報告番号	※甲　　　第　　　　号

主 論 文 の 要 旨

論文題目　Improving System Throughput Based on Multiuser Cooperative Mobility in Ad Hoc Networks
(アドホックネットワークにおけるマルチユーザ協調移動制御に基づく通信品質の改善)

氏　　名　　謝　済全

論 文 内 容 の 要 旨

It is indispensable for Society 5.0 to build an economic and efficient high-speed wireless communication network. With the large-scale popularization of intelligent devices, the era of Internet of Things (IoT) is coming. Due to the intrinsic properties of IoT devices, resource factors such as transmission power, bandwidth, and coverage are often subject to constraints when implementing applications with high quality of service (QoS) requirements. System throughput is a vital criterion for judging the user experience to ensure that QoS requirements are met. In this thesis, we consider the improvement of the system throughput as a whole, and not only the improvement of transmission rates for individual users.

In recent years, users have been able to roam with IoT devices by virtue of the widespread deployment of 5th-Generation (5G) networks. However, the current 5G technology has many limitations. Base stations, for example, are expensive to deploy and have a small coverage. Wi-Fi technology can provide cheaper and wider coverage communication than 5G cellular base stations. On the other hand, Wi-Fi has a small coverage area, and the key to its practicality is to expand the coverage area by using multi-hop. For comfortable communication anytime and anywhere, ad hoc networks can be formed based on Wi-Fi and Device-to-Device (D2D) communication by relaying users, as a necessary complement to 5G technology.

Currently, there are still some problems for achieving high QoS in ad hoc networks as follows. First, radio waves have varying throughput performance depending on the relay user's physical distance. Since physical distance often determines the fading characteristics of the signal as it propagates through space, the farther the distance the greater the signal fading, resulting in poorer throughput performance. Additionally, the degree of interference is a factor in determining throughput performance, which varies depending on the location of other users. Therefore, moving a user to a location where there is minimal interference and optimizing the physical distance between each user will optimize its throughput

performance. We collectively refer to this control method for mobile users as user cooperative mobility mechanism. Finally, given the motivation and incentives for users to move, we consider social intimacy among users as a reason they are willing to move. There are two aspects to be solved, i) the motivation to forward other users' data, and ii) the best selection of mobile users, i.e., which users should be moved. In summary, the following three problems are addressed in this research.

1. How to maximize throughput in a small number of users' application scenario while considering radio wave propagation and signal interference between each user?

2. How to leverage user mobility strategy to achieve high throughput performance and low algorithmic complexity in complex application scenarios?

3. How to maximize throughput considering the motivation for cooperation of movable users, i.e. given the social relationships and satisfying the high social intimacy between each other in the social-physical ad hoc networks?

To address these problems, previous approaches are limited to considering the single user mobility, i.e., an ***independent*** mobility strategy. The reason is that the complexity is extremely high due to the huge diversity of the solution space, and in the case of multiuser mobility, both user interference and signal strength need to be considered. This diversity makes it difficult to achieve optimality, so few researches have overcome this challenge so far. The originality of this thesis is to overcome the diversity for achieving the optimal solution by proposing a multiuser mobility control mechanism with ***cooperative*** behavior. To our best knowledge, we are the first to study the throughput performance maximization problem based on multiuser cooperative mobility in ad hoc networks. To this end, we present the following three contents, which are summarized as follows:

- First, we propose an interaction position game (IPG) to maximize throughput based on multiuser cooperative mobility. The multiuser cooperative mobility and the different geographical locations and distances between all users are jointly considered. For the conventional game-theoretic approaches, they always exploit self-centered behaviors among players and maximizes their own benefits. In this game, we use the cooperative behavior among movable users to maximize the overall system throughput performance, rather than being self-centered like the traditional game models. In summary, this research contributes to obtaining the best mobility strategy for maximizing throughput while considering the radio wave propagation and signal interference between each user.

- Second, we propose a new algorithm, called Maximum Throughput algorithm for Optimal Position (MTOP), based on the known geographic location information of fixed users. Different from previous studies, the lower and upper bounds are derived to determine the search space domain based on feasible location assembles. Furthermore, a conflict set of locations graph is defined to prove this proposition that the domain includes the optimal location allocation. In summary, this research contributes to yielding an efficient multiuser cooperative mobility strategy in a large number of users to achieve high throughput performance and low algorithmic complexity.

- Finally, we propose the Relay selection and Link Interference Degree Graph (RS-LIDG) algorithm to obtain an optimal social relay selection scheme with high intimacy requirements to maximize the system throughput for social-physical ad hoc networks. Feasible relays and multiuser cooperative mobility with satisfactory link reliability for throughput maximization are jointly considered. In summary, this research contributes to maximizing throughput while satisfying high social intimacy in social-physical ad hoc networks.

Through this thesis, we contribute to maximizing throughput performance based on multiuser cooperative mobility in ad hoc networks. First, this thesis demonstrates that the proposed IPG method achieves the best throughput by ***cooperative*** behavior different from the conventional game approaches. Second, this thesis strongly explains that the proposed MTOP algorithm achieves excellent throughput performance and lowest complexity for a large number of users. Finally, the proposed RS-LIDG algorithm is also expected to provide support for social networks to enable the best communication experience of wireless wearable devices in Society 5.0.