Turbo-counting: A new architecture for network traffic measurement

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I. Extended Abstract

There is an increasing need for fine-grained network measurement to aid the management of large networks [3]. Network measurement consists of counting the size of a logical entity called "flow," at an interface such as a router. A flow is a sequence of packets that satisfies a common set of rules. For instance, packets with the same source (destination) address constitutes a flow. Measuring flows of this type gives the volume of upload (download) by a user and is useful for accounting and billing purposes. Measuring flows with a specific 5-tuple in the packet header gives more detailed information such as routing distribution and types of traffic in the network. Such information can help greatly with traffic engineering and bandwidth provisioning. Flows can also be defined by packet classification; for example, ICMP Echo packets used for network attacks form a flow. Measuring such flows is useful during and after an attack for anomaly detection and network forensics.

Fine-grained network measurement requires routers and switches to update large arrays of counters at very high link speed (e.g. 40Gbps). A naive counting algorithm needs an infeasible amount of SRAM (Static Random Access Memory) to store the counters, and a rule for associating a flow to its counter so that arriving packets can update the right counters without delay. These challenges have made accurate per-flow measurement complex and expensive, and spawned two main approaches: (i) Exact counting using a hybrid SRAM-DRAM architecture [6], [4], [7], and (ii) approximate counting by exploiting the heavy-tail nature of flow size distribution [1].

We revisit the problem of accurate per-flow measurement. Inspired by sparse random graph codes and the Turbo-decoding principle [2], [5], we present a counter architecture, called Counter Braids, where a hierarchy of counters is "braided" using a random graph interconnection structure. Counter Braids solve the central problems of per-flow counting as follows: Braiding allows counter space to be shared across flows, thus minimizing space; and using random graphs generated on-the-fly with hash functions overcomes the flow-to-counter association problem.

We prove that Counter Braids, with a complex optimal decoder, has an asymptotic compression rate matching the information-theoretic lower bound. For implementation, we present a low-complexity, fully-analyzable message passing decoding algorithm, which can recover flow sizes with vanishing error at link speed. Evaluation on Internet traces demonstrates that almost all flow sizes are recovered exactly with only a few bits of counter space per flow.

References

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