

Section IV



Title of Project : Fusion of Computer Science, Engineering and Mathematics Approaches for Expanding Combinatorial Reconfiguration

ITO Takehiro
(Tohoku University, Graduate School of Information Sciences, Professor)

Number of Research Area : 20B401 Researcher Number : 40431548

【Purpose of the Research Project】

Combinatorial reconfiguration is a novel algorithmic concept that provides mathematical models and analysis for “transformations over state spaces.” Its appearance ranges from theory to applications. However, its technical achievements are hard to access. This research project aims at founding a common infrastructure for utilizing and applying the algorithmic technology of combinatorial reconfiguration. The research groups consist of computer scientists, engineers, and mathematicians who cooperatively work for establishing the algorithmic foundation, the implementation technology foundation, and the mathematical foundation of combinatorial reconfiguration. Then, we establish the fundamental theory that is useful for software development and integration.

【Content of the Research Project】

Consider power distribution systems as a concrete situation of combinatorial reconfiguration. A power distribution network is designed as it has multiple numbers of routes for supplying electricity. For example, the Japan standard model of power distribution networks has approximately ten octodecillion alternatives for the choice of network configurations. Even the computation of a single optimal configuration among them is out of reach. Furthermore, even if we may compute a single optimal configuration, we encounter another issue. Namely, upon a switching procedure to reconfigure the current configuration to the optimal one, we may not allow any power failure during the process. This requires us to develop a switching procedure that does not cause power failure upon the process over the state space consisting of approximately ten octodecillion alternatives from the current configuration to an optimal configuration. This is a typical example of “transformations over state spaces” which is the target of the algorithm theory called “combinatorial reconfiguration.”

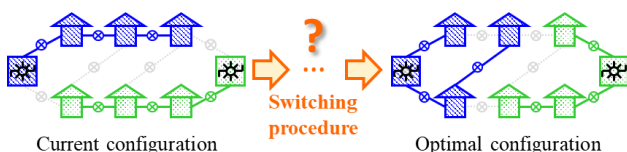


Figure 1. Example of power distribution systems

Combinatorial reconfiguration appears in various areas of research and practice, and experiences successes ranging over several fields. However, the technology of combinatorial reconfiguration is only available to the

experts who study it, and researchers in other areas and practitioners need to access those experts. On the other hand, Mathematica for symbolic computation and SAT solvers and IP solvers for combinatorial problems provide the foundations for non-experts, who can easily access those technologies and solve problems in their domains. Regretfully, combinatorial reconfiguration lacks such a common infrastructure.

In this research project, computer scientists, engineers, and mathematicians cooperatively work for founding a common infrastructure for utilizing and applying the algorithmic technology of combinatorial reconfiguration.

Group A01 with the computer science background finds “algorithmic meta-theorems” for combinatorial reconfiguration, and aims at automatic generation of combinatorial reconfiguration algorithms.

Group B01 with the engineering background finds the “implementation technology” for combinatorial reconfiguration, and aims at software development as a communication infrastructure common to theoretical research and industrial applications.

Group C01 with the mathematics background finds the “mathematical theory” for combinatorial reconfiguration, and proposes new mathematical methods that are useful for combinatorial reconfiguration.

【Expected Research Achievements and Scientific Significance】

As combinatorial reconfiguration appears in various fields, if the common infrastructure is established, the concept of “computation” can be introduced in a wide range of fields. This research project will provide the way of computation even for non-experts, and an opportunity for these fields to bring about new changes.

【Key Words】

- Combinatorial reconfiguration: A research topic that models transformations over state spaces, and analyzes the complexity of algorithms and computation.

【Term of Project】 FY2020-2022

【Budget Allocation】 123,700 Thousand Yen

【Homepage Address and Other Contact Information】

<https://core.dais.is.tohoku.ac.jp/>
core.info@grp.tohoku.ac.jp