

論文の要旨

題目 A Study on Network Survivability Analysis for Ad Hoc Networks

(アドホックネットワークにおけるネットワーク生存性評価に関する研究)

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Network survivability is an attribute that network is continually available even if a communication failure occurs, and is an emerging requirement for highly reliable communication services in wireless ad hoc networks (WAHNs) and mobile ad hoc networks (MANETs). Moreover, quantitative network survivability is defined as the probability that the network can keep to be connected even under node failures and DoS attacks, and known as one of the most important measures to design dependable computer networks. Markov modeling is a typical method to quantifying network survivability.

On the other hand, border effect in communication network area is also one of the most troublesome problems to quantify accurately the performance/dependability of WAHNs/MANETs, because the assumption on uniformity of network node density is often unrealistic to describe the actual communication area. This problem appears in modeling the node behavior of WAHNs/MANETs and in quantification of their network survivability. This fact motivates us to reformulate the existing network survivability models for WAHNs/MANETs by taking account of border effects.

In this thesis, we propose three node behavior models and consider two types network communication areas. We analysis these network survivability models by semi-Markov process (SMP) and Markov regenerative process (MRGP). Also, we develop a simulation model to validate our analytical models.

In Chapter 1, we introduce the definition of network survivability, importance of network survivability quantification and motivation of our study.

In Chapter 2, we propose two stochastic models; binomial model and negative binomial model to quantify the network survivability and compare them with the existing Poisson model. Then, we focus on the border effects, and reformulate the network survivability models based on a SMP, where two kinds of communication network areas are considered; square area and circular area. Based on some geometric ideas, we improve the quantitative network survivability measures for three stochastic models (Poisson, binomial and negative binomial) taking account of border effects.

In Chapter 3, we concern the fact that the continuous-time Markov chain (CTMC) modeling is not sufficient to analyze the relationship between battery state and node behavior in the MANET. In particular, such a problem seriously arises when we treat the transient behavior of the power-aware MANET. Here, we present the quantitative network survivability analysis for a power-aware MANET based on MRGP, and calculate the network survivability through both stationary and transient analyses for the SMP-based models.

In Chapter 4, we derive analytically the upper and lower bounds of network survivability as well as an approximate form based on the expected number of active nodes in both square and circular areas, under a general assumption that the battery life in each node is non-exponentially distributed. Also, we perform the transient analysis as well as the steady-state analysis of network survivability based on a SMP, and complement the results in Chapter 3.

We propose some analytical formulas on the quantitative network survivability in Chapter 2, Chapter 3 and Chapter 4, but we need to validate them by comparing with the exact value of network survivability in a comprehensive way. In Chapter 5, we revisit the lower and upper bounds of network survivability by taking account of border effects in network communication areas, and develop a simulation model in two kinds of communication area; square area and circular area. We compare the analytical bounds of network survivability with the simulation solution. It is shown through simulation experiments that the analytical solutions often fail the exact network survivability measurement.

Finally, some conclusions and remarks are given in Chapter 6.