P2P File-Sharing in Hell: Exploiting BitTorrent Vulnerabilities to Launch Distributed Reflective DoS Attacks

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9th USENIX Workshop on Offensive Technologies

Outline

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2013: DDoS attack record: 300 Gbps

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Spamhaus DDoS grows to Internet-threatening size

More than 300 Gb/s of traffic aimed at the anti-spam site's hosting.

by **Peter Bright** - Mar 27, 2013 8:30pm CET

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Someone has finally made a portable Bluetooth speaker that doesn't suck

BECAUSE WE CAN

2014: DDoS attack record: 400 Gbps

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Biggest DDoS ever aimed at Cloudflare's content delivery network

Network Time Protocol attack reached 400Gbps.

by **Sean Gallagher** - Feb 11, 2014 6:12pm CET

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LATEST FROM ARS TECHNICA/UK

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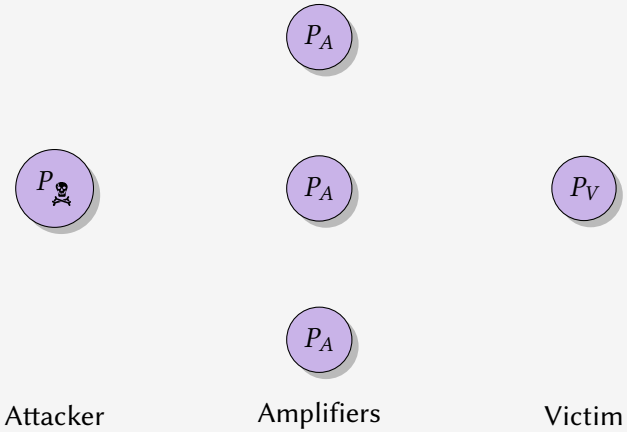
DRDoS Attacks Thread Model



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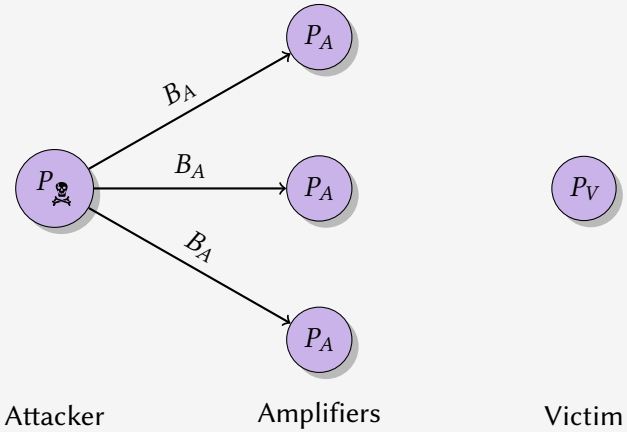

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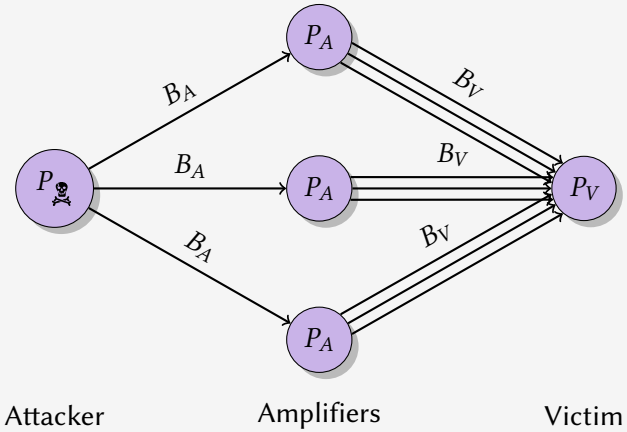

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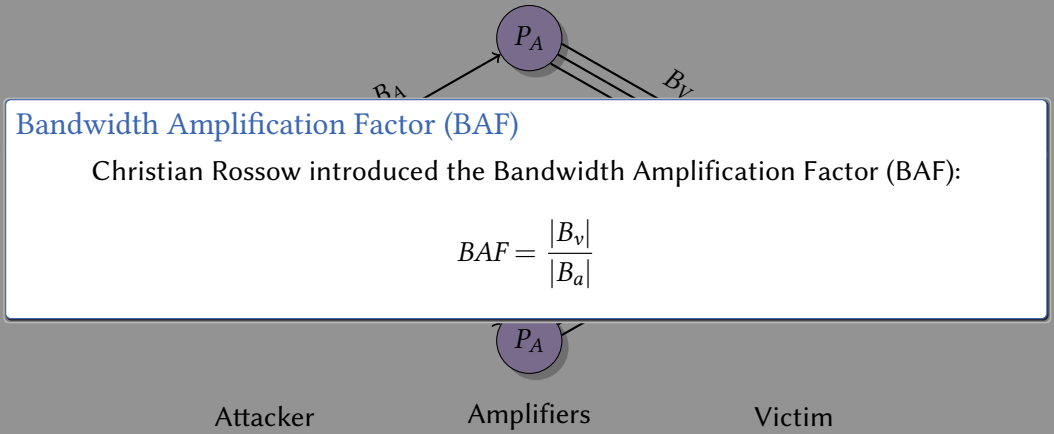
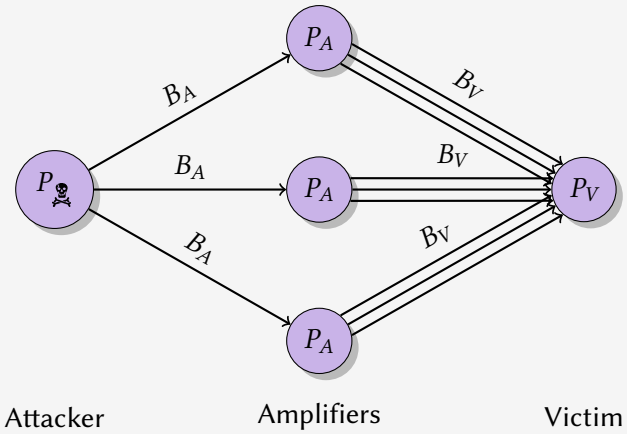


Bandwidth Amplification Factor (BAF)

Christian Rossow introduced the Bandwidth Amplification Factor (BAF):

$$BAF = \frac{|B_v|}{|B_a|}$$

Example: BAF = 5



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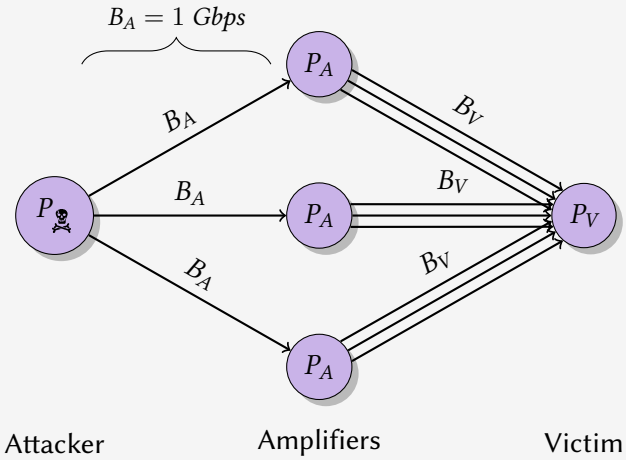

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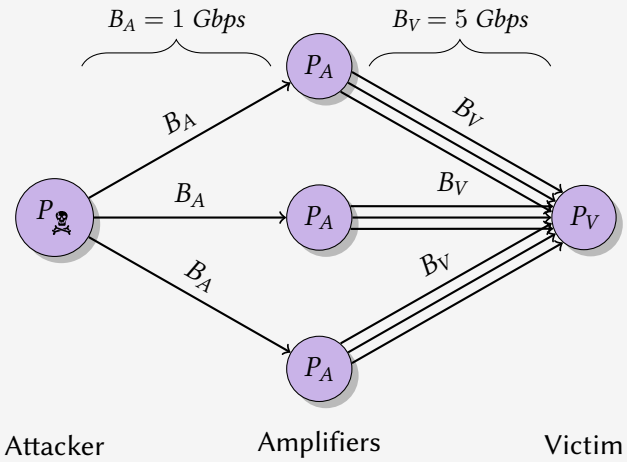


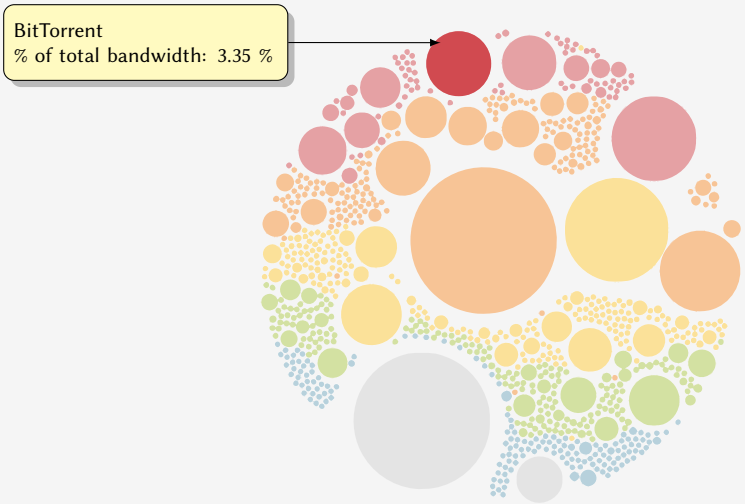
Advantages of a DRDoS Attack

- Attacker hides his own identity
- It can be initiated by a single computer, results in a distributed attack
- Amplifiers send a larger packet to the victim and therefore increase the impact of the attack

Worldwide Application Usage

Source: Paloalto Networks

Worldwide Application Usage



Source: Paloalto Networks

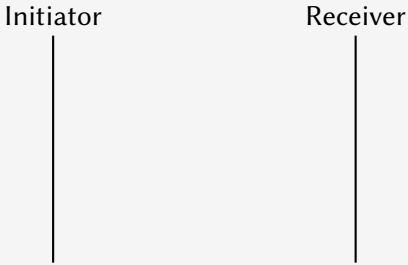
BitTorrent's protocol overview

- Variety of UDP-based protocols are used:
  - Distributed Hash Table (DHT)
  - Micro Transport Protocol (uTP)

Micro Transport Protocol (uTP)

- uTP is a reliable transport protocol which makes use of UDP
- Similarities to TCP
  - Window based flow control
  - Sequence numbers and ACK numbers
- Differences to TCP
  - Sequence numbers and ACKs refer to packets, not bytes
  - No congestion control (Slow-start, congestion avoidance, ...) $\rightarrow$ LEDBAT
  - Two-way handshake instead of a three-way handshake

uTP's two-way handshake



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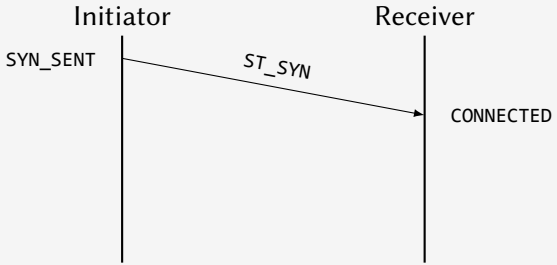

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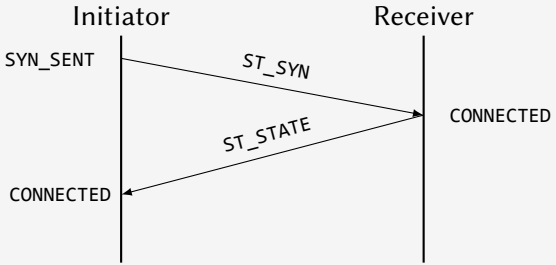

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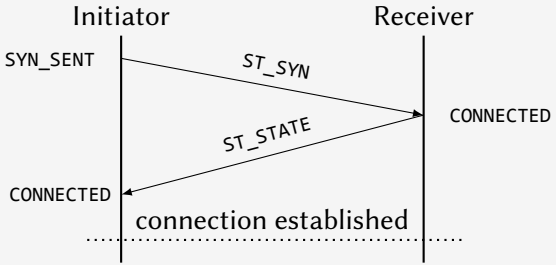

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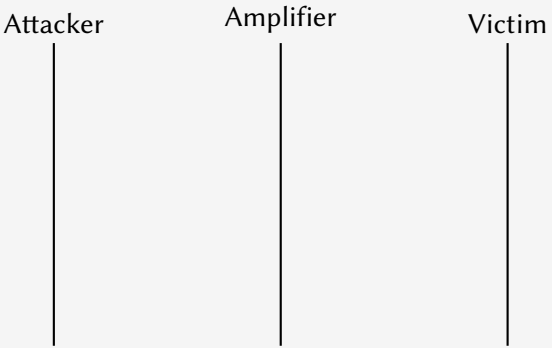
BitTorrent Handshake

`<pstrlen><pstr><extensions><info_hash><peer_id>`

- `pstrlen` = 19
- `pstr` = *BitTorrent protocol*
- `extensions` 8 bytes reserved
- `info_hash` 20 byte
- `peer_id` 20 byte

Exploiting uTP's two-way handshake



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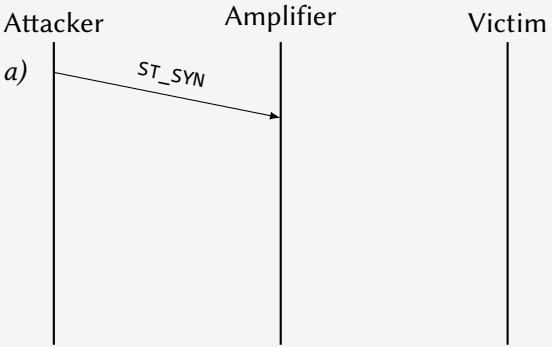

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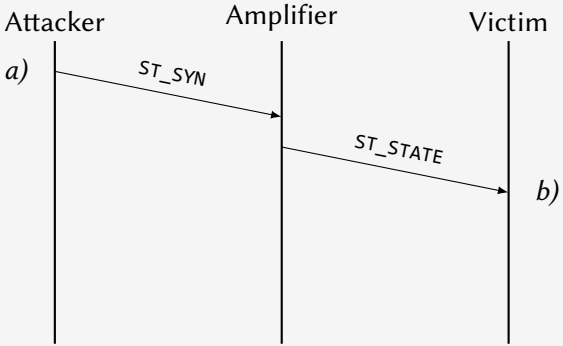

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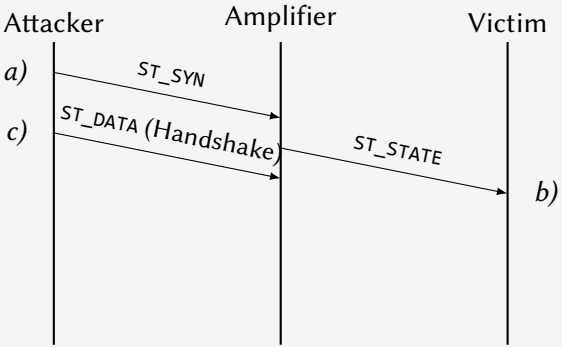

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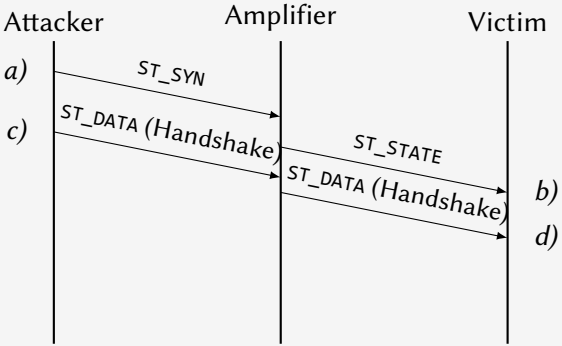

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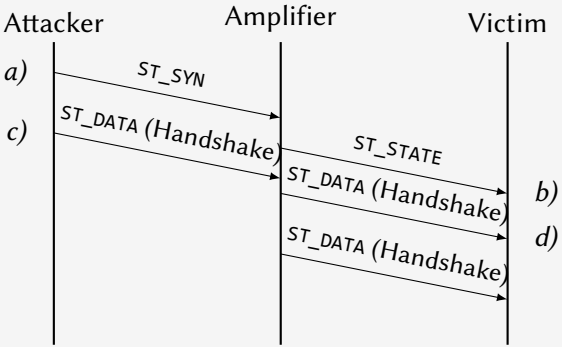

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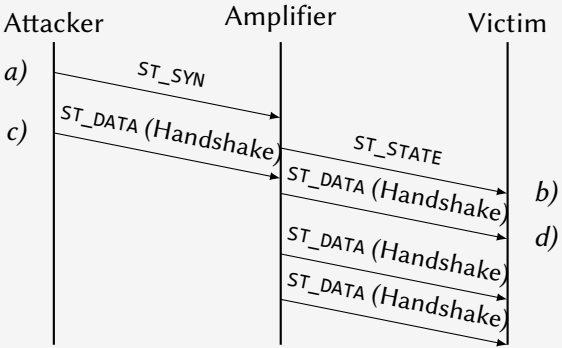

$B_V > B_A$

Definition (Packet Stuffing)

Try to cram as much BitTorrent messages into one packet as possible to minimize the connection establishment protocol flow

Amplification Factors (BitTorrent)

Description	BAF	PAF
ucat	351.5	6
uTorrent w/o extensions	27.6	3.5
Mainline w/o extensions	27.8	3.5
uTorrent with LTEP	39.6	3
Mainline with LTEP	39.6	3
Vuze w/o extensions	13.9	2
Vuze with LTEP	18.7	2
Vuze with AMP	54.3	3.5
Transmission w/o extensions	4.0	3.5
Transmission with LTEP	4.0	3.5
Transmission with AMP	4.0	3.5
Libtorrent w/o extensions	5.2	4
Libtorrent with LTEP	5.2	4

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- Aim of MSE is to obfuscate BitTorrent traffic to avoid shaping
- MSE starts a Diffie-Hellman key exchange
- After the key exchange BitTorrent packets are RC4 encrypted

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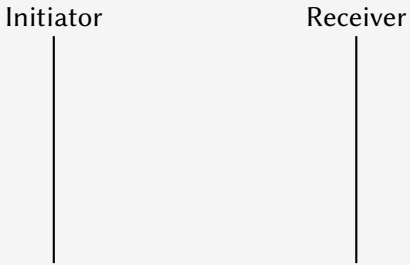

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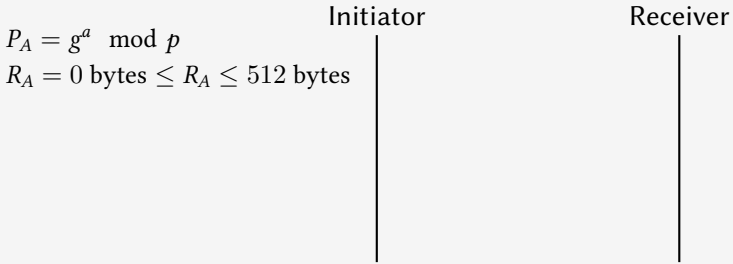

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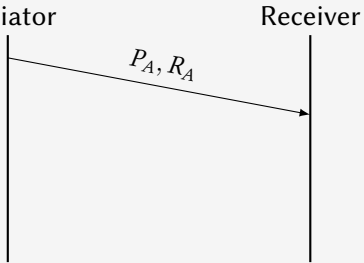
$P_A = g^a \mod p$

$R_A = 0 \text{ bytes} \leq R_A \leq 512 \text{ bytes}$



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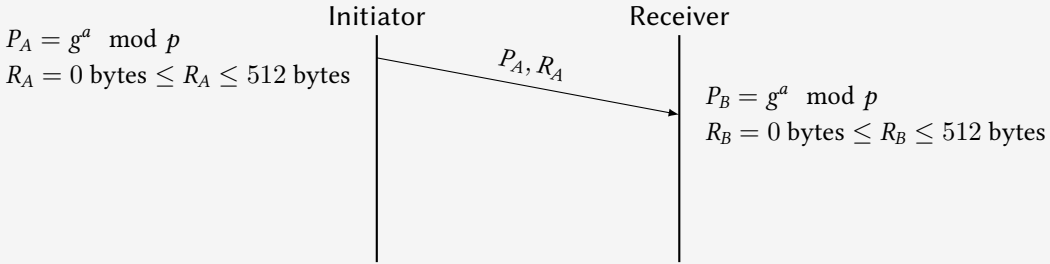

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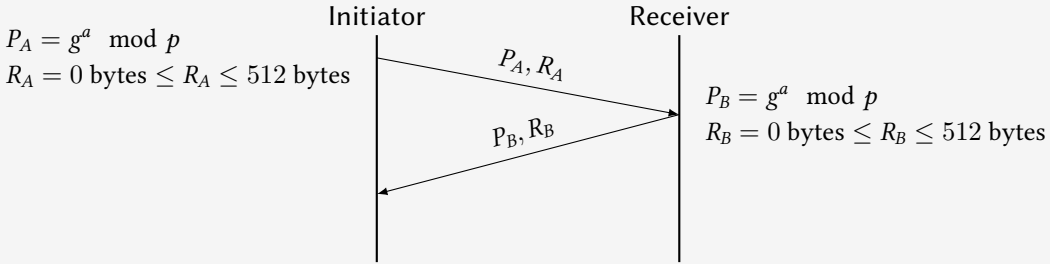

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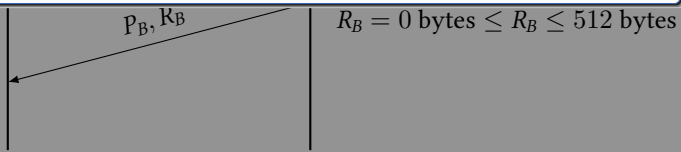
Amplification Factor (MSE)

$$4 \leq BAF_{MSE} \leq 32.5$$



Distributed Hash Table

- DHT implementation in BitTorrent is divided into two protocols:
  - Mainline DHT (MLDHT)
  - Vuze DHT (VDHT)
- MLDHT is by far the biggest overlay network (around 15–27 million users per day)
- Both protocols are not compatible with each other

Amplification Factors (DHT)

Implementation	Description	BAF
MLDHT	`ping`	0.8
	`find_node` with $K = 8$	3.1
	`get_peers` with 100 peers (IPv4)	11.9
	`get_peers` with 100 peers (IPv6)	24.5
	`get_peers` with scrapes	13.4
VDHT	`ping`	0.8
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BitTorrent Sync

- Proprietary protocol to synchronize files in a P2P way
- BTSync reached the 1 million users mark in 2013
- BTSync also uses uTP as its transport protocol

Amplification Vulnerabilities (BTSync)

Message	BAF
BTSync handshake	10.8
`ping`	120

Amplification Vulnerabilities (BTSync)

Message	BAF
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Amplification Vulnerabilities (BTSync)

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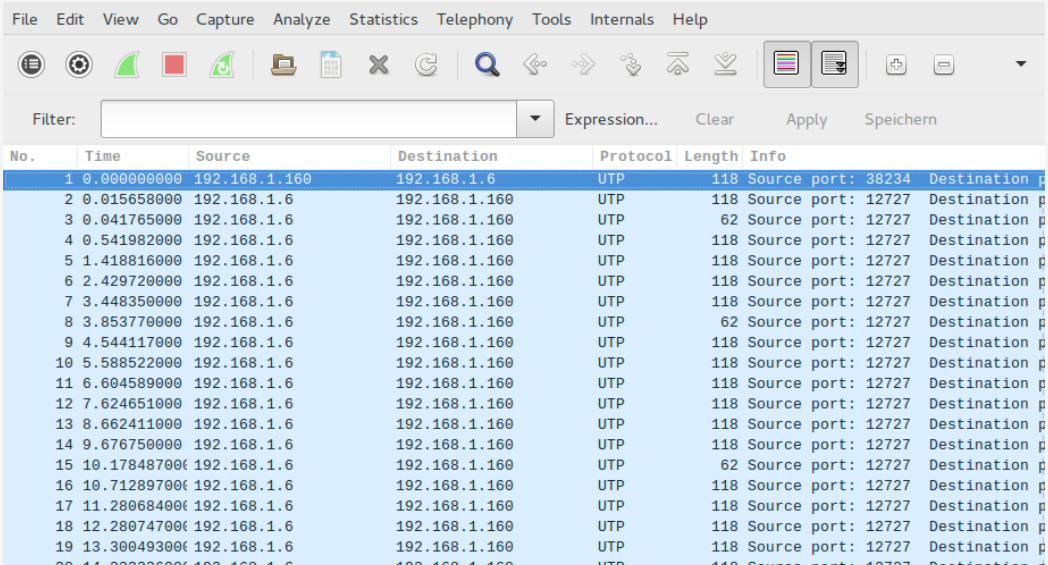
BTSync: ping flood



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.1.160	192.168.1.6	UTP	118	Source port: 38234 Destination p
2	0.015658000	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
3	0.041765000	192.168.1.6	192.168.1.160	UTP	62	Source port: 12727 Destination p
4	0.541982000	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
5	1.418816000	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
6	2.429720000	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
7	3.448350000	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
8	3.853770000	192.168.1.6	192.168.1.160	UTP	62	Source port: 12727 Destination p
9	4.544117000	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
10	5.588522000	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
11	6.604589000	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
12	7.624651000	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
13	8.662411000	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
14	9.676750000	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
15	10.17848700(	192.168.1.6	192.168.1.160	UTP	62	Source port: 12727 Destination p
16	10.71289700(	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
17	11.28068400(	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
18	12.28074700(	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p
19	13.30049300(	192.168.1.6	192.168.1.160	UTP	118	Source port: 12727 Destination p

Evadability

	DNS'13	NTP'14	BTH	MLDHT	VDHT	BTSync	MSE
SPI firwall	X	X					
DPI firewall			X	X	X	X	

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Experimental Evaluation

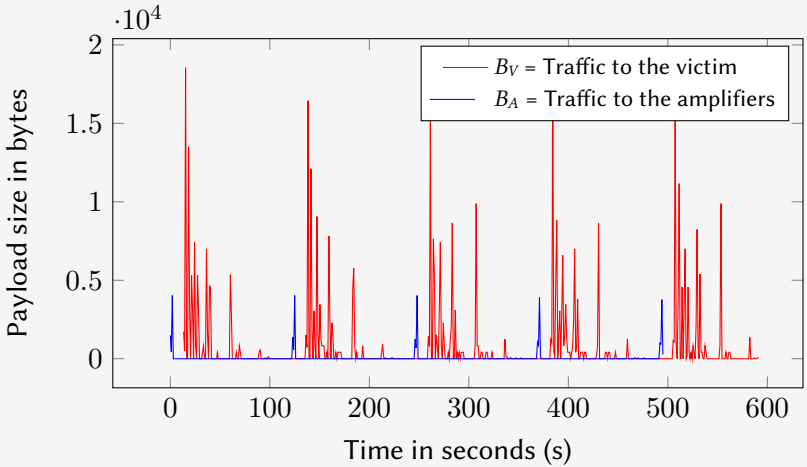
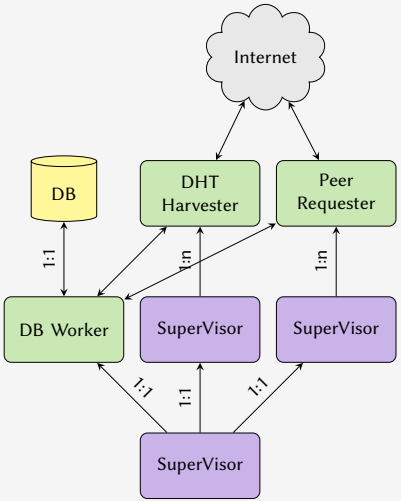


Figure: Amplification attack with 1 attacker, 31 amplifiers and 1 victim.

BitTorrent Crawler

- We wrote a BitTorrent Crawler in Elixir
- Used PirateBay magnet link database from Feb 2012
- We collected overall 9.6 million peers via MLDHT
  - Beginning from 1st January 2015 until 1st February 2015.



Payload size from the DHT responses

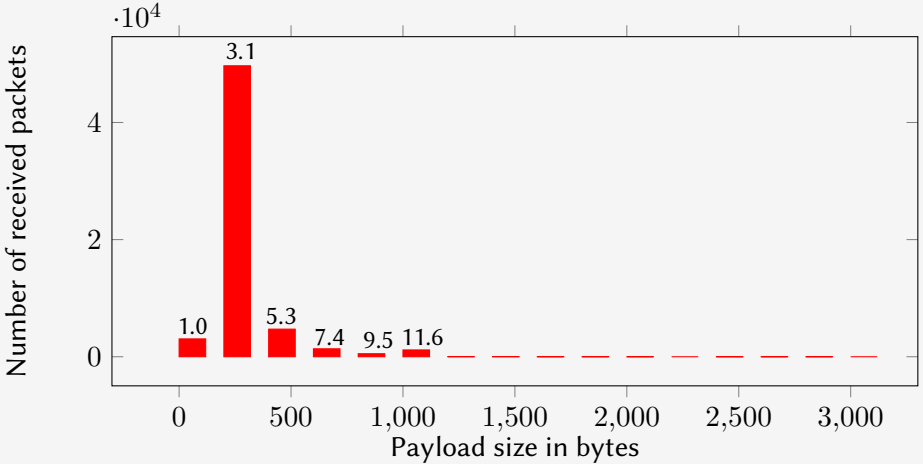


Figure: Histogram of the payload size from the DHT responses which are caused by `get_peers` requests. The numbers on top of the bars are the average BAF values.

BitTorrent handshake size from the uTP responses

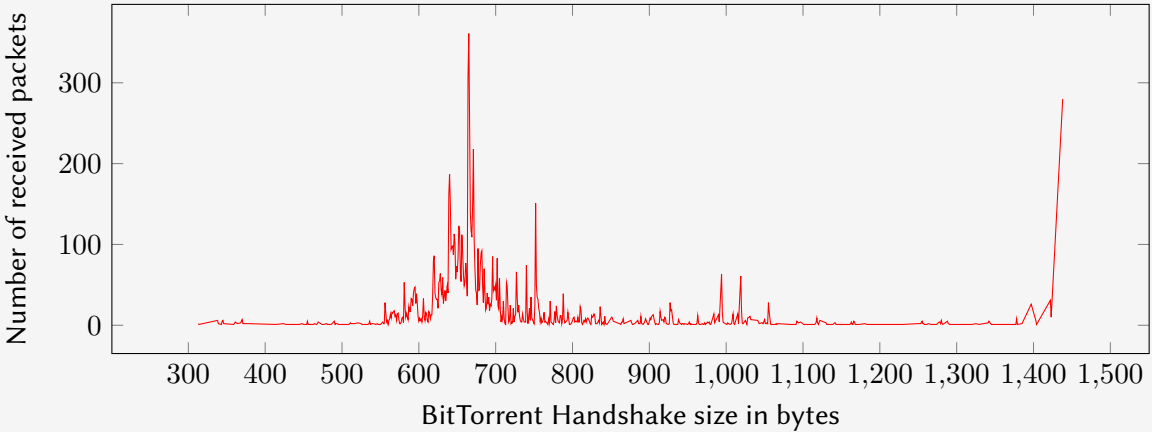
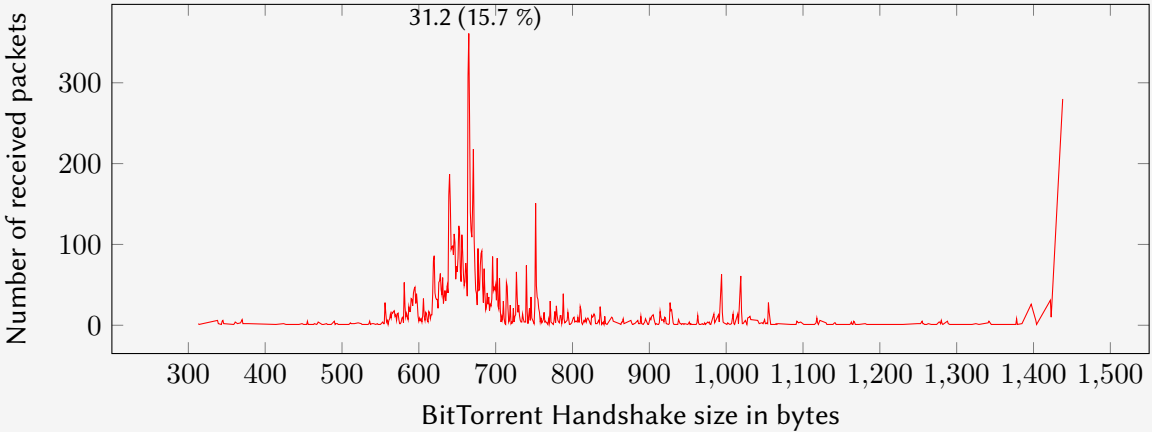


Figure: Histogram of the BitTorrent handshake size from the uTP responses.

BitTorrent handshake size from the uTP responses



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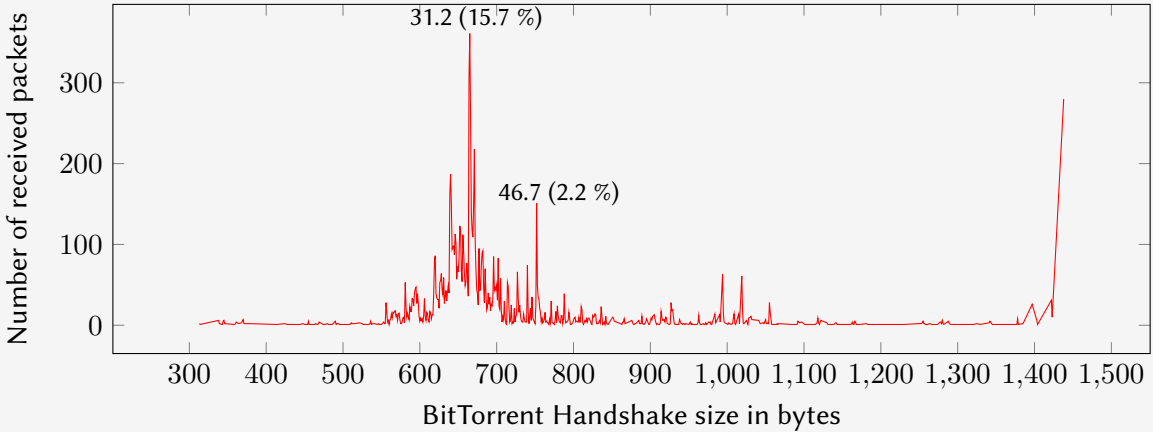

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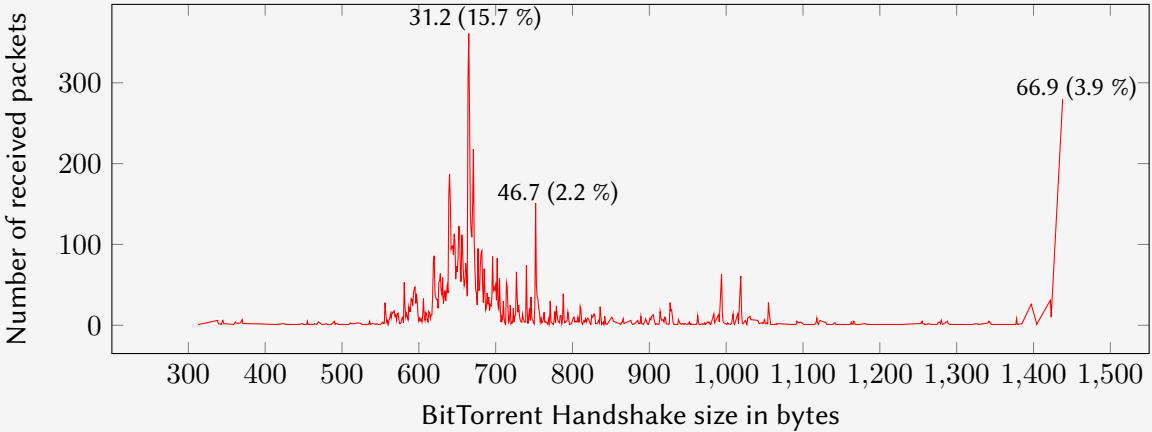

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Coutermeasures

ISP side

- BCP 38 (ingress filtering)
  - 2015: more than 70 % of the public networks deployed BCP 38

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Protocol side

- uTP
  - Three-way handshake
  - Verify the second acknowledgment
- DHT
  - Token scheme (similar to `announce_peer`)

Conclusion

- BitTorrent and BitTorrent Sync are vulnerable to DRDoS attacks
- Attacker is able to amplify traffic up to 50 times and with BTSync up to 120 times
- With Trackers, DHT and PEX, an attacker can collect millions of amplifiers
- Hard to circumvent, as the found vulnerabilities can only be defended with a DPI firewall
  - in case of MSE it is even harder

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Responsible Disclosure

uTorrent 3.4.4 49854 (beta) is released today!

Thank You

Questions?

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