Exploring the Impact of Burstiness on the Service Process at the Cash Register

Detlef Hartleb
ETSIST, Universidad
Polit´ecnica de Madrid
Madrid, Spain
dethar@gmx.de

Andreas Ahrens
Department of Electrical
Engineering and Computer Science,
Hochschule Wismar, University of
Technology, Business and Design
Wismar, Germany

Jelena Zascerinska
Centre for Education and
Innovation Research
Riga, Latvia

Abstract - **The service process is the key phase in any queue system applied to business and industry operations. The service process in shops is defined as the payment process at the cash register. The service process consists of two elements or sub-processes: the waiting in the queue to the cash register as well as the payment processing (scanning the goods, giving receipts to customers, etc). Analysis of burstiness as the indicator of the service process has been well-established. Against this background on burstiness as the indicator of the service process, burstiness is also defined as a factor that influences the service process. However, burstiness as a factor in the service process has not attracted a lot of research attention. The aim of this paper is to analyse burstiness as a factor in the service process underpinning the elaboration of scenarios of the service process for the queue management purposes. The present work mostly employs theoretical methods: scientific literature analysis, synthesis, modelling, comparison, and systematization. The theoretical research results in the outline of the conceptual framework for exploring the impact of burstiness on the service process. The key concepts have been identified, namely binary customer behaviour, buyers' burstiness, bottlenecks' emergence at the server, and queue management. The logical chain of the development has been emphasized: binary customer behaviour → buyers' burstiness → bottlenecks' emergence at the check-out station or cash register (server) → queue management. The presented logical chain allows finding out that buyers' burstiness leads to the queue appearance in the service process. In turn, queue appearance requires queue management measures. Hence, buyers' burstiness influences on the decisions in regard to queue management within the service process. Further on, two functions of buyers' burstiness are defined: the indicators of the service process, and the factor that influences the service process. This bi-modal role of buyers' burstiness in the service process highlights the complex nature of the queue**

management. Five scenarios of the service process will allow using a combination of queue management measures in each scenario or even between scenarios. The findings of the comparative study propose the structure of the service process as the unity of the waiting in the queue to the cash register and the payment processing at the cash register, i.e. scanning of the goods and the payment. The present research has some limitations. Further research tends to validate the model of five scenarios of the service process for the queue management purposes. Comparative studies on buyers' burstiness in the service process will be continued, too.

Keywords - binary customer behaviour, buyers' burstiness, bottlenecks' emergence at the check-out station (server), queue management.

I. INTRODUCTION

The service process or, in other words, server is a key component in industrial and business operations [1]. Figure 1 as depicted in [1] shows the service process or, in other words, the payment process in the buying process chain [1].

Fig. 1. The key phases in business operations [1].

Figure 2 reveals that the service process includes two sub-processes [1]:

- waiting in the queue to the cash register, and

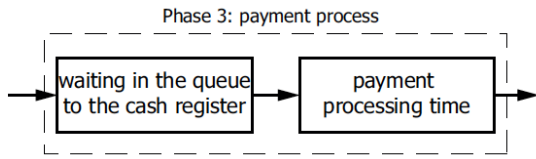- the payment processing at the cash register.

Fig. 2.   The elements of the service process [1].

It should be pointed that the service process as the unity of waiting in the queue to the cash register and the payment processing was analysed through generating functions [1] as the generating function offers closed-form solutions when modelling bursty business processes [2]. Closed-form solutions are an advantage when using a single function instead of analysing a sequence of infinite length [2]. In the analysis of the service process, generating functions were used for the analysis of the free time intervals between buyers to the cash register as a part of the payment process [1].

Similar concepts in regard to the presented service process were later presented

- in [3] as illustrated in Figure 3 developed by Kiataramkul and Neamprem [3], and

- in [4] as disclosed in Figure 4 created by Cheong and Chia [4].

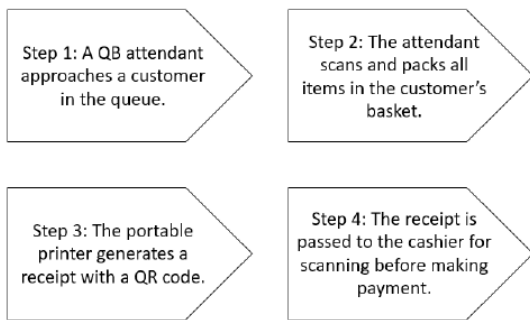Fig. 3.   The basic queueing process [3].

Fig. 4.   Process Flow for Queue Buster [4].

Table 1 demonstrates the results of the comparison of the three concepts, namely

- the service process by [1],

- the queueing process by [3], and

- the queue buster [4].

TABLE 1 RESULTS OF THE COMPARISION OF THREE CONCEPTS

Concep-tual ap-proach	Compared elements		
	Process structure	*Process units of analysis*	*Process indicators*
The service process [1]	• Waiting in the queue to the cash register, • The payment processing	The unity of the two elements: • Waiting in the queue to the cash register, • The payment processing	Burstiness that includes two parameters: • Buyers' probability: buyers' waiting times in the queue and buyers' service (payment processing) times • Buyers' concentration
The queueing process [3]	• Queue • Service mechanism	• Queue • Service channels	• Average queue length, • The average total work in process, • The average waiting time, • The average total time
The queue buster [4]	• Customer approaching in the queue • Scan and pack • QR code generation • Receipt scanning and payment	• Scan and Pack Time/Item • Payment Time • Total Time	• Wait Time, • System Time, • System Length

Table 2 described burstiness as the indicator of the service process.

TABLE 2 BURSTINESS AS THE INDICATOR OF THE SERVICE PROCESS

Indica-tor	Indicators elements			
	Buyers' probability			*Buyers' concent-ration*
Bursti-ness	• buyers' waiting times in the queue to the cash register	• buyers' service (payment processing) times at the cash register		• buyers' concentration
		• buyers' service time	• free-time intervals between buyers	

Analysis of burstiness as the indicator of the service process has been well-established [5] - [9].

Against this background on burstiness as the indicator of the service process, burstiness is also defined as a factor [10] that influences the service process [11]. Figure 5 reflects the both functions of burstiness in the service process.
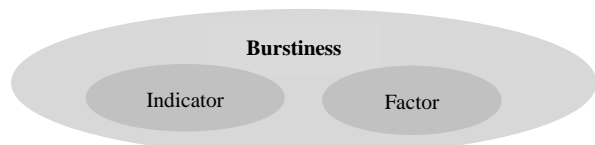

Fig. 5.   Burstiness functions.

Hence, burstiness is a bi-modal phenomenon:

- on the one side, burstiness as the indicator is used to determine developmental dynamics of the object [12], and

- on the other hand, burstiness as a factor changes the service process.

It should be noted that by bi-modal phenomenon, a phenomenon that obtains or exhibits two contrasting modes or forms is meant [13].

However, burstiness as a factor in the service process has not attracted a lot of research attention.

The aim of this paper is to analyse burstiness as a factor in the service process underpinning the elaboration of scenarios of the service process for the queue management purposes.

The present work mostly employs theoretical methods: scientific literature analysis, synthesis, modelling, comparison, systematization.

The remaining part of this paper is organized as follows: Section II introduces the conceptual framework of the research. The impact of buyers' burstiness on the service process is theoretically analysed in section III followed by five scenarios of the service process aimed at the queue management. Finally, some concluding remarks are given in Section IV.

II. CONCEPTUAL FRAMEWORK

Burstiness is a factor that influences the service process [1]. It should be noted that by factor, a reason of phenomenon change is meant [14].

Burstiness that influences the service process is related to customers [11]. In the present work, a customer is the overall term. A customer refers to anything and anyone that arrives at a facility and requires service. Examples of customers are shoppers at the check-out station or cars at the traffic light. The term "customer" has received a variety of definitions. In scientific literature, customer and client are synonymously used. Further, the term of "lost customers" is introduced by Sharma [15]. Customer also includes customer abandonment behaviour [16] in regard to a customer who stopped trying to receive a service due to a number of reasons. The term of "blocked customers" describes one who retries to get a service after a random amount of time [15]. Hence, these researchers have established the understanding of the customer behaviour based on the reception of service.

The present research is based on the concept of binary customer behaviour as depicted in Figure 6 [11].

Binary customer behaviour means to buy or not buy [17]. The use of the concept of binary behaviour allows differentiating customers into [17]

- visitors (i.e. who visit a shop but does not buy anything) and

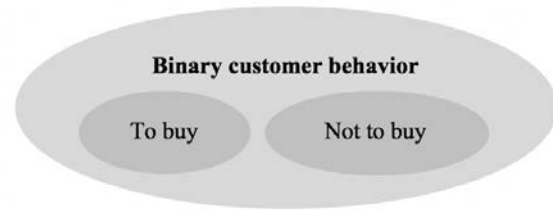- buyers (who visit a shop and buy a product).

Fig. 6. Elemenst of customer binary option [11].

Buyers are further differentiated into two types [18]:

- highly delay-sensitive but only check-out a few items, and
- highly delay-insensitive but check-out many items.

It should be noted that the authors of the present work have enhanced the buyers' differentiation proposed by Tang, Guo, and Wang [18]. The authors of the present contribution introduce two more types of buyers:

- highly delay-sensitive buyer who only checks-out many items, and
- highly delay-insensitive buyer who checks-out a few items.

Consequently, the overall term "customer" is used in the same meaning by Sharma [15] and the authors of the present work. The terms "lost customer" and "visitor" are used synonymously. Table 3 shows the inter-relationships between customer, client, visitor, lost customer, customer abandonment behaviour, buyer, highly delay-sensitive buyer who only checks-out a few items, highly delay-sensitive buyer who only checks-out many items, highly delay-insensitive buyer who checks-out a few items, and highly delay-insensitive buyer who checks-out many items.

TABLE 3 TERMS USED IN THE RESERACH

Customer / Client			
Visitor, Lost customer, Customer abandonment behaviour	*Buyer*		
	highly delay-sensitive buyer who only checks-out a few items	highly delay-sensitive buyer who checks-out many items	highly delay-insensitive buyer who only checks-out a few items	highly delay-insensitive who checks-out many items

Buyers' burstiness influences the service process [19]. Buyers' burstiness corresponds to an enhanced activity level over a short period of time followed by long periods of inactivity [19]. Buyers' bursty arrival at the server influences the service process at the cash register in a shop.

Buyers' bursty arrival at the server leads to the emergence of a bottleneck [2]. It should be noted that bottlenecks limit the flow of customers, services or products, etc [2]. A bottleneck emerges when single business processes within the business system operate at their capacity limit or beyond [2]. Due to the bottleneck, a queue appears [2]. Hence, the significance of queue management has become apparent.

It should be pointed that Table 4 shows the relationships between queuing systems, customer and server.

TABLE 4 THE RELATIONSHIPS BETWEEN QUEUING SYSTEMS, CUSTOMER AND SERVER

Queuing System	Customer	Server
Supermarket	Buyer	Cash register
Airport	Passenger	Check in counter
Bank	Client	Cash machine

The elaboration of this conceptual framework allows identifying the key concepts underlying the present research, namely

- binary customer behaviour,
- buyers' burstiness,
- bottlenecks' emergence at the server, and
- queue management.

The study presents a potential model for development indicating how the steps of the process are related following a logical chain: binary customer behaviour → buyers' burstiness → bottlenecks' emergence at the server → queue management. The presented logical chain allows finding out that buyers' burstiness leads to the queue appearance in the service process. In turn, queue appearance requires queue management measures. Figure 7 reveals the inter-relationships between the buyer burstiness, the service process and the queue management.
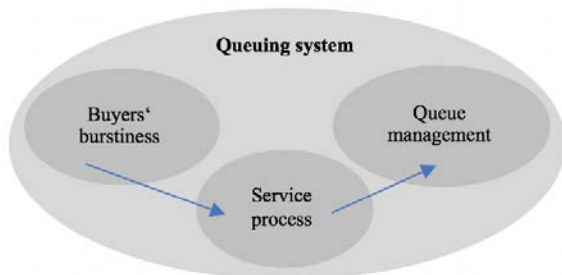

Fig. 7. The inter-relationships between the buyer burstiness, the service process and the queue management.

The presented conceptual framework directs the researchers to explore the impact of burstiness on the service process aimed at queue management.

III. IMPACT OF BUYERS' BURSTINESS ON THE SERVICE PROCESS

Impact is defined as the influence on the decisions (regardless of outcome) that shape people's lives, communities, governance, the environment, and elsewhere [20].

Burstiness is used to support decision making through designation of a tendency in a field of scientific investigation [21] as pointed in Figure 8 [6].
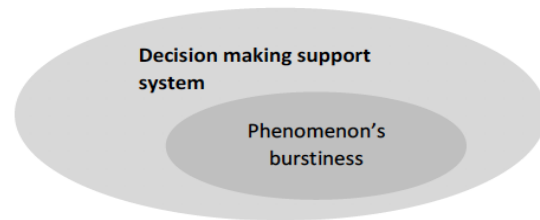

Fig. 8. The inter-connections between decision making support system and phenomenon's burstiness [6].

Consequently, buyers' burstiness influences the decisions on queue management of the service process. By queue management, planning, organizing, leading, and controlling the queuing system aimed at organising an efficient service process in order to reduce customer waiting times in the queue to the cash register or payment processing times at the cash register. The organization of the smooth flow of the service process increases [1]

- the customers' satisfaction with the service, and
- customers' loyalty to the serving company.

For the estimation of the impact of buyers' burstiness on the service process, evaluation of buyers' burstiness can be carried out. One of the reasons of the impact evaluation is the situation where decisions need to be made about whether and/or how to adapt, scale-up, mainstream or replicate projects or processes [22]. Impact evaluations are used in these circumstances because more certainty is required about the changes brought about through these kinds of intervention [22].

It is worth noting that the service process shown in [1] can be described by

- a buyer probability p_e (a visitor becomes with a probability p_e a buyer), and
- a buyer concentration (describing the level of burstiness between buyers α defined in [1]).

For a given level of concentration, probability can be low or high. The probability depends on

- the number of customers in the shop as well as
- on the number of bought goods.

Table 5 presented in [9] indicates buyers' burstiness' constructs and levels for the impact measurement.

TABLE 5 BUYERS' BURSTINESS CONSTRUCTS AND LEVELS [9]

Indicator	Constructs	Levels				
		1	*2*	*3*	*4*	*5*
		Very low	Low	Average	High	Very high
Burstiness	Probability p_e	Low or high	Low or high	Low or high	Low or high	Low or high
	Concentration $(1-\alpha)$	0.0 – 0.10	0.11 – 0.39	0.41 – 0.59	0.60 – 0.79	0.80 – 1.0

Buyers' burstiness is limiting the service process.

A burstiness level serves as an indicator of bottlenecks [1].

A high level of burstiness, expressed by the buyers concentration, increases the possibilities of bottleneck emergence [1].

The payment processing times at the cash register are quite regular [1]. However, the analysis of the free time intervals at the cash register describing the buyer waiting in the queue to the cash register allows drawing the conclusion on its bursty behaviour [1]. The bursty behaviour of the cashier free time intervals implies long breaks that alternate with many short breaks [1].

TABLE 6 SCENARIOS OF THE SERVICE PROCESS

Process	The service process				Traffic flow	
Process elements	*Waiting in the queue to the cash register*		*The payment processing*		*Scenario Nr*	*Queue description*
Constructs	Probability	Concentration	Probability	Concentration		
Levels	Low	Low	Low	Low	1	No queuing
	High	Low	Low	Low	2	Pre-Queuing
	High	High	Low	Low	3	Queuing
	High	High	High	Low	4	Pre-traffic jam
	High	High	High	High	5	Traffic jam

Based on these findings of the impact of burstiness on the service process, scenarios of the queue within the service process can be identified. For modelling purposes, Levels 1-3 are used as a low level, and Levels 4-5 – as a high level. Five scenarios of the service process for the queue management purposes are described in Table 6.

IV. CONCLUSIONS

The theoretical research results in the outline of the conceptual framework for exploring the impact of burstiness in the service process. The key concepts have been identified, namely

- binary customer behaviour,
- buyers' burstiness,
- bottlenecks' emergence at the server, and
- queue management.

The logical chain of the development has been emphasized: binary customer behaviour → buyers' burstiness → bottlenecks' emergence at the server → queue management. The presented logical chain allows finding out that buyers' burstiness leads to the queue appearance in the service process. In turn, queue appearance requires queue management measures. Hence, buyers' burstiness influences the decisions in regard to queue management within the service process.

Further on, two functions of buyers' burstiness are defined:

- the indicator of the service process, and
- the factor that influences the service process.

This bi-modal role of buyers' burstiness in the service process highlights the complex nature of the queue management. Five scenarios of the service process will allow using a combination of queue management measures in each scenario or even between scenarios.

The findings of the comparative study presented in Table 1 propose the structure of the service process as the unity of the waiting in the queue to the cash register and the payment processing.

The present research has some limitations. A limitation is the conceptual framework based on the key concepts, namely

- binary customer behaviour,
- buyers' burstiness,
- bottlenecks' emergence at the server, and
- queue management.

Another limitation is the comparative study carried out on the works found via the google search. If the access to other databases would be available, the other findings of the comparative study could be outlined.

The two functions of buyers' burstiness also could limit the investigation of the service process. If other functions of buyers' burstiness within the service process would be determined they could help extend the understanding of the organization of the service process.

Further research tends to validate the model of five scenarios of the service process for the queue management purposes. Comparative studies on buyers' burstiness in the service process will be continued, too.

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