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Article / Book Information

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種別(和文)	論文要旨
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

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学生氏名： Student's Name	宮 太地		指導教員（主）： Academic Supervisor(main)	山岡克式	
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

In today's world, where everything is connected to the Internet, ad hoc networks are an indispensable technology for society - autonomous, distributed, and cooperative infrastructure-less communication networks.
As the quality requirements of networks, such as bandwidth and latency, have become more refined and wireless communication protocols have diversified, heterogeneous ad hoc networks, in which multiple local ad hoc networks are interconnected by protocol translators called gateways, have attracted the attention of many researchers and engineers.

This paper is titled "A Study on Gateway Mobility Control for Heterogeneous Ad Hoc Networks" and comprises seven chapters.
Chapter 1, "Introduction," introduces the development of ad hoc network-related technologies and the current social demands and describes their potential applications, especially in the field of swarm robots.
Chapter 2, "Related Works," systematically summarizes the technical issues by surveying a wide range of existing studies on 1) interoperability of ad hoc networks, 2) shortest path searching algorithms on the graph theory, 3) routing protocols for ad hoc networks, 4) wireless communication network designs on swarm robotics to realize real-time video transmission, and 5) formation control algorithm for swarm management.
Chapter 3, "Application Modeling and Problem Statement," introduces examples of heterogeneous ad hoc networks composed of drone swarms and abstracts a drone-based video transmission network, the target of this study, into a general graph model.
In Chapter 4, "Experimental Analysis of Communication Relaying Latency in Low-Energy Ad Hoc Networks," measurement experiments are planned and conducted in an ad hoc network constructed using actual embedded devices. The numerical data obtained by the experiments clarify that an application processing delay generated by a low-power embedded CPU can be greater than the delay caused by the wireless link and accounts for a large proportion of the end-to-end communication delay. This fact indicates that in ad hoc networks, a simple reduction in the number of end-to-end path hops can effectively reduce end-to-end delay. Besides, based on the increasing trend of processing delay in relation to the amount of relay traffic, a mathematical model describing the end-to-end delay in a low-energy ad hoc network is proposed.
Chapter 5, "Link Stabilizer and Path Optimizer," proposes two types of gateway mobility control algorithms: link stabilizer and path optimizer. The former is a microscopic mobility control algorithm that aims to maintain stable wireless links between gateways and neighboring nodes. The latter is a macroscopic mobility control algorithm involving the gateway's long-distance movement by dynamically reconfiguring the network topology to construct end-to-end shortest paths. This method is characterized by connecting the ends with the shortest physical path between them by relocating the gateways for each communication request. It can significantly reduce communication distance compared to the existing method that searches for the logical shortest path. Computer simulation results show that these algorithms improve gateway availability and connection stability and reduce the average end-to-end delay of the network.
Chapter 6, "Path Coordinator," proposes the path coordinator as a mobility control in high-traffic environments. While the algorithm in Chapter 5 is an independent mobility

control for each gateway, it is unique in that the path coordinator operates all gateways in the network cooperatively and relocates them simultaneously. It allows for discovering a globally optimal gateway placement rather than a local optimum. Computer simulations assuming actual drone specs show that the algorithm smooths communication quality and improves the allowable delay satisfaction rate even under heavy loads. A conceptual communication protocol is also designed to implement these three algorithms in an autonomous decentralized environment.
Chapter 7, ″Conclusion and Future Works,″ summarizes the efforts of this study and outlines issues that need to be considered when expanding the scope to more general situations in the future.

In summary, this paper shows that the three proposed gateway mobility control algorithms can be applied to a heterogeneous ad hoc network consisting mainly of drones to improve gateway availability and reduce end-to-end communication delay under a wide variety of traffic conditions and node mobility patterns.
This study contributes to the sustainable development of technologies around ad hoc networks and thus provides a basis for new technologies in the future society.