

# Executive Summary: NTP-based Data Infiltration Channels

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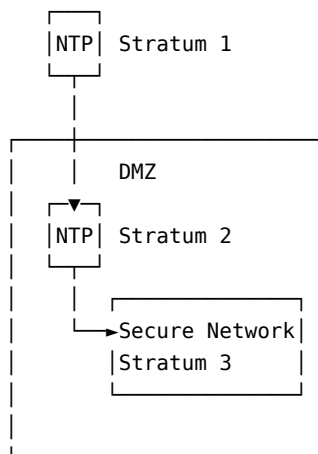
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Many papers focus on creating covert channels for the purpose of data exfiltration. That is, they attempt to remove some information from a protected network. Less common appears to be the concept of data *infiltration*, where a covert channel is established to secretly move information *inside* a protected network. Many exfiltration oriented channels make assumptions about extant arbitrary infiltration channels being available for loading the tooling necessary to establish the outbound channel. We are proposing studying and implementing an NTP-based covert channel for infiltrating unauthorized information into a secure network.

cated in a controlled DMZ. That NTP server synchronizes its clock by connecting to one or more trusted NTP pools. Any information that can survive a stratum layer\* may reach devices through the DMZ.

## Problem Statement

In typical enterprise threat scenarios, data infiltration is often achieved by way of phishing emails, TLS tunnels, or shell access. From there, exfiltration may be achieved by a number of covert channels. However, in certain locked-down networks, it may not be possible to send inbound email, establish a TLS tunnel, or directly access protected machines. On the other hand, administrators of these networks typically *do* want their machines clocks to be synchronized, since Bad Things<sup>TM</sup> happen when clocks drift out of sync. This presents NTP as a potential channel whereby information from the Internet can slowly leak into the inside of a protected network. We will consider two scenarios: DMZ access and direct access.



## DMZ Access

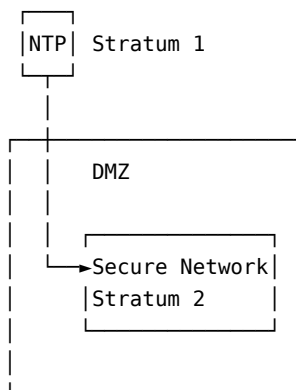
In DMZ access, devices in a secure network synchronize their clocks via an NTP server that is lo-

**Figure 1.** The DMZ Access NTP scenario, where an NTP server in a DMZ serves replies to clients in a secure inner network.

\*In NTP, a stratum is a layer of devices that are the same distance from a reference clock. Reference clocks, considered a source of truth, are at stratum layer 0. Servers that rely on reference clocks are at stratum layer 1, and so on. In our DMZ scenario, if public pools are at stratum 1, then the DMZ NTP server is at stratum 2, and internal devices are at stratum 3.

## Direct Access

In direct access, devices in a secure network synchronize their clocks directly via NTP to a trusted, publicly available, pool. Any information that the NTP server can pack into an NTP reply may reach devices inside this network.



**Figure 2.** The Direct Access NTP scenario, where clients in a secure inner network are allowed direct access to NTP pool servers.

## Project Summary

We are proposing the creation of an extended Berkeley Packet Filter (BPF) eXpress Data Path (XDP) filter that can be layered on top of existing NTP servers, or on routers between an NTP server and the target client, that can modify NTP server replies such that data may be infiltrated into secure networks. We will consider prior art on NTP covert channels and NTP as a covert storage cache and devise a method for data infiltration in one or both of the two scenarios.

After identifying a potential covert channel for one or both scenarios, we will fully define and document the channel. We will pay attention to factors such as: channel bandwidth, channel resilience, channel covertness, and so on.

After defining the channel, we will implement and test the channel in a virtual environment. There will likely be two components to the channel, an XDP filter and a receiver application that can decode received information. Ideally, we will be able to build the receiver with nothing but tools available on the target machine, requiring no outside applications. However, for the purposes of this paper, we will consider the infiltration of data into a

secure network as “good enough,” and leave data reconstruction as a problem for the reader.

## Project Breakdown

This is a rough outline of our project plan. At this stage, steps may be added or removed as necessary.

1. Study prior art on NTP storage channels and NTP covert caches
2. Identify potential NTP storage channels that satisfy the following criteria:
  - Do not noticeably interfere with normal NTP functionality
  - (Optionally) survive a stratum layer
3. Design and document one or more covert channels that meet these criteria
4. Implement the channel as a BPF XDP filter, with a receiver application
  - Document a method to reconstitute data using nothing but OS native utilities
5. Demonstrate our implementation working in a virtual machine environment

Our final deliverables will be:

- A working sender and receiver application
- A report with the following sections:
  1. Abstract
  2. Introduction, covering background on NTP channels
  3. Related works in NTP covert channels
  4. Design of our channel
  5. Implementation of our channel
  6. Methods for discovering and defeating our channel
  7. Conclusions and Future Work
  8. Bibliography
- A video reviewing the above paper and demonstrating our implementation

## Project Milestones

The milestones are presented in rough expected chronological order.

- (Milestone 1 - Cyrus) Potential NTP storage channels identified for selection
- (Milestone 2 - Stephen) Chosen NTP storage channel(s) identified, designed, and documented

- (Milestone 3 - Rafael) BPF XDP filter implemented
- (Milestone 4 - Rafael) Receiver application implemented
- (Milestone 5 - Ramon) Native receiver methodology documented
- (Milestone 6 - Ramon) Techniques to defeat our covert channel documented
- (Milestone 7 - Cyrus) Report finalized
- (Milestone 8 - Stephen) Video review and demonstration

**Project Timeline**

Milestone	Expected Completion Date
Preliminary Milestones	
1	12 July 2021
2	19 July 2021
Development Milestones	
3	02 August 2021
4	02 August 2021
5	09 August 2021
6	09 August 2021
Report Milestones	
7	16 August 2021
8	20 August 2021