# Applying Blockchain To Energy Delivery Systems

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## Problem Statement

Energy Delivery Systems are deployed in an environment that is geographically distributed utilizing public internet infrastructure for communications. The integrity of measurements, commands, and authenticity of control devices performing communication are critical for trusted operations.

## Solution

Develop a secure network for a geographically diverse Energy Delivery System by using blockchain to develop this network to make it more reliable and secure.

The blockchain will be used by humans/devices to query metrics and data from the blockchain.

## Functional Requirements

**Blockchain:**

- Consist of at least five nodes for transaction consensus
- consist of multiple nodes to act as orderers

**Smart Contract Layer & API:**

- API: expose the Smart Contract functions upon authentication
- Smart Contracts: read, update, delete, and query data

**User Interface:**

- Ability to request/view measurements and/or metrics if the user has the authority to do so

**Operation Environment:**

- Blockchain network, UI and API: run on linux-based virtual machines provided by PowerCyber

## Non-functional Requirements

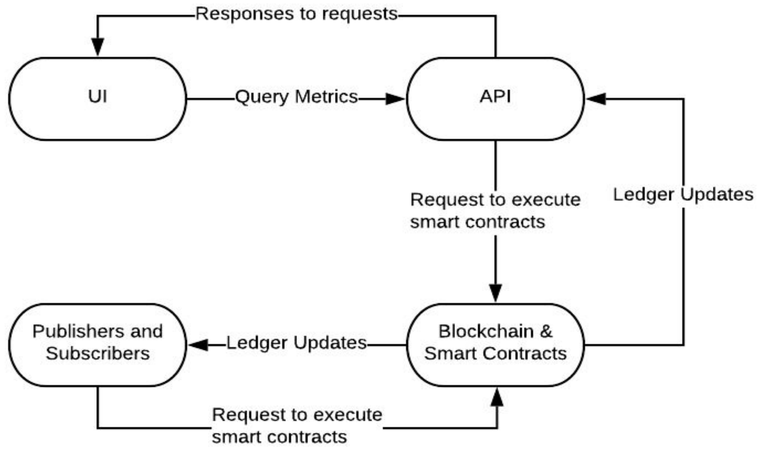
- Blockchain network nodes: be ran using Docker Containers
- Smart Contracts: update blockchain network
- Include a descriptive project wiki
- CI/CD: can run all tests and deploy to the necessary environments

## Engineering Standards and Design Practices

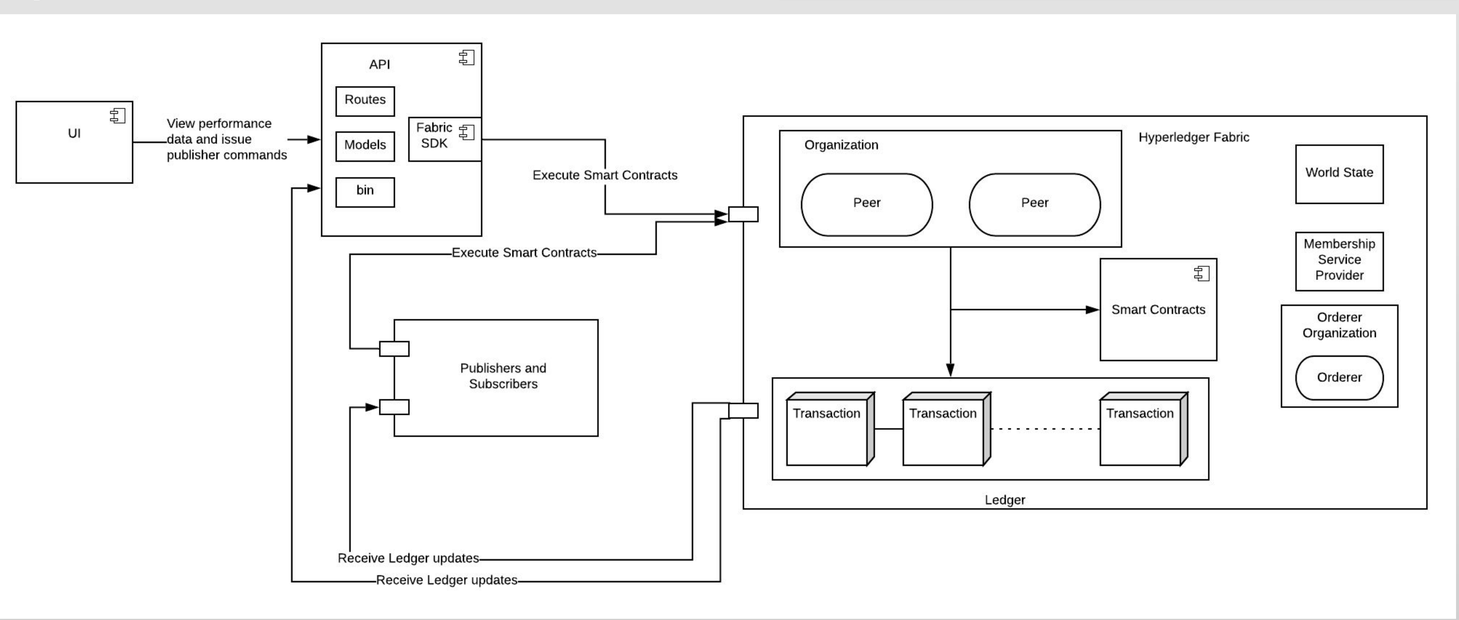
- 1028-2008 - IEEE Standard for Software Reviews and Audits
- 26515-2018 - IEEE International Standard - Systems and software engineering -- Developing Information for Users in an Agile Environment
- NERC CIP-011-2 - Cyber Security - Information Protection

## Design Approach

### Conceptual Design




### System Architecture

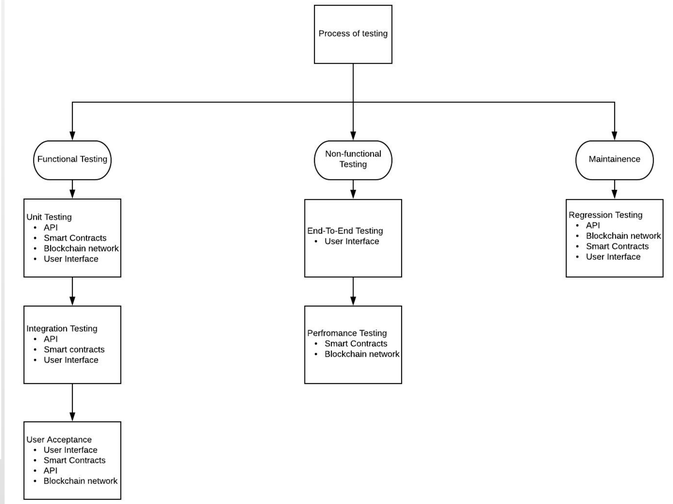



## Energy Application

Our network resembles the NASPInet architecture consisting of five organizations, three of those publishing immutable PMU data and the remaining two reading the PMU data.

## Testing

### Testing Process




## Results

**PMU data:**

- Publishing rate of 60 results per second over three organizations

**Future work:**

- Scalability of the Network
- Does adding more readers impact performance?