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Stationary distribution of the tandem fluid queue and its application to the accumulated priority queue

Abstract

We consider two fluid queues in the joint process $\{(\varphi(t), X(t), Y(t)) : t \geq 0\}$, with contents at time t denoted by $X(t)$ and $Y(t)$, respectively, that are being driven by a background Markov chain $\{\varphi(t)\}$ with some finite state space $\mathcal{S}$ and an irreducible generator $\mathbf{T}$. The first queue behaves as a standard fluid queue with lower boundary at 0, and fluid rates r_i. Thus, the content $\{X(t)\}$ increases at rate r_i when $\varphi(t) = i$, unless r_i is negative and $X(t)$=0.

The behaviour of the second fluid queue depends on both $\varphi(t)$ and $X(t)$ in the following way. The fluid level $Y(t)$ increases at rate $\widehat{c}_i$ when $X(t) > 0$ and $\varphi(t) = i$, and decreases at rate $\breve{c}_i$ when $X(t) = 0$ and $\varphi(t) = i$, unless both levels are at 0. In the latter case, $Y(t)$ increases as soon as $\varphi(t)$ makes a transition to a state that makes the first buffer fill up (so that $X(t)$ and $Y(t)$ increase together).

We derive expressions for the stationary distributions of this process and discuss its application to the accumulated priority queue.