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Phase Transition in Lattice Networks with Heavy-Tailed User Behaviors

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Abstract

The phase transition that network turns from free-flow state to congestion state is greatly influenced by the traffic. Empirical data analyses proved that actual traffic shows self-similarity (or long-range dependence) due to heavy-tailed user behaviors. Related literature works have pointed that there is a stable critical point of packets generation rate (PGR in short) at which the phase transition occurs, however, these works have ignored the heavy-tailed user behaviors and are only applicable to the short-range dependent traffic. In this paper, we make new contributions by analyzing the phase transition considering heavy-tailed user behaviors modeled by Pareto ON/OFF sources. We theoretically analyzed the critical point of PGR and proved that: 1) different from the previous works the critical point of PGR is varying with the heavy-tailed user behavior,which shows that it is unstable; 2) however, the average of critical point of PGR is derived to be same to the stable critical point of PGR with short-range dependent traffic; 3) particularly in the lattice networks with i.i.d heavy-tailed user behavior model, the average critical point of PGR is mainly determined by the average users number and an estimation of the critical point of average users number is provided. Numerical simulations have illustrated the effectiveness and validity of the theoretical results. Moreover, we also find the heavy-tailed behavior could make the network more congested and reduce the network transport efficiency by the simulations.

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