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A Proposal to Harmonize BIM and IoT Data Silos using Blockchain Applications

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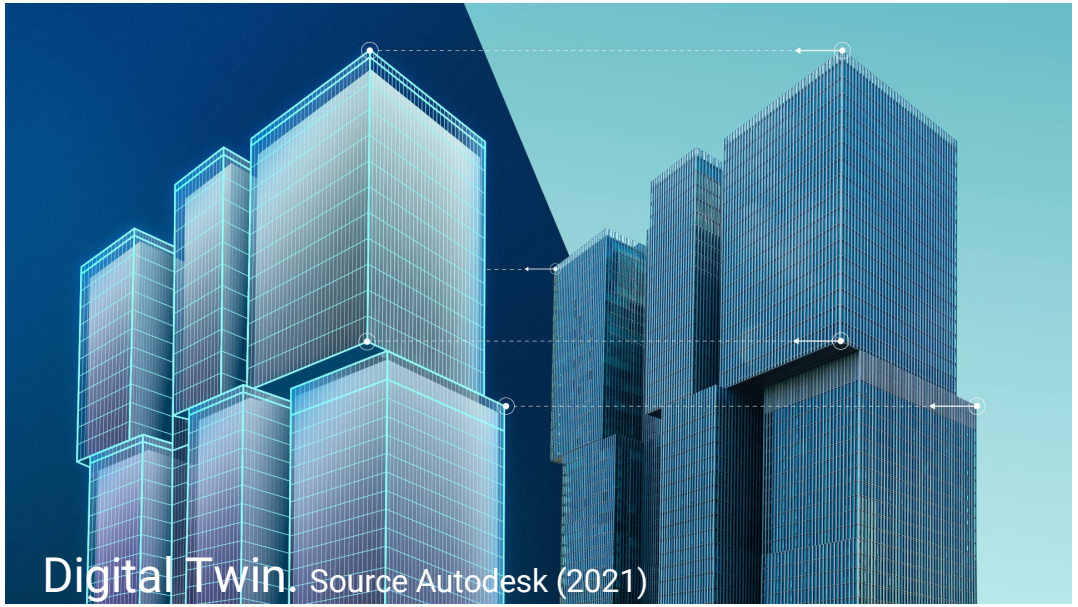
Learning Points

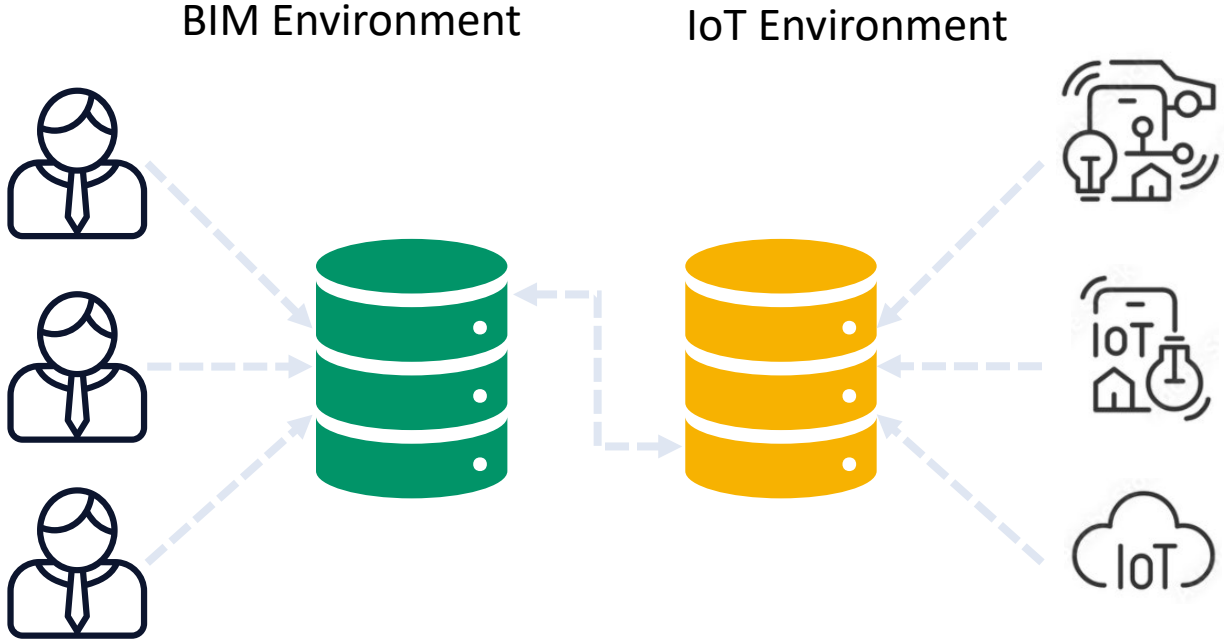
1. **Research Background**
2. **Challenges of BIM and IoT Data Integration**
3. **Blockchain**
4. **Proof of Concept**

Research Background

- The integration of BIM and IoT provides significant **end-to-end benefits**
- **Data silos** have impacted the integration process
  - **Disconnected system** - centralized, unintegrated database system across two or multiple repositories
  - **Fragmented data** - file-based system creates data reliability and interoperability issue
  - **Security** - vulnerable to attacks from data theft and malicious activities



Digital Twin. Source Autodesk (2021)

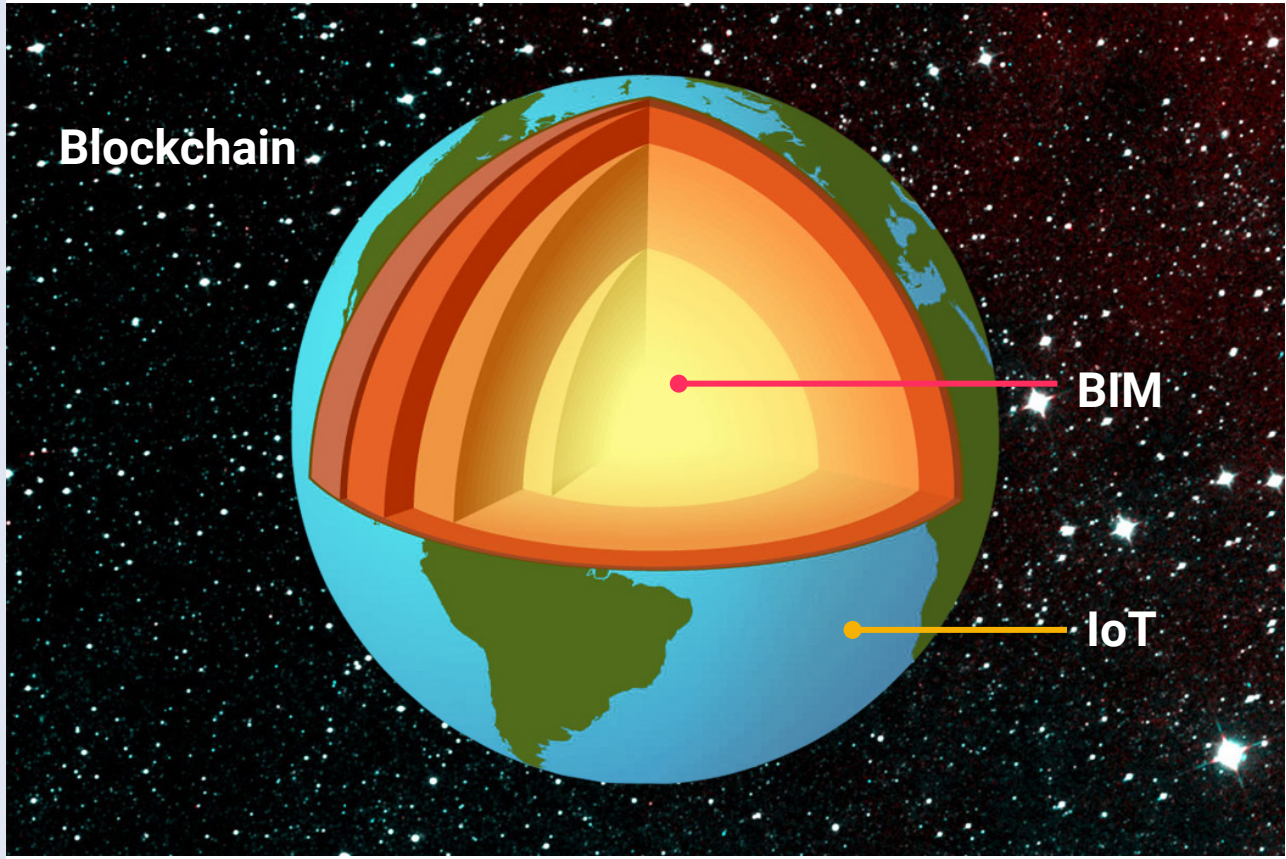


BIM and IoT Data Silos. Source Author (2020)

Research Background

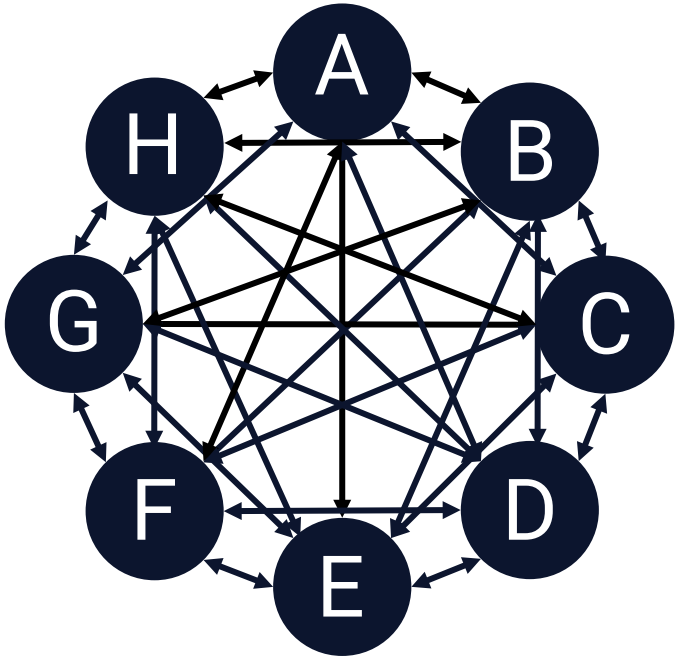
Data harmonization using Blockchain applications aims to building

- **Relationship** – between shared environments for more connected BIM & IoT
- **Trust** - Allows data to be shared while providing reliability, security, **transparency**, and privacy for data owners to maintain control of their build assets and access
- **Value** - Leverage the end-to-end benefits of information provided by harmonizing data silos and democrats access to data



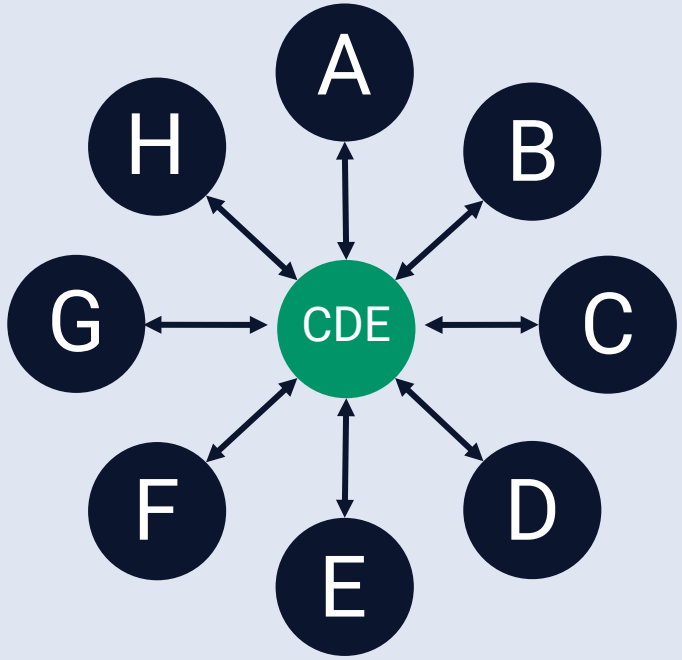
Anatomy of Technology

BIM & IoT integration Challenges



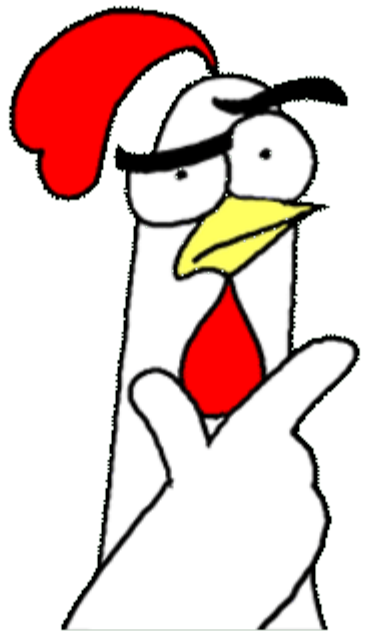
Traditional Information Sharing

=>



Common Data Environment (CDE)

Does CDE change how data is shared and governed?



BIM & IoT integration Challenges

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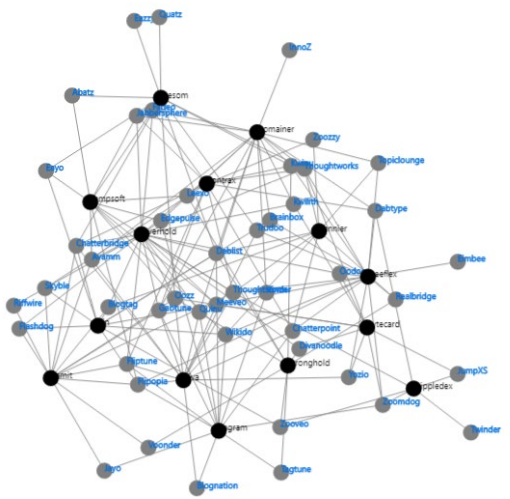


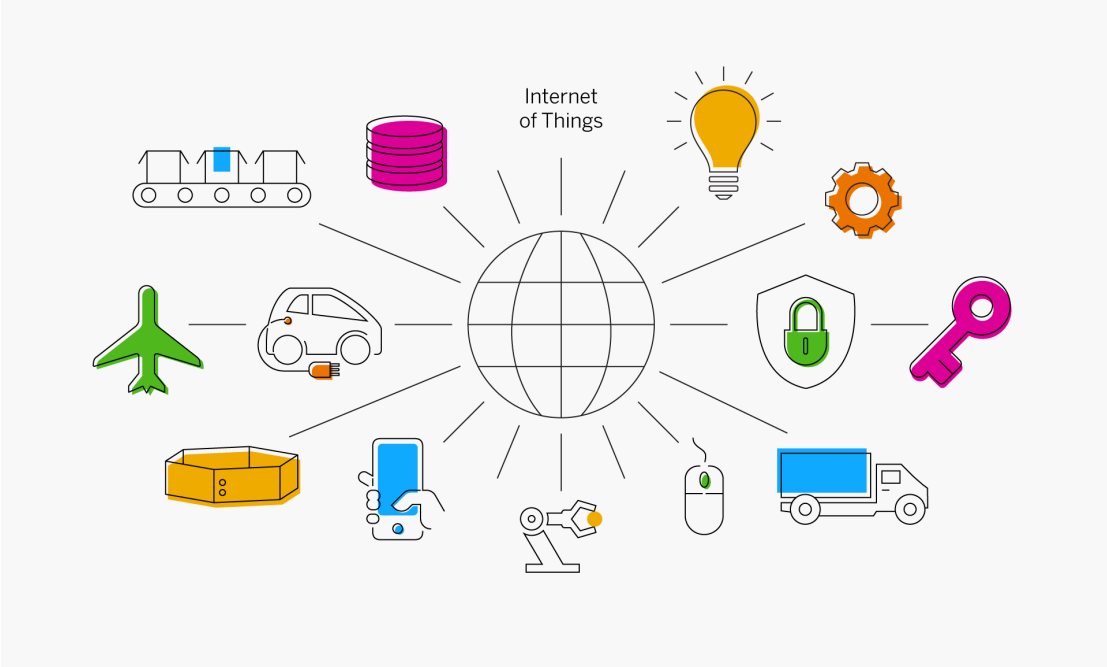
BIM management complexity. Source Author (2020)

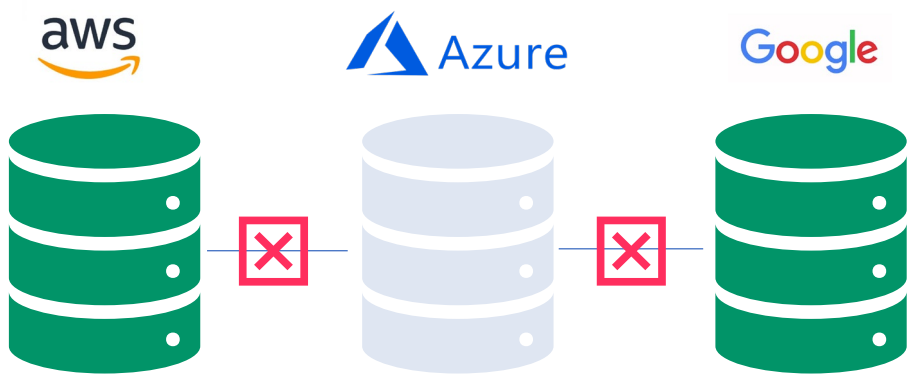
CDE issues

- Lack of **clarity** regarding roles and responsibilities, interoperability, etc.
- Not **immutable** resulted **anomalies** and data **redundancy**
- **File-based** not a databased system
- Resource **intensive** for version-control, audit table, access log creation etc. and impossible to verify
- Raising **trust** issues
- **Silo** in collaboration

BIM & IoT integration Challenges

- IoT is a system that employs **interconnected** smart **devices** to transfer data using internet
- IoT data is inherently **heterogeneous** and **noisy** by nature because of different hardware, operating systems, used software and gateway requirements
- Vendor no incentive to share data/market with their competitors. Data **locked in-silo** caused interoperability issues



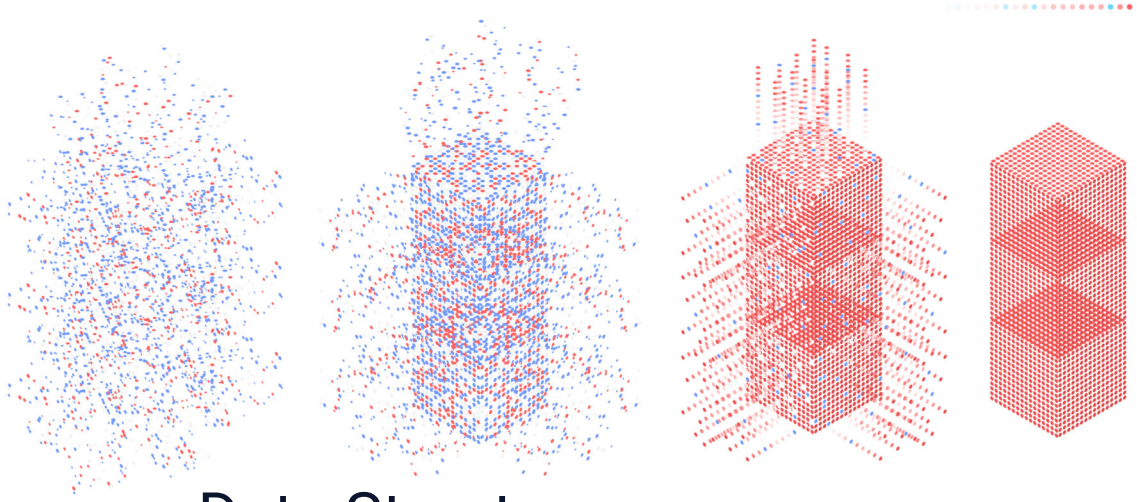


Lock-in silo. Source Author (2020)

Re-thinking BIM and IoT Integration

- Consider approaches that can establish the end-to-end collaboration via a **single source of truth** that can enable **relationship**, **trust**, analysis and informed decision making (**value**)

Single Source of Truth. Source Author (2020)



Data Structure. Source Threehouse (2021)

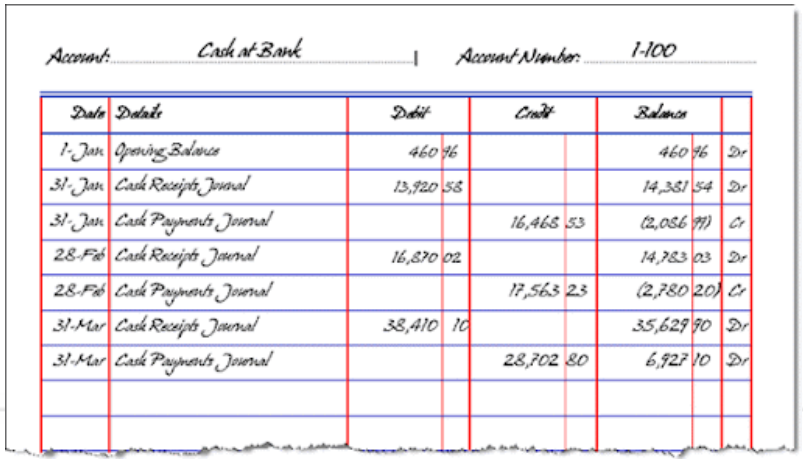
Blockchain technology emerged as a disruptive innovation to **democratic** data sharing.

Blockchain

What is Blockchain?

- Not a Cryptocurrency
- Digital Ledger
  - Record transactions

Cryptocurrencies changed how we see money, perceived value and ownership.



Account: Cash at Bank | Account Number: 1-100

Date	Details	Debit	Credit	Balance	
1-Jan	Opening Balance	460 96		460 96	Dr
31-Jan	Cash Receipts Journal	13,920 58		14,381 54	Dr
31-Jan	Cash Payments Journal		16,468 53	(2,086 99)	Cr
28-Feb	Cash Receipts Journal	16,870 02		14,783 03	Dr
28-Feb	Cash Payments Journal		17,563 23	(2,780 20)	Cr
31-Mar	Cash Receipts Journal	38,410 10		35,629 90	Dr
31-Mar	Cash Payments Journal		28,702 80	6,927 10	Dr

LEDGER

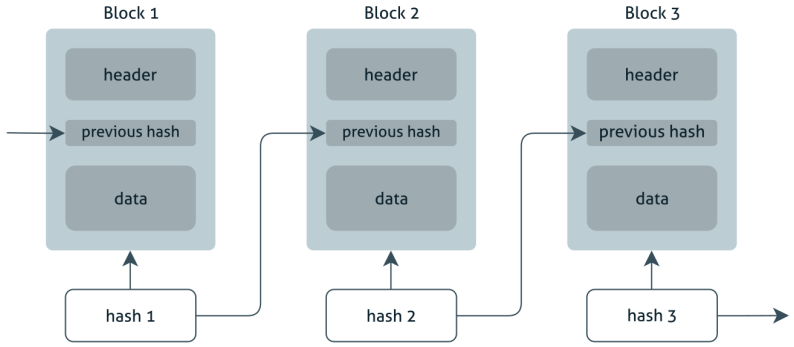
ACCOUNT TYPE	CASH				
TRANSACTION DATE	TRANSACTION DETAIL	REFERENCE	DEBIT	CREDIT	BALANCE
1/1/16	Expenses for Jan	Ref#1	$100.00		$100.00
2/1/16	Tax withheld	Ref#2		$110.00	($10.00)

Traditional Ledger. Source IBM (2021)

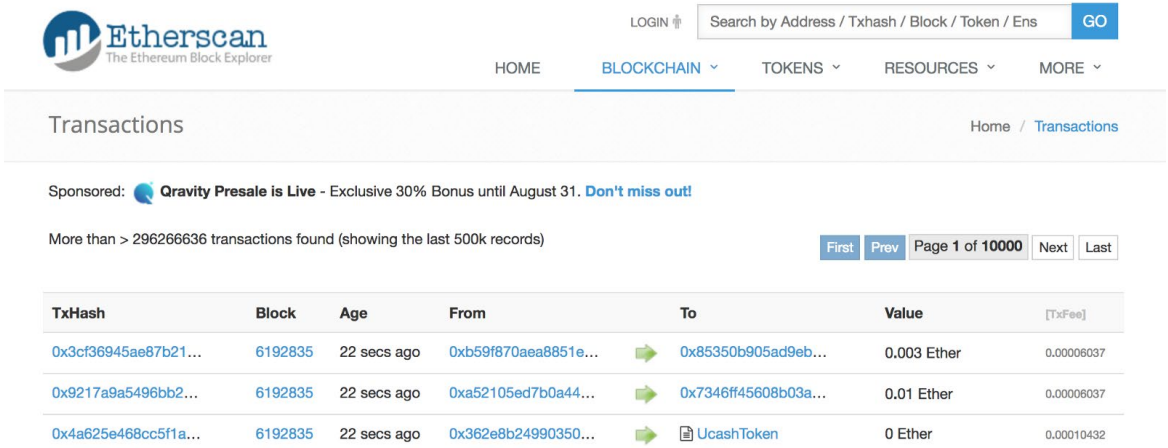
Blockchain

Blockchain Digital Ledger

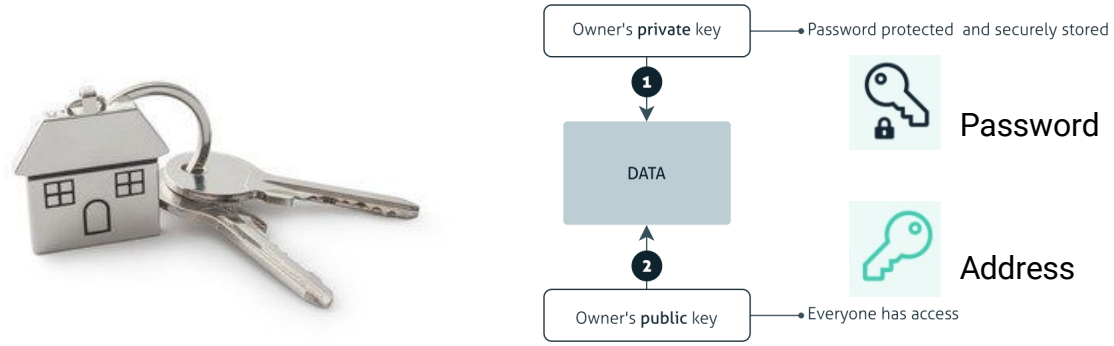
- **Immutable -** Each transaction contains a hash of the previous transaction thus making it very difficult to tamper with
- **Transparent -** permitting users read-only admission to prior dealings and the capability to review the content
- **Distributed -** shared and synchronized across network
- **Decentralized -** distributing and dispersing power away from a central authority



The Blocks. Source Fábio José (2018)

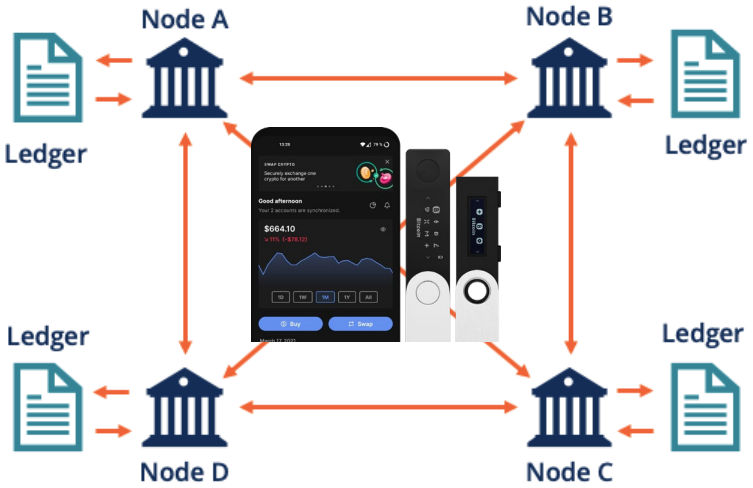


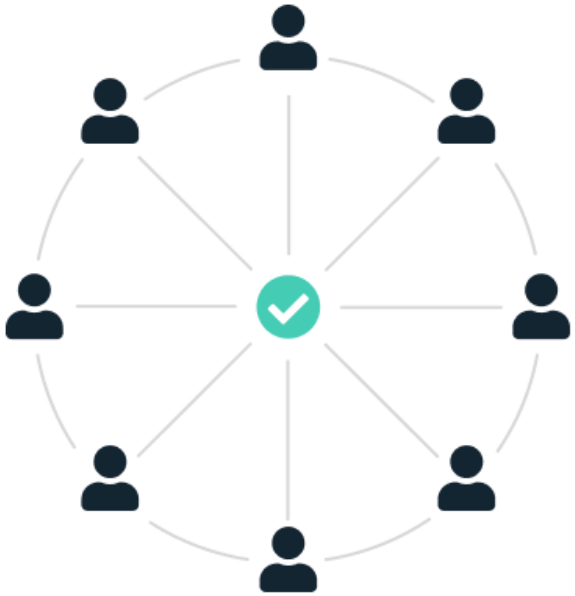
Blockchain Ledger. Source Etherscan (2021)

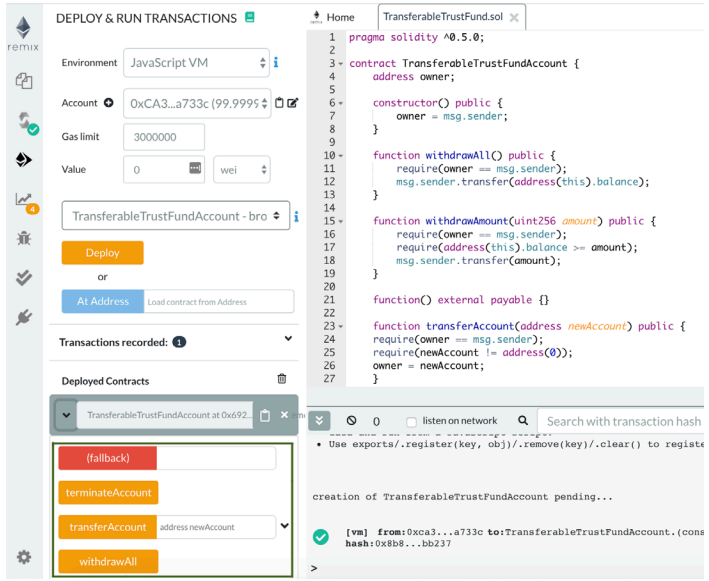


The Keys. Source Fábio José (2018)

Blockchain Components







- **Distributed Ledger Databased**
  Transactions record that is consensually shared and synchronized across network of computer
- **Consensus Mechanism**
  Agreement protocols on a single data value or a single state of the network among distributed processes
- **Smart Contract**
  Segment of code that triggered when certain events are activated

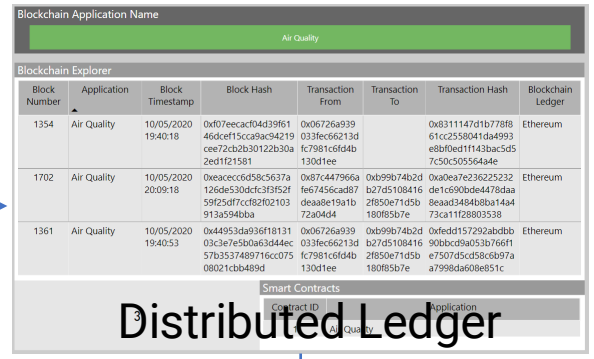
Proof of Concept

- A **smart contract** for health and safety record was created to test the function of **Blockchain components**
- Demonstrates how to **collect** telemetry information and **link** the data with the distributed ledger and BIM model

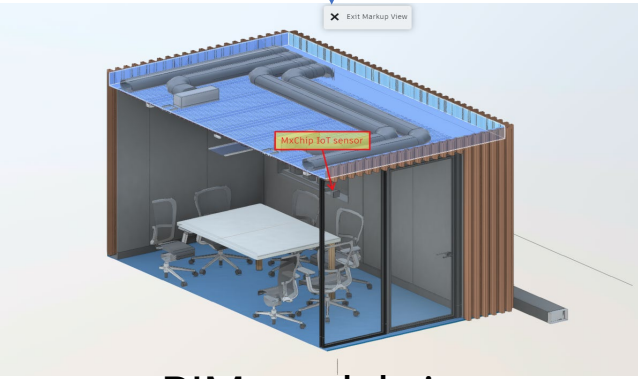
Solution Architecture

- Microsoft **Azure** for building and managing the **IoT** data (IoT Hub) and **smart contract** (Blockchain Workbench)
- Interconnectivity between **BIM data** and the Azure platform was achieved via Autodesk **Forge API**

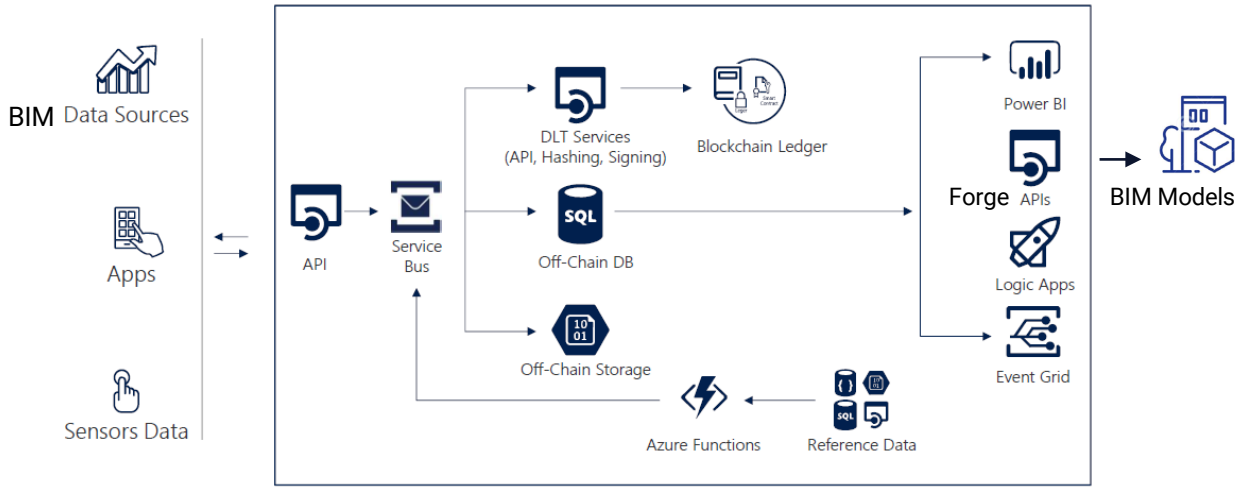
MxChip IoT Device



Distributed Ledger

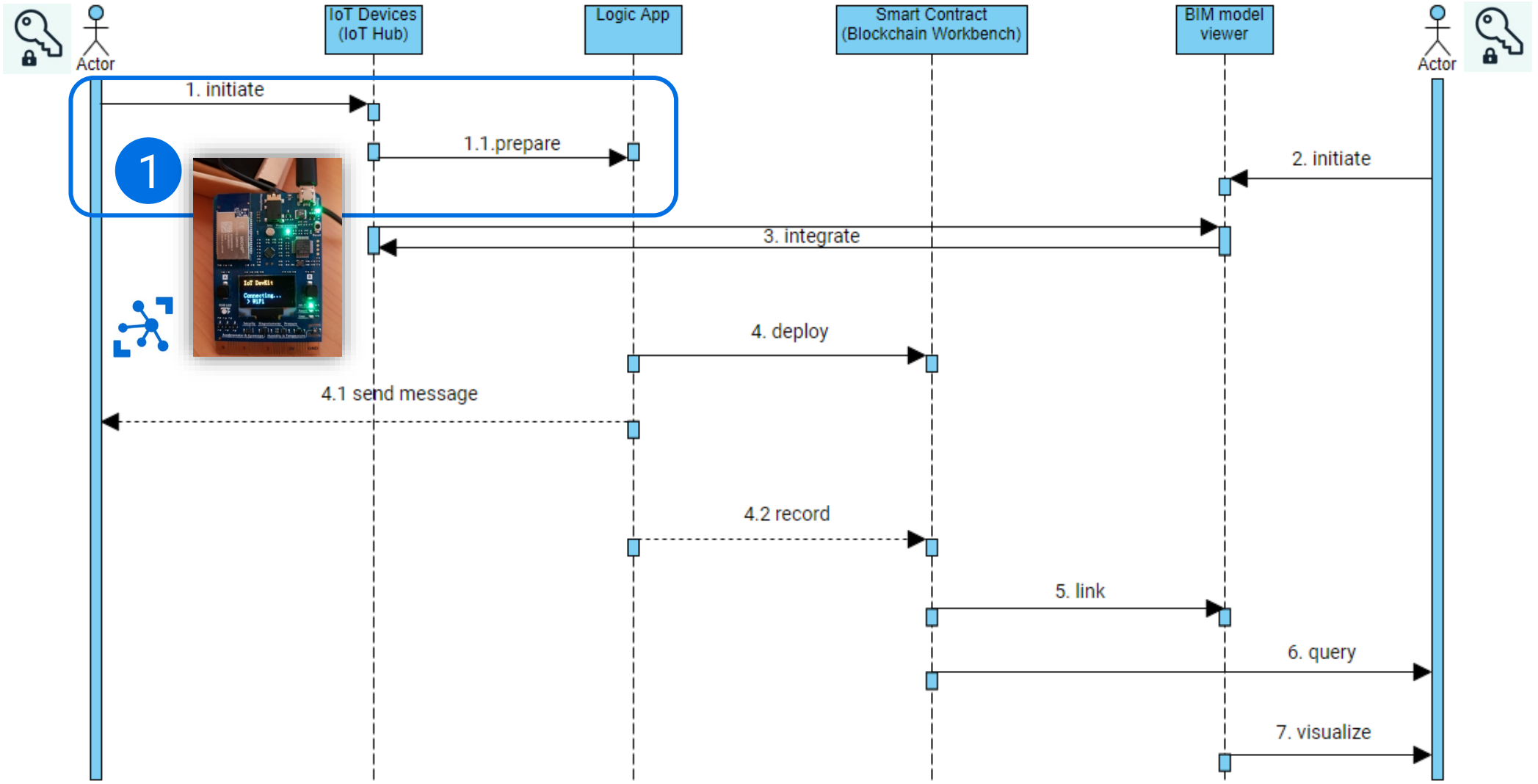


BIM model viewer



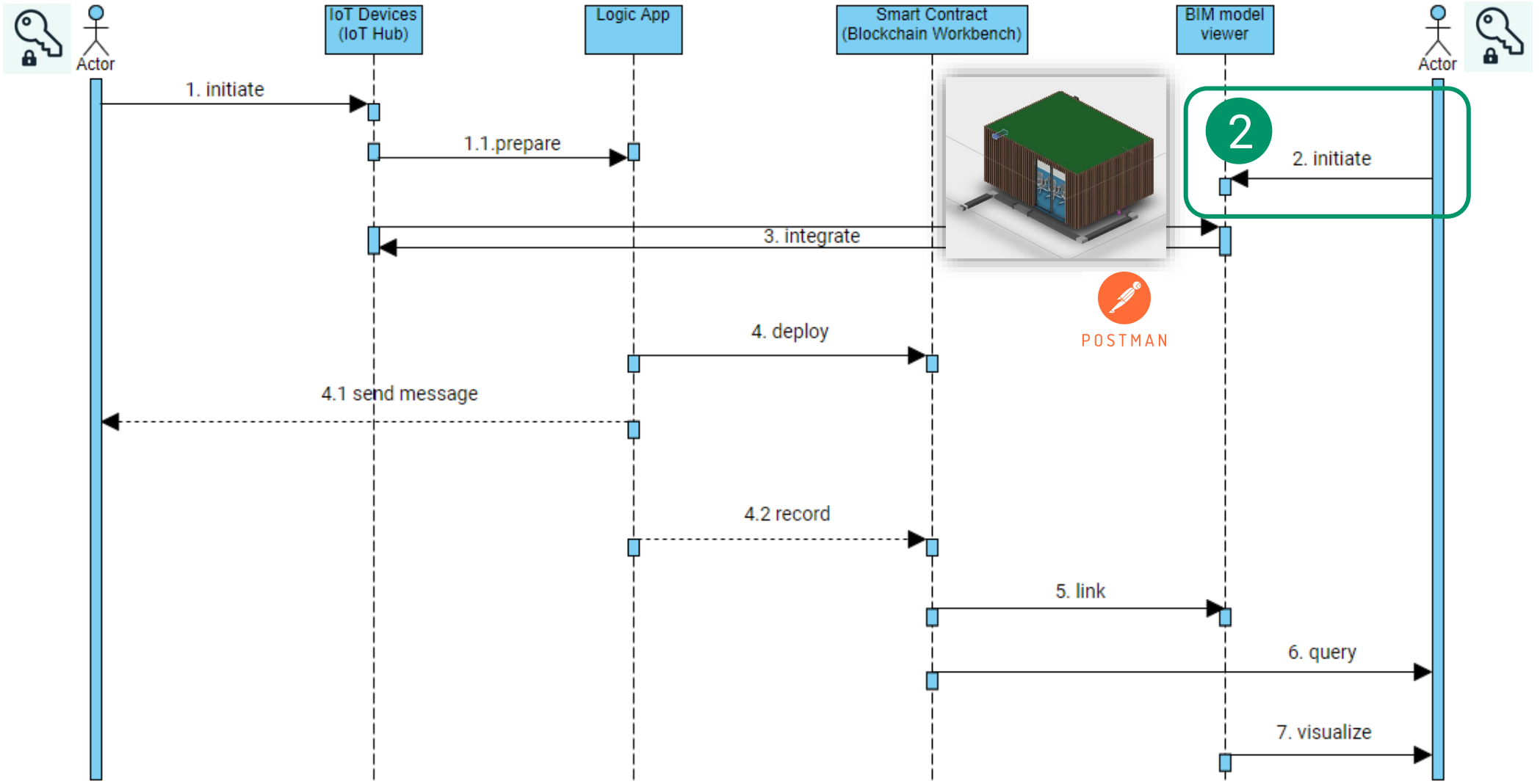
Azure blockchain architecture. Source Microsoft (2020)

Proof of Concept



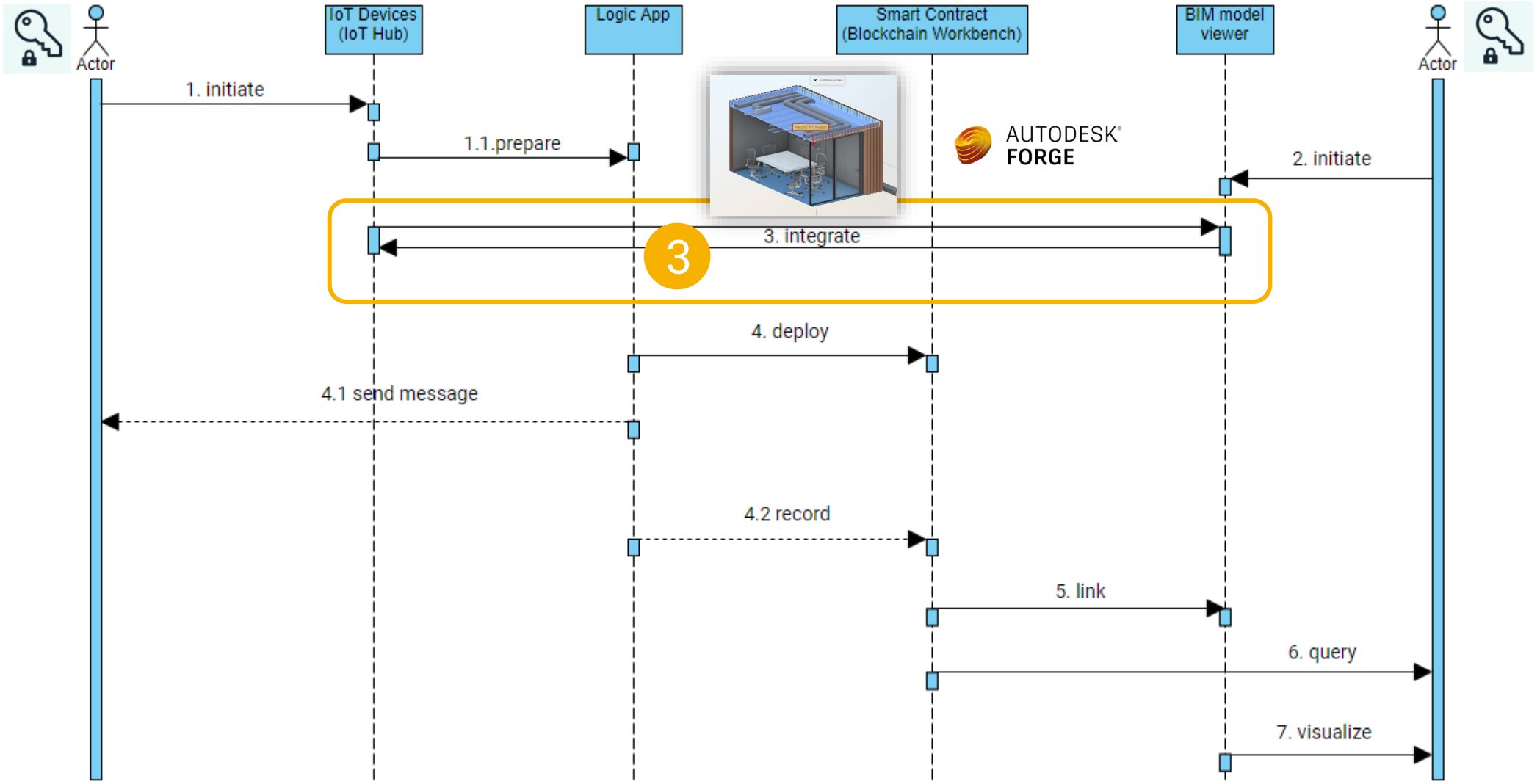
Step 1 - The MXchip IoT Devkit with a temperature and humidity sensors was installed in a meeting room to capture and provide telemetry data.

Proof of Concept



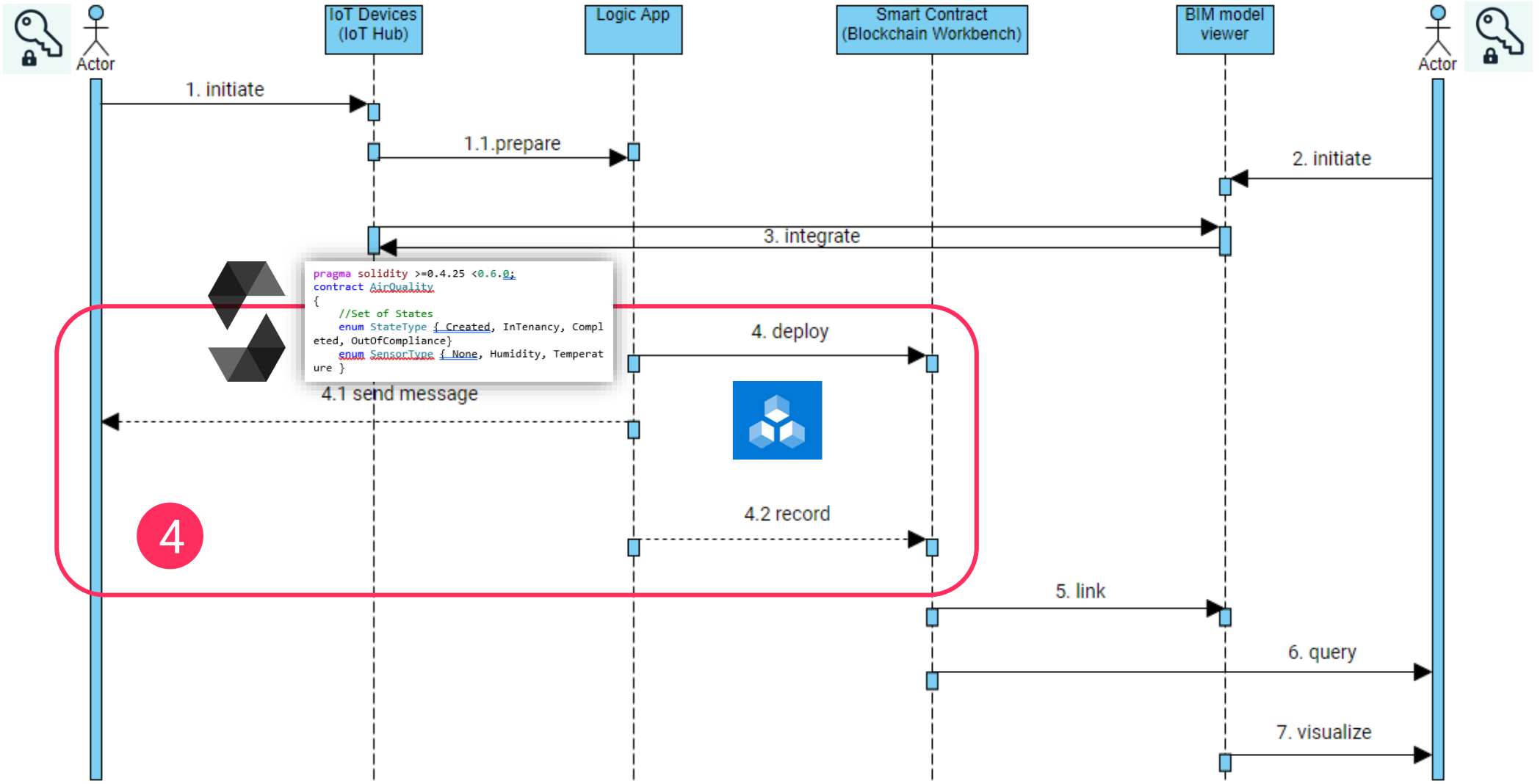
Step 2 - BIM models were initiated to web viewer to host metadata from digital assets

Proof of Concept



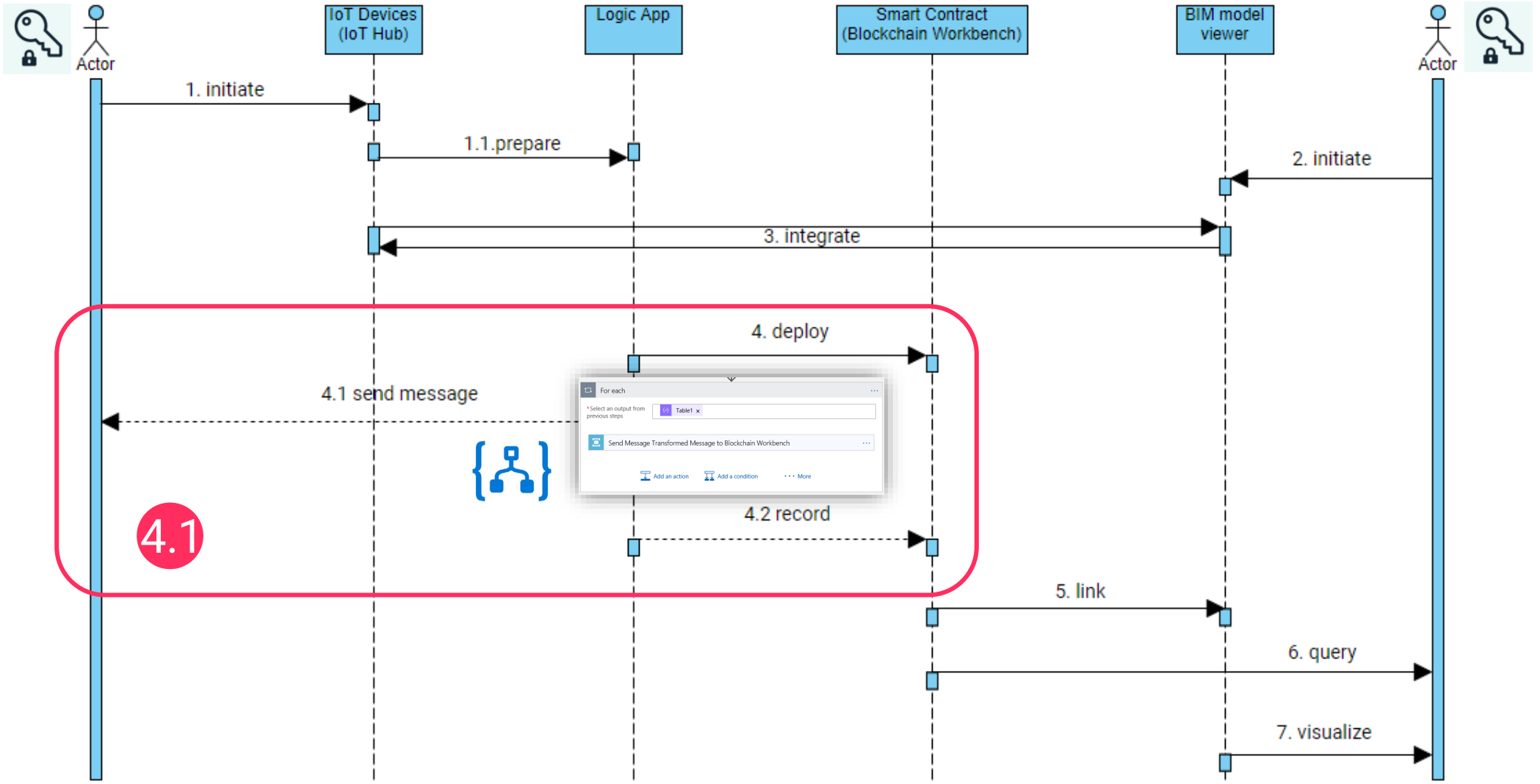
Step 3 - Data from IoT sensor were linked into the digital model in the web app

Proof of Concept



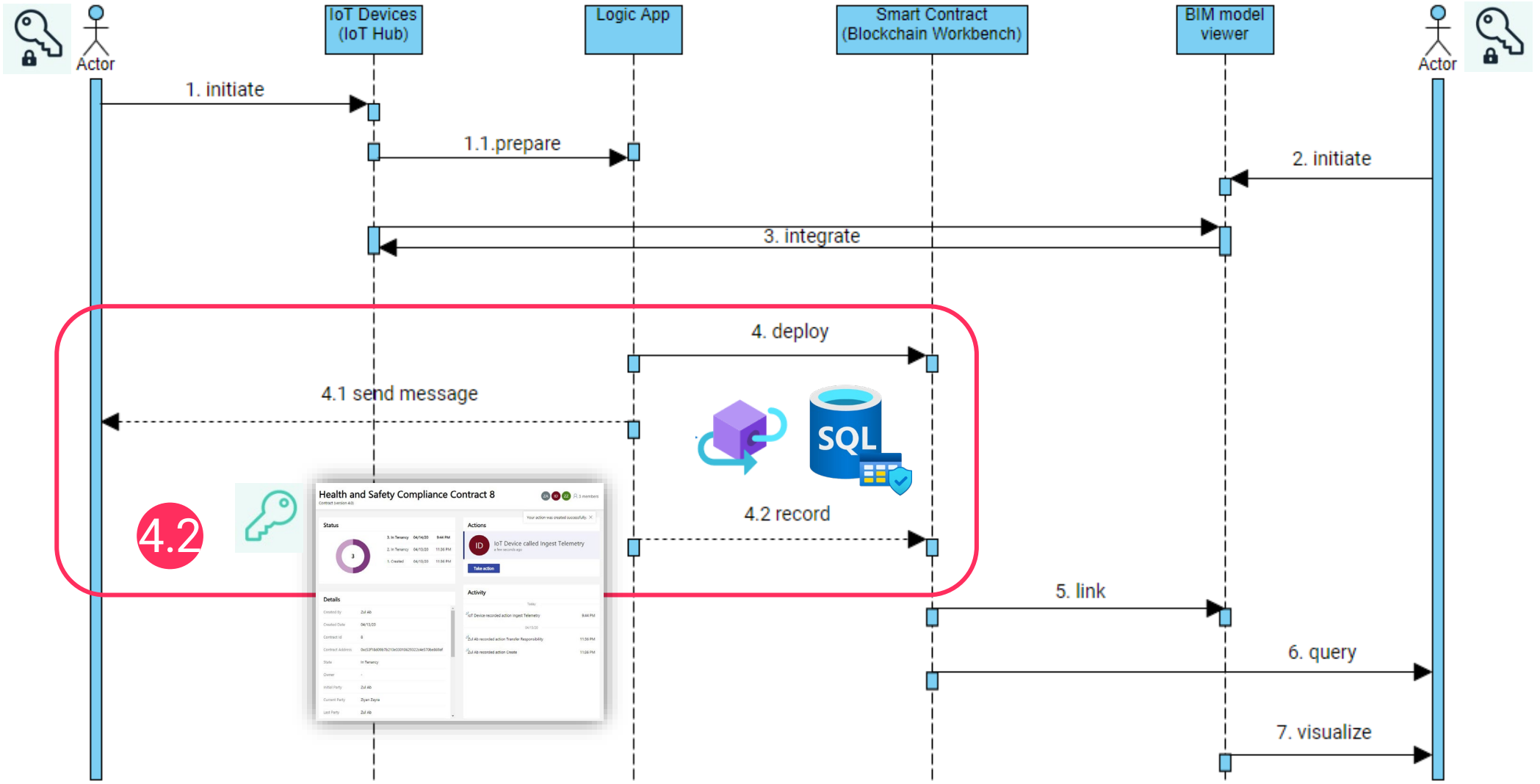
Step 4 – Smart Contract deployment

Proof of Concept



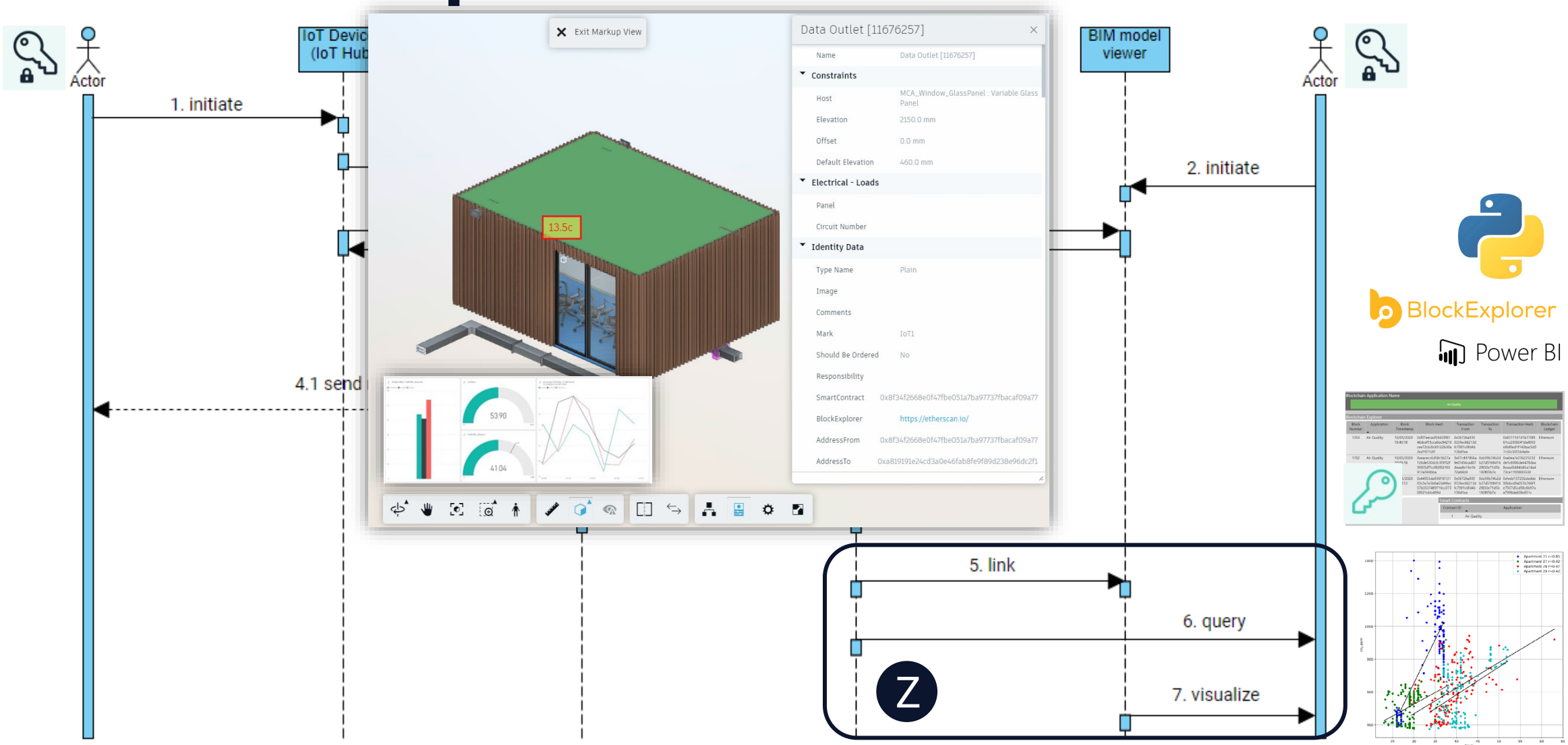
Step 4.1 – Automated monitoring process by the Logic app

Proof of Concept



Step 4.2 – The smart contact application was built to secure the transactions data between multiple counterparties at any given time.

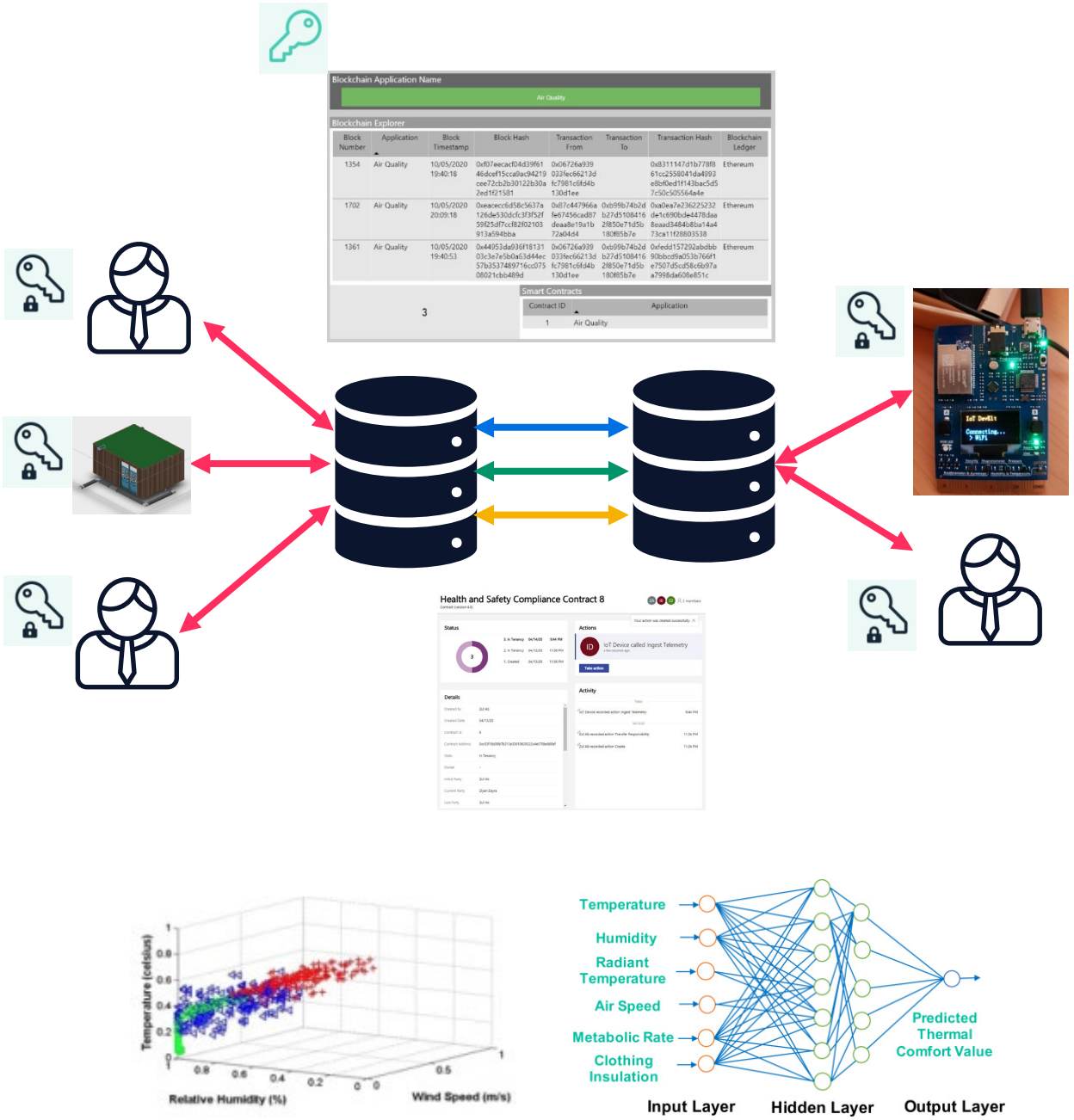
Proof of Concept



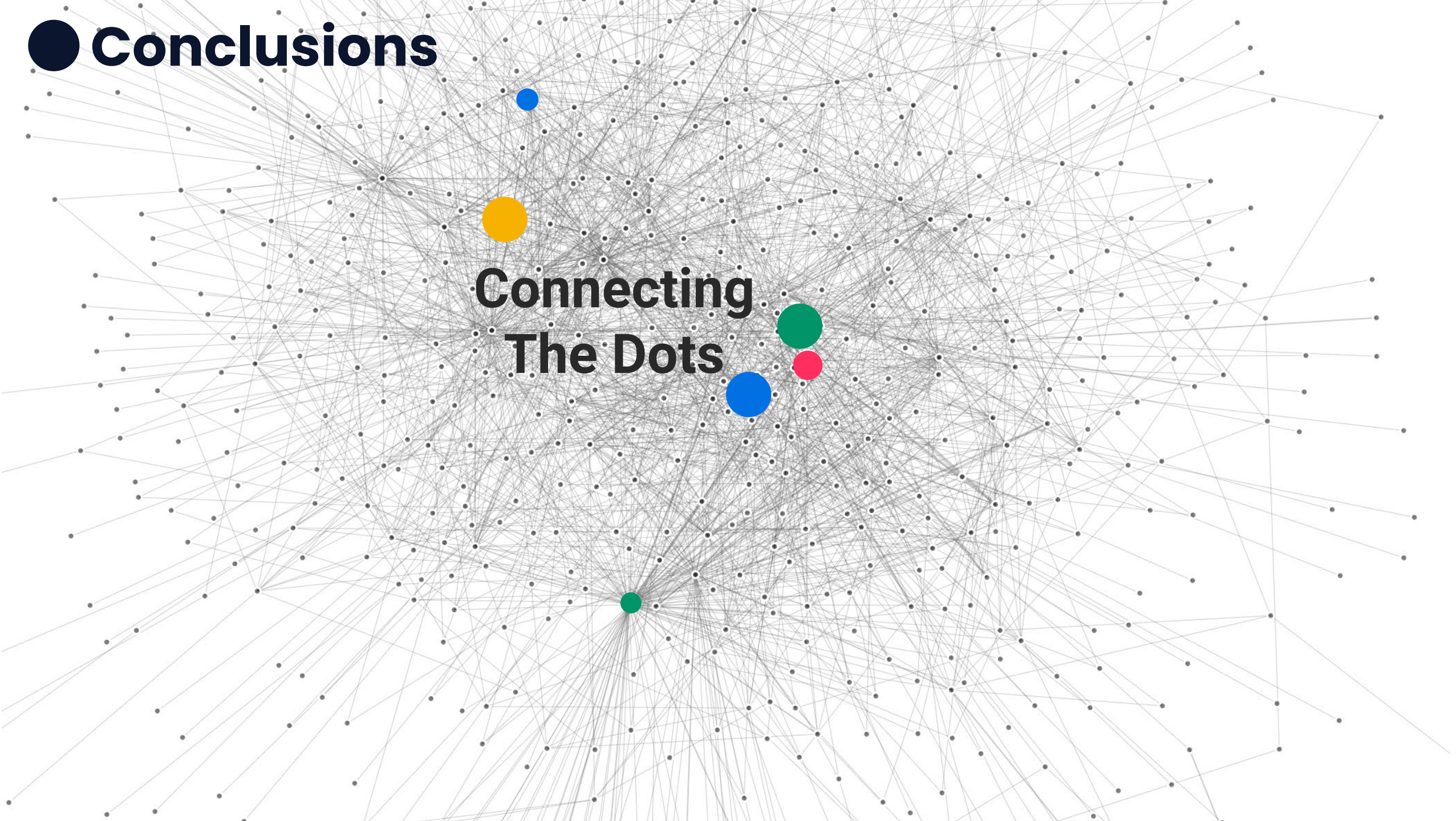
Step 5,6,7 – Link, query and visualize. Information can be viewed and query at any point in time in the Blockchain explorer

Findings

- The **Smart contract** records agreement **relationship** between BIM and IoT environment and promotes a foundation for a more transparent, secure, and better data exchanges model
- Blockchain **keys** allow appropriate access to verified data and gave maximum control and **transparency** over what data is shared and how. A **single source of truth** among participants can be achieved when **trust** is distributed, and **consensus** is applied to transactions with no central point of failure
- Data transacted within the environments were validated, recorded, and registered in the **distributed ledger**. The **valuable** verified time-series datasets can be used to improve predictive data analytics in the built environment and obtain a more accurate prediction and decision making



Conclusions



Thank You!