SEPIA: Aggregation of Network Measurements Using Multiparty Computation

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A number of network security and monitoring problems can substantially benefit if a group of involved organizations aggregates private data to jointly perform a computation. For example, aggregation of private data is useful for alert signature extraction, collaborative anomaly detection, multi-domain traffic engineering, detecting traffic discrimination, and collecting network performance statistics. However, all these approaches face a delicate privacy versus utility trade-off. Some private data typically have to be revealed, which prohibits the acquisition of many data providers, while data anonymization, used to remove sensitive information, complicates or even prohibits developing good solutions [3]. Moreover, the ability of anonymization techniques to effectively protect privacy is questioned by recent studies [2]. One possible solution to this privacy-utility tradeoff is multiparty computation (MPC).

For almost thirty years, MPC [4] techniques have been studied for solving the problem of jointly running privacy-preserving computations on data distributed among multiple organizations. However, MPC techniques are typically impractical in terms of computation and communication cost. For this reason, they have mainly attracted theoretical interest in the last decades and only recently a real-world sugar-beet auction [1] was demonstrated. Adopting MPC techniques to network monitoring and security problems introduces the additional challenge of dealing with voluminous input data that require processing in *near real-time*. This is not presently possible with existing general-purpose MPC frameworks.

Therefore, we design, implement, and evaluate SEPIA, a library for efficiently aggregating multi-domain network data using MPC in the semi-honest adversary model. The foundation of SEPIA is a set of optimized MPC operations, implemented with performance of parallel execution in mind. On top of these comparison operations, we design and implement novel MPC protocols tailored for network security and monitoring applications. The *event correlation* protocol identifies events that occur frequently in multiple domains. The protocol is generic having several applications, for example, in alert correlation or in identification of multi-domain network traffic heavy-hitters. In addition, we introduce SEPIA's *entropy* and *distinct count* protocols that compute the entropy of traffic feature distributions and find the count of distinct feature values, respectively. These metrics are used frequently in traffic analysis applications, e.g., in network anomaly detection. We implement these protocols along with a vector addition protocol to support additive operations on timeseries and histograms.

Our evaluation of SEPIA's performance shows that SEPIA protocols run in near real-time with 5-minute windows, with up to 140 input providers and 9 computation nodes. Compared to implementations using existing general-purpose MPC frameworks, our protocols are significantly faster requiring, for example, 3 minutes for a task that takes 2 days with a general-purpose framework. Moreover, we run SEPIA on traffic data of 17 networks collected during the global Skype outage in August 2007 and show how the networks can use SEPIA to troubleshoot and timely detect such anomalies. Finally, we discuss novel applications in network security and monitoring that SEPIA enables.

References

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