# How the Great Firewall of China Detects and Blocks Fully Encrypted Traffic

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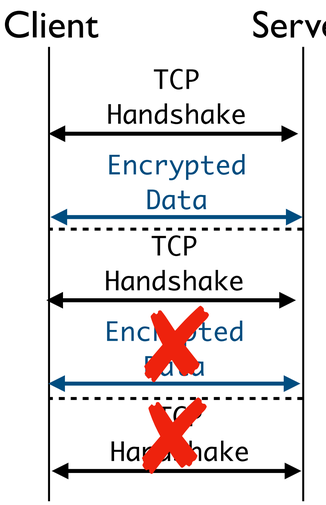
**Project Homepage**

## What happened?

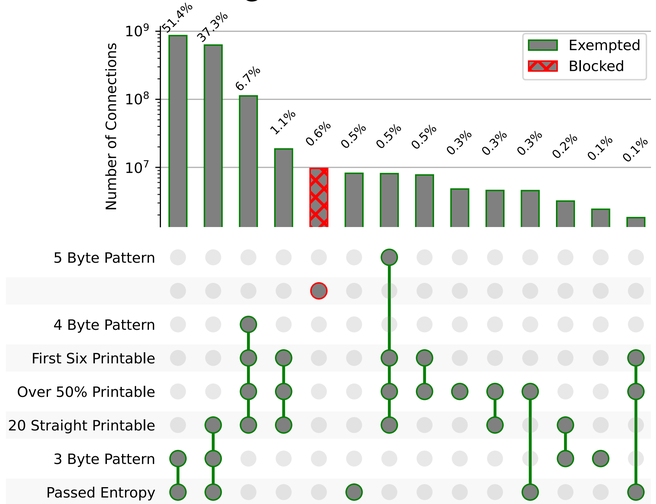



On November 6, 2021, the Great Firewall of China (GFW) started **dynamically blocking fully encrypted traffic in real time.** Such capability affected a large set of censorship circumvention protocols used by **tens of millions of users**.

**Fully encrypted proxies** encrypt all traffic including headers, while protocols like TLS send plaintext headers.

## Evaluating the Detection Algorithm

We simulated the traffic detection algorithm on a network tap at the University of Colorado Boulder. Our evaluation suggests that **the false positive rate of the detection algorithm is as low as 0.6%.**




## Reverse Engineering the GFW

We sent millions of experimental probes past the GFW to reverse engineer what was blocked. We find **five rules** that govern blocking.

**Fraction of `bits=1`**

49 fa e3 91 5c 83 — avg 4 bits/byte — BLOCKED

00 01 02 03 04 05 — avg 1.67 bits/byte — NOT BLOCKED

**Protocol Fingerprints**

f9 ab cd ef 9a 8d c1... — No Match — BLOCKED

GET␣/␣HTTP/1.1\r\n... — HTTP Matches — NOT BLOCKED

16 03 01 00 a5 01 00... — TLS Matches — NOT BLOCKED

Block the connection *unless any of the following hold*

- Fraction of `bits=1` ≤ 42.5% or ≥ 57.5%
- The first six bytes are printable ASCII
- >50% of bytes are printable ASCII
- 20 contiguous bytes are printable ASCII
- Matches the fingerprint for HTTP or TLS

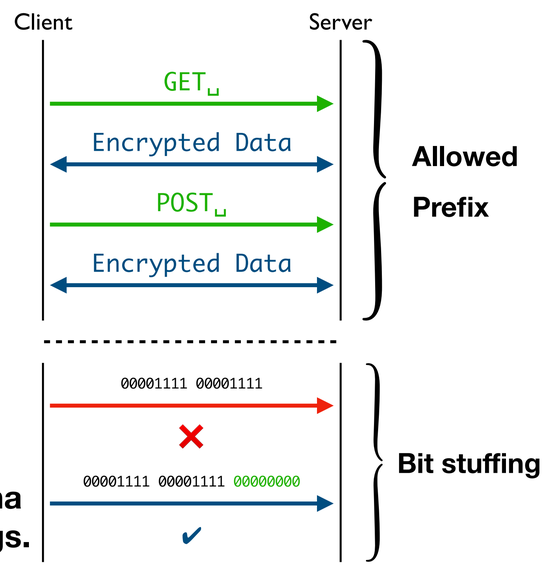
## Effective and Immediate Mitigations

**Patched Tools**

Lantern, Outline, shadowsocks, Psiphon, V2Ray (VMess)

Our research findings have been integrated into **all mainstream fully encrypted protocols.**

These mitigations have helped **tens of millions of users in China and Iran to bypass the blockings.**




## Response Timeline

- **Nov 6 '21** — **Blocking begins. We begin measurement**
- Nov 8-11 '21 — CCP central committee plenary session
- **Nov 16 '21** — **Our initial report**
- **Jan 13 '22** — **First mitigation released**
- Mar 13 '23 — Xi started his third term
- **Mar 15 '23** — **Blocking ends**

We took **immediate actions** to measure and understand the blocking. We **rapidly and responsibly** disclosed our research findings to both anti-censorship tool developers and the general public.

The blocking was likely **politically driven**, as it started 2 days before a major political convention and ended 2 days after the confirmation of Xi's third term.