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APPLYING AGENT-BASED COORDINATION MECHANISM TO MITIGATE VOLTAGE FLUCTUATIONS

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Abstract. Increasing share of distributed renewable resources (DRES) in low voltage (LV) and medium voltage (MV) networks raises new technical and power quality challenges such as voltage fluctuation, which limits further penetration of DRES in LV and MV networks. This paper aims to develop a coordination control mechanism for solving voltage fluctuation based on Muti-Agent System (MAS) technology. The proposed solution includes communication free fast control that estimates future state variables based on input from forecasting model and slow control that acts as secondary control layer, which ensures integrity of voltage control system.

Keywords: Multi-Agent System, centralised control, decentralised control, voltage fluctuations, voltage regulation

INTRODUCTION

The share of distributed renewable resources (DRES) in LV and MV networks is being increased in recent years. Though government policies and market encourage the penetration of DRES, power quality problems such as voltage fluctuation along the feeder act as bottleneck for further penetration of DRES in LV and MV networks [1]. INCREASE is an EU-FP7 project that aims to increase the share of DRES in LV and MV networks by solving technical bottlenecks including voltage fluctuation. This paper addresses an agent-based coordination mechanism developed for INCREASE.

Technologies used for mitigating voltage fluctuations vary from smart control of HV/MV transformer [2], reactive power compensation, curtailment of DRES, or Information and Communication Technology (ICT) aided active control of DRES. These technologies can be categorized as centralised, decentralised, or hybrid control actions. This paper analyses centralised, decentralised, and hybrid control technologies, thus reveals an effective approach for solving voltage problem in LV and MV networks.

At present use of advancement in ICT for smarter control of electric power network cannot be neglected. MAS is a promising method for exploiting advancements in ICT to solve challenges in LV and MV networks [3]. A concept was developed that creates synergy by combining forecasting technologies, advancements in ICT, and power electronics; which will be explained in this paper.

MULTI –AGENT SYSTEM

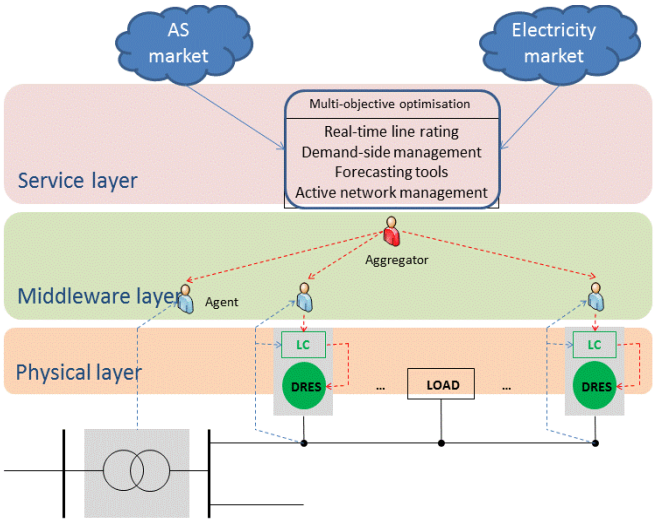

Figure 1 MAS system in INCREASE

Agent is piece of code that represents device and its characteristics, which also inherits *reactivity*, *pro-activeness* and *social ability [3]*. Number of agents and corresponding architecture is called as Multi Agent System. MAS is an effective way of addressing environment where each entity perceives different level of importance for the same goal that leads to conflict of interest. For instance, changing tap setting of a smart transformer may be beneficial for a feeder; conversely, another feeder may suffer from high/low voltage problem. MAS is capable of managing such conflict of interest by introducing negotiation and coordination mechanism. As illustrated in figure 1, agents serve as middleware layer that bridge the hardware layer with the service layer. The middleware layer compensates lack of flexibility of the hardware layer and lack of interface ability of the service layer thus acts as an ideal bridge.

CENTRAL VS DECENTRALISE CONTROL

Centralised control is replica of HV grid management system that engineered for MV and LV networks, which includes complex communication network. Thus, reliability of centralised control may be jeopardised when communication fails or communication delay increases. In contrast, decentralised control technologies only uses local measurement thus free from communication and associated problems. The decentralised control technologies are not matured as centralised control technologies. Thipnatee Sansawatt et al. [4] explained number of decentralised control technologies and limitation of respective technologies. A hybrid approach is proposed by D.B. Megherbi [5], which exploits benefits from both centralised and decentralised control technologies; however, even this approach is communication dependant. Since centralised control relatively encourages penetration of DRES [4], decentralised control is comparatively less matured, and field trials of INCREASE will be based on master slave communication architecture, it was concluded that centralised control is efficient approach for minimising voltage fluctuation.

AGENT-BASED COORDINATION MECHNISM

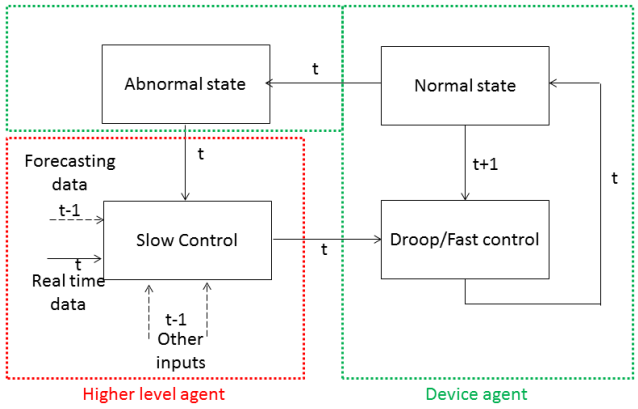

Figure 2 Controls in INCREASE

To mitigate the voltage fluctuation problem in LV and MV networks, three layers of control have been proposed which are droop control, fast control and slow control. Droop control is an integral part of inverter, which implemented at power electronics level of the inverter; Fast control needs to be free of communication to ensure reliability of system; slow control should be act as auxiliary protection layer in case of primary control fails. In proposed control architecture, droop, fast control act as primary control and slow control acts as auxiliary control. Figure 2 explains droop control, fast control, slow control, and associated agents. In fast control, future state variable are calculated using forecasting data of supply and demand; hence need of real time measurements to calculate state variables is eliminated therefore reliability of the fast control is increased. In this paper forecasting data are used instead of pseudo measurements hence results would be more valid than pseudo measurements based distributed control [2]. Slow control acts as auxiliary control and it will be activated when device agent experiences abnormality thus ensures reliability of control architecture.

CONCLUSION

Conflict of interest in LV and MV networks cannot be ignored, which can be addressed effectively by MAS. Study of development of MAS technology resulted that centralised control based MAS likely to be effective approach for developing and testing the solutions for voltage fluctuations in LV and MV networks. Coordination of communication free fast control is achieved by calculating state variables based on forecasting data, which eliminates the need of real time measurements and communication in fast control thus increases the reliability of control system. In addition to this, slow control acts as auxiliary control, which further increases the reliability of MAS based voltage control system.

REFERENCES

[1] Chen, L., Univ. of Manchester, M. U., Qi, S., & Li, H. (2012). Improved Adaptive Voltage Controller for Active Distribution Network Operation with Distributed Generation. *Universities Power Engineering Conference (UPEC), 2012 47th International*, (pp. 1-5). London.

[2] Linwei Chen, Shaofan Qi and Haiyu Li, " Improved adaptive voltage controller for active distribution network operation with distributed generation", Universities Power Engineering Conference, London, UK, 2012

[3] Phuong H. Nguyen, PhD Thesis, "Aulti-Agent System based Active Distribution Network", Eindhoven University of Technology, 2010

[4] Panahis N. Vovos, Aristides E. Kiprakis, A. Robin Wallace and P.Harrison, "Centralised and Distributed Voltage Control: Impact on Distributed Genration Penetration", IEEE Transaction on Power Systems, Vol. 22, No. 1, Feb 2007

[5] D. B. Meghebi and M. Madera, "A Hybrid P2P and Master-Slave Architecture for Intelligent Multi-Agent Reinforcement Learning in A Distributed Computing Ennvironment: A Case Study", Dept. of Electr. & Comput. Eng., Univ. of Massachusetts, MA, USA, 2010