Blockchain for Optimized Security and Energy Management (BLOSEM)

Spring FE Project Review Meeting – May 19, 2021

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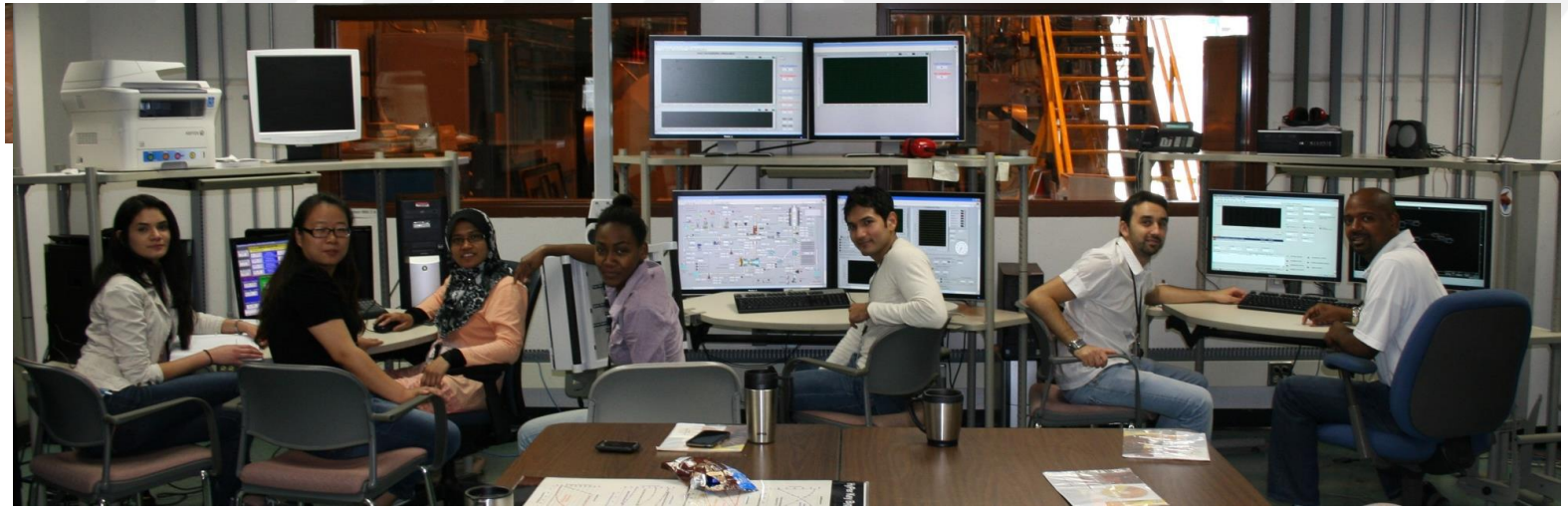
Agenda

- Project Objectives
- Energy Use Cases
- Unified Testing Platform
- BLOSEM Use Case Demonstrations
- Current State of Blockchain Research



BLOSEM Goals & Objectives

Blockchain for Optimized Security and Energy Management (BLOSEM)

- Create a **multi-lab, unified testing platform (BLOSEM UTP)** that has interoperability to support a wide variety of blockchains. This testing environment will be representative of the modern grid of the future by encompassing generation, transmission, distribution, and end user (edge) for the electric grid.
- **Identify and implement specific use cases** that leverage inherent features of blockchain & ledger-based technologies to prevent, detect, and mitigate cyber-attacks.
- **Accelerate the pipeline of validated cyber-physical security concepts** from laboratory to utility sector, de-risking through standardized metrics and testing.

GMLC Project 5.2.3 : Secure Communications of Information used for Grid Operations, for Normal Operations, and/or during Emergency Response

Sponsors:

U.S. DEPARTMENT OF ENERGY | Office of Fossil Energy

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BLOSEM Project Partners

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Labs

National Energy Technology Laboratory
NREL Transforming ENERGY
The Ames Laboratory
SLAC
Pacific Northwest National Laboratory

Contributors

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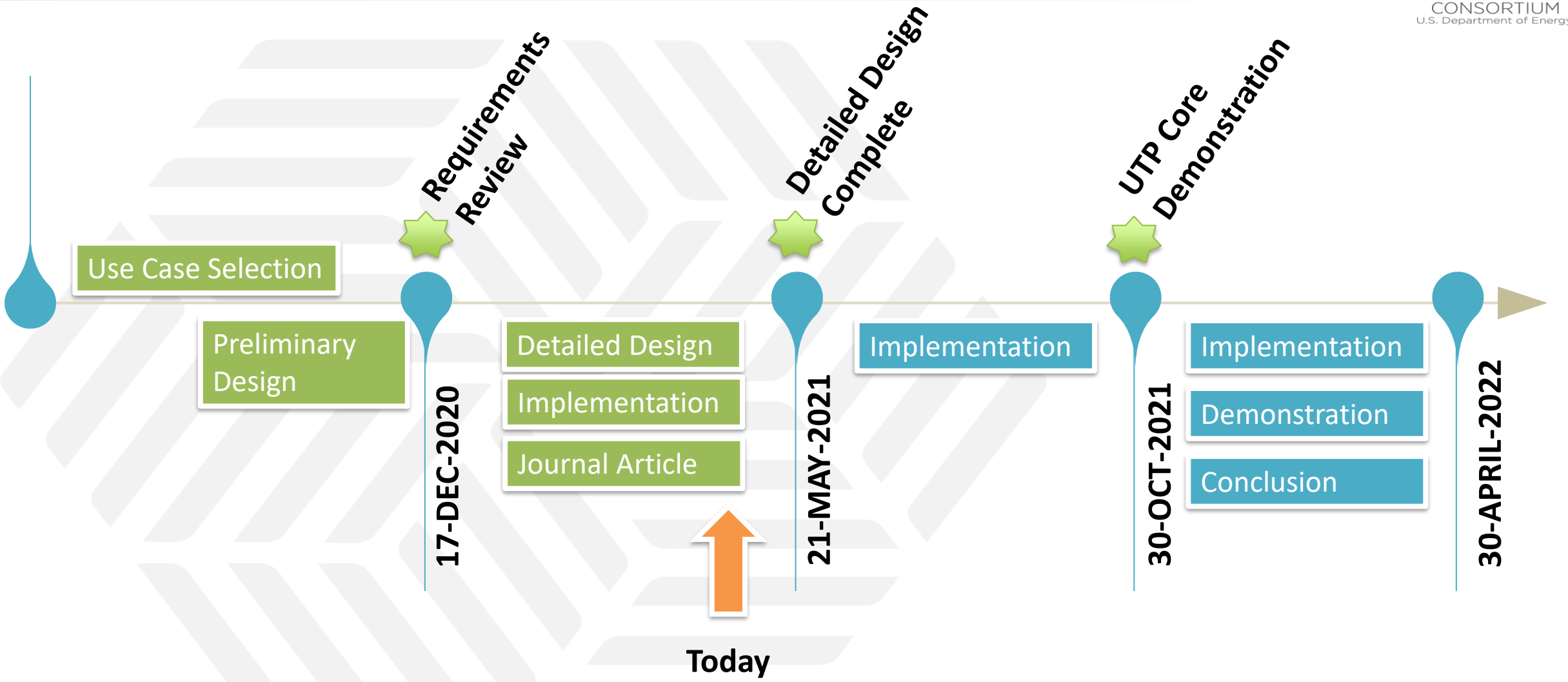
IEEE Blockchain
Energy Web Foundation
NIST National Institute of Standards and Technology
GE

BLOSEM Project Status



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USE CASE DOWN SELECTION

Energy Blockchain Use Cases

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Utility Communications and Configuration Management

1. SDN for control center and substation coordination (Sub-case # 1)
2. SDN for control center and substation coordination (Sub-case #2)
3. Remote DER Control and Coordination
4. Replacing Cross-Utility Exchanges

Market

14. Grid Services Marketplace (Energy Focus)

Device/Sensor Coordination and Data Integrity

5. Grid automation, sensor integration, autonomous data acquisition from grid assets
6. Dynamic Controls of Demand Response from Generation
7. Create an access protected and immutable library of Process Knowledge
8. Securing the data and algorithms used for parallel performance monitoring and digital twins
9. Establish Immutable and Access Controlled Historian

Supply Chain

10. Secure ID (Identity Management)
11. Supply Chain Security, Life Cycle Monitoring, and Real-time Auditing

Blackstart

12. Grid Automation, System Segmentation, and Blackstart
13. Optimizing Restart from System Interruptions (blackstart, black sky, etc.)

Use Case Down Selection

ID	Category	Title
1	Utility Communications and Configuration Management	SDN for control center and substation coordination: Integrity check for patch management
2		SDN for control center and substation coordination: Data coordination between SDN planes
3		Remote DER Control and Coordination
4		Replacing Cross-Utility Exchanges
5	Device/ Sensor Coordination and Data Integrity	Grid automation, sensor integration, autonomous data acquisition from grid assets
6		Dynamic Controls of Demand Response from Generation
7		Create an access protected and immutable library of Process Knowledge
8		Securing the data and algorithms used for parallel performance monitoring and digital twins
9		Establish Immutable and Access Controlled Historian
10	Supply Chain	Secure ID (Identity Management)
11		Supply Chain Security, Life Cycle Monitoring, and Real-time Auditing
12	Blackstart	Grid Automation, System Segmentation, and Blackstart
13		Optimizing Restart from System Interruptions (blackstart, black sky, etc.)
14	Transactive Markets	Grid Services Marketplace (Energy Focus)

Final Selection of Use Cases

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Supply Chain Security, Life Cycle Monitoring, and Real-time Auditing

- Improve asset lifecycle tracking process by logging events that change the configuration and relevance of an asset to operations
- Valid for manufacturer to delivery to install to maintenance to decommissioning
- Timescale: Event-driven

DER Coordination and Control: Supporting Secure Wholesale Market Participation and Information Exchange with Generation

- Facilitate DER aggregators (DERA) bidding into both the day-ahead (DA) and real-time (RT) energy markets
- Validate that expected performance of the DERA does not cause challenges for secure distribution system operation
- Timescale: minutes; hours/day

Dynamic Controls of Demand Response from Generation

- Facilitate dynamic controls for generation application by improving authenticity & integrity of change requests to operations
- Valid for responding to load demand changes and frequency regulation
- Timescale: Seconds; Continuous

BLOSEM UNIFIED TESTING PLATFORM

UTP Core – Scope and Objectives

Objectives:

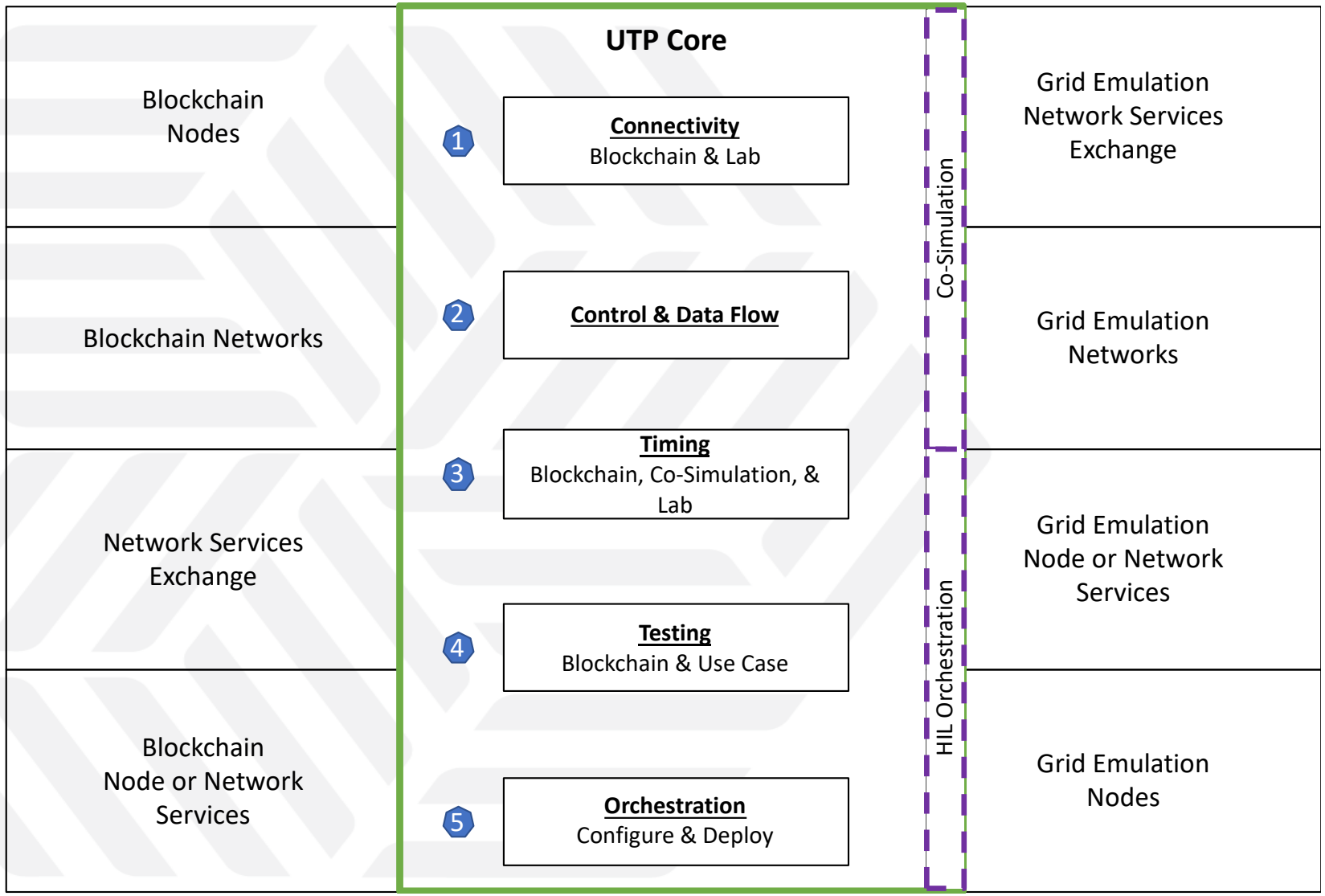
Enable the project goal of de-risking and accelerating Blockchain applications for energy systems:

- Enable the ability to rapidly connect blockchain solutions with grid emulation environments, including hardware-in-the-loop and co-simulation configurations
- Decouple the dependencies of the specific blockchain under test to enable modularity, interoperability, and reusability to more rapidly connect and evaluate diverse blockchain solutions
- Develop core functionality to enable the flow of data and commands in a use case agnostic manner, easily extendible to new grid emulation system configurations

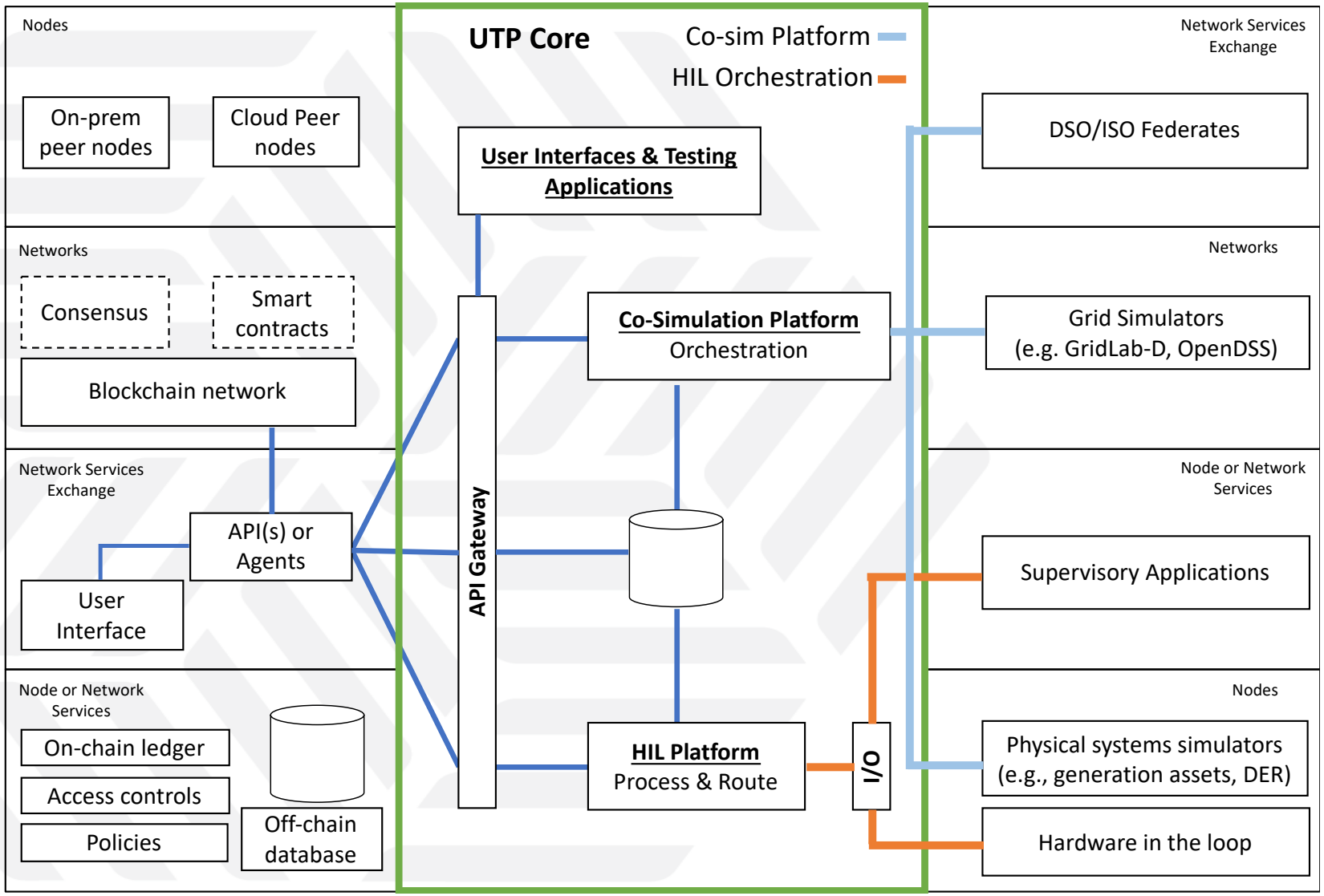
Core Functional Responsibilities:

- *Connectivity*
  - Communication interfaces for providing the incoming/outgoing requests and events
- *Control and Data Flow*
  - Platform for enabling the flow of information. Extends interfaces to process and route from source to destination.
- *Time Synchronization and Management*
  - Enable the coordination of time within asynchronous, concurrent environments that may need to synchronize for shared data and operations.
- *Testing Infrastructure*
  - Platform for hosting, recording, and analyzing the testing metrics for the Blockchain and the Use Case
- *System Automation and Data Orchestration*
  - Enabling configurability and automation of defining resources and connections within the BLOSEM environment.

UTP Core Component Responsibilities



UTP Core – Framework Components



UTP Core – Testing and Evaluation

Providing logging and application infrastructure for measuring the performance of a blockchain solution to meet the needs of use case tasks

Preliminary categories of testing metrics:

- Latency
- Throughput
- Repeatability
- Failure Rate
- Scalability
- Transaction Scheduling
- Privacy
- Security

USE CASE – SUPPLY CHAIN

Supply Chain – Scope and Objectives

Use Case Research Goals:

- Is the device or software that **shipped the same asset that was received**?
- Is the device or software deployed in operations the same asset that **continues to be installed and operating**?
- What is the **risk introduced and the urgency of remediation** when a **vulnerability** has been discovered or a cyber incident has occurred?
  - Can this traceability and risk assessment be *applied to hardware and software sub-components*?
- What vulnerability and cyber incident information is required to be **shared broadly across organizations**, and what must be kept to sharing within sub-groups of the network stakeholders?

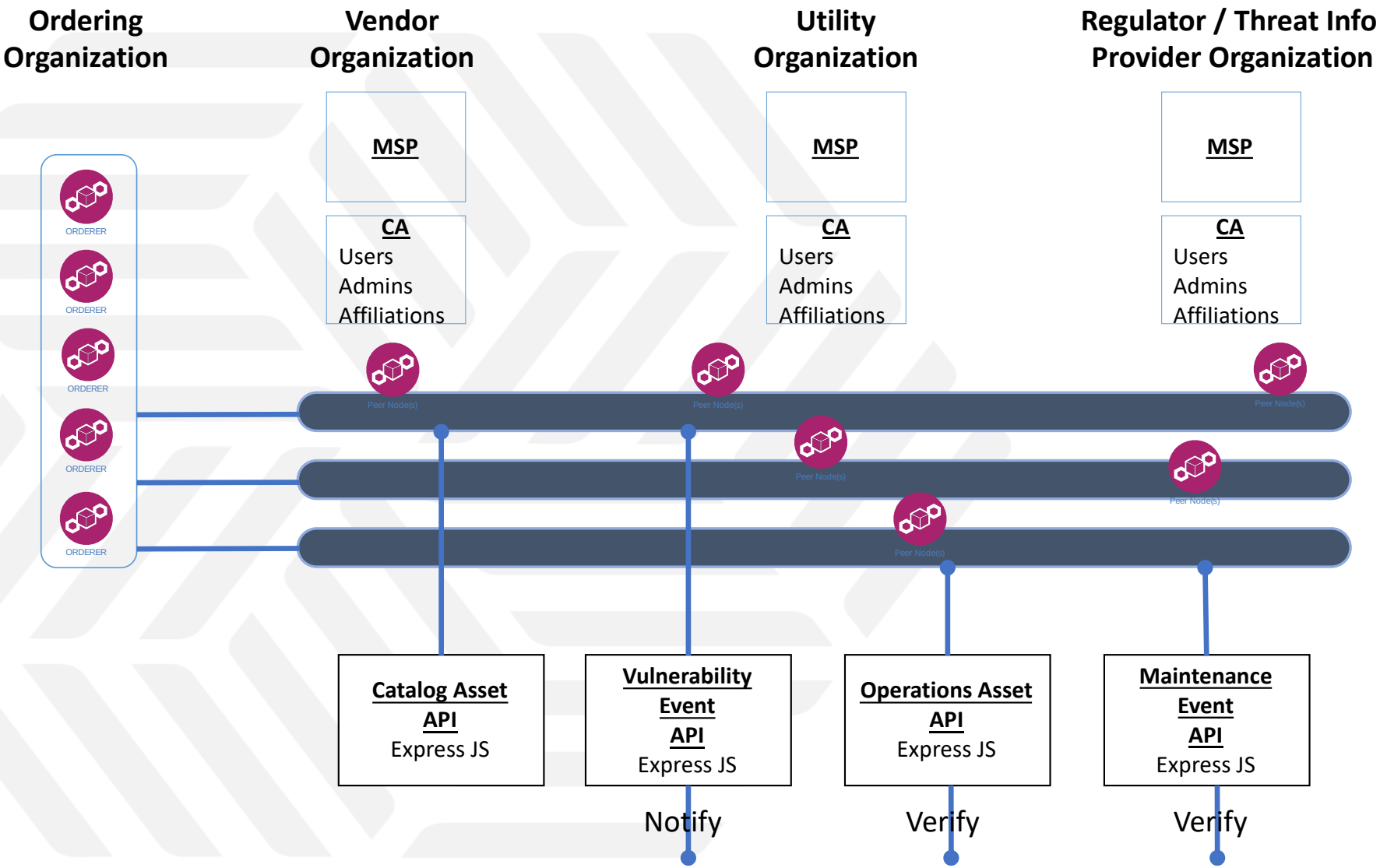
Use Case Pain Point Objectives:

- Asset information isn't trusted or traceable.
- Asset tampering, cloning, and imposter device
- Missing or limited asset information
- Asset vulnerability and/or cyber threat issues aren't widely shared.
- Not all information is digitized.
- Opportunity to automate the impact assessment of a cyber incident or vulnerability

Supply Chain – Implementation Plans

- Digital Objects for Lifecycle Information
  - Catalog Assets
    - Vendor published device definition – HW/SW subcomponents and linked to vulnerabilities
  - Operations Assets
    - Operationally deployed asset with installation details and custom configurations
  - Vulnerability Events
    - Participant disclosed metadata linked to a Catalog item
  - Maintenance Events
    - Logging changes to the configuration of an operationally deployed asset (e.g. repairs, updates, location, etc.)
- Applying to three categories of assets:
  - Software Applications
    - Executables and dependencies installed in operations
  - Embedded Systems
    - Electrical, mechanical, and embedded software sub-components
  - Hardware Only Sensors
    - Supplementing with compute to participate
- Embedding functions for challenge/response re-verification of device hosted configuration

Supply Chain – Blockchain Architecture



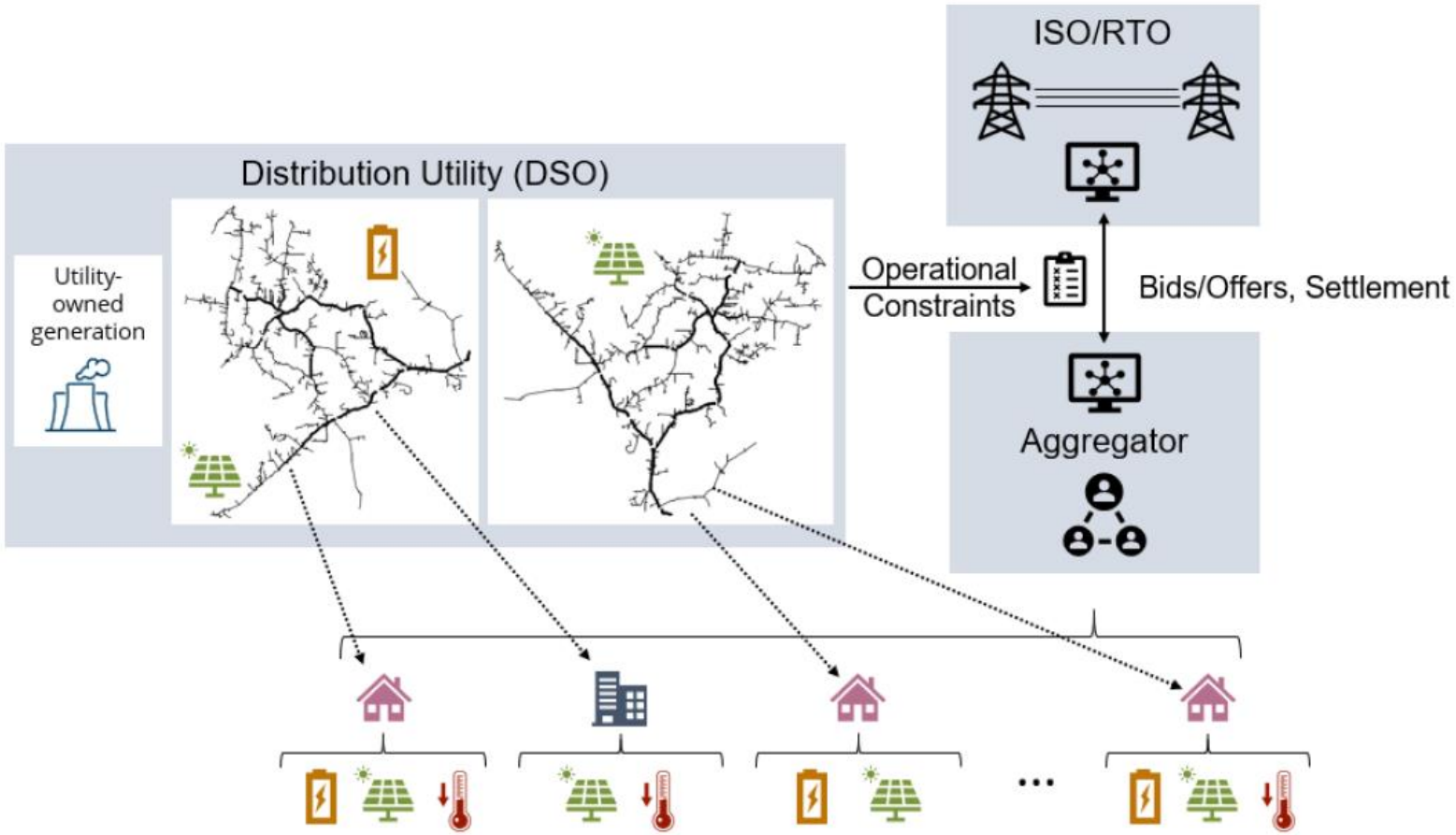
Supply Chain – Metadata Discussion

Primary key		Attributes						
Partition key: PK1	Sort key: SK1							
HDA-IO	Communications	comm_type	comm_protocol	comm_src	comm_src_port	comm_dest	comm_dest_port	
		ModBus	TCP	128.123.156	90	123.456.789	50	
	Decomission	decomm_instructions	decomm_sector_approval	decomm_status				
		Decomission after 20 years	Approved	Approved				
	General	ledger_id	vendor	title	part_number	version	creation_date	ledger_creation_date
		8989989	Woodward	HDA-IO	897-987	First	02/14/2020	02/20/202
	HW-1681-140	hw_parent	hw_vendor	hw_quantity	hw_component_name			
		5458-089	Texas Instruments	2	IC - 7032			
	HW-1681-247	hw_parent	hw_vendor	hw_quantity	hw_component_name			
		5458-089	Microchip Technology	1	IC-AT27C1024 OTP SMT			
	HW-1687-379	hw_parent	hw_vendor	hw_quantity	hw_component_name			
		5458-089	Renases	1	IC - 1KX8 CMOS Dual Port RAM (Master)			
	HW-1687-380	hw_parent	hw_vendor	hw_quantity	hw_component_name			
		5458-089	Renases	1	IC - 1KX8 CMOS Dual Port RAM (Slave)			
	HW-5458-089	hw_parent	hw_vendor	hw_quantity	hw_component_name			
		5466-315	Woodward	1	Module-High Density Analog I/O SMT			
	HW-5466-315	hw_vendor	hw_quantity	hw_component_name				
		Woodward	1	MicroNet Plus High Density Analog Module				
	SW-5413-606	sw_parent	sw_supplier	sw_author	sw_relationship	sw_relationship_assertion	sw_component_name	
		5466-315	Woodward	Woodward	self	known	Address DCode Pal SMT	
	SW-5413-607	sw_parent	sw_supplier	sw_author	sw_relationship	sw_relationship_assertion	sw_component_name	
		5466-315	Woodward	Woodward	self	known	5009 VME Control	
	SW-5418-6789	sw_parent	sw_supplier	sw_author	sw_relationship	sw_relationship_assertion	sw_component_name	
		5466-315	Woodward	Woodward	self	known	AT27C1024 BOOT PROM HDA Modules	

- Hardware Bill of Materials for logic bearing components
- Software Bill of Materials for NTIA minimum fields and dependency relationships
  - NTIA minimum fields
- Communication – Port / Protocol for automating network control
- Installation Metadata for automating Risk assessment decisions
  - Owner
  - Location – Site ID, Business Unit
  - Impact – PERA Zone, Category, Classification

USE CASE – DER COORDINATION & CONTROLS

DER Coordination Use Case



DER Coordination Scope & Objectives

Objectives:
- Examine and demonstrate BLOSEM platform components for blockchain-based grid operations use-cases.
- Facilitate distributed communications architecture across disparate DER owners and energy entities.
- Establish trust anchors with integrity and confidentiality through blockchain in a trustless environment.

In Scope:
- Flexible access controls + address grid constraints
- Address tier-bypassing (FERC Order 2222)
  - Double-counting, distribution factor
- Contract mediation (delegation of control authority)
- Communication with utility-owned generation

Out of Scope:
- Control system design (leverage from existing work)
- Non-FERC 2222 architectures
- Peer-to-peer markets (markets in general)

Entities in Scope:
- Distributed Energy Resource (DER) owners – through lab resources
- DER Aggregators (DERA)
- Distributed System Operators (DSO)
- Utility owned generation
- Independent System Operators (ISO) / Regional Transmission Operators (RTO) – No SCUC/SCED modeled

CURRENT STATE OF BLOCKCHAIN RESEARCH

BLOSEM Review Article for Publication

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Activities

- **Literature review/survey** of blockchain projects
- **Mapping use cases** to BLOSEM categorization matrix

Scopes

Blockchain projects and R&D efforts within **U.S. DOE and U.S. Power utility industries**

A Survey of Blockchain Research & Development Activities

Outcomes

- **BLOSEM Categorization Matrix;** Energy System Domains and Blockchain Properties
- **R&D Opportunities and Recommendations**
- Early September – submission for **journal publication**

CONCLUSION

Conclusion

- BLOSEM team seeks to create a multi-lab, unified testing platform (BLOSEM UTP) that has interoperability to support a wide variety of blockchains and accelerate the pipeline of security solutions from laboratory to industry

- Surveyed and down selected Energy use cases of Blockchain
  - Inputs collected from within the project team, industry advisors, and DOE program managers
  - Delivered the *Use Case Milestone Report* in September 2020

- Developing a Unified Testing Platform to rapidly connect new use cases to laboratory grid emulation environments and evaluate new blockchain solutions
  - Abstracting Blockchain connections from Laboratory components
  - Designing evaluation frameworks for Use Case fit to a Blockchain under test
  - Closed the *Preliminary Design Requirements Review* in February 2021

- Publishing a journal article for the current state of Blockchain energy research and a framework for assessing the Blockchain research portfolio

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Thank you!

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