

# A Cloud-Based Parallel Space-Saving Algorithm for Big Networking Data

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**ABSTRACT** As the network continues to evolve, completely analyzing the traffic requires immeasurable resources. In situations of processing enormous streaming data, the most significant  $k$  items (Top- $k$ ) are more interesting, and some streaming algorithms are deployed due to relatively limited memory and also limited processing time per item. Space-saving is such one of the most popular algorithms for computation of frequent and Top- $k$  elements in data streams. In this paper, this algorithm is implemented in the cloud for analyzing big networking data, and an empirical formula of the counter number is derived for efficiently maintaining Top- $k$  items. Meanwhile, easily understandable proof manner is presented to prove the merging ability of Space-saving algorithm, and some experiments are conducted to affirm the effectiveness of the algorithm.

**INDEX TERMS** Network traffic, Top- $k$ , streaming algorithm, parallel algorithm.

## I. INTRODUCTION

Since there was an incredible growth in network traffic over the past years, we should have tools for collecting, and processing information at a scale previously unheard of. For this purpose, cloud-based systems like Apache Spark [1] have found their way into the mainstream and have seen widespread implementation in many fields including network traffic analysis.

Comparing to previously used parallel computing frameworks, like HPC (high-performance computing) [2], Spark allows users to treat a cluster of computers just like a single machine. The whole philosophy here is to automatically take work apart into small tasks and process them in a distributed manner and to automatically recover from failures [3]–[6]. Spark makes it easier and cheaper for us to run distributed applications.

There are many data computations where the size of the data is too big to work with on a single machine, but a moderate cluster is perfect. To achieve the ability to process very large datasets, some works [7]–[9] had been done to implement the parallelism of Spark, by converting existing local algorithms to the Spark parallel model. In order to efficiently analyze network traffic, we focus on the

Space-Saving algorithm that is used for finding Top- $k$  and frequent items in this paper.

Streaming data processing is beneficial in most scenarios where new, dynamic data is generated on a continual basis. In computer science, streaming algorithms are algorithms for processing data streams in which the input is presented as a sequence of items and may be examined in only a few passes, typically just one pass. These algorithms often have a limited memory much less than the input size, and also limited processing time per item. These constraints mean that an algorithm produces an approximate answer based on a summary or sketch of the data stream in memory.

The Space-Saving algorithm uses a data structure called Stream-Summary (SS) as shown in Fig. 1 to monitor the frequent items. The Stream-Summary data structure consists of a fixed number of counters, each associated with an item to be monitored. Frequency count and estimated error corresponding to each item are also stored in the counter. All counters with the same count are linked together and point to a parent bucket. Buckets are kept in a sorted doubly linked list, created and deleted dynamically as new items arrive.

When a new item arrives, if it is in the set of monitored items, increase the corresponding counter, otherwise remove

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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

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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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## **Table of Contents A Parallel Space Saving Algorithm For Frequent Items And**

1. Understanding the eBook A Parallel Space Saving Algorithm For Frequent Items And
  - The Rise of Digital Reading A Parallel Space Saving Algorithm For Frequent Items And
  - Advantages of eBooks Over Traditional Books
2. Identifying A Parallel Space Saving Algorithm For Frequent Items And
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an A Parallel Space Saving Algorithm For Frequent Items And
  - User-Friendly Interface

4. Exploring eBook Recommendations from A Parallel Space Saving Algorithm For Frequent Items And
  - Personalized Recommendations
  - A Parallel Space Saving Algorithm For Frequent Items And User Reviews and Ratings
  - A Parallel Space Saving Algorithm For Frequent Items And and Bestseller Lists
5. Accessing A Parallel Space Saving Algorithm For Frequent Items And Free and Paid eBooks
  - A Parallel Space Saving Algorithm For Frequent Items And Public Domain eBooks
  - A Parallel Space Saving Algorithm For Frequent Items And eBook Subscription Services
  - A Parallel Space Saving Algorithm For Frequent Items And Budget-Friendly Options
6. Navigating A Parallel Space Saving Algorithm For Frequent Items And eBook Formats
  - ePub, PDF, MOBI, and More
  - A Parallel Space Saving Algorithm For Frequent Items And Compatibility with Devices
  - A Parallel Space Saving Algorithm For Frequent Items And Enhanced eBook Features
7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of A Parallel Space Saving Algorithm For Frequent Items And
  - Highlighting and Note-Taking A Parallel Space Saving Algorithm For Frequent Items And
  - Interactive Elements A Parallel Space Saving Algorithm For Frequent Items And
8. Staying Engaged with A Parallel Space Saving Algorithm For Frequent Items And
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers A Parallel Space Saving Algorithm For Frequent Items And
9. Balancing eBooks and Physical Books A Parallel Space Saving Algorithm For Frequent Items And
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection A Parallel Space Saving Algorithm For Frequent Items And
10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
11. Cultivating a Reading Routine A Parallel Space Saving Algorithm For Frequent Items And
  - Setting Reading Goals A Parallel Space Saving Algorithm For Frequent Items And
  - Carving Out Dedicated Reading Time

12. Sourcing Reliable Information of A Parallel Space Saving Algorithm For Frequent Items And
  - Fact-Checking eBook Content of A Parallel Space Saving Algorithm For Frequent Items And
  - Distinguishing Credible Sources
13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
14. Embracing eBook Trends
  - Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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