MedChain

Blockchain-based Access Control System for Medical Data

Muhammad Talha Paracha
supervised by
Dr. Troncoso-Pastoriza & **Dr. Raisaro**
with
Prof. Hubaux

About me

Recently graduated from NUST, Pakistan
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Aspire to become a computer scientist

About the talk

Medical data-analysis

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MedChain

- Design
- Integration
- Demo
- Performance evaluation

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Conclusion

Medical data-analysis

Hospital 1

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Hospital 2

i2b2

...

Hospital N

ElasticSearch

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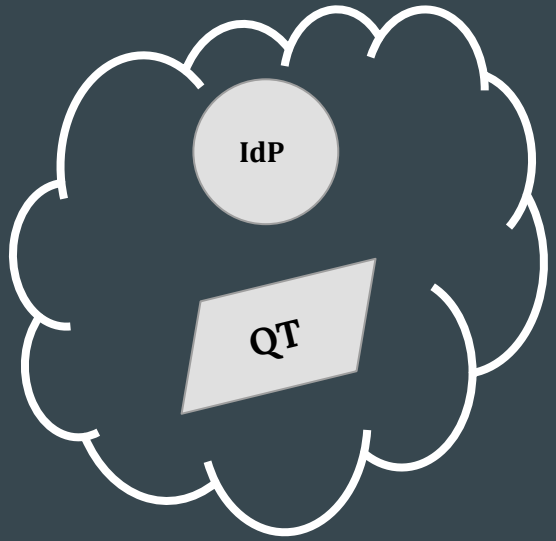

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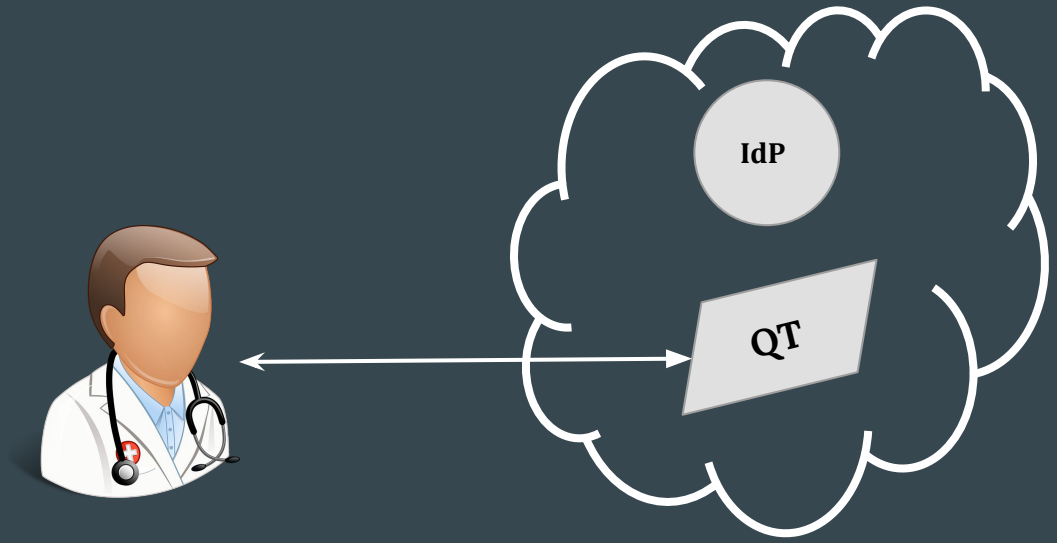
IdP = Identity Provider
QT = Query Tool



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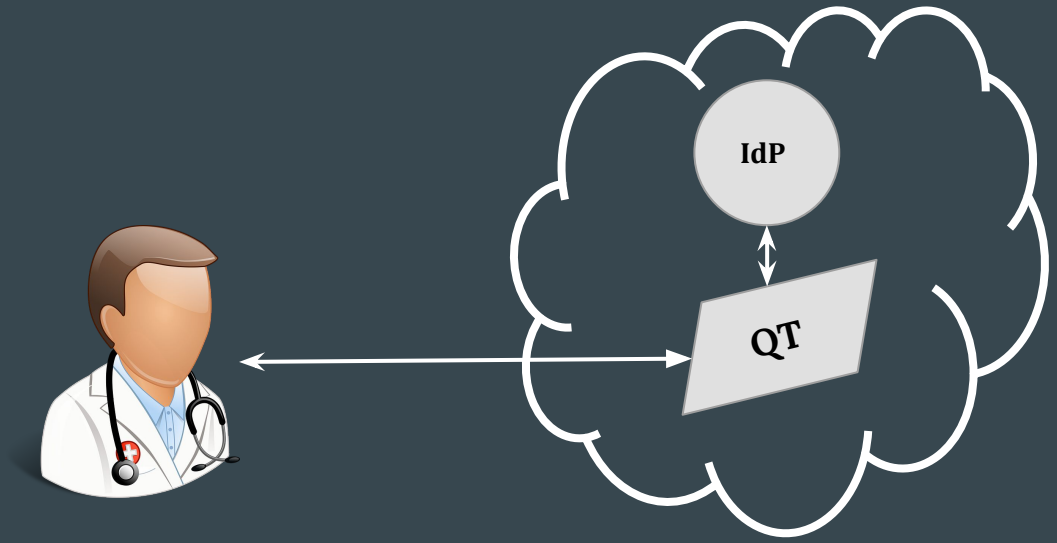

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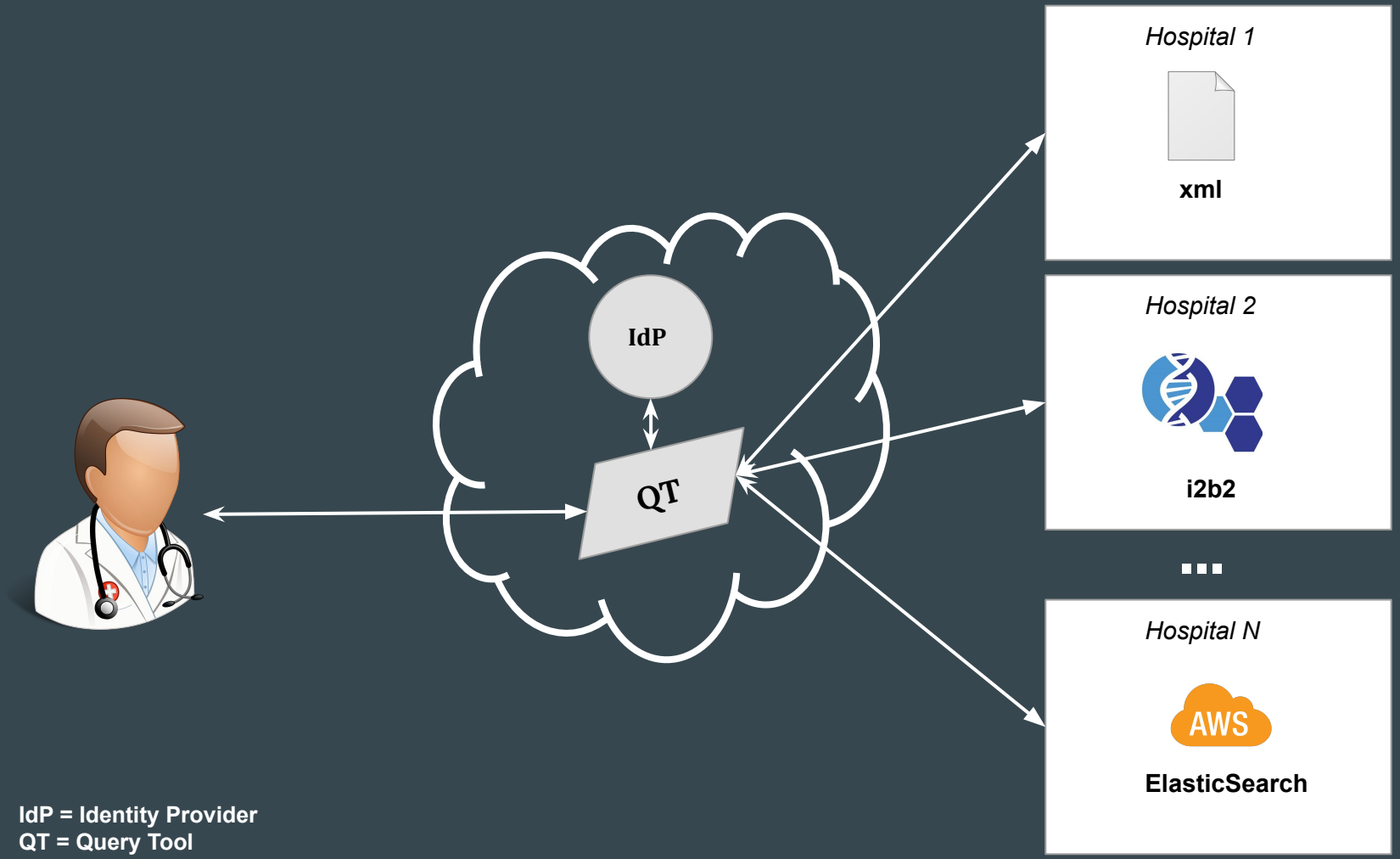

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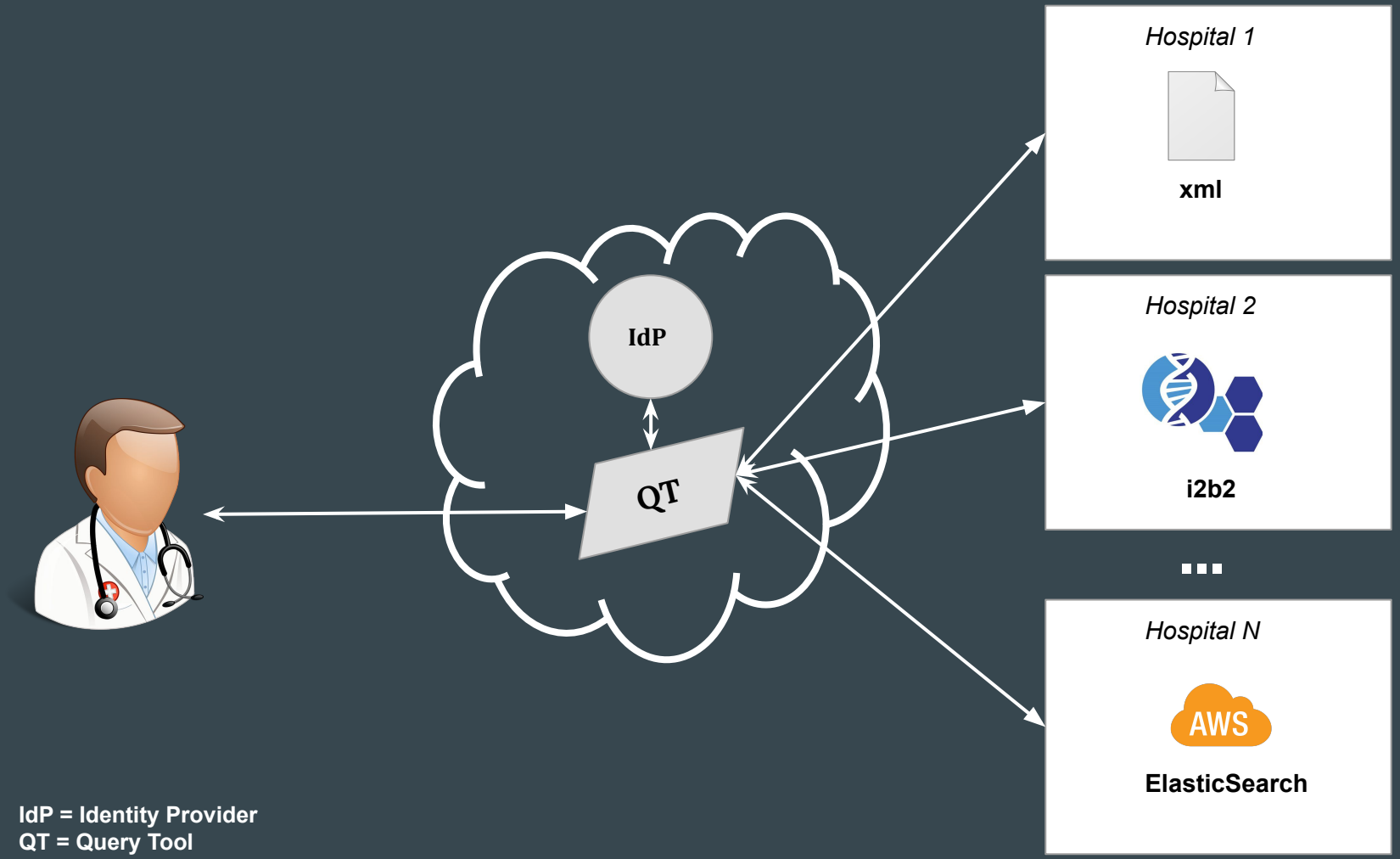
Threat model

- Malicious external agents
- Dishonest internal agents

IdP = Identity Provider

Vulnerabilities of current approaches

Single Point of Failure	• IdP can be compromised



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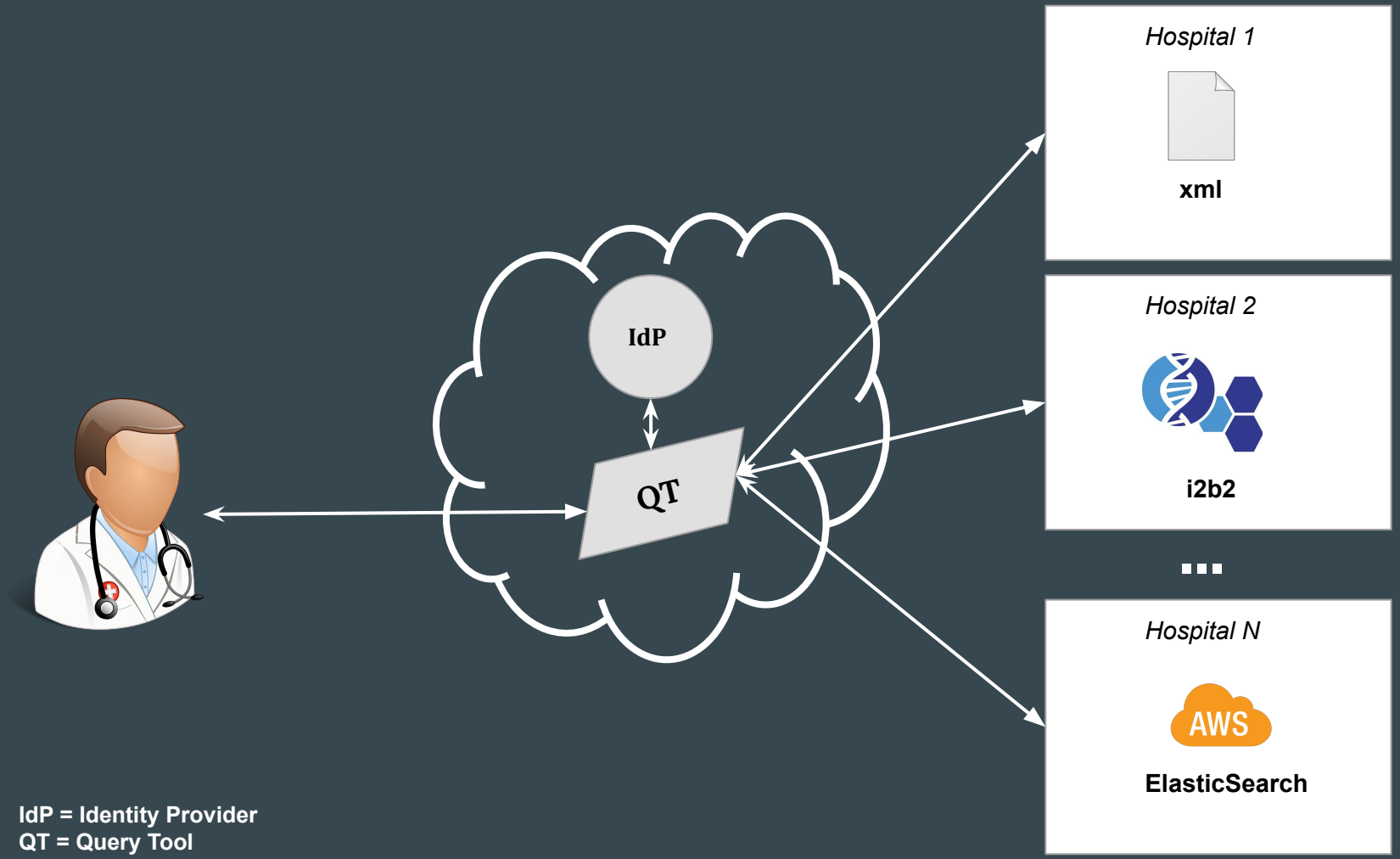
No Auditability (by the resources)	• Resources are not aware of the end-user who wants to access the data.



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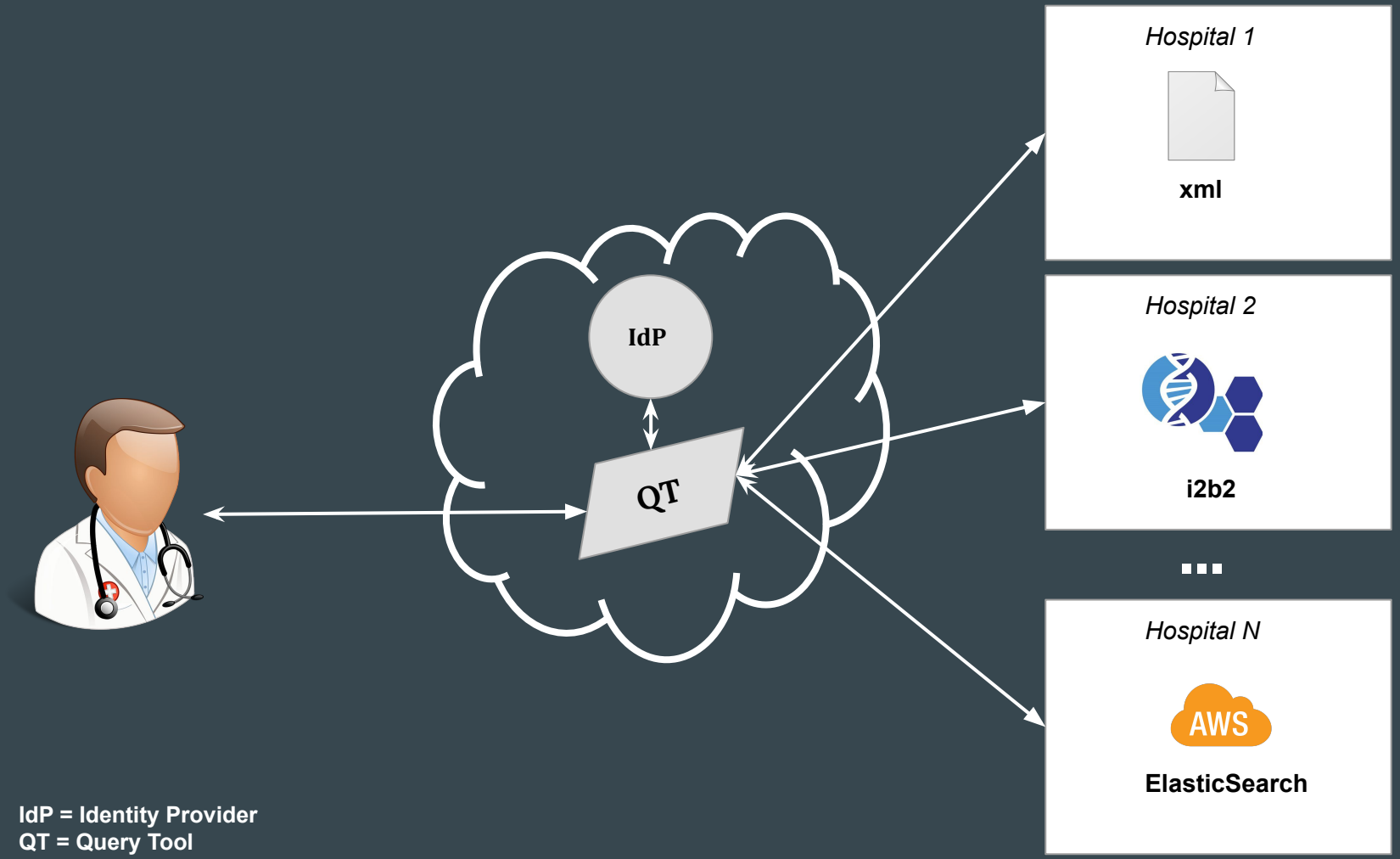
Vulnerabilities of current approaches

Single Point of Failure	• IdP can be compromised
No Auditability (by the resources)	• Resources are not aware of the end-user who wants to access the data
No Authorization (only Authentication)	• Access control policies for different users cannot be specified



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Project objective:

Build a **decentralized**, **auditable, immutable** access control system for medical data analysis

Blockchains

DEDIS Omniledger Implementation

- Inspired by the research on
  - **ByzCoin**: Byzantine fault-tolerant collectively signed transactions.

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- Permissioned-blockchain.
- Introduces **Distributed Access Rights Control (DARC)** data-structure.

DARCs

- Mapping of actions to expressions.

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  - doSomething: identityA **AND** (identityB **OR** identityC)
- **Rules can reference other DARCs**
  - doSomethingGroup1: identityA
  - doSomethingGroup2: identity B **OR** C
  - doSomething: doSomethingGroup1 **AND** doSomethingGroup2

MedChain:

Omniledger with predefined contracts (and DARCs) suitable for providing an access control system for medical data analysis

MedChain: Design

Hospital 1

Hospital 2

Hospital 1

Hospital 2

Admin1

Admin2

Hospital 1

Hospital 2

Admin1

Manager1x

Manager1y

Manager2x

Manager2y

Admin2

Hospital 1

Hospital 2

Admin1

Manager1x

Manager1y

User1x

User1y

Manager2x

Manager2y

Admin2

User2x

User2y

Admins: A1, A2
Managers: M1x, M1y, M2x, M2y
Users: U1x, U1y, U2x, U2x

Admins: A1, A2
Managers: M1x, M1y, M2x, M2y
Users: U1x, U1y, U2x, U2x

Genesis

evolve: A1 & A2

create_darc: A1 & A2

Admins: A1, A2
Managers: M1x, M1y, M2x, M2y
Users: U1x, U1y, U2x, U2x

Genesis

evolve: A1 & A2

create_darc: A1 & A2

Managers1

evolve: A1

include: M1x & M1y

Admins: A1, A2
Managers: M1x, M1y, M2x, M2y
Users: U1x, U1y, U2x, U2x

Genesis

evolve: A1 & A2

create_darc: A1 & A2

Managers1

evolve: A1

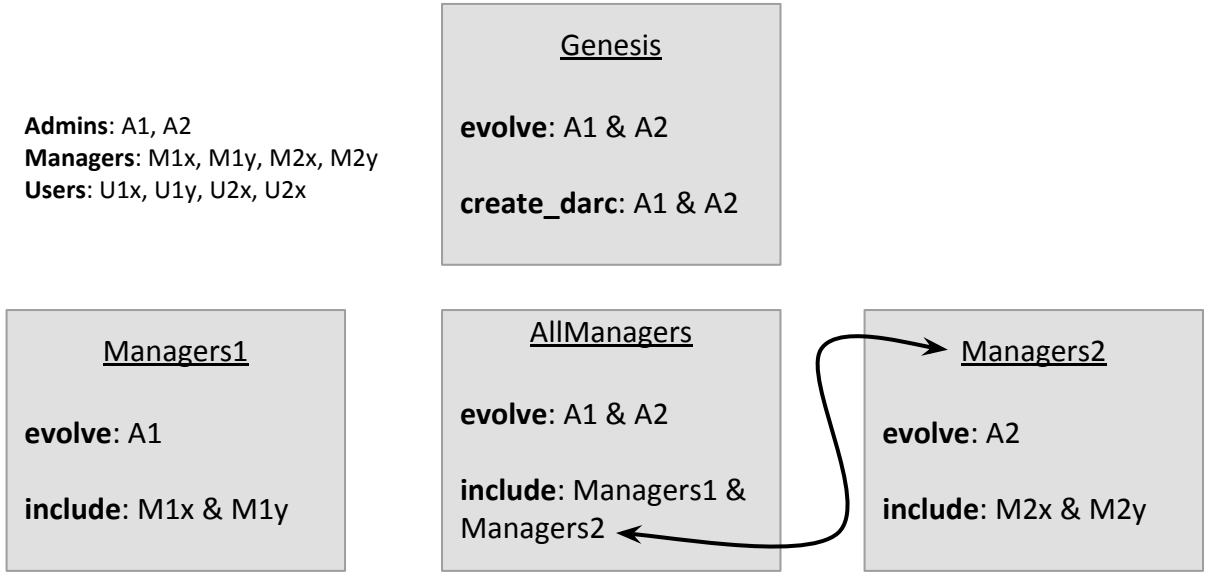
include: M1x & M1y

Managers2

evolve: A2

include: M2x & M2y

Admins: A1, A2
Managers: M1x, M1y, M2x, M2y
Users: U1x, U1y, U2x, U2x



Admins: A1, A2
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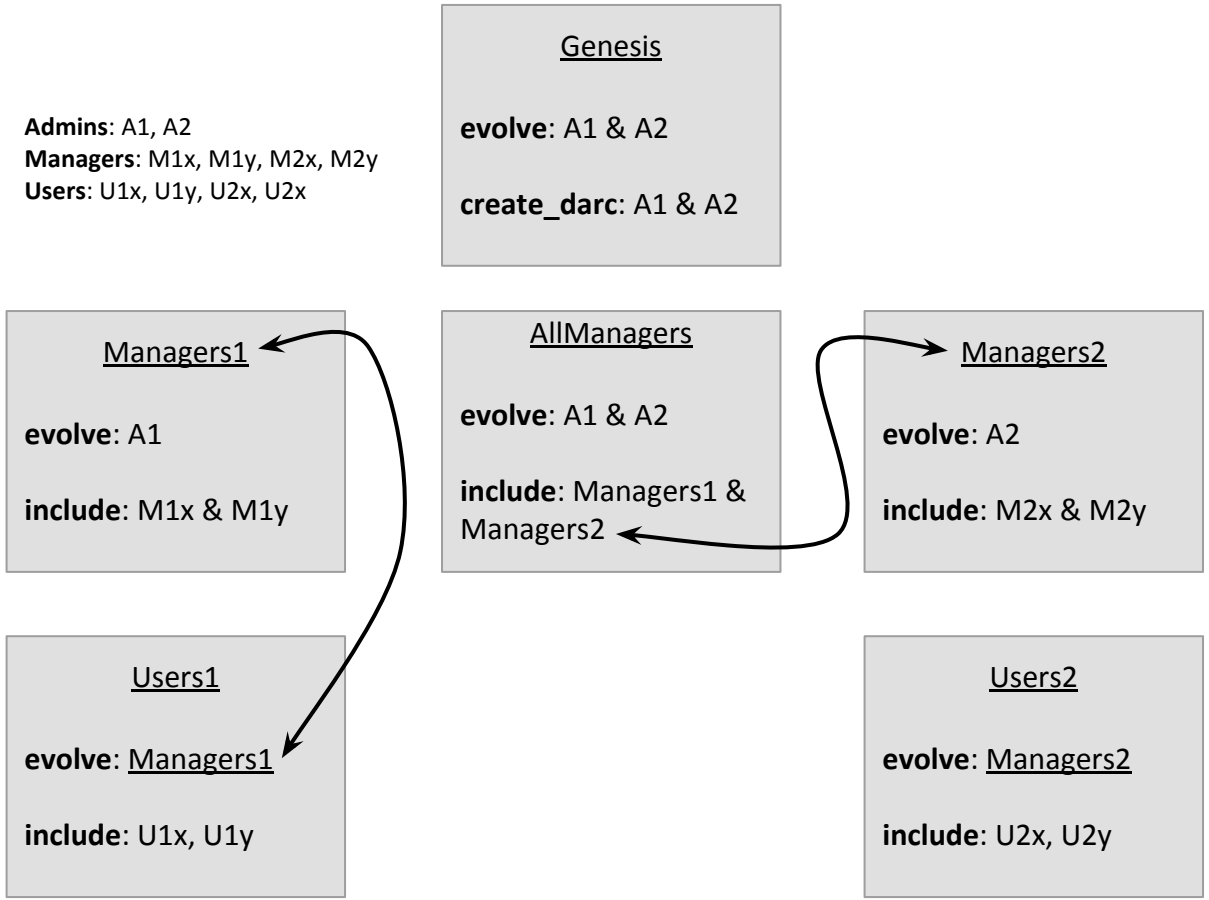

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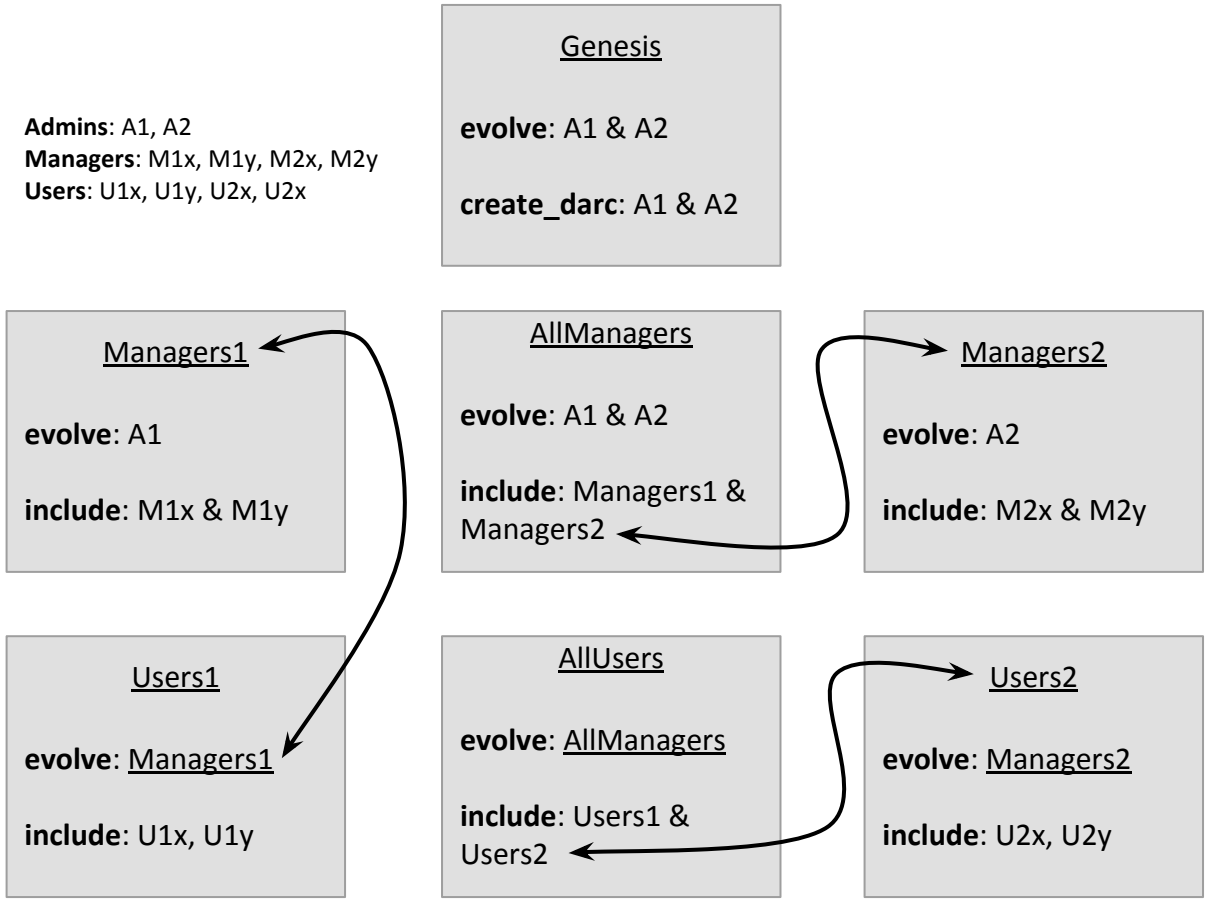

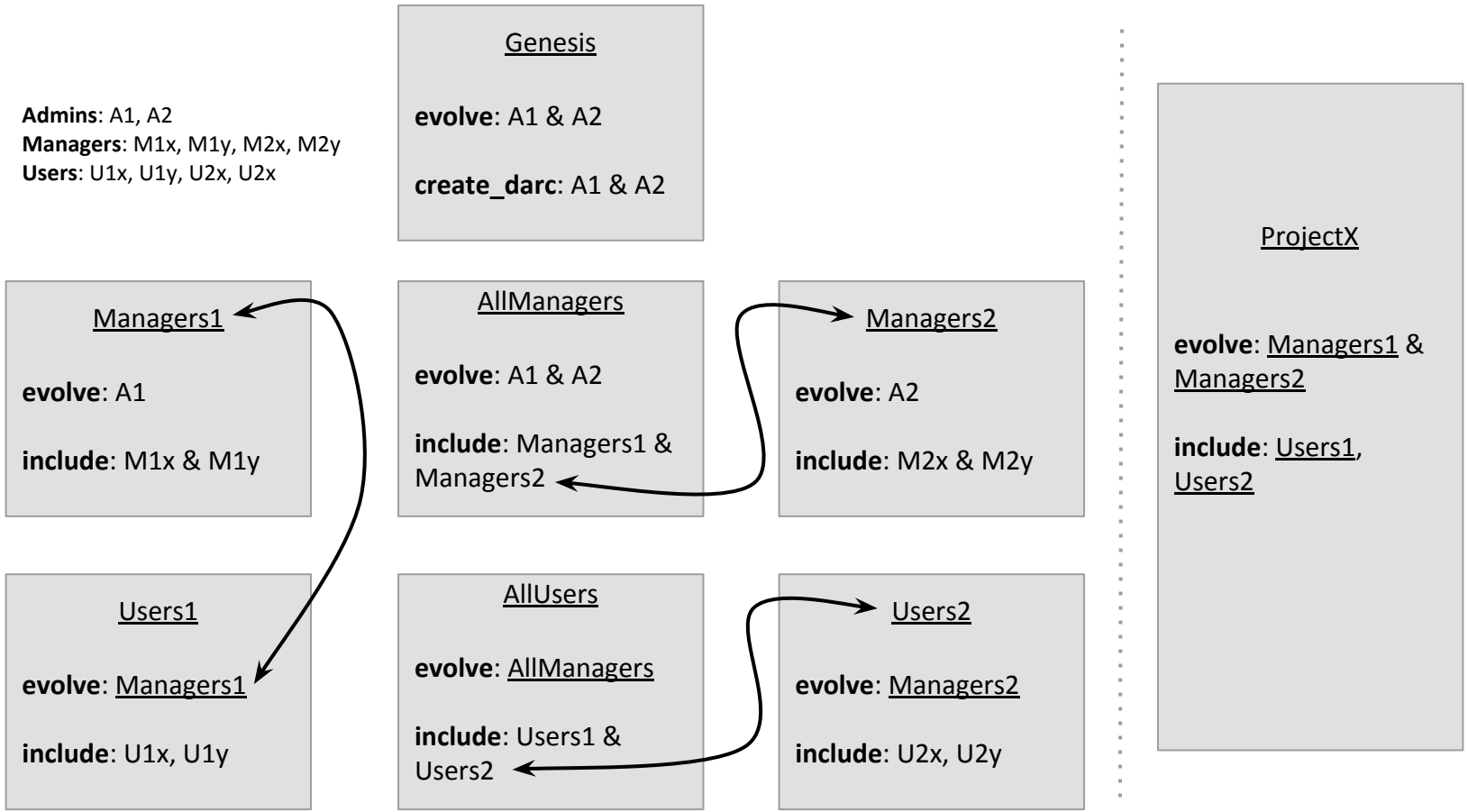
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create_darc: A1 & A2
Managers1
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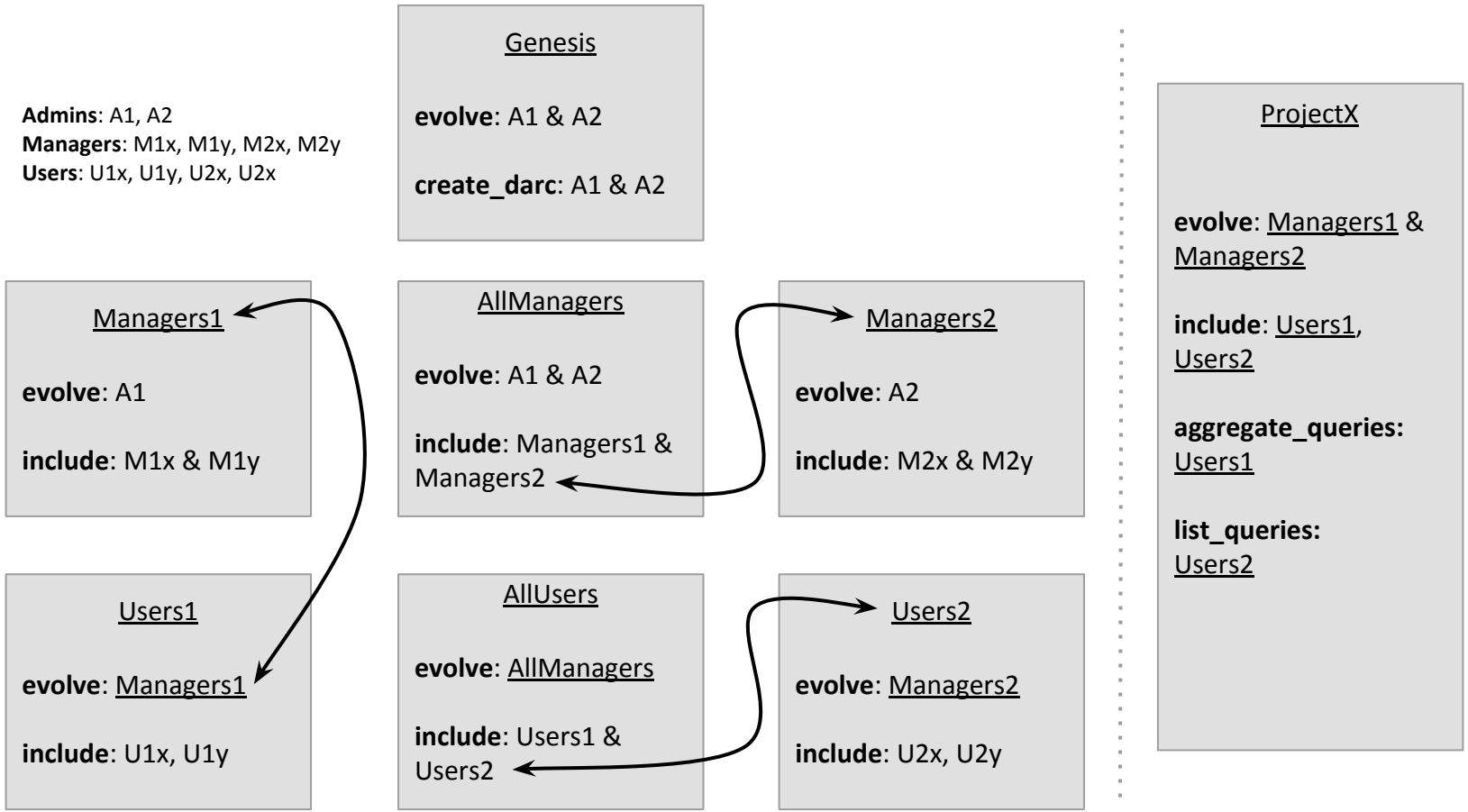
include: M1x & M1y
AllManagers
evolve: A1 & A2
include: Managers1 & Managers2
Managers2
evolve: A2
include: M2x & M2y
Users1
evolve: Managers1
include: U1x, U1y
AllUsers
evolve: AllManagers
include: Users1 & Users2
Users2
evolve: Managers2
include: U2x, U2y
ProjectX
evolve: Managers1 & Managers2
include: Users1, Users2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Managers2
evolve: A2
include: M2x & M2y
Users1
evolve: Managers1
include: U1x, U1y
AllUsers
evolve: AllManagers
include: Users1 & Users2
Users2
evolve: Managers2
include: U2x, U2y
ProjectX
evolve: Managers1 & Managers2
include: Users1, Users2
aggregate_queries: Users1
list_queries: Users2

MedChain: Design (contd.)

- We develop contracts for validating access control;
  - getListOfProjects
  - runQuery

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Contracts, after successfully validating access control, append information to the blockchain (which provides an immutable log of the system events).

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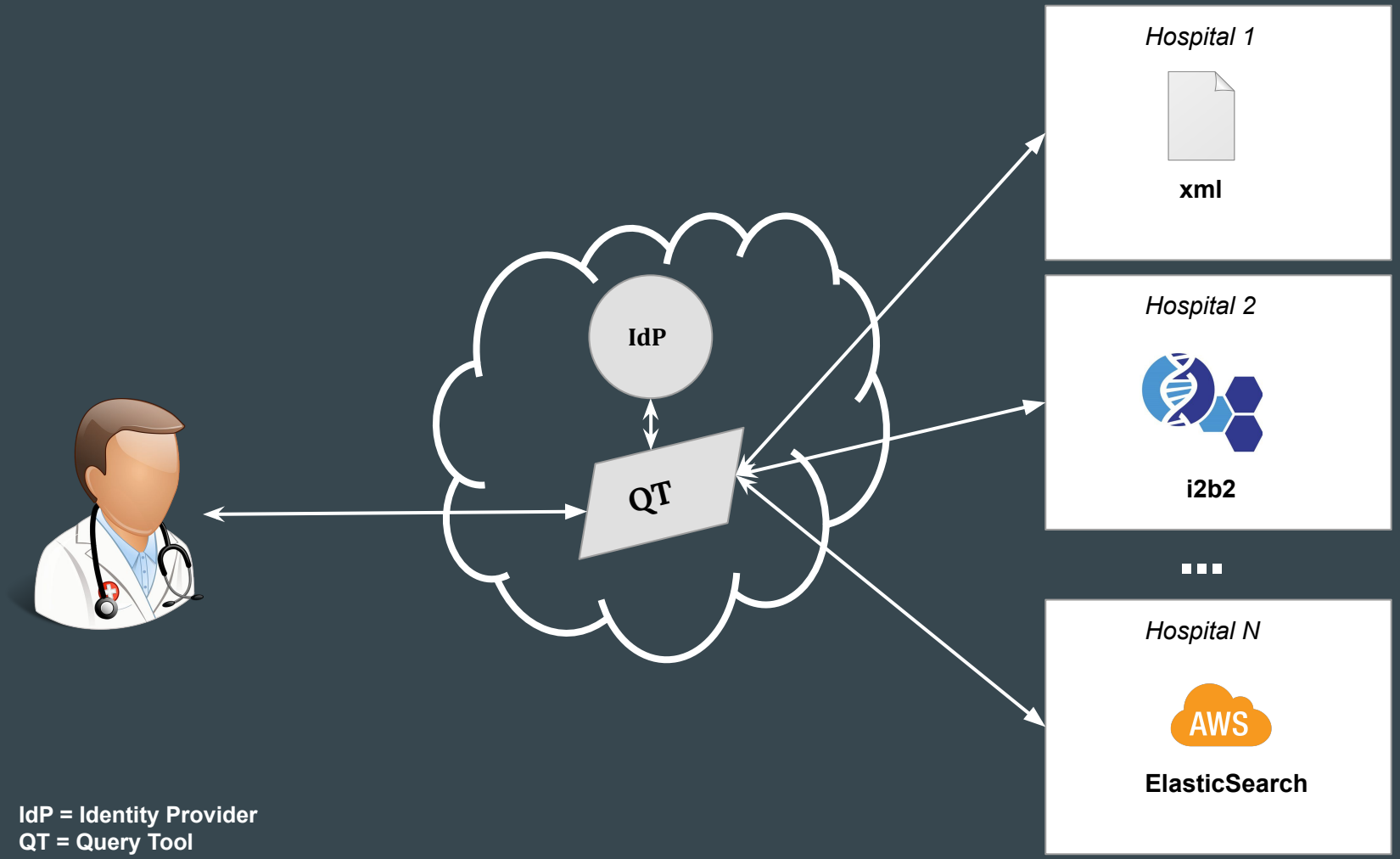
Contracts, after successfully validating access control, append information to the blockchain (which provides an immutable log of the system events).

Clients can then interact with the blockchain to retrieve the information logged (along with a proof).

MedChain: Integration



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Inter-Resource Communication Tool (IRCT)

- Developed at the Harvard University Medical School

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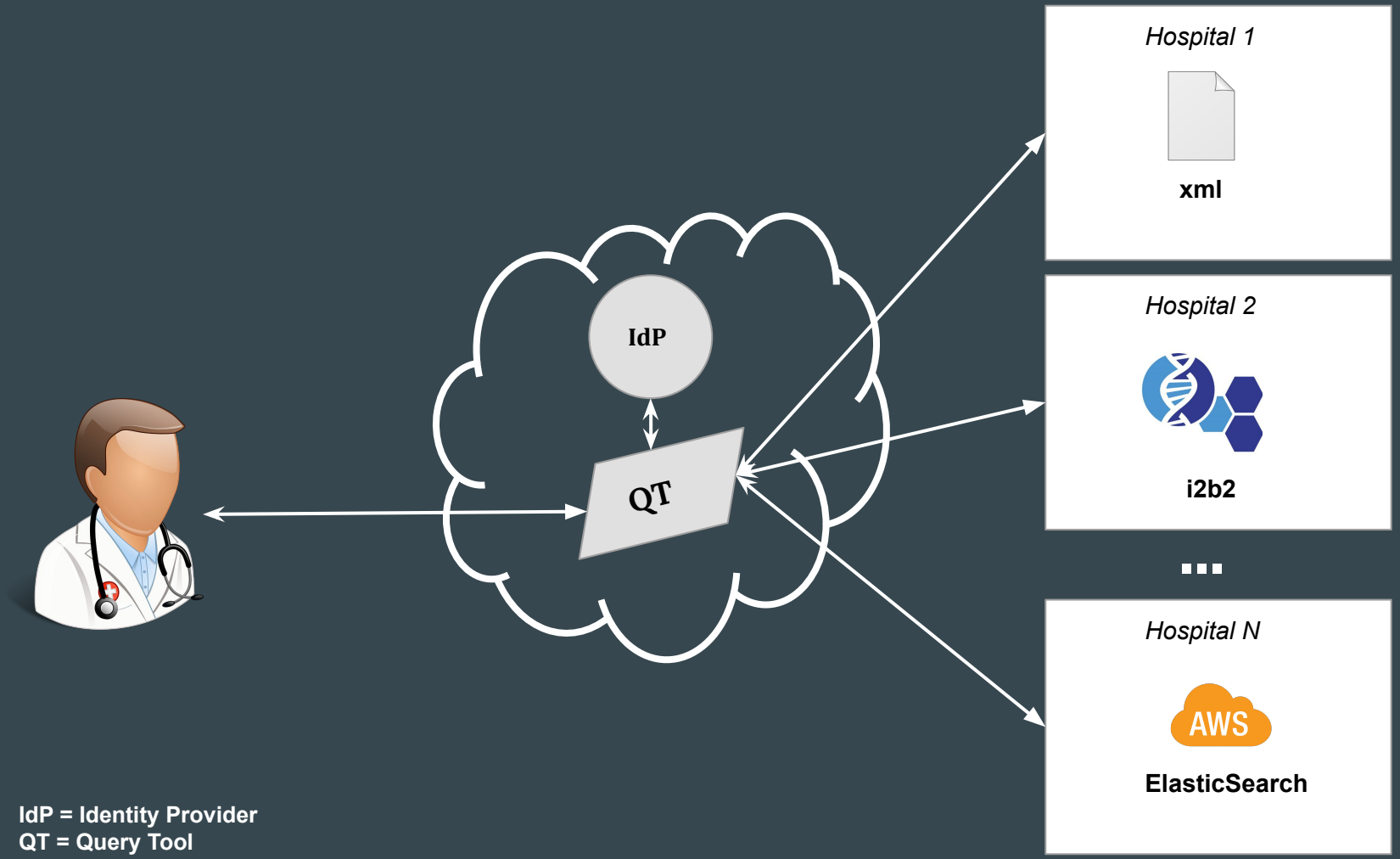

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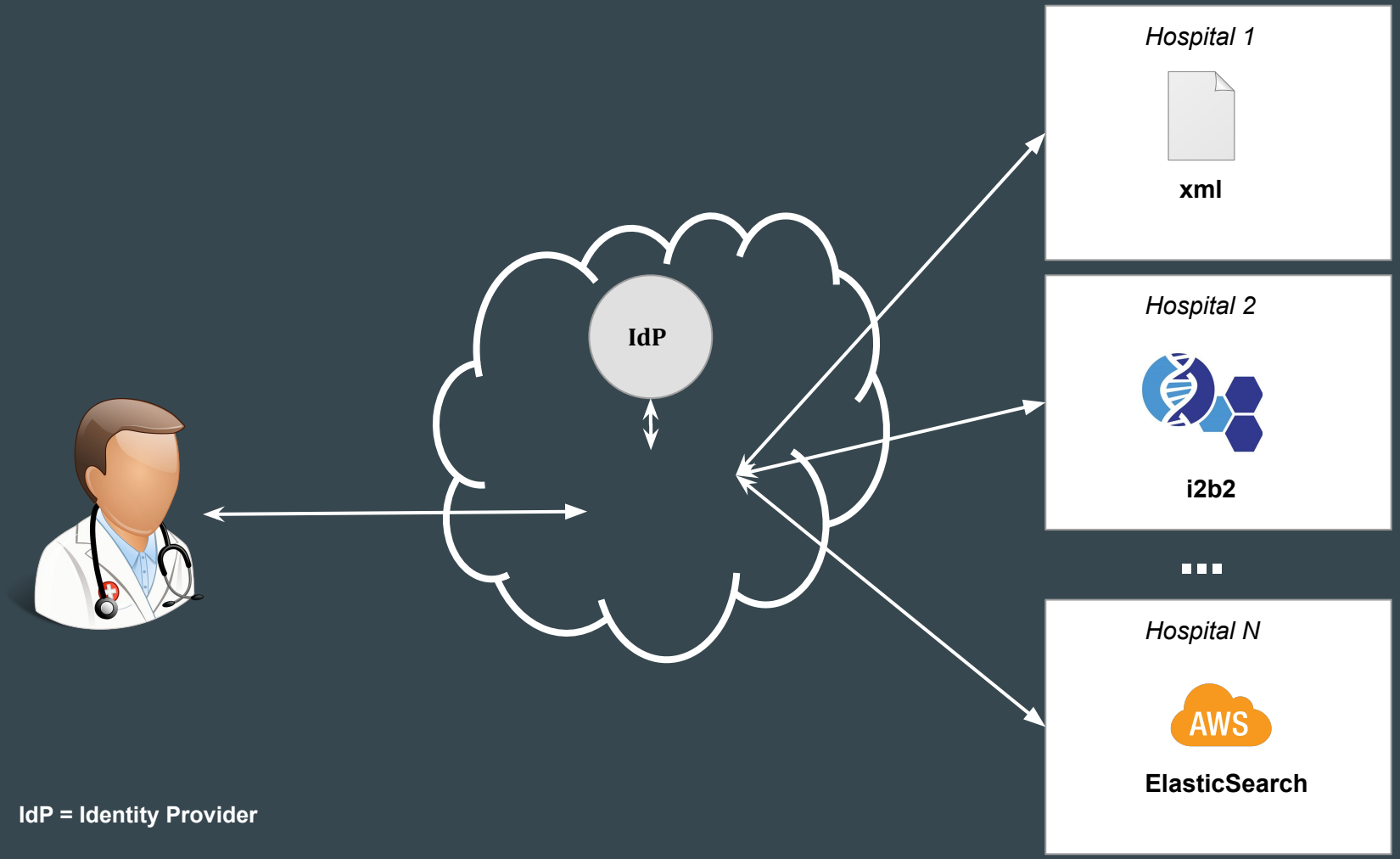

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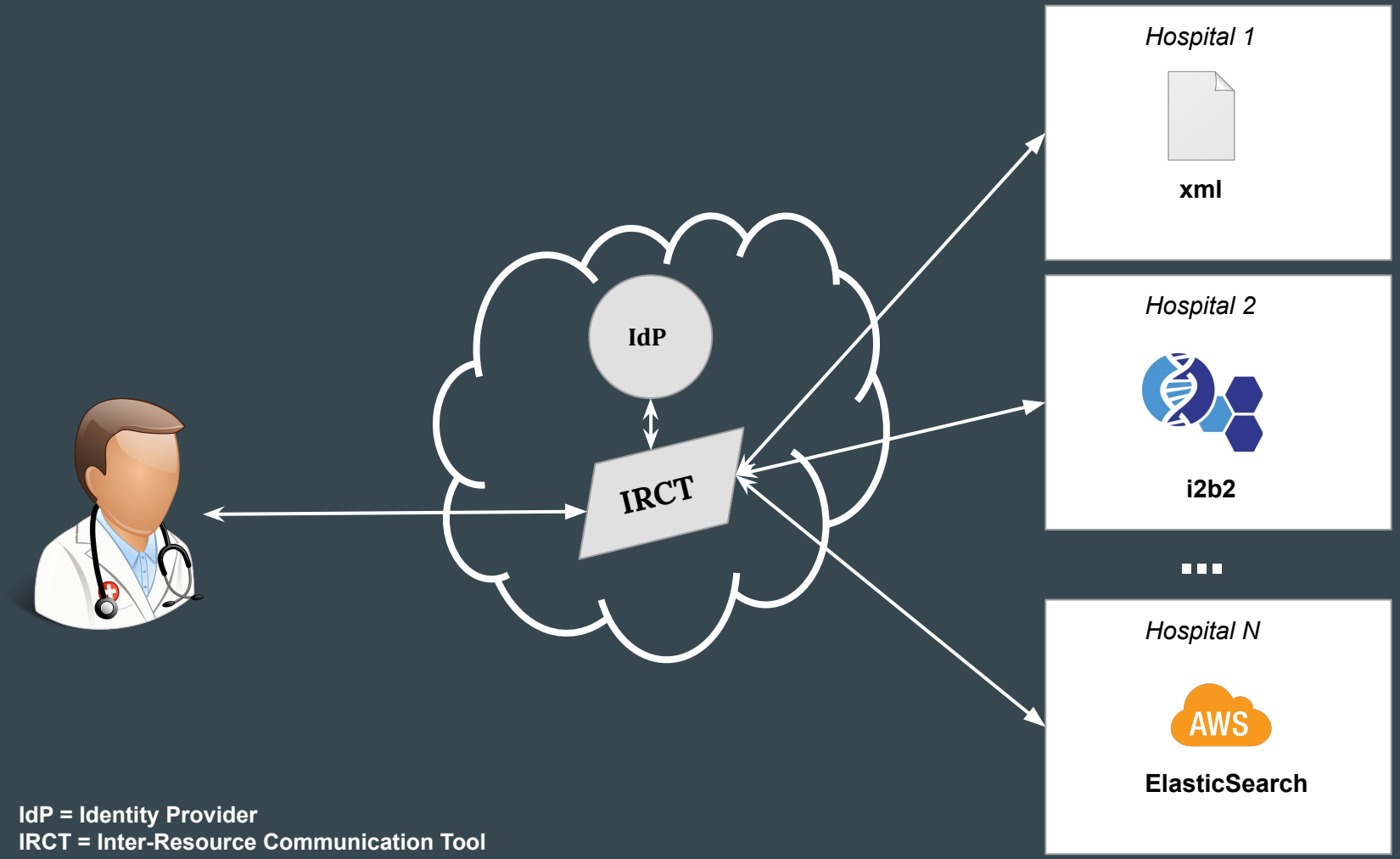

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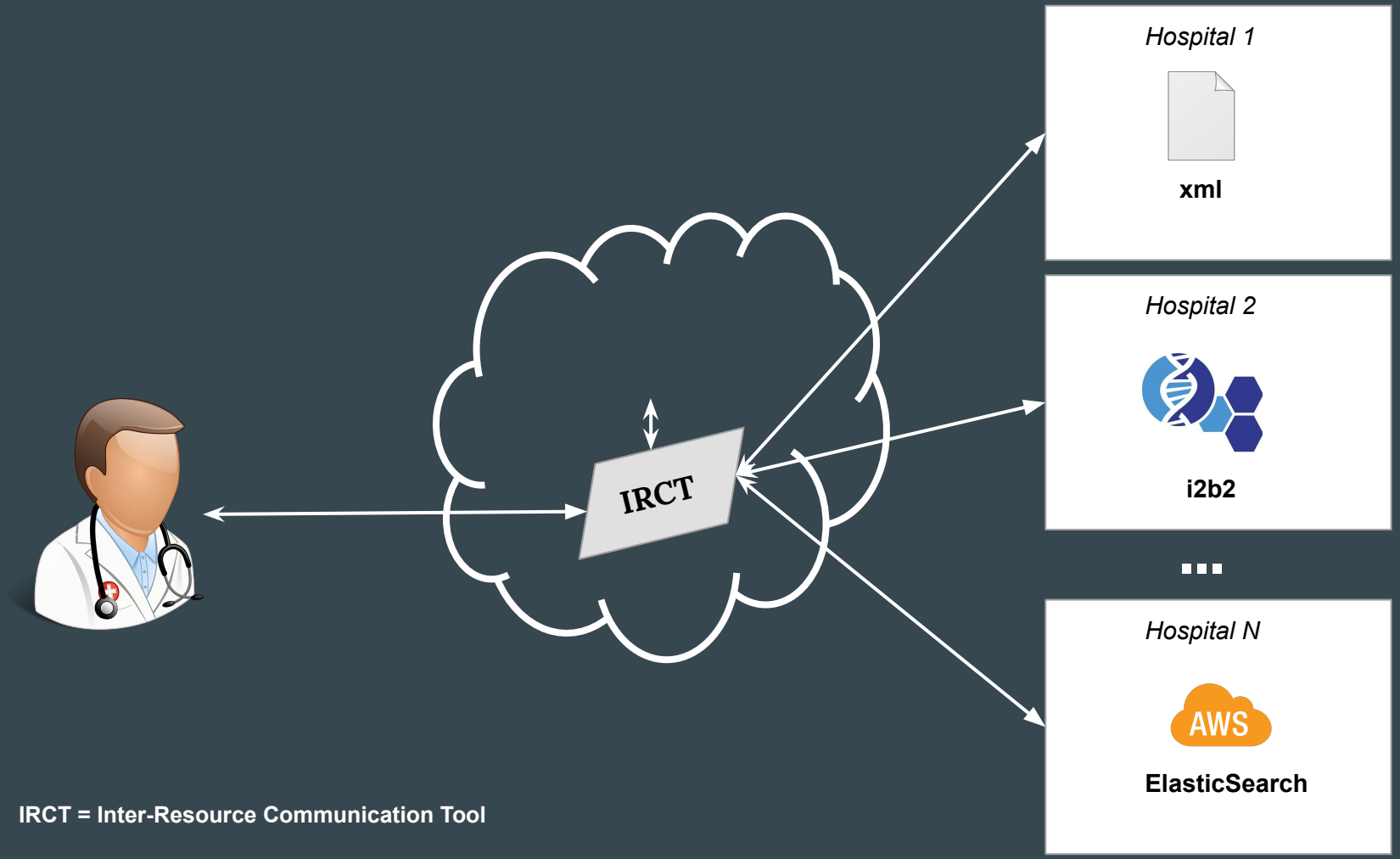

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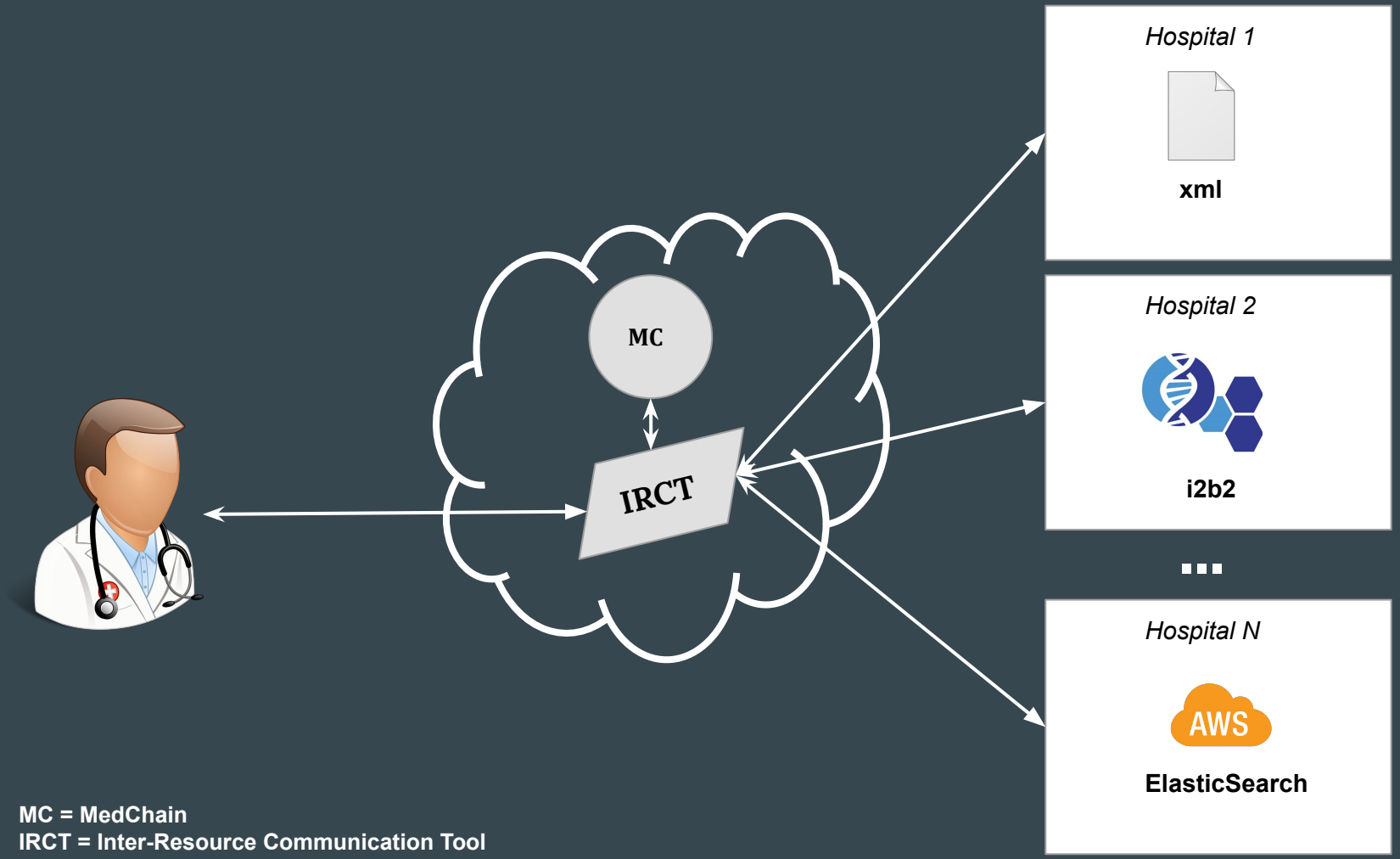

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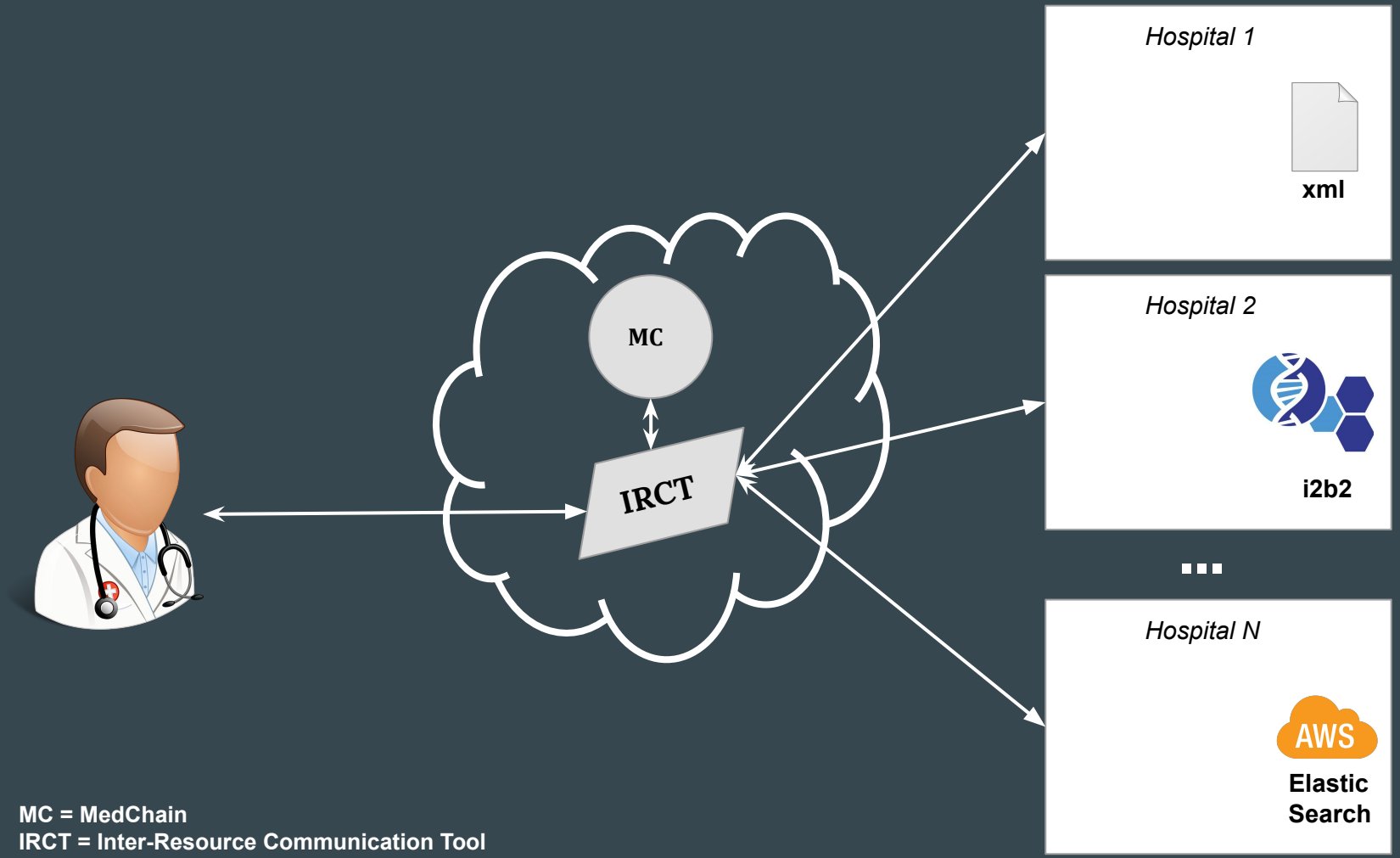

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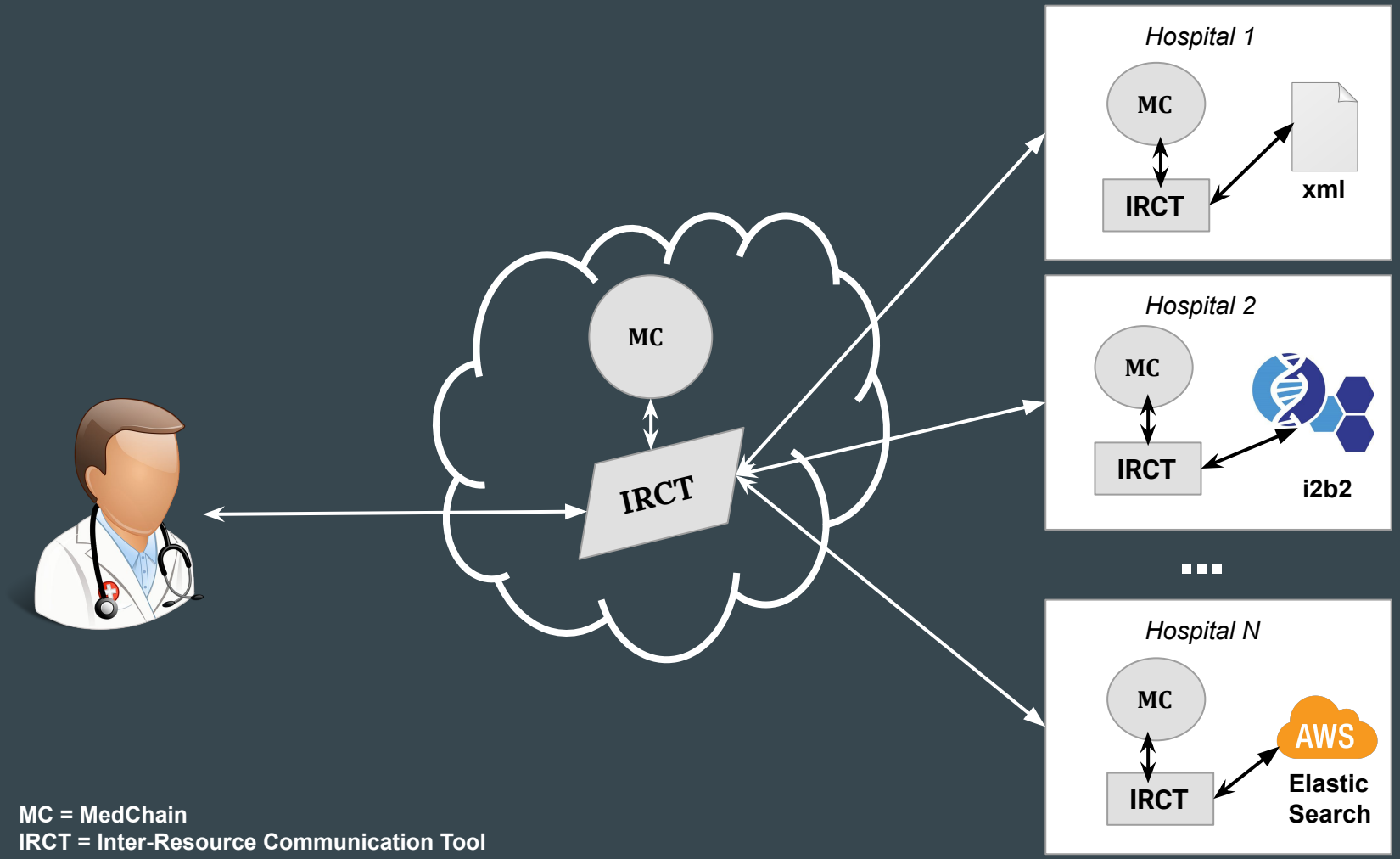

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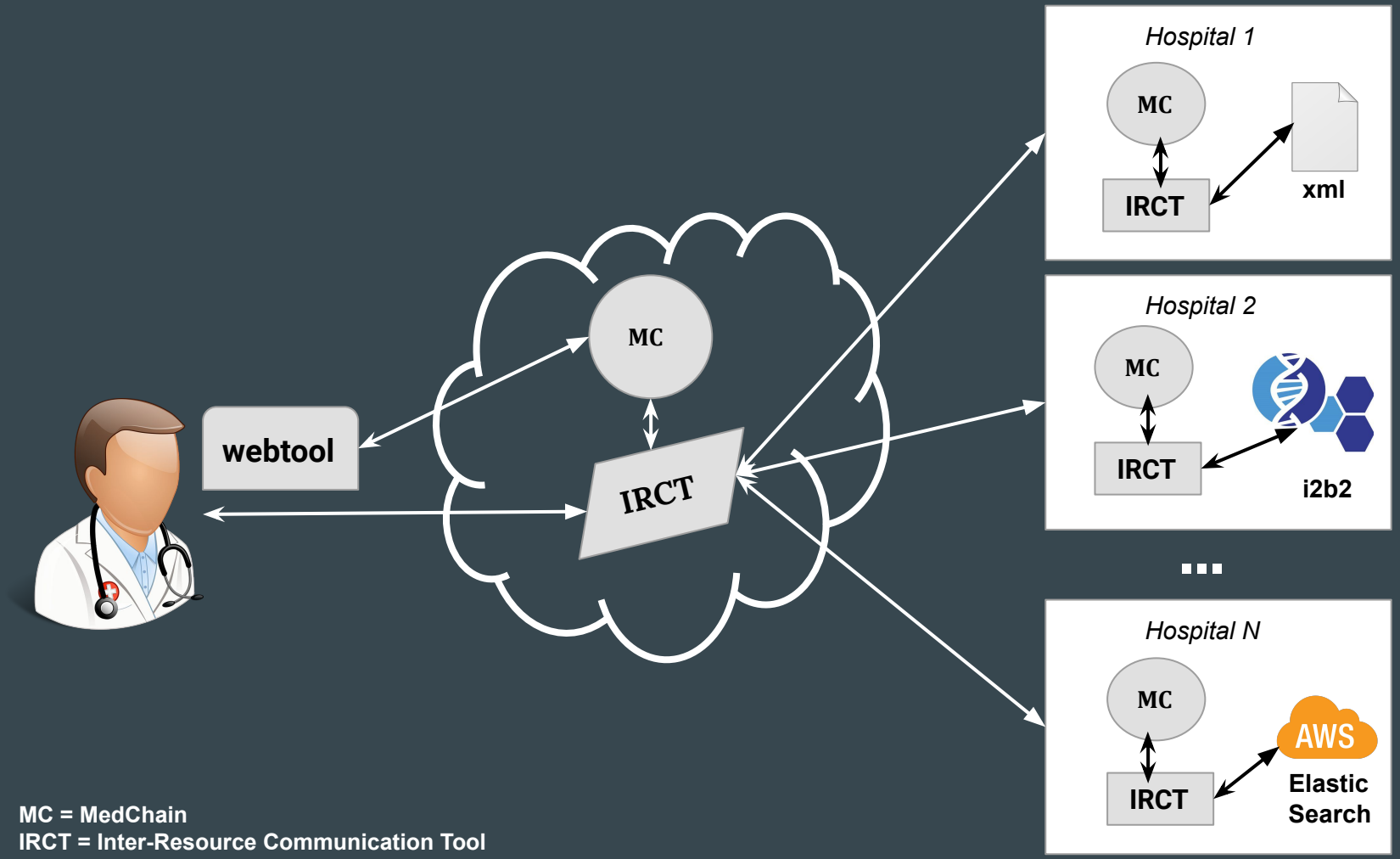

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MedChain Features

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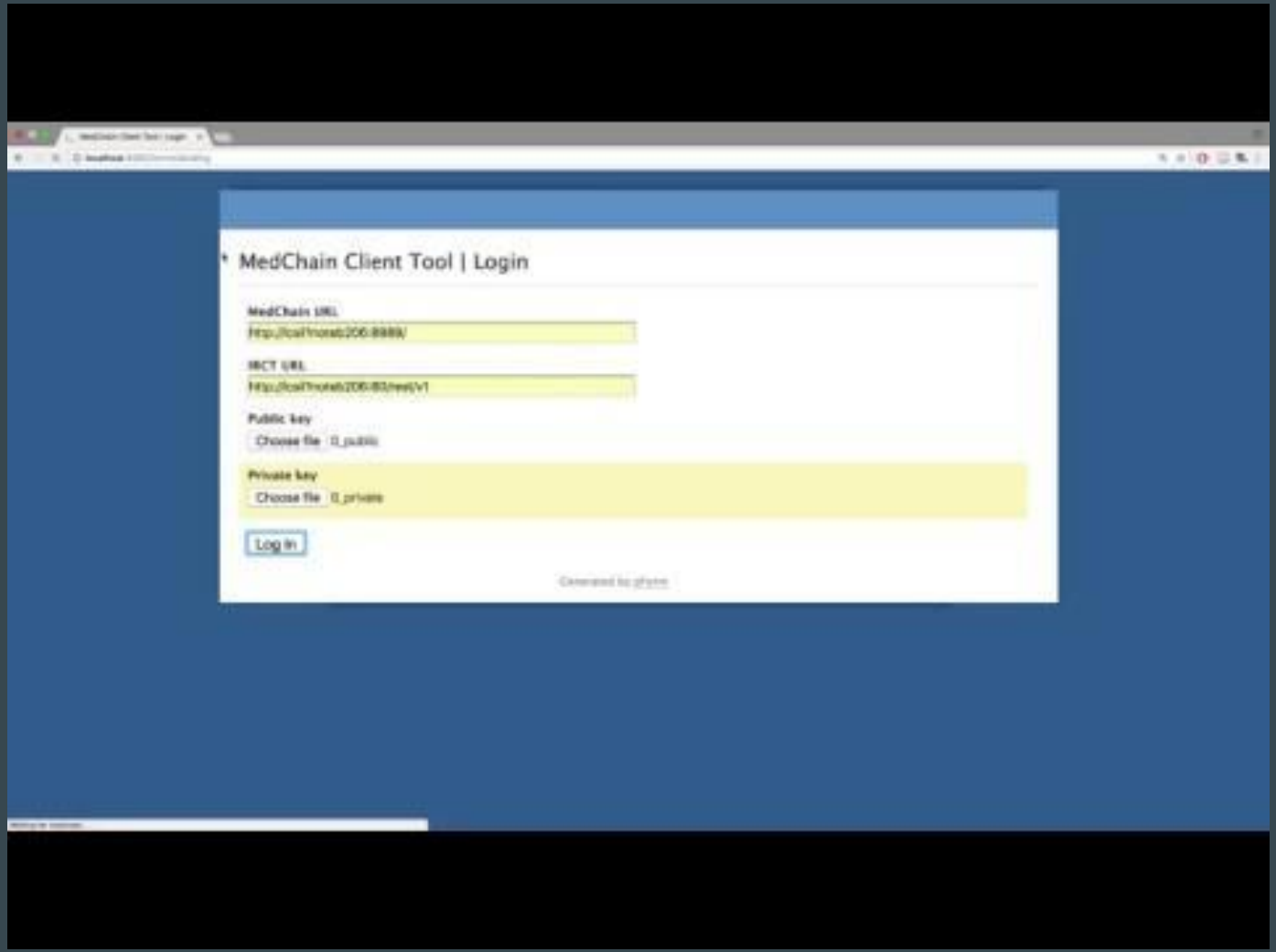
Decentralization	• Requires ⅔ of the nodes to vote on changes • Control can be delegated to multiple people
Auditability	• All accesses are logged on the blockchain
Authorization	• Access control rules are stored on the blockchain, and enforced at the resources
Rotation of keys	• Users can rotate their secret keys with ease, by evolving the respective DARCs

MedChain: Demo*


MedChain Client Tool | Login
MedChain URL
IRCT URL
Public key
Choose file
Private key
Choose file
Log In

MedChain: Performance Evaluation

Experimental Setup

- 3 servers (from the IC Cluster) to form a cothority for MedChain

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  - artificial delay of 15ms (mean) and 10ms (std. deviation) on packets from each server.

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- **Experiments with increasing number of users / projects to see how well the system scales**

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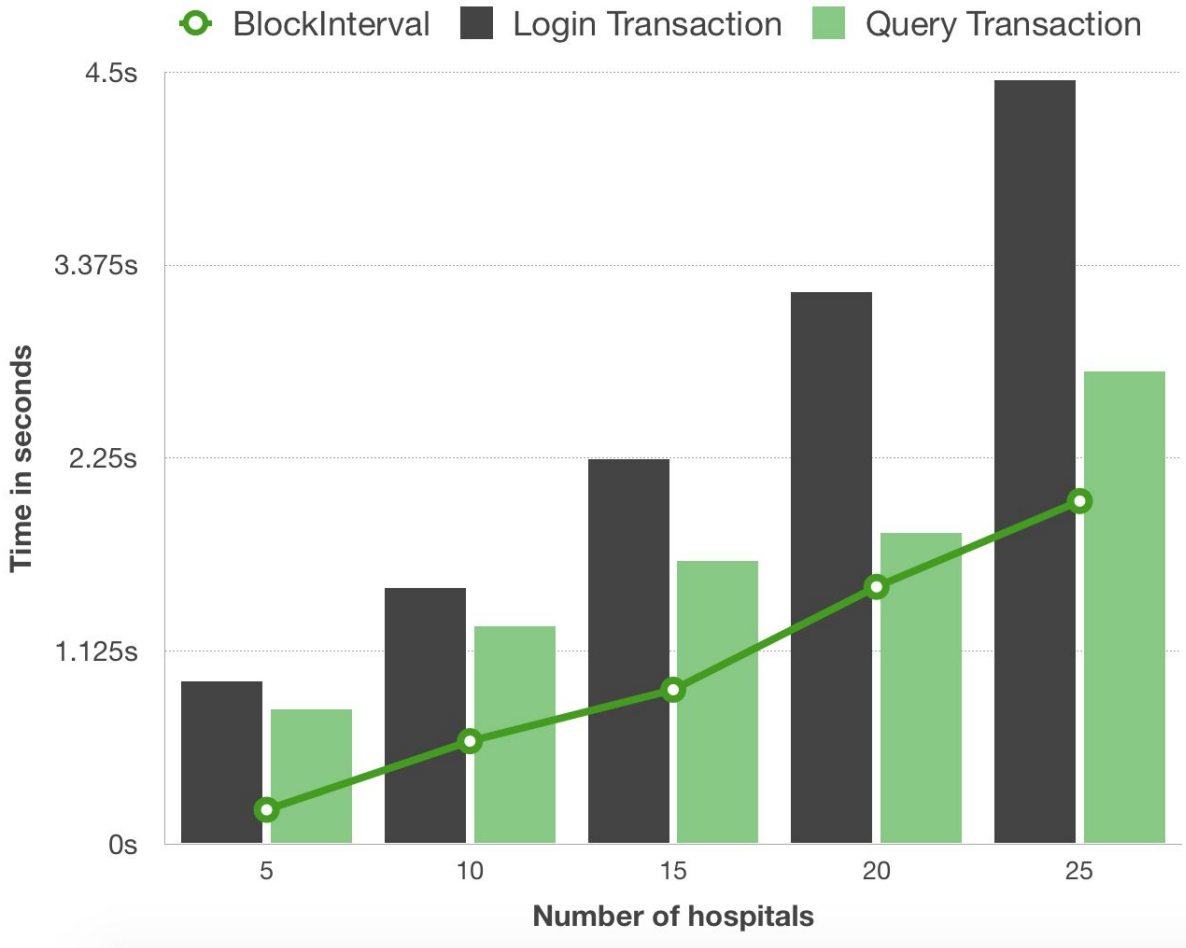
- Experiments with increasing number of users / projects to see how well the system scales
- **Each data-point in the results corresponds to the median from 5 runs of an experiment**

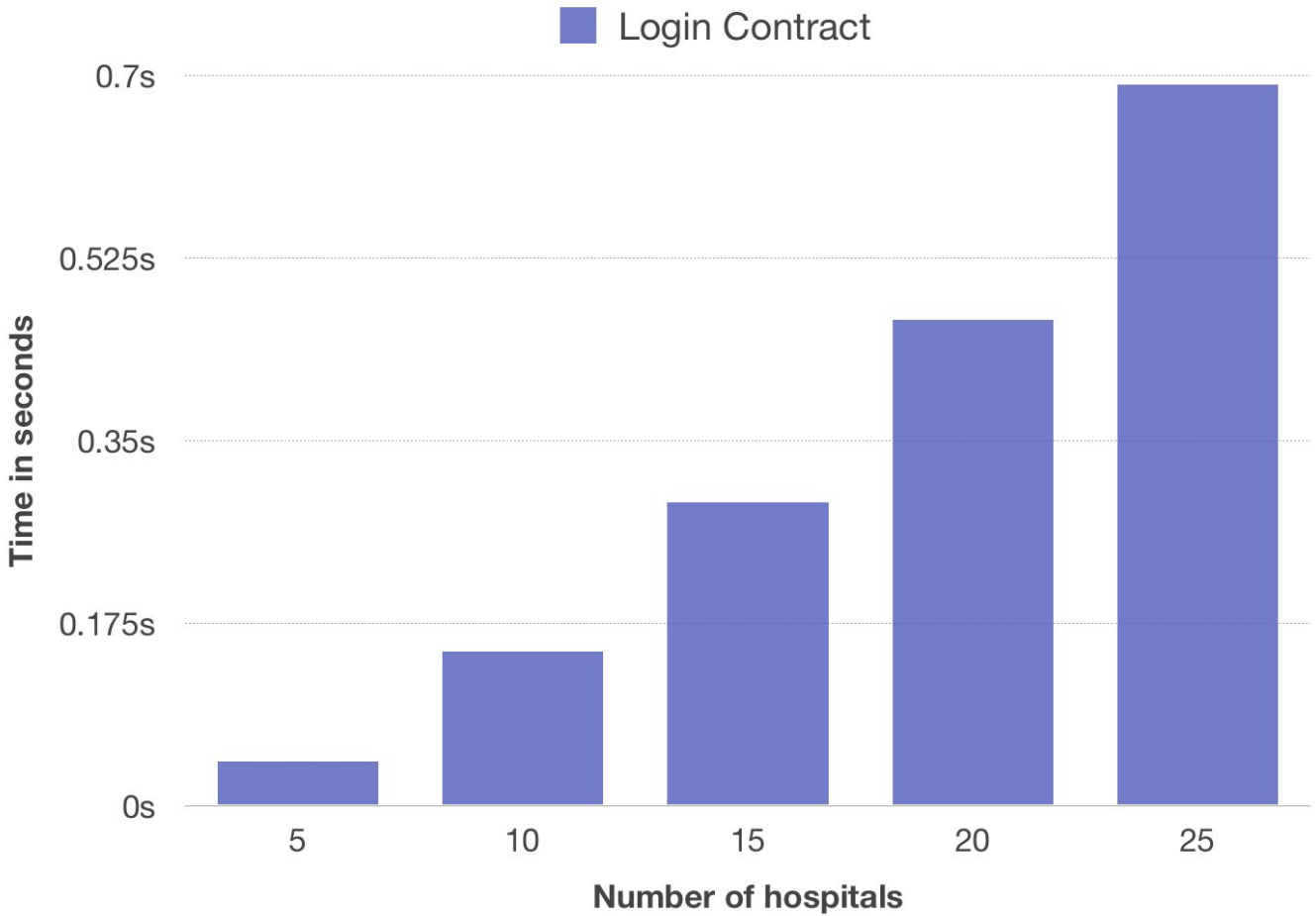
Experiment 1: System Overview

- **Time taken** vs **number of hospitals** in the system
- Other variables were configured as follows
  - **50 users / hospital**
  - **3 projects / hospital**
  - **20% hospitals / project**
- Block-interval was fine-tuned for each run

Time taken during user-login, and **query appendment**



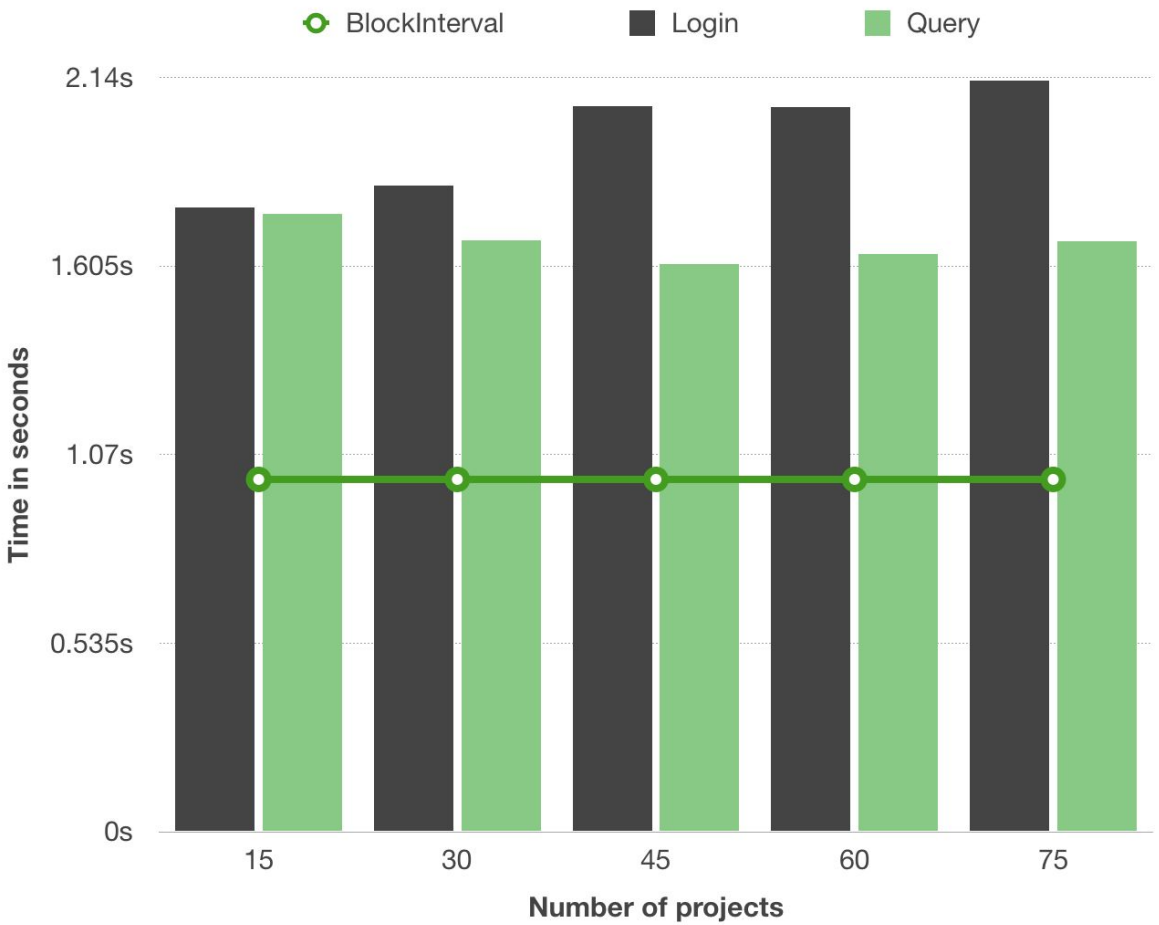
Time taken by the login contract at each node



Experiment 2(a): Differential Analysis

- **Time taken** vs **number of projects** in the system
- Other factors constant:
  - **15 hospitals**
  - **750 users**
  - **150 users / project**
- Block-interval was kept constant at 1 second

Time taken during user-login, and **query appendment**



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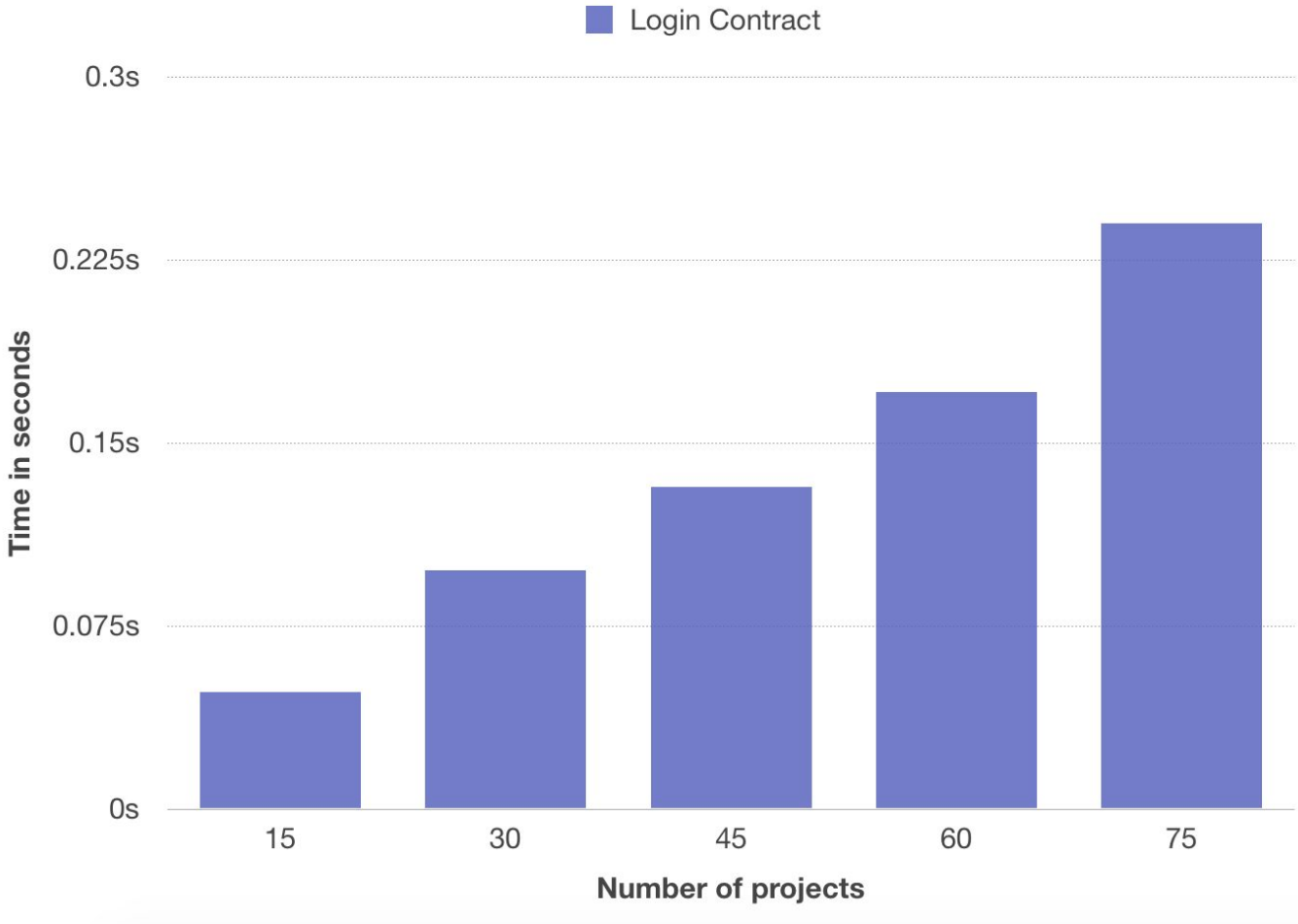
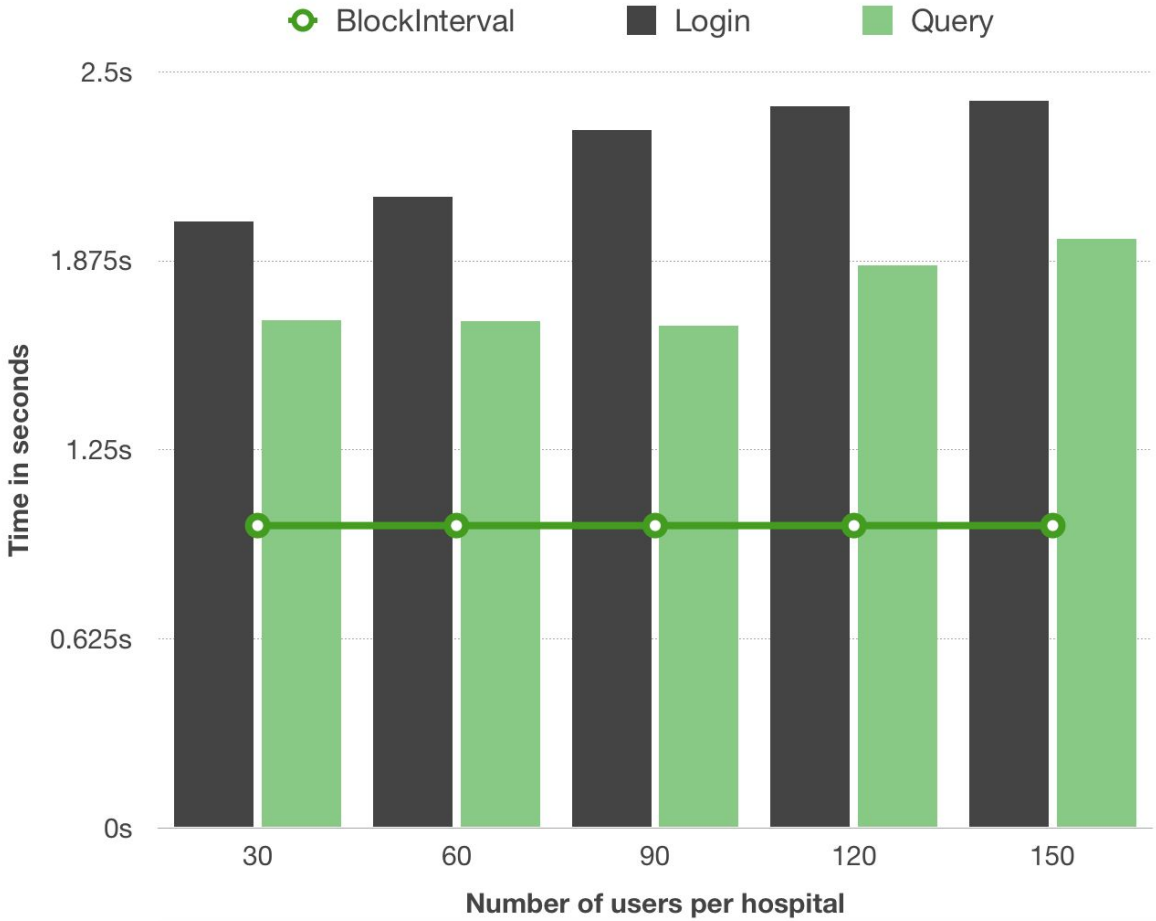


Experiment 2(b): Differential Analysis

- **Time taken** vs **number of users/hospital** in the system
- Other factors constant:
  - **15 hospitals**
  - **45 projects**
  - **3 hospitals / project**
- Block-interval was kept constant at 1 second

Time taken during user-login, and **query appendment**



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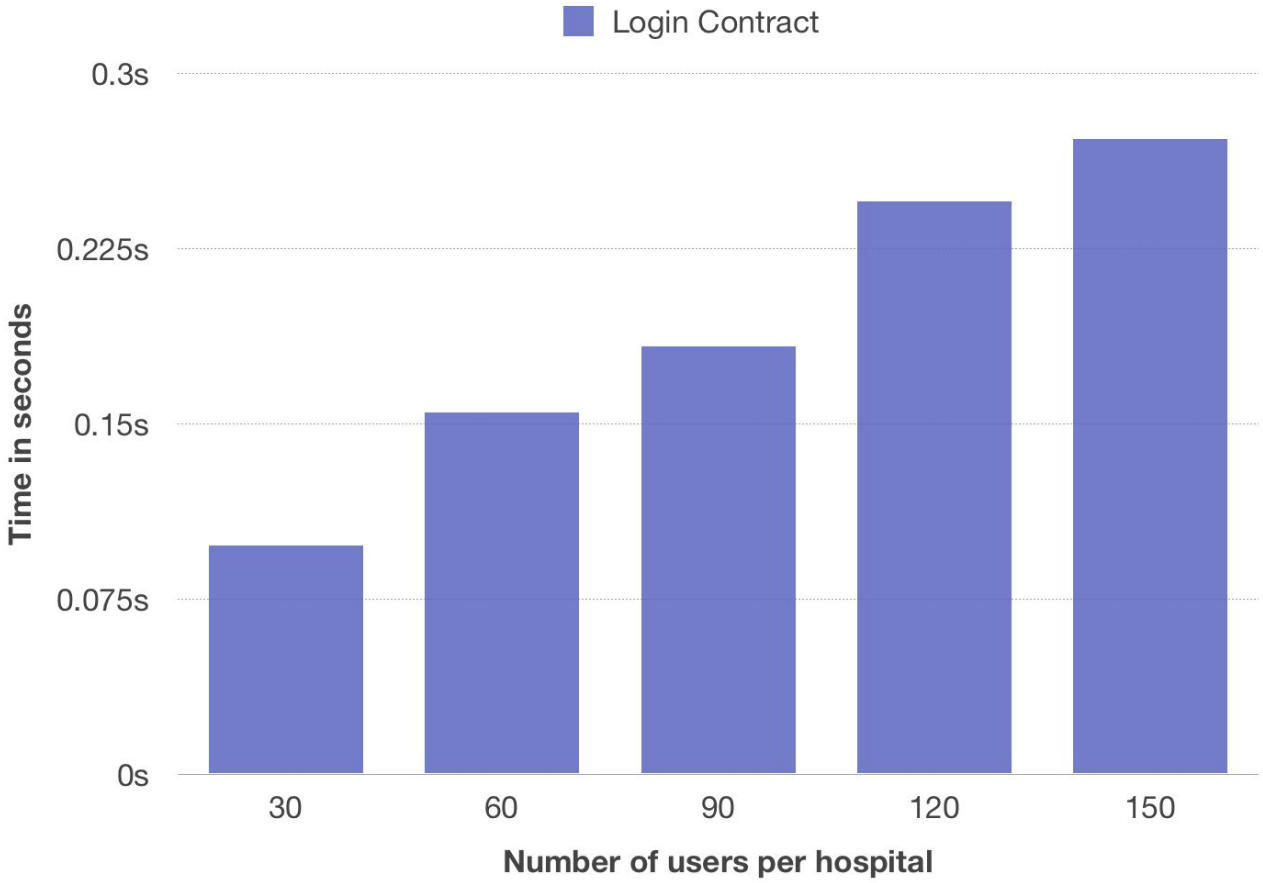

Conclusion

Contributions

- Developed MedChain by writing contracts (and DARCs) on top of Omniledger.

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- **Designed the system architecture**

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All code + documentation available at https://github.com/DPPH/MedChain & https://github.com/DPPH/IRCT

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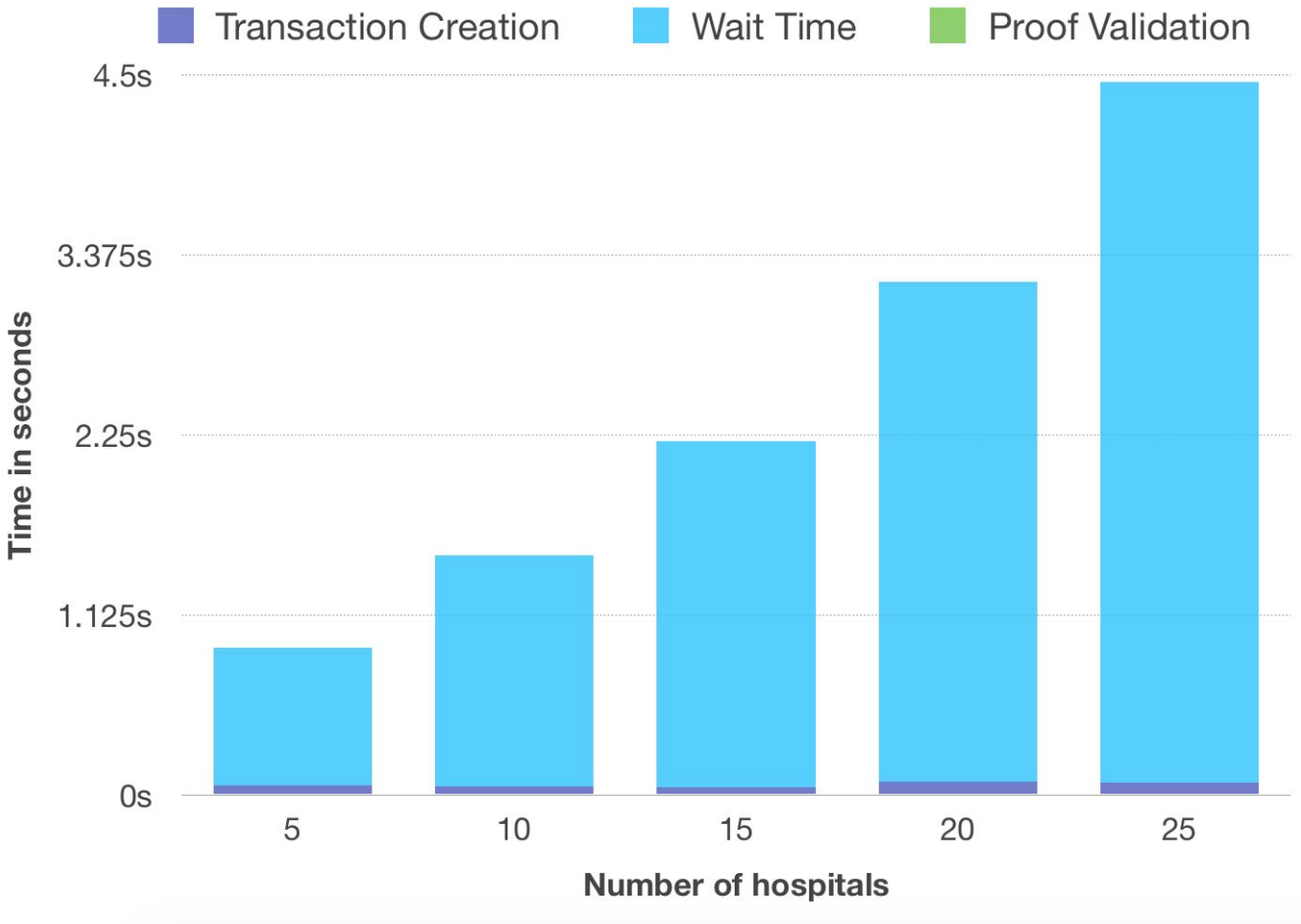
Thank you for listening.

Questions?

Breakdown of the time taken during user-login



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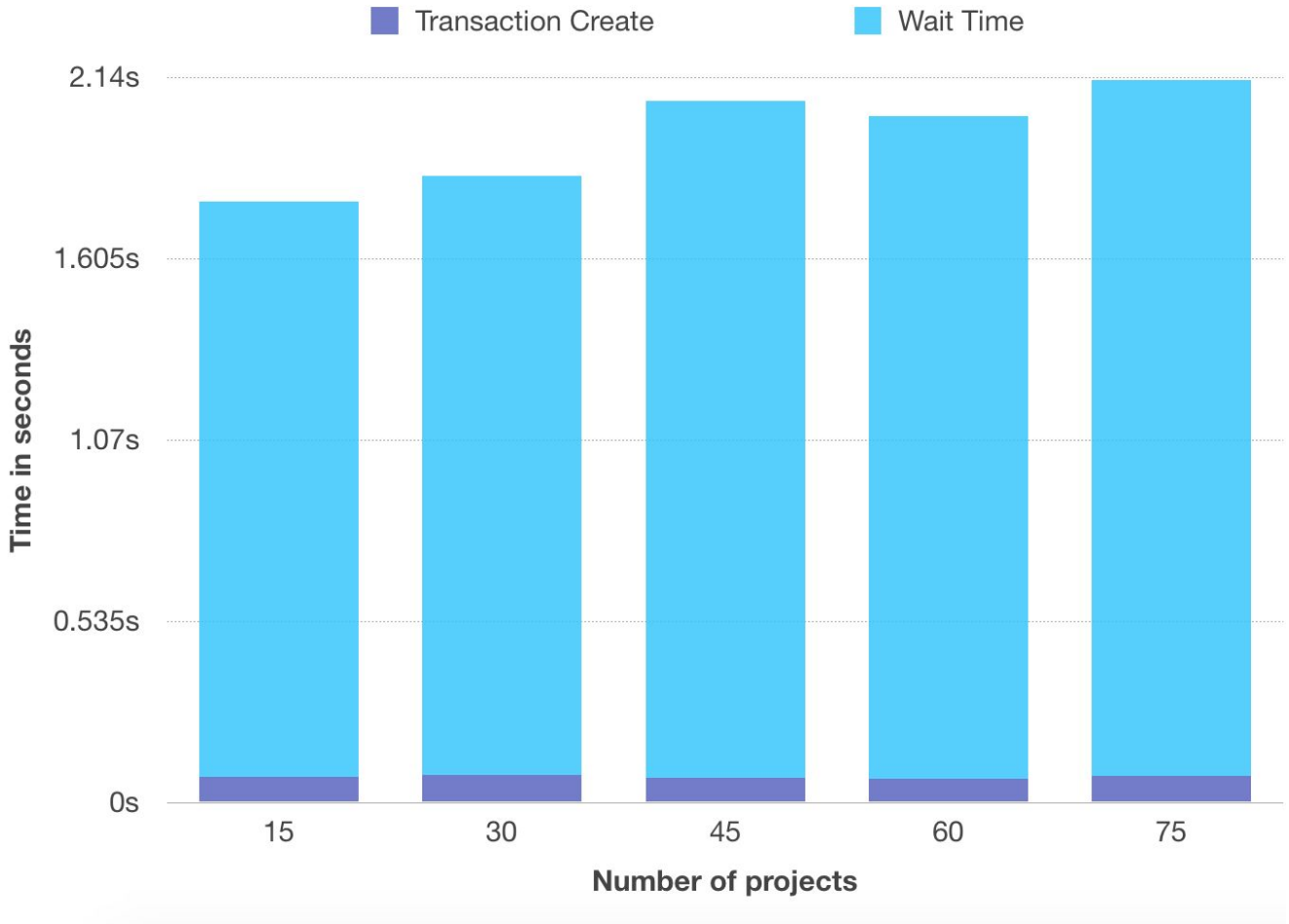

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