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論　文　要　旨

Mobile ad hoc network (MANET) represents a kind of self-organizing network architecture, which consists of mobile devices communicating with each other over peer-to-peer wireless links without centralized infrastructure. Since MANETs can be deployed and reconfigured rapidly at very low cost, they are appealing for many critical applications, such as disaster relief, emergency rescue, battlefield communications, traffic offloading and cover extension for future 5G networks. To efficiently facilitate the application and commercialization of MANETs, understanding the fundamental performance of such networks is of great importance.

The available performance studies for MANETs suffer from two major limitations. First, they mainly focus on the asymptotic behaviors of network performance as the network size tends to infinity, while the actual achievable performance is largely uninvestigated. Second, to make their analysis tractable, these studies are usually based on the ideal assumption of infinite buffer, which does not hold for a practical MANET. Therefore, it is important to have a thorough study on the actual achievable performance of MANETs under the practical limited-buffer constraint.

For a general MANET with limited-buffer constraint, this thesis is devoted to exploring its actual achievable performance in terms of the throughput, end-to-end (E2E) delay and throughput capacity. We first consider the scenario with only the relay-buffer constraint, where each network node maintains a shared limited relay

buffer for storing relay packets of all other nodes. For such a MANET, we develop an efficient theoretical framework to model its dynamic behaviors characterized by the buffer occupancy process, packet source-queuing process and packet delivery process. This theoretical framework is general since it applies to any distributed MAC protocol and any mobility model that leads to the uniform distribution of nodes' locations in steady state. With the help of this framework, we derive the exact expressions for both throughput capacity and expected E2E delay. Case studies are further conducted under two typical network scenarios to demonstrate the application of the proposed theoretical framework.

We then extend our study to the MANETs where both the source buffer and relay buffer are subject to the limited-buffer constraint. Based on the Queuing theory and birth-death chain theory, we develop a general theoretical framework to fully depict the occupancy processes of both source buffer and relay buffer, such that the corresponding stationary occupancy state distributions (QSDs) can be derived. With the help of OSDs, we further obtain the exact expressions of throughput, expected E2E delay and throughput capacity. Finally, extensive simulations and numerical results are presented to demonstrate the efficiency of the proposed theoretical framework and illustrate our theoretical findings. It is expected that the theoretical results developed in this thesis will provide a useful guideline for the practical design and optimization of MANETs.

審査結果の要旨

This thesis studied the fundamental performance of an important class of two-hop relay MANETs under the limited-buffer constraint, which represents a significant progress in the performance study of practical MANETs. This thesis first considered the scenario with only the relay-buffer constraint and developed an efficient theoretical framework to characterize the relay buffer occupancy process. With the help of this framework, the exact expressions of throughput capacity and expected end-to-end (E2E) delay were derived. This thesis then extended the performance study to the MANETs with both limited relay-buffer and relay buffer were analyzed, which enables the exact expressions of throughput, expected E2E delay and throughput capacity to be derived. All theoretical results were verified with extensive simulation results. It is expected that the results developed in this thesis will be helpful for the application and commercialization of MANETs.

・論文の構成

Chapter 1 Introduction

Chapter 2 Related Works

Chapter 3 Preliminaries

Chapter 4 Throughput Capacity of MANETs under Relay-Buffer Constraint

Chapter 5 End-to-end Delay of MANETs under Relay-Buffer Constraint

Chapter 6 Throughput and Delay of MANETs under General Buffer Constraint

Chapter 7 Conclusion

Appendix A Proofs of Chapter 4

Appendix B Proofs of Chapter 5

Appendix C Proofs of Chapter 6

・研究目的の妥当性，従来の手法との比較においての有意性，および理論・実験手法の新規性

This thesis studied the fundamental performance of an important class of two-hop relay MANETs under the limited-buffer constraint, which is expected to provide precious insights to the design and optimization of future communication networks.

The available performance studies for MANETs suffer from two major limitations. First, they mainly focused on the asymptotic behaviors of network performance as the network size tends to infinity, while the actual achievable performance is largely uninvestigated. Second, to make their analysis tractable, these studies were usually based on the ideal assumption of infinite buffer, which does not hold for a practical MANETs. Different from these works, this thesis conducted a thorough study on the actual achievable performance of MANETs under the practical limited-buffer constraint, representing an important progress in the performance study of practical MANETs.

・得られた知見のシステム情報科学の分野における意義

The results of this thesis provide the following insights.

1. The novel theoretical frameworks developed in this thesis could be helpful for exploring the performance in other MANET scenarios as well.
2. The theoretical findings revealed in this thesis could serve as the important guidelines for the design of practical MANETs with the limited-buffer constraints.