Algorithms for Synchronizing Command and Control Data in Disconnected, Intermittent and Low-Bandwidth Environments

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In this work, we study the problem of reconciling similar sets of Command and Control (C2) data within a distributed, intermittent, and low-bandwidth (DIL) environment. We begin by developing a simple mathematical model that characterizes C2 data synchronization. Using this model, we produce lower bounds on the minimum throughput required between two hosts in order to synchronize their data. Afterwards, we consider algorithms capable of synchronizing C2 data and evaluate their performance.

In order to account for the unreliable nature of the DIL environment, any synchronization method considered has the following properties:

1) The method uses minimal communication rounds, and
2) The throughput between any two hosts on the network is limited.

Motivated by the setup described above, we consider the following mathematical problem:

Suppose there are two hosts $A$ and $B$, where Host $A$ has access to the set $S_A \subseteq GF(2)^b$ and Host $B$ has access to the set $S_B \subseteq GF(2)^b$. Which information should be sent from Host $A$ to Host $B$ in a single round so that Host $B$ can compute $S_B \setminus S_A$?

It is also desirable that any proposed solution possess low complexity. In the literature (c.f. [7]), this problem is known as the set-reconciliation problem.

In this work, we propose an approach to the set-reconciliation problem that, similar to [7], uses a Counting Bloom Filter (CBF) [6]. However, by using a decoding algorithm similar to [5], our approach achieves a lower probability of incorrect reconciliation. We show that our approach compares favorably to the work in [5], and, in many cases, it requires less throughput while maintaining the same order of complexity.

REFERENCES

This work represents a continuation of the C2 Synchronization Service (C2SS) project [15].