

## **BRAVO FOR QED QUEUES**

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The BRAVO effect stands for “Balancing Reduces Asymptotic Variance of Outputs”. It is a stochastic queueing systems phenomenon where the long term asymptotic variability of the number of departures is significantly reduced in critically loaded (balanced) cases in comparison to non-critically loaded cases. For example, in the single server finite capacity M/M/1/K queue, the asymptotic variability is around  $2/3$  when the arrival and service rates are equal, yet is around 1 (as a Poisson process) otherwise. Formally the asymptotic variability is the limit of the ratio of the variance of the number of departures and the mean number of departures.

In this talk we consider the BRAVO effect for multi-server queues and show that it occurs under the quality and efficiency driven (QED) scaling regime. The QED scaling regime based on the many-server asymptotics of Halfin and Whitt (1981) is a well studied asymptotic analysis regime in which the number of servers and the load are increased in a manner such that the delay probability goes to a constant. We consider finite multi-server Markovian queues under a form of QED scaling and obtain a BRAVO effect. Hence BRAVO for QED.