

論文内容の要旨

博士論文題目

A Study on Uniform k -partition and Graph Class Identification in the Population Protocol Model

個体群プロトコルモデルにおける k 分割問題とグラフ形状判定問題に関する研究

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(論文内容の要旨)

In recent years, autonomous distributed systems consisting of low-performance devices have attracted attention. For example, there is growing interest in a technology called molecular robotics, in which molecules themselves are designed as robots. To construct algorithms specialized for such low performance devices, we deal with a population protocol model; in this model, devices only have greatly limited resources. So far, researchers have studied various problems in this model. In this dissertation, we tackle with two important challenges of the population protocol model.

One is to handle multiple tasks. Since devices are low-performance, one device may not handle multiple tasks. Thus, it is necessary to develop a mechanism to handle multiple tasks. As an approach to achieve it, we address network partitioning on the population protocol model. By partitioning a network into some groups, devices can handle multiple tasks by assigning different tasks to each group. In this dissertation, we study the uniform k -partition problem on the population protocol model. This problem aims to divide a network into k groups of the same size, where k is a given positive integer. To cope with various situations, we consider the problem on various assumptions. Moreover, since devices only have greatly limited resources, we mainly study space-complexity to solve the problem.

As a result, on various assumptions, we clarify the solvability and space-complexity of this problem. The other challenge is efficient task execution. To execute tasks efficiently, we address investigation of the structure of networks. As many studies have shown, the structure of networks has a high impact on the efficiency of the algorithm. Hence, by understanding the structure of networks, we can apply appropriate algorithms to execute tasks efficiently. In this dissertation, we study graph class identification problems that aim to understand the structure of networks (i.e., graph class of networks). In particular, as basic structures of networks, we focus on lines, rings, k -regular graphs, stars, trees, and bipartite graphs. As a result, we clarify the solvability and space-complexity of the problems for the graphs.

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(論文審査結果の要旨)

令和4年1月7日に開催した公聴会の結果を参考に令和4年2月9日に本博士論文の審査を行った。以下のとおり、本博士論文は、申請者が独立した研究者として研究活動を続けていくための十分な素養を備えていることを示すものと認める。

本論文では、低性能デバイス群のための分散計算モデルである個体群プロトコルモデルに関して研究を行い、以下の成果を達成している。

1. 個体群を2分割、 k 分割する問題に対し、計算モデルに関する様々な仮定の下で問題の可解性、可解の場合は空間計算量の解明を行い、多くの場合において、空間計算量の下界と上界を一致させる結果を得ている。
2. 個体群プロトコルモデルにおけるコミュニケーショングラフの形状判定問題に対し、いくつかのグラフ形状に関して、計算モデルに関する様々な仮定の下で問題の可解性を解明し、可解の場合は空間計算量に関して効率の良いプロトコルを提案している。

上記の結果は、個体群プロトコルの計算可能性、空間計算量に関して基盤となる成果であると評価できる。よって、本論文は、博士（理学）の学位論文として価値あるものと認める。