Gap Structure and Characteristic Properties for Analysing Buyers' Burstiness in e-Business Process

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Abstract: Optimization of e-business process allows increasing earning profits in e-business. Models based on gap processes for the analysis of buyers' burstiness in e-business process have attracted an increased research interest in order to succeed in the optimization of e-business process. The research aim is to find model approaches for creating gap structures and the description of their characteristic properties with a required accuracy underpinning elaboration of a new research question. Interdisciplinary research was carried out within the present investigation. The results of the present research show gap structures and gap characteristic properties. In e-business, gap structure means a range of shop visitors who do not buy any product. The gap characteristic properties are defined as gap density and gap distribution function. The empirical study involved eight experts from different countries to validate the model and to project the research. The findings of the study allow drawing the conclusions on the experts' positive evaluation of the mathematical model for analysis of buyers' burstiness in e-business process. The novel contribution of the paper is revealed by the comparison of model approaches for creating gap structures and the description of their characteristic properties with a required accuracy. Directions of further research are proposed.

1 INTRODUCTION

Economy is at the heart of the well-being of modern society. However, economy depends on success of companies and/or enterprises including e-companies to organise their business and/or e-business processes in an efficient way. Optimization of e-business process allows increasing earning profits in e-business. Optimization of business process implies (Ahrens et al., 2015; Ahrens et al., 2018) such choices as

- quantity of goods to be delivered and
- number of the staff to be employed,
- goods' pricing,
- goods discounts,
- computer software to be installed,
- networking between a business company and its customers to be established,
- queue management, etc.

Additionally, such a result of business process as purchase and/or sale of a good or service indicates the output of this process.

Efficient use of company's scarce resources to create, using knowledge, commodities and distribute them among people (Khumalo, 2012, p. 606) requires good or right decisions as delivered in Figure 1 (Ahrens et al., 2015).

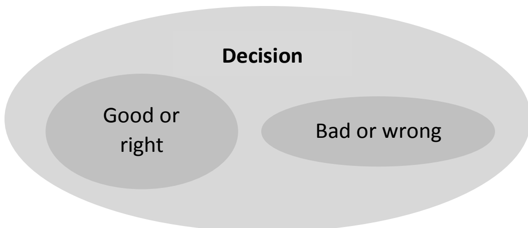

Figure 1: Decision differentiation.

Good or right decisions are expected to ensure fast and harmonious ways to the well-being of society in general, company including e-company

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and/or individual in particular as illustrated in Figure 2 (Ahrens et al., 2015).

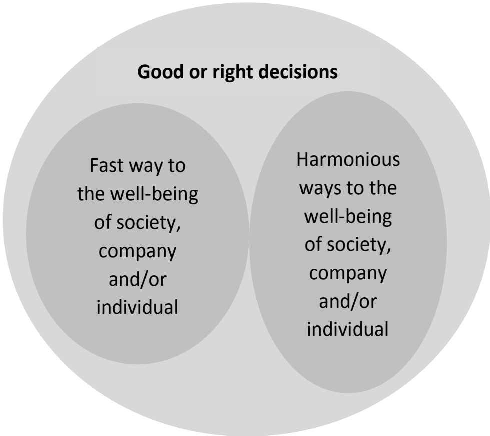

Figure 2: Elements of good or right decisions.

In contrast, bad or wrong decisions serve as a source of conflict or stress for society in total and/or individual in particular as shown Figure 3 (Ahrens et al., 2015).

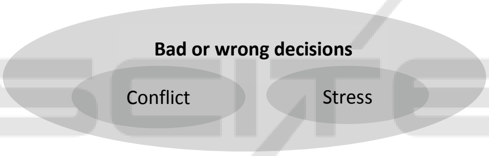

Figure 3: Elements of bad or wrong decisions.

Good or right decisions are expected to ensure fast and harmonious ways to the well-being of society, company and/or individual. Therefore, decision-making support systems are of great research interest. Predictive capacity is one of the forms of support to the decision making (Cronqvist et al., 2015). For example, the most recurrent techniques to predict and analyse market behaviour are Technical and Graphic Analysis (Biglieri and Almeida, 2018). As the research on forecasting and prediction in many life domains remains of high interest, certain research efforts have been devoted to a newly emerged research area on such a phenomenon as burstiness. It should be noted that beginning in 1960 Gilbert presented the first model in telecommunications which emphasized that bit errors occurred in bundles or, in other words, bursts (Gilbert, 1960; Elliott, 1963). Since then, the issues of a general procedure to analyse the performance or, in other words, business process in the present research, are still relevant today. Figure 4 demonstrates the phenomenon of burstiness in a range of scientific fields (Ahrens et al., 2016).

Scientific field	Phenomenon of burstiness
Telecommunications	Burstiness of bit-errors in data transmission
Economics	Burstiness of crises
Natural sciences	Burstiness of disasters or earthquakes
Logistics	Burstiness of traffic
Social media	Burstiness of hot topic, keyword or event
Business	Burstiness of workload
E-Business	Burstiness of buyers

Figure 4: Burstiness in different scientific fields.

Burstiness is used to support decision making through designation of a tendency in a field of scientific investigation (Pierrehumbert, 2012) as pointed in Figure 5.

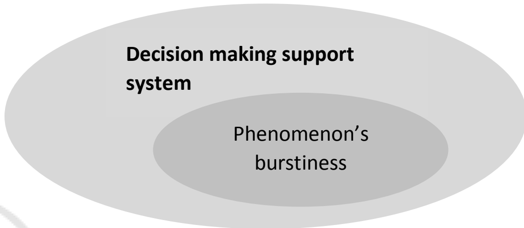

Figure 5: The inter-connections between decision making support system and phenomenon's burstiness.

Analysis of burstiness as a predictor of performance was carried out in

- the management science (Riedl and Woolley, 2017) as well as
- e-business (Ahrens and Zaščerinska, 2017b),
- entrepreneurship education (Ahrens et al., 2018).

Further on, modern decision making support systems are closely connected with data analytics and management. The proliferation, ubiquity and increasing power of computer technology has dramatically increased data collection, storage, and manipulation ability (Dermino and Fortingo, 2015). As data sets have grown in size and complexity, direct "hands-on" data analysis has increasingly been augmented with indirect, automated data processing (Dermino and Fortingo, 2015). Automated detection has been already aided by other discoveries in computer science (Dermino and Fortingo, 2015), such as

- neural networks, cluster analysis, genetic algorithms (1950s),
- decision trees and decision rules (1960s), and
- support vector machines (1990s).

However, effective methods and approaches for automated detection are still an open research area that is constantly being developed.

Burst detection method as a method for automated detection has recently attracted a lot of research interests (Fei et al., 2013; Kalogeratos et al., 2016). Intense research activities on burst patterns were carried out (Subašic´ and Berendt, 2010). However, a lack of common procedures today makes it impossible to compare methods in a principled way (Subašic´ and Berendt, 2010). The burst detection method exploits the burstiness nature of a phenomenon (Fei et al., 2013). Burst means sudden concentration, for example buyers' concentration, in time periods (Fei et al., 2013).

For the optimization of e-business process, a mathematical model based on gap processes for analyzing buyers' burstiness has been presented (Ahrens and Zaščerinska, 2017a). The previous research focused on

- determination of criteria for qualitative decisions (Ahrens et al., 2015),
- identification of criteria of burstiness (Ahrens et al., 2016),
- analysis of buyers' burstiness as a predictor of performance (Ahrens and Zaščerinska, 2017b) as well as
- the model's parameter estimation and practical application (Ahrens and Zaščerinska, 2017a),
- mathematical analysis of gap processes (Ahrens et al., 2018).

The research question is as follows: What are gap structure and gap characteristic properties?

The aim of the research is to find model approaches for creating gap structures and the description of their characteristic properties with a required accuracy underpinning elaboration of a new research question.

The present contribution employs interdisciplinary research as interdisciplinary research assists in synthesizing, connecting and blending ideas, data and information, methods, tools, concepts, and/or theories from two or more disciplines in order "to make whole" (Repko, 2012).

For the purposes of the present research, the synergy between e-business and telecommunications is promoted as the phenomenon of customers in the e-business process as well as bit-errors in data transmission appear to be of a similar nature, namely, the bursty nature. Such methodologies that consider the bursty nature of bit-errors in data transmission have been successfully implemented in telecommunications for optimizing data communication protocols and will be adopted in this work to the buyers' burstiness in e-business process. It should be noted that the present research is not limited to only two scientific disciplines, namely, e-business and telecommunication, but is based on a number of scientific disciplines such as business, social media, logistics, literature, etc.

The process of interdisciplinary research is organized in three phases (Ahrens and Zaščerinska, 2016):

- In Phase 1 of the interdisciplinary research, an issue is separately explored by two or more scientific disciplines.
- In Phase 2, the same issue is examined by the synergetic point of view of these two or more scientific disciplines.
- In Phase 3, results of the analysis are interpreted.

The remaining part of this paper is organized as follows: Section 2 introduces methodological foundation of burstiness. Buyers' burstiness in e-business is presented in Section 3. The associated results of an empirical study will be presented in Section 4. Finally, some concluding remarks are provided in Section 5 followed by a short outlook on interesting topics for further work.

2 METHODOLOGICAL FOUNDATION OF BURSTINESS

Queuing theory serves as the methodological foundation of burstiness.

Queuing theory is the mathematical study of waiting lines, or queues (Möller, 2014). Queuing theory (or "queueing theory") examines every component of waiting in line to be served, including the arrival process, service process, number of servers, number of system places and the number of "customers" (which might be people, data packets, cars, etc.) (Shanmugasundaram and Banumathi, 2017). The arrival process is closely connected with burstiness as phenomenon's arrival is of bursty nature (Froehlich and Kent, 1998). Burstiness effects the queue as a higher level of burstiness increases delay (Kumar, 1994) in a waiting line. Figure 6 demonstrates the relationship between the queuing theory and its elements, namely the arrival process and burstiness.

There is a number of approaches to burstiness analysis. Table 1 (adapted from Ahrens et al., 2016) presents three approaches to burstiness analysis. The approach entitled Gap Processes for Analysing Burstiness (Ahrens and Zaščerinska, 2016) has been recently developed. Gap processes have emerged due to the constantly growing meaning of the Internet as an open global communication system that leads to a huge number of different communication applications and services for the giant community of Internet users. Users may access several communication services per time whereas every service requires certain communication parameters like bandwidth, delay, error-rates or jitter to work with adequate quality of transmission. A service provider who likes to offer network quality depending on communication services such as real time audio or video transmission requires appropriate tools for access network design, monitoring and enhancement.

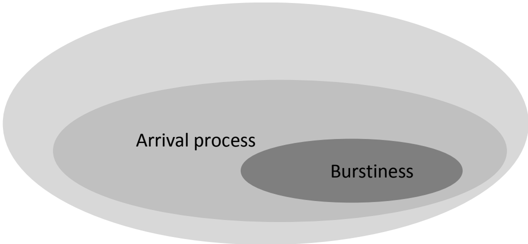

Figure 6: The relationship between queueing theory, arrival process and burstiness.

Table 1: Three approaches to burstiness analysis (adapted from Ahrens et al., 2016)

Approach's element	**Hidden Markov Model (HMM)**	**Kleinberg's burst detection algorithm (2002)**	**Gap Processes for Analysing Burstiness (Ahrens and Zaščerinska, 2016)**
Methodological background	A sequence model or sequence classifier is a model whose job is to assign a label or class to each unit in a sequence, thus mapping a sequence of observations to a sequence of labels (Jurafsky and Martin, 2016).	The algorithm for detecting bursty network traffic that yields a nested representation of the set of bursts and imposes a hierarchical structure on the overall stream.	Gap distribution function within a sequence of the disturbed and interrupted transmission intervals
Feature	Markov chain is only useful for assigning probabilities to unambiguous sequences (Jurafsky and Martin, 2016) as system state is partially observable.	Sequence of batched georeferenced documents	Sequential independence of gaps between two researchers Or sequentially independent gaps of length *k* between the individual phenomenon

Important characteristics of radio channels, such as interrelationships between bit-errors, are included in digital models, which are used for several optimization tasks. Multipath propagation is a typical effect in radio channels such as the short wave channel since the emitted electromagnetic waves are subject to diffraction, refraction and reflection. Therefore, they reach the receiving site at different angles and with different attenuation and phase. Thus, the channel output shows dependencies between adjacent symbols (Wilhelm, 1976; Ahrens, 2000). For instance, for the development of channel coding algorithms these effects have to be considered, and the optimization requires a corresponding digital channel model. The simple model of a memoryless channel cannot be applied.

Figure 7 illustrates the differences between a memoryless channel and a channel with memory ("x" denotes a bit error and "-" a correct bit).

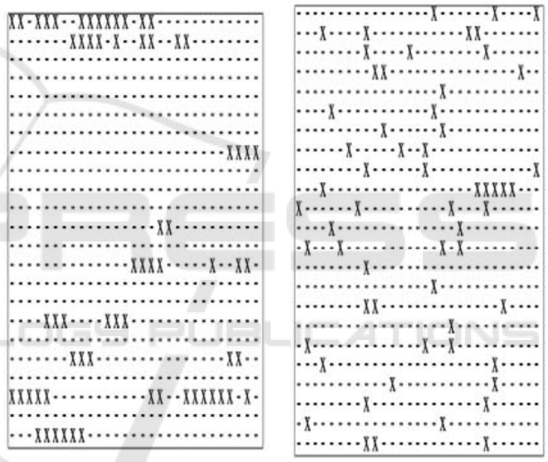

Figure 7: Error structures with and without memory in Information and Communication Technology (ICT).

From digital channel modeling it is known that the bit-error rate is not sufficient to describe a lot of digital channels (e. g. Wireless channels) since the bit errors do not appear independently from each other. Often channels with memory arise, and the bit-errors appear concentrated. Similar dependencies can be found in data networks regarding the characteristics of the traffic (e.g. the temporal intervals between consecutive data packets) (Kessler et al., 2003). Such processes can be identified as gap processes, i.e., the temporal intervals between data packets as well as the bit-errors in telecommunication systems (Ahrens et al., 2018). Frequently used and well-suited practical approximations are provided, if the model is based on the independence of the gap intervals (Wilhelm, 1976). These models are completely described by the gap density or the gap distribution, respectively. The assumption that successive gaps are statistically independent is regarded as a good practical approximation. The analysis of error structures of real wireless channel connections in Central Europe leads to the gap distribution such as exponential, Weibull or gap-distribution functions defined by Wilhelm (Wilhelm, 1976; Ahrens, 2000; Wilhelm, 2018). It should be noted that the terms "gap", "gap process" and "gap distribution function" are used synonymously in the present contribution. Gaps are rooted in the Hidden Markov Models (HMM) (Ahrens, 2000)**.**

As regard to the historical development of this approach, Gilbert's work (Gilbert, 1960) has been extended by Wilhelm who introduced some closed form solutions for describing the bit-error distributions in wireless communication channels such as the short-wave transmission channel (Wilhelm, 1976) by outlining regenerative model approaches. These investigations were encouraged by practical measurement campaigns in the sixties and seventies. Wilhelm elaborated already at that time simulation models such as the L-model or the A-model which took the effect of burstiness into consideration. He recognized that the bit-error probability (also sometimes referred as bit-error rate) is not sufficient to describe the effect of burstiness in wireless communication. Instead he defined solutions which take burstiness into account by defining models with two input parameters such as the bit error rate and the error concentration value. Wilhelm (Wilhelm, 1976) mapped the process of bit-errors in telecommunication systems onto processes defined by gaps between two consecutive bit errors. Since the gap-length undergoes some variations, the statistical description requires appropriate probability distribution functions. By defining a gap-distribution function (defined as the probability that a gap between two bits in larger than k bits) or a gap-density function (defined as the probability that a gap between two bits equals k bits) he could find closed form solutions. The model characteristic has later been extended by Ahrens (2000). Supported by practical measurements, these models make use of the assumption that the block error rate (i.e. a block with at least one bit-error) can be described as a function of the bit-error probability and the block length. In the double-logarithmic scale the linearity between the block error rate and the block length is used to define the simulation model characteristic as well as is used to define the inherent concentration between consecutive bit-errors. The model characteristic is proved by many measurements campaigns (Ahrens, 2000).

Digital simulation models such as the beforehand mentioned models for describing burstiness in wireless transmission systems are an important prerequisite for optimizing the underlying components for data transmission such as transmitting or receiving algorithms. Such simulation models have been heavily used for optimizing of coding schemes. So was the probability of undetected errors for shortened Hamming codes investigated by Lange and Ahrens (Lange and Ahrens, 2001) on bursty channels. Another example showing the importance of such simulation models is the modelling of connection arrivals in Ethernet-based data networks (Kessler et al., 2003), where the intervals between consecutive data packets in a data network were analysed. What has however interested communication protocol developers and coding theorists, are the probabilities of error structures in any finite time interval such as the block length or the cycle length of a transmission procedure (Wilhelm, 2018). These probabilities are typically difficult to present analytically (Wilhelm, 2018).

Many studies have found that the block error probability ($p_B(n)$) dependent on the block length (n) in the initial part is linear when presented double-logarithmically (Wilhelm, 2018). With this approach, in the seventies Wilhelm (2018) developed the ***L-model*** (Gap Model) and ***A-model*** (Gap Model) with complete sets of formulae concerning the probabilities of error structures occurring in bursts, and in blocks. These gaps are assumed to be statistically independent from each other. With these models, the bursty nature of transmission errors in ICT could be simulated.

For comparison purposes, Table 2 demonstrates the model of analysis of burstiness of hot topic, keyword, event in a sequence of batched georeferenced documents in social media developed by a group of Japanese researchers as geo-annotated user-generated data on social media sites is becoming one of the most influential sources of information (Kotozaki et al., 2015). This group of Japanese researchers built their model of analysis of burstiness of hot topic, keyword in a sequence of batched georeferenced documents on Kleinberg's burst detection algorithm (2002), which is based on the queuing theory for detecting bursty network traffic (Kotozaki et al., 2015). It should be noted that Kleinebrg's solution does not provide clear distinction between within-burst and out-of-burst records (Mai et al., 2015).

Table 2: Criterion and indicator of burstiness in social media.

Criterion	Indicator
Burstiness of hot topic, keyword, etc in a sequence of batched georeferenced documents	Locality

A comparative analysis of the model of analysis of burstiness of hot topic, keyword in social media shown by the group of Japanese researchers (Kotozaki et al., 2015) and the model for evaluation of researchers' burstiness in research process (Ahrens et al., 2016) is reflected in Table 3.

Table 3: Comparison of models for analysis of burstiness in social media and research.

Model's element	Social media	Research process
Criteria	Burstiness of hot topic, keyword, etc in a sequence of batched georeferenced documents	Researchers' burstiness
Indicators	Locality	Researchers' probability
		Researchers' concentration
Feature	Sequence of batched georeferenced documents	Sequential independence of gaps between two researchers or sequentially independent gaps of length *k* between the individual researchers
Methodological background	Kleinberg's burst detection algorithm (2002), based on a queuing theory for detecting bursty network traffic and yields a nested representation of the set of bursts that imposes a hierarchical structure on the overall stream.	Gap distribution function within a sequence of the disturbed and interrupted transmission intervals

The comparative analysis of Table 3 reveals that Kleinberg's burst detection algorithm, which is based on the queuing theory, is applicable to a sequence of phenomena while gap distribution function is featured by sequential independence of gaps between two researchers (Ahrens et al., 2016). The comparative analysis assists in drawing such a conclusion as a process including business process is characterized by independence of gaps between two researchers or, in other words, research subject or object.

Therefore, mathematical models that consider the bursty nature of bit-errors in data transmission have been successfully implemented in telecommunications for optimizing data communication protocols and will be adopted in this work to the optimization of bursty business processes. The approach based on gap processes is now considered as a possible solution of analysis of buyers' burstiness in business process.

3 BUYERS' BURSTINESS IN E-BUSINESS PROCESS

Phenomenon's burstiness is revealed as phenomenon's frequency at an unusual high rate (Kalogeratos et al., 2016). Interval of high-activity alternating with long low-activity periods can be found in many areas of our daily life. A classical example is e-business process. By e-business process, the process of buying and/or selling of goods and/or services through ICT is meant (Ahrens et al., 2015). Bursty e-business process is the process in which high-activity of buying and/or selling of goods and/or services through ICT alternates with low-activity intervals.

e-Business process which ends without a purchase or sale means a gap (Ahrens et al., 2015) in the present work. The gap process can be understood as a sequence of intervals. The gaps between two buyers are assumed to be statistically independent from each other (Ahrens et al., 2015). Figure 8 demonstrates gap structures. In Figure 8, buyers are represented by "x" within a sequence of shop visitors indicated by "-". In e-business, gap structure means a range of shop visitors who do not buy any product. In graphs of gap structure, the gap generally refers to the difference between shop visitors indicated by "-" and buyers represented by "x".

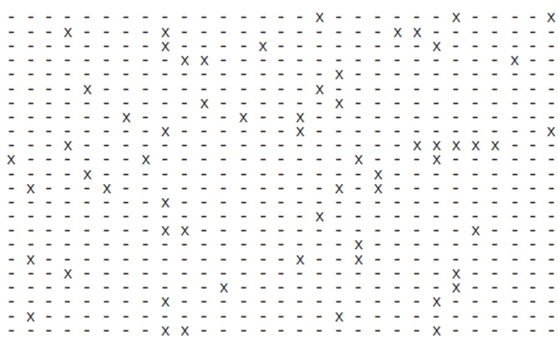

Figure 8: Gap structures.

In bursty situations, not only purchases and sales are of any research interest but also how concentrated goods are sold or bought. That is why models which focus only on purchases and sales with a given probability are not exact enough to describe e-business process. It should be noted that phenomenon is described through criteria, indicators and constructs. According to the theoretical findings of Lasmanis (2003, p. 9) and Špona and Čehlova (2004, p. 88), criteria serve to structure, assess and evaluate while indicators determine developmental dynamics. Criteria can be determined by analysis of (Špona and Čehlova, 2004, p. 88) definition of the research object, structure of the research object and factors. Analysis of source of criteria determines the use of terminology on *criteria, indicators* and construct as following:

- term *criterion* is defined as the key element to structure object of the research,
- term *indicator* is identified as the component to determine developmental dynamics of the object and
- term *construct* is specified as the sub-component of the research object.

Comparative analysis of the terms "criteria", "indicator" and "construct" with "parameter", "characteristic" and "property" leads to understanding that the following terms are used synonymously:

- criteria and parameter,
- indicator and characteristic, and
- construct and property.

The inter-connections between the terms "criteria, indicators and constructs", on the one side, and "parameter, characteristics and characteristic properties", on the other side, can be illustrated by the definition of the term "parameter": a parameter means definable, measurable, and constant or variable characteristic, dimension, property, or value, selected from a set of data (or population) to understanding a situation (or in solving a problem) (Business Dictionary, 2015).

In general, the buyers' probability can serve as a clear indicator of how often people decide to buy e.g. a product. However, the buyers' probability does not deliver any information about how concentrated the purchases and/or sales are. Thus, gap characteristic properties include buyers' probability and buyers' concentration (Ahrens et al., 2015) as summarized in Table 4.

Table 4: Criterion and indicators of burstiness in e-business process.

Criterion	Indicators
Buyers' burstiness	Buyers' probability
	Buyers' concentration

From the modelling of peoples' buying behaviour, it is known that the whole process of buying cannot be described by the buyer's probability since often buyers do not appear independently from each other. Therefore, in many cases the analogy with channels with memory arises. A proper solution can be found when describing the temporal intervals between buyers by gaps. The modelling of such processes requires statistical parameters of a gap process such as the gap density v(k) = P(X = k) and the gap distribution u(k) = P(X ≥ k). Here it is worth noting that the discrete variable k is given through the time resolution of the underlying (measurement) system. Frequently used and well-suited practical approximations are provided if the model is based on the independence of the gap intervals. Figure 9 gives an overview of different gap distribution function used to model burstiness in the process of buying as well as burstiness of bit-errors in telecommunication systems.

Type	Distribution
Exponential	$e^{-\beta_e k}$
Weibull	$e^{-(\beta_w k)^{\alpha_w}}$
Wilhelm	$((k+1)^{\alpha} - k^{\alpha}) \cdot e^{-\beta \cdot k}$

Figure 9: Several distribution functions.

The focus of this contribution is the approximation of the measured gap interval distribution by a suitable distribution function. As quality parameter for the approximation between the measured gap interval distribution and a given distribution function the mean square error is used and minimized.

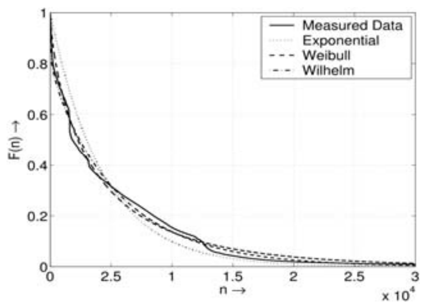

Figure 10: Gap interval distribution of measured data and approximated distribution functions.

Figure 10 visualizes exemplarily the measured gap distribution compared to the approximating distribution functions.

The parameter of approximated distribution function are presented in Table 5. Besides the Weibull distribution, the Wilhelm distribution approximates best the measured gap distributions in the sense of minimizing the mean square error E_{min}.

Table 5: Optimum parameters of distribution functions for measurement interval.

Distribution	α	β	$E_{\min}$
Exponential	–	$2,3152 \cdot 10^{-4}$	$70,9053$
Weibull	$0,7142$	$2,6267 \cdot 10^{-4}$	$14,9366$
Wilhelm	$0,9664$	$1,6426 \cdot 10^{-4}$	$11,3894$

It can be stated from Figure 10, that the statistical properties of the buying process are well approximated by distribution functions with two parameters (Weibull, Wilhelm), whereas distribution functions with only one single parameter (Exponential) provide not such a good result. Thus, the mean time between of two consecutive buyers i.e. the buyer probability, is not sufficient to describe the buying process.

4 EMPIRICAL ANALYSIS

The present part of the contribution demonstrates the design of the empirical study, results of the empirical study and findings of the study.

The design of the empirical study comprises the purpose and question, sample and methodology of the present empirical study.

The guiding study question is as follows: What is experts‘ evaluation of the model for analysis of buyers’ burstiness in e-business process?

The purpose of the empirical study is to analyze experts’ evaluation of the model for analysis of buyers’ burstiness in e-business process.

The present empirical study is justified by the use of the expert method that is considered to be one of the most appropriate for collecting, analyzing and evaluating of information, as well as for forecasting, when it is necessary to take responsible decisions in relation to innovations (Iriste and Katane, 2018) in a variety of processes including the e-business process. The method by means of which obtained results are based on the opinions and assessments of competent experts is called an expertise, an expert’s opinion or the method of expert assessment (Iriste and Katane, 2018).

The present empirical study involved three experts from different countries in September 2017, one expert in January 2018 and four experts in May 2018. All the respondents have been awarded PhD Degree in different sciences. As the respondents with different cultural backgrounds and diverse educational approaches were chosen, the sample was multicultural. Thus, the group (age, field of study and work, mother tongue, etc.) is heterogeneous. The sample of eight experts consisted of

- three researchers who acted as reviewers at the 13th International Joint Conference on *e-Business and Telecommunications* (ICETE 2017),
- one expert from IGI Global, International Publisher of Information Science and Technology Research as well as
- four researchers who acted as reviewers at the 3rd International Conference on Pervasive and Embedded Computing (PEC 2018)

In order to save the information of the study confidential, the respondents’ names and surnames were coded as E1 (Expert 1), E2 (Expert 2), E3 (Expert 3), E4 (Expert 4), E5 (Expert 5), E6 (Expert 6), E7 (Expert 7), and E8 (Expert 8).

Interpretive research paradigm (Taylor and Medina, 2013) that corresponds to the nature of humanistic pedagogy (Luka, 2008) was used in the present empirical study. Interpretive paradigm is characterized by the researchers’ practical interest in the research question (Cohen, Manion and Morrison, 2007). Researcher is the interpreter.

Exploratory research was employed in the empirical study (Phillips, 2006). Exploratory research is aimed at generating new questions and hypothesis (Phillips, 2006). The exploratory methodology proceeds from exploration in Phase 1 through analysis in Phase 2 to hypothesis development in Phase.

The qualitatively oriented empirical study allows the construction of only few cases (Mayring, 2004). Experts should be selected according to the aim of the research (Iriste and Katane, 2018). The choice of experts was based on two criteria (Flyvbjerg, 2006) such as recognized knowledge in the research topic and absence of conflict of interests. The number of experts depends on the heterogeneity of the expert group: the greater the heterogeneity of the group, the fewer the number of experts (Okoli and Pawlovski, 2004). Thus, eight is an appropriate number of experts to make a decision in relation to the innovation, namely gap structures and characteristic properties for analysis of buyers' burstiness in e-business process, as well as to forecast and project the present research (Iriste and Katane, 2018). Therein, the non-structured interviews comprised eight experts who were researchers from different countries. It should be noted that all the researchers were connected with research in such scientific fields as e-business, computing and telecommunications. All the eight researchers have an extended research experience and they have decisively contributed to their fields of expertise.

In order to analyse the model for analysis of buyers' burstiness in e-business process, non-structured inteviews were caried out. Non-structured interviews with experts were conducted in order to search for the main categories of the research field (Kroplijs and Rascevska, 2004).

Expert 1 emphasized that the mathematical model for characterizing e-business process is interesting. He found the idea to be interesting and the model – fair. The expert suggested to implement and show the related empirical work.

Expert 2 underlined that the authors argued that burstiness is a feature that appears in many different fields. The expert acknowledged that the authors proposed a model for buyers' burstiness in e-business processes based on gap processes. The expert pointed out that the authors deal with the interesting problem, the contribution is well-written and structured. Further on, the expert stressed that the proposed model makes sense. The expert was interested in hints about how this model could be used to improve the performance of e-business processes.

Expert 3 highlighted that the problem of buyers' burstiness in e-business processes had been examined, and the authors proposed a new model. The problem is relevant and interesting. The expert wished to clarify the benefits and use of the proposed model.

Expert 4 pointed that the submitted paper proposes to obtain a mathematical model of the burstiness of e-business with gap process. The author found that digital channel models such as Wilhelm distribution are well suited for describing the statistical properties.

Expert 5 admitted that the submitted paper addresses an interesting problem. Expert 5 suggested

- a more detailed experimental evaluation to be reported,
- more clear comparisons with the literature on the gap analysis should be discussed, and
- the advantages of adopting the proposed analysis should be presented more in detail.

Expert 6 identified that the paper aims to model the burstiness that occurs during the buying process of e-business transactions by defining the gap structures and characteristics which occurs during the bursts. The paper states the methodological foundation of burstiness using queuing theory and presents three approaches used to analyze such burstiness. The paper defines burstiness in the context of E-business processes. The paper defines gap as an E-business process that ends without a purchase and uses it to model the burstiness in the buying behaviors of E-business users.

Expert 7 disclosed that by applying queuing theory to the E-business phenomenon, the authors design a novel analytical model by combining two different disciplines. Expert 7 described that the paper clearly defines what gap structure and gap characteristic are and how they are applied to the E-business processes.

Expert 8 revealed that the idea of relate bit-error of traffic to business is interesting. The book gives a very interesting point to relate the bursty property of bit-error to business process. Queuing theory and Hidden Markov Models (HMM) are highly related to the main topic. The main strength of the contribution is that it identifies the common property between phenomenon of business process and bit-errors in data transmission to be of a similar nature, namely, the bursty nature. More analysis and evaluation in this area will be very useful and important.

Summarizing content analysis (Mayring, 2004) of the data reveals that experts positively evaluated the mathematical model based on gap processes for studying buyers' burstiness in e-business process.

5 CONCLUSIONS

The process of buying can be characterized by the intervals between two consecutive buyers. Based on measured gap interval distributions, suitable distribution functions and their parameters are determined. As a quality parameter, the minimum mean square error was used. Beside the Weibull distribution digital channel models like the Wilhelm distribution are well suited for describing the statistical properties. However, the applicability of this model concerning the simulation of buyers' behaviour deserves further study.

This paper analyzed the burstiness of e-business process aimed at obtaining a mathematical model based on gap processes which was finally validated by experts in the field. The empirical findings of the research allow drawing the conclusions on experts' positive evaluation of the model based on gap processes for analysis of buyers' burstiness in e-business process.

The empirical findings assist in identifying advantages of the presented research on the proposed model based on gap processes for analysis of buyers' burstiness in e-business process. It should be noted that advantages are identified as any trait, feature or aspect that gives an individual, entity or any other thing a more favorable opportunity for success (Business Dictionary, 2016a). In contrast, disadvantages are identified as any trait, feature or aspect that does not give an individual, entity or any other thing a more favorable opportunity for success (Business Dictionary, 2016b). Such advantages of the presented research on the proposed model based on gap processes for analysis of buyers' burstiness in e-business process are outlined as

- the carried our research facilitates the investigation of burstiness in a variety of scientific fields,
- the presented research is of interdisciplinary nature,
- a novel analytical model is designed by combining two different disciplines, and
- the implemented research identifies the common property between phenomenon of e-business process and bit-errors in data transmission to be of a similar nature, namely, the bursty nature.

Validity and reliability of the research results have been provided by involving other researchers into several stages of the conducted research. External validity has been revealed by international co-operation as following:

- the research preparation has included individual interdisciplinary consultations given by other researchers,
- the present contribution has been worked out in co-operation with international colleagues and assessed by international colleagues,
- the research has been partly presented at international conferences.

Therein, the findings of the present research are validated by other researchers.

The following research question has been put forward: What are advantages of the model based on gap processes for the analysis of buyers' burstiness in e-business process?

The present research has limitations. The inter-connections between *e-business process*, *the buyers' burstiness* and *gap processes* have been set. Theoretical integration of gap processes into a simulation model for the optimization of business processes could be a limiting parameter as gap processes are rooted in telecommunications. Moreover, simulation models for optimization of business and other processes are mostly based on the queueing theory. It should be noted that gap processes are an emerging phenomenon in the field of the queueing theory. Another limitation is the empirical study based on experts' evaluation only. Therein, the results of the study cannot be representative for the whole area. Nevertheless, the results of the research, namely the elaborated model based on gap processes for analysis of buyers' burstiness in e-business process, may be used as a basis for optimization of e-business process. If the results of other empirical studies had been available for analysis, different results could have been attained. There is a possibility to continue the study.

The inter-relationships between the queueing theory and gap processes are to be further analysed. Comparative study of gap processes in telecommunications and other scientific fields is to be carried out within the future research. Integrating the proposed simulation model based on gap processes of bursty business process in a queuing model would be the next step in order to benefit from the simulation model presented in this work. Parameter such as waiting time or queue length should be studied and predicted. Further research tends to facilitate the advancement of the theoretical framework on burstiness in diverse and dynamic environments. The search for relevant methods, tools and techniques for burstiness detection, regulation, monitoring, measurement, management, simulation, evaluation in diverse and dynamic environments is proposed. Further research facilitates practical applications of the validated simulation model based on gap processes for the optimization of business process to evaluate buyers' burstiness in business process as well as in a variety of diverse and dynamic environments. A comparative research of models for evaluation of burstiness in diverse and dynamic environments could be carried out, too. Further research would tend to implement empirical studies with participation of other groups of respondents.

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