Link Us If You Can: Enabling Unlinkable Communication on the Internet

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Outline

1. Introduction
   - online communication privacy

2. HTor
   - overview
   - challenges

3. Evaluation

4. Application scenario
Outline

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4. Application scenario
Hide our traces/identities

Why difficult?

Protect online privacy = Never online
Roles in this privacy battle on online communication

What to protect?
- content?
Introduction

online communication privacy

Roles in this privacy battle on online communication

What to protect?
- content?
- identity?
Introduction

- Online communication privacy

Roles in this privacy battle on online communication

What to protect?
- content?
- identity?
- or, behavior?
Roles in this privacy battle on online communication

What to protect?
- content?
- identity?
- or, behavior?
- unlinkable communication
Existing Popular Solutions

You’ve gone incognito

Now you can browse privately, and other people who use this device won’t see your activity. However, downloads and bookmarks will be saved. Learn more

Chrome won’t save the following information:
- Your browsing history
- Cookies and site data
- Information entered in forms

Your activity might still be visible:
- Websites you visit
- Your employer or school
- Your internet service provider
Existing Popular Solutions
Existing Popular Solutions

- User
- Entry node
- Relay node
- Exit node
- Resource

TOR NETWORK

Encrypted
How to mask our online behaviors (or say, to keep unlinkability)?

- relay & encryption (Tor, VPN, HTTPS)
How to mask our online behaviors (or say, to keep unlinkability)?

- relay && encryption (Tor, VPN, HTTPS)
- end-to-end correlation attack / tagging attack / website fingerprinting
How can we make our traffic unlinkable?

- First, import delay. If your message is delivered without delay, global watchers can easily follow the message.

**Figure:** Mix network (threshold and shuffle)
How can we make out traffic unlinkable?

- First, import **delay**. If your message is delivered without delay, global watchers can easily follow the message.
- **sleeper attack.**

**Figure:** Mix network (threshold and shuffle)
How can we make out traffic unlinkable?

- Second, cut off the **direct** link. Find a service provider.

**III. Service providers (SPs)**

A sends $E(M)$ to B by SPs

**Figure:** Service providers (encryption and a large anonymity set)
Introduction

online communication privacy

How to prevent various attacks/interventions from global adversaries?

Why almost all anonymous networks are vulnerable?

- Rely on other participants to ensure correct communication. But participants can actively ruin the security of anonymous networks.
Introduction

online communication privacy

How to prevent various attacks/interventions from global adversaries?

Why almost all anonymous networks are vulnerable?

- Rely on other participants to ensure correct communication. But participants can actively ruin the security of anonymous networks.
- Service providers are apparent targets waiting for attacks and analysis. An anonymous network client usually behaves differently because it interacts with relay nodes rather than true websites.
If there exists a service provider

Faced with GPA/GAA, the SP can satisfy:

- It does not appear to provide communication services.
- A large anonymity set.
- Previous messages can be denied.
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Covert channel

Prisoner model:

Alice → Walter (passive) → Bob

prisoner

Warden

prisoner
Covert channel is defined as any manner of transferring data by means that were not intended for that purpose.
Covert channel is defined as any manner of transferring data by means that were not intended for that purpose.

We do not want network watchers to think that I’m communicating with the service provider.
IV. HTor

A sends $E(M)$ to B by browsing web pages
Work flow
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How to build covert channels in HTTP request?

More and more companies use cookie profiling (personalized marketing) to record user behaviors as visitors move across pages on your website.

**Figure:** Covert channel design in HTTP requests
For normal visitors, the website collects records of user behaviors and encrypt them into session cookies. For HTor users, a hidden message is expanded to the same length and also encrypted into session cookies.
How to build covert channels in HTTP response?

There are many ways to build covert channels in HTTP responses as the content in HTTP response is large enough to hide several messages.
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Exploiting static files as carriers are suspicious.
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Exploiting static files as carriers are suspicious.

User-specific contents are much better. Thanks to personalized marketing, some contents like ADs or personalized suggestions can be user-specific without suspicion. We can build covert channels on them at will.
Deniable communication over HTTP

Simply changing keys for each message (one-time-pad) does not work in HTTP due to two reasons:

- Stateless. Every HTTP request should be sent before HTTP response is received.
- The server cannot proactively send messages to clients no matter how many messages are waiting for that client.
Deniable communication over HTTP

Figure: One-round-pad
HTor has reliable security against GPA, keep covert, and ensure K-unlinkability and Deniability.

**Figure:** Simple HTor.
Unlinkable communications over unreliable servers

Against GAA:

*Figure: HTor group mechanism.*
Advantages/Disadvantages

The advantages of HTor Over Tor:
- Covertness.
- Deniability.
- Unlinkability against global adversaries.

The disadvantages of HTor:
- Message delays.
- Limited message length.
Evaluation

Implementation

- Resource consumption.
- Message delays.
Resource consumption

<table>
<thead>
<tr>
<th>Number of Clients</th>
<th>Normal server</th>
<th>Server with SHTor</th>
<th>Server with HTor</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>3.0</td>
<td>15.4</td>
<td>88.9</td>
</tr>
<tr>
<td>200</td>
<td>4.0</td>
<td>5.9</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>19.7</td>
<td>32.3</td>
<td>30.5</td>
</tr>
</tbody>
</table>
Resource consumption

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<tr>
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<th>Server with HTor</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.6</td>
<td>0.6</td>
<td>7.7</td>
</tr>
<tr>
<td>200</td>
<td>0.6</td>
<td>0.6</td>
<td>13.0</td>
</tr>
<tr>
<td>1000</td>
<td>0.6</td>
<td>1.5</td>
<td>58.5</td>
</tr>
</tbody>
</table>

- Normal server
- Server with SHTor
- Server with HTor
Evaluation

Delay

![Delay Frequency Chart]

- **Delay Frequency**
- **Delay seconds (s)**: 0, 2000, 4000, 6000
- **Frequency**: 60, 20, 0
Evaluation

Delay

![Graph showing delay in seconds against received messages index. The graph highlights silent hours.]

- **Delay**
  - Measurement of delay in seconds against the index of received messages.
  - Silent hours indicated on the graph.
About behavior simulator

If you make sure you are not being monitored by GAA:
No need to use BS to scheduler your messages. Send HTTP requests at will.

If you are not sure:
Do use BS to simulate your browsing behavior to completely avoid suspicion.
No need to rely on HTTP protocol

We choose HTTP because HTTP is everywhere and thus is very suitable to be a carrier to build covert channels.

The key insight of HTor is to exploit covert channels to design a covert, easy-to-reach, scalable and anonymous network.
Use HTor in suitable scenarios

Do not use HTor if you:

- don’t care online communication privacy.
- want instant messaging. Message delay is inherent in HTor.

Please try HTor if you:

- want to communicate with someone without any traces and suspicions.
- rely on your own website (Personal website or corporate website) to achieve secure communications.
Thank You!