



# A parallel space saving algorithm for frequent items and the Hurwitz zeta distribution

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## ABSTRACT

In general, a message-passing based parallel version of the space-saving algorithm designed to solve the  $k$ -summary problem. The algorithm determines in parallel frequent items, i.e., those whose frequency is greater than a given threshold, and it therefore works for counting queries and many other different scenarios. We apply our algorithm to the detection of frequent items in both real and synthetic datasets whose probability distributions feature zero-Hurwitz and a Zipf distribution respectively. Also, we compare its parallel performance and accuracy against a parallel algorithm recently proposed for message-passing based parallel space-saving algorithms.

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## 1. Introduction

Discovering frequent items is a data mining problem that attracted many researchers, owing to its relevance for applications in several domains. This problem is a  $k$ -line problem in the literature, depending on the specific application, as for the analysis of social network analysis [1] and web page [2,3]. Additionally, applications include network traffic analysis [4,5,6]. The analysis of web logs [7]. Computational and theoretical complexity [8], ecological field studies [9], etc. Several sequential references have been provided, in their turn [10]. Cormode and Muthukrishnan classify existing algorithms as being either counter or sketch based. Mihov and Cole [11] proposed the first counter-based sequential algorithm, which has been rediscovered independently by Demetrescu et al. [12] and Karp et al. [13]. Recently designed counter-based algorithms include JoinCounting [14] and Space Saving [15]. In particular, Space Saving has been shown to be the most efficient and accurate algorithm among counter-based ones [16], which motivates our choice of designing a parallel version of this algorithm. Multiple sketch-based solutions are CountSketch [17] and CountMin [18]. In the parallel setting, we presented in [19] a message-passing based parallel version of the Frequent algorithm, while [20] presents a shared-memory parallel version. A parallel version of the Lossy Counting algorithm has been proposed in [21]. Parallel versions of the Space-Saving algorithm for shared-memory architectures have been designed in [22] and [23]. A GPU Sketching Processing Unit accelerated algorithm for frequent items appeared in [24] and [25]. Novel shared-memory parallel algorithms for frequent items were recently proposed in [26].

A similar problem, finding frequent elements, is strongly related to the problem of association patterns mining, which originates from the analysis of market basket data. Such datasets are frequently used to be bought by customers, traditionally referred to as transactions. Association patterns mining entails discovering the so-called association rules that express set of items. Frequent

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# A Parallel Space Saving Algorithm For Frequent Items And

**Robin G. Qiu**



## **A Parallel Space Saving Algorithm For Frequent Items And:**

**Computational Science and Its Applications - ICCSA 2018** Osvaldo Gervasi, Beniamino Murgante, Sanjay Misra, Elena Stankova, Carmelo M. Torre, Ana Maria A.C. Rocha, David Taniar, Bernady O. Apduhan, Eufemia Tarantino, Yeonseung Ryu, 2018-07-03 The five volume set LNCS 10960 until 10964 constitutes the refereed proceedings of the 18th International Conference on Computational Science and Its Applications ICCSA 2018 held in Melbourne Australia in July 2018 Apart from the general tracks ICCSA 2018 also includes 34 international workshops in various areas of computational sciences ranging from computational science technologies to specific areas of computational sciences such as computer graphics and virtual reality The total of 265 full papers and 10 short papers presented in the 5 volume proceedings set of ICCSA 2018 were carefully reviewed and selected from 892 submissions The paper Nitrogen Gas on Graphene Pairwise Interaction Potentials is available open access under a Creative Commons Attribution 4.0 International License via link [springer.com](http://springer.com)

**Data Processing on FPGAs** Jens Teubner, Louis Woods, 2022-05-31 Roughly a decade ago power consumption and heat dissipation concerns forced the semiconductor industry to radically change its course shifting from sequential to parallel computing Unfortunately improving performance of applications has now become much more difficult than in the good old days of frequency scaling This is also affecting databases and data processing applications in general and has led to the popularity of so called data appliances specialized data processing engines where software and hardware are sold together in a closed box Field programmable gate arrays FPGAs increasingly play an important role in such systems FPGAs are attractive because the performance gains of specialized hardware can be significant while power consumption is much less than that of commodity processors On the other hand FPGAs are way more flexible than hard wired circuits ASICs and can be integrated into complex systems in many different ways e.g. directly in the network for a high frequency trading application This book gives an introduction to FPGA technology targeted at a database audience In the first few chapters we explain in detail the inner workings of FPGAs Then we discuss techniques and design patterns that help mapping algorithms to FPGA hardware so that the inherent parallelism of these devices can be leveraged in an optimal way Finally the book will illustrate a number of concrete examples that exploit different advantages of FPGAs for data processing

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**Soft Computing for Problem Solving** Kedar Nath Das, Jagdish Chand Bansal, Kusum Deep, Atulya K. Nagar, Ponnambalam Pathipooranam, Rani Chinnappa Naidu, 2019-11-27 This two volume book presents the outcomes of the 8th International Conference on Soft Computing for Problem Solving SocProS 2018 This conference was a joint technical collaboration between the Soft Computing Research Society Liverpool Hope University UK and Vellore Institute of Technology India and brought together researchers engineers and practitioners to discuss thought provoking developments and challenges in order to select

potential future directions The book highlights the latest advances and innovations in the interdisciplinary areas of soft computing including original research papers on algorithms artificial immune systems artificial neural networks genetic algorithms genetic programming and particle swarm optimization and applications control systems data mining and clustering finance weather forecasting game theory business and forecasting applications It offers a valuable resource for both young and experienced researchers dealing with complex and intricate real world problems that are difficult to solve using traditional methods

*Applied Reconfigurable Computing. Architectures, Tools, and Applications* Steven Derrien, Frank Hannig, Pedro C. Diniz, Daniel Chillet, 2021-06-23 This book constitutes the proceedings of the 17th International Symposium on Applied Reconfigurable Computing ARC 2021 held as a virtual event in June 2021 The 14 full papers and 11 short presentations presented in this volume were carefully reviewed and selected from 40 submissions The papers cover a broad spectrum of applications of reconfigurable computing from driving assistance data and graph processing acceleration computer security to the societal relevant topic of supporting early diagnosis of Covid infectious conditions

**Annual ACM Symposium on Parallel Algorithms and Architectures**, 2005 **Parallel and Distributed Processing and Applications**, 2005 **2005 IEEE International Conference on Service Operations and Logistics, and Informatics** Robin G. Qiu, 2005 **Seventh International Conference on Parallel and Distributed Systems** Yoshitaka Shibata, 2000 Presents 66 contributions from the July 2000 conference The technical areas covered are multimedia systems group communications checkpointing and commitment Web based computing distributed shared memory multicast object oriented programming routing fault tolerant systems high performance databases parallel systems mobile systems distributed algorithms multi agent systems and parallel and distributed query processing Annotation copyrighted by Book News Inc Portland OR

**Proceedings of the ... ACM SIGPLAN Symposium on Principles & Practice of Parallel Programming**, 2007 **2001 IEEE International Conference on Data Mining** Nick Cercone, Tsau Y. Lin, Xindong Wu, 2001 This proceedings of the November 2001 conference explores the design analysis and implementation of data mining theory and systems The 72 regular papers and 37 posters discuss data mining algorithms data and knowledge representation modeling of data to support data mining scalability issues st

**KDD ...**, 2006 **Algorithms, Sequential & Parallel** Russ Miller, Laurence Boxer, 2000 This work aims to provide an understanding of the analysis and applications of algorithmic paradigms to both the traditional sequential model of computing and to a variety of parallel models Concepts are applied to a broad range of subject areas including matrix operations

**Proceedings of the Twenty-Fourth ACM SIGMOD-SIGACT-SIGART Symposium on Principles of Database Systems**, 2005 *3rd IEEE International Conference on Data Mining* Xindong Wu, 2003 ICDM 03 brings together researchers and practitioners who describe their original research results and practical development experiences in Data Mining technology The papers explore subjects in many related data mining areas such as machine learning automated scientific discovery statistics pattern recognition

knowledge acquisition soft computing databases data warehousing data visualization and knowledge based systems Data mining is an emerging and highly interdisciplinary field The ICDM 03 proceedings cover a broad and diverse range of topics related to data mining theory systems and applications

**High Performance Computing** ,2003 Advances in Distributed and Parallel Knowledge Discovery Hillol Kargupta,Philip Chan,2000 This book presents introductions to DKD and PKD extensive reviews of the field and state of the art techniques Foreword by Vipin Kumar Knowledge discovery and data mining KDD deals with the problem of extracting interesting associations classifiers clusters and other patterns from data The emergence of network based distributed computing environments has introduced an important new dimension to this problem distributed sources of data Traditional centralized KDD typically requires central aggregation of distributed data which may not always be feasible because of limited network bandwidth security concerns scalability problems and other practical issues Distributed knowledge discovery DKD works with the merger of communication and computation by analyzing data in a distributed fashion This technology is particularly useful for large heterogeneous distributed environments such as the Internet intranets mobile computing environments and sensor networks When the data sets are large scaling up the speed of the KDD process is crucial Parallel knowledge discovery PKD techniques addresses this problem by using high performance multiprocessor machines This book presents introductions to DKD and PKD extensive reviews of the field and state of the art techniques Contributors Rakesh Agrawal Khaled AlSabti Stuart Bailey Philip Chan David Cheung Vincent Cho Joydeep Ghosh Robert Grossman Yi ke Guo John Hale John Hall Daryl Hershberger Ching Tien Ho Erik Johnson Chris Jones Chandrika Kamath Hillol Kargupta Charles Lo Balinder Malhi Ron Musick Vincent Ng Byung Hoon Park Srinivasan Parthasarathy Andreas Prodromidis Foster Provost Jian Pun Ashok Ramu Sanjay Ranka Mahesh Sreenivas Salvatore Stolfo Ramesh Subramonian Janjao Sutiwaraphun Kagan Tummer Andrei Turinsky Beat W thrich Mohammed Zaki Joshua Zhang

**Automata, Languages and Programming** Javier Leach Albert,1991 Papers presented at the 18th International Colloquium Madrid Spain July 1991 on such matters as logic and functional programming complexity concurrency graph algorithms complexity and computational geometry Annotation copyrighted by Book News Inc Portland OR

**Proceedings of the 1998 ACM CIKM International Conference on Information and Knowledge Management** Georges Gardarin,1998 **AI ...** ,2001 **Proceedings of the Twenty-First ACM SIGMOD-SIGACT-SIGART Symposium on Principles of Database Systems** ,2002

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