Public Health Surveillance

&

Blockchain Technologies

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(CO**llaborative **M**anagement **P**latform for detection and **A**nalyses of **(Re-)** emerging and foodborne outbreaks in **E**urope**)

- **What:**
  - Rapid identification, containment and mitigation of emerging infectious diseases and foodborne outbreaks,
- **How:**
  - By developing a cross-sector and cross-pathogen analytical framework and globally linked data and information sharing platform,
- **Who:**
  - Authorities and other users in the human health, animal health and food safety domains
- **Data:**
  - Sequence-based pathogen data in combination with associated clinical, epidemiological and other metadata

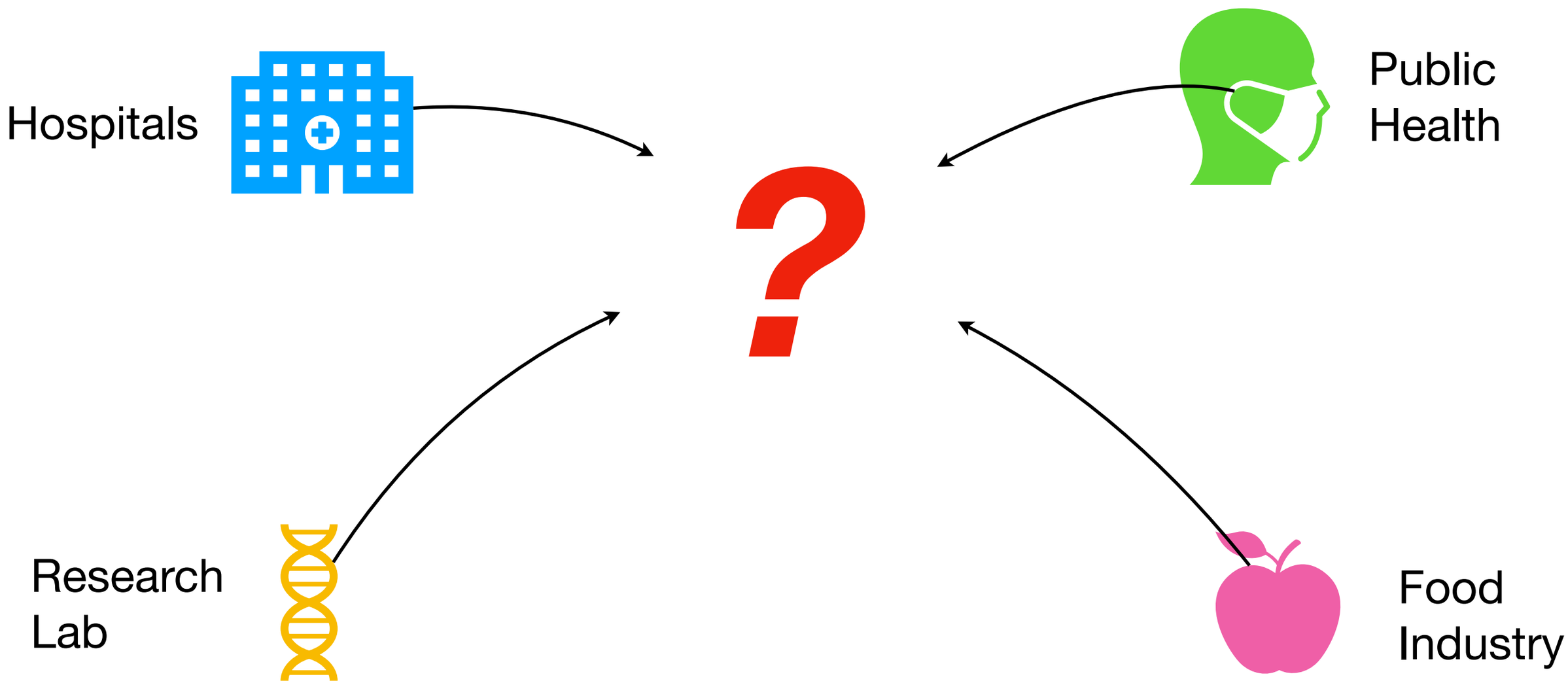
2011 German E. coli outbreak

Number of cases reported to the WHO as for 21 July 2011[11]

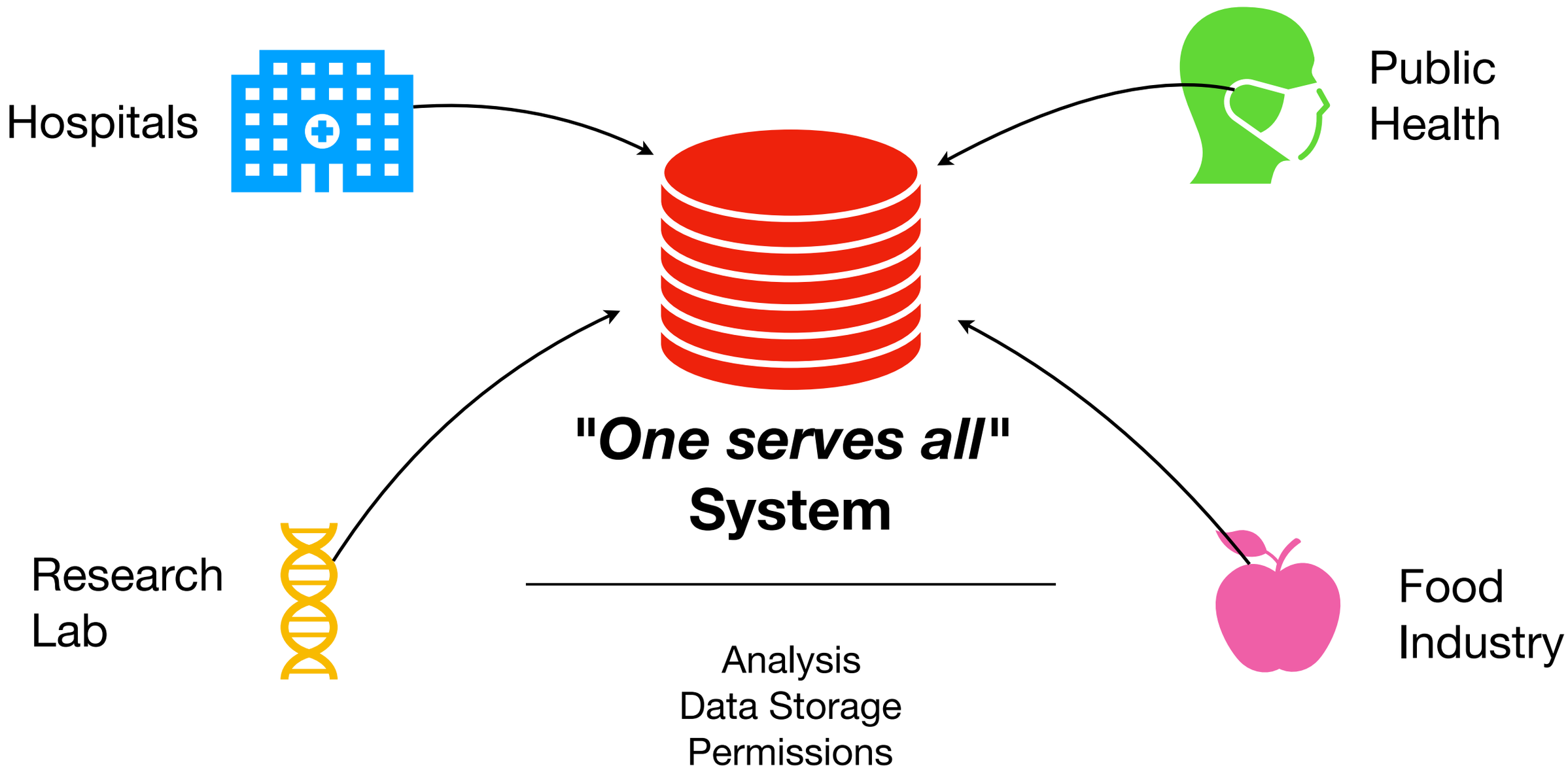
Country	Deaths	HUS cases	Non-HUS cases
Germany	48	857	3078
Sweden	1	18	35
Denmark	0	10	15
France	0	7	10
Switzerland	0	5	0
Netherlands	0	4	7
United States	1	4	2
United Kingdom	0	3	4
Poland	0	2	1
Austria	0	1	4
Luxembourg	0	1	1
Spain	0	1	1
Canada	0	0	1
Czech Republic	0	0	1
Greece	0	0	1
Norway	0	0	1
Total	**50**	**908**	**3,167**

- **4075 people** were affected and **50 died**, 48 of whom were in Germany.
- German officials made **incorrect statements** linking the strain to **cucumbers imported** from **Spain.**
- Spanish exporters **lost US$200 million** per week.
- **Seeds imported from Egypt** (*~2009*) were likely the source of the outbreak.

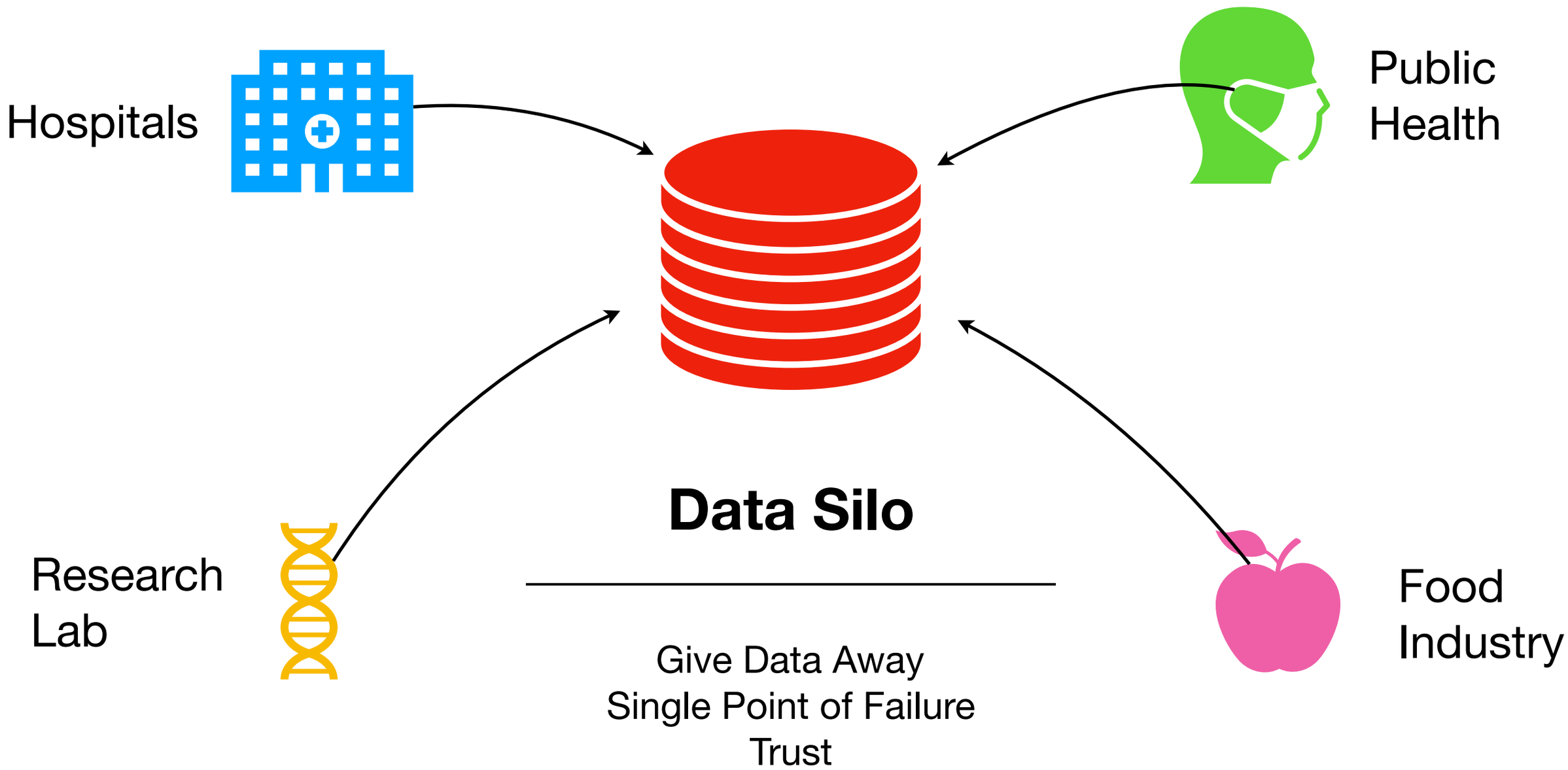
Current Solution



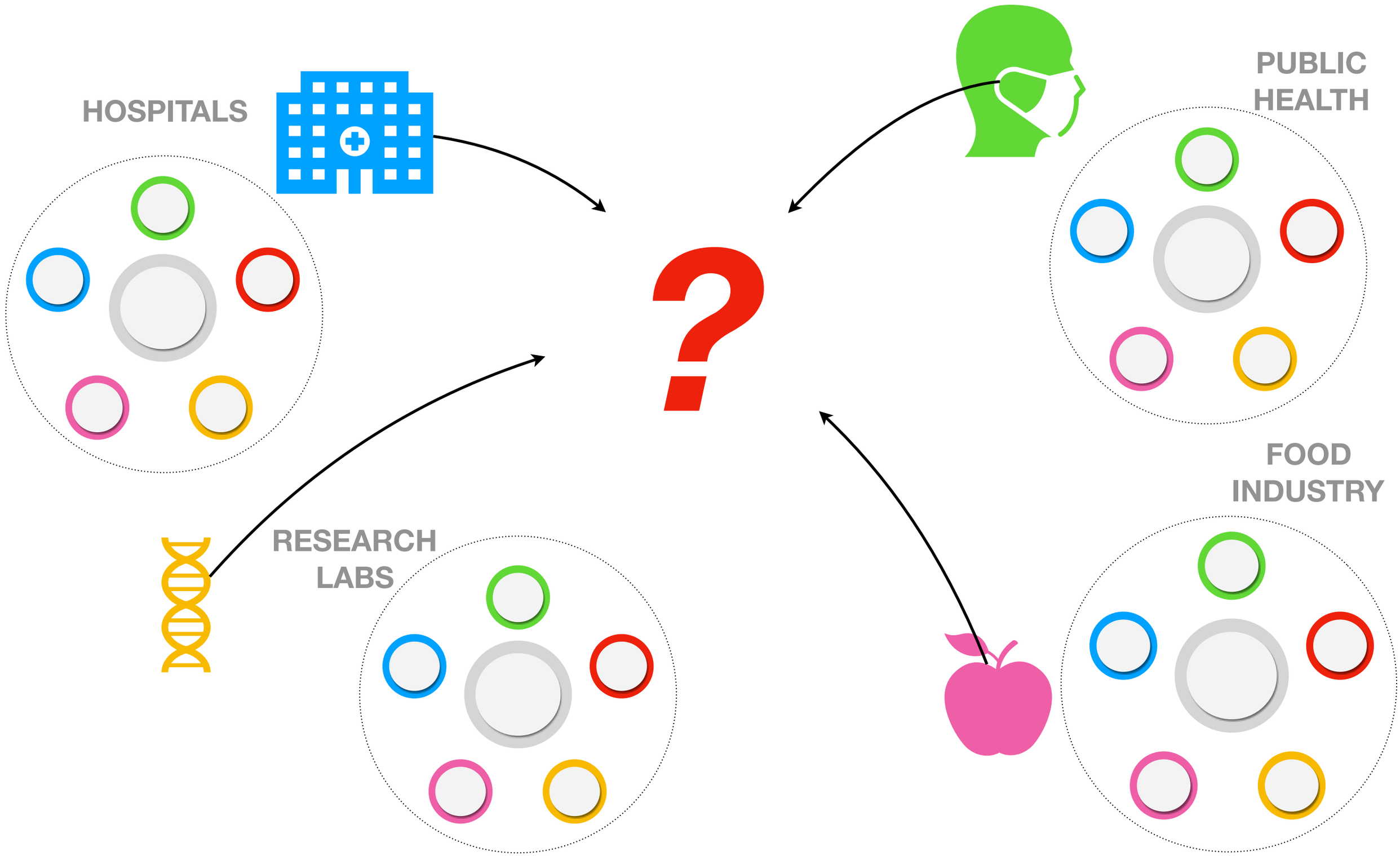
Current Solution



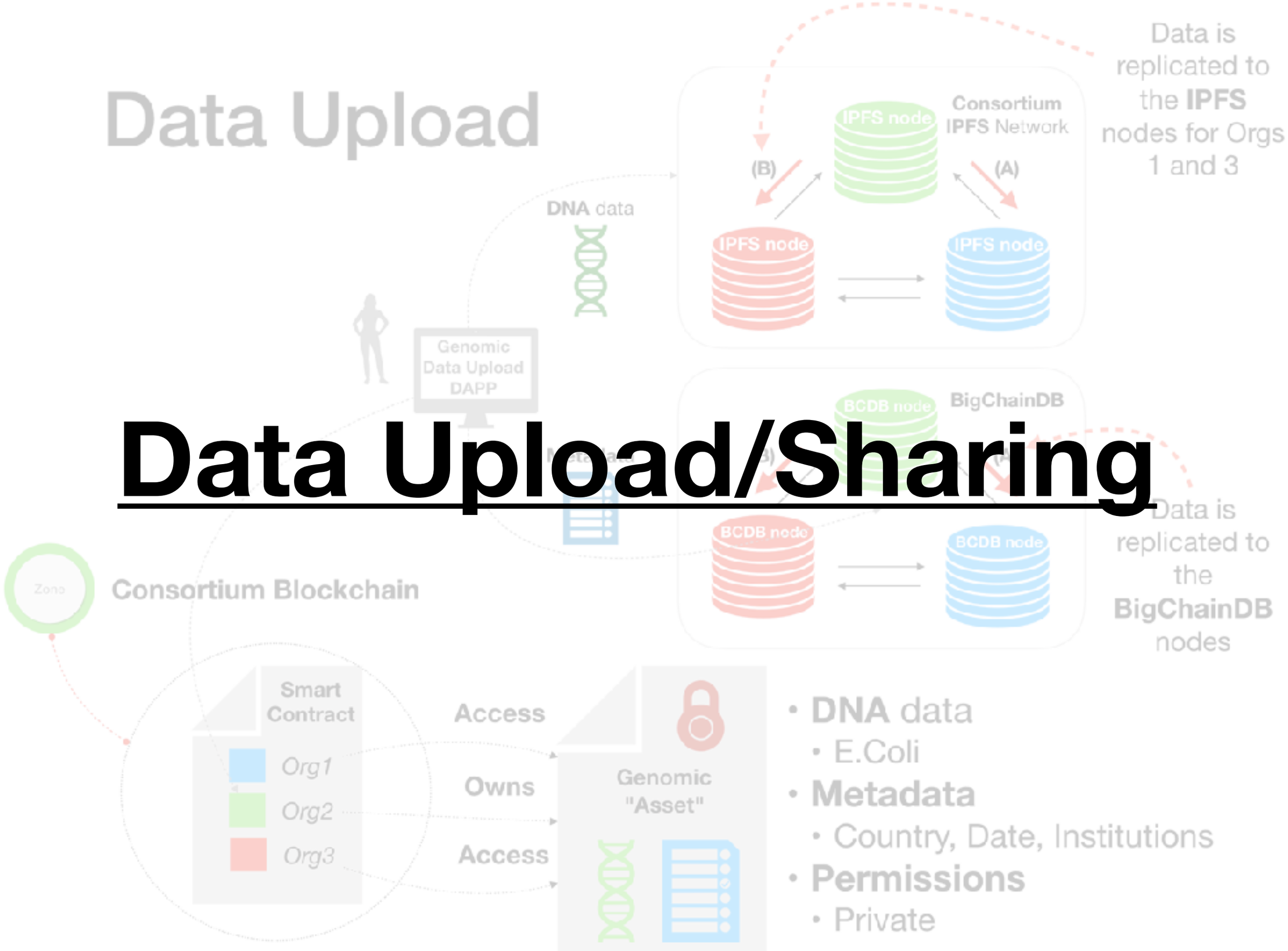
Current Solution?



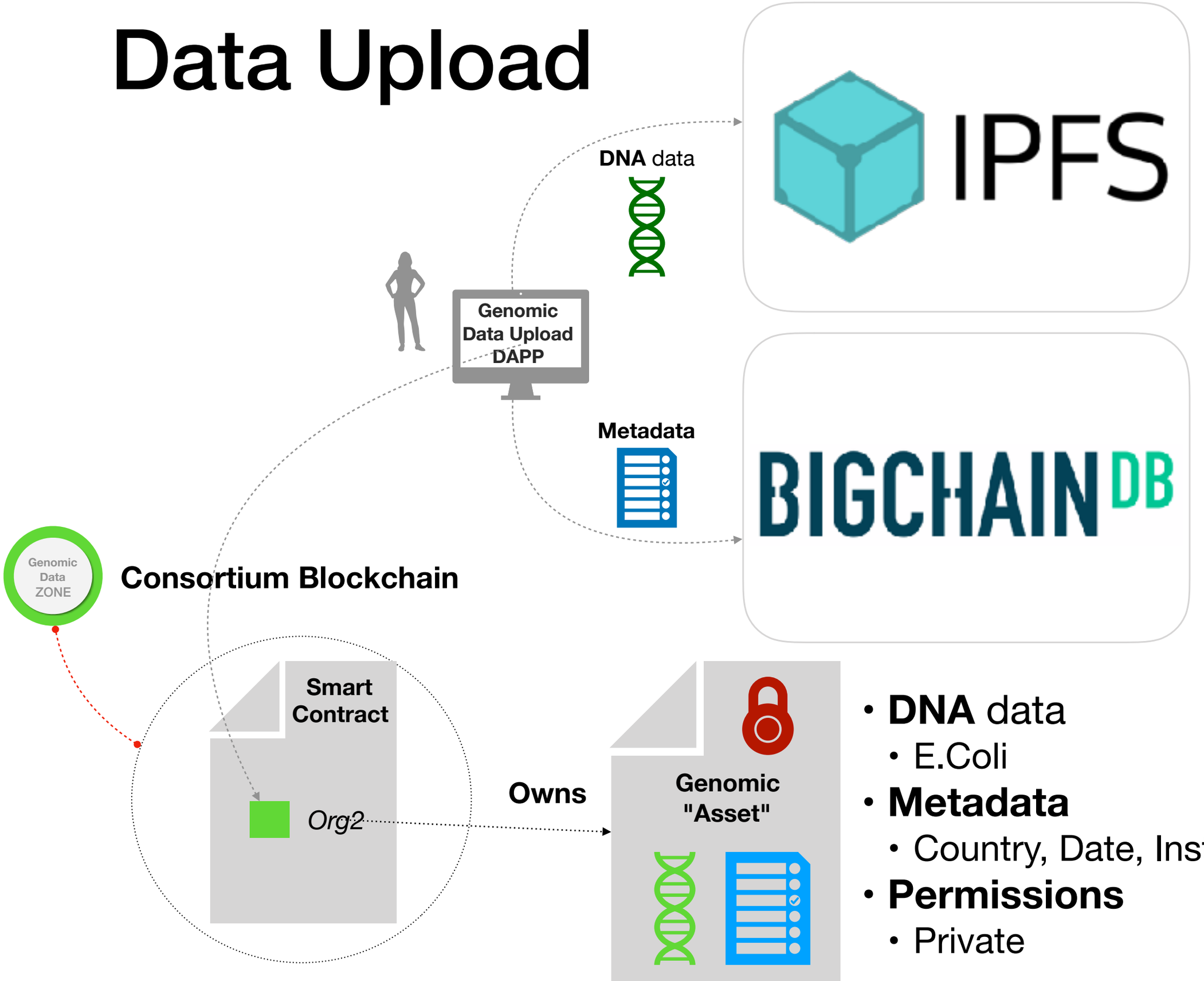
Decentralized Solution?



Data Upload/Sharing

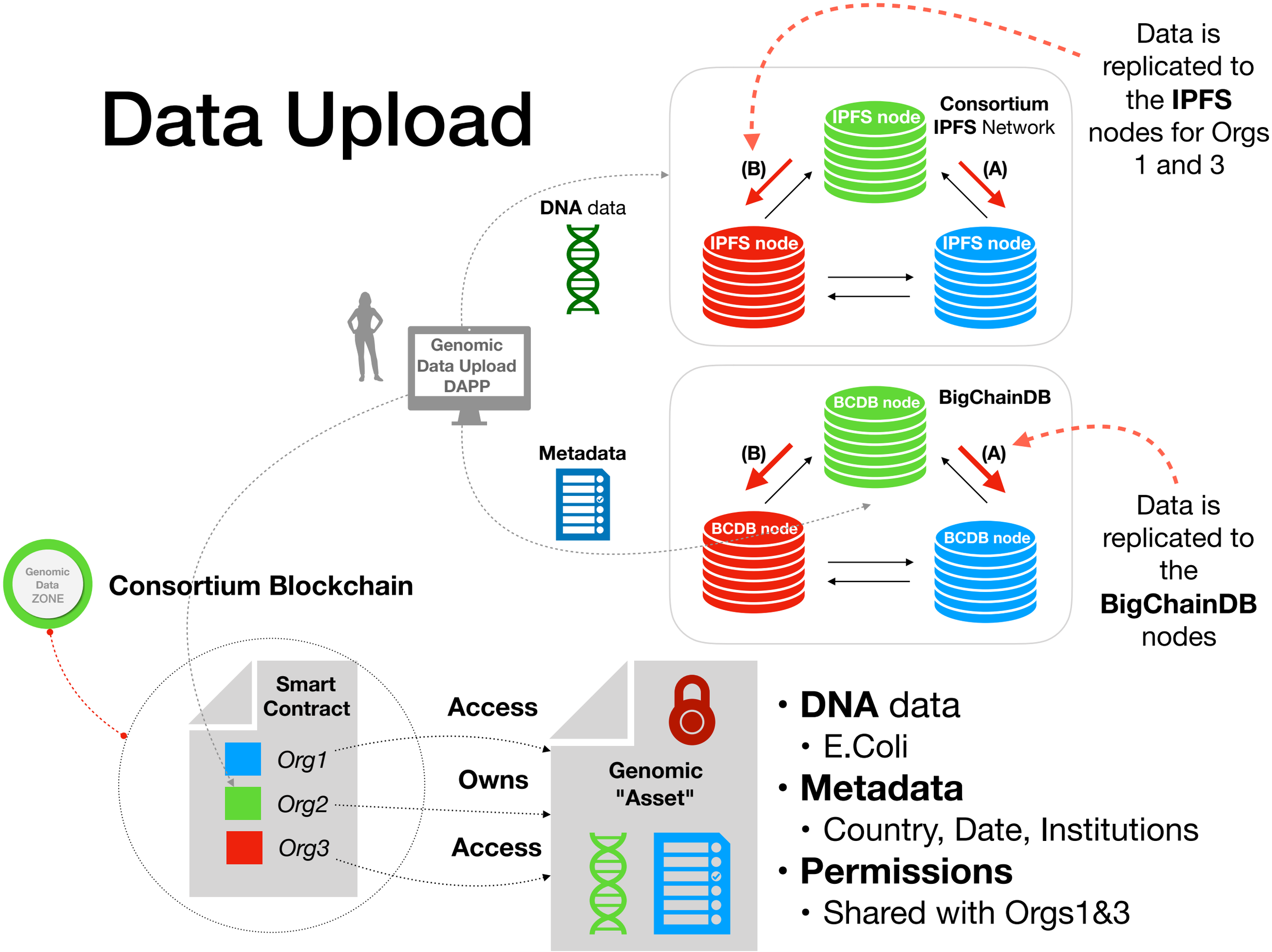


Data Upload



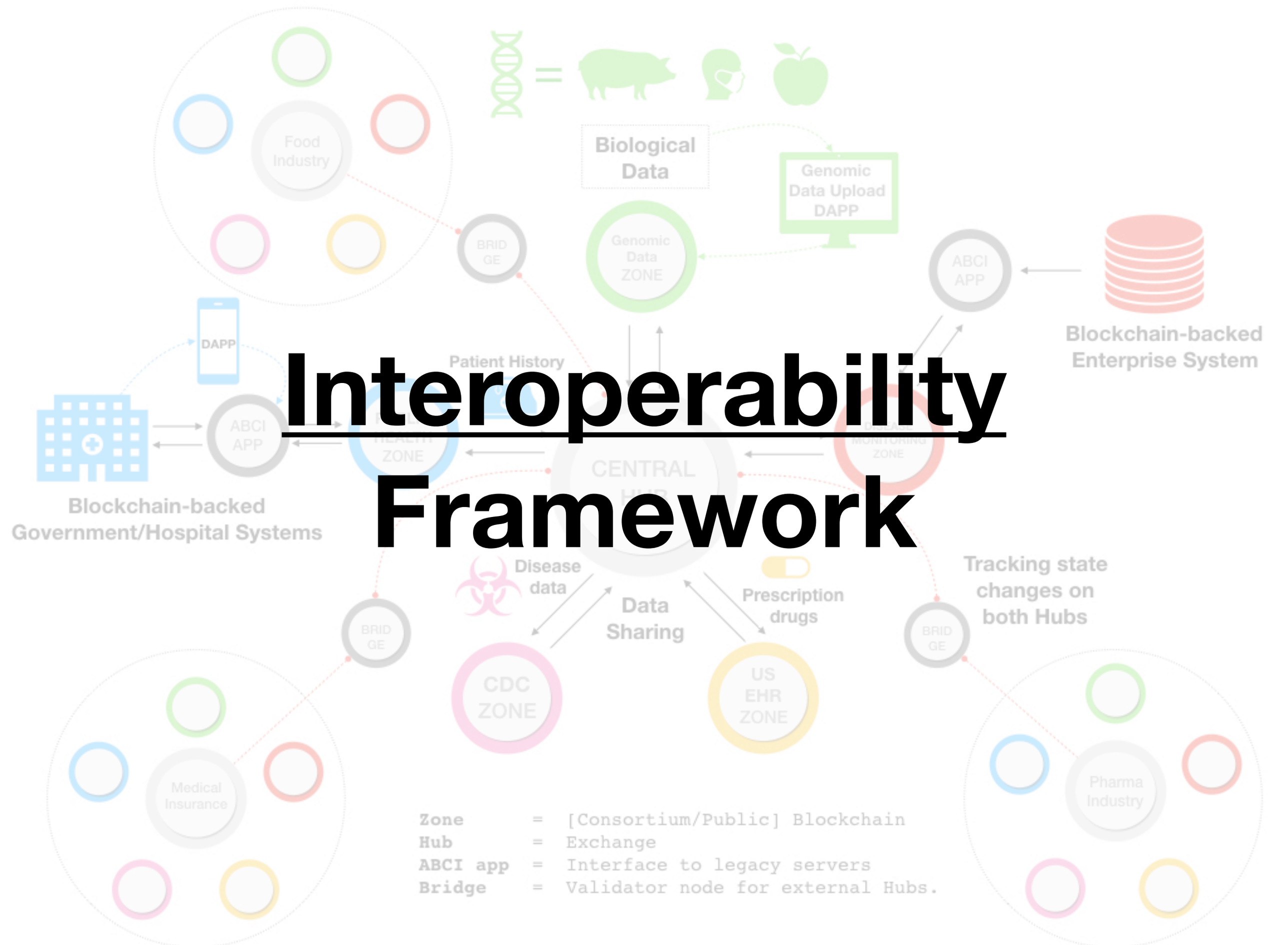
- **DNA** data
  - E.Coli
- **Metadata**
  - Country, Date, Institutions
- **Permissions**
  - Private

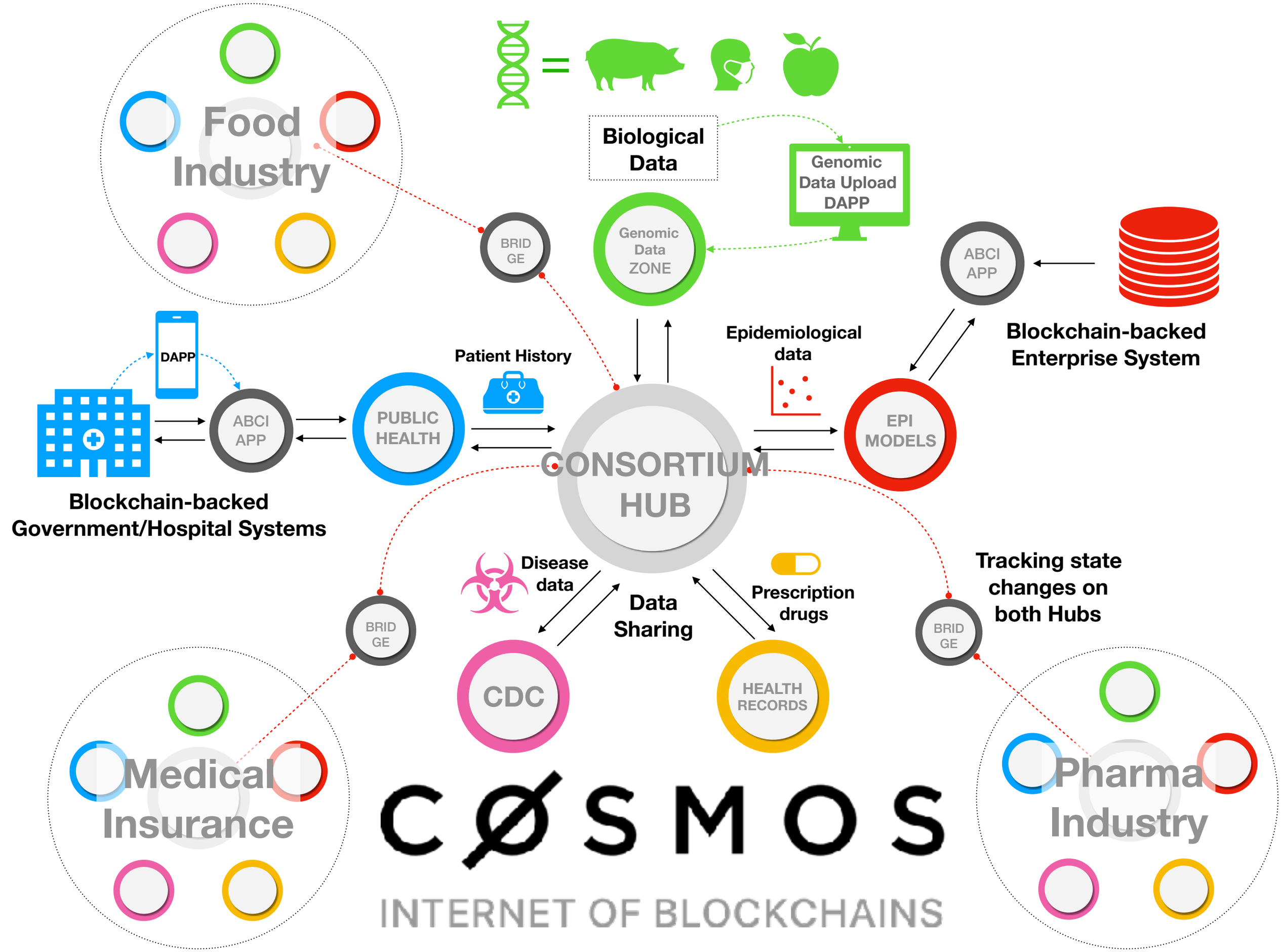
Data Upload



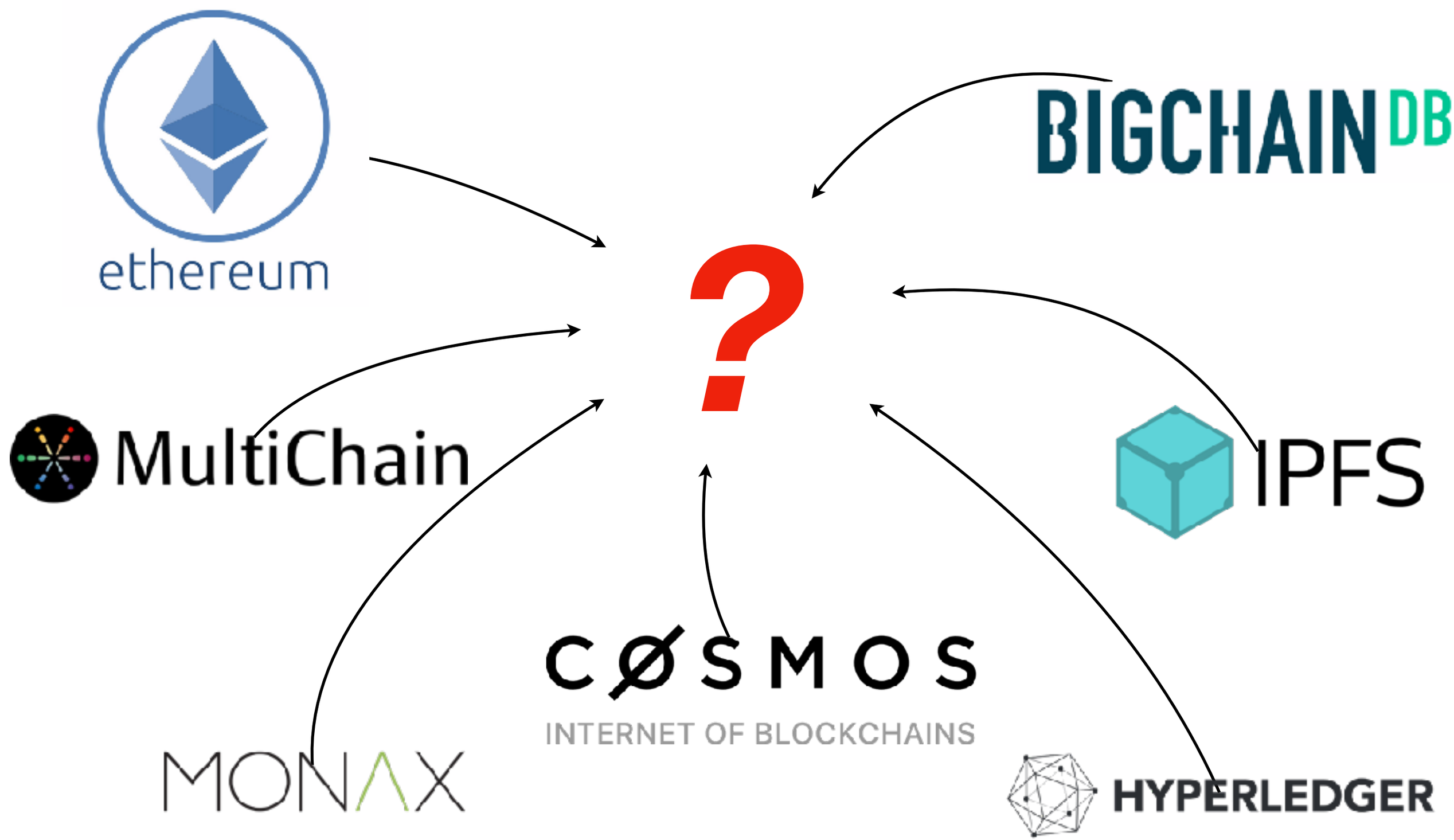
- **DNA** data
  - E.Coli
- **Metadata**
  - Country, Date, Institutions
- **Permissions**
  - Shared with Orgs1&3

Interoperability Framework




Food Industry
Biological Data
Genomic Data Upload DAPP
BRID GE
Genomic Data ZONE
ABCI APP
Blockchain-backed Enterprise System
DAPP
Patient History
Epidemiological data
ABCI APP
PUBLIC HEALTH
CONSORTIUM HUB
EPI MODELS
Blockchain-backed Government/Hospital Systems
Disease data
Data Sharing
Prescription drugs
Tracking state changes on both Hubs
BRID GE
BRID GE
CDC
HEALTH RECORDS
Medical Insurance
Pharma Industry
COSMOS
INTERNET OF BLOCKCHAINS

Questions


ethereum
BIGCHAINDB
?
MultiChain
IPFS
COSMOS
INTERNET OF BLOCKCHAINS
MONAX
HYPERLEDGER

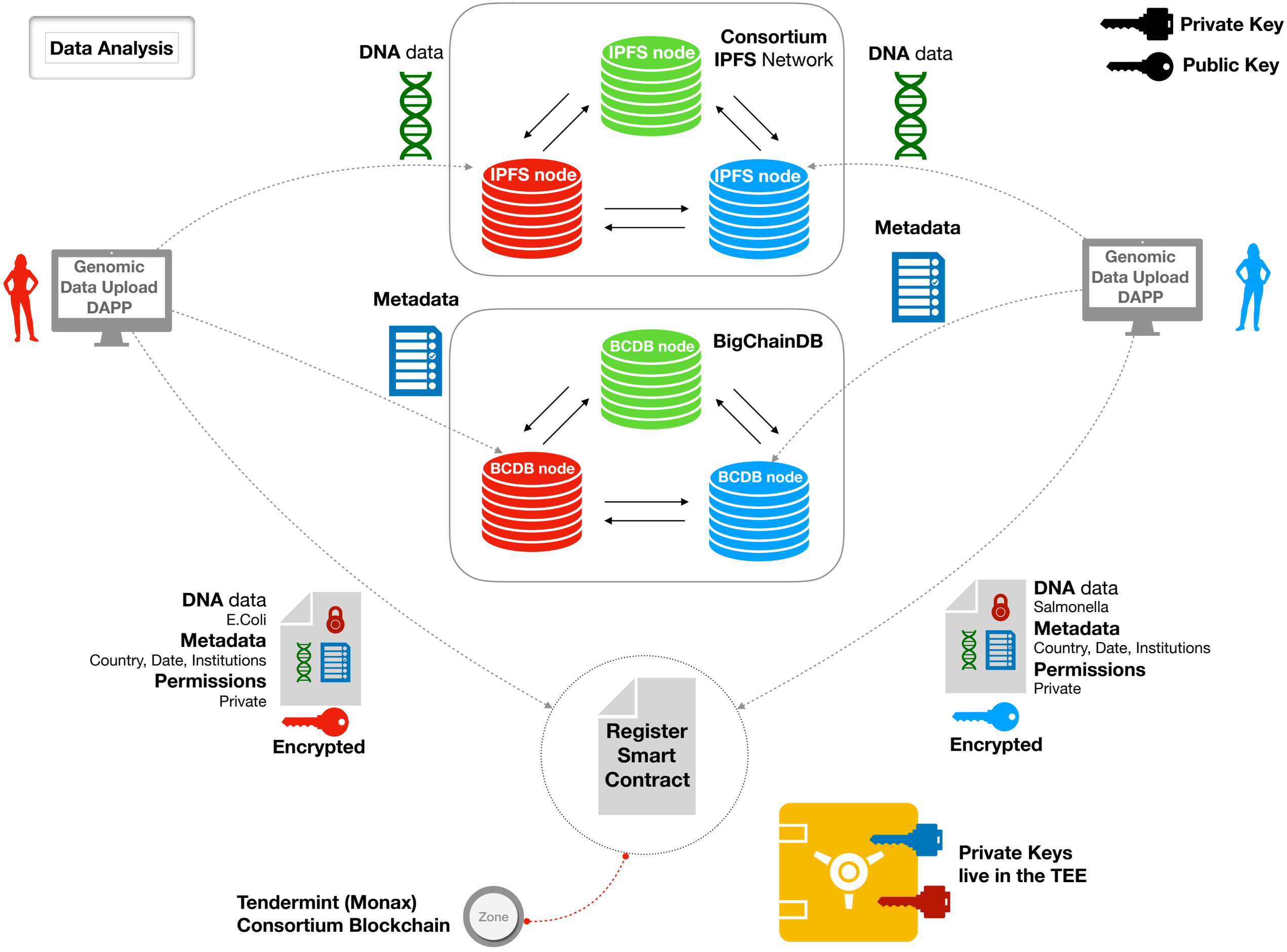
Appendix: Security and Privacy

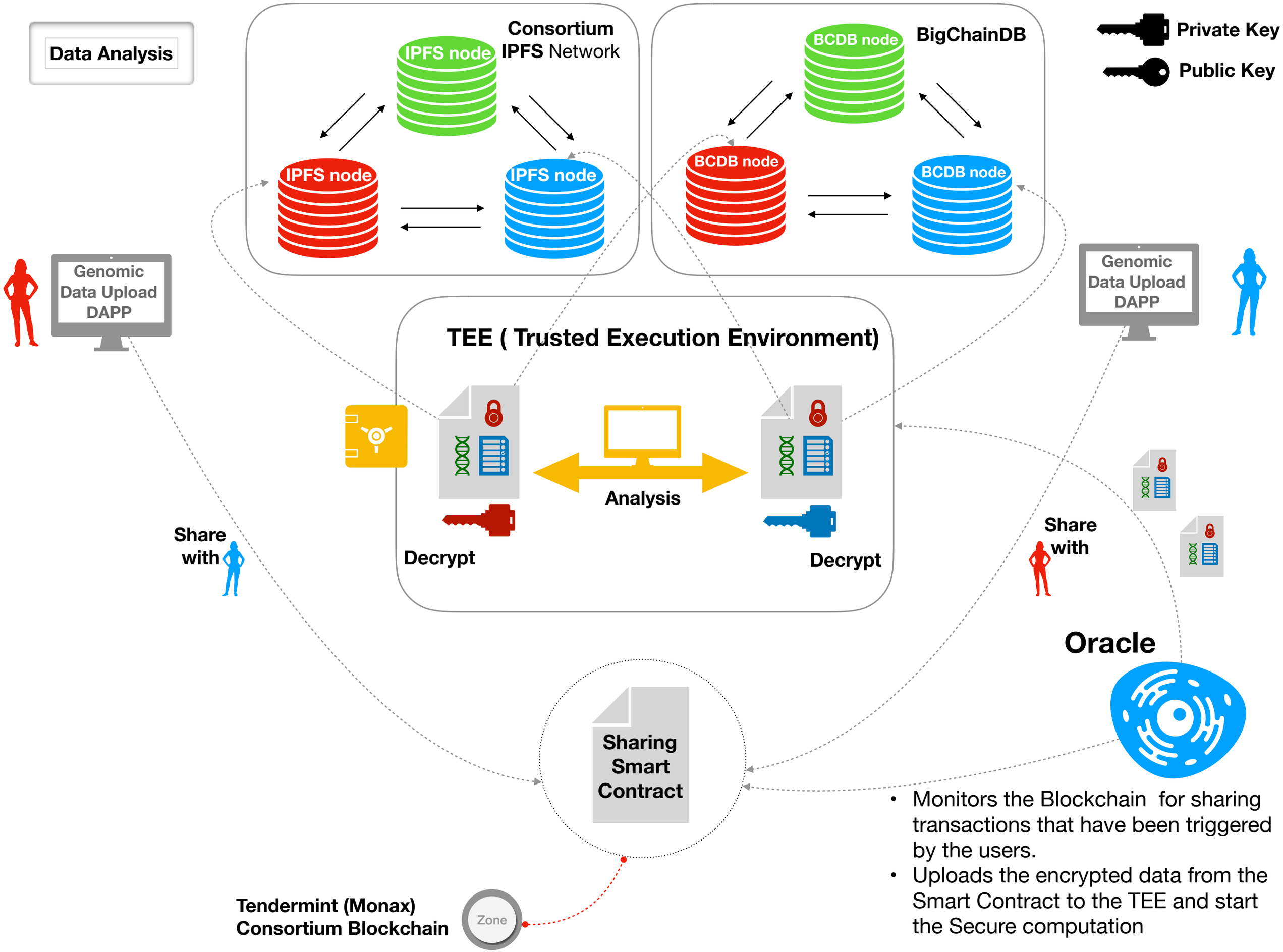
TEEs
(Trusted **E**xecution **E**nvironment**s)**

Hardware support for secure computation

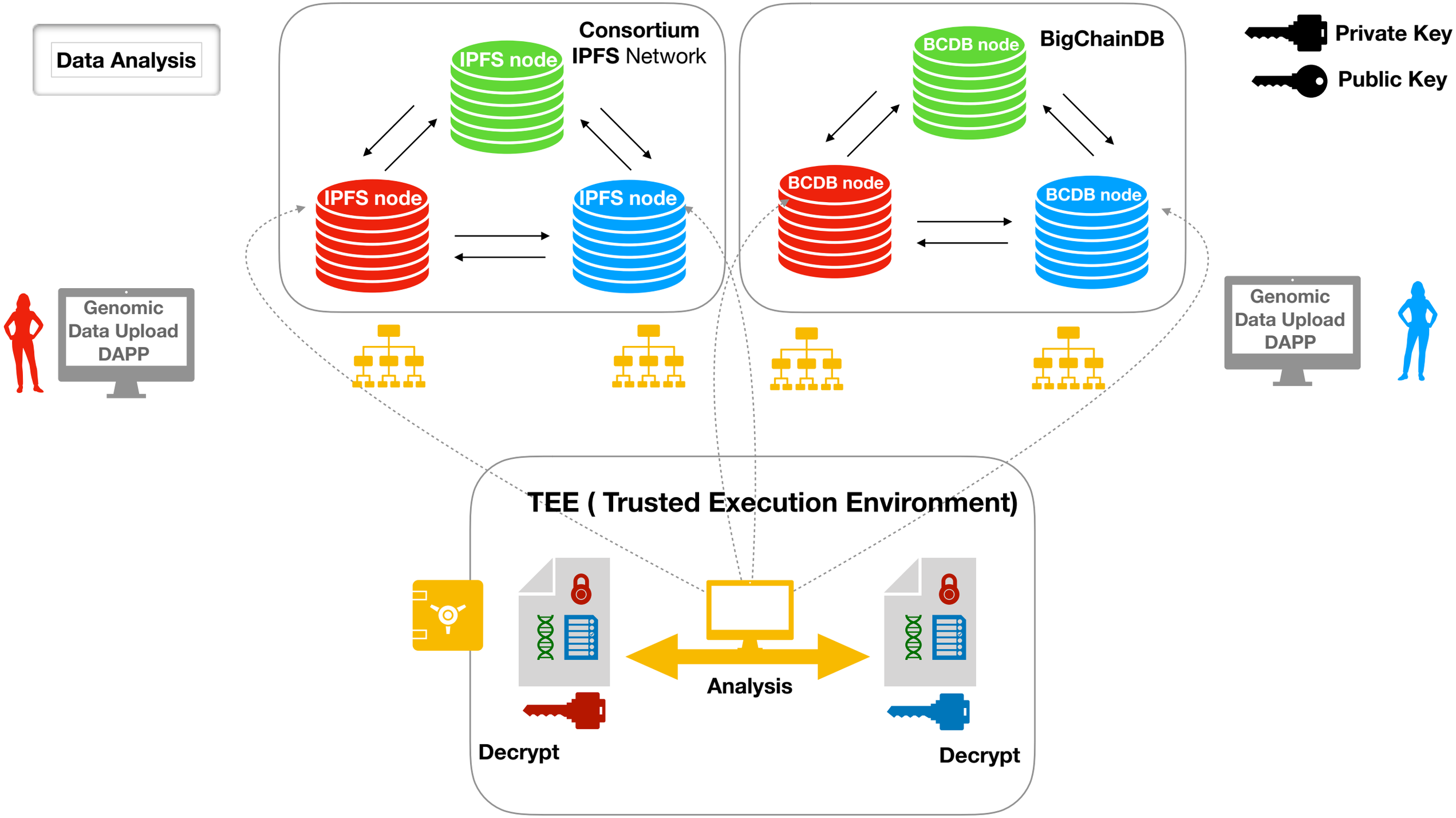
Homomorphic Encryption

Computation on encrypted data

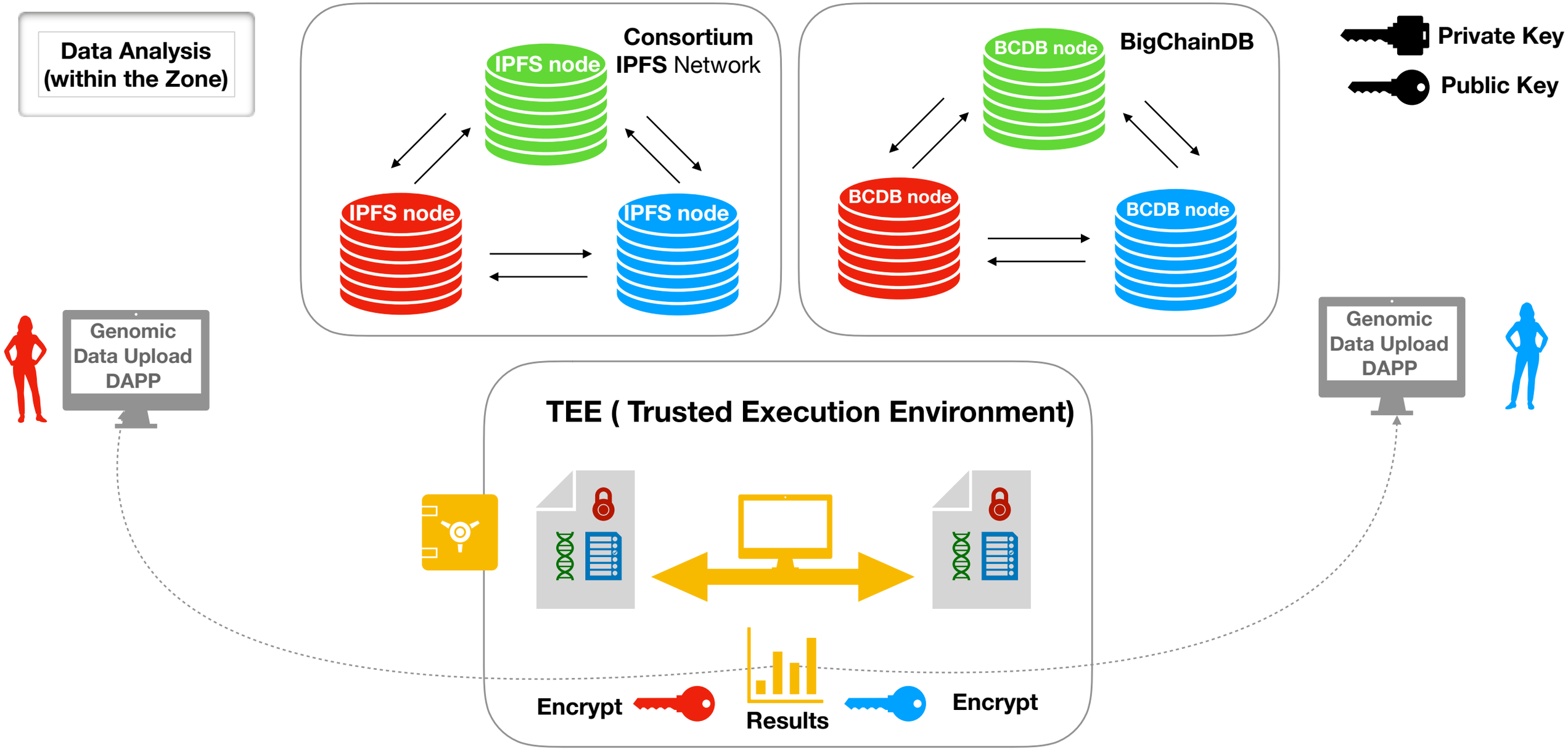

Data Analysis
Private Key
Public Key
DNA data
Consortium
IPFS Network
IPFS node
IPFS node
IPFS node
DNA data
Metadata
Genomic
Data Upload
DAPP
Genomic
Data Upload
DAPP
Metadata
BigChainDB
BCDB node
BCDB node
BCDB node
DNA data
E.Coli
Metadata
Country, Date, Institutions
Permissions
Private
Encrypted
DNA data
Salmonella
Metadata
Country, Date, Institutions
Permissions
Private
Encrypted
Register
Smart
Contract
Private Keys
live in the TEE
Tendermint (Monax)
Consortium Blockchain
Zone



- Monitors the Blockchain for sharing transactions that have been triggered by the users.
- Uploads the encrypted data from the Smart Contract to the TEE and start the Secure computation



If applicable for the problem (i.e. *Machine learning models*), **Homomorphic Encryption + Federated Learning** can be used to send the encrypted model where the data lives and then return the encrypted results to the TEE.



The results are encrypted using the Public Keys and sent to the users

References

- Tendermint (Byzantine fault-tolerant replicated state machines in any programming language)
- Myth Busting: Can a blockchain save healthcare?
- The Coco Framework: open source system that enables high scale, confidential blockchain networks that meet all key enterprise requirements providing a means to accelerate production enterprise adoption of blockchain technology. (Health Data in Trusted Executed Environments)
- Monax: Permissioned Blockchains
- Cosmos: Internet of Blockchains
- Hyperledger Burrow: modular blockchain client with a permissioned smart contract interpreter partially developed to the specification of the Ethereum Virtual Machine (EVM)
- BigChainDB: A scalable “big data” database with some blockchain characteristics added, including decentralization, immutability and native support for assets.
- IPFS: A peer-to-peer hypermedia protocol to make the web faster, safer, and more open.
- OpenMined: Encrypted, Decentralized Artificial Intelligence via Smart Contracts, Federated Learning and Homomorphic Encryption (Introducing Open Mined: Decentralised AI)