179 A Scenario on Market Based Automatic Generation Control

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1. Introduction

In a deregulated environment, Automatic Generation Control (AGC), as an ancillary service essential for maintaining the system reliability, acquires a fundamental role to enable power exchanges and to provide better conditions for the electricity trading. Since the AGC system is faced by new uncertainties in the liberalized electricity market, a reevaluation in traditional modeling and control structures is highly needed.

In response to the coming challenge of integrating computation, communication and control into appropriate levels of system operation and control, this work introduces a multi-agent based scenario to perform the automatic generation control task in a deregulated environment.

2. Overal Framework

In a liberalized electricity market, control is highly decentralized. Each load matching contract requires a separate control process, yet this control processes must cooperatively interact to maintain system frequency and minimize time error. Since a separate control process is needed for each load matching contract, there must be a Virtual Control Area (VCA) associated with each contract group. Therefore, the concept of physical control area is replaced by VCA. The boundary of the VCA encloses the Gencos and the Discos associated with the contract. The Discos receive the regulating power directly or through Transmission companies (Transcos). Such a configuration with a multi-agent based control center is shown conceptually in Fig. 1. Each VCA will be interconnected to each other either through Transco or Gencos.

The proposed multi-agent based control framework includes two main agents: Data Acquisition and Monitoring (DAM) agent, and, Decision and Control (DC) agent. The Gencos send the bid regulating reserves *Fi($,t)* to the DAM agent through a secure internet service. The DAM agent sorts these bids by pre-specified time period and price. Then, it sends the sorted regulating reserves with the demanded load from Discos and the measured tie-line flow and area frequency to the DC agent, continuously. DC agent checks and resorts the bids according the congestion condition and screening of available capacity. Then DC agent computes the Area Control Error (ACE) signal and the participation factors $\alpha_i(t)$ in order to load following by the available Gencos to cover the total contracted load demand $\sum \Delta P_{Li}(t)$ and local load disturbance $\Delta P_{di}(t)$. The tracking of load disturbance (uncontracted demand) in each distribution area is considered as a contract violation case and the related cost must be paid by the corresponded Disco(s)[1].

It is assumed that in a VCA, the necessary hardware and communication facilities to enable reception of data and control signals are available and Gencos can bid up and down regulations by price and MW-volume for each predetermined time period T to the regulating market. Also the control center can distributes load demand signals to available generating units on a real-time basis.

3. Participation Factors

The participation factors which are actually time dependent variables, must be computed dynamically by DC agent based on the received bid prices, availability, congestion problem and other related costs in case of using each applicant (Genco). The following computation method may give a useful solution for this purpose.

Assume that DC agent determines a regulating price R_{Pi} for each applicant based on the mentioned aspects and the all yielding costs, and

$$R_{P1} < R_{P2} < \cdots < R_{Pn} \qquad \text{………………... (1)}$$

The DC agent prepares a priority list sorted by regulating price as given in table 1. Then DC agent tries to fully utilize the capacity of one regulating object in the table, before calling on the next which is more expensive. In each T step, the DC agent is comparing the total load demand and available unit capacity. First, the capacity of the cheapest unit is checked. If this is sufficient to cover the demand, the participation factor of the unit is set equal to 1, otherwise to cover the total load demand, the second cheapest item is considered and so on.

Table 1. The sorted list for $T_i < t < T_{i+1}$.

	Genco 1	*Genco 2*	…	*Genco n*
Regulating power (MW)	P_{g1}	P_{g2}	…	P_{gn}
Regulating price ($/MW)	R_{P1}	R_{P2}	…	R_{Pn}

For three (or more units) the participation factors are calculated to set all but the most expensive unit in use at the minimum capacity. In a given VCA, the sum of participation factors will always be equal to 1.

$$\sum_{i=1}^{n} \alpha_i(t) = 1 \qquad \text{………………... (2)}$$

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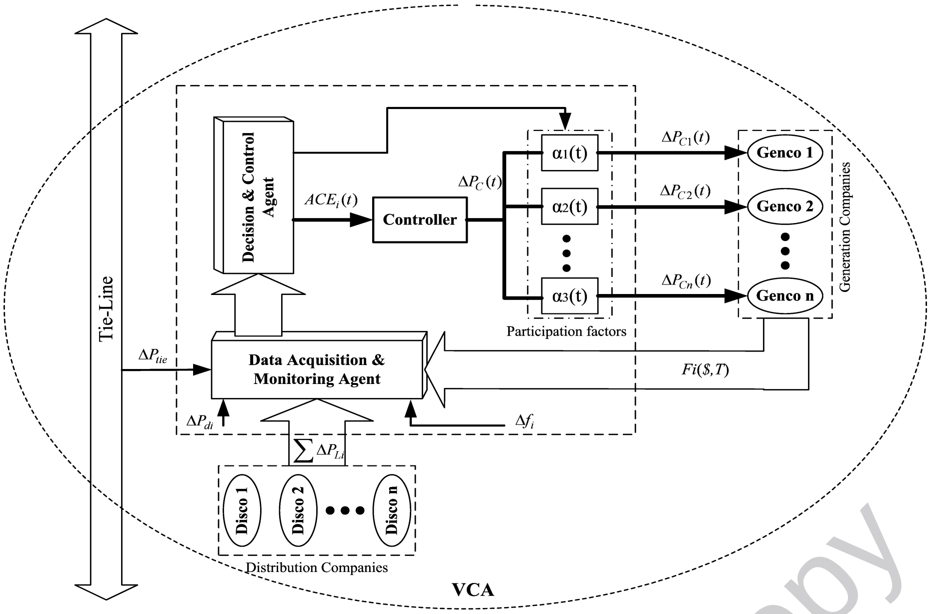

Fig. 1. Proposed multi-agent based AGC scheme

Based on above explanation for each time step *T*, the area participation factors to be computed as fallows:

$$\alpha_1(t) = \begin{cases} \dfrac{P_{g1}(t)}{M(t)} & ; \quad M(t) > P_{g1}(t) \\ 1 & ; \quad M(t) \le P_{g1}(t) \end{cases} \quad \text{........ (3)}$$

and

$$\alpha_k(t) = \begin{cases} \dfrac{M(t) - P_{g1}(t) - P_{g2}(t) \cdots - P_{gk-1}(t)}{M(t)} & ; \quad \sum_{i=1}^{k-1} \alpha_i < 1 \\ 0 & ; \quad \sum_{i=1}^{k-1} \alpha_i = 1 \end{cases}$$

.... (4)

where,

$$M(t) = \sum \Delta P_{Li}(t) + \Delta P_{di}(t) \quad \text{.................... (5)}$$

Therefore, each Genco will share to the area load following according to its determined participation factor.

$$\Delta P_{Ci}(t) = \alpha_i(t) M(t) \quad \text{.................... (6)}$$

and,

$$\sum_{i=1}^{n} \alpha_i(t) \Delta P_{Ci}(t) = M(t) \quad \text{.................... (7)}$$

Where $M(t)$ is satisfied by the control signal $\Delta P_C(t)$ shown in Fig. 1.

Since both of the number and the order of AGC participant Gencos may change, an important challenge in this subject is the transition from T_i to T_{i+1} . In this condition, a desired algorithm must be able to carry out a smooth transition from one set of units to another. A simple scenario is given in Ref. (2).

4. Dynamic Controller

Each participating unit will receive its share of the demand $\Delta P_{gi}(t)$, according to its participation factor, through a dynamic controller which it usually includes a simple PI structure in real world power system. The optimal tuning of PI controller is very important to meet the robust performance for a wide area operating conditions. Optimal PI parameters ensure a smooth coordination between generator set-point signals and the scheduled operating points $\alpha_i(t)\Delta P_C(t)$. Some effective design methodologies are already developed by authors for tuning the PI parameters[3,4].

Acknowledgments

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