Real-World Sybil Attacks in BitTorrent Mainline DHT

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Contents

BitTorrent MLDHT

BitTorrent is the most influential P2P software

BitTorrent adopted DHT to support trackless mode

- More reliable and robust to single point of failure
- Avoid legal issues and becoming the lawyer's target

Two incompatible versions

- Mainline DHT (MLDHT)
- Vuze DHT
- Both are Kademlia-based DHT

BitTorrent MLDHT

Building block of modern P2P software

- More and more P2P softwares supports MLDHT, over 16,000,000 users

Forms a peculiar ecosystem

- Different implementation has slightly different interpretation of the standard protocol

Only minimum functionalities of Kademlia

- MLDHT is simple but weak

Measurement Platform

Two dedicated machines monitor the system

- Prevent the “sample gap” due to soft- and hardware failure
- Two crawlers with different crawling policy

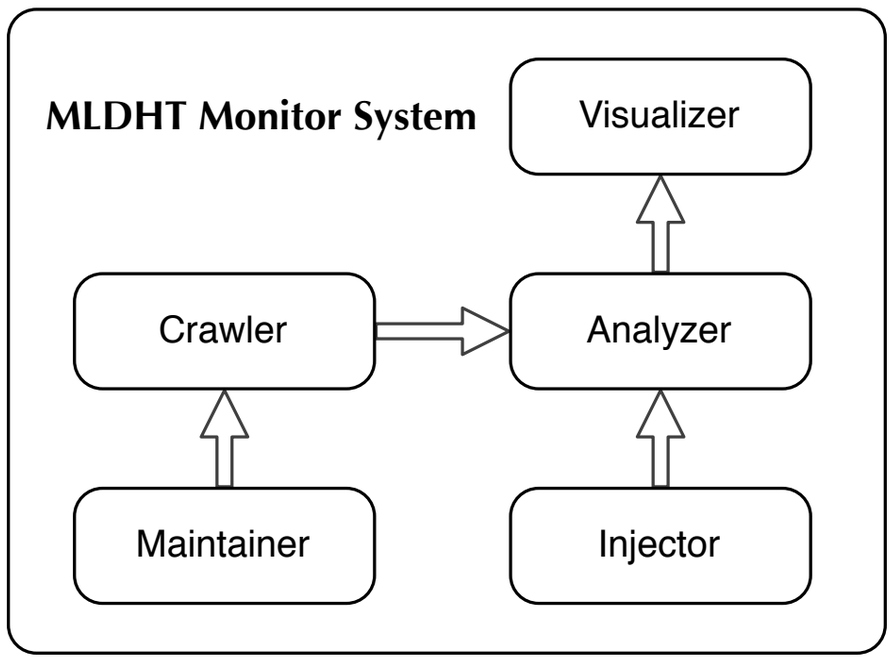
Continuously take “snapshot” of MLDHT

- 15 mins interval, started since 2010-12-07
- Over 67,000 samples are collected

Measurement Platform

A full-fledged monitoring system

- Five main components
- Automatically collect and analyze the sample
- Together with several honeypots to catch specific attacks



Two Basic Attacks - Sybil Attack

First introduced by Douceur in “The Sybil Attack” in 2002

Inject multiple fake identities into the system

Use them as a starting point to perform further attacks

Can also be considered as routing table attack

Two Basic Attacks

Horizontal Attack

- Spread sybils widely across the system
- Pollute as many routing table as possible

Vertical Attack

- Isolate an node by filling routing table with malicious nodes
- Target can be content (more general than Eclipse Attack)

Hybrid Attack

- Combined both Horizontal and Vertical attacks

BitTorrent MLDHT - Four Control Messages

PING

– Probe a node's availability.

FIND_NODE

– Given a target ID, find the K closest neighbors of the ID.

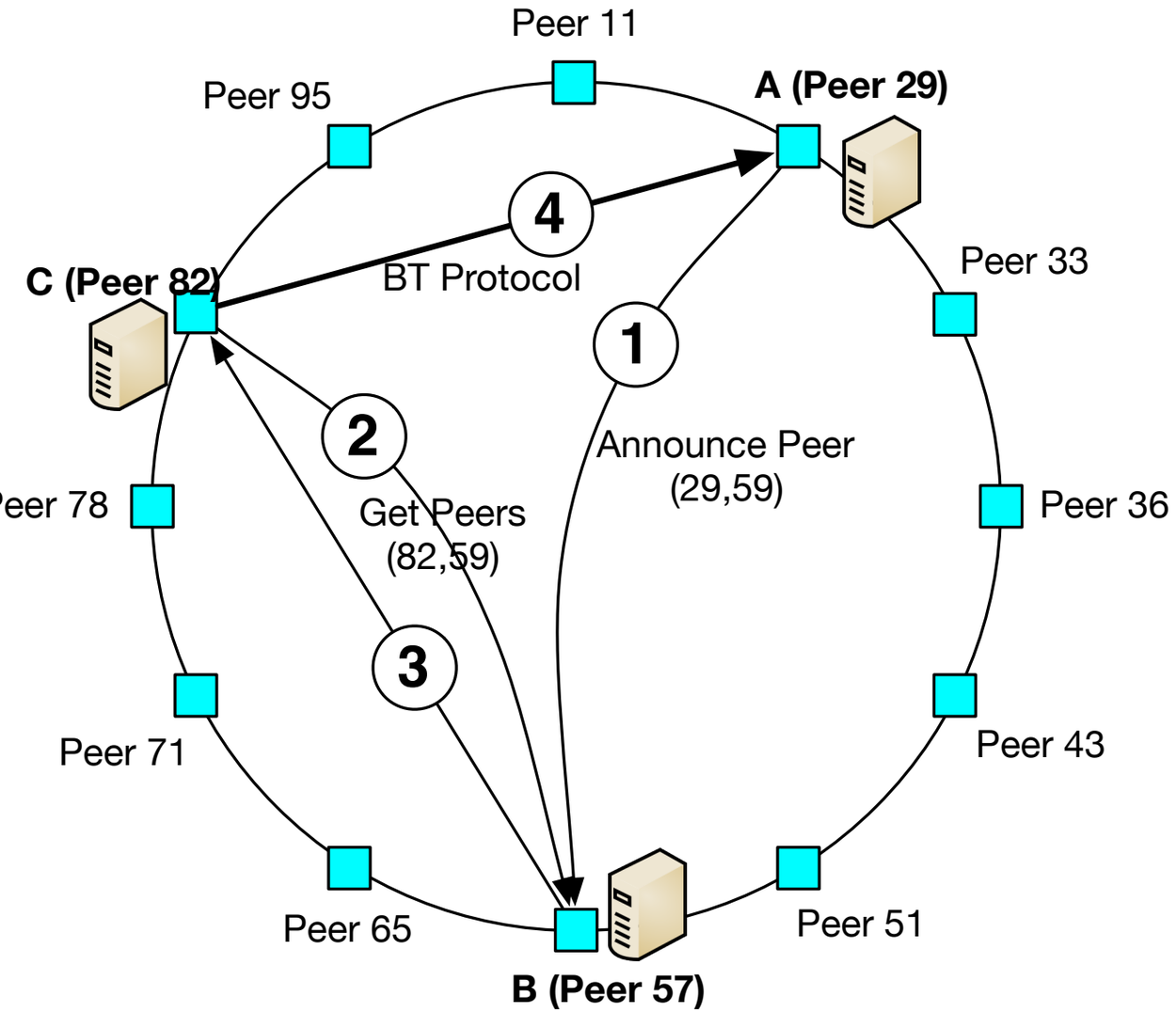
GET_PEERS

– given an infohash, get the initial peer set.

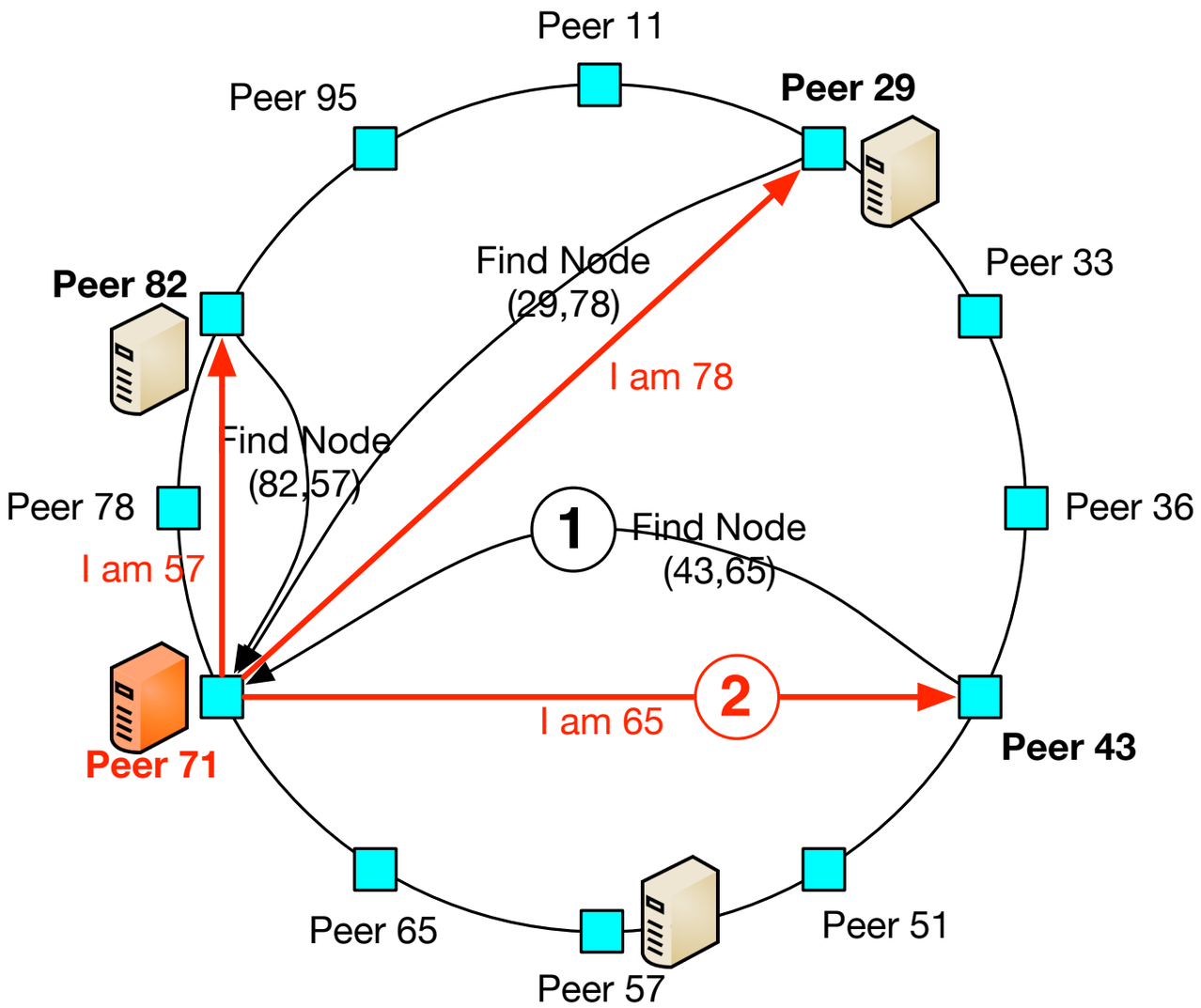
ANNOUNCE_PEER

– a peer announces it belongs to a swarm.

Normal Operation



Two Basic Attacks
- Horizontal Attack



Two Basic Attacks - Horizontal Attack

Horizontal attack spreads sybils widely across the system

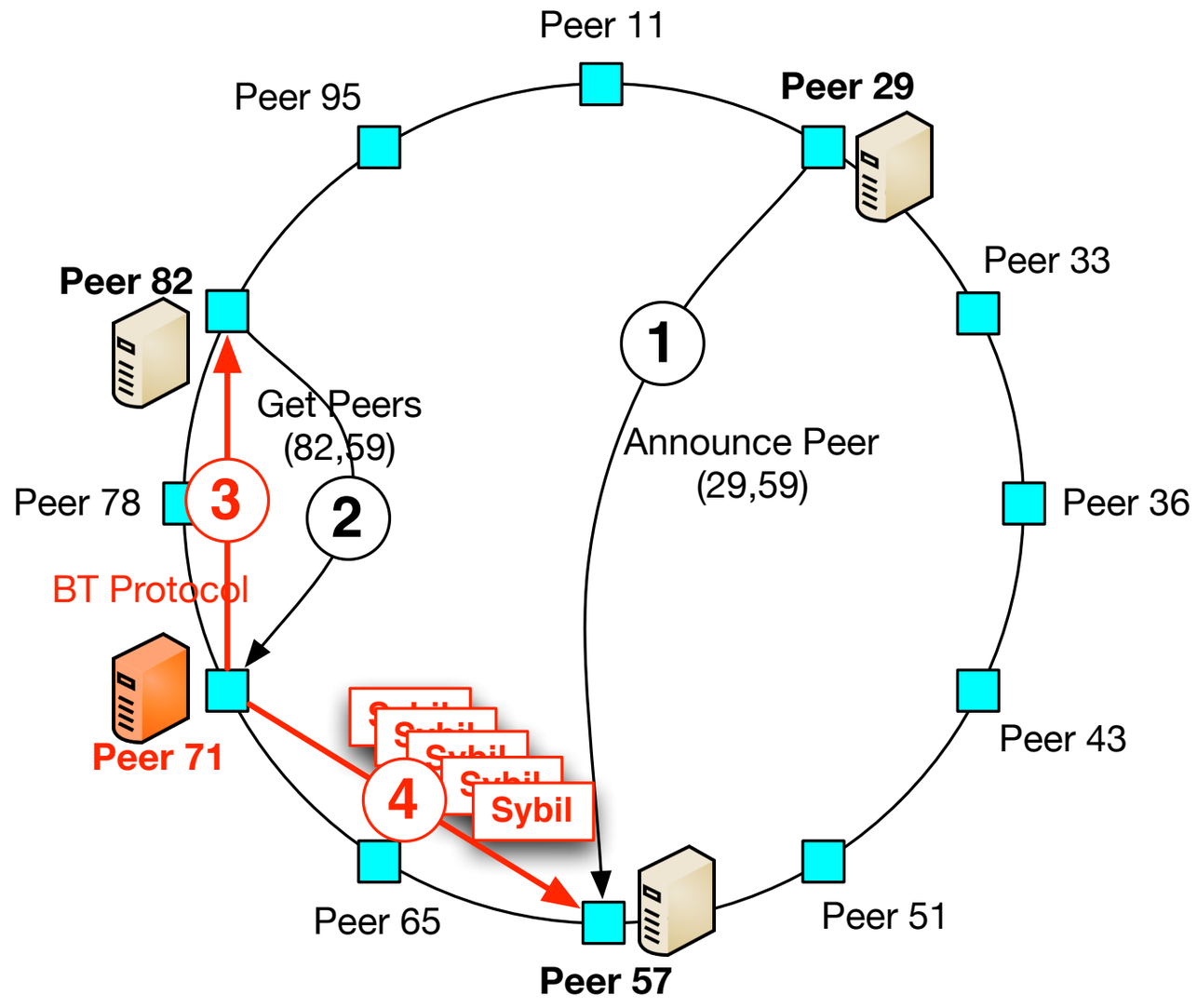
The aim is to pollute as many routing tables as possible

The number of sybils in one routing table is not the concern

A successful horizontal attack can let the attacker sniff most of the control messages and therefore hijack the system

In MLDHT, this attack can be carried out with very limited physical resources

Two Basic Attacks - Vertical Attack



Two Basic Attacks - Vertical Attack

Vertical attack attempts to insert as many sybils as possible in one specific routing table.

Similar to eclipse attack, but broader in the sense it can target content

After launching an attack, the attacker waits for an interesting target ID, either node ID or content infohash. Then, the attacker inserts sybils close to the target to ”isolate” it from the others.

Honeypot Design
- Three Types of Honeypots

Detector

- First round filtering, identifying suspicious nodes
- Work on the MLDHT protocol level

MLDHT honeypot

- Second round filtering, identify vertical and hybrid attacks
- Work on the MLDHT protocol level

BitTorrent honeypot

- Work on the BitTorrent protocol level
- Identify further malicious behaviors

Honeypot Design
- Three Types of Honeypots

Detector

First round filtering, identifying suspicious nodes

Use FIND_NODE to find “non-existent” ID in MLDHT

– If some node claims as the owner of the ID ---> Suspicious!

Use GET_PEERS to find “non-existent” infohash in MLDHT

– if someone comes to us with those IDs ---> Suspicious!

Try to catch horizontal attacks

– because in reality, horizontal attack is the starting point of a successful large-scale attack

Honeypot Design - MLDHT Honeypot

MLDHT honeypot

Detect vertical and hybrid attacks

Suppose our own ID is x, use GET_PEERS to find x+1

– Not such content with infohash x+1 at all in MLDHT

– Normal behavior is replying with k nodes with closest ID

– However, lots of nodes came and used “scrape” to probe us

– Some immediately started vertical attacks by inserting sybils

– Some tried to set up BT level connection to get the metainfo

Honeypot Design
- BitTorrent Honeypot

BitTorrent honeypot

Work on the BitTorrent protocol level

Third round filtering, check if there are further actions

Most tried to get the metainfo for the infohash

But nobody really tried to retrieve any data

Real-World Attacks

Two main players (or attacker?)

- Mr. ISP and Mr. 50
- Suspicious behavior, but not really malicious (depends on the standards)

Quite amount of smaller players from various orgs

Real-World Attacks - Mr. 50

Two (or more) virtual nodes from Amazon EC2 platform large-scale horizontal attacks

The one with IP starting with 50 was the most active one

The app was optimized to perform horizontal attack

- Not maintain states for the nodes
- Only answer certain messages in order to stay in RT
- Collect infohashes, later other nodes will get metainfo
- Like a virus, even the honest node can help propagate

Real-World Attacks - Mr. 50

Very active since the beginning of 2011

We can see the clear “test phase” and “deploy phase”

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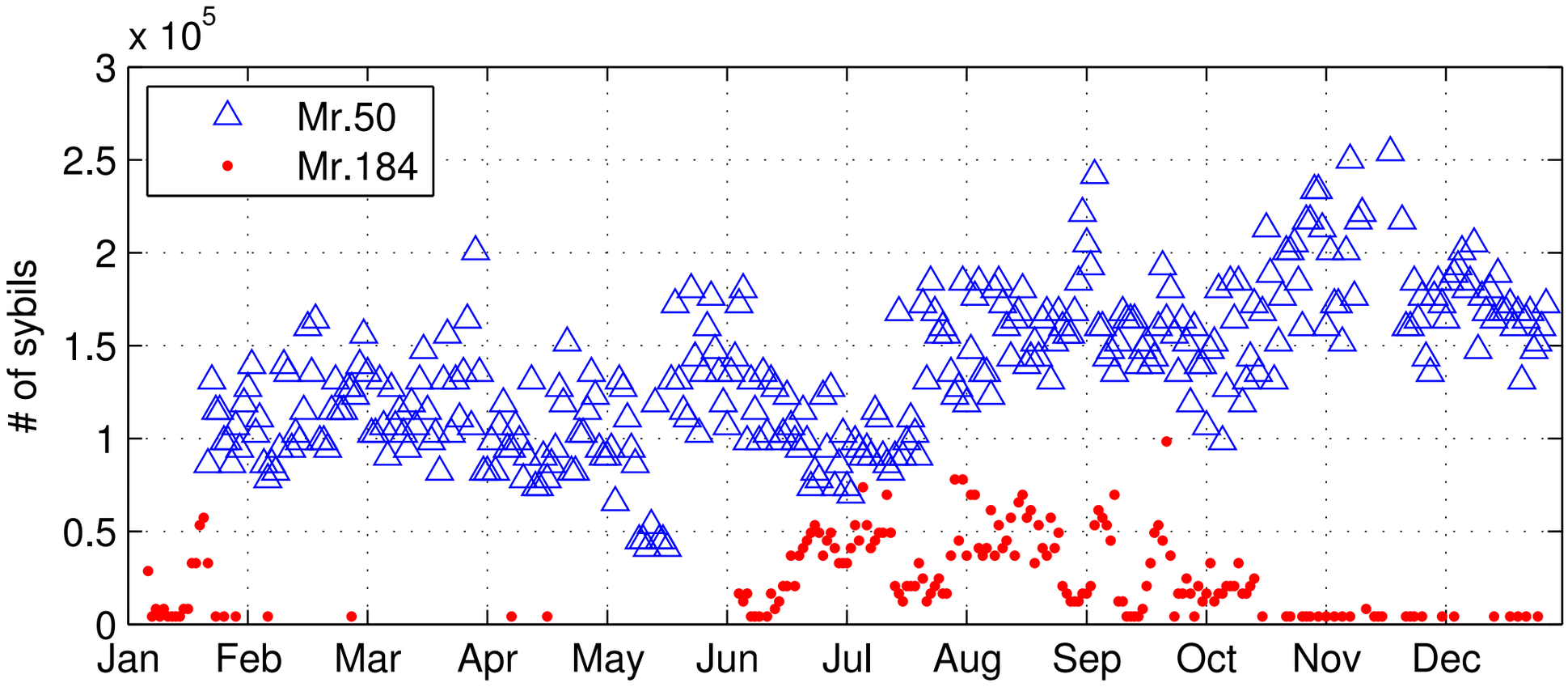

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Several ISPs perform intensive “vertical attacks”

- Very resourceful
- Further investigation shows the main purpose is to localize BitTorrent traffic

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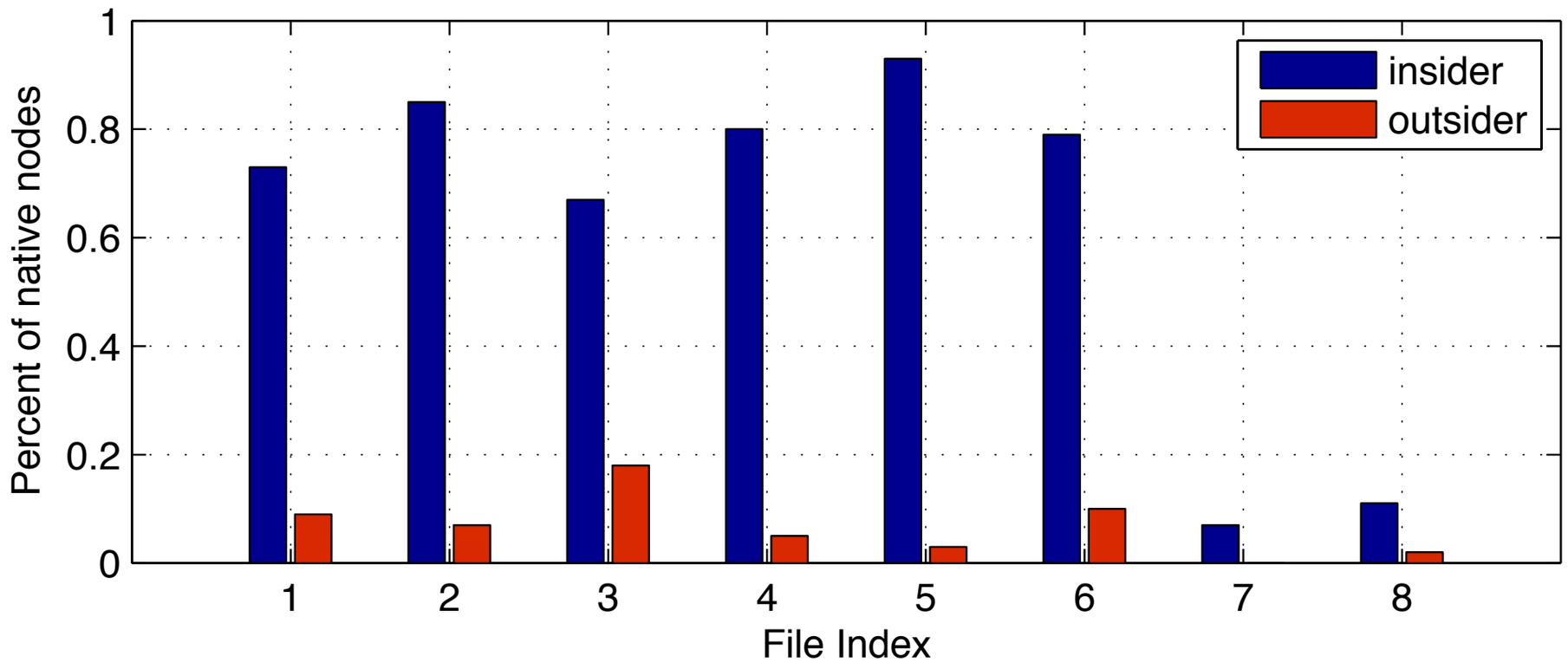

Real-World Attacks
- Mr. ISP

insider - connect to MLDHT with an IP in the ISP network

outsider - connect to MLDHT with an IP outside ISP

native node - node in the same ISP network

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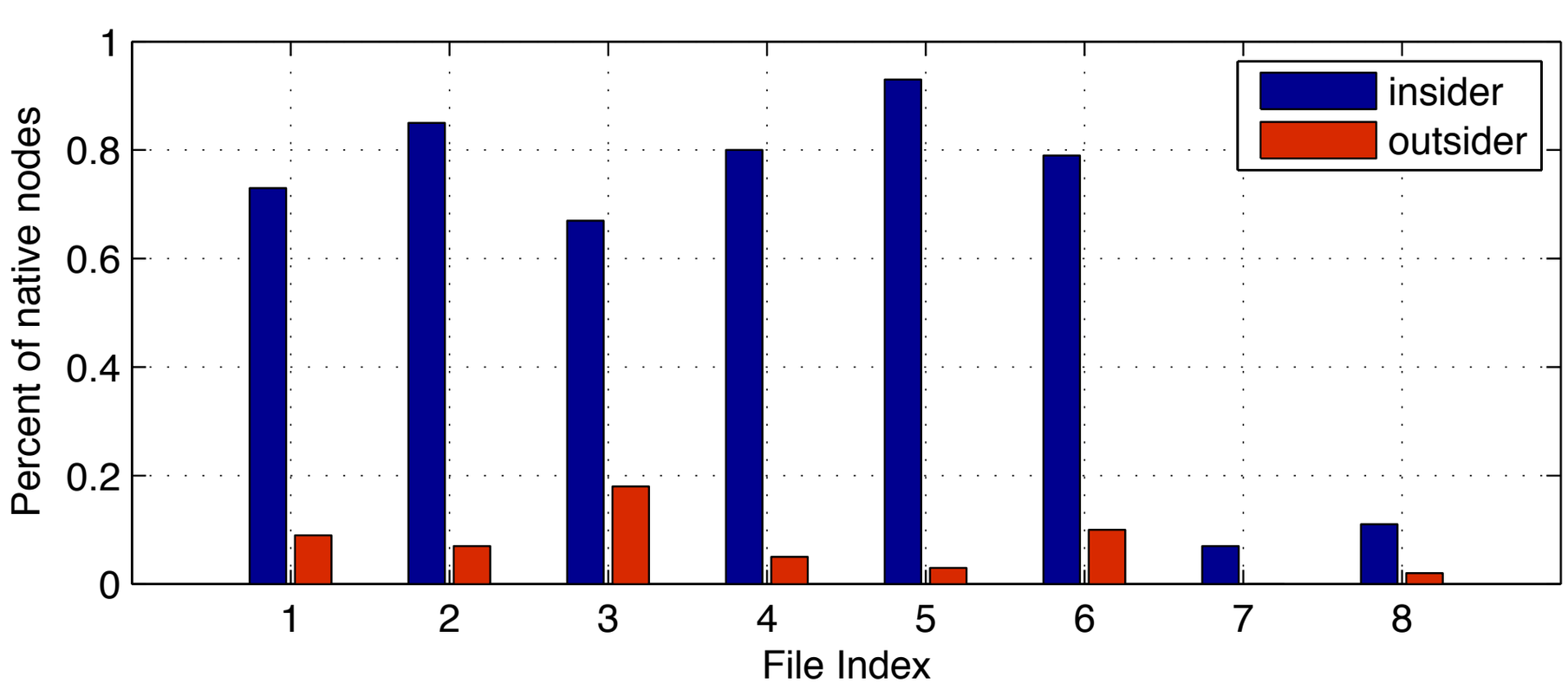


Threats & Analysis

Monitor a large fraction of user activities and traffic

Can disturb operation of system

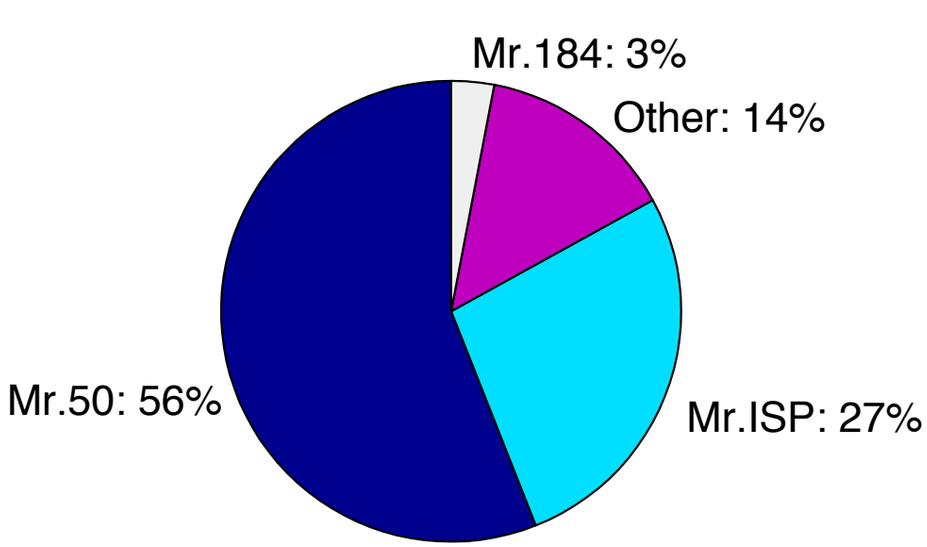
Pollute or even effectively censor certain content

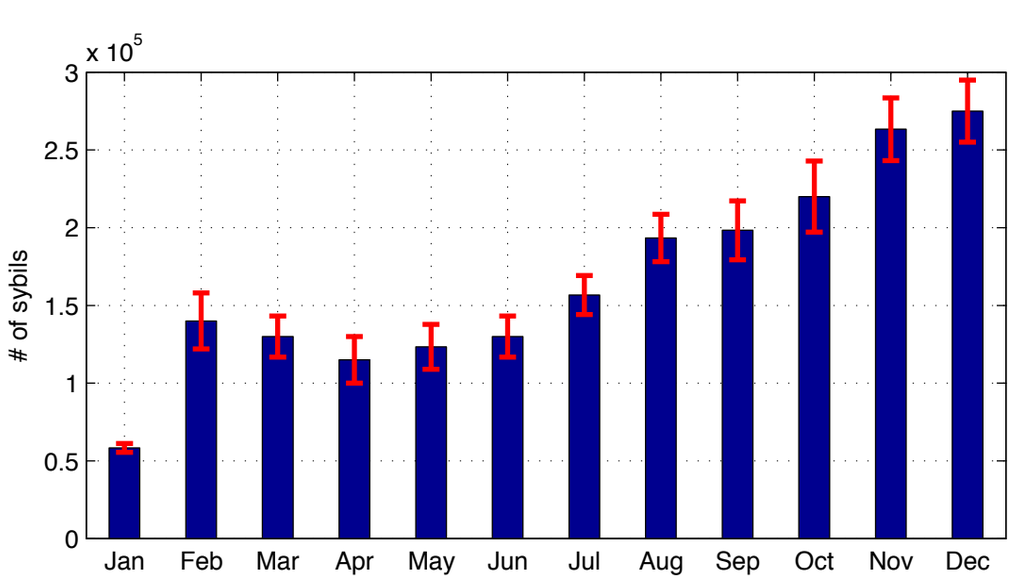
Hijack system with limited resource is possible

Violate user privacy

Threats & Analysis

The trend of sybil attack is increasing





Possible Solutions

Root of the problem - Letting a node choose its own ID

Weakness has been well-understood over a decade, but the problem is still there

Various solutions, but no silver bullet

- central, trusted authority to issue ID
- charge money on ID
- introduce social network into the system

Conclusion

Introduce two basic attacks in MLDHT

Hybrid attack can hijack whole system with limited physical resources

Extensive measurements to identify real-world attacks

Analyze potential damage and discuss possible solutions

Thanks!

Questions?