Form 3

Abstract of Thesis

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Title	GAME THEORETICAL MODELS AND SOLUTION APPROACHES FOR DYNAMIC MODULAR COVERING LOCATION PROBLEMS (動的モジュラー被覆配置問題のゲーム理論によるモデルとその解法)

Abstract of Thesis

Facility location decisions are one of the important elements in the strategic planning of supply chains and they have applications in both private and public sectors. The importance of having optimal facility locations has two main folds. The first reason is that facility location decisions are strategic and they cannot be easily changed. The second reason is that the location of facilities can have a direct impact on other supply chain decisions as well. This thesis addresses the importance of locating emergency facilities by developing the novel game theoretical model for covering facility location problem. First, by defining different structural units of the facilities as the modules, a modular maximal covering location problem having back-up service coverage for demand nodes in a multi-period framework is proposed. Considering back-up services for the demand of points from the modules can increase the service quality that is a vital optimization objective for applications such as emergency services. A heuristic method and a genetic algorithm are developed to solve the computational test problems.

Second, a hybrid covering location problem that integrates the set covering and maximal covering location problem is developed for the first time to benefit from the advantages of these two models in one model. The hybrid model distinguishes between facilities and the structural units of facilities as the modules and locates the facilities according to the coverage concept of set covering location problem to provide service for all demand points. The hybrid model assigns the limited number of modules using the coverage concept of maximal covering location problem to maximize the total covered demands.

Third, using the developed models in the previous parts, this thesis studies the covering facility location problems from non-cooperative game theoretical approach to investigate the related non-cooperative theoretical and mathematical model of covering model and the solving complexity. The non-cooperative approach is studied using the Stackelberg game perspective for maximal hub covering location problem, which is resulted into a bi-level mathematical formulation of the problem. In the bi-level maximal hub location problem, the freight companies who seek to find the optimal location of the hubs to have the maximal amount of covered demand are the leaders, while the customers looking for the minimum price among different available companies are the followers. Furthermore, the difficulty to deal with the bi-level mathematical model is addressed in order to solve the problem. Two reformulation techniques as dual-based and Karush-Kuhn-Tucker-based reformulation are developed to reformulate the bi-level problem to a single level problem. As the obtained single-level problems are difficult to solve, a Benders-decomposition-based method is proposed and used to solve the test problems and investigate the efficiency of the reformulation techniques and the solution procedure.

The obtained results from numerical experiments and analysis indicate that the integrated mathematical model developed for hybrid covering location problem is capable of improving the coverage percentage compared to the conventional models and other possible integrated models. The case study that is conducted to validate the capability of the hybrid model also approves the applicability of this model in modeling emergency humanitarian logistic systems. Furthermore, the developed maximal hub location problem can reflect the non-cooperation framework for freight companies while they compete to attract more customers by rational behaviors who want to use the player with less price. On the other hand, the developed reformulation and decomposition procedures to solve the problem approves the efficiency of the procedures to solve large scale problems.

The future work for this thesis can be suggested as studying the developed models in the presence of uncertainty from both stochastic and robust optimization point of views. The other direction for future studies is to develop an efficient solving procedure for the developed hybrid covering location model.

様式７

論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

本論文では，施設の配置のみならず，現実の問題に即して配備する設備や応援要請を含む問題に施設配置問題を拡張し，その解法や事例応用を示したものである．

第1章の序論と第６章の結論を含め，以下の各章から構成されている．

第2章では、基礎となる施設配置問題と，非協力ゲーム理論や一般的解法を述べている．

第3章では，警察や消防などの緊急施設の配置問題を扱っている．管轄外への応援要請への対応や消防車や救急車などの設備配置計画も含む現実的な施設配置問題を考え，0-1計画問題として定式化している．遺伝アルゴリズムによる解法とヒューリスティック解法を提案し，数値実験により厳密解法と比較し，提案解法の有用性を確認している．

第4章では，拡張された配置問題として，集合被覆と最大被覆を含むハイブリッドモデルを提案している．このモデルには，長期的な戦略的決定と短期的な戦術的決定が含まれている．すなわち，動的な施設配置とともに，動的な需要に見合った各種設備配置を求めるモデルとなる．一事例研究として，日本の危機管理における物資配送計画を含む救急センターの配置問題へ適用している．また，他の複合モデルと比較するとともに，いくつかの問題で，提案モデルの妥当性を示している．

第5章では，貨物運送の配送センターの配置問題などの動的最大被覆問題をシュタッケルベルグ問題として扱っている．需要が増大するという将来予測の下で，配送センターの増設と運搬車両の増設という二つの戦略が考えられ，運搬業者は上位レベルで需要を満たしつつ価格を決定し他社と競い，利用客は下位レベルで配送コストの最小化を行う．KKT条件を用いて通常の計画問題に変形した後，ベンダーズ分解による解法が提案されている．数値例を用いて提案解法の妥当性が確認されている．

以上のように本論文は，施設配置問題を現実に合わせて拡張し，解法や解析法を与えるとともに，事例研究により有用性を示したものであり，施設配置計画モデルの発展と応用に貢献している．よって，博士（工学）の学位論文として価値のあるものと認める．