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# 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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