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A Biologically Inspired Fluid Model of the Cyclic Service System

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Abstract. A deterministic fluid model in the form of nonlinear ordinary differential equations is developed to provide the description for a multichannel service system with service-in-random-order queue discipline, abandonment and re-entry, where servers are treated like enzyme molecules. The parametric analysis of the model's fixed point is given, particularly, how the arrival rate of new customers affects the steady-state demand. It is also shown that the model implies a saturating clearing function (yield vs. demand) of the Karmarkar type providing the mean service time is much shorter than the characteristic waiting time.

Keywords: fluid queues, multiple server, abandonment, re-entry, random order service, clearing function.

AMS Subject Classification: 90B22.

1 Introduction

Historically, the service sector was long considered a sort of marginal economic activity that did not fit into agriculture and manufacturing categories. However from 1980s on its share in most economies has steadily expanded. By 2020, the service sector contributes to around two thirds of the total global GDP, whereas for the most industrialized economies this indicator exceeds three fourth [34].

The rapid development of the service sector in many economies has stimulated a renewed interest in multi-server queueing models. These models are particularly important in large-scale service systems, such as customer contact