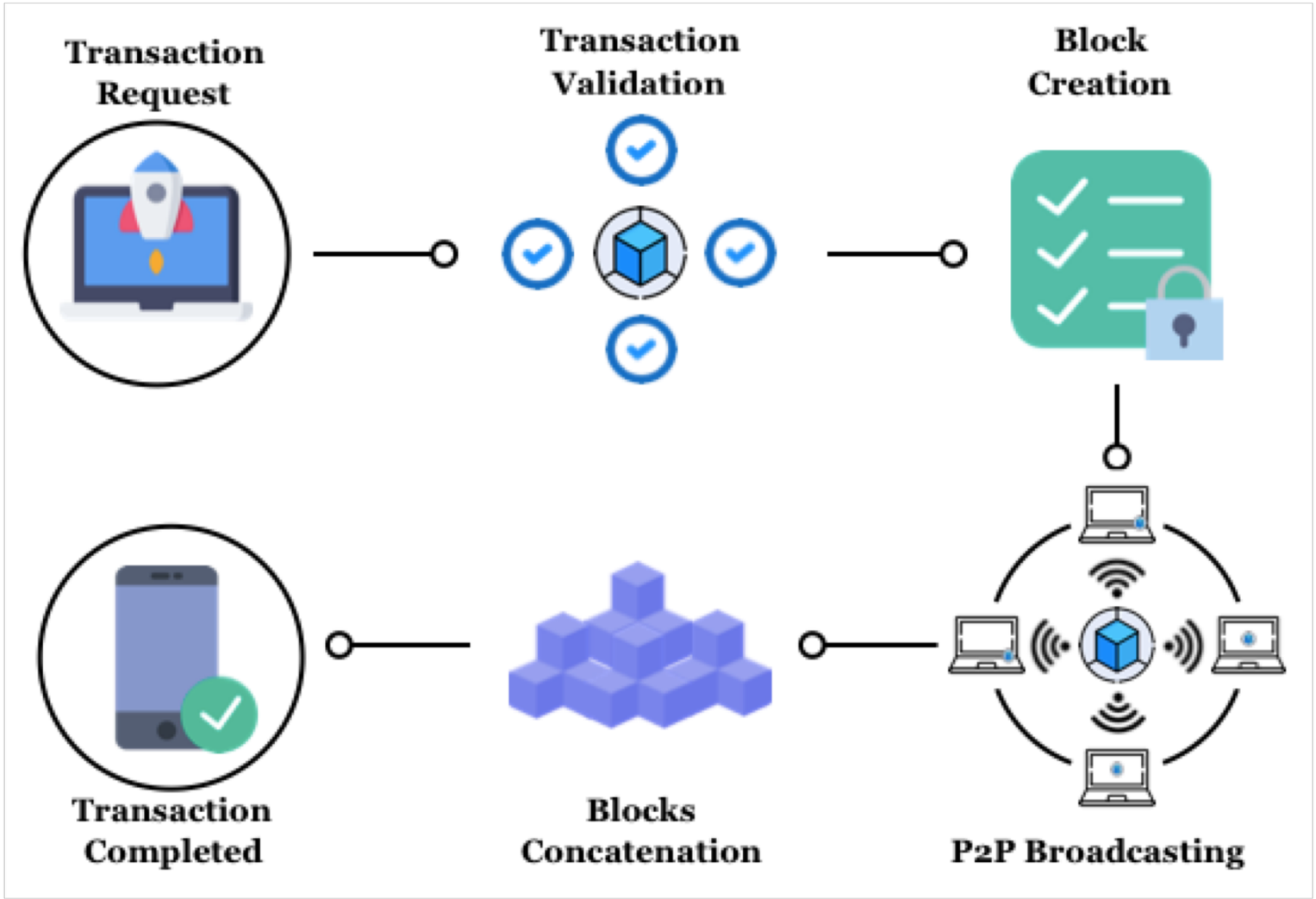
NOT YET

☹

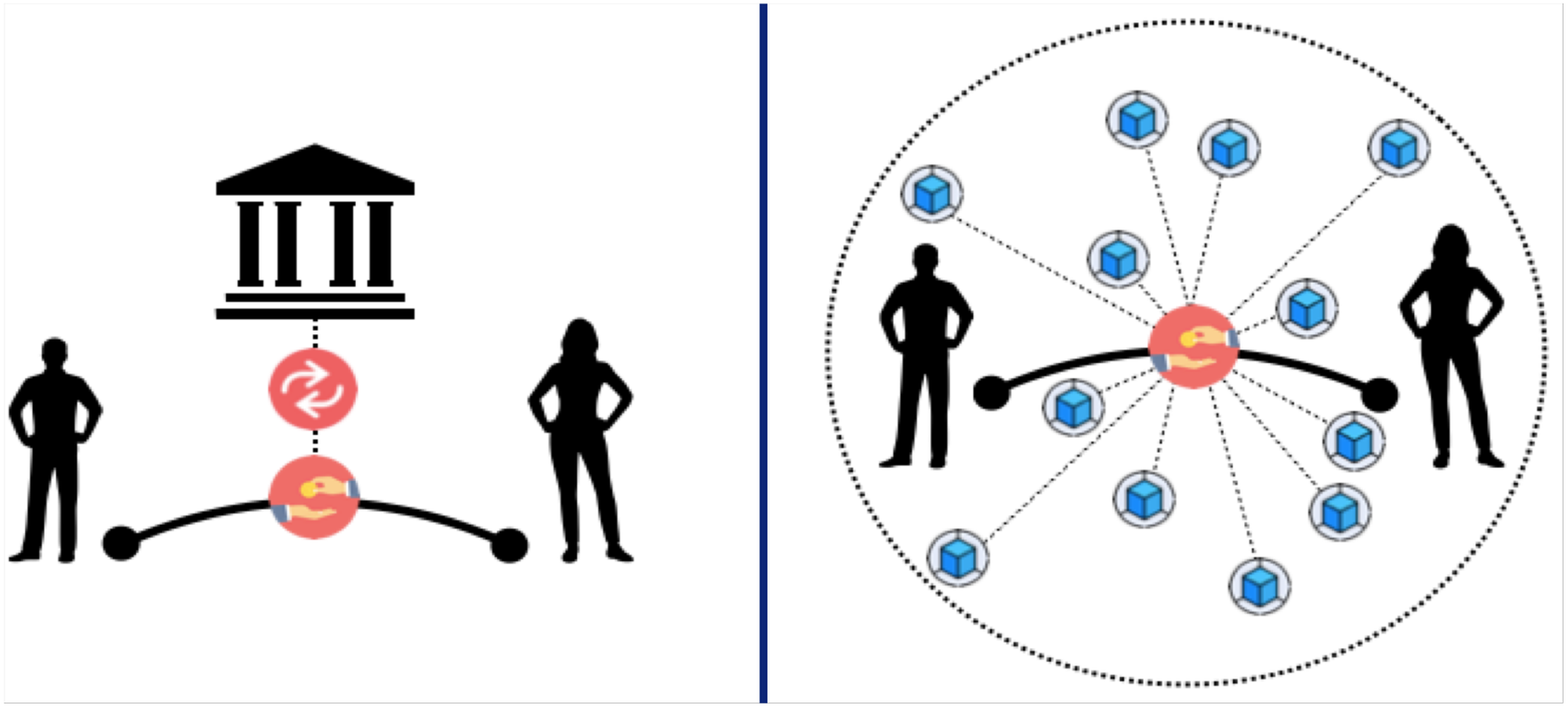
2) Blockchain Technology

- BLOCKCHAIN E' UN DATABASE: decentralizzato, distribuito e criptato con precise regole di sicurezza.
- UN DATABASE BASATO SUL CONSENSO: è un archivio aperto a tutti i partecipanti che può essere modificato solo con il consenso di tutti i partecipanti.
- Blockchain garantisce assoluta IMMUTABILITA' e INCORRUTTIBILITA'.
- Inoltre è aperta e TRASPARENTE. Tutti i partecipanti possono vedere tutte le transizioni in qualsiasi momento.

2) How does it work?

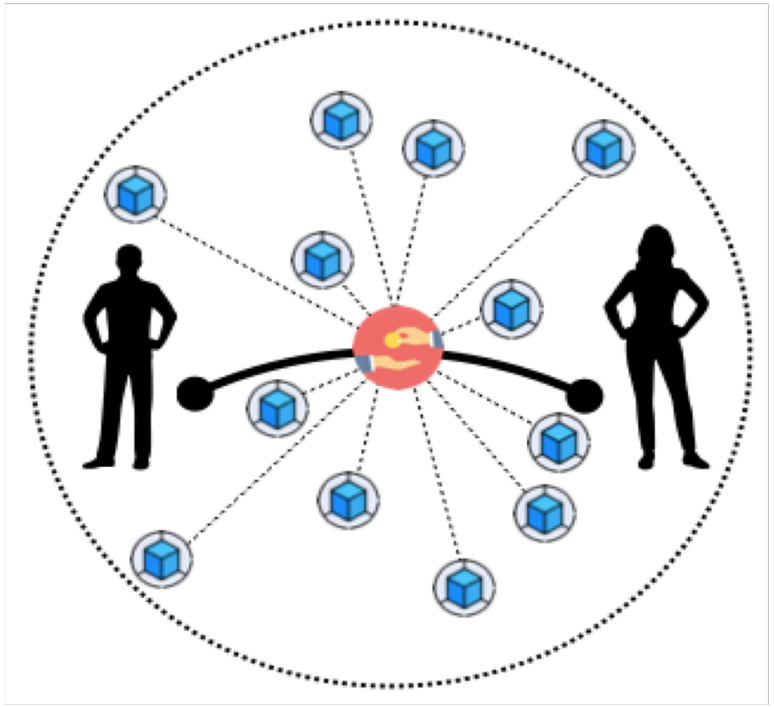


2) Blockchain's Disruption



Sharing is Caring!

2) Blockchain's Ecosystem

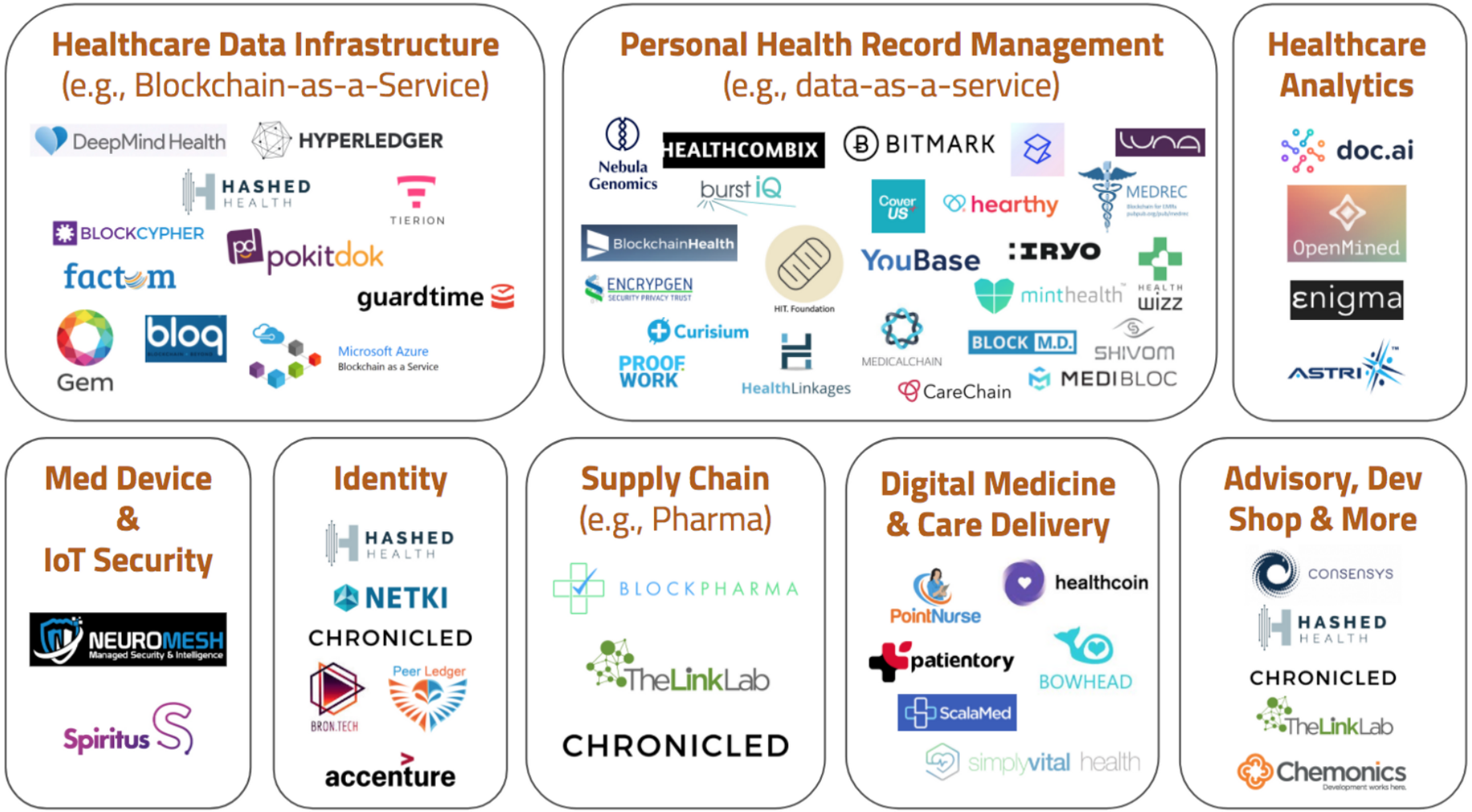


- **Chi controlla?**
  Ministero della Salute
  Consiglio Superiore di Sanità
  Agenas

- **Chi partecipa?**
  Ospedali
  Dottori
  Medici
  Università Mediche
  Centri di Ricerca
  Compagnie Farmaceutiche
  Farmacie

2) Blockchain's Ecosystem

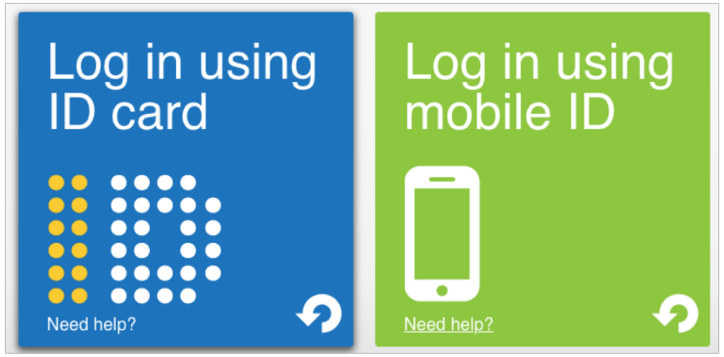
Healthcare-related blockchain projects



2) Blockchain's Ecosystem

Each person in Estonia that has visited a doctor has an online e-Health record that can be tracked. Identified by the electronic ID-card, the health information is kept completely secure and at the same time accessible to authorised individuals.

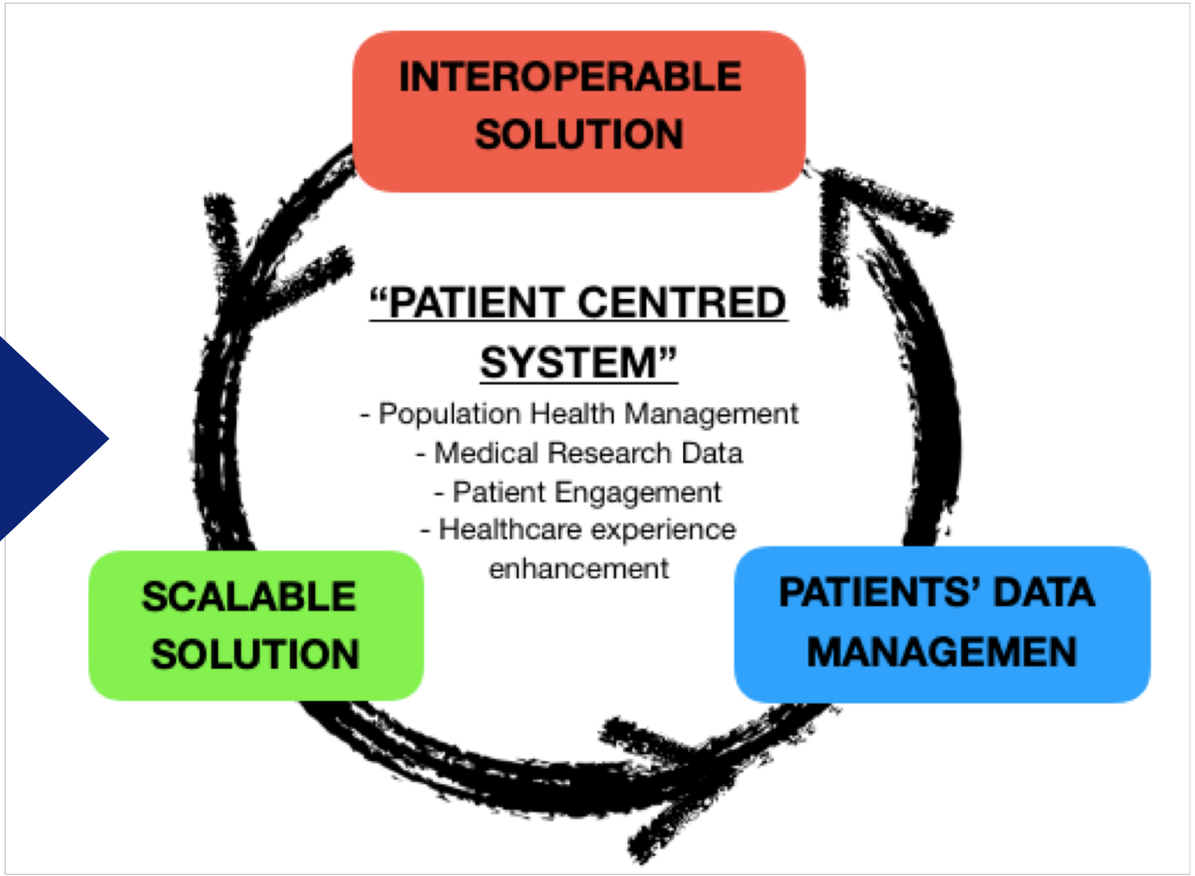
Functioning very much like a centralized, national database, the e-Health Record actually retrieves data as necessary from various providers, who may be using different systems, and presents it in a standard format via the e-Patient portal.



3) Blockchain Benefits

Healthcare Systems' IT Problems
Different IT Systems
Information Blocking
Incomplete, Incorrect Medical Data
Health Data privacy
Health Data security
Health Data accessibility
Data Silos
Data complexity
Claim Process Complexity
High Care Costs

Critical Properties Blockchain Solution



3) Blockchain Benefits

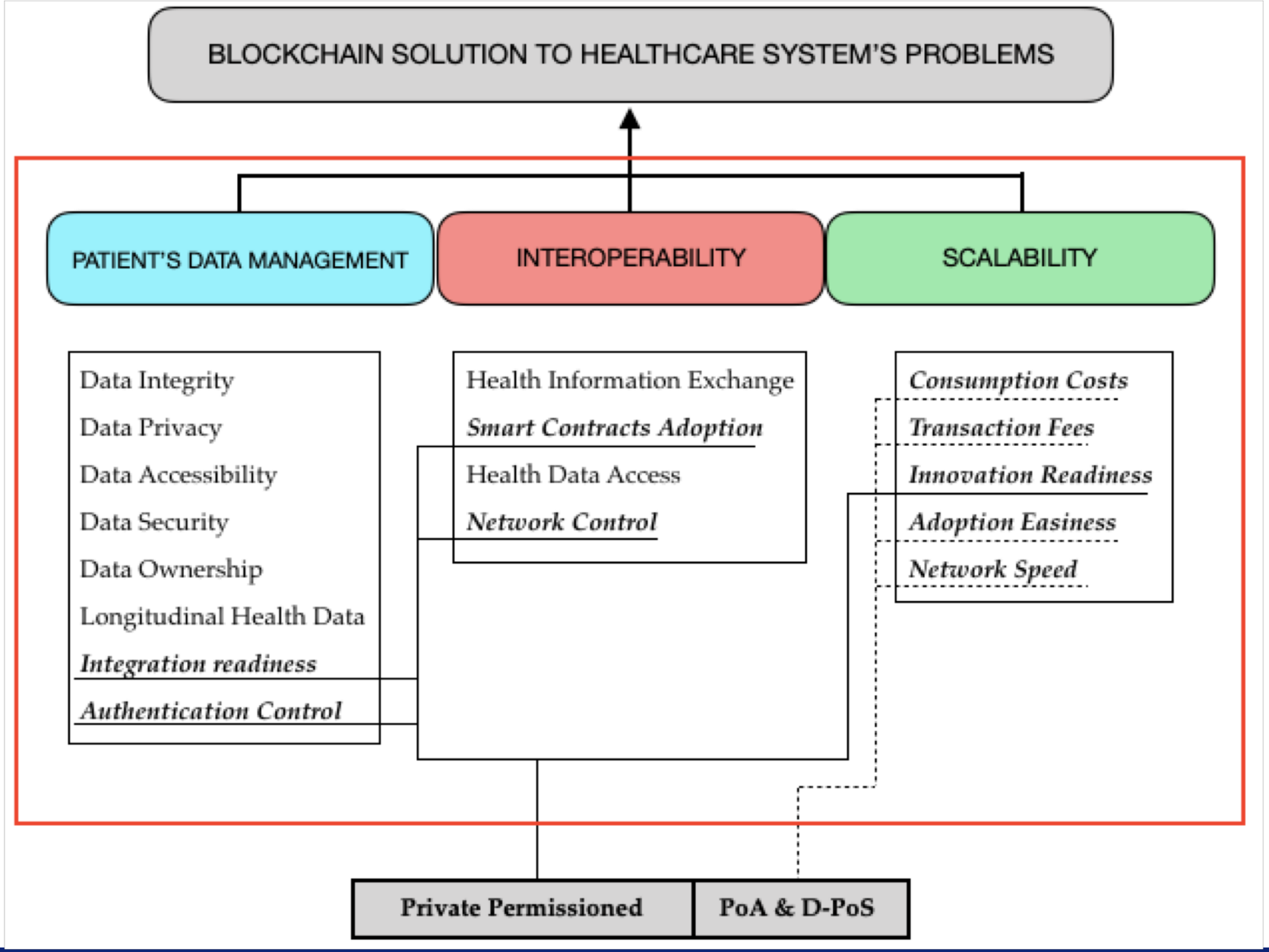
Blockchain's Benefits to the Healthcare System

Patients' Data Management
Data Integrity
Data Privacy
Data Security
Data Ownership
Longitudinal Health Data
Integration Readiness
Authentication Control

Scalability
Consumption Costs
Transaction Fees
Innovation Readiness
Adoption Easiness
Network Speed

Interoperability
Health Information Exchange
Smart Contracts Adoption
Health Data Access
Network Control

3) Blockchain Direct Benefits



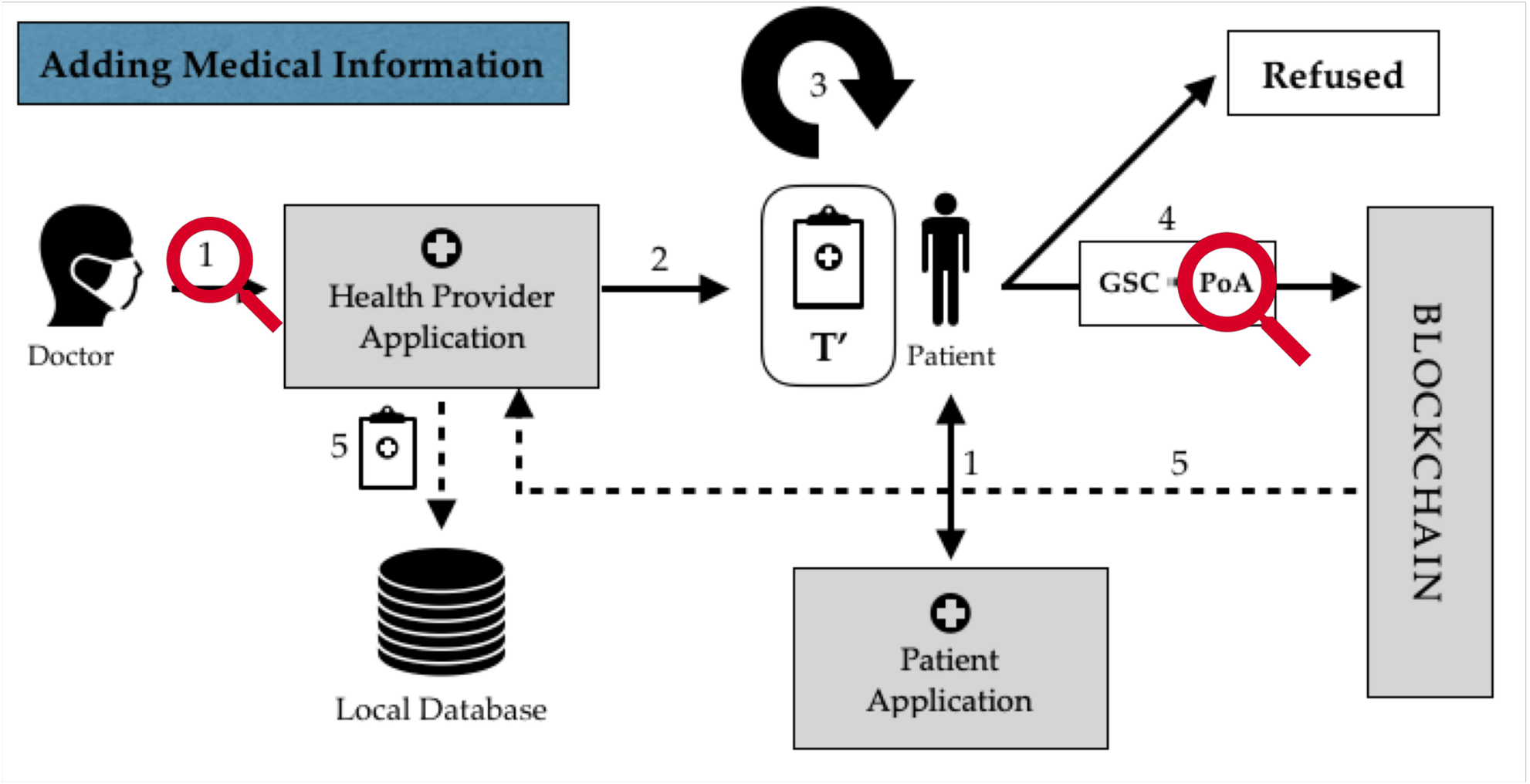
3) Indirect Benefits

Medical Errors
Healthcare Costs
Environmental Footprint
Waiting time
Billing Process
Complexity
Frauds

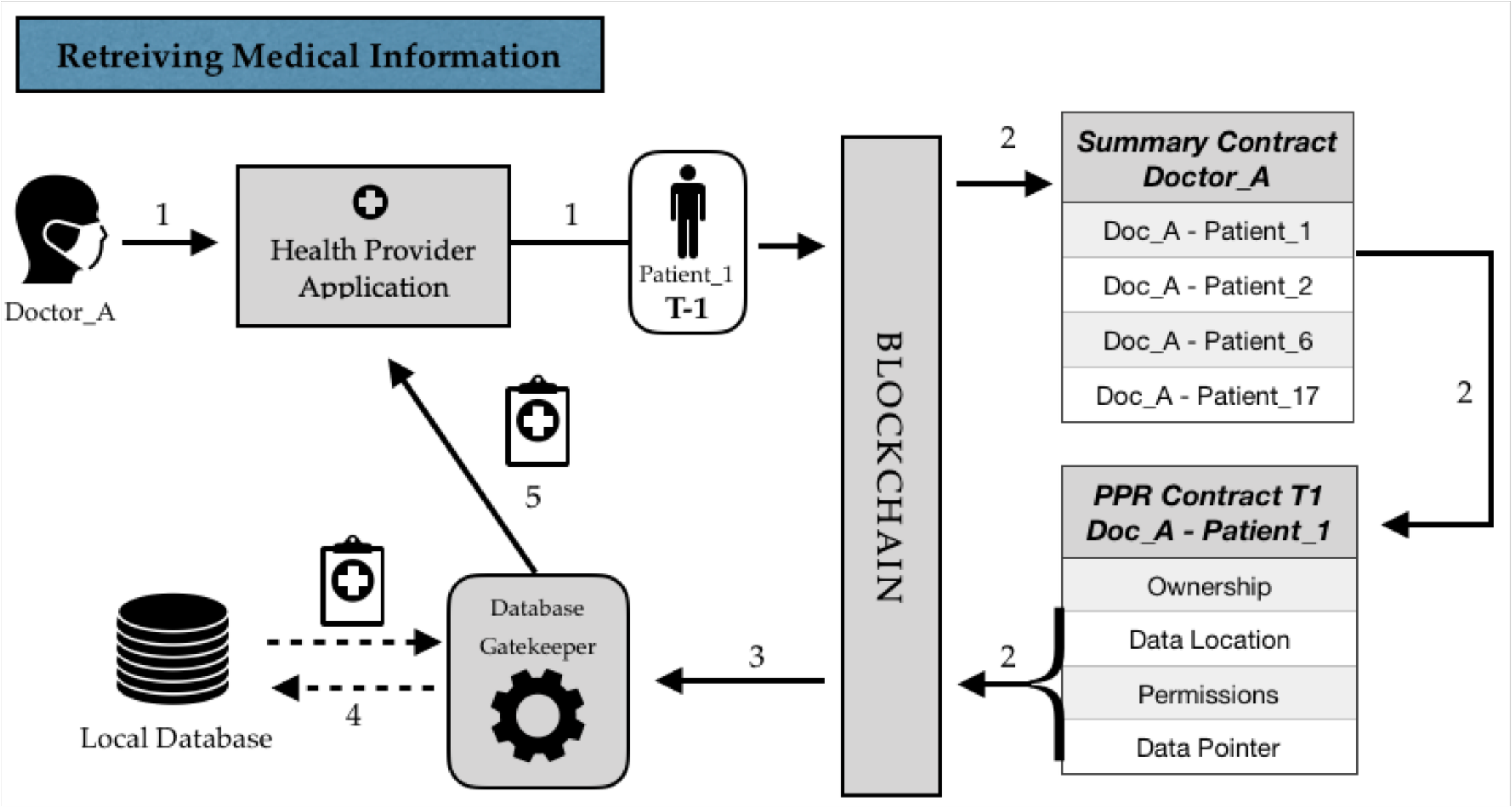
Quality of care
Patient Involvement
Digitalisation
Standard Data Format
Interoperability
Medical Data Sharing
Medical Research
Longitudinal Medical Data
Transparency
Efficiency
Population Health Management

4) Use Case

1: Identification Phase
2: Doctor Endorsement Phase
3: Patient Endorsement Phase
4: Validation Phase



4) Use Case


Retreiving Medical Information
Doctor_A
1
Health Provider Application
1
Patient_1
T-1
BLOCKCHAIN
2
Summary Contract Doctor_A
Doc_A - Patient_1
Doc_A - Patient_2
Doc_A - Patient_6
Doc_A - Patient_17
2
PPR Contract T1 Doc_A - Patient_1
Ownership
Data Location
Permissions
Data Pointer
2
3
Database Gatekeeper
4
Local Database
5

5) Conclusion

- *The future path that blockchain technology will take in the healthcare system remains to be seen.*

- *Besides the adoption of a blockchain solution, such improvements will be possible only through a real shift in the behaviour of patients, doctors, and care providers.*

- *To conclude, this research encourages the comprehension of the benefits that different blockchain technologies can bring to the healthcare system.*

Which questions do you have?

FEEL FREE TO CONTACT ME

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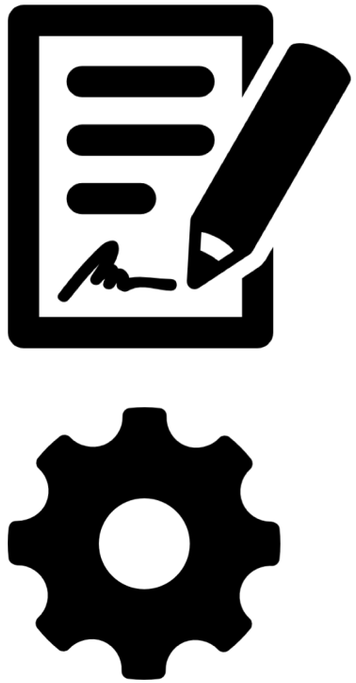
4) Use Case

SMART CONTRACTS

1. **Gate Smart Contract (GSC).** Has the duty of checking that the Identification and Endorsement Phase have been successfully completed.

2. **Patient-Provider Smart Contract (PPR).** It saves the Patient-Health Provider relationships. These relationships include pointers to the local database where medical data have been saved, the stewardship and the access of the medical data.

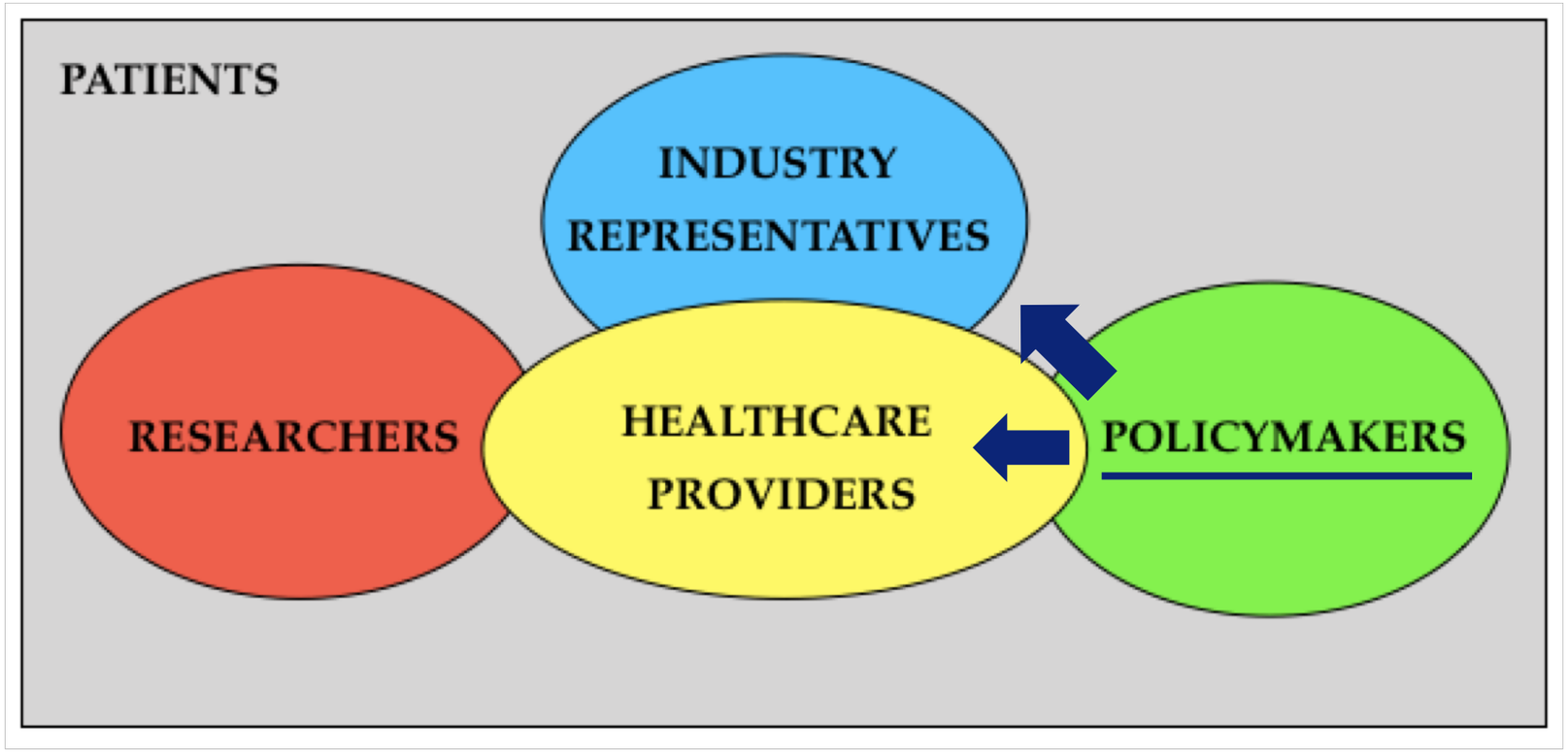
3. **Summary Contract (SC).** This smart contract lists all the PPR relationship of a patient, or a provider, to represent all the old and current engagements of the nodes participating in the network.



8) Conclusion

HEALTHCARE STAKEHOLDERS

Stakeholders and hurdles have been identified assuming that the blockchain solution will be implemented on a national scale in a developed country.



8) Conclusion

HURDLES FOR FUTURE ADOPTION

Financial challenges

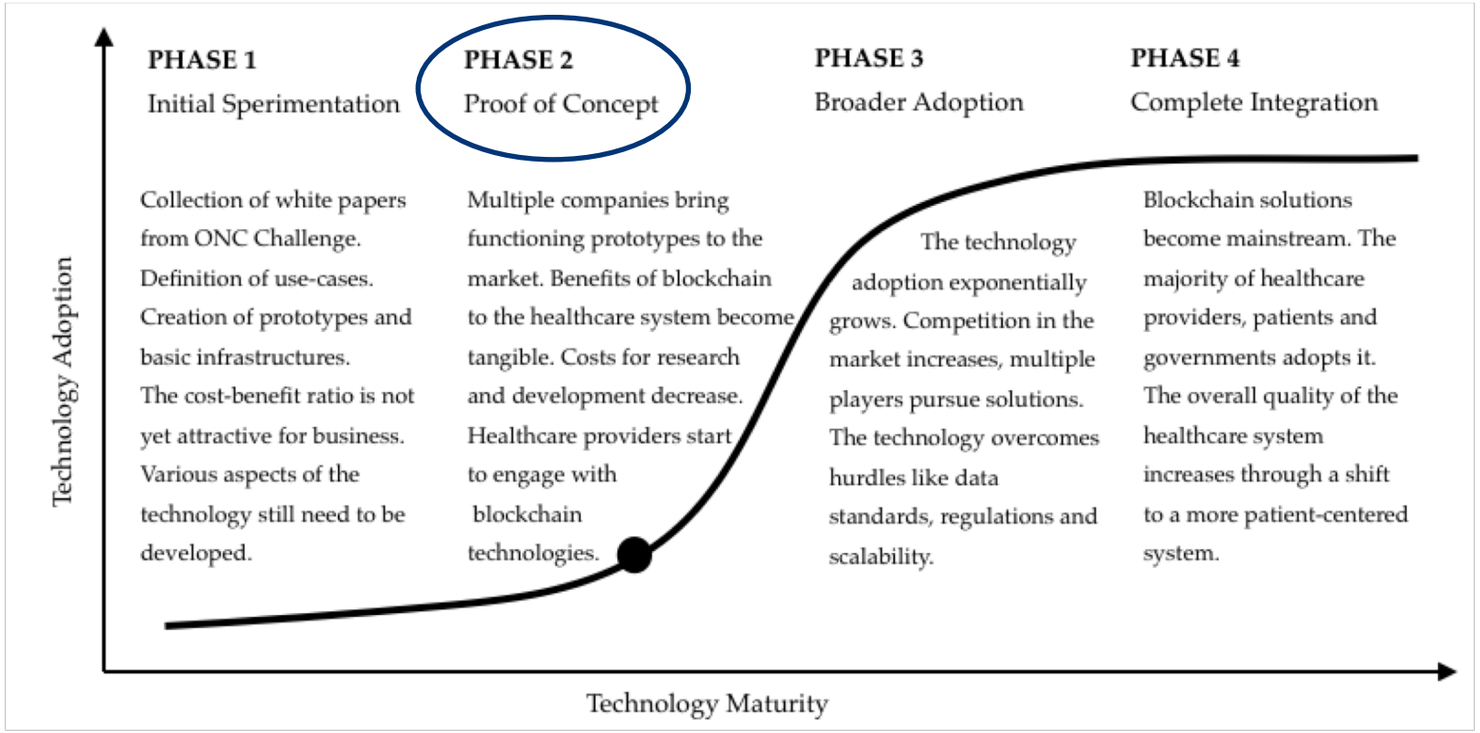
- Workforce
- Implementation

Consortium creation

- Regulations
- Data Standards
- For-profit organisations

Social barriers

- Scepticism
- Resistance
- Adoption time



4) Research Questions

Which type of blockchain and consensus algorithm meets and fulfils the essential criteria for a blockchain solution to be applied to the healthcare system?

1. *Which are the essential properties for a healthcare blockchain solution that should be considered in a multicriteria evaluation of blockchain technologies like different networks type and consensus algorithms?*

2. *Should a blockchain solution for the healthcare system be implemented on a public or private, and permissioned or permissionless network? Which are the different benefits and limitations of these types of networks when applied to the healthcare system?*

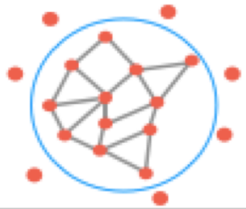
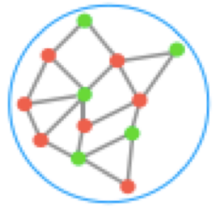
3. *Which consensus mechanism fit best in such a blockchain solution in the healthcare system, Proof of Work (PoW), Proof of Stake (PoS), Delegated Proof of Stake (D-PoS), or Proof of Authority (PoA)? Which are the different benefits and limitations of PoW, PoS, D-Pos and PoA when applied to the healthcare system?*

4) Research Focus

CONSENSUS ALGORITHMS

Consensus Algorithm	Resource Used
PoW	Computing Power
PoS	Ownership of tokens
D-PoS	Ownership of tokens and peer reputation
PoA	Certified authorities, randomly selected

NETWORK TYPE

Blockchain Type	Visualization
Public Permissionless	
Public Permissioned	
Private Permissionless	
Private Permissioned	

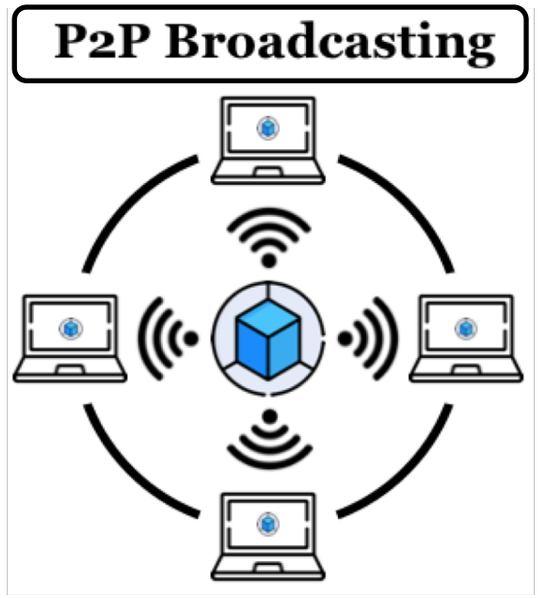
4) Research Focus

TYPE OF NETWORK

Who can participate in this network?

Does it need to be Private or Public?

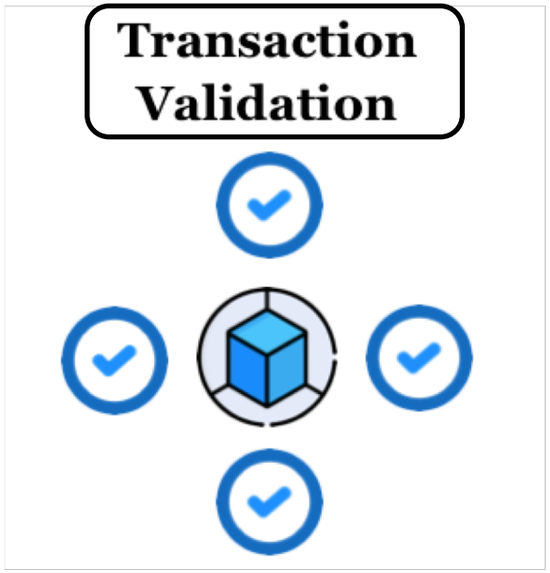
Does it need to be Permissioned or Permissionless?



TYPE OF CONSENSUS ALGORITHM

How should consensus between nodes be reached?

Which algorithm between PoW, PoA, PoS and D-PoS is the best one for such a solution?



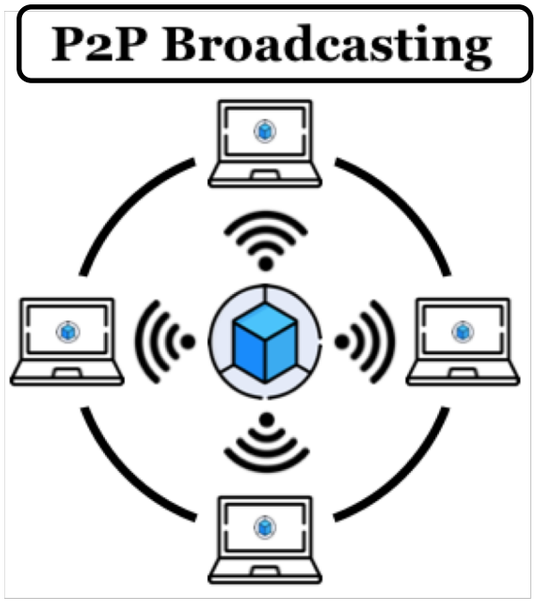
5) Experts Validation Interviews

- Effects of different consensus algorithms and network type on the of blockchain's benefits.

Blockchain Features	Public Permissioned	Public Permissionless	Private Permissioned	Private Permissionless
Innovation Readiness	0	0	14	8
Integration Readiness	0	0	14	8
Authentication Control	3	2	14	7
Smart Contracts Adoption	0	0	14	14
Network Control	4	0	14	8

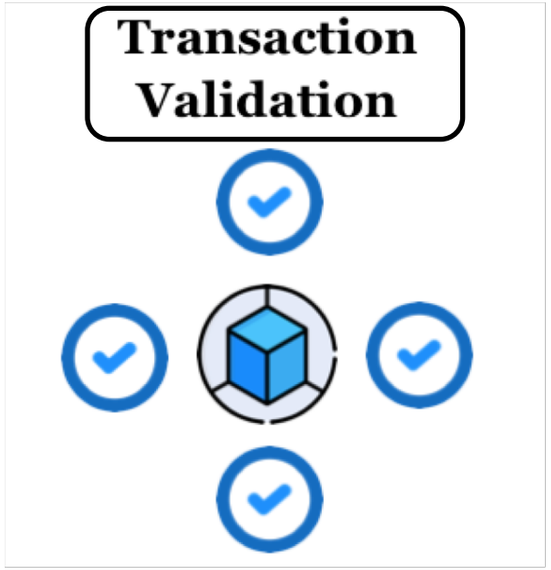
Effect	PoW	PoS	D-PoS	PoA
Network Speed	0	8	11	12
Consumption Costs	0	8	9	13
Adoption Easiness	6	10	11	11
Transaction Fee/Costs	10	9	11	0

6) Research Results



TYPE OF NETWORK:

PRIVATE PERMISSIONED



TYPE OF CONSENSUS ALGORITHM

D-PoS

PoA

6) Research Results

TYPE OF CONSENSUS ALGORITHM

- ***Network Speed:*** PoA provides the best speed. Indeed, it lowers competition, there is no need to select miners or minters in charge of validating transactions. Second to PoA, D-PoS also allows thousands of transactions per second.
- ***Consumption Costs:*** PoA again has the lowest energy consumption since there is no need to select the validating nodes and, no need to do mining. D-PoS and PoS have also low energy consumption while, PoW, according to experts, will not be sustainable in the long run.
- ***Adoption Easiness:*** It refers to the time and cost needed to adopt such a solution. PoA is preferred over D-PoS. PoA has no need for tokenisation and a more restricted number of nodes to instruct. D-PoS instead, needs to create a system of incentives (tokenisation) for minting blocks and, it needs more nodes to participate and instruct.
- ***Transaction Fees:*** Regarding the exploitation of fees to run and maintain the network, D-PoS is preferred over PoA since the last does not include network tokenisation. However, the difficulty in introducing and managing tokens is higher when compared to the benefits such a fee can induce to the network.

6) Research Results

TYPE OF NETWORK: PRIVATE PERMISSIONED

- ***Innovation readiness:*** Ethereum and Hyperledger platforms allow blockchains to make use of innovative technologies like IoT and A.I, and allows the exploitation of Big Data analysis. Restrictions, control and regulations provide more efficiency and effecacy.
- ***Authentication control:*** Such a network enables consortiums to deploy a more strict authentication control for nodes that want to join the network when compared to public networks. This identity verification frauds and hacking attemps.
- ***Integration readiness:*** The modularity of a blockchain solution implemented on a private permissioned network with Hyperledger Fabric or Ethereum, provides the best integration possible with the existing health It infrastructure. Consortiums can plug-in tools to support the features they want.
- ***Network control:*** A private permissioned network allows health consortiums in charge, to control nodes' permissions, restrictions and activities.
- ***Smart contracts:*** A self-executable and immutable contract between two parties. Private permissioned blockchains built with both Hyperledger Fabric and Ethereum allow selected developers to code smart contracts. Fabric is preferred since it does not need any cryptocurrency to run the smart contracts.