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Stochastic Modeling of Fog Computing Networks: Tandem Queues with Batch Arrivals and Services

Communication Info

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Abstract

Fog computing networks are designed to support delay-sensitive and computation-intensive applications by bringing cloud services closer to end users. Due to the bursty and event-driven nature of task generation in such systems, computational requests often arrive and are processed in batches. In this paper, we develop and analyze a tandem batch-service queueing model to represent multi-stage fog computing architectures. The system is modeled as a sequence of $M^{[X]}/M^{[Y]}/1$ queues, where tasks arrive in batches and are served in batches at each fog node. The underlying process is formulated as a quasi-birth–death (QBD) process, and its infinitesimal generator is derived explicitly. Using the matrix-geometric method, we obtain the stationary distribution and establish the stability condition of the system. Key performance metrics, including the expected number of tasks in each node, system throughput, and mean delay, are derived analytically. Numerical results illustrate the impact of batch size distributions and service rates on system performance, providing insights into the design and dimensioning of fog computing networks.

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