ETH zürich

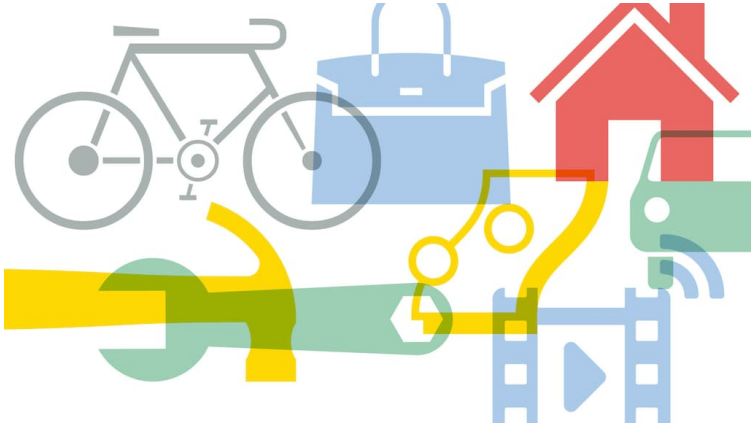
Self-regulatory Sharing Economies in Smart Grids and Smart Cities

Evangelos Pournaras

airbnb

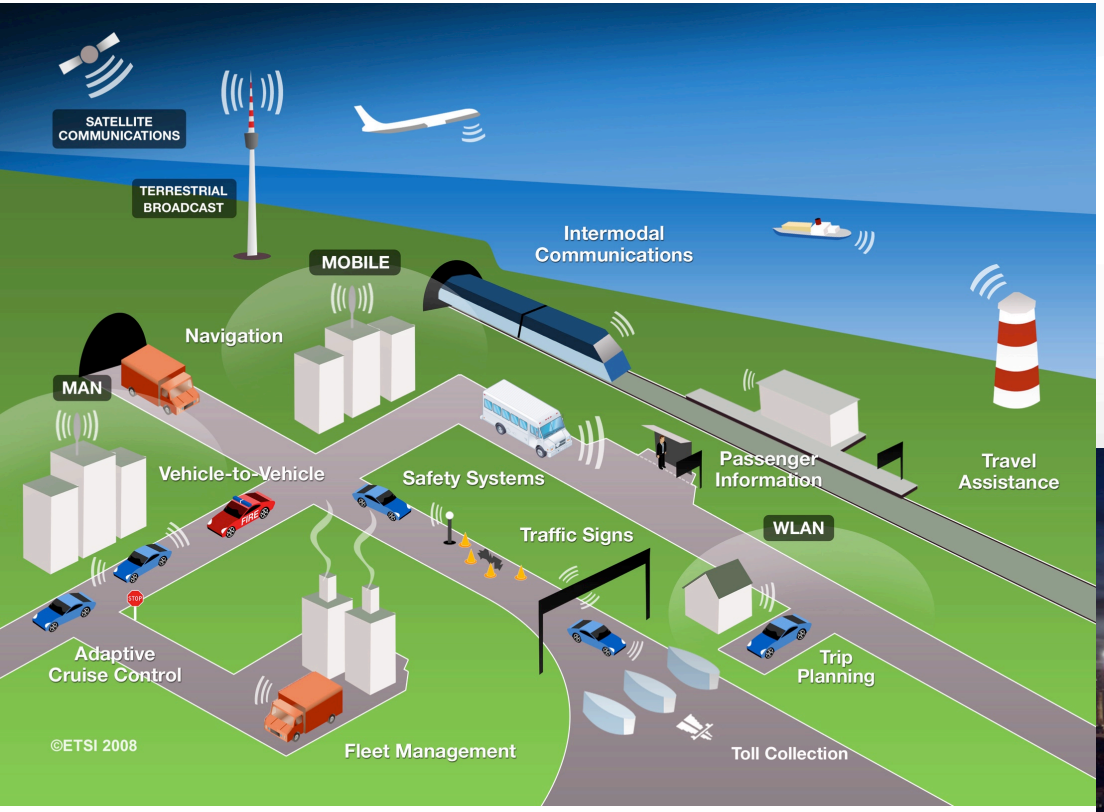
Sharing resources & services in the **Internet of Things** era

Online, participatory, bottom-up, decentralized

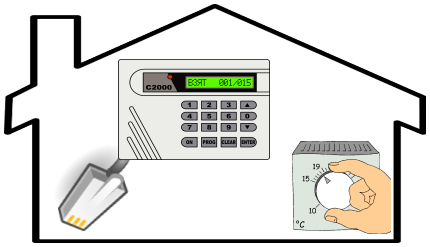


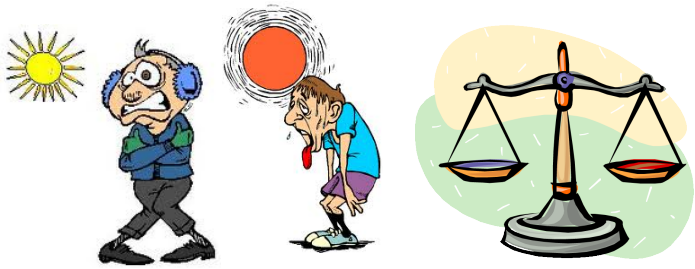
Smart Grids

Smart Cities



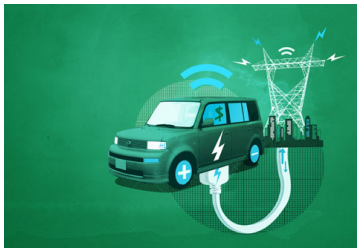
Smart Grids: Local-to-global Objectives



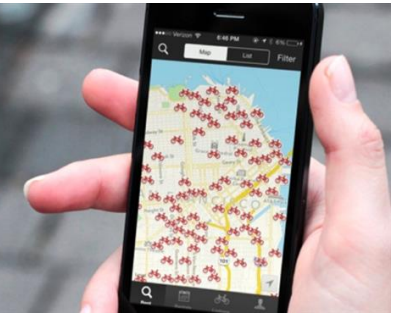


Local: make a shower, cook, laundry, charge EV

Global: prevent a blackout,
minimize production costs,
maximize use of renewables



Smart Cities: Local-to-global Objectives



Local: station to pick or leave a bicycle

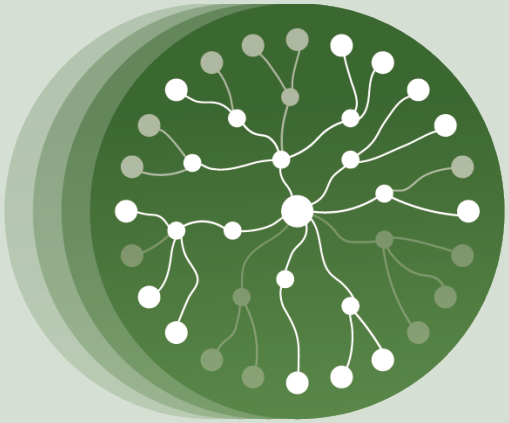
Global: prevent overload/underload of bicycle stations
minimize manual bicycle relocations
minimize operational costs
minimize investment costs

Research Question

*How to design a **decentralized & participatory** self-regulation of sharing economies that encounters for values such as **privacy, autonomy & fairness**?*

I-EPOS

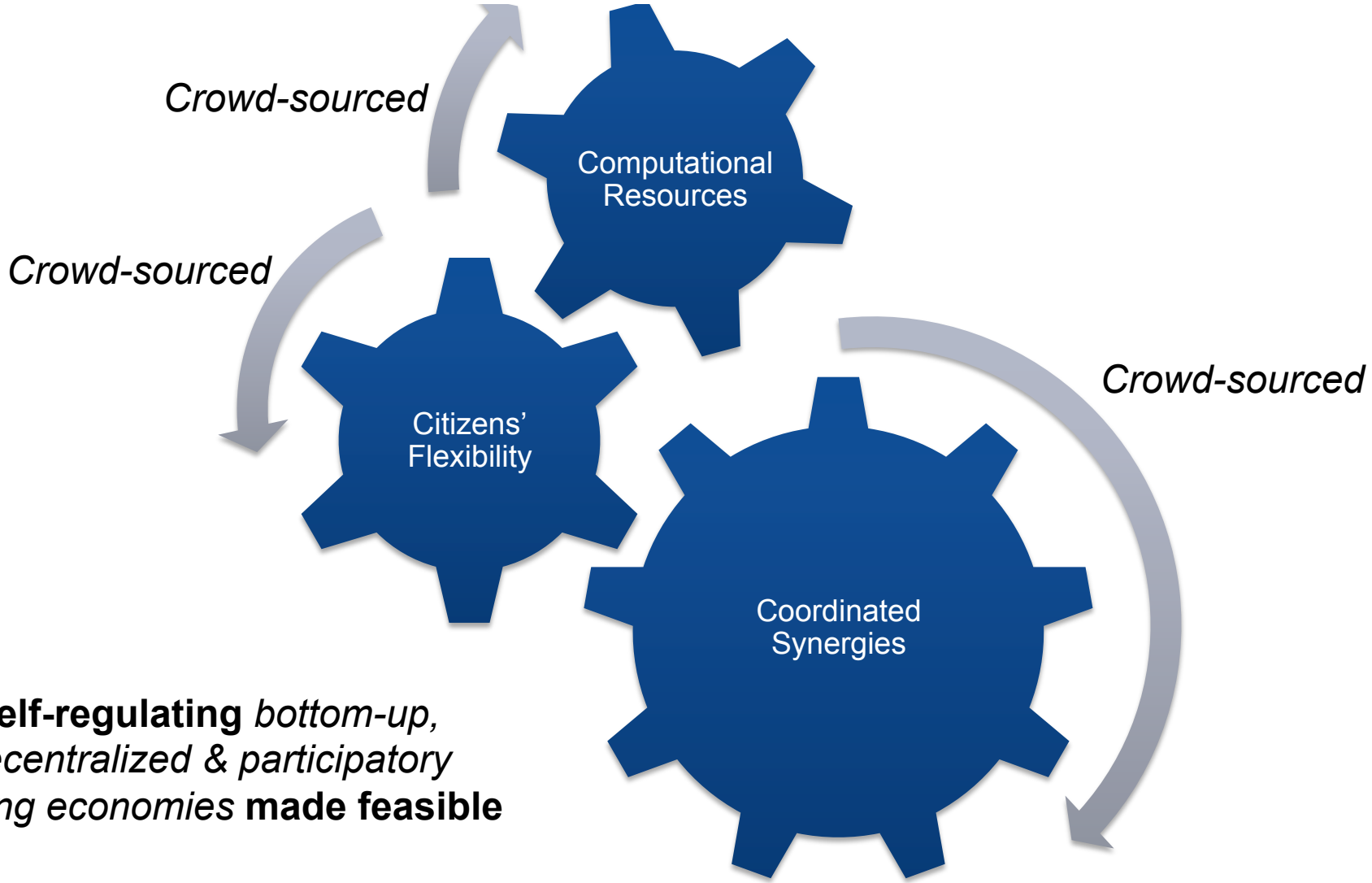
Iterative
Economic
Planning &
Optimized
Selections



EPOS

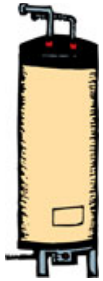
epos-net.org

Crowd-sourced Self-Regulation

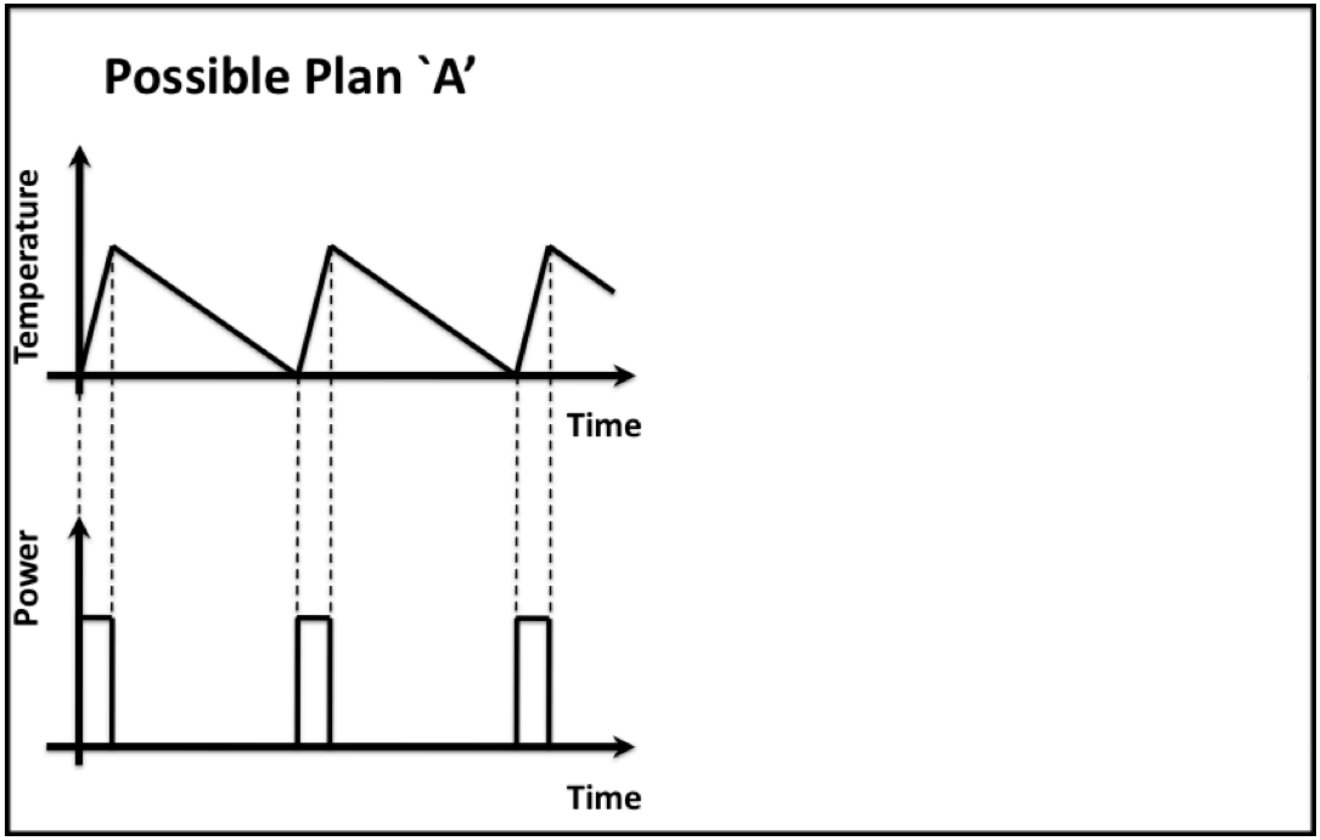


Self-regulating *bottom-up, decentralized & participatory sharing economies* **made feasible**

Participation Model



Self-determination of flexibility: planning of (alternative) citizens' options



LG introduces its first Smart Grid-Ready Refrigerator the DIOS

Category: Environment Household - *Tags:* Household, Lg, Lge, Smart Adapt, Smart Grid, Wi-fi, Wifi

+1 0

Barely 24 hours Samsung's Smart Grid Ready fridge, LG is now announcing its very own connected Smart Grid-Ready DIOS Fridge in Korea. The new smart refrigerator offers updates and information that can be accessed via smartphones and tablets. It offers three powerful smart savings options: late night saving, preferable time saving and the Smart Grid-ready.

The smart fridge also comes with Smart Adapt, which allows owners to keep their refrigerator software up-to-date with the latest upgrades, features and options. The smart fridge is also a source of useful information as it keeps track of daily schedules and dispenses regular weather reports. And instead of having to jot notes on sticky memos, family members can turn the fridge's LCD screen into a note pad to leave messages for each another.

Via LGE

4 Comments

Tweet 21 Like 5 Category ENVIRONMENT HOUSEHOLD

Available Technologies

Grid Friendly Appliance™ Controller

Battelle Number(s): 12782-E, 13538-B
Patent(s) Issued
Available for licensing in all fields

Summary

The Grid Friendly Appliance controller developed at PNNL senses grid conditions by monitoring the frequency of the system and provides automatic demand response in times of disruption.

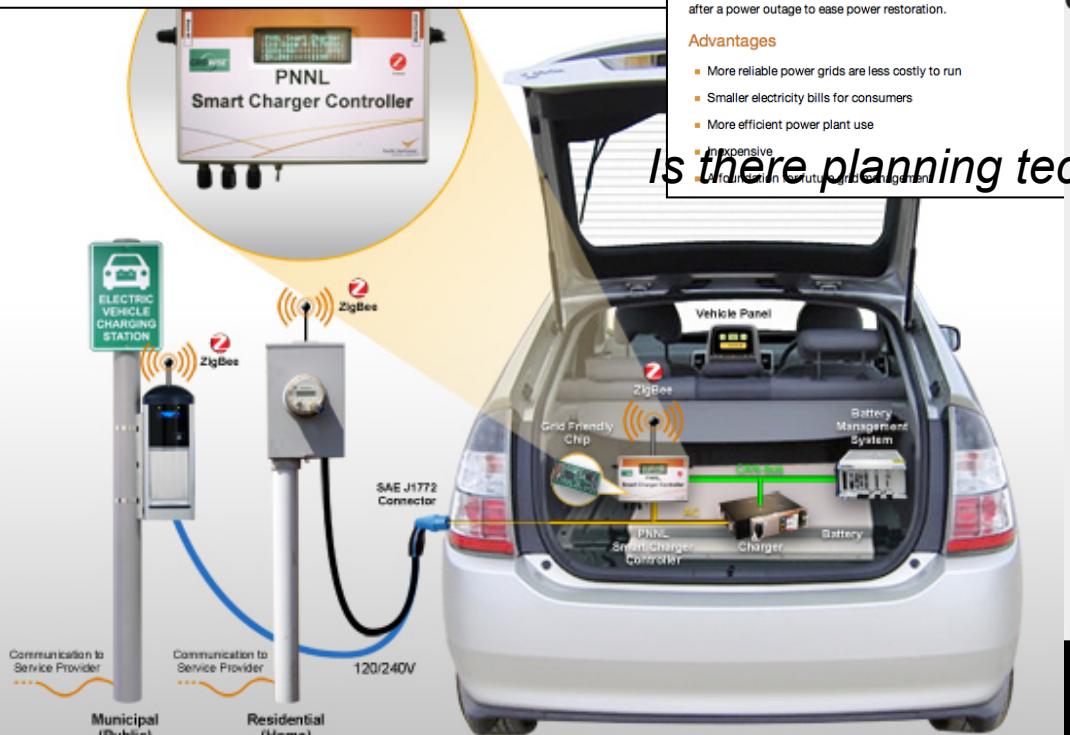
(click on image for full size)

A coin-sized integrated circuit developed by researchers at Pacific Northwest National Laboratory may help solve the nation's overworked electricity grid. Called The Grid Friendly™ Appliance Controller, the circuit board would turn normal household appliances into one that would better regulate energy usage and help prevent local and national blackouts.

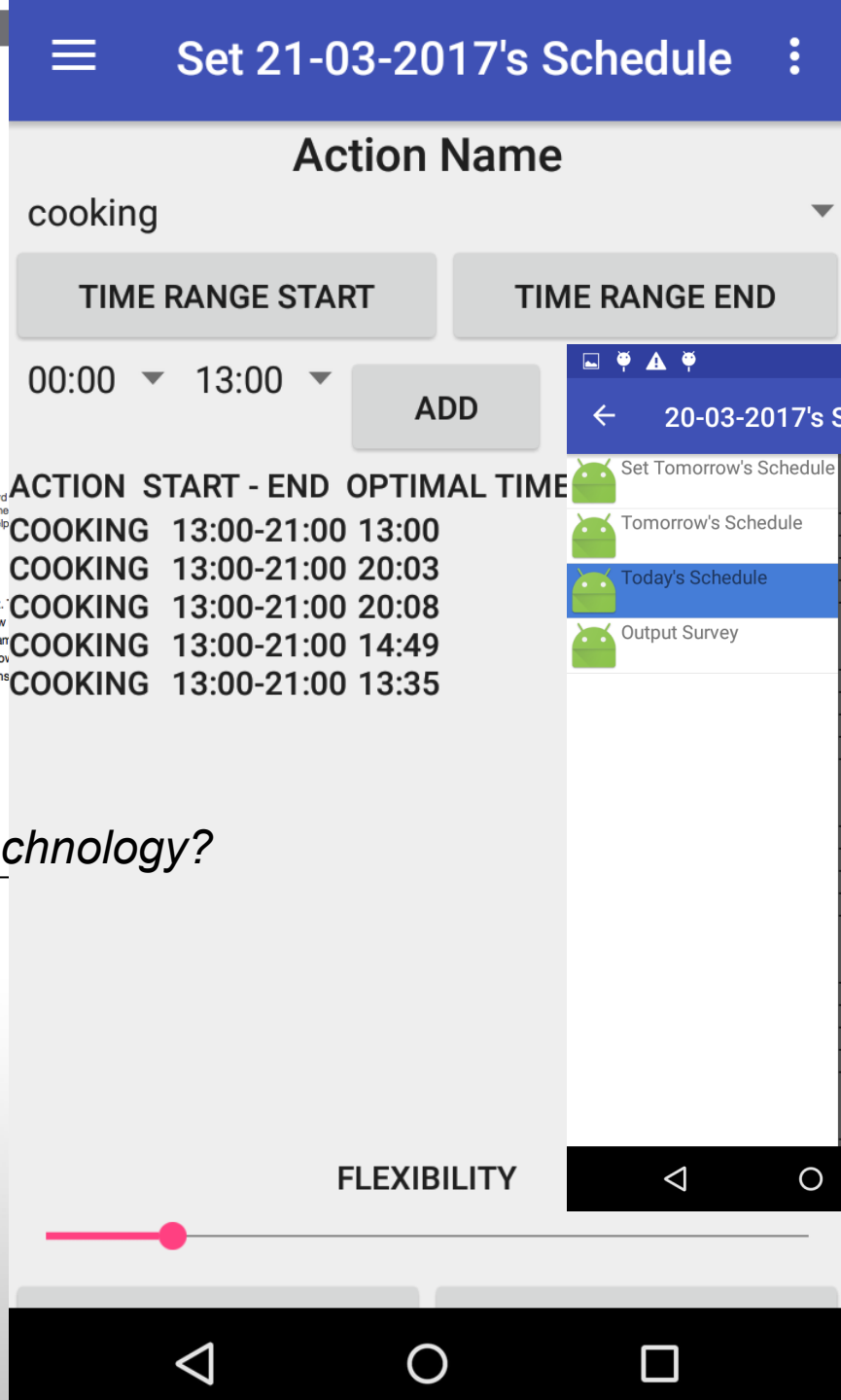
Within the North American power grid a disturbance of 60-Hz frequency is an indicator of serious imbalance between supply and demand that, if unarrested, leads to a blackout. can be installed in household appliances and turn them off for a few seconds to allow the grid to stabilize. The controllers can be program in fractions of a second when a disturbance is detected, whereas pov come up to speed. They can even be programmed to delay restart ins after a power outage to ease power restoration.

Advantages

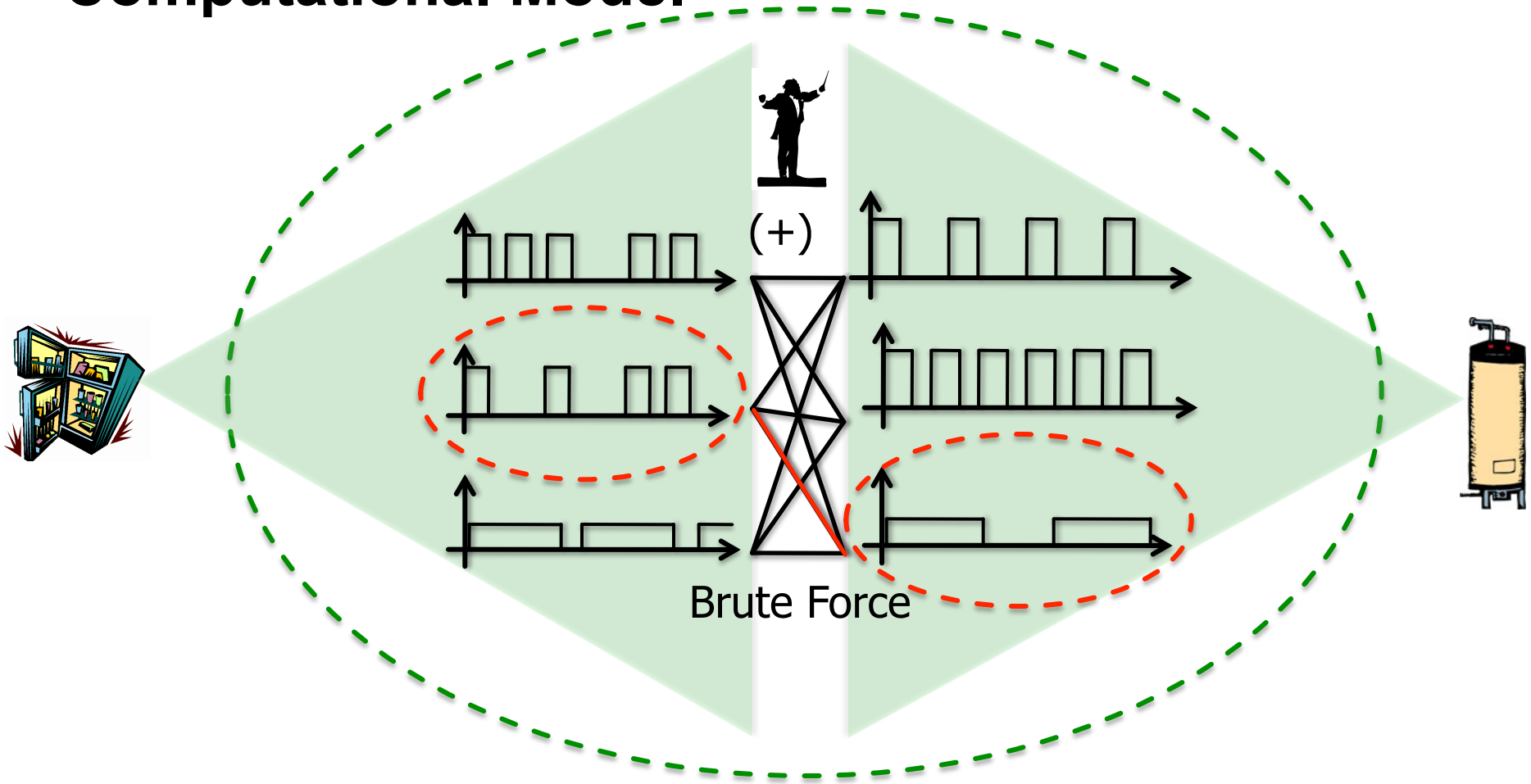
- More reliable power grids are less costly to run
- Smaller electricity bills for consumers
- More efficient power plant use
- Inexpensive
- Information for utility and consumers



Is there planning technology?



Computational Model



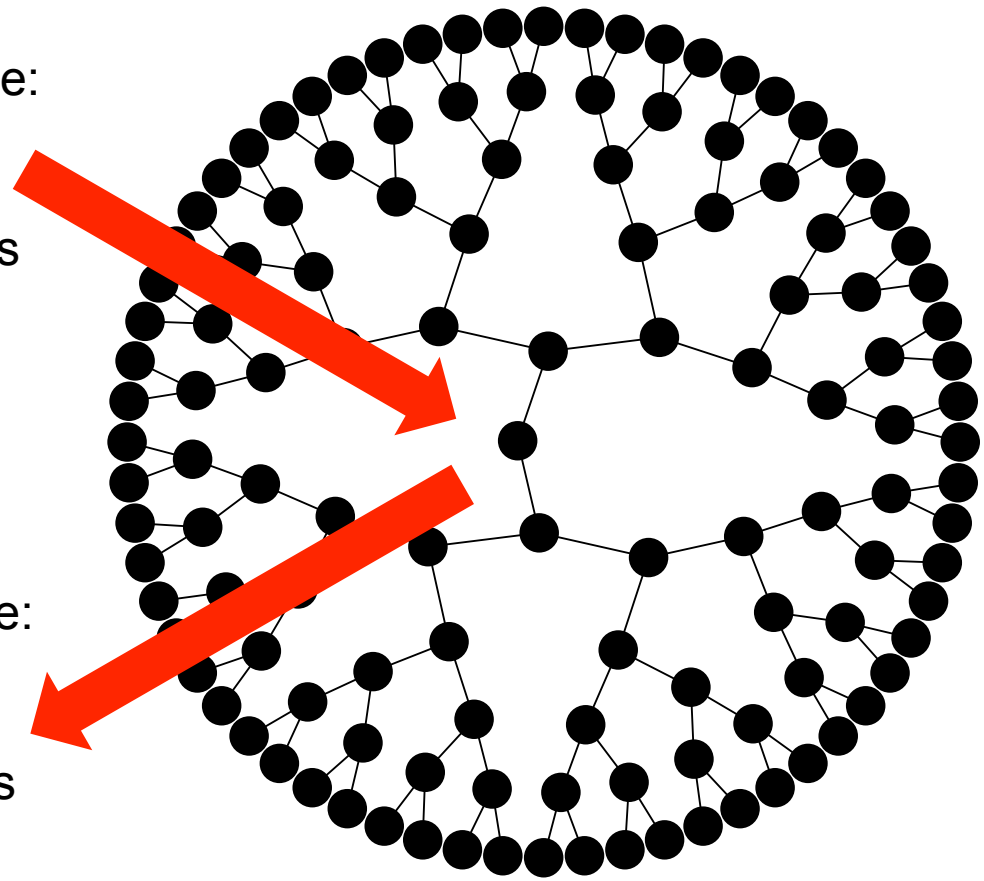
Complexity = # of possible plans$^{\text{\# of devices}}$

Combinatorial optimization problem – NP hard

Decentalized Collective Decision-making

Bottom-up phase:
leaves to root

Initial selections



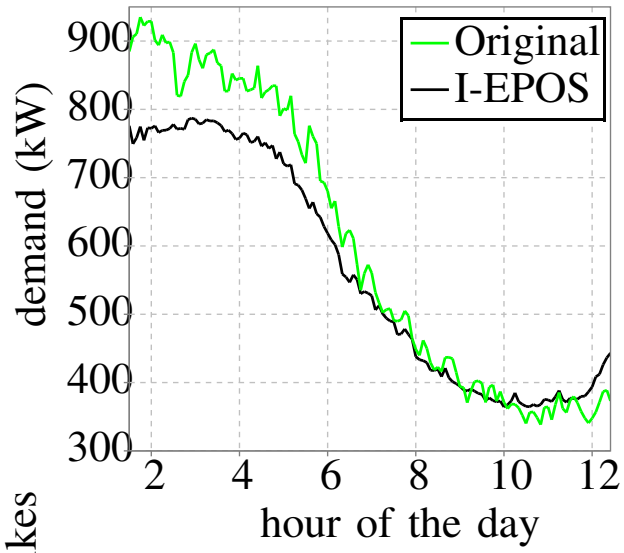
Top-down phase:
root to leaves

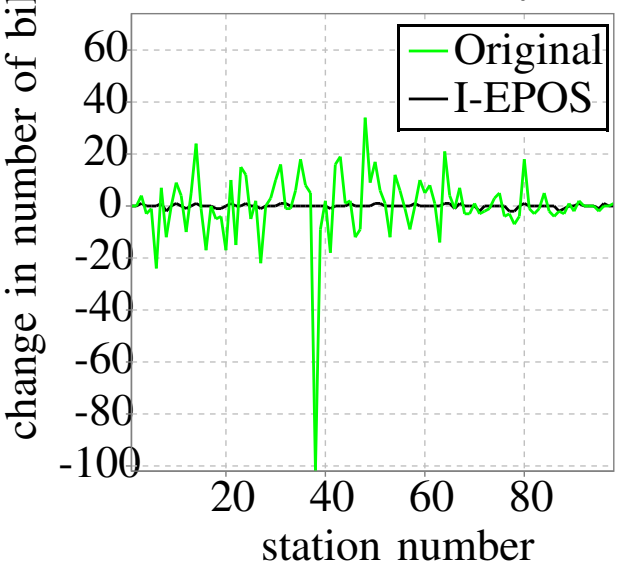
Final selections

EPOS functionality

1 bottom-up + 1 top-down phase = 1 learning iteration

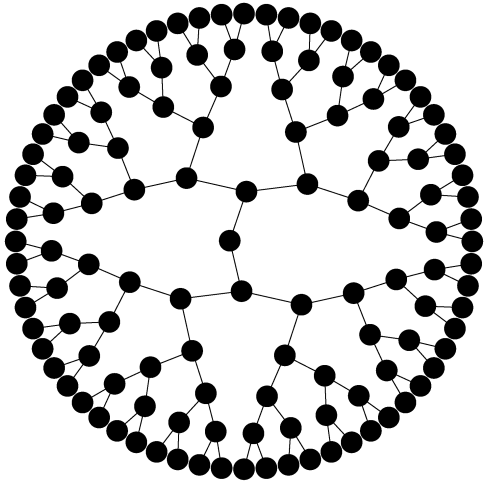
Proof-of-concept

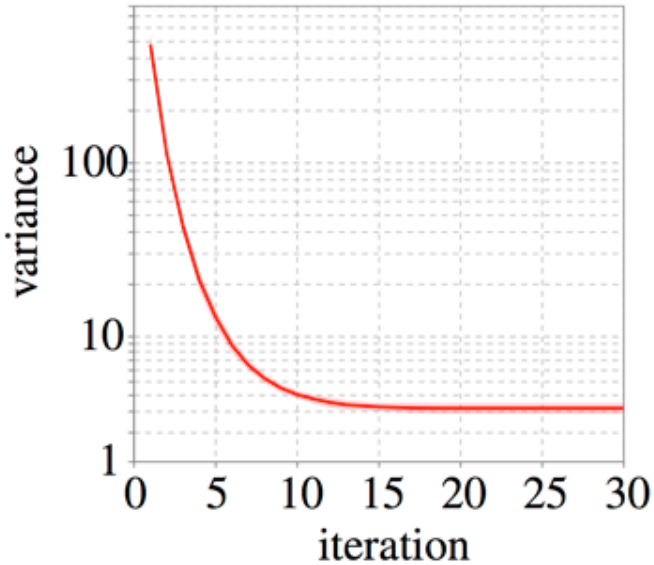




Pacific Northwest SMART GRID DEMONSTRATION PROJECT

Power peak-shaving





Stations load-balancing

Hubway Data Visualization Challenge

Social Measures

Mean agents' local cost

Social Discomfort

$$E_L = \mu\{f_L(\mathbf{s}_{\mathfrak{a}}) \mid \mathfrak{a} \in \mathcal{A}\}.$$

Normalized standard deviation of the agents' local cost

Social Fairness

$$U = \frac{\sigma\{f_L(\mathbf{s}_{\mathfrak{a}}) \mid \mathfrak{a} \in \mathcal{A}\}}{\mu\{f_L(\mathbf{s}_{\mathfrak{a}}) \mid \mathfrak{a} \in \mathcal{A}\}}.$$

Related Work

Large-scale decentralized combinatorial optimization

Very limited work

COHDA, EPOS, Greedy

Exchange of full information

computatially expensive brute force operations

network fragility

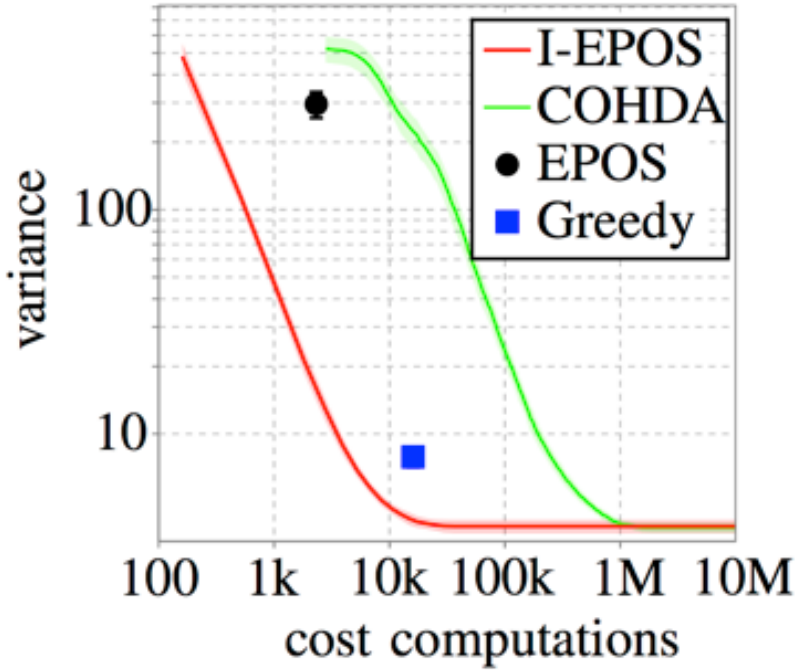
E. Pournaras, M. Warnier, and F. M. Brazier, “Local agent-based self-stabilisation in global resource utilisation,” *International Journal of Autonomic Computing*, vol. 1, no. 4, pp. 350–373, 2010.

C. Hinrichs, S. Lehnhoff, and M. Sonnenschein, “COHDA: A combinatorial optimization heuristic for distributed agents,” in *International Conference on Agents and Artificial Intelligence*. Springer, 2013, pp. 23–39.

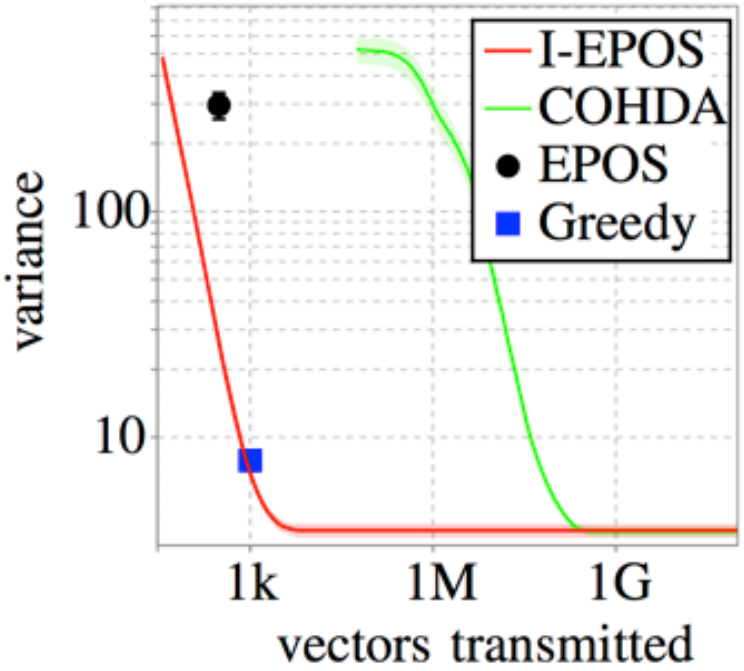
Comparison with Related Work

Superior performance even when compared to systems storing complete information & performing expensive brute-force operations

Computational cost

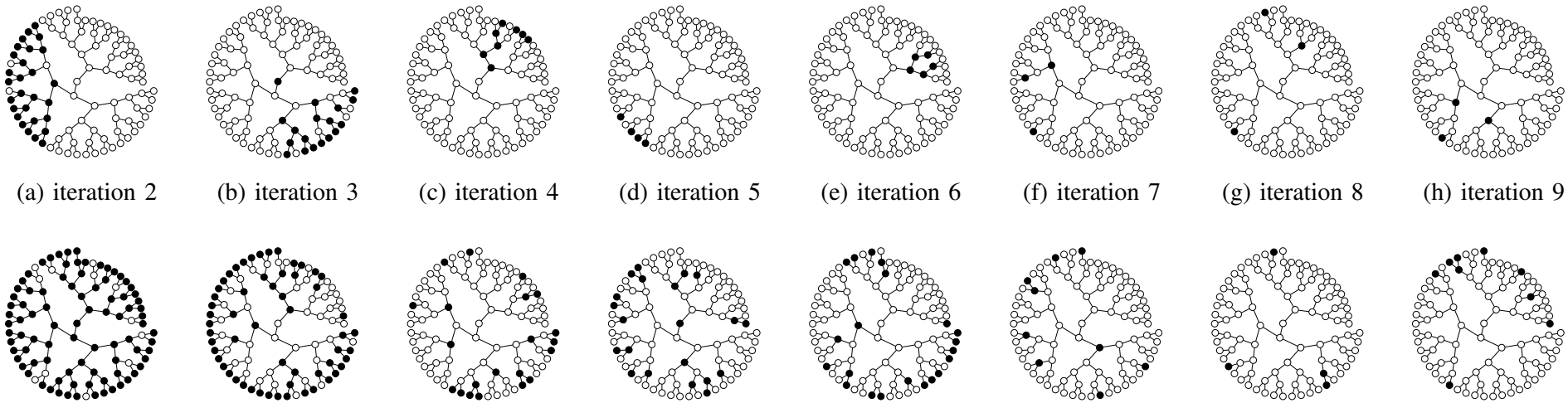


Communication cost



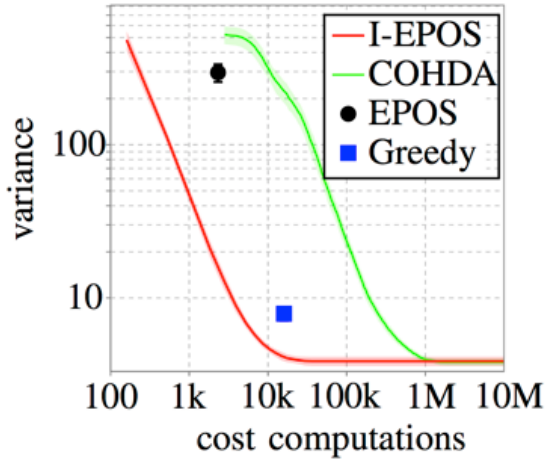
I-EPOS vs. COHDA

I-EPOS



COHDA

Converges faster with fewer changes!



Community Target Groups

System developers & researchers

artifact extension, new optimization algorithms, benchmarks use

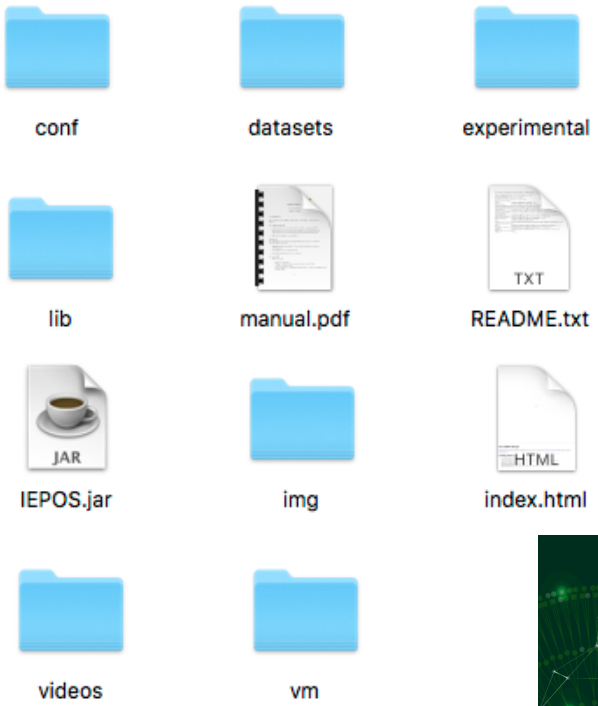
Policy-makers & non-computer scientists

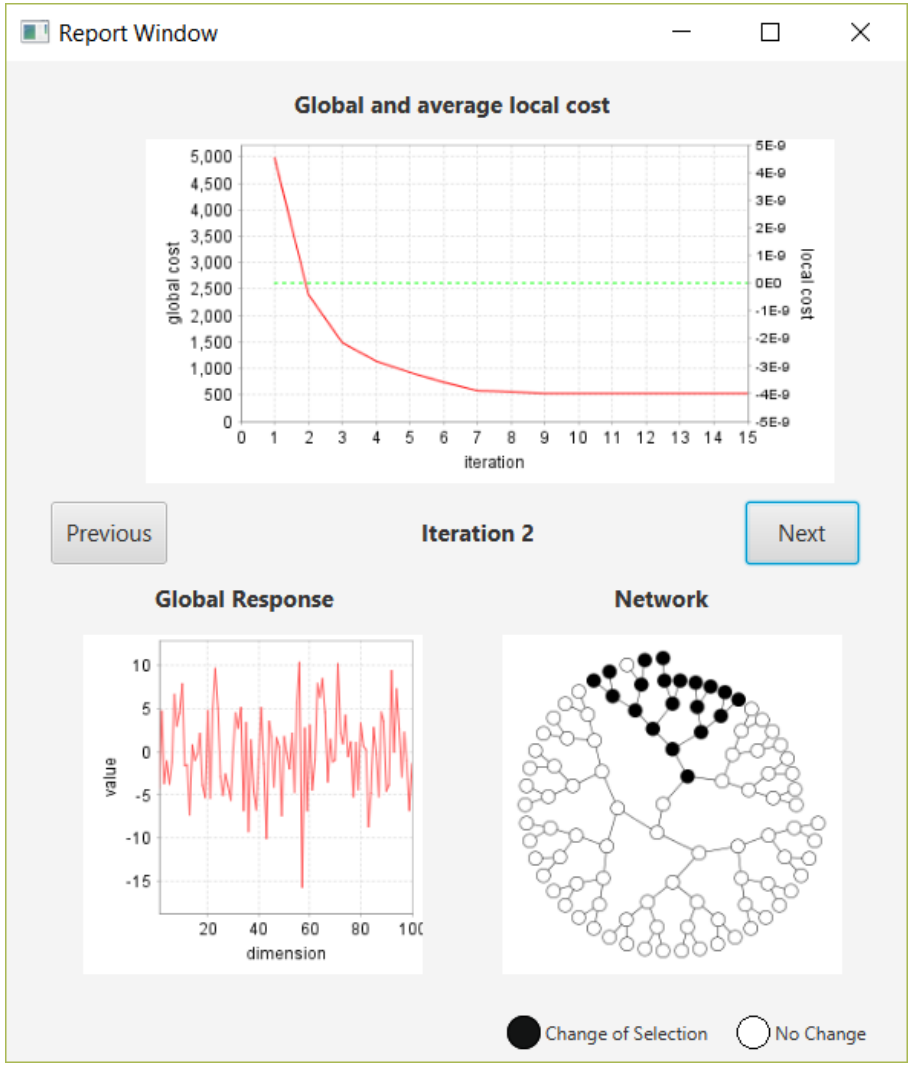
GUI use for evaluation of datasets system scenarios

Enterpreneurs

Virtual laboratory of innovation, evaluation of new application & business use cases

Download it Today!





Download the software exemplar (2.7 GB)

http://epos-net.org/shared/I-EPOS.zip

Follow the instructions: index.html

Open source: https://github.com/epournaras/EPOS/

Demonstration

Questions?

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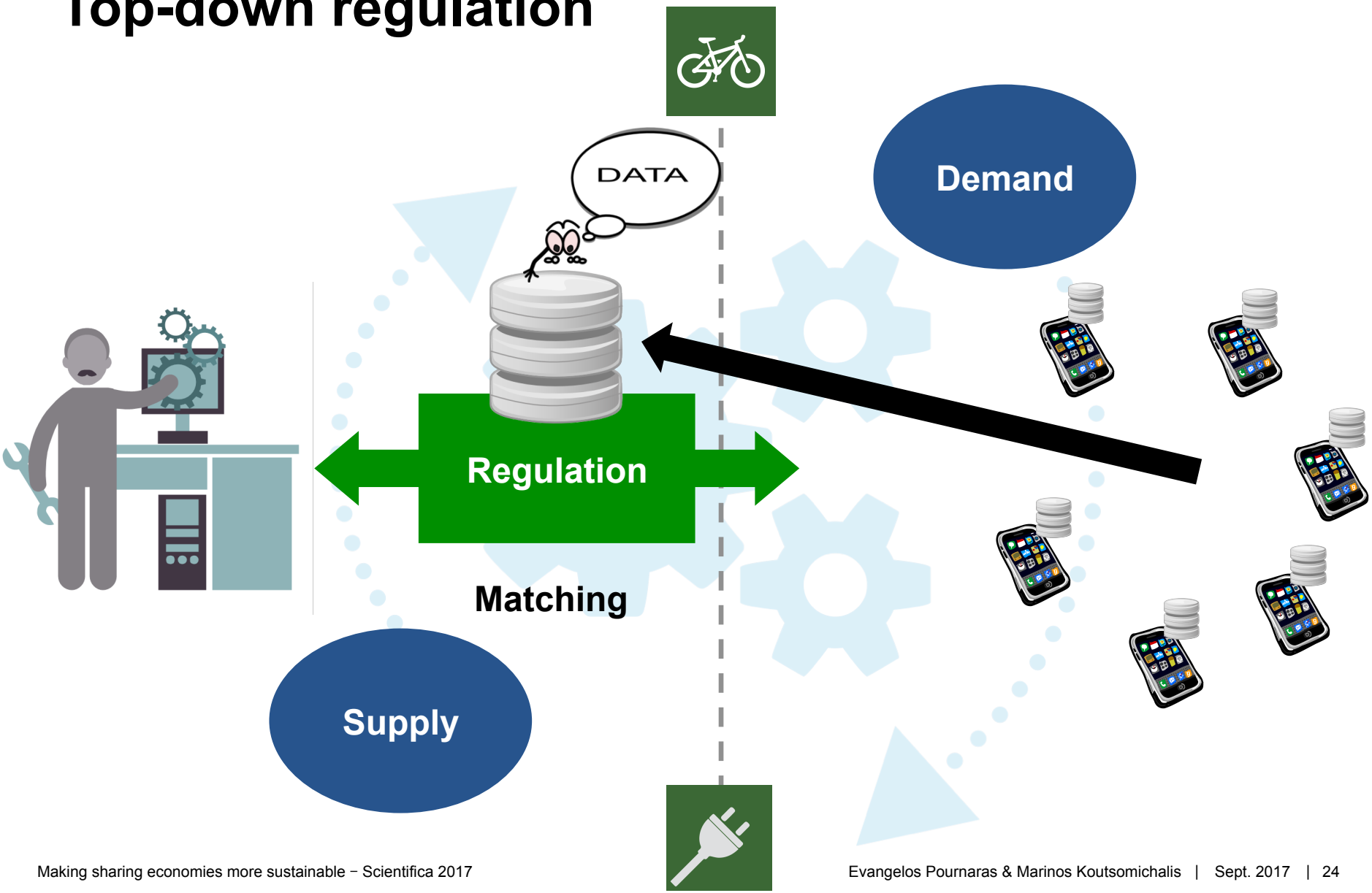
epos-net.org

References

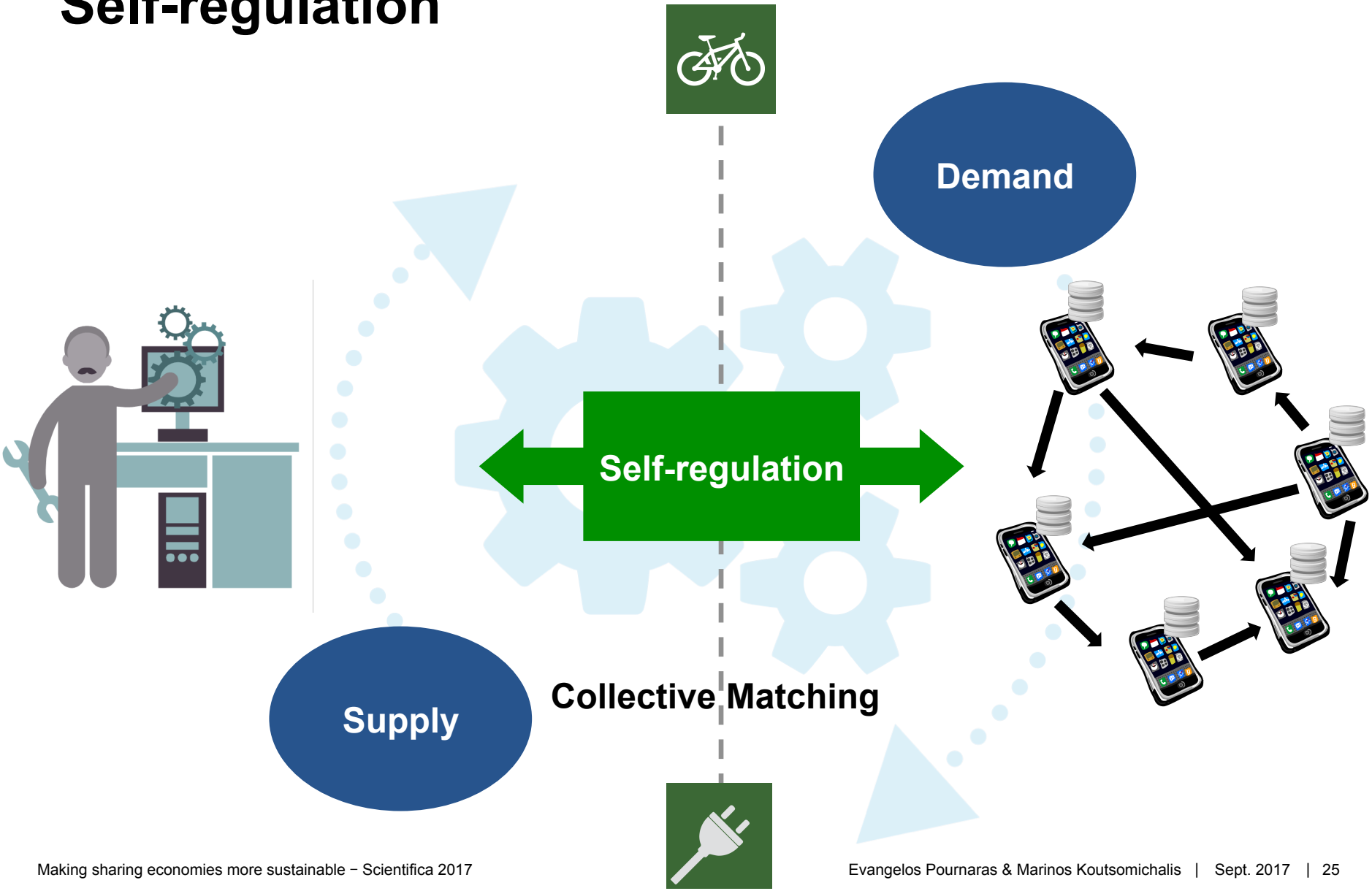
[1] Peter Pilgerstorfer and Evangelos Pournaras, Self-adaptive Learning in Decentralized Combinatorial Optimization-A Design Paradigm for Sharing Economies, in the Proceedings of the 12th International Symposium on Software Engineering for Adaptive and Self-managing Systems-SEAMS-2017, Buenos Aires, May 2017 © IEEE

Backup Slides

Top-down regulation



Self-regulation



Libraries

Protopeer: simulation/live, deployment, logging, etc.

JUNG: tree topology visualization

JFreeChart: Ploting for performance evaluation

JavaFX: Interactive UI