



Queueing-inventory: analytical and simulation modeling and classical and retrial queues and inventory

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Published online: 11 July 2024

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Abstract

This is the PREFACE to the Special Issue “Queueing-inventory: analytical and simulation modeling and classical and retrial queues and inventory”. The year 2022 was the 30th anniversary of Queueing-inventory. It was in that connection that the guest editors requested Professor Endre Boros, the Editor-in-Chief of Annals of Operations Research, for permission to guest edit a special issue. This was granted by the Editorial Board of the journal.

Keywords Queueing-inventory · Classical queue · Retrial queue · Classical inventory · Retrial inventory · Analytical and simulation modeling

Queueing-Inventory (QI) models were introduced independently by Sigman and Simchi-Levy (1992) and Melikov and Molchanov (1992). Prior to this, inventory models were analyzed under the assumption that the time to service the customers with the inventory items was insignificant. Thus, the incoming customers are queued only if at demand epochs the inventory level is zero provided backlogs are permitted. This occurs when the replenishment time is positive. However, in real life situations we notice that the time to serve the customers is positive (and mostly random). Thus, there exists a possibility that the customers need to wait in the queue before getting serviced with inventory even when the inventory level is positive at the times of the arrivals of the customers. In effect the study of QI models turns out to be the management of the queue of customers and the queue of stocked items. Quite often the number of items stocked is finite because of the holding cost of the stocked items. Further, the management has to ensure the quality of service provided to the customers. One of the ways is to replenish the stock whenever the

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level of inventory drops to a critical level (referred to as *safety stock*) so as to make sure that the stock does not deplete to zero and thus increase the waiting time of the customers.

Since 1992, several researchers started working on QI models and 335 papers have appeared in the literature. In the last decade of the 20th century, very few contributions in QI were reported. With the advent of the 21st century several researchers started investigation in QI. One of the most prominent contributions in QI is the product form solution, introduced in Schwarz et al. (2006; also see Schwarz & Daduna, 2006; Otten et al., 2016; Otten et al., 2020). In the product form solution, the steady state joint distribution of the number of customers in the system and the number of items in the inventory turns out to be the product of the probability of the number of customers in the system and the probability of the number of items in the inventory, which is obtained by assuming that no customer joins during the time when the inventory level is zero. This is despite the strong correlation between the duration of the lead time for replenishment of the inventory and the number of customers joining during the lead time. Subsequently, product form solution for the general lead time case was obtained by Saffari et al. (2013), for production inventory by Krishnamoorthy and Viswanath (2013), Baek and Moon (2014), Otten et al. (2016), Otten et al. (2020). Lian et al. (2005) introduced a discrete-time inventory in which the inventoried items are perishable, having a common life time (CLT) and hence subject to removal (all remaining items together) from the inventory on realization of CLT. This CLT is assumed to be discrete phase type distributed. However, the authors restricted the study to inventory with negligible service time. They considered the case of finite back log and zero lead time for replenishment. Since then, it was extended to continuous time case by Chakravarthy (2010) and Krishnamoorthy et al. (2016). Reservation, cancellation, and overbooking of inventory were discussed by Shajin et al. (2020). All these models deal with discrete inventory items. However, some raw materials used in food manufacturing are stored in liquid form. In these cases, the quantity required for each customer is no longer unit-sized (see Yu et al., 2024).

It is worth mentioning that Kazimirsky (2006) introduced a different way of looking at the QI: customers arrive according to batch Markovian arrival process (BMAP) and served one by one according to a general distribution. Each customer requires an additional item for service. The server processes such items when he is idle. The processing time for each item is generally distributed. In the absence of the additional item at a service commencement epoch, the server first processes an item and then starts service of that customer.

The year 2022 is the 30th anniversary since the study of QI models started. Therefore, the guest editors felt it quite appropriate to bring out a special issue on QI along with classical queues and classical inventory models. With this we approached the Editor-in-Chief of *Annals of Operations Research*, Professor Endre Boros, who kindly approved our request.

The total number of manuscripts submitted for this SI was 46 (including those of the Guest Editors). 44 manuscripts underwent a rigorous review process. Two papers were not considered for processing because those were outside the scope of the special issue. The number of papers accepted for publication was 24.

There are four invited papers in this special issue. These are:

- O. Boxma, D. Perry, and W. Stadje (2023), Perishable inventories with random input: a unifying survey with extensions.
- H. Daduna (2023), On queueing-inventory-location problems.
- A.N. Dudin and V. Klimenok (2023), Analysis of *MAP/G/1* queue with inventory as the model of the node of wireless sensor network with energy harvesting.

R. Nekrasova, E. Morozov, D. Efrosinin, and N. Stepanova (2023). Stability analysis of a two-class system with constant retrial rate and unreliable server.

The review process

For each paper there were three to four referees who did a magnificent job of keeping the time schedule to submit their reviews. All manuscripts went through a second round of review; a few others had three or four rounds of review before being accepted/rejected. Thus, a very high level of screening was done for each paper, including those that were invited.

The Guest Editors wish to extend their heartfelt thanks to Professor Endre Boros, Editor-in-Chief and the Editors for giving them an opportunity to guest edit the special issue. Thanks are also due to the editorial staff and office staff for their kind cooperation. Ms. Ann Pulido (Publications Manager) and Mr. Prithviraj Shanmugham deserve special mention for their readiness to help whenever the Guest Editors/Referees/Authors had difficulties with online submission of the Reports/Papers related to the special issue. We express our heartfelt gratitude to all those who submitted their manuscripts to the special issue.

The Guest Editors express their heartfelt gratitude to all reviewers for their time and patience.

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