Blind Dynamic Resource Allocation in Closed Networks via Mirror Backpressure

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We study the problem of maximizing payoff generated over a period of time in a general class of closed queueing networks with finite, fixed number of supply units which circulate in the system. Demand arrives stochastically, and serving a demand unit (customer) causes a supply unit to relocate from the "origin" to the "destination" of the customer. We consider general controls including entry control, pricing, and assignment. Motivating applications include shared transportation platforms and scrip systems.

Inspired by the mirror descent algorithm for optimization and the backpressure policy for network control, we introduce a novel family of *Mirror Backpressure* (MBP) control policies. The MBP policies are simple and practical, and crucially do not need any statistical knowledge of the demand (customer) arrival rates.

Under mild conditions, we show that MBP policies lose at most $O(\frac{K}{T} + \frac{1}{K})$ payoff per customer relative to the optimal policy that knows the demand arrival rates, where K is the number of supply units and T is the total number of customers over the time horizon. The key technical challenge we overcome is that the number of supply units at any node can never be negative. Simulation results in a realistic ridehailing environment support our theoretical findings.[1,2]

CCS Concepts: • **Theory of computation** → **Stochastic control and optimization**; **Computational pricing and auctions**; • **Mathematics of computing** → *Network optimization.*

Additional Key Words and Phrases: backpressure; mirror descent; dynamic pricing; shared transportation platforms; scrip systems; queueing

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