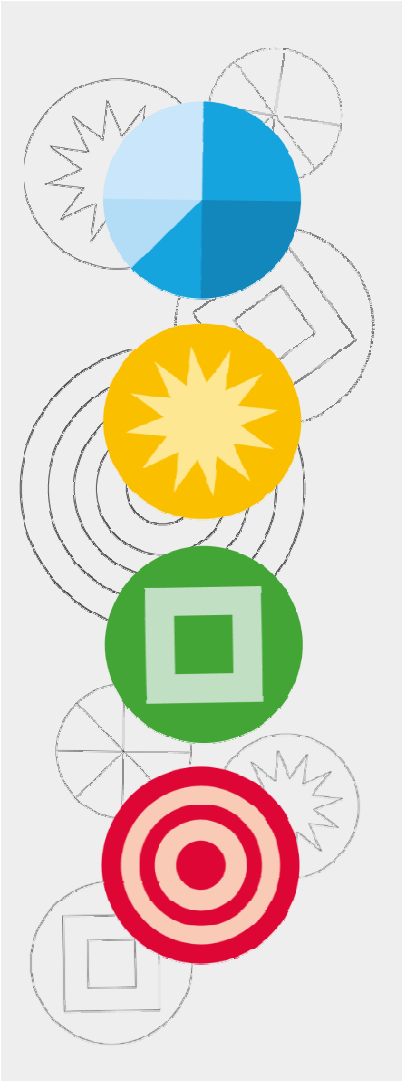


DLTs and Smart Contracts to increase smart grid flexibility

Massimo Bertoncini
Senior Innovation Manager for Smart Energy Systems
Engineering Ingegneria Informatica, R&D Department

Joint AIOTI- EC Workshop on Open marketplaces to spur innovative energy services

Brussels, 22 October 2018

www.eng.it

Blockchain for Smart Energy at Engineering R&D

- Value Proposition
  - **Blockchain enabling decentralization and trusted disintermediation of multi-stakeholder smart energy grids business and technical processes management, with increasing level of robustness (no single point of failure)**
- Where
  - ***H2020 EIT DLS OCS, H2020 eDREAM, H2020 SOFIE, H2020 COORDINET*** projects
    - DLTs **for decentralized tamper proof trusted energy/flexibility data/transactions storage and synchronized sharing, through validation and consensus**
    - DLTs and smart contracts for **decentralized P2P trusted marketplaces for flexibility/energy trading**
      - Special case: DLTs and smart contracts for **p2P market-like decentralized smart electricity network management & control**
    - DLTs and smart contracts as win-win **data marketplaces** among **data providers** (IoT devices) and **data processors** (utility-scale processing-oriented services)
    - **Blockchains interoperability**
    - **Blockchain as a service**

eDREAM: Project identity card

•Title: **eDREAM - enabling new Demand Response Advanced Market oriented and secure technologies, solutions and business models**

•H2020 Call: 2020-LCE-2017-SGS, topic LCE-01-2016-2017
•Funding Instrument: RIA (research and Innovation Acti

•Duration: 36 months (*Starting Date: 1st January 2018*)

•EU Contribution AND Total Costs: 3.822.125 Euro

• Coordinator: Engineering Ingegneria Informatica

•Country Coverage: Italy, Greece, Romania, Spain, UK

•Website: www.edream-h2020.eu

eDREAM: A novel Blockchain based Demand response decentralized ecosystem

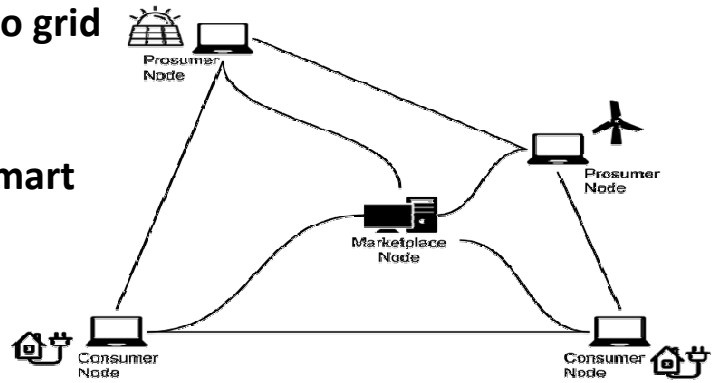
- Main Concept
  - near real time scalable **trusted blockchain-enabled technological and business ecosystem** aimed to optimally detect, exploit, and optimize prosumer-level and aggregated **flexibility provisioning** to DSOs and other energy stakeholders
- Scope
  - **Optimized Demand Response** within a progressively **decentralized energy system** through
    - Distributed Ledger Technologies (DLTs) and blockchain enabling **secure data handling**
    - Distributed Ledger Technologies (DLTs), blockchain and smart contracts for **P2P local energy and flexibility marketplaces**, enabling **dynamic P2P coalitions of prosumers** for increased prosumer autonomy and energy system democratization

eDREAM: DLTs and smart contracts as enabler of increased smart grid flexibility

- To increase **energy value chain democratization** via larger **smaller-scale energy consumers active participation to Demand Response** and local flexibility marketplaces
- To **achieve fairer energy prices** for energy consumers, while increasing at the same time energy & flexibility marketplaces "liquidity" and transparency, due to **BC data broadcasting and synchronization, which** enable P2P prosumers coalitions
- Increased **prosumers participation** to DR
- **Reduced cost of Demand Response transactions burden** through DLTs/blockchains automated built-in "trust" (e.g. on-the-fly microcontracts enabling reduction of DR prosumers contract setup and management, reduction of DR verification time)
- Promote the deployment of novel **more cooperative and decentralized strategies to manage energy networks**, performing flexibility optimization

eDREAM: trusted P2P decentralized energy and flexibility trading

• Provides a **P2P trusted marketplace-based solution for optimal management of decentralized energy and flexibility trading (balancing services to grid operators)**



• Leverages on the combination of **IoT** with **Blockchain DLTs** and **Smart Contracts**

• **Private/Permissioned blockchain** on the top of **Ethereum**

• **Multi-level blockchain** usage

• **DLTs** enabling

• **distributed tamper-proof** metered energy consumption data, cleared energy/flexibility transaction (who sell energy at what price), data storage

• real **energy and financial (token) P2P transaction** data storage, validation and consensus

• **DLTs and Smart Contracts** enabling **centralized** or **decentralized P2P coordination** among market participants

• **one-to-one hierarchical or multilateral synchronized P2P interactions** among individual prosumers and market operator

eDREAM: trusted P2P decentralized energy and flexibility trading

- **Local decentralized market operator**
- hosting one blockchain node
- in charge of distributing and managing "tokens" for trusted energy/flexibility transactions executions
- No cryptocurrencies used for financial transactions

•Implementation of **automated market clearing mechanisms**, where different stakeholders, including RES generators, prosumers as flexible stationary and/or movable loads (EVs), storage resources and market operator will be operating through their own trading agents/nodes

• Exploiting **smart contracts** for expressing **individual prosumer preferences** (es selling/buying what energy within what price) and managing market bilateral interactions among prosumers and market node

- **Centralized vs P2P decentralized market models**
- No reciprocal information exchange on flexibility offers/bid shared among prosumers and among buyers (no P2P markts)
- prior **information sharing** is allowed among energy/flexibility sellers AND among energy/flexibility procurers (P2P markets) – **prosumers coalitions** enabled

eDREAM: supported use cases/applications and validation

•**Use cases supporting** a variety of **m-n or 1-n market models**, with ***multiple commodity (energy or flexibility) sellers and multiple buyers***

• N-M **energy trading**

• N-M **flexibility trading**

• N prosumers - M aggregators ->eDREAM

• N aggregators-M flexibility procurers (TSO, DSO, BRP)

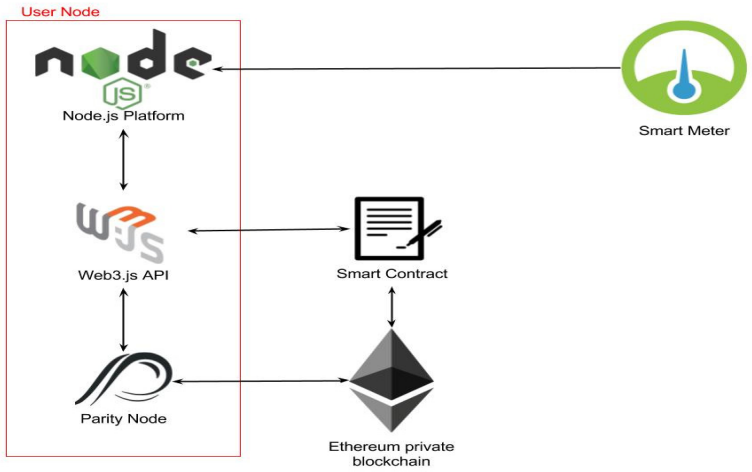
• 1-N **flexibility trading**

• special case where the market operator role may be taken over by the aggregator or by a DSO as "technical aggregator" or for the network control ->eDREAM

• **Real validation** actually in place along real life **microgrids** and **aggregators** (e.g. aggregated flexibility management) providing flexibility services (balancing services)to the grid operator in Italy and UK

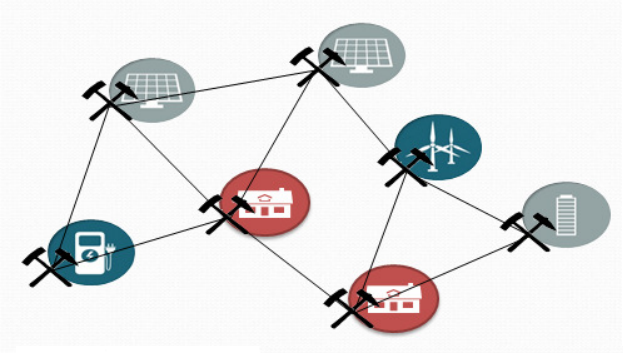
Technical Implementation for Prosumer Node Architecture

- Based on **Parity** advanced Ethereum client (currently V1.11)
- Explores Proof-of-Authority capabilities (using **Aura** validation engine)
- ready to switch to **Proof-of-Stake** as available
- Support for **Solidity V0.4**

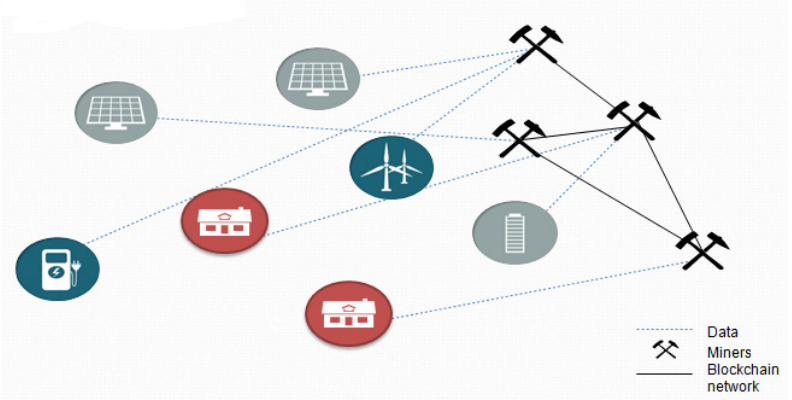


Configurations supported

- ***Prosumers as Miners Nodes***
- Suitable for large prosumers
- Maximum decentralization
- Nodes are rewarded from mining but also from being "activ part" of the system
- **Not an "out-of-the-box" solution (setup required)**



- ***Third Party Miners Nodes***
- Suitable for small prosumers
- Small embedded systems send data from prosumers to blockchain nodes
- Easier configuration
- **Mining rewards are the only incentive for running nodes**



- ***Hybrid Configuration***

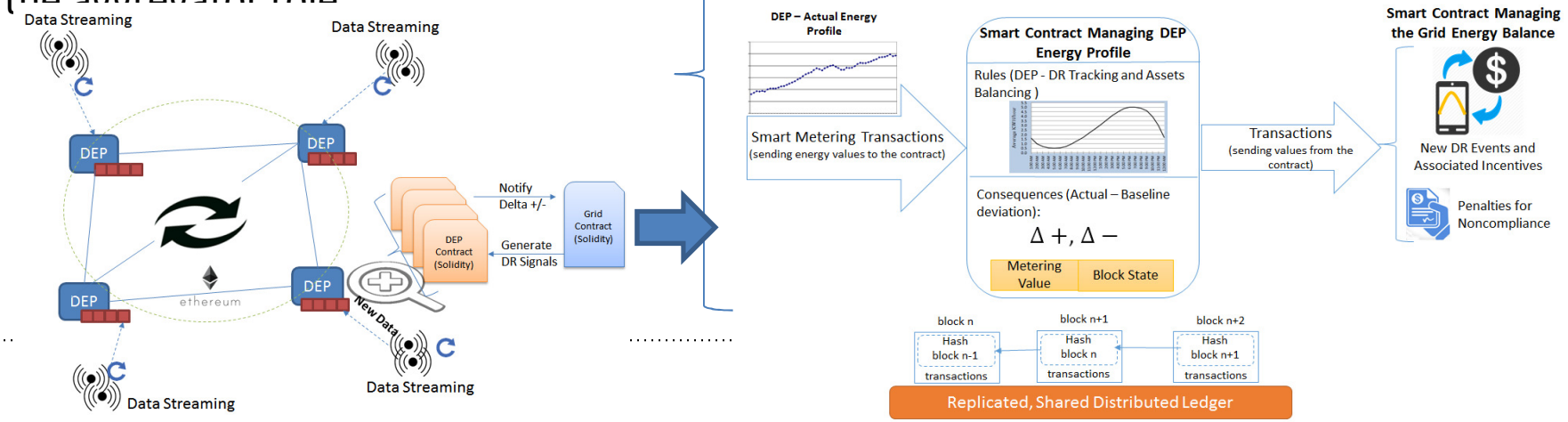
eDREAM: DLTs and smart contracts for smart grid decentralized control

• **P2P Markets-like** mechanisms have proven to be suitable for resource allocation and **control of autonomous selfish parties**

• Our approach leverages on
• using the **market-based coordination methaphor** to manage grid network control
•smart contracts as a way for **imbalance minimization** and
•**tokens** to **reward imbalance** between planned and real measurements to describe network deviations from planned state
•Modeling a decentralized branch of DSO grid or the combination of a branch of grid network with third party owned-assets as a **private blockchain network**
• **Distributed Consensus Verification** of the measured values via **Permissioned blockchain over Ethereum**

eDREAM: DLTs and smart contracts for smart grid decentralized control

- Enabling Technologies: IoT based smart metering, self-enforcing smart contracts, distributed consensus (PoW vs. PoS)
- May be instantiated for **incremental grid control strategy** via:
- controlling grid-owned assets
- where the above is not sufficient to balance the grid, P2P coordinated market-based non-grid owned flexibility optimized management (N flexibility providers-1 DSO as technical aggregator-> market operator role collapsed into the aggregator role



Smart Meters and IoT integration with BC

•Smart meter is used to monitor net production consumption (energy injected or withdrawn from the grid)
•SCT 013-030 & Arduino UNO
  - Non-invasive
  - Low cost

- Readings in the range 15 secs -15 minutes
- Actually integration testing with IoT smart meters
- Tamper proof seal
- Next steps: smart meters with embedded smart contracts
- Virtualizartion stack for smart contracts over IoT devices

Challenges and Open Issues

- **Smart contract readings granularity**: what is the minimum required amount?
- *Block time granularity needs to be comparable with monitoring rate needed by smart contract*
- **Proof-of-Stake maturity** level: still non sufficient ("Casper" client testing started)
- **Scalability and carbon footprint of BC**
- **Blockchain throughput**
- *Implementing **sharding** and **second layer protocols** (es. Lightning Network), while maintaining the desirable security and decentralisation properties of blockchains*
- *Quorum – private transactions & permissioned ledger*

- IoT vs Blockchain integration: what data to store in the blockchain?

eDREAm Platform as Enabler for Decentralized Data Marketplace