

What is a Cognitive Grid?

- Smart Grid is the term used for the set of technologies that will enable a more efficient and real-time informed power generation, transmission and consumption system
- A Cognitive Grid is a Smart Grid that acts as a self-aware whole rather than having scattered smartness. is a new paradigm for architecting learning and self-adaptive power generation enterprises that can dynamically adjust their resources, configuration and outputs to meet the constantly changing external and internal conditions, requirements and needs.
- It learns holistically, and its goal is systems-level efficiency, resiliency and security
- It dynamically adjusts performance, striving for real-time optimization of all three network layers of a power generation system (physical, data, social)

Research Objective:

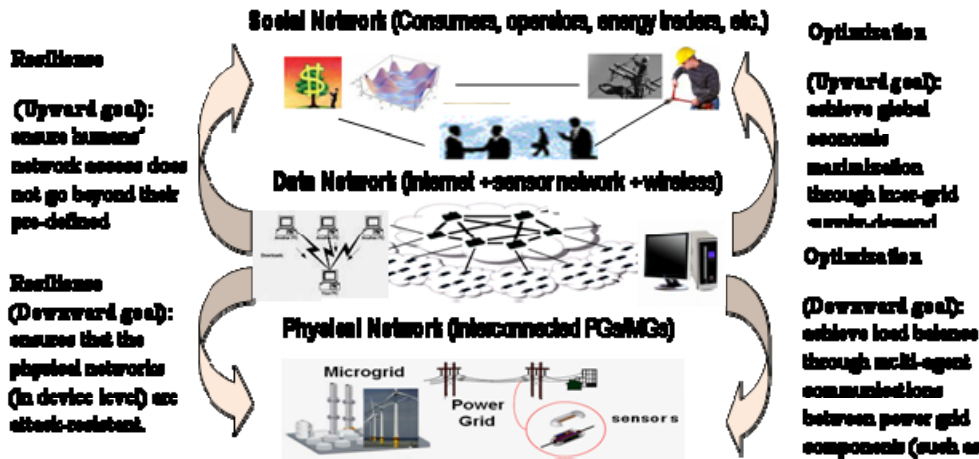
The objective of this research is to model the smart power grid as a Cognitive Enterprise with the ability to sense and/or forecast the pertinent changes, contextualize the information, make timely decisions that affect resource allocation and product configuration, monitor the impact of these decisions and learn for improved future decision-making.

Methodology: Multi-Agent Optimization

$$R(t_k) = U(t_k) - C(t_k),$$

$$U(t_k) = \frac{\sum_{t_s}^t f(P)}{t_e - t_s},$$

$$C(t_k) = \begin{cases} \frac{C(X)}{t_e - t_s} & t_e - t_s > t_{delay} \\ C_{max} & otherwise \end{cases}$$



Formulating the Optimization Problem

The optimization problem can be formulated as follows:

$$\begin{cases} \text{Minimize } C_{total}(z, t) \\ = \sum_1^i C_{pg,z}(i, t) \times G_{pg,z}(i, t) + \sum_0^j C_{dg,z}(j, t) \times G_{dg,z}(j, t) + \sum C_{imp}(zp, t) \times F_{imp}(zp, t) \end{cases}$$

Given the constraints:

$$\begin{cases} \sum_0^i G_{pg,z}(i, t) + \sum_0^j G_{dg,z}(j, t) + \sum F_{imp}(zp, t) = D_z(t) \\ G_{pg,z}(i, t) < CapG_{pg,z}(i, t) \end{cases}$$

Where $C_{total}(z, t)$ is the total power production cost within the power grid operated by operator z within time period t in dollars, $C_{pg,z}(i, t)$ is the cost of power produced at facility i within the grid operated by z at within time period t in dollars per MW, $G_{pg,z}(i, t)$ is the amount of electricity generated within centralized facility i within the grid operated by z , $C_{dg,z}(j, t)$ is the cost of power produced at distributed generation facility j connected to the grid operated by z at within time period t in dollars per MW, $G_{dg,z}(j, t)$ is the amount of electricity generated within distributed generation facility j connected to the grid operated by z , $C_{imp}(zp, t)$ is the cost of electricity sold by neighboring agent zp , $F_{imp}(zp, t)$ is the amount of electricity purchased from neighboring grid zp during time period t and $CapG_{pg,z}(i, t)$ is the maximum power generation capacity of facility i within grid operated by z . $D_z(t)$ is the total demand on the power grid during time period t and can be predicted based on Eq. 8 or measured with delay using the sensors on the physical network