A QUEUEING SYSTEM TO MODEL COOPERATIVE WIRELESS NETWORKS WITH COUPLED RELAY NODES AND SIMULTANEOUS PACKET RECEPTION

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In this work we analyze a novel Markovian queue to model cooperative wireless systems (i.e. network-level cooperation) with two coupled relay nodes and simultaneous packet reception. We consider a network of three saturated source users, say $S_i, i = 0, 1, 2$, two relay nodes of infinite capacity, say $R_1, R_2$ and a common destination node $D$. Source users transmit packets to the destination node with the cooperation of relays. More precisely, relay nodes assist source users by re-transmitting their blocked packets to the destination node. Node $D$ can handle at most one packet, which forwards outside the network. We consider the following cooperation strategy between sources and relay nodes: If the transmission of a source’s $S_0$ packet to the node $D$ fails, $S_0$ forwards its blocked packet to both relay nodes in order to exploit the spatial diversity they provide, and the broadcast nature of wireless communication. On the other hand, if the transmission of a source’s $S_i, i = 1, 2$, packet to the node $D$ fails, $S_i$ forwards its blocked packet only to the relay node $R_i$. More concretely, we have assumed that user $S_0$ transmits within the overlapping area created by the intersecting covering regions of both relay nodes, and thus, its blocked packets are forwarded to both relays, while the background user $S_i$ transmits within only the covering region of the relay node $R_i$. Due to the wireless interference, the re-transmission rate of a relay node is affected by the state of the other relay node. In particular, it depends on the presence/absence of packets stored in the other relay node. Such a situation gives rise to an opportunistic cooperation scheduling scheme between relay nodes. Besides its practical applicability, our work is also theoretically oriented. We provide for the first time in related literature an exact analysis of a model that unifies three fundamental queueing systems: the retrial queue with two orbits and constant retrial policy, the generalized two-demand model (i.e., fork-join queue), and the model with two coupled processors. We study a three dimensional Markov process presenting the number of packets in $R_1, R_2$ and $D$, provide necessary and sufficient conditions for ergodicity, and show that the steady-state performance of such an intricate model is expressed in terms of the solution of a Riemann-Hilbert boundary value problem.