

mit
media
lab

MedRec

Using Blockchain for Medical Data Access and Permission Management



MedRec:

Research Motivation

Technical Implementation

Prototype Evaluation & Deployment

Interoperability

Future for Big Data applications

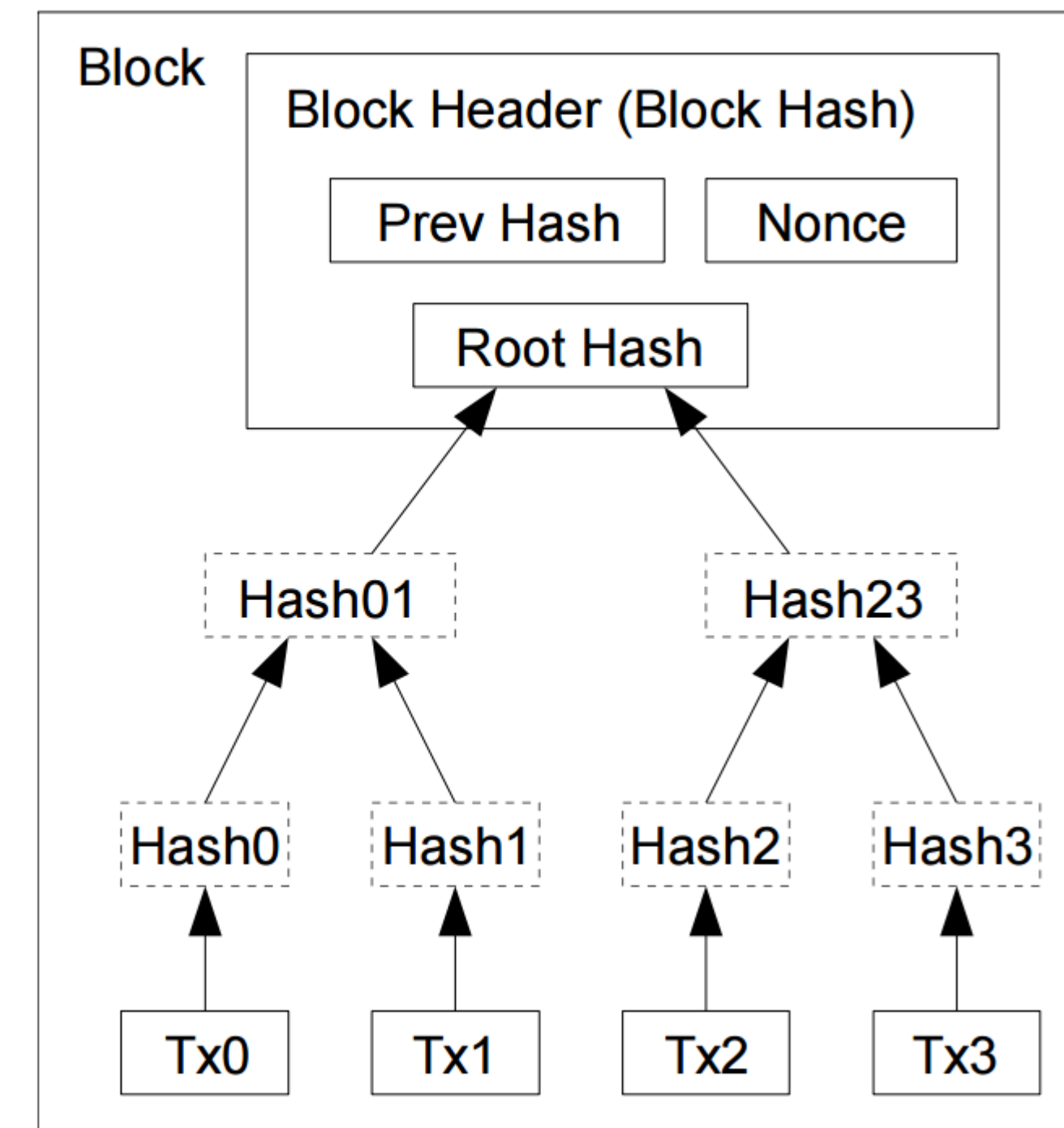
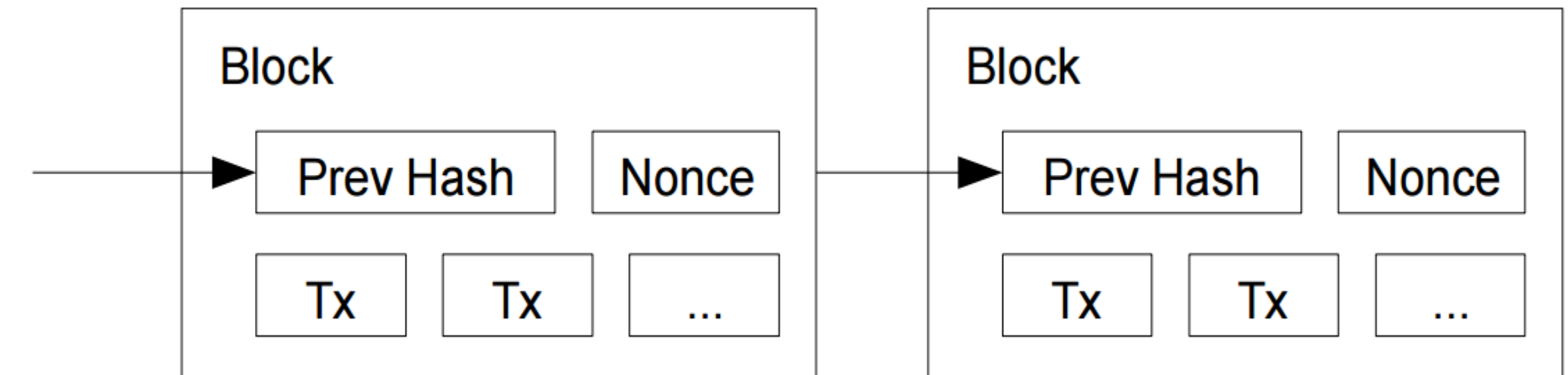
National Healthcare Priorities

Challenges & Next Steps



Blockchain Refresher

- Immutability, provenance and time-stamping
- A “trustless” P2P architecture, maintained by “mining” via Proof of Work hashing algorithm → Consensus



Source: Nakamoto. Bitcoin White Paper. 2008

MedRec Research Prototype | Motivation

1. Unify patient access to their medical data across providers, physicians, and treatment sites
2. Enable patient-initiated data sharing and “smart” permissioning
3. Empower researchers with Big Data from electronic health records (aggregate & anonymized)



MedRec Prototype | Key Implementation Choices

- “Smart contracts” on an Ethereum blockchain
- Updates managed through a notification system
- All medical data stays distributed in physician’s existing data storage infrastructure
- All nodes retain a copy of the blockchain permission log



MedRec Prototype | Smart Contracts

Patient-Provider Relationship (PPR)

- public key Ethereum addresses
- pointers to medical data (SHA-256 hashes)
- network location for data retrieval
- permission strings

Summary Contract

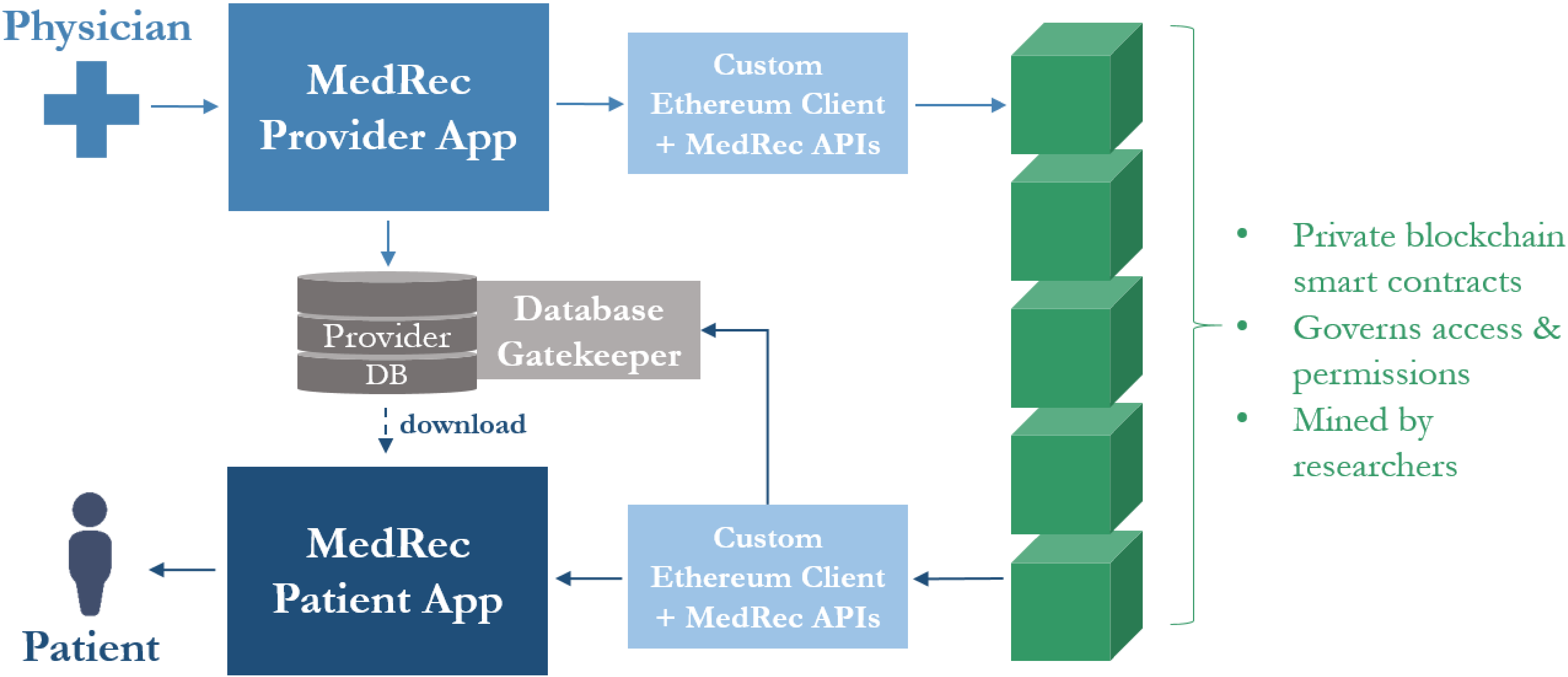
- Per user, a list of all PPR addresses for lookup
- A status variable for each PPR, indicating new content

Registrar Contract

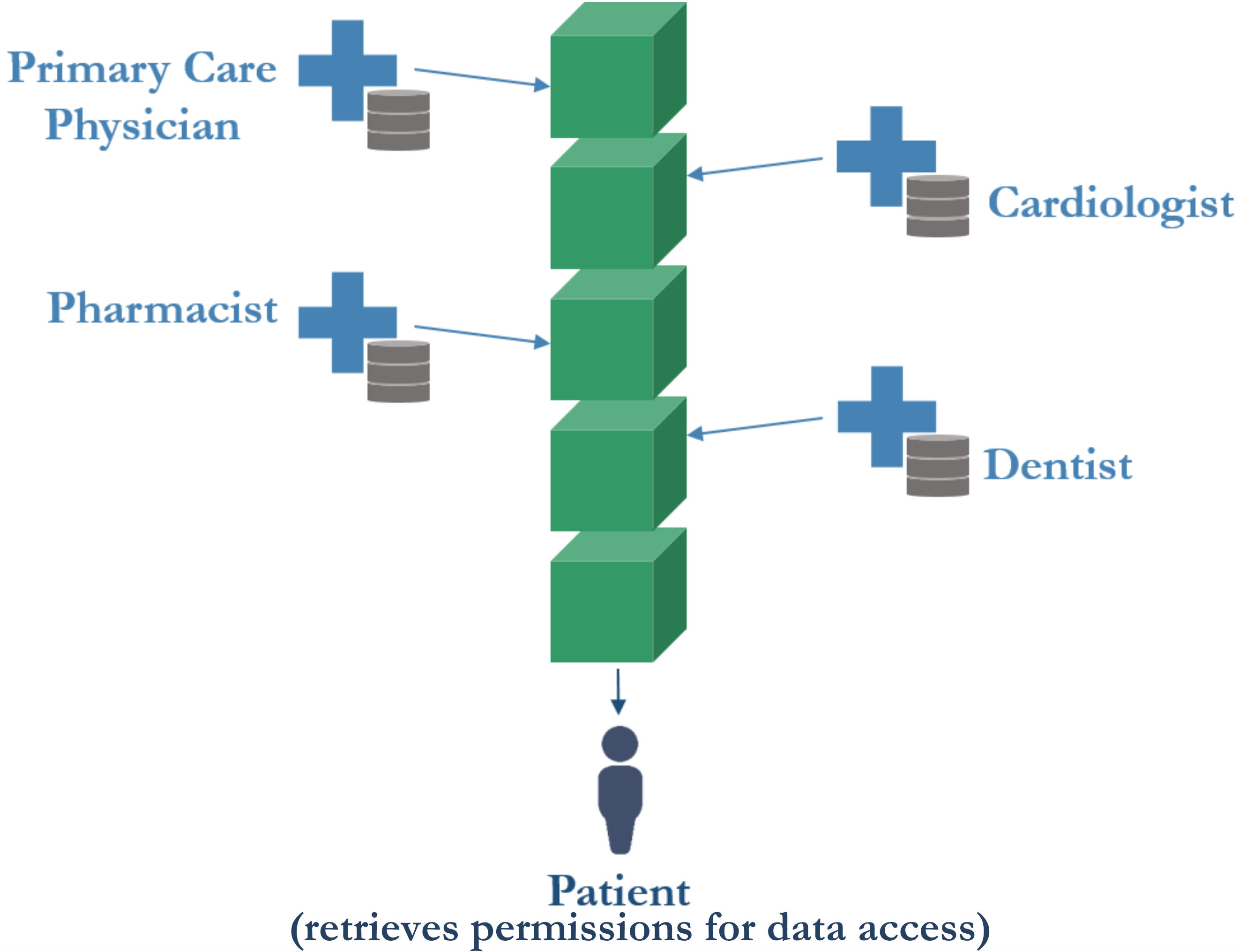
- public key Ethereum addresses → Identity string
- public key Ethereum address → Summary Contract address
- Custom registrar logic



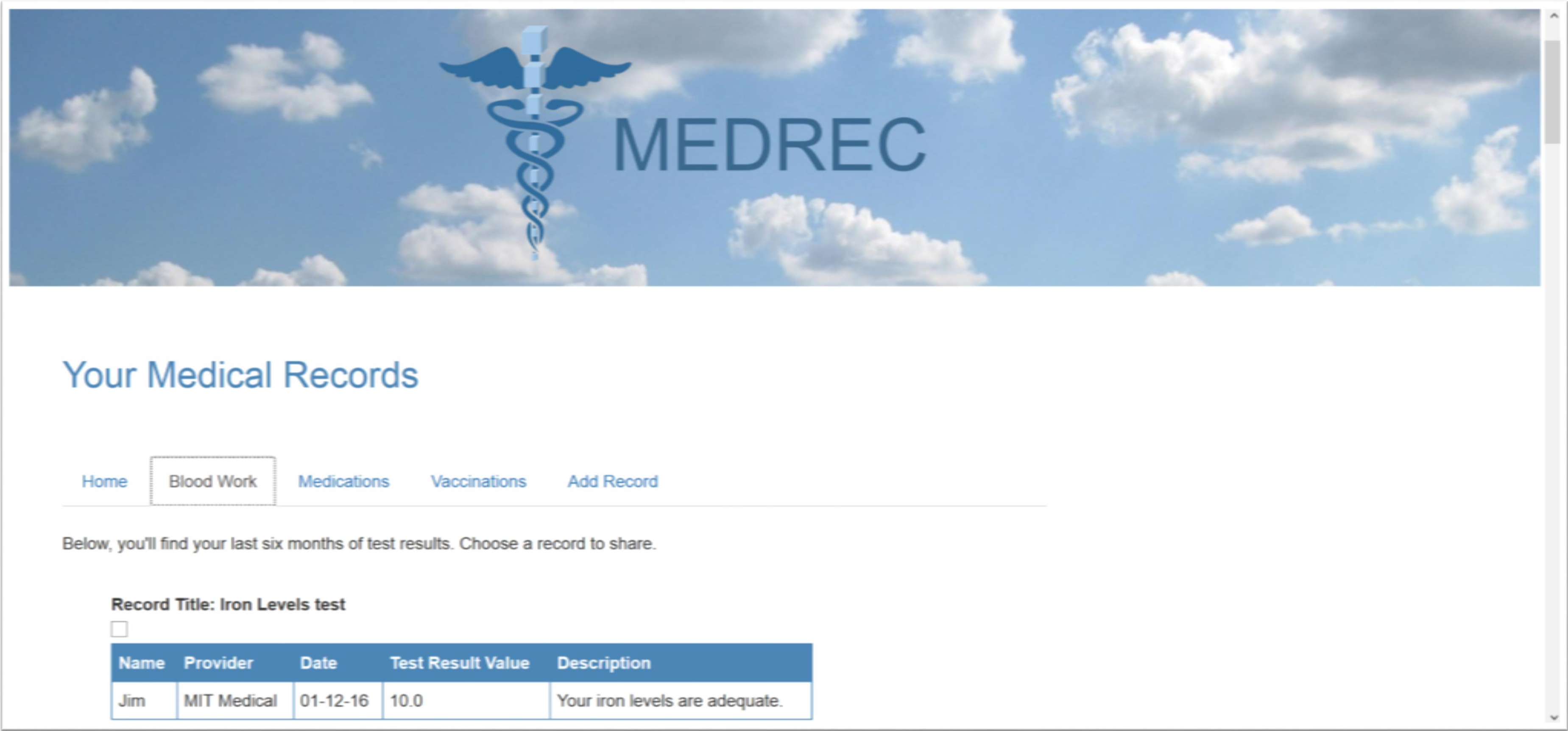
MedRec System Diagram | single node



MedRec System Diagram | multi-node network



MedRec User Interface



MedRec

Your Medical Records

Home **Blood Work** Medications Vaccinations Add Record

Below, you'll find your last six months of test results. Choose a record to share.

Record Title: Iron Levels test

Name	Provider	Date	Test Result Value	Description
Jim	MIT Medical	01-12-16	10.0	Your iron levels are adequate.



MedRec Virtual Machines

Miner

- Listens for new “transactions”
- Mining difficulty can be customized
- Always up-to-date on the latest block
- Supports many mining nodes

Physician/Care Provider

- Runs a webapp UI view
- Runs a custom Ethereum client, crawling the chain listening for updates pertinent to that identity

Patient

- Runs a webapp UI view
- Runs a custom Ethereum client, crawling the chain listening for updates pertinent to that identity



MedRec Virtual Machines | Miner

```
MINGW32:/c/Users/Aura/Documents/GitH...
I0920 09:48:11.213315 18644 worker.go:336] ?? Mined block (#7596 / f004b664).
  Wait 5 blocks for confirmation
I0920 09:48:11.214358 18644 worker.go:557] commit new work on block 7597 with
0 txs & 0 uncles. Took 751.044µs
I0920 09:48:11.214521 18644 worker.go:435] ?? ?? Mined 5 blocks back: block #
7591
I0920 09:48:12.723633 18644 worker.go:557] commit new work on block 7597 with
0 txs & 0 uncles. Took 492.568µs
I0920 09:48:50.480626 18644 worker.go:336] ?? Mined block (#7597 / e72106dc).
  Wait 5 blocks for confirmation
I0920 09:48:50.481424 18644 worker.go:557] commit new work on block 7598 with
0 txs & 0 uncles. Took 528.931µs
I0920 09:48:50.481566 18644 worker.go:435] ?? ?? Mined 5 blocks back: block #
7592
I0920 09:48:51.181930 18644 worker.go:557] commit new work on block 7598 with
0 txs & 0 uncles. Took 567.803µs
I0920 09:49:02.094330 18644 worker.go:336] ?? Mined block (#7598 / ed811638).
  Wait 5 blocks for confirmation
I0920 09:49:02.095224 18644 worker.go:557] commit new work on block 7599 with
0 txs & 0 uncles. Took 591.433µs
I0920 09:49:02.095380 18644 worker.go:435] ?? ?? Mined 5 blocks back: block #
7593
I0920 09:49:02.219427 18644 worker.go:557] commit new work on block 7599 with
0 txs & 0 uncles. Took 500.393µs
```

Block number

Turns to “1 txs” when a transaction is found



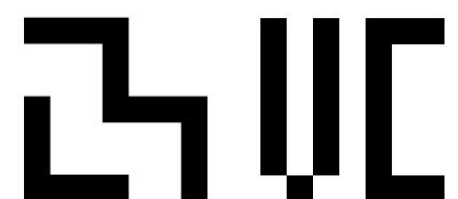
MedRec Virtual Machines | Physician/Care Provider

```
MINGW32:/c/Users/Aura/Documents/GitH...
%quickref -> Quick reference.
help      -> Python's own help system.
object?   -> Details about 'object', use 'object??' for extra details.

In [1]: MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
MEDREC: crawling the chain
```

Initially crawling the chain for updates

Waiting for requests or newly submitted patient records



MedRec Virtual Machines | Patient

```
MINGW32:/c/Users/Aura/Documents/GitH...  
%quickref -> Quick reference.  
help      -> Python's own help system.  
object?   -> Details about 'object', use 'object??' for extra details.  
  
In [1]: MEDREC: crawling the chain  
MEDREC: Found the following updates: Contract fa91f062d35e9654b844dc327f73a61a4e  
7daf49, provider c45785cf6f3c19fafb9bb90624f2c2b4a9c2e649, hostname medrecords-2  
.media.mit.edu, status: InfoUpdateAvailable  
MEDREC: crawling the chain  
MEDREC: Found the following updates: Contract fa91f062d35e9654b844dc327f73a61a4e  
7daf49, provider c45785cf6f3c19fafb9bb90624f2c2b4a9c2e649, hostname medrecords-2  
.media.mit.edu, status: InfoUpdateAvailable  
MEDREC: crawling the chain  
MEDREC: Found the following updates: Contract fa91f062d35e9654b844dc327f73a61a4e  
7daf49, provider c45785cf6f3c19fafb9bb90624f2c2b4a9c2e649, hostname medrecords-2  
.media.mit.edu, status: InfoUpdateAvailable  
MEDREC: crawling the chain  
MEDREC: Found the following updates: Contract fa91f062d35e9654b844dc327f73a61a4e  
7daf49, provider c45785cf6f3c19fafb9bb90624f2c2b4a9c2e649, hostname medrecords-2  
.media.mit.edu, status: InfoUpdateAvailable  
MEDREC: crawling the chain  
MEDREC: Found the following updates: Contract fa91f062d35e9654b844dc327f73a61a4e  
7daf49, provider c45785cf6f3c19fafb9bb90624f2c2b4a9c2e649, hostname medrecords-2  
.media.mit.edu, status: InfoUpdateAvailable
```

Initially crawling the chain for updates

Finds an update, identifies the relevant Patient-Provider Contract address and Provider address

Patient web app will now display a notification related to this update



Prototype Evaluation | Hospital Deployment



- Local integration with BIDMC data servers (SQL Server)
- Testing ability to smoothly intake and parse a standard clinical document
- Linking our Database Gatekeeper utility to hospital test server endpoint
- Completing multiple end-to-end system flows

MedRec Prototype | Interoperability

- Designed as a system of Open APIs – FHIR rails, Argonaut Project, etc
- Designed with HIPAA regulations in mind
- Designed to accept standardized data formats, or work directly with on-premise DBs
- Goal: support end-to-end encryption for the off-chain data transfer



MedRec | A framework for Big Data applications

Identifying patterns & trends in your personal healthcare data



MedRec | A framework for Big Data applications

Identifying patterns & trends in your personal healthcare data

Predictive analytics based on MedRec population data



MedRec | A framework for Big Data applications

Identifying patterns & trends in your personal healthcare data

Predictive analytics based on MedRec population data

For researchers: precision medicine, specify demographic data, longitudinal studies



MedRec | A framework for Big Data applications

Identifying patterns & trends in your personal healthcare data

Predictive analytics based on MedRec population data

For researchers: precision medicine, specify demographic data, longitudinal studies

Analytics layer for trend discovery: narcotics abuse, conflicting prescriptions, epidemiological trends



MedRec | National Healthcare Priorities

ONC Interoperability Roadmap:

“Individuals have access to longitudinal electronic health information, can contribute to the information, and can direct it to any electronic location”

“Learning Health System”

“Service Oriented Architecture”

“Healthcare Directory & Resource Location”

“Consistent Representation of Authorization to Access Electronic Health Information”



MedRec | National Healthcare Priorities

Precision Medicine Initiative & PCOR:

- Establishing a national research cohort*
- Evidence-based, personalized research*



MedRec | National Healthcare Priorities

Precision Medicine Initiative & PCOR:

- Establishing a national research cohort*
- Evidence-based, personalized research*



Data Sovereignty | Open Stack for Big Data in Healthcare

MedRec | Your Perspective

How can this project contribute to an interoperable, health IT stack?



MedRec | Challenges & Considerations

- Privacy: frequency analysis on open blockchain
- Natural, limiting size of a MedRec “network”
- Data aggregation across many endpoints
- Relying on digitization of medical records
- Relying on momentum behind FHIR & record standardization



Next Steps & Future Work

- Preparing to open-source the code in Fall 2016
- Additional real-world deployments
- Moving from POC to scalable code base
- Extensibility to other non-healthcare use cases
- Integrating with other Blockchain + Open Data projects



Thank you to our sponsors & collaborators!

MIT Media Lab Consortium

MIT Digital Currency Initiative

Beth Israel Deaconess Medical Center

For more information on the MedRec project, please email:

medrec@mit.edu

Read our blog post at:

pubpub.org/pub/medrec

