G-DaM: A Blockchain based Distributed Robust Framework for Ground Water Data Management

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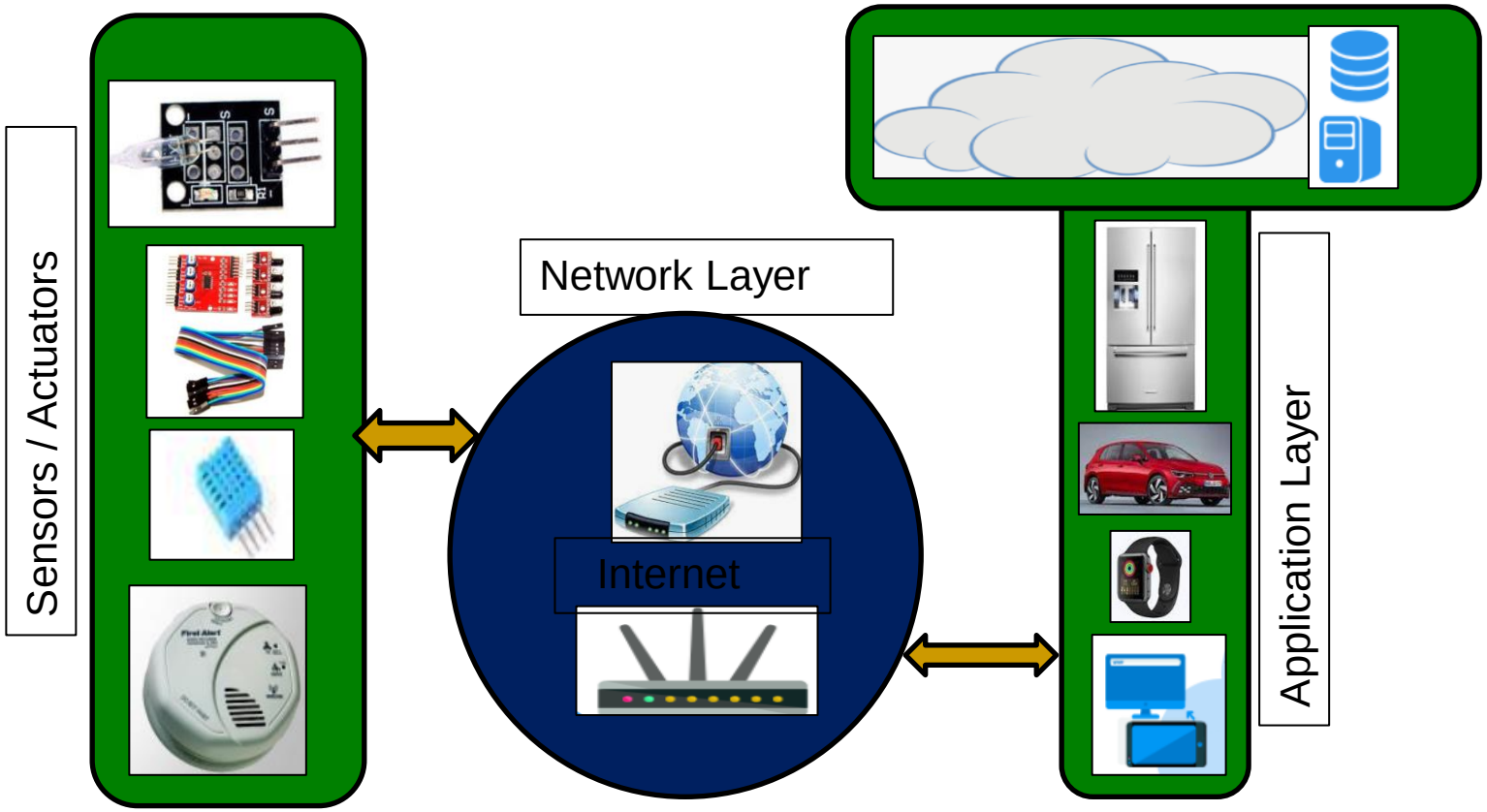
Talk Outline

- Introduction-IoT & Groundwater Data
- Sources and Recipients of Groundwater Data
- Motivation and Challenges
- Related Research
- Issues in Existing Works and Novel Solution
- Groundwater data End Systems, DDS and BC
- Proposed Blockchain Based Water Quality Data Management System
- Implementation and Verification
- Experimental Results
- Conclusion and Future Work

Introduction
IoT –Internet of Things

- Application Fields
  - Smart City
  - Smart Medical(IoMT).
  - Smart Farming(IoAT)
  - Smart Industrial (IIoT)
  - Smart Energy(IoE)
  - Smart Supply chain and Retail.
  - Smart Home.



Introduction-Ground Water Data

Water Contamination

Availability of Water

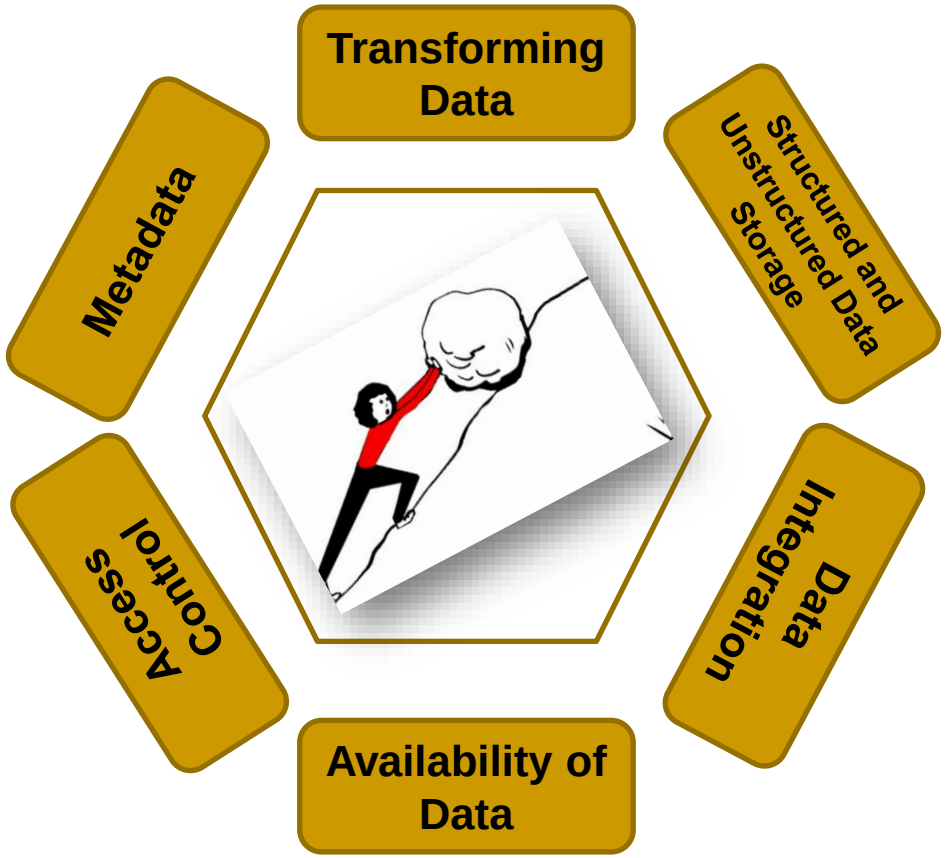
Wireless Sensors/
Satellites

Groundwater
Data

Data Research

- Groundwater is 1.69 % of total water on earth.
- Source of sustenance.
- Data collected from diverse sources.
- Helps in Increasing Food Production
- Checking Water Availability
- Predicting Water supplies.
- Analysis of Contaminant Water .

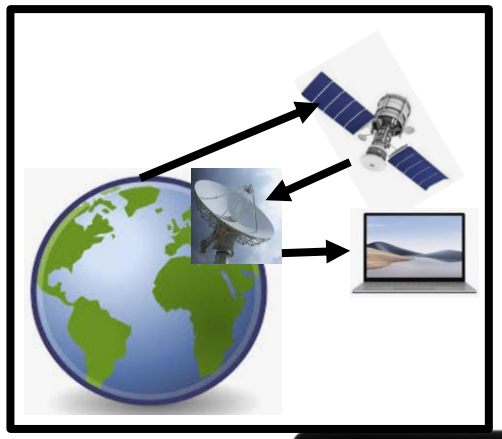
Challenges in Existing Ground Water Data Management System



- Transferring Data
- Data storage
- Data Integration
- Availability of Data
- Access Control
- Metadata

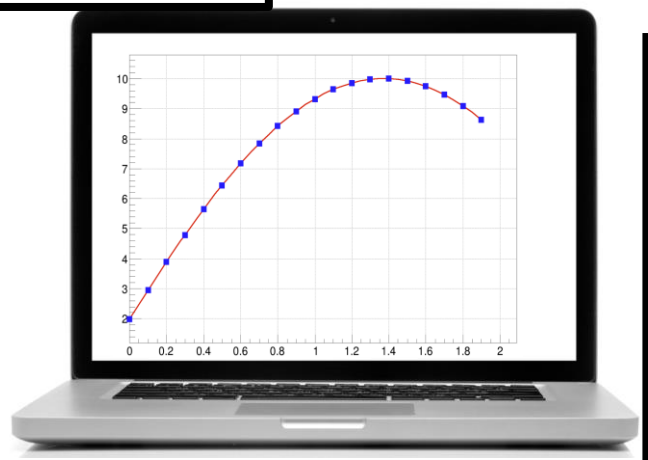
Sources of Groundwater Data

Remote Sensing



IoAT-Smart Farming

On-field Data Collection

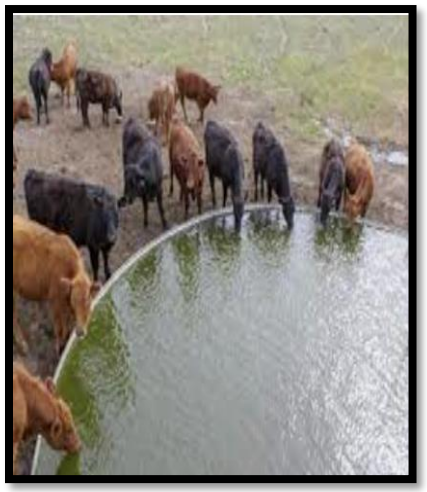


Computer Simulation

- On field Data
- Historical
- Remote Sensing
- Computer Simulation
- Web and Social Media
- Internet of Things(IoT)

Recipients of Groundwater Data

Irrigation

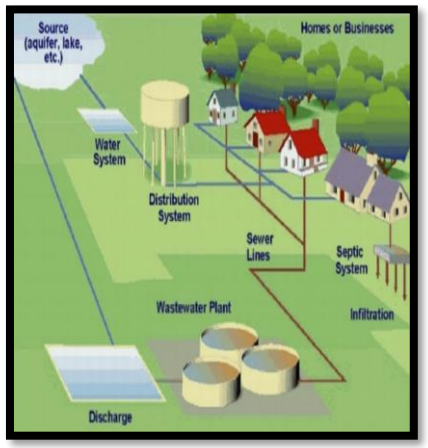


Livestock

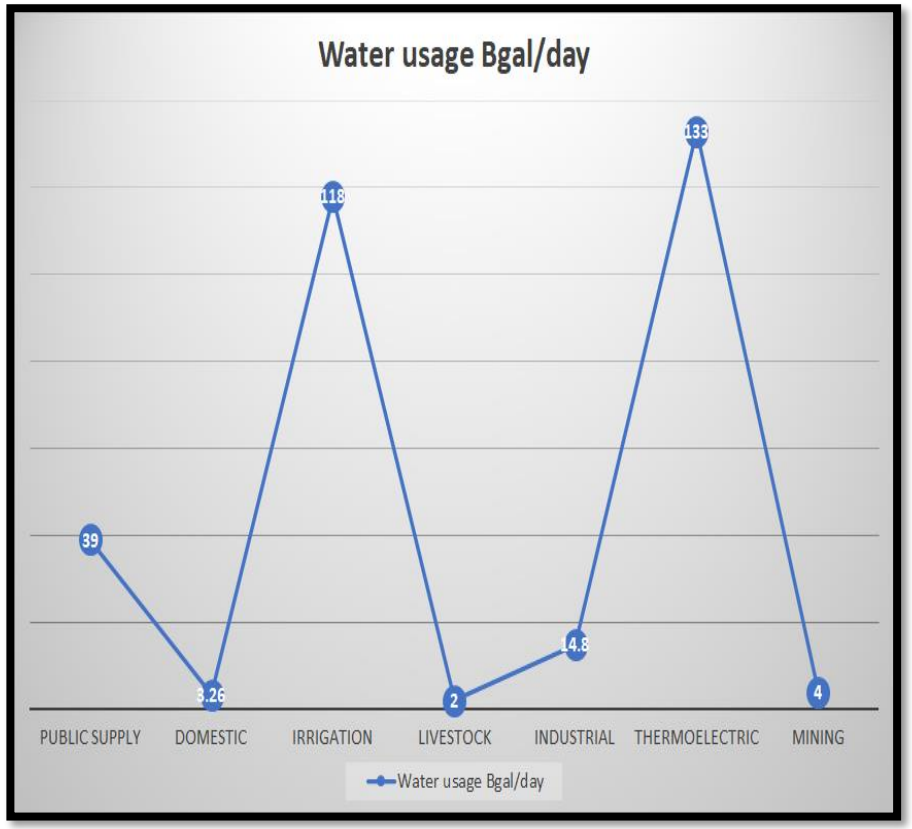
Thermoelectric

Mining

Industrial



Public Supply

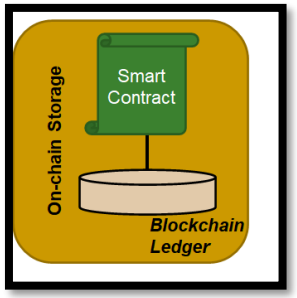


Related Research

Application	Domain	Data Storage	Security Level	Cost	Computation
Nguyen et al.[4]	Supply-chain Data	Decentralized-On-Chain	High-SH	High	High
Umamaheshwari et al.[5]	Crop Farming Data	Decentralized-On-Chain	High-SH	High	High
Pincheira et al. [6]	Water Usage Data	Decentralized-On-Chain	High-SH	High	High
Turganbaev et al. [7]	Groundwater Data	Centralized	Low	High	High
Yi et al. [8]	Groundwater Data	Centralized	Low	High	High
Zhu et al. [9]	Groundwater Data	Centralized	Low	High	High
Iwanaga et al. [10]	Groundwater Data	Centralized	Low	High	High
G-DaM [Current-Paper]	Groundwater Data	Decentralized-On-Chain	High-DH	Low	Low

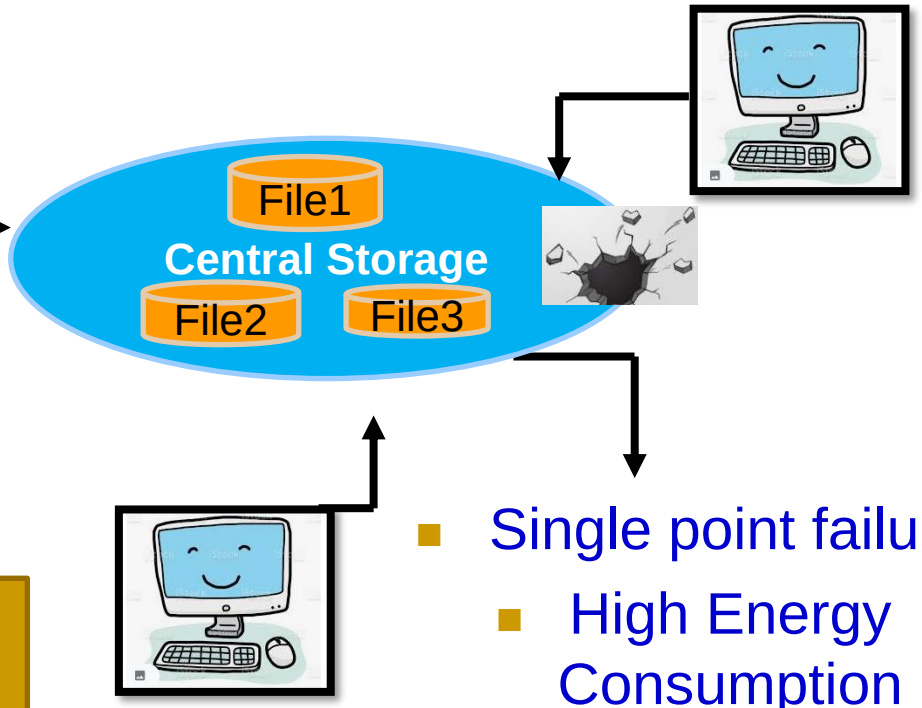
Issues in Existing works

- Centralized Data storage.
- Decentralized –On-Chain Storage
  - High Transaction Fees
  - High Block validating Time(Mining Time)



1 Eth=1811.41 $
1MB= 3.768 Eth

1 KB=13 Seconds
1MB= 3.7 Hours

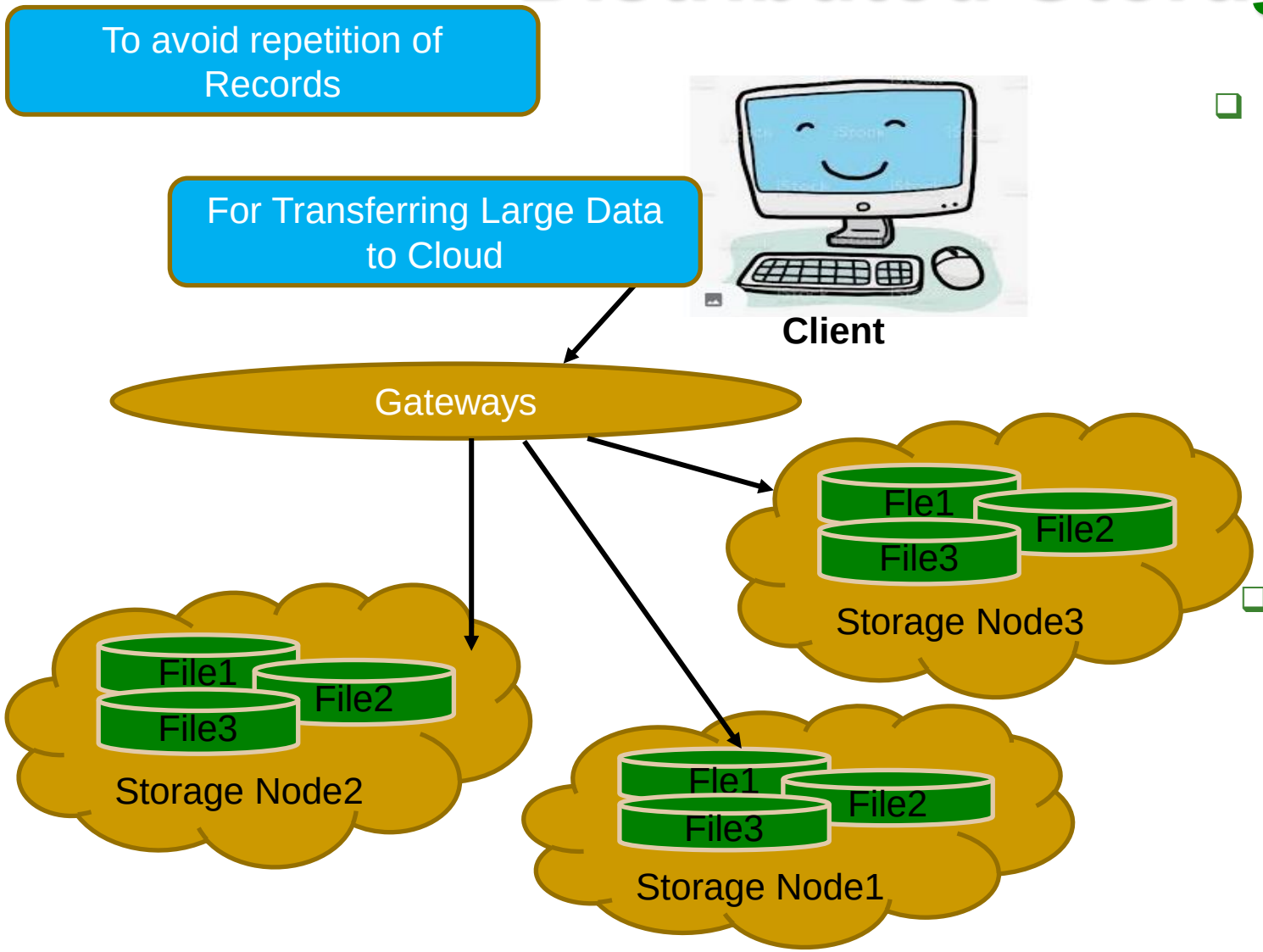


- Single point failure
- High Energy Consumption
- Bandwidth Bottlenecks

Novel Solutions in G-DaM

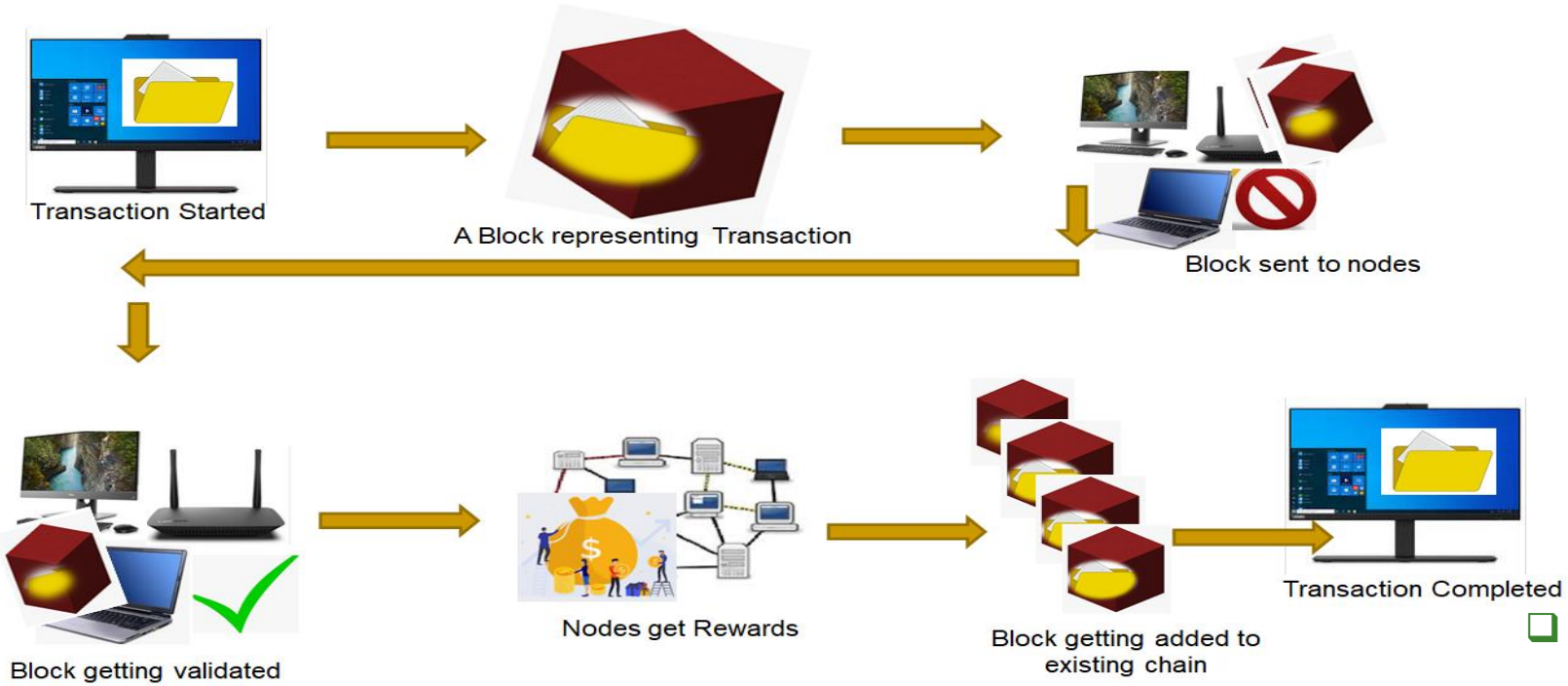
- Blockchain used to mitigate uncertain facts and Increase Ground Water Data Quality.
- Use Distributed Data Storage for storing Bulk Data
- Perform Double Hashing Refuge
- Results with Reduced Transaction Fee and Time with increase data quality and Integrity.

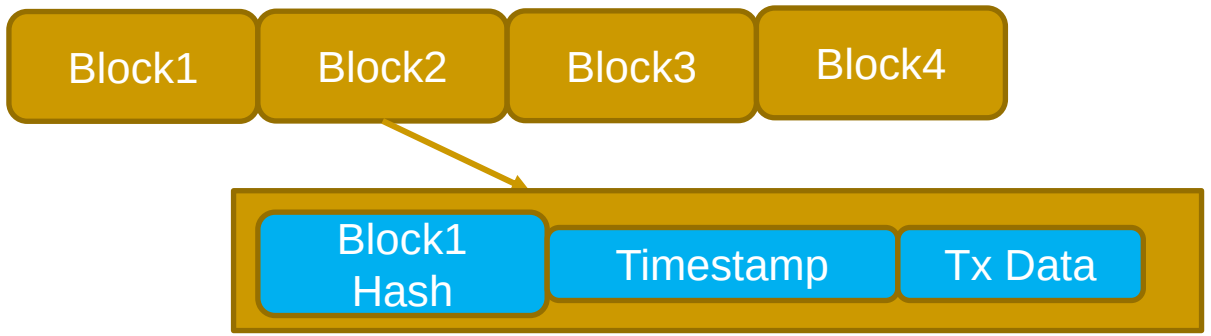
Distributed Storage



- Why?
  - High availability of Data
  - Disaster Recovery Process
  - Reduced Cost
  - Increased Performance
  - Bulk storage
- Drawbacks
  - No Time Stamp
  - Duplication of Data

Blockchain





- What?
  - Data stored as ledger records
- Types
  - Public
  - Private
  - Consortium
  - Hybrid
- Why?
  - Decentralized
  - No Administrator
  - Data cannot be modified
  - Embedded Timestamp

Distributed Storage in G-DaM

Various Data Collected

Nodes/Users Participating

IPFS Network

Distributed Storage

Generate Hash

Hash Values

Ethereum Network

On-chain Storage

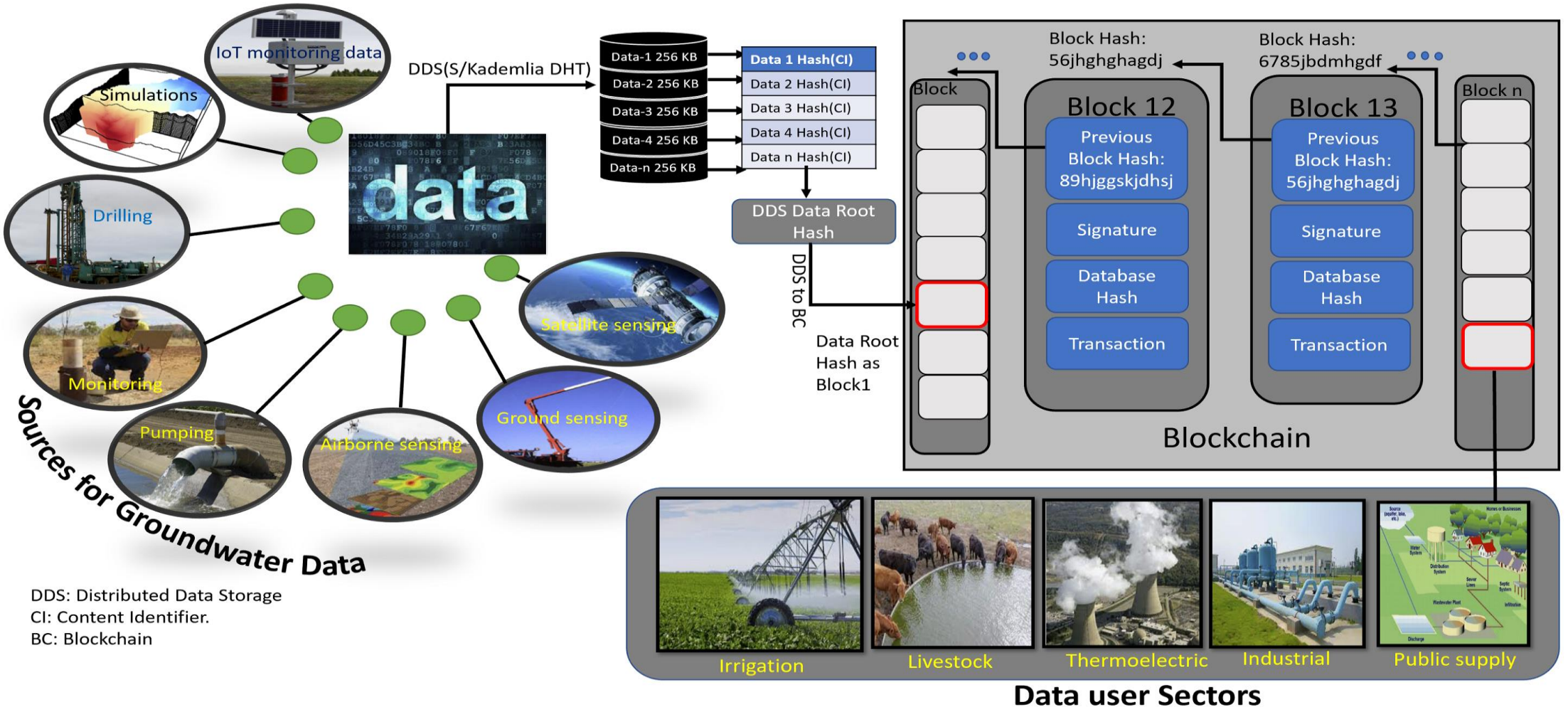
Smart Contract

Blockchain Ledger

Off-chain Groundwater Data Storage with synched ledger

:Flow of Data
:Data Access
:Network
:Update TX's

Proposed Architecture of G-DaM



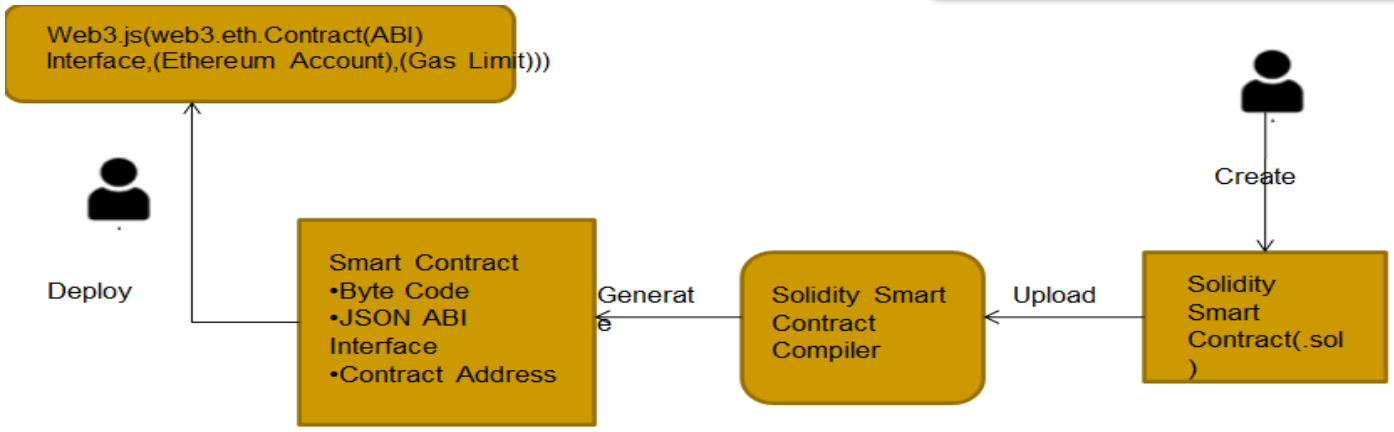
DDS: Distributed Data Storage
CI: Content Identifier.
BC: Blockchain

Data Flow in Proposed System

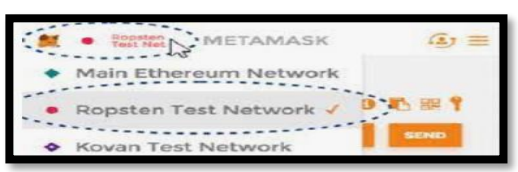
- Adding Groundwater Data File.
  - IPFS creates Segments of the File.
  - Creates Content Identifiers(CI) and DDS Hash.
- Linking IPFS Data to Ethereum Smart Contracts(BC).
  - Verified Data based on Content Identifiers.
  - Added to Blocks as Transactions.
  - ECC applied to Transactions Data to give Transaction root hash.
- Retrieving Groundwater Data File.
  - Compares received checksum CI with Source CI to retrieve the file.

Technologies used for Implementation

- React JS for Front end
- IPFS
- BC: Smart Contract
- Ropsten Test Network



Create and Deploy Smart Contract

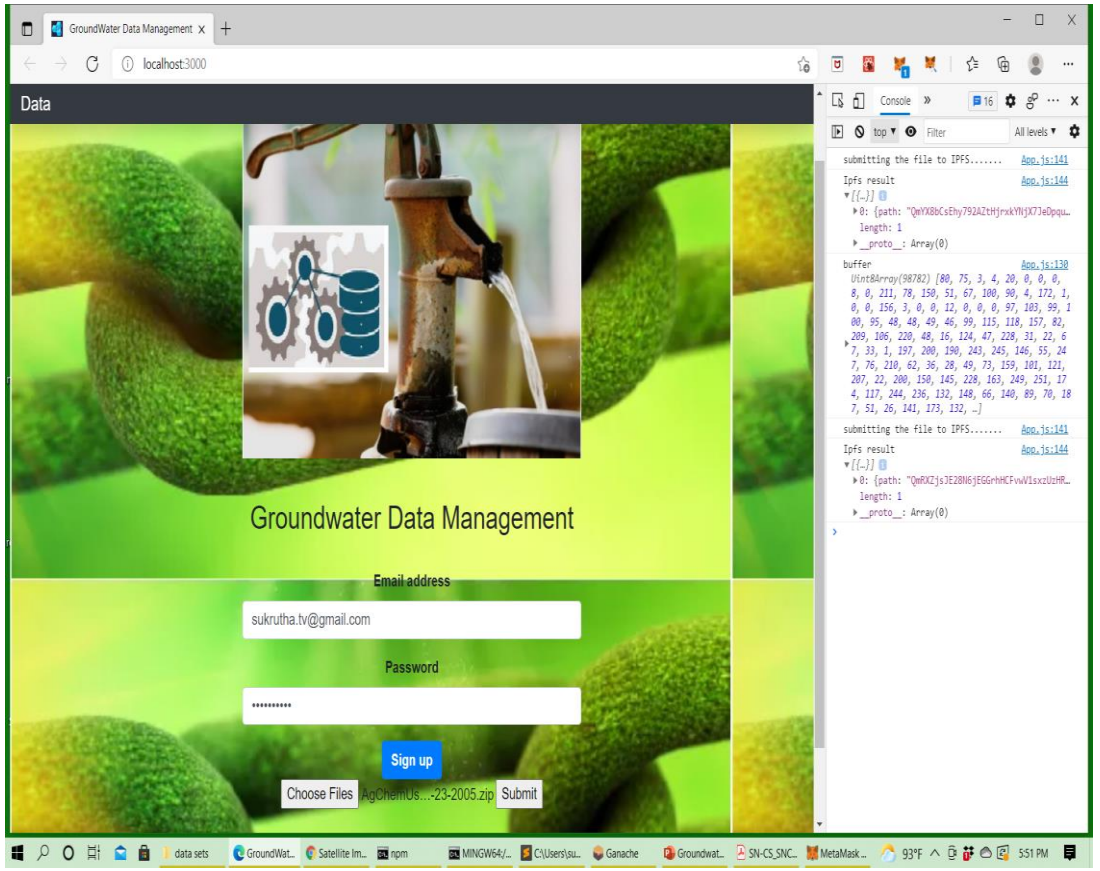


Developing Ethereum Smart Contracts

- Node.js
- Truffle Framework
  - Smart Contract Management
  - Automated Testing
- Meta mask Ethereum Wallet
- Ganache
- Web 3 Provider

G-DaM Functional Verification

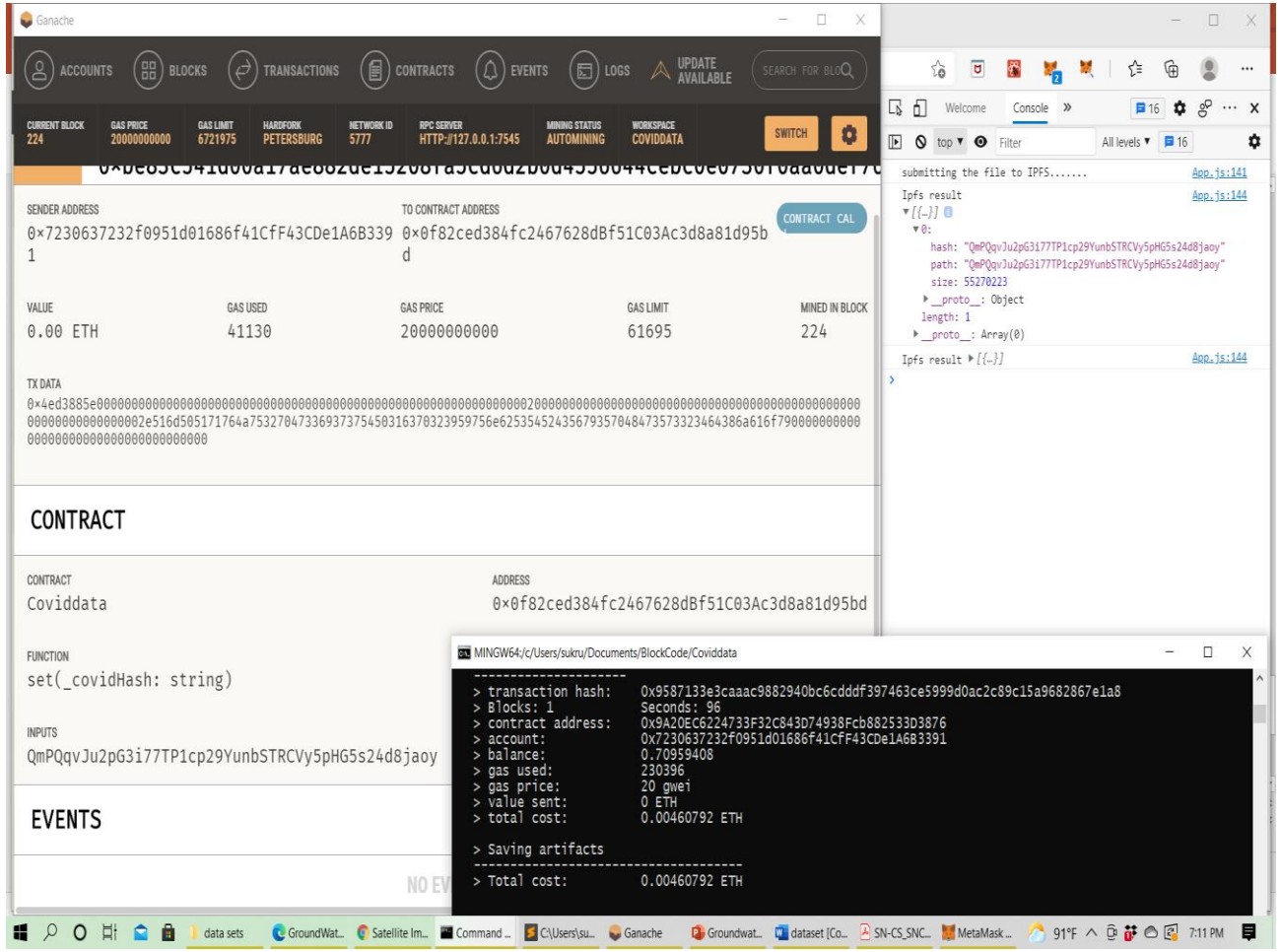
- Groundwater Data is redirected towards IPFS residing in End Systems.
- IPFS Generates Hash of the Groundwater Data.
- The IPFS Hash is stored on Blockchain as a Transaction.
- Blockchain generates Transaction Hash.



G-DaM User Interface

Validation

- Ropsten Testnet is used to see the actual working of the transaction.
- Inserting API Infura Key in configuration file for deploying Data file to Testnet network.
- Cost to upload Groundwater Data is measured and paralleled to Traditional BC Cost.



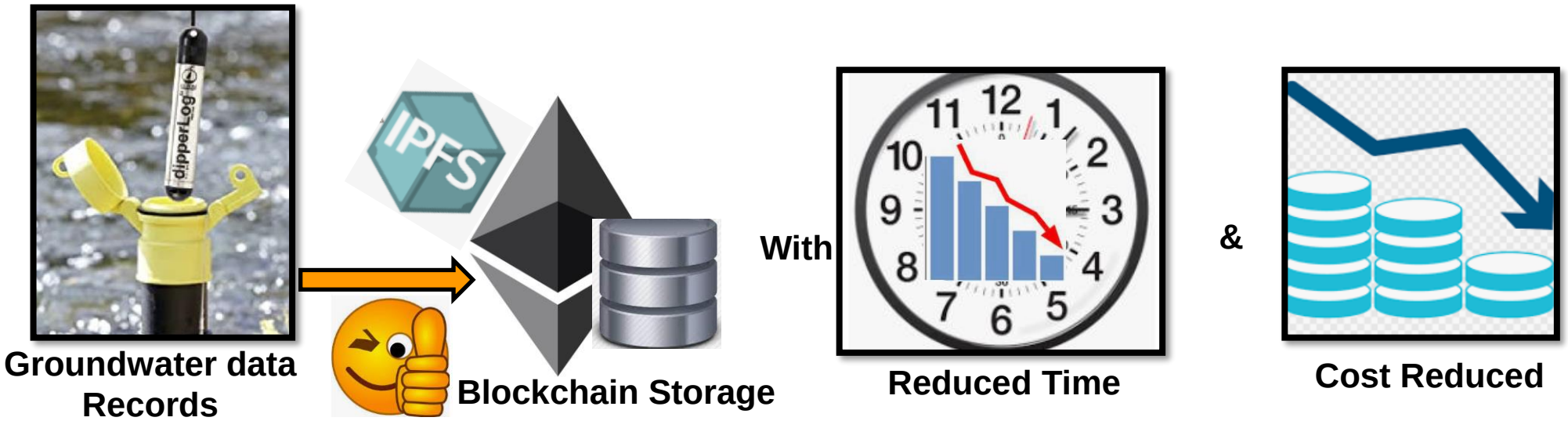
Validating through Ropsten Testnet

Experiment Results of G-DaM

File	File size	Deploy Time(Sec)	Mining Time(Sec) [BC]	Mining Time(Sec) [BC+DDS]	Gas Fee [BC]	Gas Fee [BC+DDS]	Tx Cost [BC]	Tx Cost [BC+DDS]
.txt-Chemical use in agriculture	97 KB	32	13	39	3.104 eth	0.00460792eth	$5,622	$8.34
.csv-Water use in agriculture	4.41 MB	24	57	77	141.12eth	0.00489103eth	$255,626	$8.85
.csv-Affected water bodies	4.97 MB	4	64	7	159.04 eth	0.00491564eth	$288,086	$ 8.9
.zip-Nebraskagroundwaterdata	11.6 MB	72	150	46	371.2 eth	0.00367895eth	$672,395	$6.66
.gis-Waterdataset	52.7 MB	96	685	57	1686.4 eth	0.00543623eth	$3054,761	$ 9.8

Conclusion

- Issues like data integrity, privacy, data quality and latency are reduced in this novel DDS and BC approach.
- The data upload and mining time of blockchain is significantly decreased.
- The proposed application is a precise and cost-effective solution and useful for Groundwater data storing.



Future Work

- The stakeholders and the sectors of the groundwater data can be made more confidential through Private Blockchain.
- Thus, having extensive control of the groundwater data flow.


Thank You!