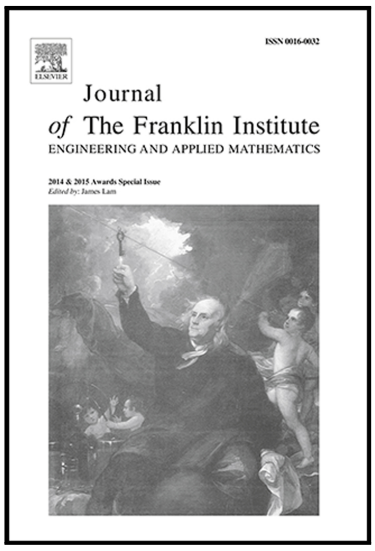


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# Non-centralized Control for Flow-based Distribution Networks: A Game-theoretical Insight

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**Abstract**

This paper solves a data-driven control problem for a flow-based distribution network with two objectives: a resource allocation and a *fair* distribution of costs. These objectives represent both cooperation and competition directions. It is proposed a solution that combines either a centralized or distributed cooperative game approach using the Shapley value to determine a proper partitioning of the system and a fair communication cost distribution. On the other hand, a decentralized non-cooperative game approach computing the Nash equilibrium is used to achieve the control objective of the resource allocation under a non-complete information topology. Furthermore, an invariant-set property is presented and the closed-loop system stability is analyzed for the non-cooperative game approach. Another contribution regarding the cooperative game approach is an alternative way to compute the Shapley value for the proposed specific characteristic function. Unlike the classical cooperative-games approach, which has a limited application due to the combinatorial explosion issues, the alternative method allows calculating the Shapley value in polynomial time and hence can be applied to large-scale problems.

*Key words:* Flow-based distribution networks, population games, Nash equilibrium, cooperative games, Shapley value, dynamic resource allocation, partitioning approach, distributed control.

## 1 Introduction

The ideal centralized control scheme in which a single entity governs a system using full information, disposing of enough time to gather all the measurements, and to compute and transmit all the control inputs, may not be realistic for certain systems. Real large-scale control problems usually present issues that limit the application of centralized control strategies, e.g., fast dynamics with demanding response times, unavailability of full information, intractability of the problem due to its sheer size, among others. These issues are of special interest in the control field and a great effort has been placed into the development of non-centralized control techniques in order to mitigate them. In addition, significant technological changes have occurred during the last decades that have modified the way these problems are addressed. This is particularly visible if the methods used some decades ago [34] are compared with those used today [17]. Nowadays, computing and networking elements are pervasive and state-of-the-art control techniques are more and more sophisticated to take advantage of the new possibilities that technology offers.

This paper focuses on one of the recent trends in the development of non-centralized control techniques. In particular, during the last years different control strategies, which are able to adapt dynamically to the evolution of the system

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