BLOCKCHAIN, USER PREFERENCES, AND CONSENSUS REACHING

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Blockchain technology: a technology for storage and data exchange, *neutral*, *secured*, *fully decentralized*. Transactions are stored in a distributed ledger. Most applications rely on dedicated crypto-currencies (Bitcoin, Solarcoin, Ethereum, etc.).

Solarcoin four year value https://coinmarketcap.com/currencies/

Specificities:

- *Authentified* and *secured* transactions (Proof of Work)
- Transactions are identified but agents remain *anonymous*

Smart contracts: programs which execute automatically the terms and conditions of a contract.

Ex. rainforest blockchain: each time a product in the world uses DNA from rainforest species, origin countries are remunerated -> a new bio-economy.

Rainforest alliance bank of code and blockchain

Questions:

- How can we model a smart contract on top of a peer-to-peer energy market?
- What are the guarantees (if any) for consensus reaching and robustness against attacks and Byzantine behaviors?

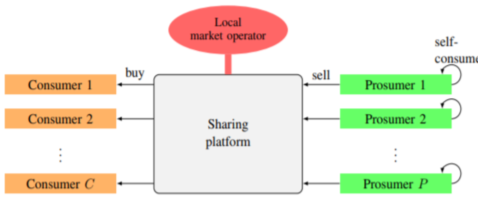
The Model:

- *N* set of N nodes, $N = P \cup C$ and $P \cap C = \{\}$

Each node can be either a *prosumer* (possibility to generate and consume (part) of her own energy while selling the excess by the intermediate of a sharing platform), or *a consumer-only* (without generation facility)

- *P*, prosumer set
- *C*, consumer set

} • A **two-sided market**
• Asymmetric role of the prosumers



Consumer-only model: usage benefit for consuming a quantity y_t^C of energy, with $y_t^{C\#}$ target demand

$$U_C(y_t^C) = -\eta^C(y_t^C - y_t^{C\sharp})^2 + \tilde{\eta}^C,$$

Preferences leading to a utility $\tilde{U}_C(y_t^C)$

- RES-based generation, locality of production
- Prosumer origin

Consumer C utility for consuming y_t^C energy units with p_t^* market clearing price

$$\Pi_C(y_t^C) = \tilde{U}_C(y_t^C) - p_t^\star y_t^C.$$

Prosumer model: usage benefit for consuming x_t^P energy units and sharing s_t^P energy units on the platform, with $x_t^{P\#}$ target consumption and μ_t probability that a prosumer is matched to a consumer

$$U_P(x_t^P) = -\eta^P(x_t^P - x_t^{P\sharp})^2 + \tilde{\eta}^P,$$
$$\mu_t := \min\left\{\frac{\sum_{C\in\mathcal{C}} y_t^C}{\sum_{P\in\mathcal{P}} s_t^P}; 1\right\}.$$

Prosumer P utility for consuming x_t^P energy units and sharing s_t^P energy units on the platform

$$\Pi_P(x_t^P, s_t^P) = U_p(x_t^P) + p_t^\star \mu_t s_t^P - c_P(x_t^P + s_t^P).$$

Modeling the platform:

$$\max_{y_t^C} \quad \Pi_C(y_t^C), \qquad \text{s.t.} \quad y_t^C \le \kappa^C, \quad 0 \le y_t^{CP}, \forall P \in \mathcal{P}.$$

$$\max_{x_t^P, s_t^P} \quad \Pi_P(x_t^P, s_t^P), \qquad \text{s.t.} \quad x_t^P + s_t^P \le \kappa^P, \quad 0 \le x_t^P, s_t^P.$$

A repeated game: The consumer-prosumer game takes place T_C time periods ahead and is repeated

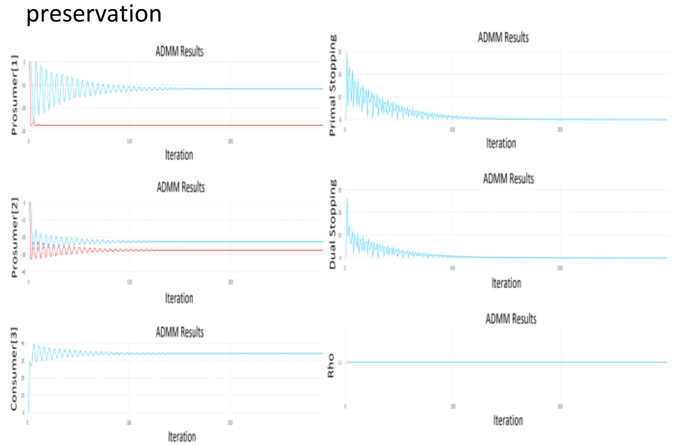
(i) *Miner selection* (node with the highest reputation index)

(ii) consumer –prosumer interaction -> market clearing price $(p_t^*)t=1,\dots, T_C$

(iii) *reputation update* with A_ν^n age of the last mined block for node n

$$R_{\nu+1}^C = R_\nu^C + \mathbf{1}_{\frac{1}{T_C}\sum_{t=1}^{T_C}\|y^C_{(\nu-1)T_C+t} - y^{C\sharp}_{(\nu-1)T_C+t}\| \le \tau} + A_\nu^C,$$
$$R_{\nu+1}^P = R_\nu^P + \mathbf{1}_{\frac{1}{T_C}\sum_{t=1}^{T_C}\|x^P_{(\nu-1)T_C+t} - x^{P\sharp}_{(\nu-1)T_C+t}\| \le \tau} + A_\nu^P.$$

ADMM-reformulation of the platform problem -> *privacy* preservation



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