SYSTEM-OF-SYSTEMS THAT ACT LOCALLY FOR OPTIMIZING GLOBALLY

EU FP7 - SMALL/MEDIUM-SCALE FOCUSED RESEARCH PROJECT (STREP)
FP7-ICT-2013.3.4: ADVANCED COMPUTING, EMBEDDED AND CONTROL SYSTEMS
D) FROM ANALYZING TO CONTROLLING BEHAVIOUR OF SYSTEM OF SYSTEMS (SOS)

The Local4Global System (WP3/WP4): Methodological Advances

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Local^{4}Global
Contact Information

For information regarding this Project: Check the Project Web-Site: http://local4global-fp7.eu

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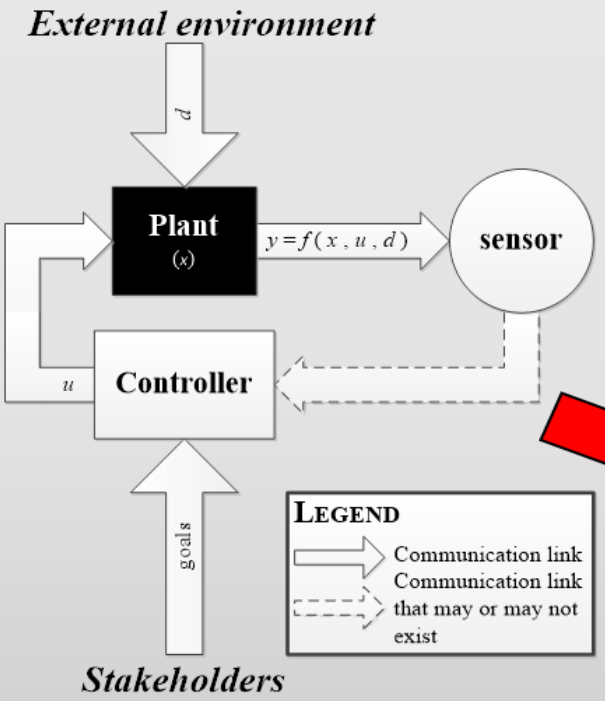
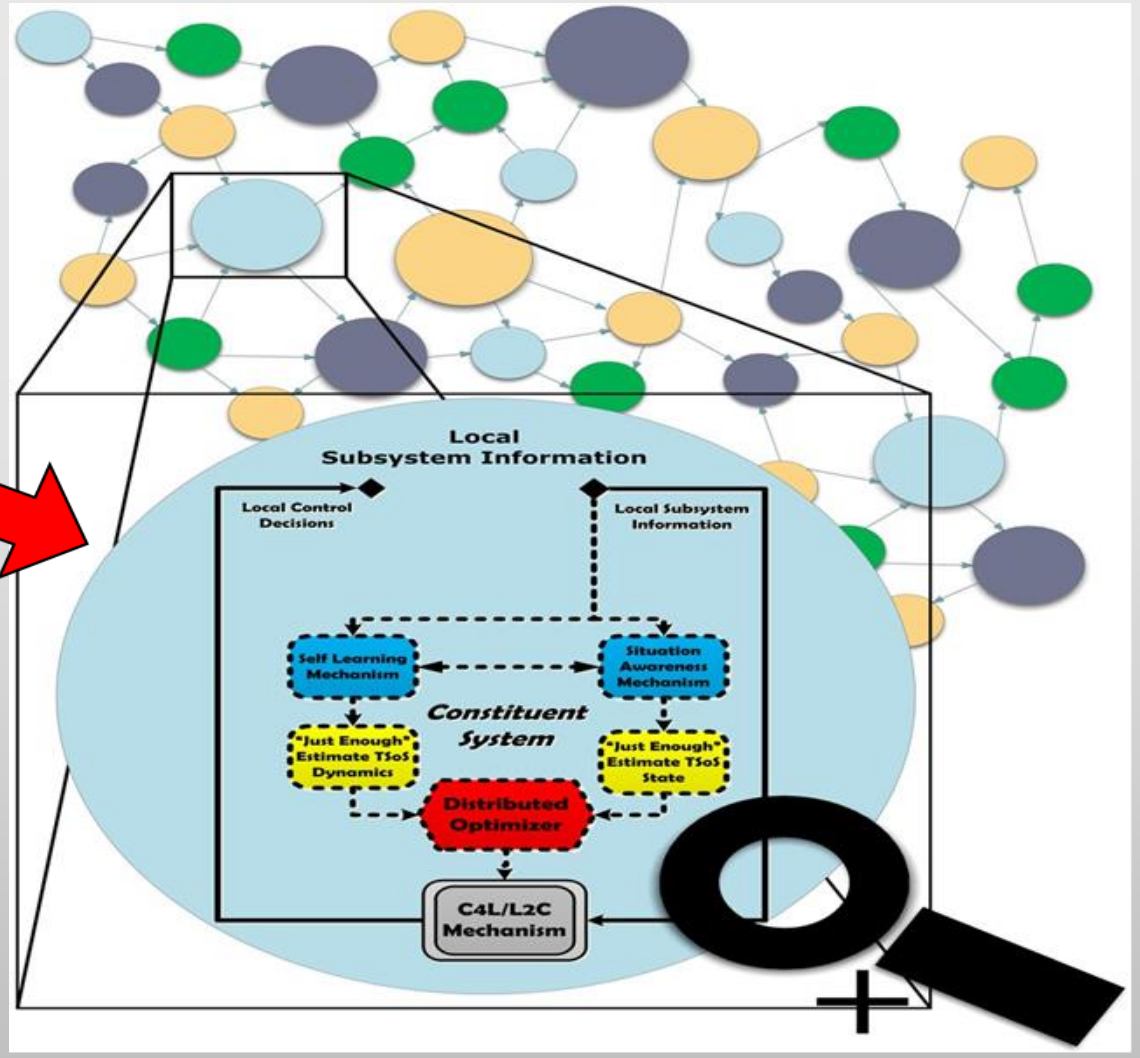
The Local4Global pursued response to TSoS control vs traditional control approaches





The basis: Cognitive Adaptive Optimization

- CAO=Cognitive Adaptive Optimization
- Problem it solves (Mathematical formulation):

  Optimize the objective function J(X) when there is no analytical formula for J.
- Algorithm format:

  $$X(k+1)=X(k)+\mathbf{P}(X(k), J(k))$$
- Similar convergence properties as classical optimization methods (which require analytical expression of J)
- Very computationally efficient
- Applications: fine-tuning of Large-Scale Control Systems, Robotics, Image Retrieval, etc.
- Extension to Control System Design: the PCAO algorithm (objective function is a cost related to the optimal control-based JHB equation)

Just-Enough-Learning CAO (or Big-Data CAO)

- N agents (constituent systems) interacting and cooperating towards optimizing a total cost criterion J.

$$J=J(X1, X2, \ldots, Xj, \ldots, Xn)$$

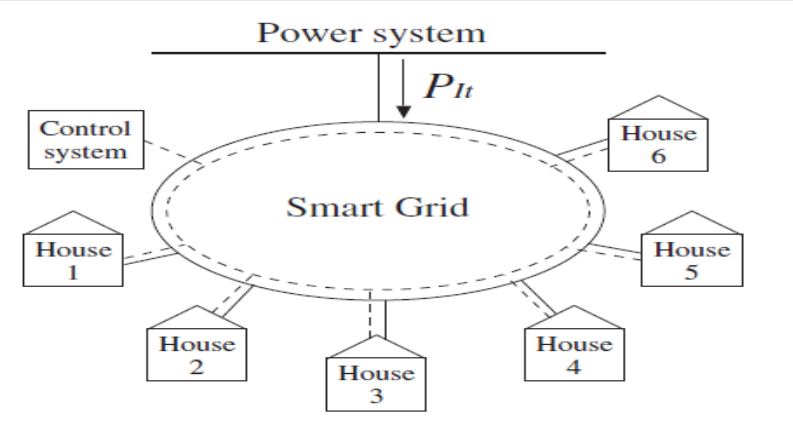
- *X1, X2, …, Xj, …, Xn* are the vectors to be optimized by each agent.
- Classical optimization tools require that each agent has information about all *X1, X2, …, Xj, …, Xn*
- Moreover, usually they require knowledge of the analytic form of J.
- Just-enough-learning CAO: each agent needs two types of information at each iteration:
  - the local vector to be optimized.
  - the measured values of the total cost.
- Mathematically speaking, the “Just-Enough-Learning” CAO operates as follows:

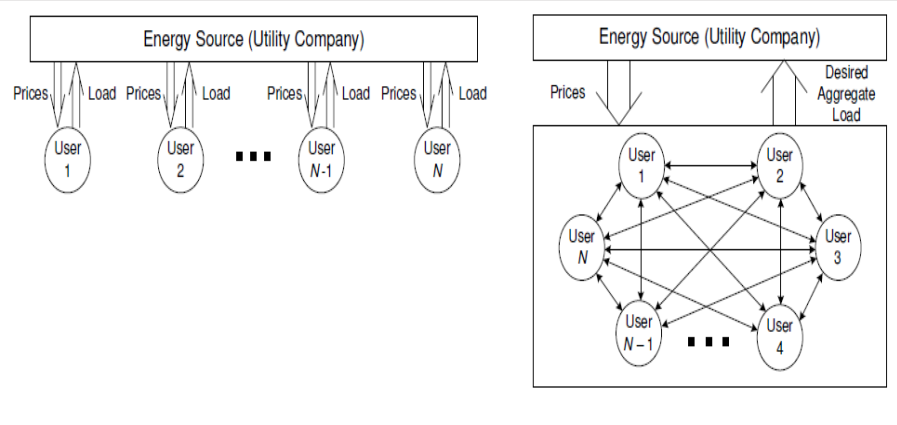
$$Xj(k+1)=Xj(k)+\mathbf{Pj}[Xj(k), J(k), J(k-1), \ldots., J(k-p)]$$

Extensions Just-Enough-Learning PCAO (or Big-Data PCAO)

- Extension to control systems design using the HJB
- Each agent's controller uses only local measurements as well as the global cost value.
- Need to "estimate" what is happening: just-enough-situation awareness
- Convergence and stability, as well as computational simplicity.
- No need for a model for the system
- Two different "modes" of operation:
  - Fully adaptive (model free)
  - "Tuner" for model-based controllers

A “small” SoS benchmark for testing theoretical achievements





Each house has different occupant schedules/needs

Each house has 3-4 control elements/Houses=apartments in the same building

L4G control (with local measurements) achieved almost the same performance as the globally optimal (full knowledge of the SoS dynamics and states) at the expense of slower convrgence.

Controller	Savings/Improvements	Iterations
Globally optimal	**55%**	**450**
Globally optimal/local information	**20%**	**650**
L4G	**55%**	**650**