D3A - An Energy Market Design for the Transactive Grid

Sarah Hambridge, PhD

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Why are we building the D3A?
The energy system is fundamentally transforming

A grid based on low-cost, renewable, intermittent power needs a new architecture capable of securely coordinating an increasingly distributed, decentralized electric system.
D3A Mission: Establish markets for monetising DERs, including flexible and grid forming devices

A reliable market structure that monetises DERs creates a rational incentive for their mass adoption and contribution to the energy transition.

To effectively utilize distributed energy resources (DERs), DERs must be

• Full participants in local energy markets and contribute to trade prices (placing bids and offers).

• Be incentivised to promote grid stability through participation in local balancing.
D3A: A Hierarchical Market Model

The hierarchical model is constructed out of stacked areas. Within areas, markets are established. Through this recursive model, easy scaling is possible.
Semantics: Agents

“Agents” are digital representations, i.e. twins, of physical assets. “Virtual Agents” may or may not have a physical representative. In a decentralised system, agents interact through smart-contracts on Blockchain.
Markets are the trading channels with which agents are representing their respective digital assets, every Area has its respective market.

Additional Markets: Congestion Mgmt.

Energy Plan

Frequency

Sensor

Voltage

Energy Trading

kWh

Grid Balancing

Hz

Capacity Dispatch

T0

T0 + 1

T0 + 2

T0 + N

Balancing Capacity Market 1

Balancing Capacity Market 2

Balancing Capacity Market N

Spot Market 1

Spot Market 2

Spot Market N

Energy Plan

Planned Dispatch

ΔkWh

VAR
Semantics: Areas

Areas are the market zones in which local markets are established. Deploying D3A, a grid would be divided into areas according voltage level and ownership (e.g. DSO, TSO, etc).

What is the function of an area?
- Agent registry
- Location for energy markets
- Defines ownership or context as profit center
- Stacks recursively into area hierarchy

What defines an area?
- Profit center / channel for transactions
- Ownership
  - Home / factory
  - Community
  - Grid owner
**D3A: Strategies**

Strategies describe the behaviour of agents, and thus the way they interact with each other through the market.

- **Device Agent**
- **Physical Asset**

**Autonomous Device Strategy**
- market estimation
- base and/or flex load (forecasting)
- generation (forecasting)
- cost model
- bid or offer price determination

**Physical Asset** describes its state
- current state
- other relevant data

**Blockchain**

**Spot**

**Aggregated Demand/Supply Curve**

**Digital**

**IAA Agent Spot Balancing**

**e.g. consuming device**

**e.g. producing device**
D3A: User Story
D3A is sub-divided into “tech” modules; each allowing certain shareholders access to its process:

D3A Modules:
1. Forecasting Technology
2. Bidding Strategies
3. Market Technology
4. Market Algorithms
5. Stakeholder Validation
6. Device Registration

Substitute “Homeowner” with:
- Local Power Plant
- DER
- Community Micro Grid
- Etc...
D3A: Development Stages

**Simulation**
- Topology
  - Configure grid setup
  - Set market design
  - Establish bidding strategies
  - Set simulation duration
  - Customise load & generation profiles
- Events
  - Load growth & disturbances
  - Changing topology
  - Disruptive events
  - Changing weather
- Simulation
  - Run market simulation based on topology and event parameters
- Results
  - Visualise and aggregate results
  - Export transaction history
- Optimisation
  - Results of simulation feed optimisation model
  - Grid topology is optimised

**Deployment**
- Hardware integration
- D3A smart contracts deployment
- Smart meter communication protocol
- Blockchain scaling solution; para-chains
- White-label UI for D3A user interaction

**Hardware Integration**
- Embedding software on hardware
- System architecture design
- Closed loop simulation
**D3A: Roadmap**

**Event Horizon June 19-20, 2019**
- Live D3A Demo and UI release
- Use Case results presentation

**Spring 2019**
- User Interface (UI) under construction for limited release
- Use Case simulations and research with industry partner collaborations

**Summer 2019**
- Second phase UI development

**Spring 2020**
- Deploy on Energy Web Chain
- Power flow, congestion management feature development
Thank You!

Contact: d3a@gridsingularity.com
sarah@gridsingularity.com

https://github.com/gridsingularity/d3a

Cumulative Trading For Each Area
The total energy traded for each area, segmented to show the origin or destination of trades to other areas

House 4 Consumed 2,554 kWh from House 4