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

DAZHONG HE, YANG YANG, AND JUN LIU, (Member, IEEE)

Center for Data Science, Beijing University of Posts and Telecommunications, Beijing 100876, China
School of Information and Communication Engineering, Beijing University of Posts and Telecommunications, Beijing 100876, China
Beijing Laboratory of Advanced Information Networks, Beijing University of Posts and Telecommunications, Beijing 100876, China
Beijing Key Laboratory of Network System Architecture and Convergence, Beijing University of Posts and Telecommunications, Beijing 100876, China

Corresponding author: Dazhong He (hdz@bupt.edu.cn)

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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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 *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 Table of Contents Preface Introduction A Primer in Hardware Design FPGAs FPGA Programming Models Data Stream Processing Accelerated DB Operators Secure Data Processing Conclusions Bibliography Authors Biographies Index *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

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