UNIVERSITATEA TEHNICĂ DIN CLUJ-NAPOCA

Faculty of Automation and Computer Science

DSRL Distributed Systems Research Laboratory

Blockchain based demand response services: Terni City pilot

eDREAM

enabling new Demand REsponse Advanced, Market oriented and secure technologies, solutions and business models

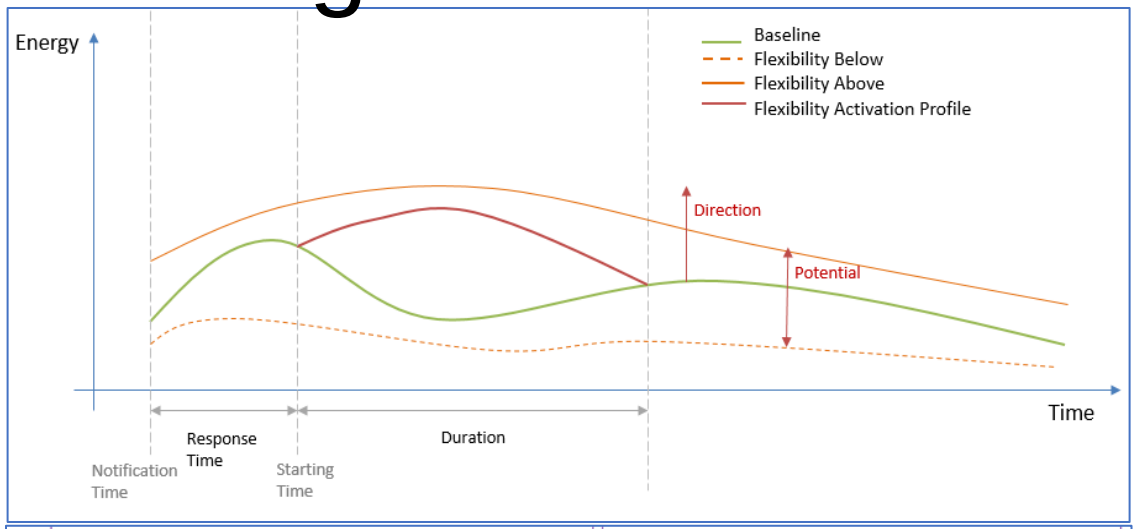
European Commission HORIZON 2020

PRO INVENT, Cluj-Napoca, ROMANIA, November 2021

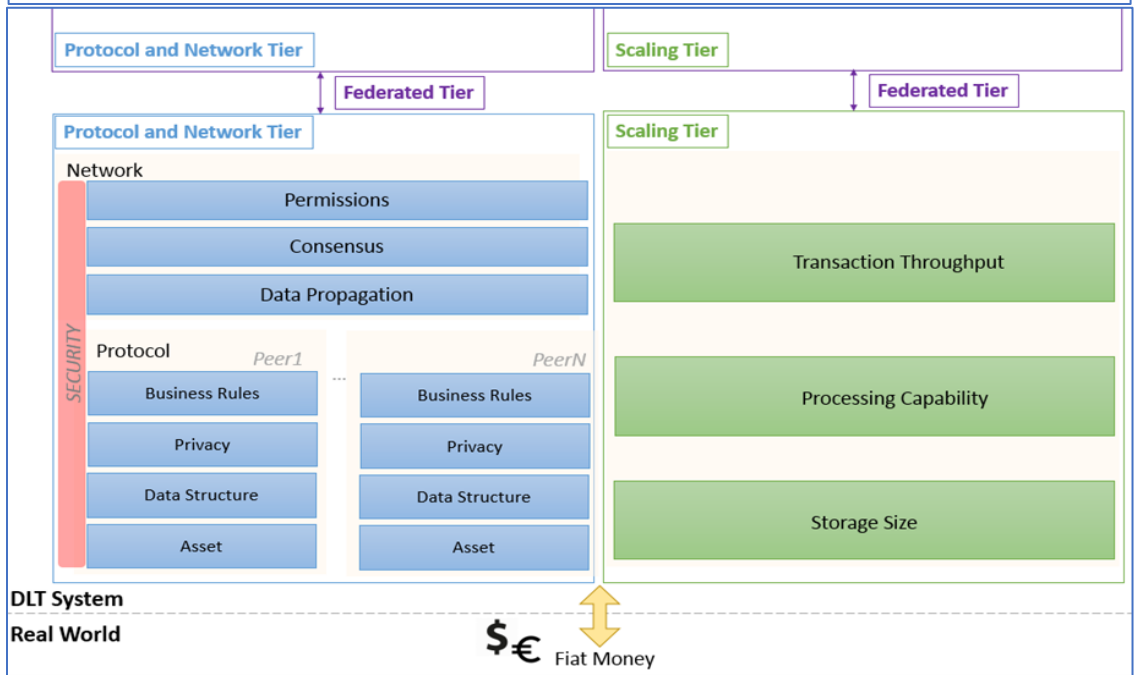
Presentation Outline

- Blockchain based Demand Response Management and Financial Settlement
- Demand Response using Blockchain
  - DR Requests registration
  - DR monitoring
- Demand Response using Blockchain in Terni Pilot
- Relevant Publications

Blockchain based Demand Response Management and Financial Settlement (1)



- The production and consumption forecasts are evaluated in order to detect any possible imbalances
- The DSO will ask the aggregators to address the imbalance by issuing a flexibility request
- The aggregators will use their resource/prosumer portfolio to answer to the DR Flexibility request



- Blockchain is the solution chosen for local flexibility markets management
- Prosumers can leverage on their flexible resources and aggregate with other peers to offer solutions to flexibility requests

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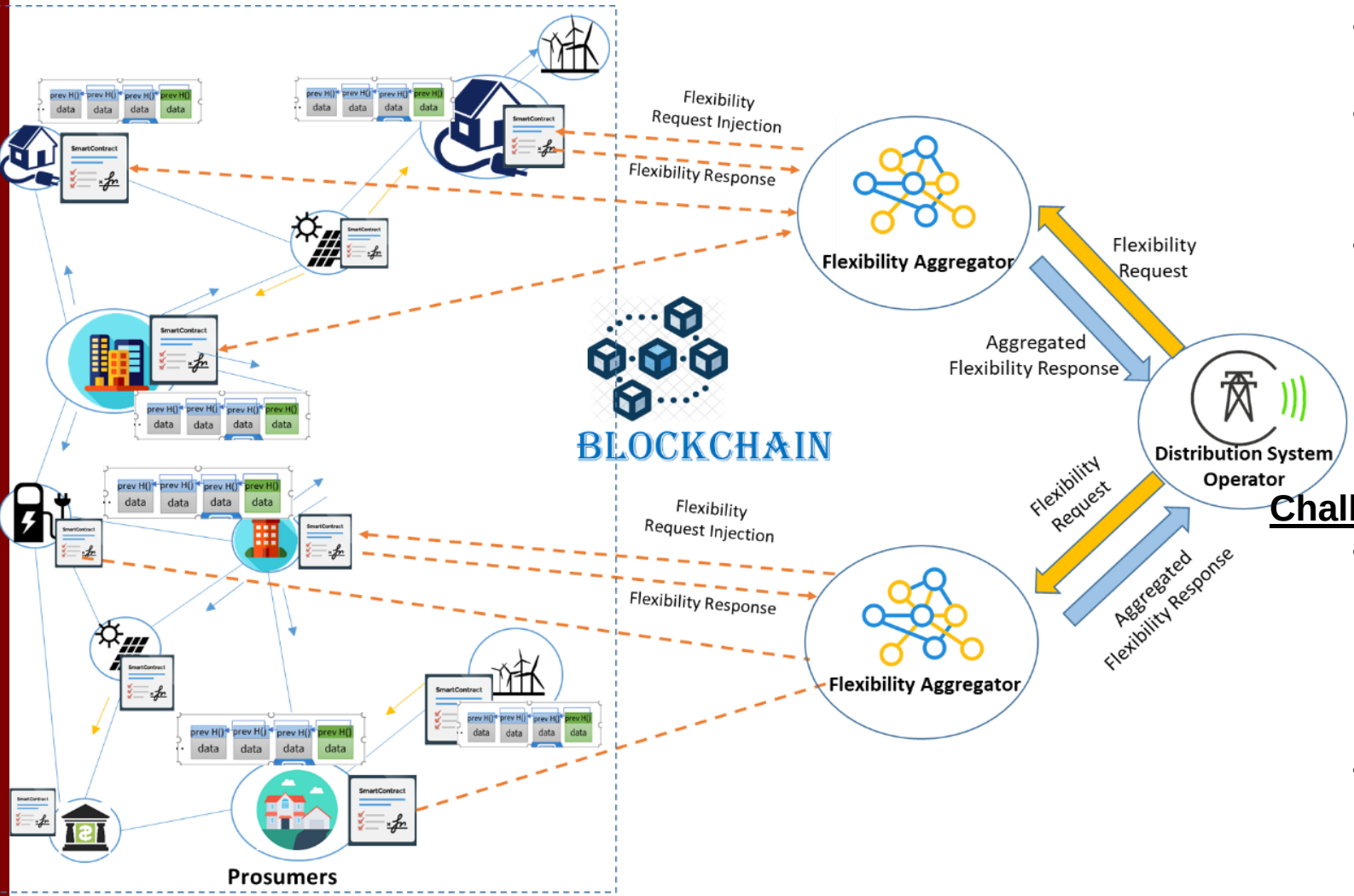
Blockchain based Demand Response Management and Financial Settlement (2)



Opportunities

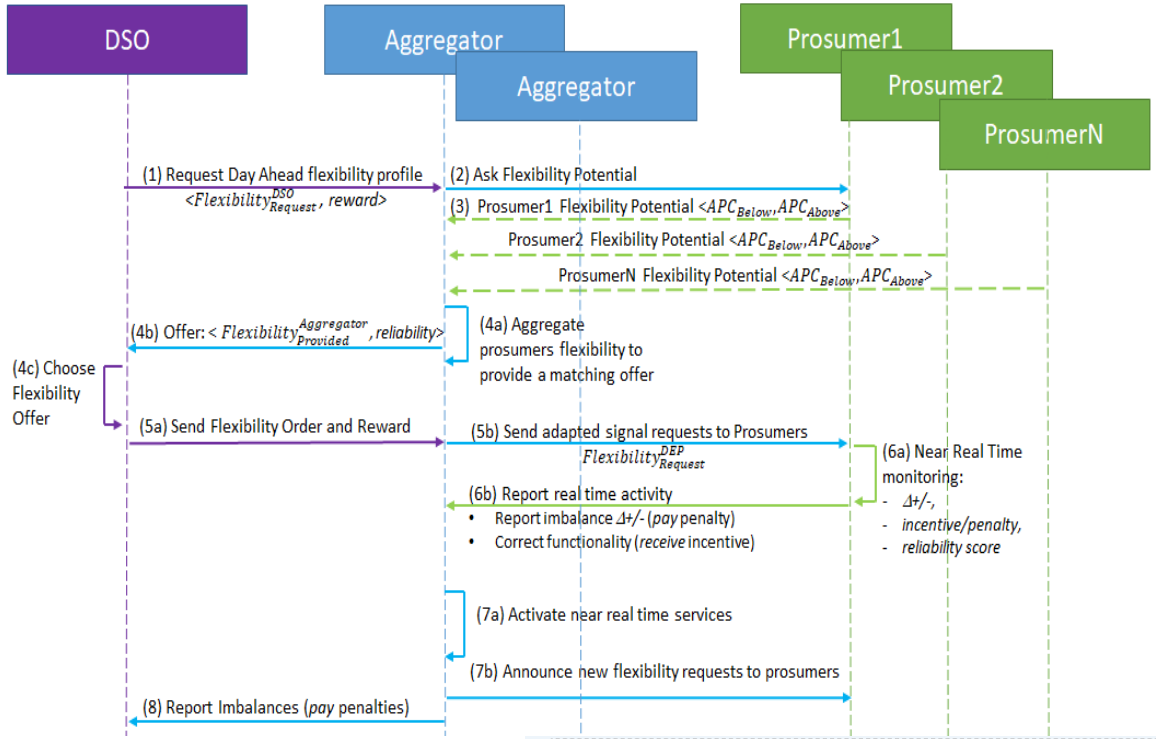
- Decentralized control
- Blockchain functioning as an escrow for the funds associated to DR Programs
- The flexibility response is evaluated through the smart contract and subject to consensus on chain
- Based on the delivered flexibility prosumers are evaluated and rewarded/penalized in near-real time

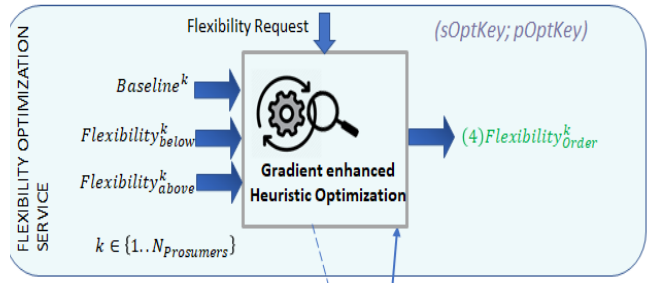
Challenges

- **Scalability**: the data received from the sensor can not be directly registered on chain => it would lead to high cost and a bottleneck due to the low transaction throughput
- **Privacy**: the consumption values should not be publicly revealed on chain

Demand Response using Blockchain

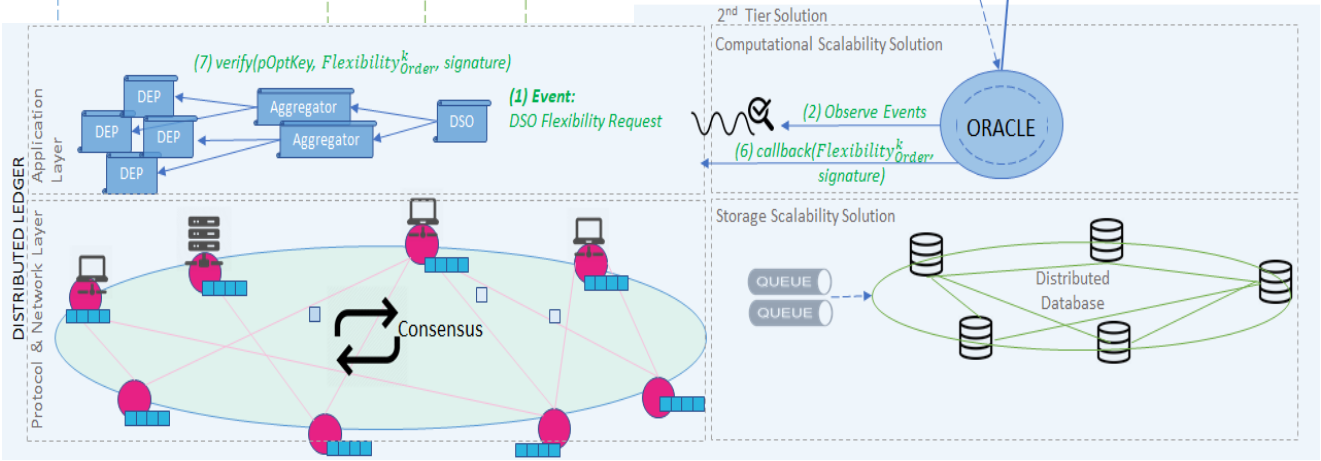
> DR Requests Registration





(5) ($Flexibility^k_{Order}$, $sign(sKey, Flexibility^k_{Order})$)

(3) Call External Service with Portfolio of Prosumers Information



Actors:

- **DSO** – Baseline Estimation; Decision Makings; Issues DR request Profile
- **Aggregators** – assesses the flexibility potential of its portfolio; Optimizes and assigns requests to its prosumers' portfolio
- **Prosumers** – answers to DR Requests

Demand Response using Blockchain

> DR Monitoring

Follow the correct activity of the Prosumer in near-real time

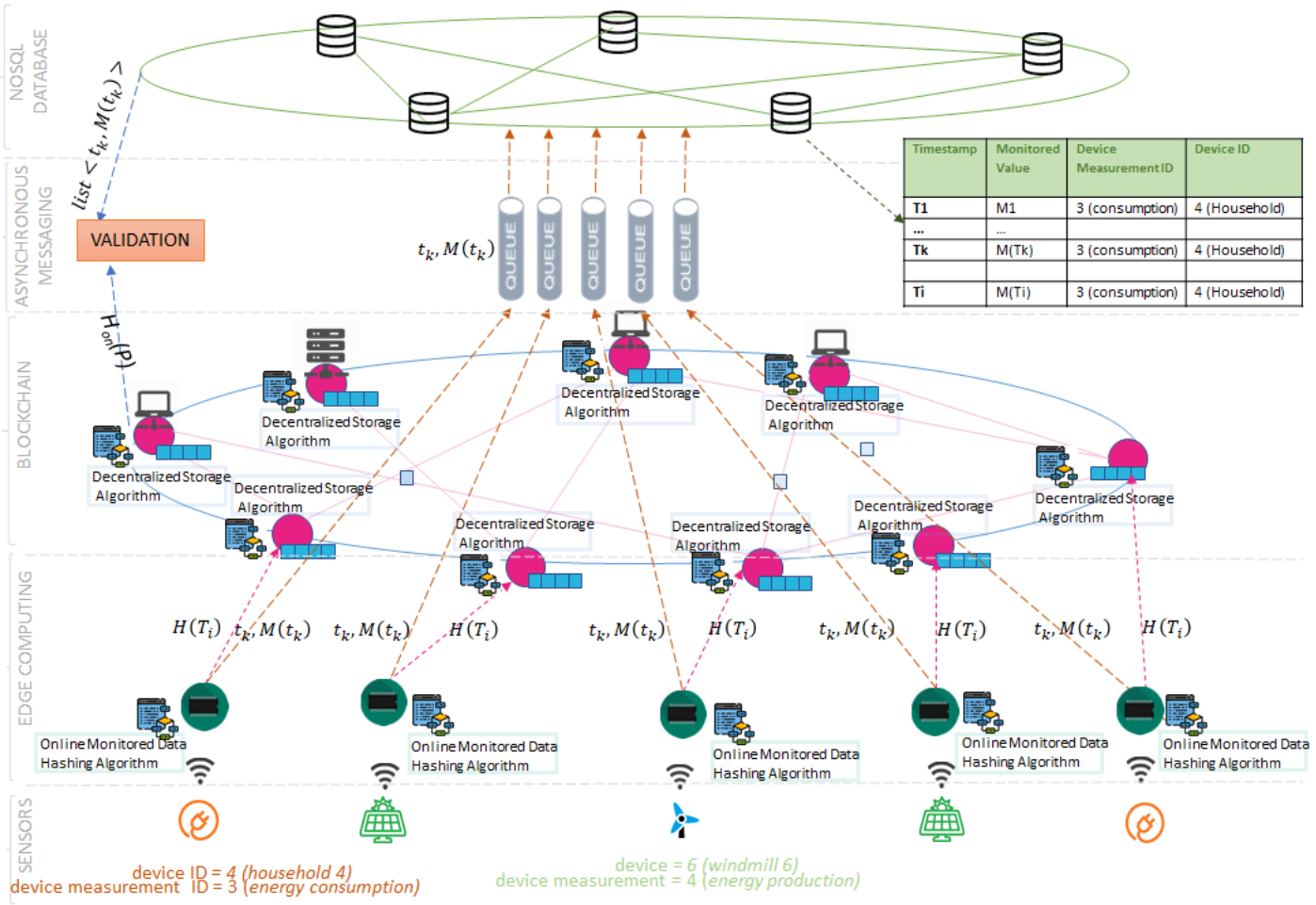
- Reward the prosumer's correct behavior
- Detect imbalances, penalize and report them

Solution Combines:

- blockchain ledger
- with distributed queuing systems
- NoSQL database

And offers

- tamper proof, provenance tracking and self-enforcing smart contracts benefits brought be the blockchain technology for the on-chain stored data.
- Scalability and tamper evidence on the off-chain stored data



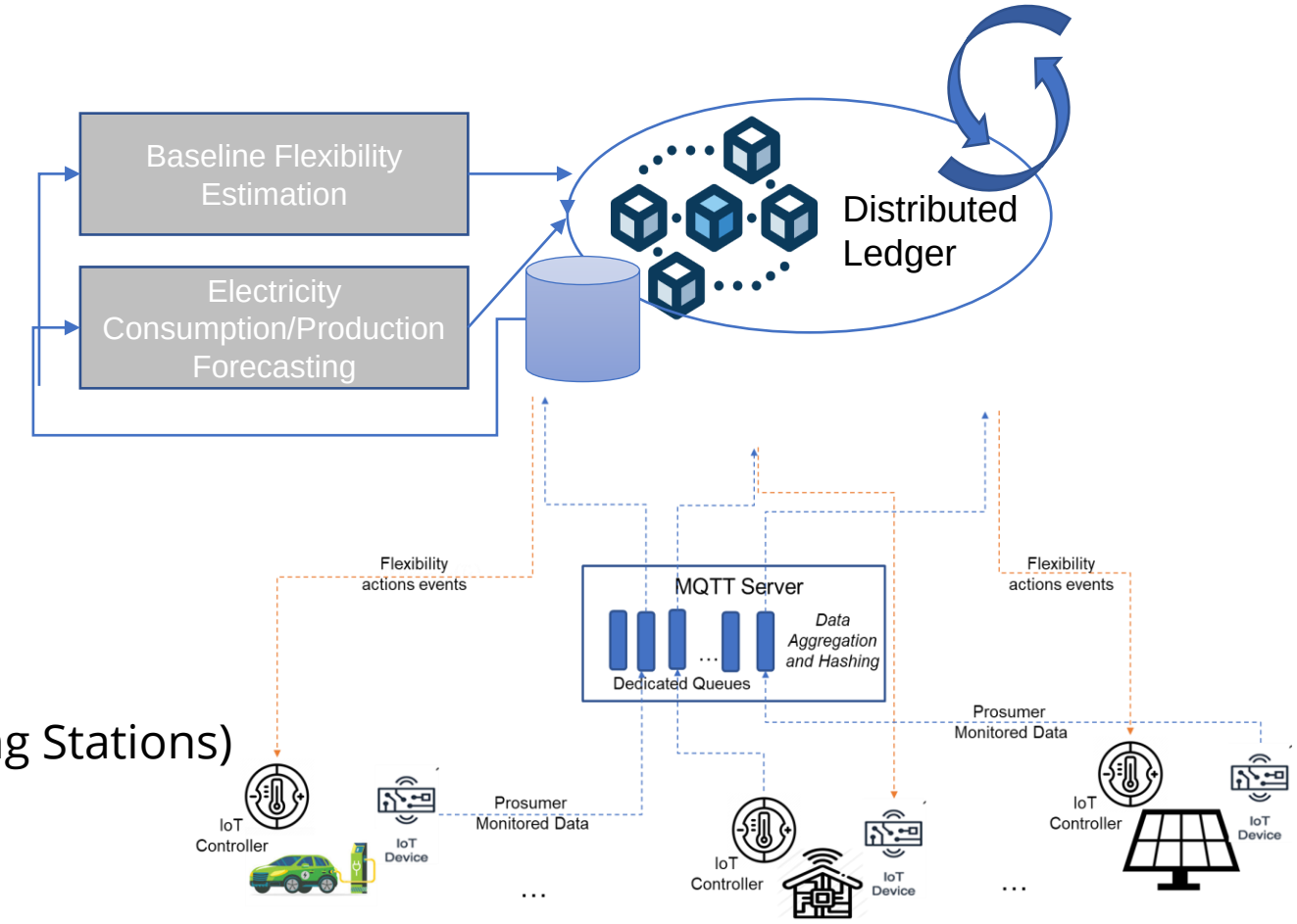
DR using Blockchain in Terni Pilot

> Pilot Description

Demo conducted in Terni Pilot

Actors:

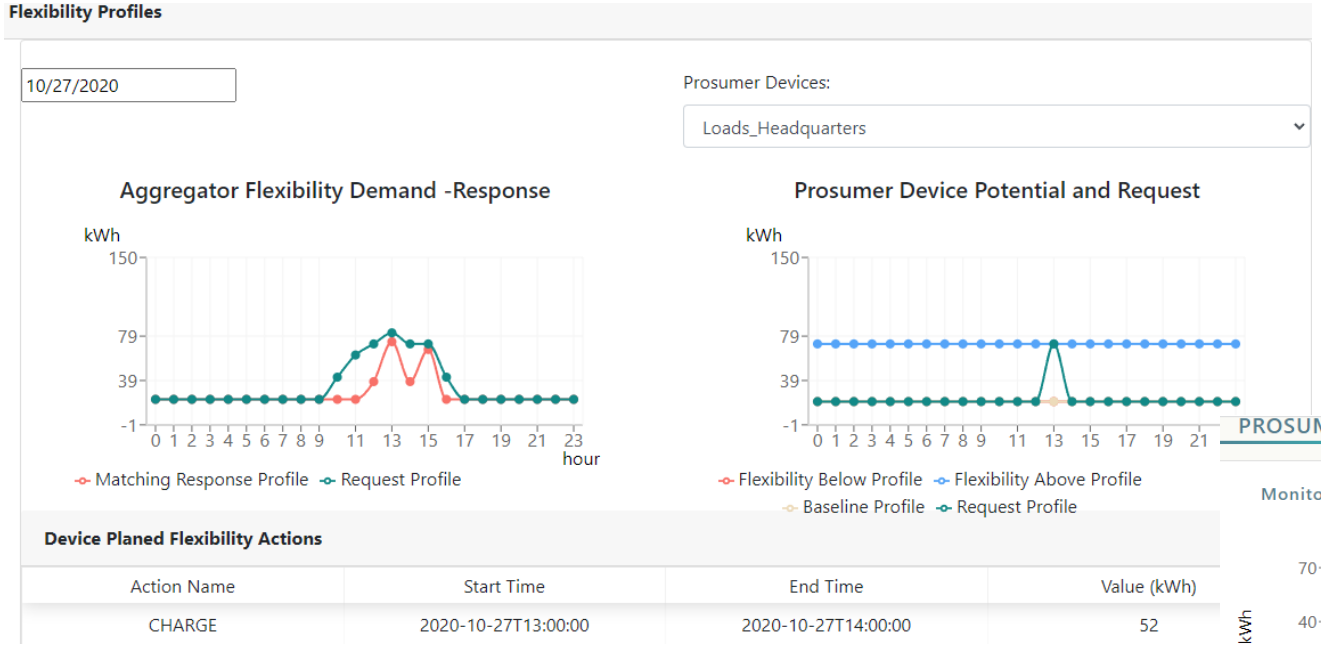
- DSO
- Terni Aggregator
- Prosumers
  - Storage Systems
    - **actions of 16 KWh per hour**
  - Buildings (Cooling Systems and EV Charging Stations)
    - **actions of 52 KWh per hour**
  - EV Charging Stations
    - **Consider actions per hour of 45 KWh**

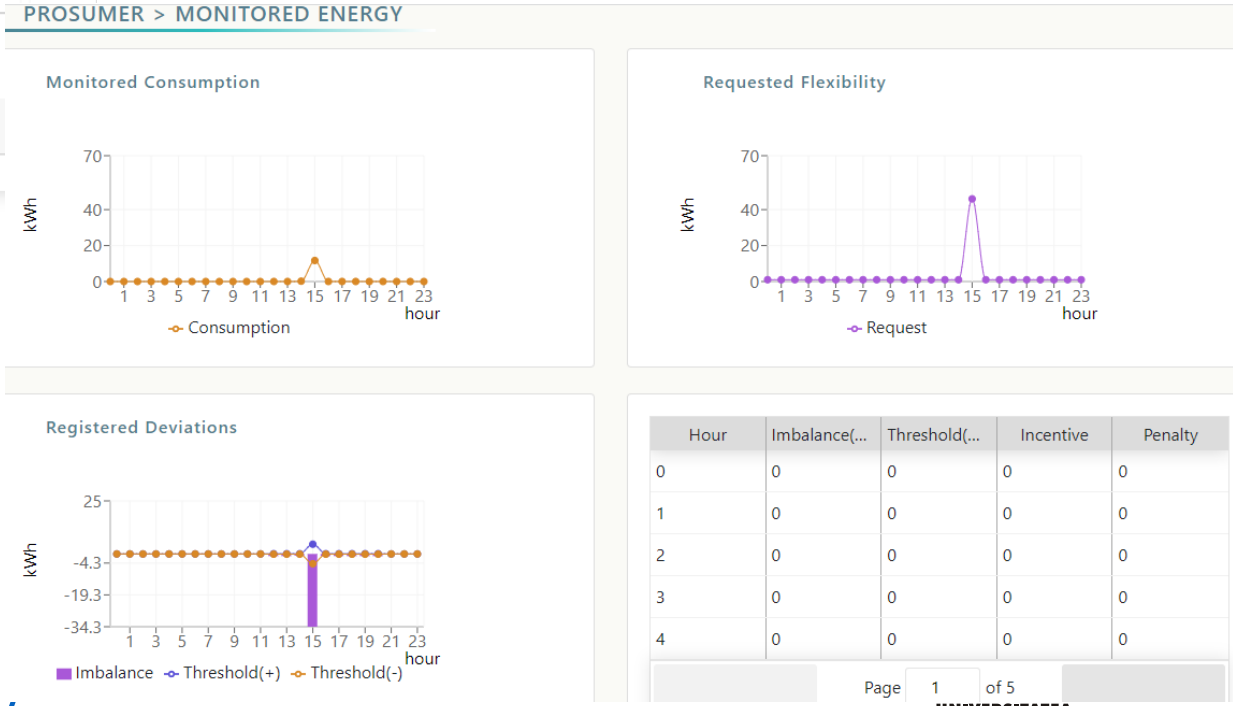


Tool available at: http://193.226.5.80:5000/

DR using Blockchain in Terni Pilot

> Test Results





Tool available at: http://193.226.5.80:5000/

Relevant Publications

- Published Papers:
  - **Claudia Pop,** Tudor Cioara, Marcel Antal, Ionut Anghel, Ioan Salomie, and Massimo Bertoncini. "Blockchain based decentralized management of demand response programs in smart energy grids." Sensors 18, no. 1 (**2018**): 162. https://doi.org/10.3390/s18010162
  - **Claudia Pop**, Antal Marcel, Tudor Cioara, Ionut Anghel, David Sera, Ioan Salomie, ... & Bertoncini Massimo. “Blockchain-based scalable and tamper-evident solution for registering energy data. “ Sensors, 19(14) (**2019**) : 3033, https://doi.org/10.3390/s19143033
  - **Claudia Pop**, Antal Marcel, Cioara Tudor, Anghel Ionut, Salomie Ioan, Bertoncini Massimo “A Fog Computing enabled Virtual Power Plant Model for Delivery of Frequency Restoration Reserve Services”. *Sensors* **2019**, *19*, 4688. https://doi.org/10.3390/s19214688
  - **Claudia Pop**, Antal Marcel, Cioara Tudor, Anghel Ionut, Salomie Ioan, “Blockchain and Demand Response: Zero-Knowledge Proofs for Energy Transactions Privacy”. *Sensors* **2020**, *20*, 5678.

- More info:
  - https://edream-h2020.eu/

Demo Movie