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Time-Varying Many-Server Finite-Queues in Tandem: Comparing Blocking Mechanisms via Fluid Models

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Abstract

This paper focuses on the mechanism of Blocking Before Service (BBS), in time-varying many-server queues in tandem. BBS arises in telecommunication networks, production lines and healthcare systems. We model a stochastic tandem network under BBS and develop its corresponding fluid limit, which includes reflection due to jobs lost. Comparing our fluid model against simulation shows that the model is accurate and effective. This gives rise to design/operational insights regarding network throughput, under both BBS and BAS (Blocking After Service).

Keywords: Many-server flow lines with blocking, Communication blocking, Blocking Before Service (BBS), Time-varying queueing networks, Fluid models, Reflection, Functional Strong Law of Large Numbers

1. Introduction

Tandem queueing networks with blocking arise in many communication, production and service systems [1, 2, 3]. This paper focuses on communication blocking, which is also known as Blocking Before Service (BBS) or two-stage blocking [2]. Under this mechanism, a service cannot begin at Station i if there is no available capacity (buffer space or idle server) at Station $i+1$.

1.1. Motivation and Examples

Clearly, the BBS mechanism is prevalent in telecommunication networks [4, 5, 3]. However, BBS is not uncommon in production lines; for example, in the steel, plastic molding and food processing industries [6], as well as in the chemical and pharmaceutical industries [7]. In the latter, for example, a work-in-process can be unstable or unsafe and, thus, cannot be detained/blocked after