

DoS Attacks and Network Defenses

CS155 Computer and Network Security

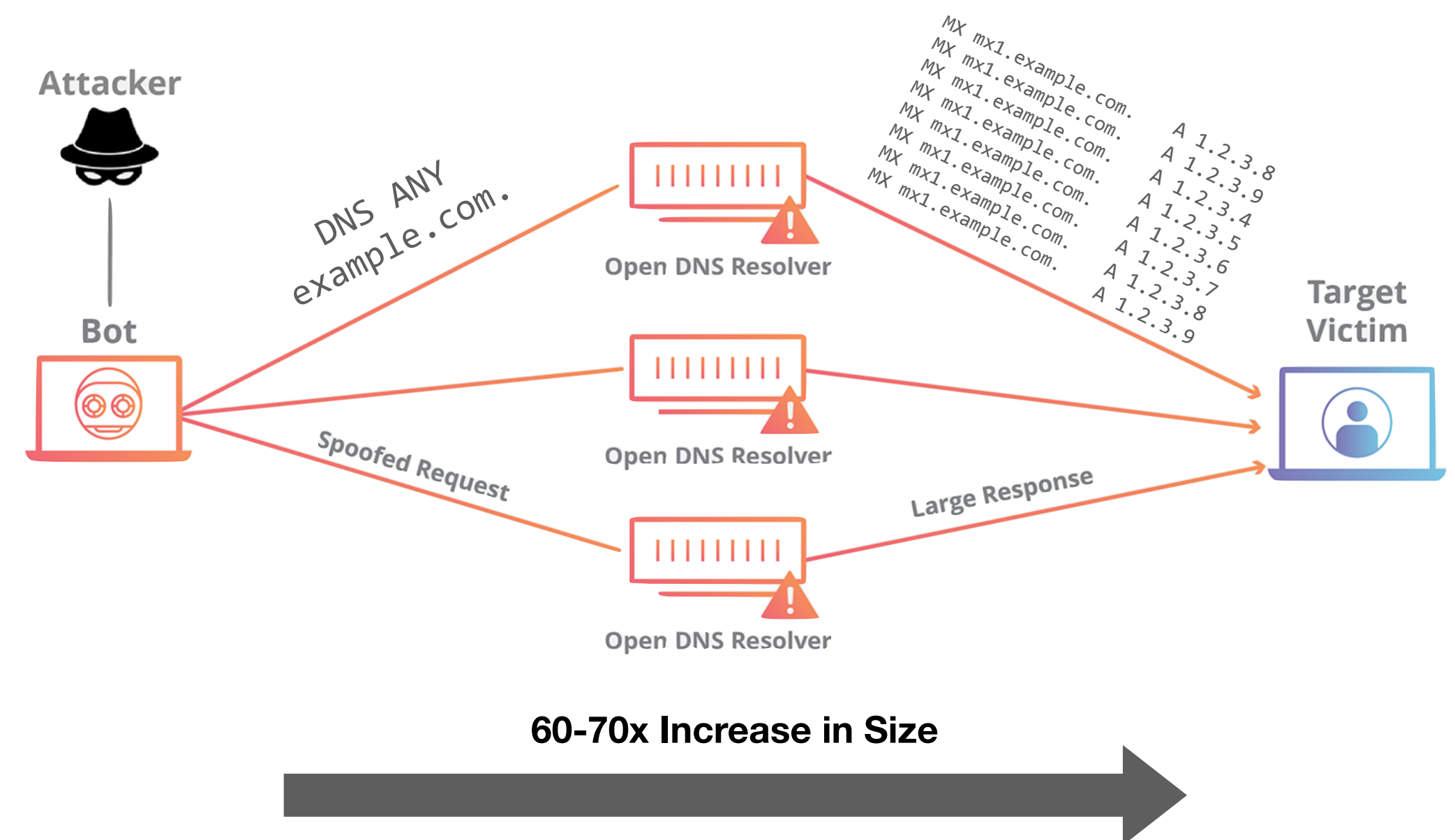
Stanford University

Amplification Attacks

Services that respond to a single (small) UDP packet with a large UDP packet can be used to amplify DOS attacks

Attacker forges packet and sets source IP to victim's IP address. When service responds, it sends large amount of data to the spoofed victim

The attacker needs a large number of these services to amplify packets. Otherwise, the victim could just drop the packets from the small number of hosts



Common UDP Amplifiers

DNS: ANY query returns *all* records server has about a domain

NTP: MONLIST returns list of last 600 clients who asked for the time recently

DNS: Do not have recursive resolvers on the public Internet.

NTP: Do not respond to commands like MONLIST

Both are considered misconfigurations today, but often 100Ks of misconfigured hosts on the public Internet

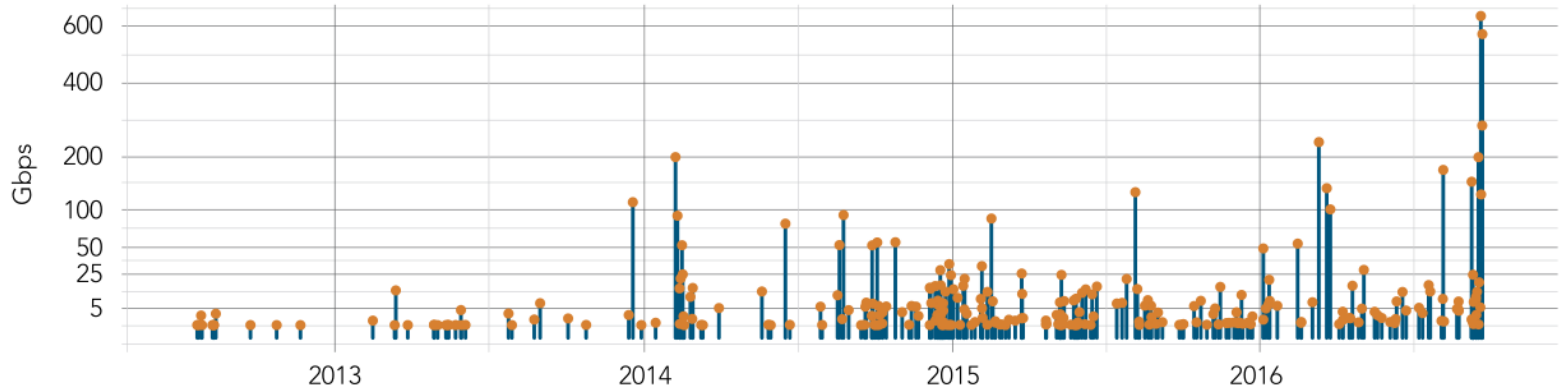
Amplification Attacks

2013: DDoS attack generated 300 Gbps (DNS)

- 31,000 misconfigured open DNS resolvers, each at 10 Mbps
- Source: 3 networks that allowed IP spoofing

2014: 400 Gbps DDoS attacked used 4,500 NTP servers

DDoS Attacks on Krebs on Security



THE WALL STREET JOURNAL.

October 21, 2016

Cyberattack Knocks Out Access to Websites

Popular sites such as Twitter, Netflix and PayPal were unreachable for part of the day



twitter

amazon
web services™

PayPal

NETFLIX

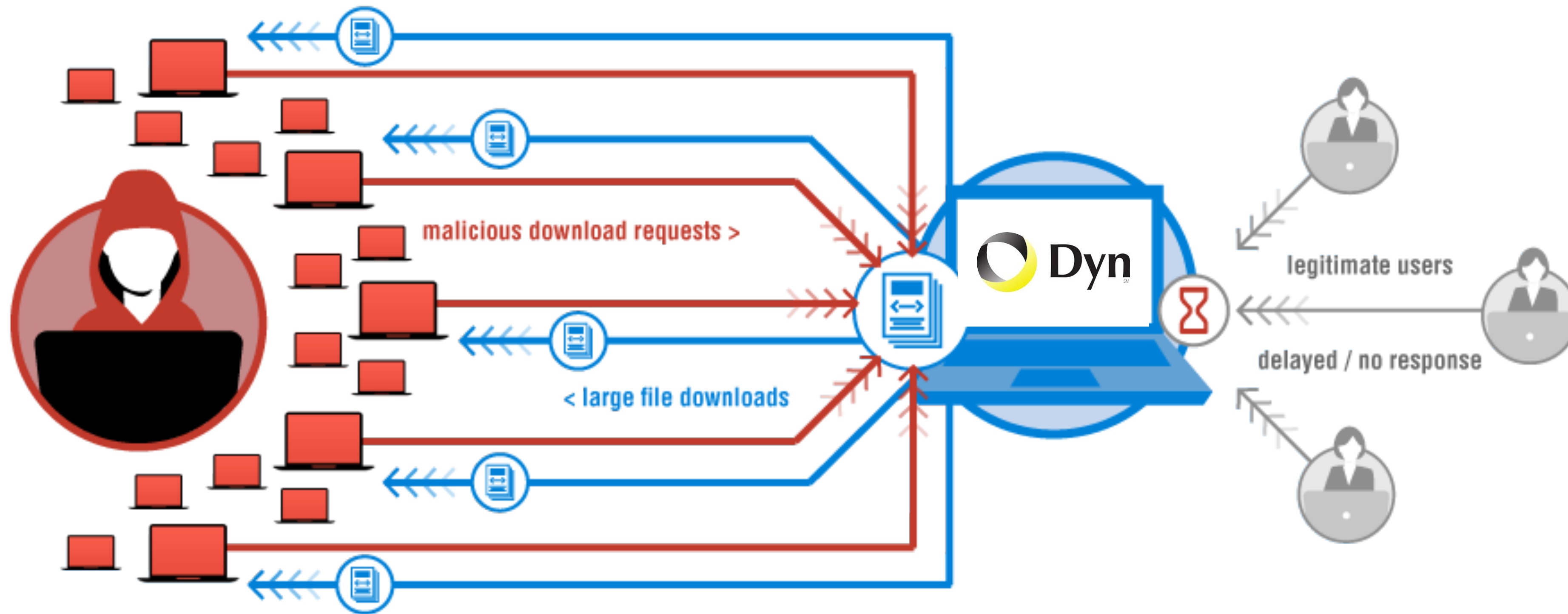
SOUNDCLOUD

Spotify®

GitHub

reddit

New York Times



“We are still working on analyzing the data but the estimate at the time of this report is up to 100,000 malicious endpoints. [...] There have been some reports of a magnitude in the 1.2 Tbps range; at this time we are unable to verify that claim.”

A Botnet of IoT Devices

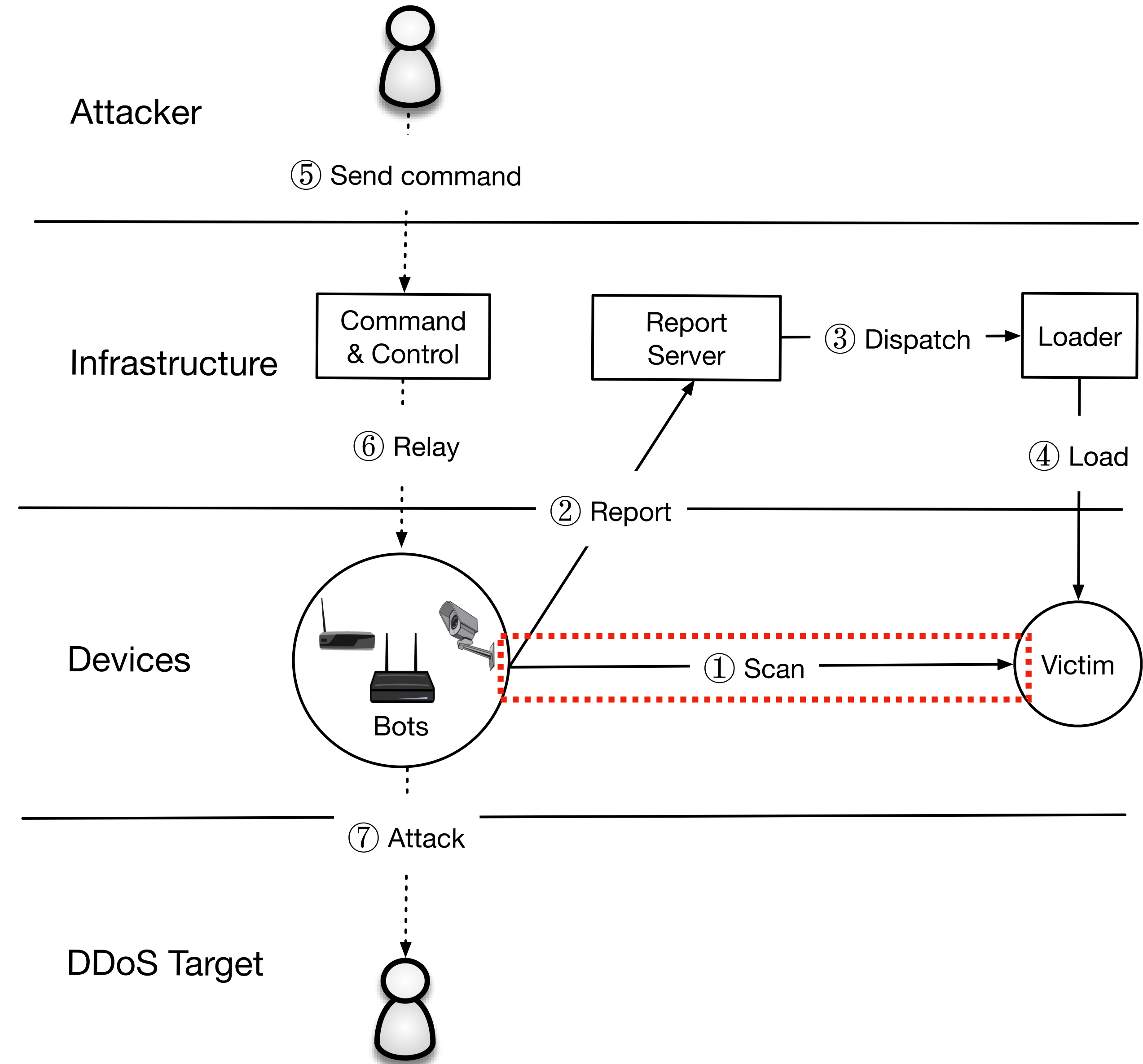


~~≈ 200K Hosts~~
200K IoT devices

Not Amplification.
Flood with SYN, ACK, UDP, and GRE packets

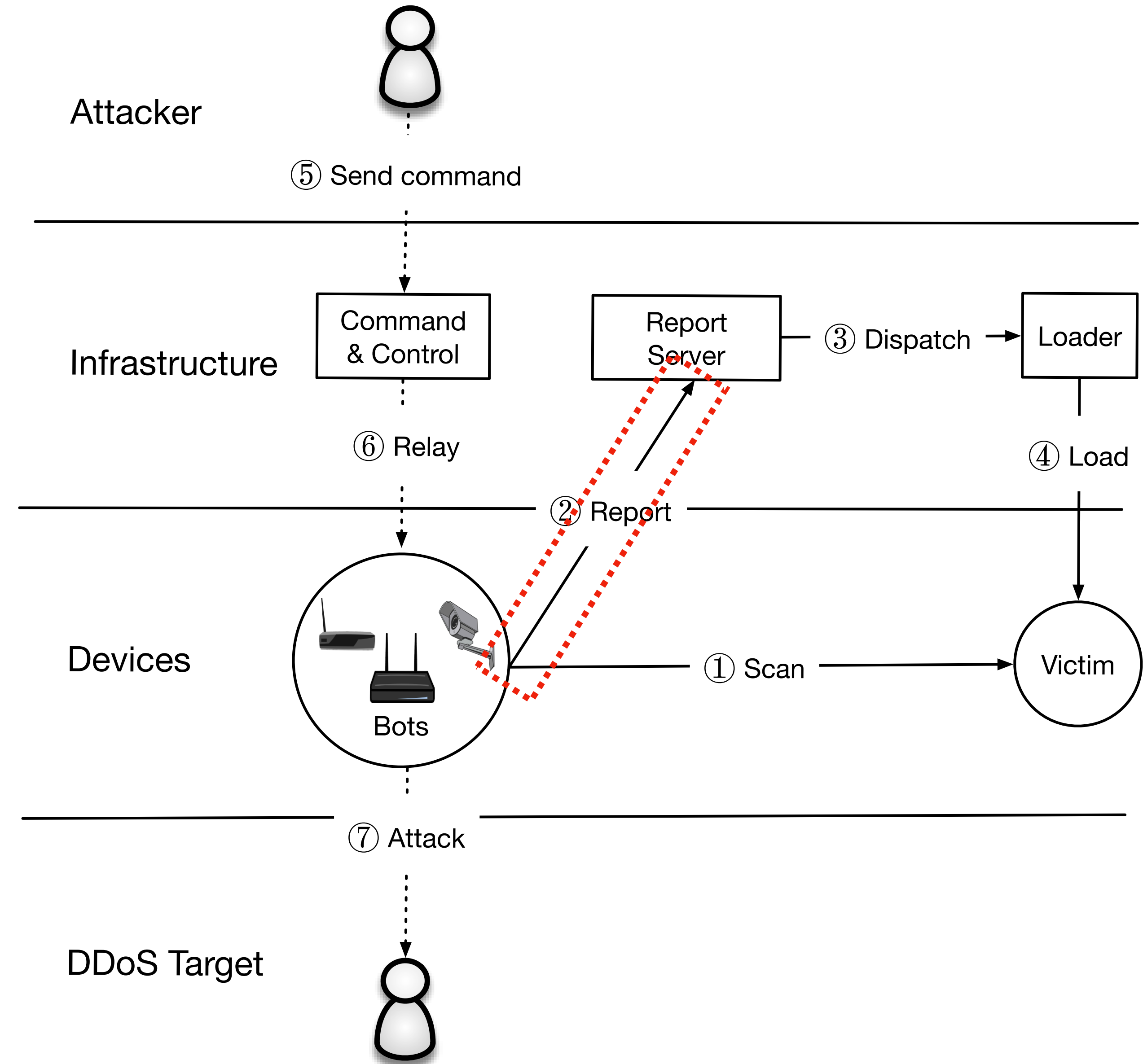
The Mirai Malware

1. Bots statelessly scan for victims on TCP/23 and TCP/2323. They attempt to login over telnet with a set of hardcoded credentials



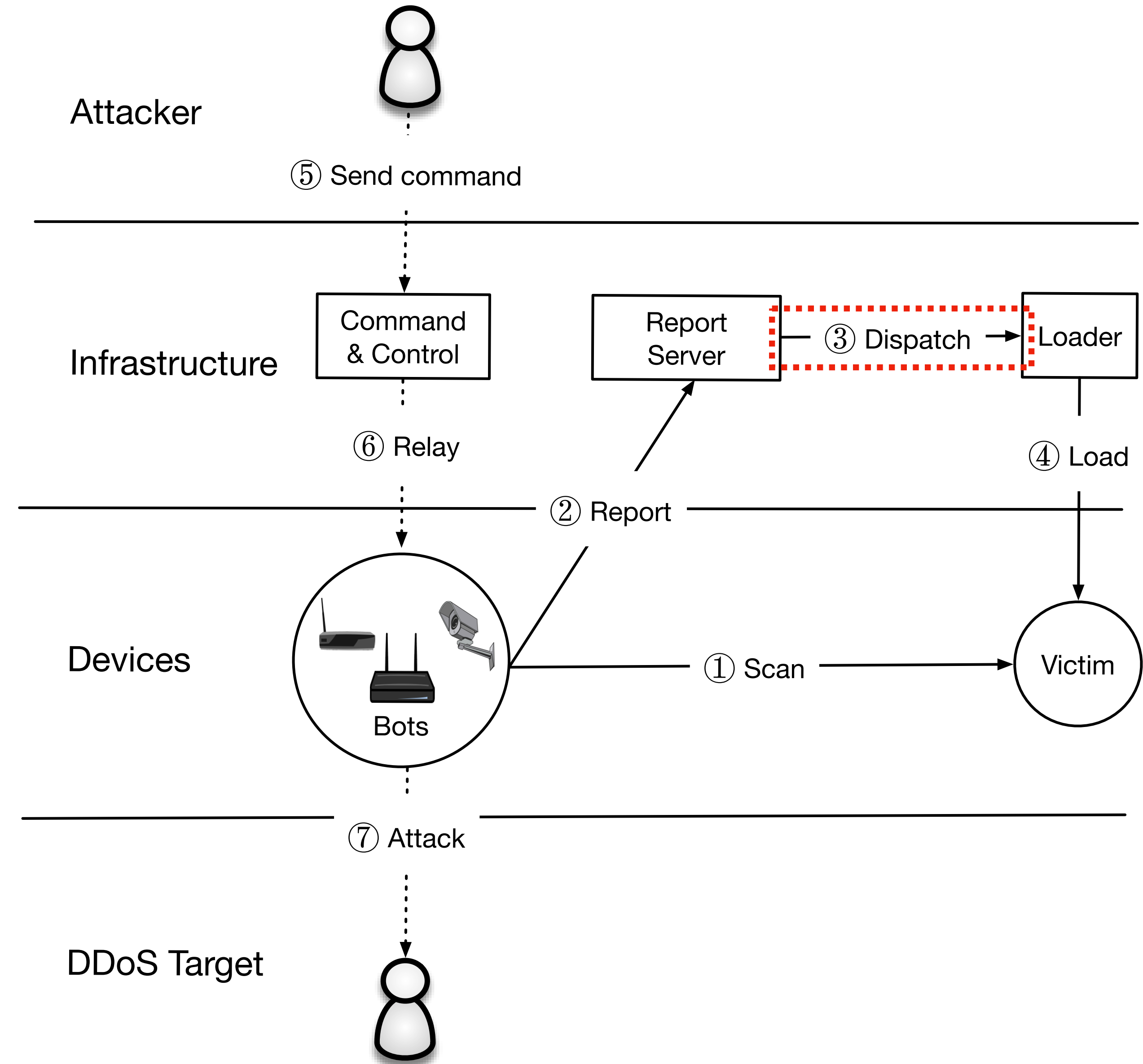
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2. **Scanner** reports details about vulnerable host to central **C2 server**



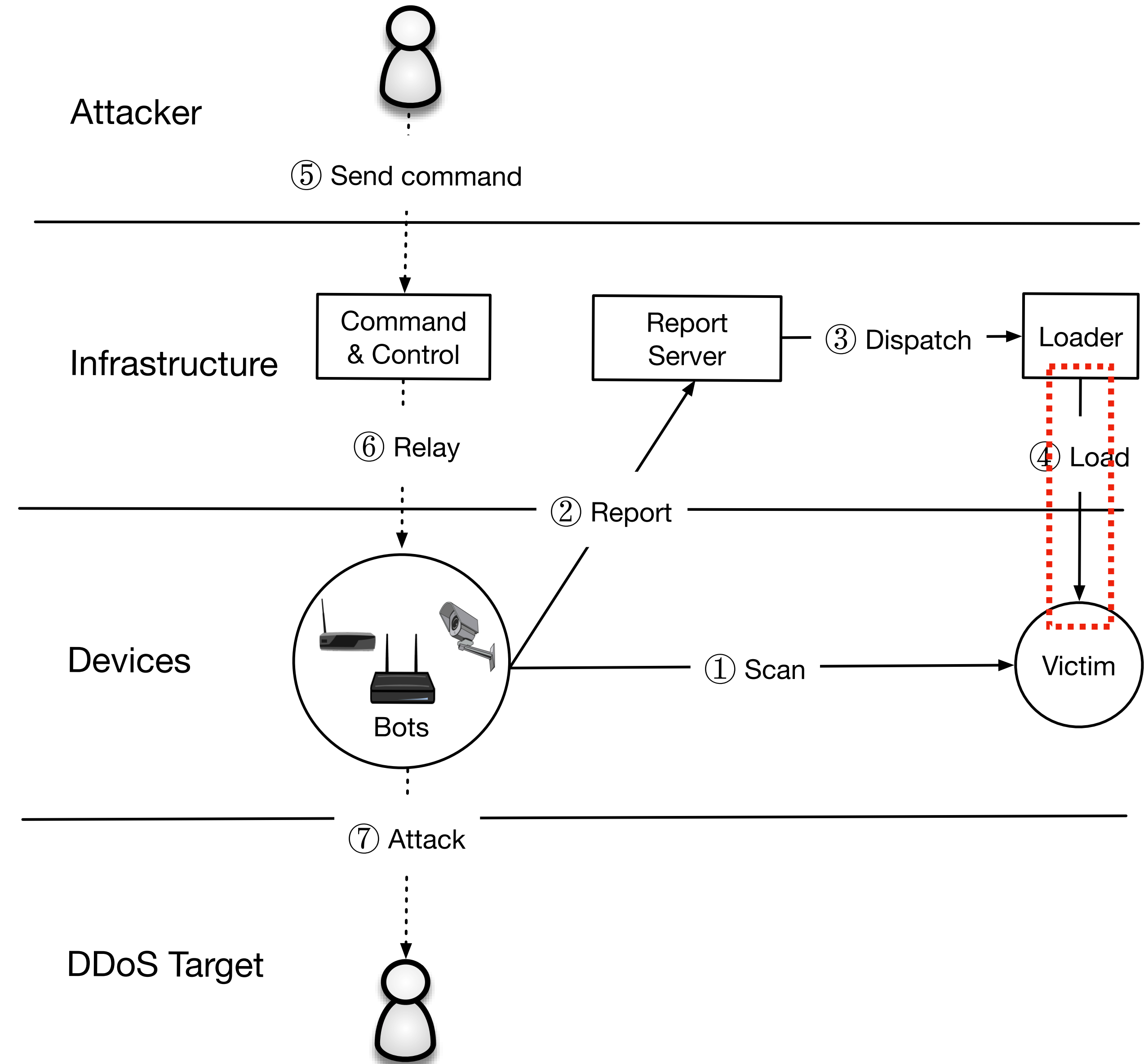
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2. **Scanner** reports details about vulnerable host to central **C2 server**
3. **C2 server** dispatches command to **loader** to load malware onto IoT device
4. **Loader** logs into device, downloads and installs architecture-specific malware, kills telnet service, removes other malware, and waits for instructions

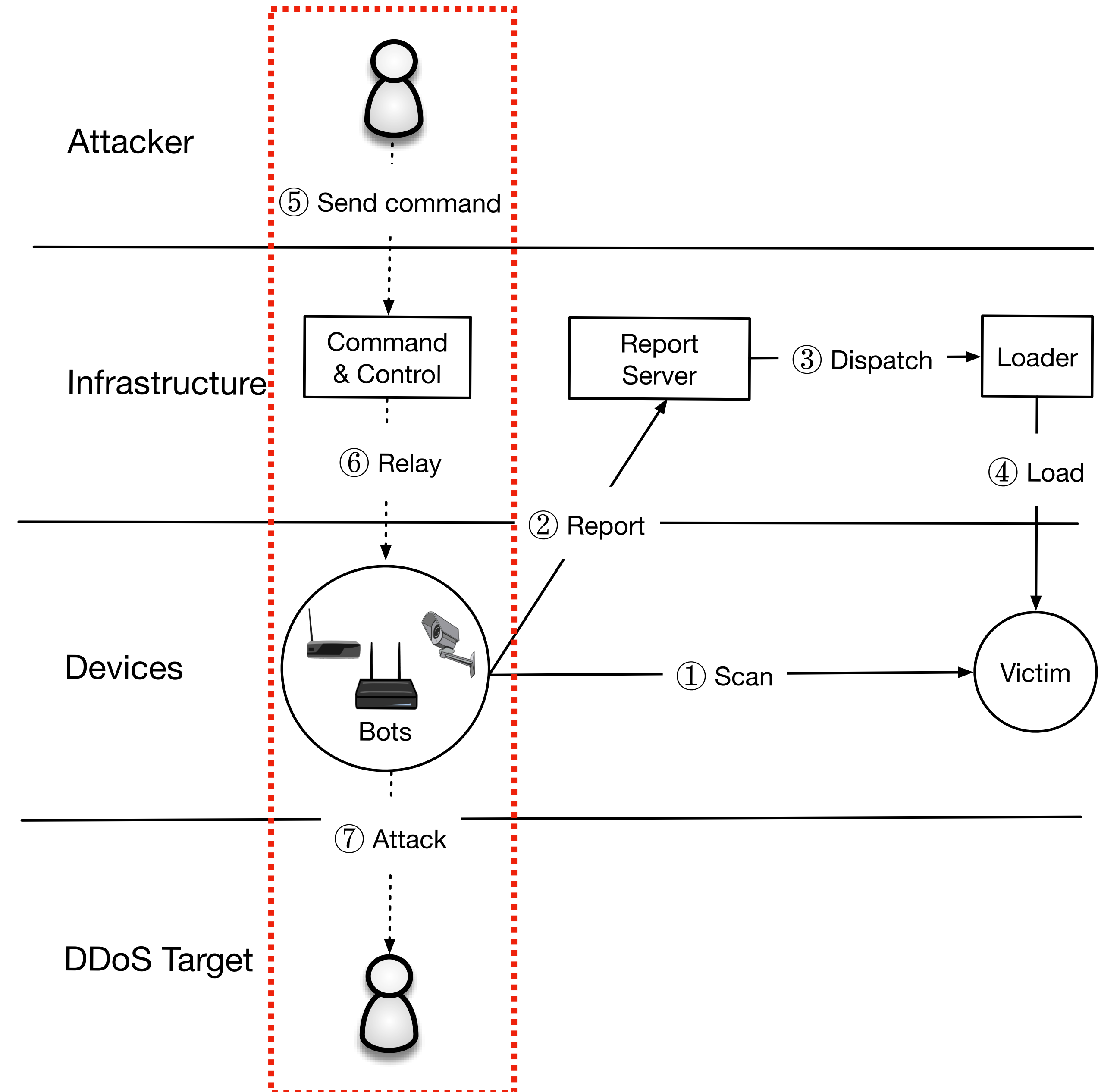


The Mirai Malware

5-7. Later, the **bot master** will issue commands to pause scanning and to start an attack

Attack Command:

- Action (e.g., START, STOP)
- Target IP(s)
- Attack Type (e.g., GRE, DNS, TCP)
- Attack Duration

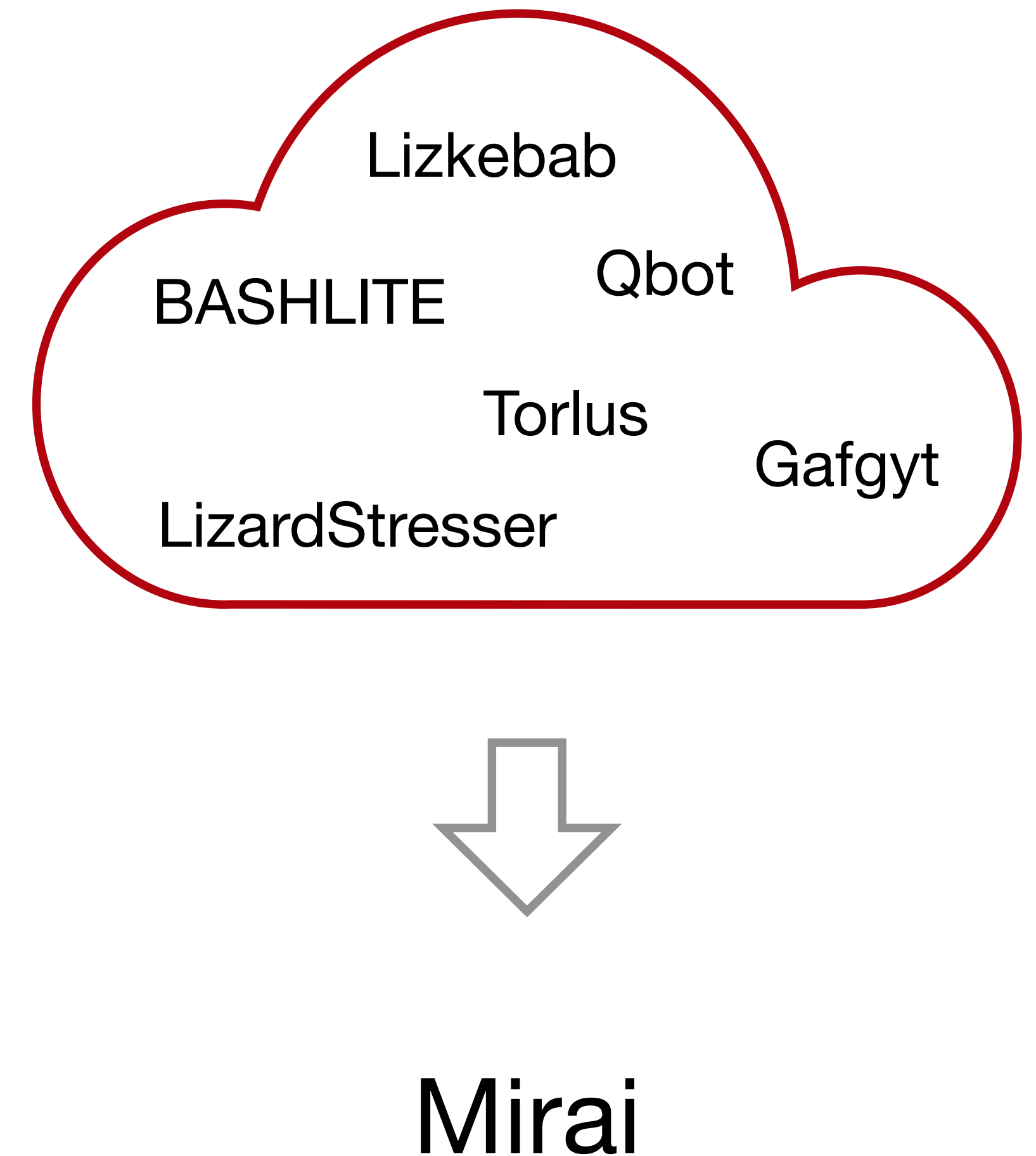


What made Mirai Successful?

The Mirai malware is (astoundingly) badly written. It uses no new or complex techniques.

Mirai was successful because:

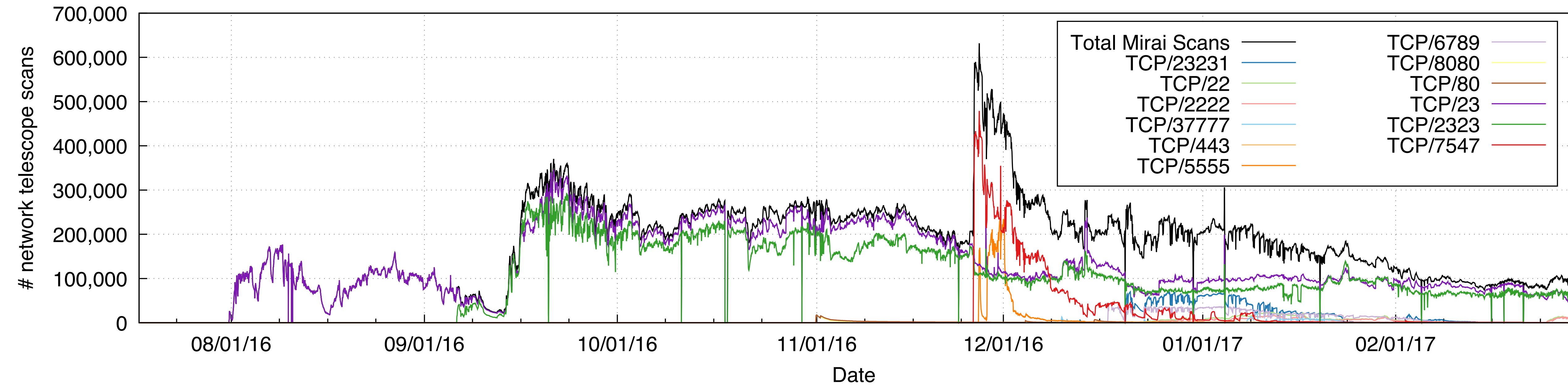
1. IoT security bar is very low
2. Attack simplicity enabled the malware to compromise heterogeneous hardware
3. Stateless scanning was an improvement over prior versions



Password Guessing

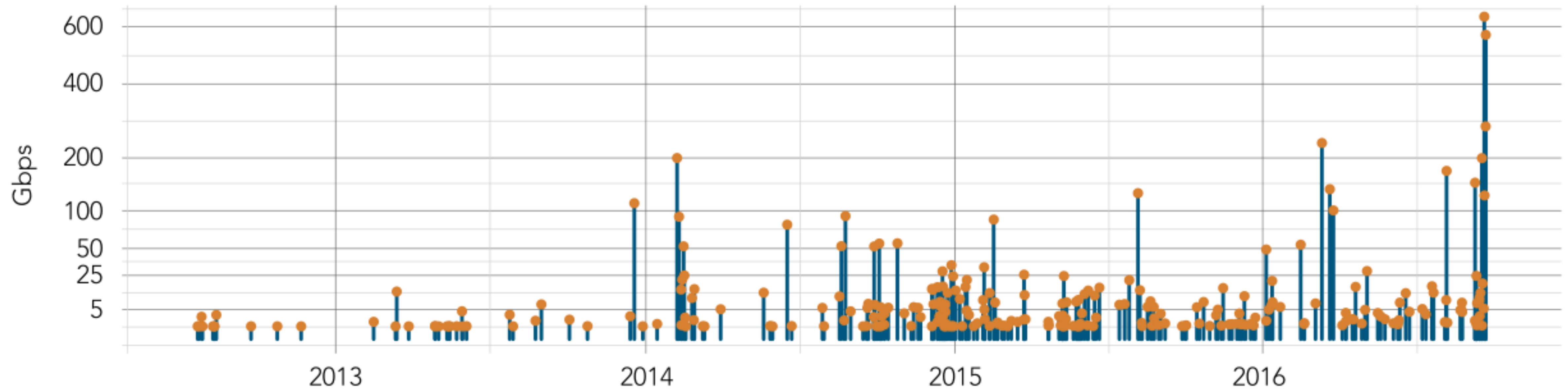
Password	Device Type	Password	Device Type	Password	Device Type
123456	ACTi IP Camera	klv1234	HiSilicon IP Camera	1111	Xerox Printer
anko	ANKO Products DVR	jvbzd	HiSilicon IP Camera	Zte521	ZTE Router
pass	Axis IP Camera	admin	IPX-DDK Network Camera	1234	Unknown
888888	Dahua DVR	system	IQinVision Cameras	12345	Unknown
666666	Dahua DVR	meinsm	Mobotix Network Camera	admin1234	Unknown
vizxv	Dahua IP Camera	54321	Packet8 VOIP Phone	default	Unknown
7ujMko0vizxv	Dahua IP Camera	00000000	Panasonic Printer	fucker	Unknown
7ujMko0admin	Dahua IP Camera	realtek	RealTek Routers	guest	Unknown
666666	Dahua IP Camera	1111111	Samsung IP Camera	password	Unknown
dreambox	Dreambox TV Receiver	xmhdipc	Shenzhen Anran Camera	root	Unknown
juantech	Guangzhou Juan Optical	smcadmin	SMC Routers	service	Unknown
xc3511	H.264 Chinese DVR	ikwb	Toshiba Network Camera	support	Unknown
OxhlwSG8	HiSilicon IP Camera	ubnt	Ubiquiti AirOS Router	tech	Unknown
cat1029	HiSilicon IP Camera	supervisor	VideoIQ	user	Unknown
hi3518	HiSilicon IP Camera	<none>	Vivotek IP Camera	zlxx.	Unknown
klv123	HiSilicon IP Camera				

Mirai Population




~600K devices compromised

DDoS Attacks on Krebs on Security



“The magnitude of the attacks seen during the final week were significantly larger than the majority of attacks Akamai sees on a regular basis. [...] In fact, while the attack on September 20 was the largest attack ever mitigated by Akamai, the attack on September 22 would have qualified for the record at any other time, peaking at 555 Gbps.”

Arrest of Paras Jha, Josiah White, Dalton Norman



Paras Jha

2nd

President at ProTraf Solutions, LLC
Greater New York City Area | Computer & Network Security

Current

ProTraf Solutions

Education


Rutgers University-New Brunswick

Follow

295
followers

<https://www.linkedin.com/in/paras-jha-561ba110a>

Background

 Summary

Paras is a passionate entrepreneur driven by the want to create. Highly self-motivated, in 7th grade he began to teach himself to program in a variety of languages. Today, his skillset for software development includes C#, Java, Golang, C, C++, PHP, x86 ASM, not to mention web "browser languages" such as Javascript and HTML/CSS.







Jha and White were co-founders of Protraf Solutions LLC, a company that specialized in mitigating large-scale DDoS attacks

Primarily used botnet to extort Minecraft server operators

MINECRAFT



Booter Services

\$23.99 1 month	\$34.99 1 month	\$44.99 10 years
1 Month Gold	1 Month Diamond	Lifetime Bronze
Time per boot2400 sec	Time per boot3600 sec	Time per boot600 sec
Concurrents1	Concurrents2	Concurrents2
Total network220Gbps	Total network220Gbps	Total network220Gbps
ToolsIncluded	ToolsIncluded	ToolsIncluded
Support24/7	Support24/7	Support24/7
Buy with Paypal 	Buy with Paypal 	Buy with Paypal 
 bitcoin	 bitcoin	 bitcoin

[FREE] World's Largest Net:Mirai Botnet, Client, Echo Loader, CNC source code release

Yesterday, 12:50 PM (This post was last modified: Yesterday 04:29 PM by Anna-senpai.)



Anna-senpai 

L33t Member



Preface

Greetz everybody,

When I first go in DDoS industry, I wasn't planning on staying in it long. I made my money, there's lots of eyes looking at IOT now, so it's their wet dream to have something besides qbot. However, I know every skid and their mama, it's their wet dream to have something besides qbot.

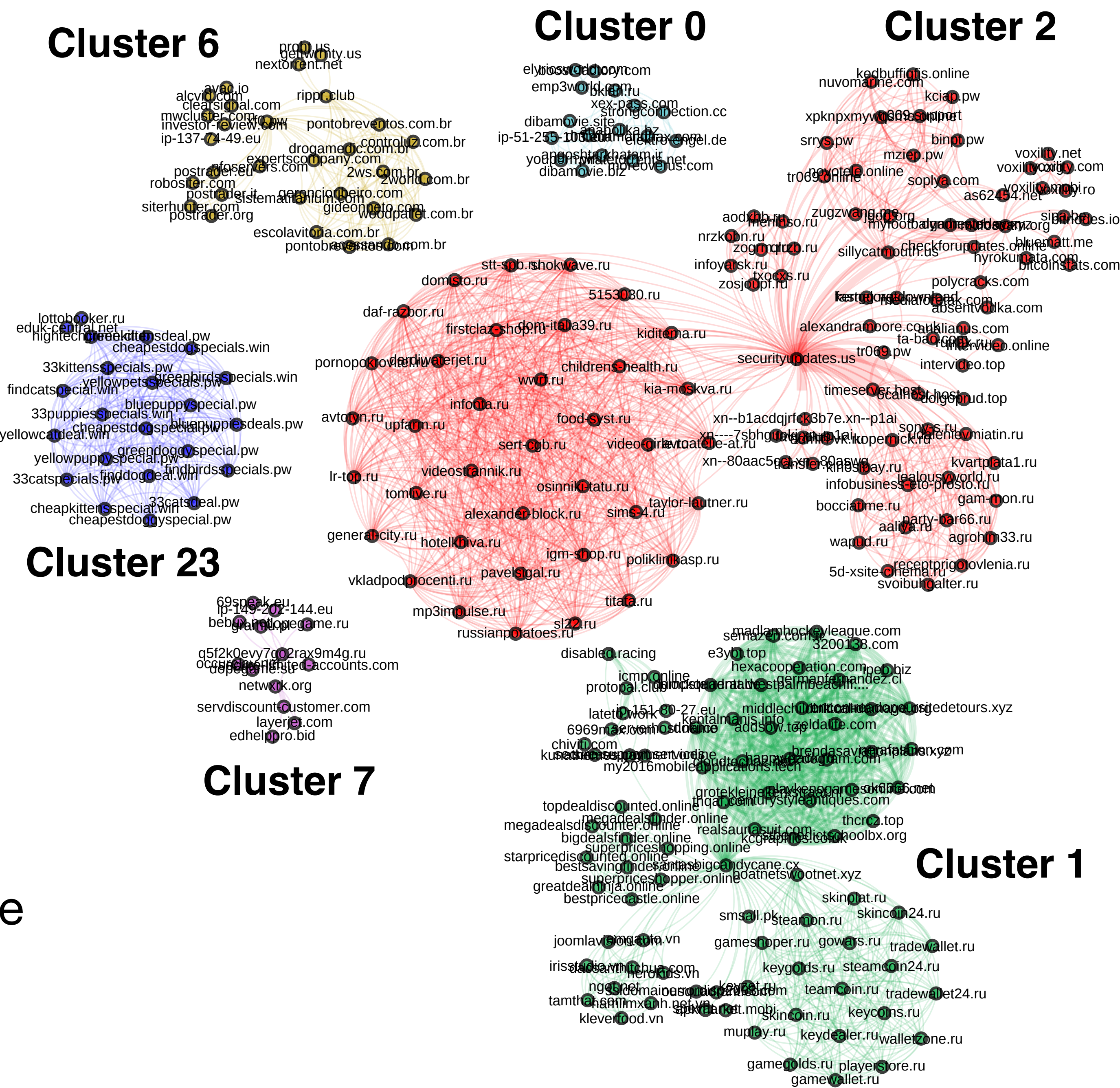
So today, I have an amazing release for you. With Mirai, I usually pull max 380k bots from telnet alone. However, after the Krebs DDoS, shutting down and cleaning up their act. Today, max pull is about 300k bots, and dropping.

So, I am your senpai, and I will treat you real nice, my hf-chan.

September 1, 2016

Major Variants

- (1) Original Botnet: Krebs, OVH
- (2) Liberian Provider, Russian Auction Site
- (6) Dyn Attack, Gaming Sites
- (7) Russian Blog, Italian Politician, etc.



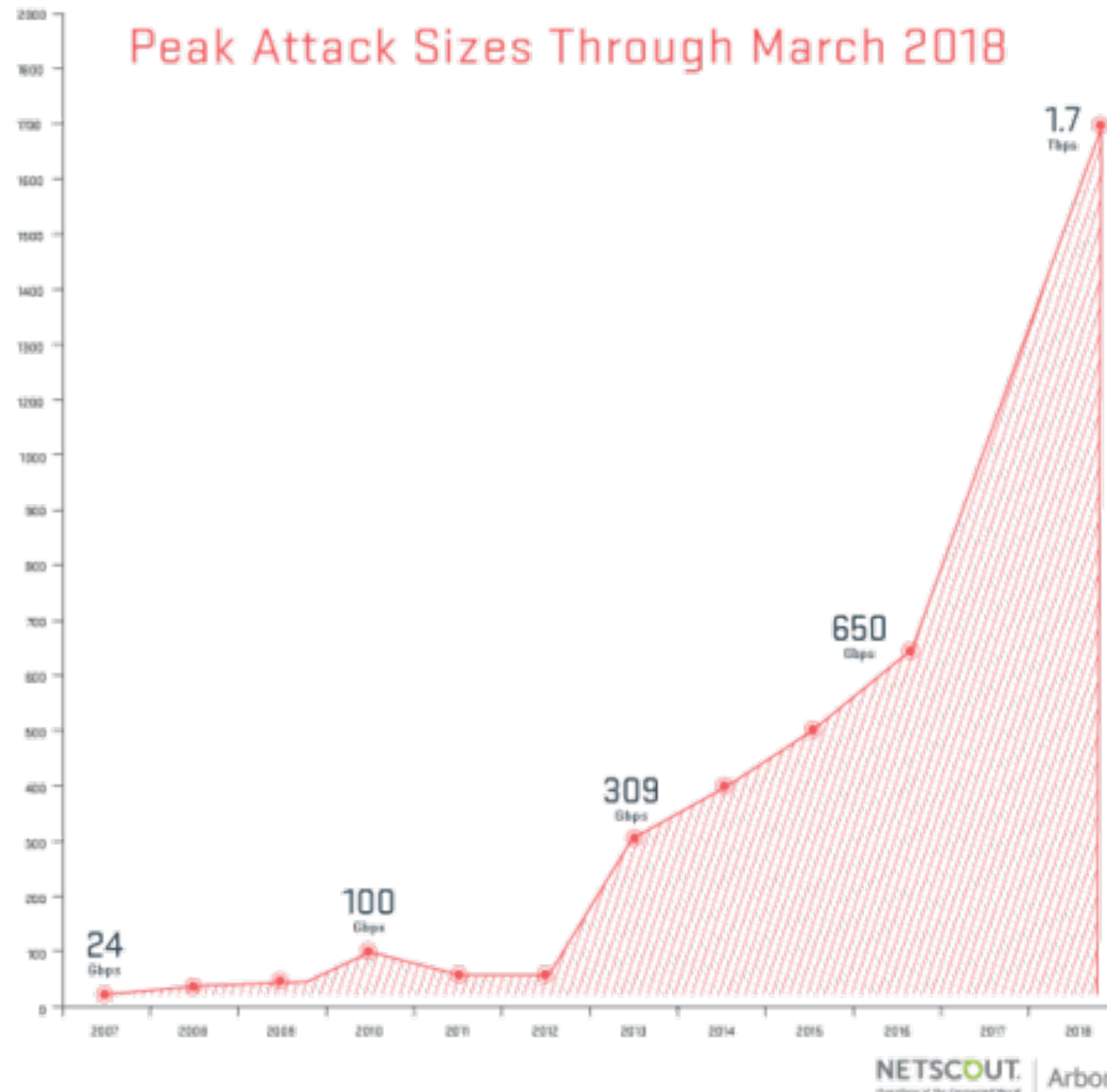
Dyn Attack

The New York Times

“It is possible, investigators say, that the attack on Dyn was conducted by a criminal group that wanted to extort the company. Or it could have been done by “hacktivists.” Or a foreign power that wanted to remind the United States of its vulnerability.”

Targeted IP	rDNS	Passive DNS
208.78.70.5	ns1.p05.dynect.net	ns00.playstation.net
204.13.250.5	ns2.p05.dynect.net	ns01.playstation.net
208.78.71.5	ns3.p05.dynect.net	ns02.playstation.net
204.13.251.5	ns4.p05.dynect.net	ns03.playstation.net
198.107.156.219	service.playstation.net	ns05.playstation.net
216.115.91.57	service.playstation.net	ns06.playstation.net

Memcache



Memcache: retrieve large record

The server responds by firing back as much as 50,000 times the data it received.

Exist both a UDP and TCP version. Only works for UDP! TCP would require a three-way handshake and server would realize IP had been spoofed.

Mirai Attacks

DDoS attack hits OVH.
1.2 Tbps claim

9/18/16

9/21/16

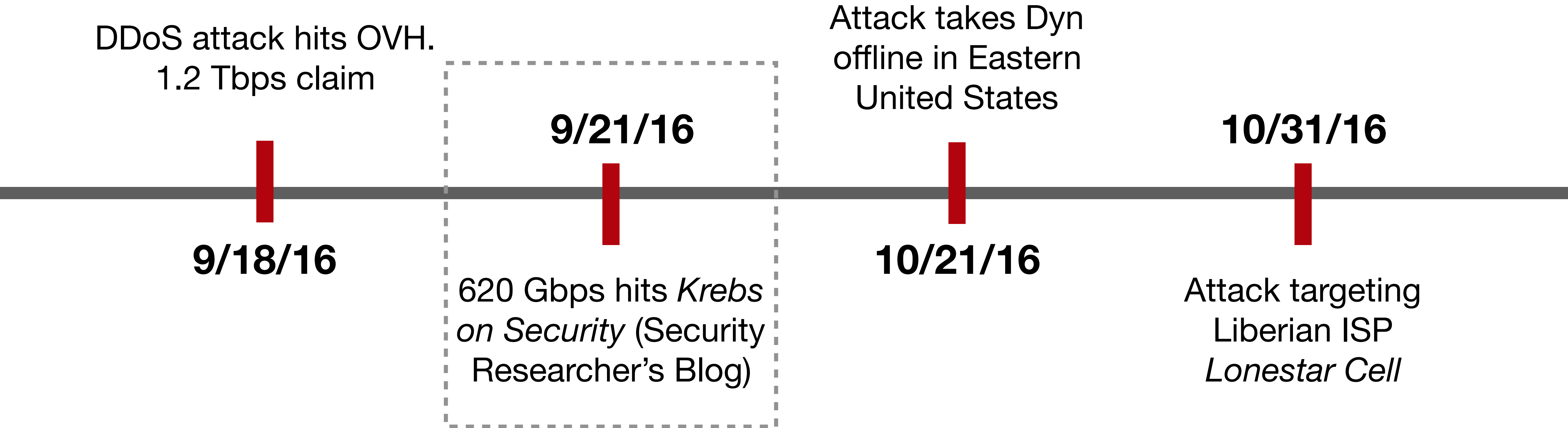
620 Gbps hits *Krebs
on Security* (Security
Researcher's Blog)

Attack takes Dyn
offline in Eastern
United States

10/21/16

10/31/16

Attack targeting
Liberian ISP
Lonestar Cell



Brian Krebs

Retribution for article exposing the creators of vDOS—a popular booter

KrebsOnSecurity

In-depth security news and investigation

08 Israeli Online Attack Service ‘vDOS’ Earned SEP 16 \$600,000 in Two Years

vDOS — a “booter” service that has earned in excess of \$600,000 over the past two years helping customers coordinate more than 150,000 so-called distributed denial-of-service (DDoS) attacks designed to knock Web sites offline — has been massively hacked, spilling secrets about tens of thousands of paying customers and their targets.

The vDOS database, obtained by KrebsOnSecurity.com at the end of July 2016, points to two young men in Israel as the principal owners and masterminds of the attack service, with support services coming from several young hackers in the United States.



How do I purchase a vDos plan?

Purchasing a booter plan is easy and only takes a few minutes, we accept the following payment methods, based on your billing country/region and the currency in which you want to pay to make it an easy, secure and a quick shopping experience for you.

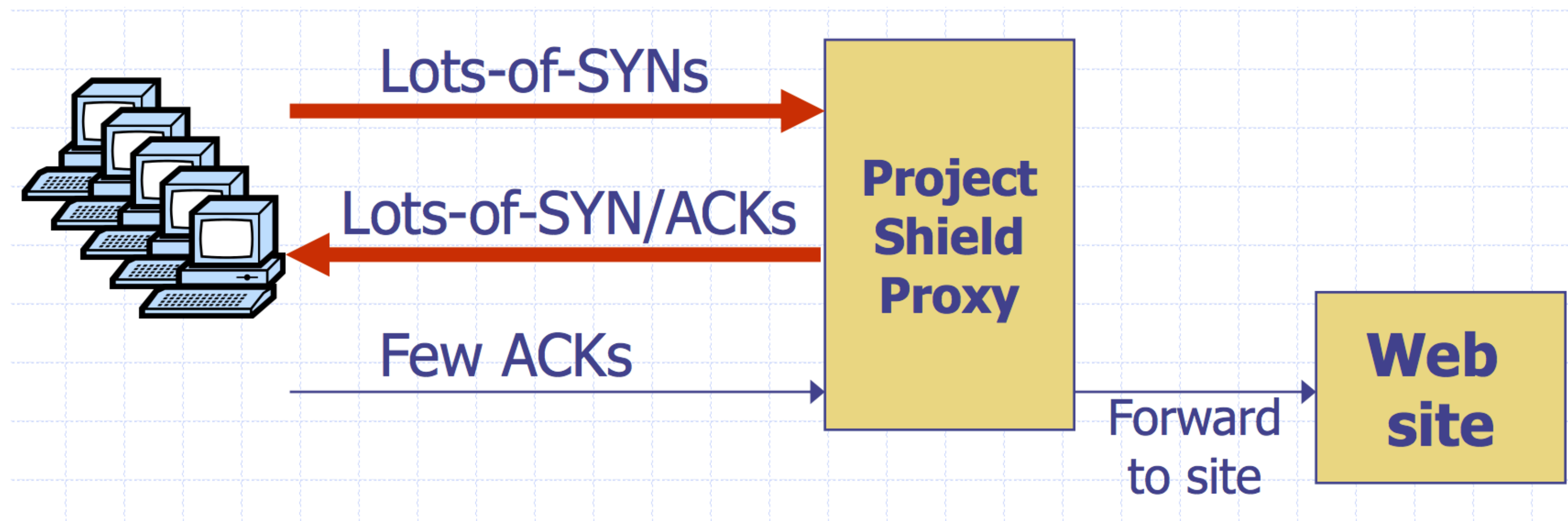
Bitcoin, we believe in the huge potential of this new digital currency.



Google Project Shield

DDoS Attacks are often used to censor content. In the case of Mirai, Brian Krebs's blog was under attack.

Google Project shield uses Google bandwidth to shield vulnerable websites (e.g., news, blogs, human rights orgs)



Moving Up Stack: GET Floods

Command bot army to:

- * Complete real TCP connection
- * Complete TLS Handshake
- * GET large image or other content

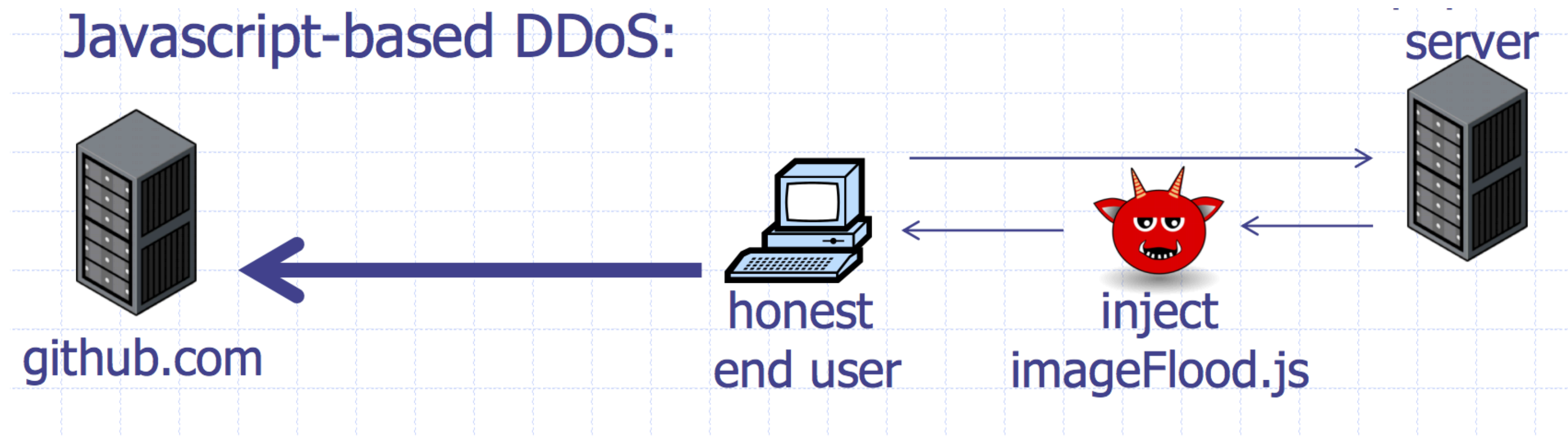
Will bypass flood protections.... but attacker can no longer use random source IPs

Victim site can block or rate limit bots

Github Attacks

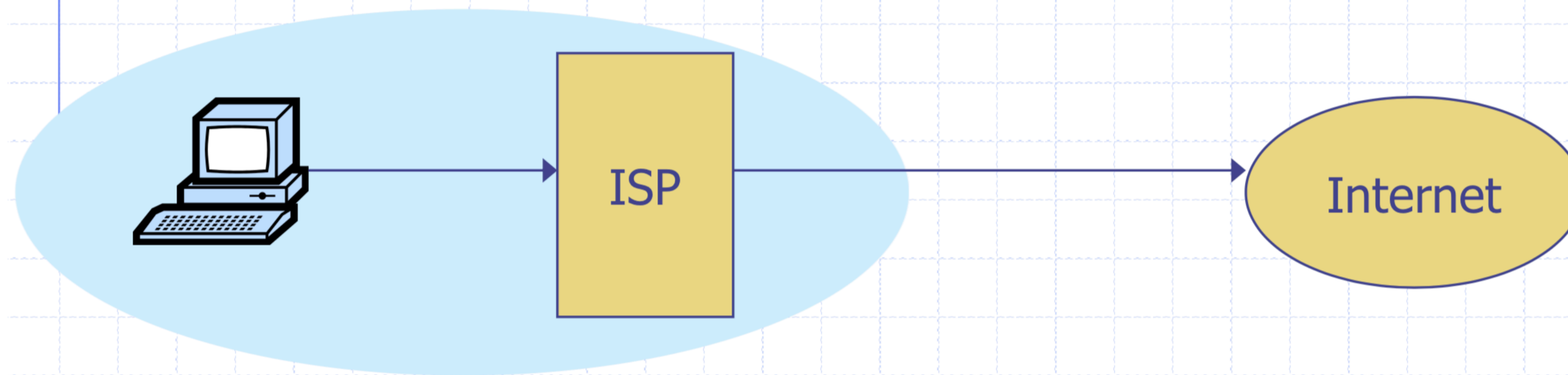
1.35 Tbps attack against Github caused by javascript injected into HTTP web requests

The Chinese government was widely suspected to be behind the attack



Ingress Filtering

◆ Big problem: DDoS with spoofed source IPs



◆ Ingress filtering policy: ISP only forwards packets with legitimate source IP (see also SAVE protocol)

Ingress Filtering

All ISPs need to do this — requires global coordination

If 10% of networks don't implement, there's no defense

No incentive for an ISP to implement — doesn't affect them

As of 2017 (from CAIDA):

33% of autonomous systems allow spoofing

23% of announced IP address space allow spoofing

2013 300 Gbps attack sent attack traffic from only 3 networks

Client Puzzles

Idea: What if we force every client to do moderate amount of work for every connection they make?

Example:

1) Server Sends: C

2) Client: find X s.t. $LSB_n(SHA-1(C || X)) = 0^n$

Assumption:

Puzzle takes 2^n for the client to compute (0.3 s on 1Ghz core)

Solution is trivial for server to check (single SHA-1)

Client Puzzles

Not frequently used in the real world

Benefits:

- * Can change n based on amount of attack traffic

Limitations:

- * Requires changes to both protocols, clients, and servers
- * Hurts low power legitimate clients during attack (e.g., phones)

Network Defenses

Local Services

Review: Popular TCP and UDP services live on standardized ports.
HTTPS servers listen on TCP/443. SSH on TCP/22.

Some services you don't want listening on the public Internet.

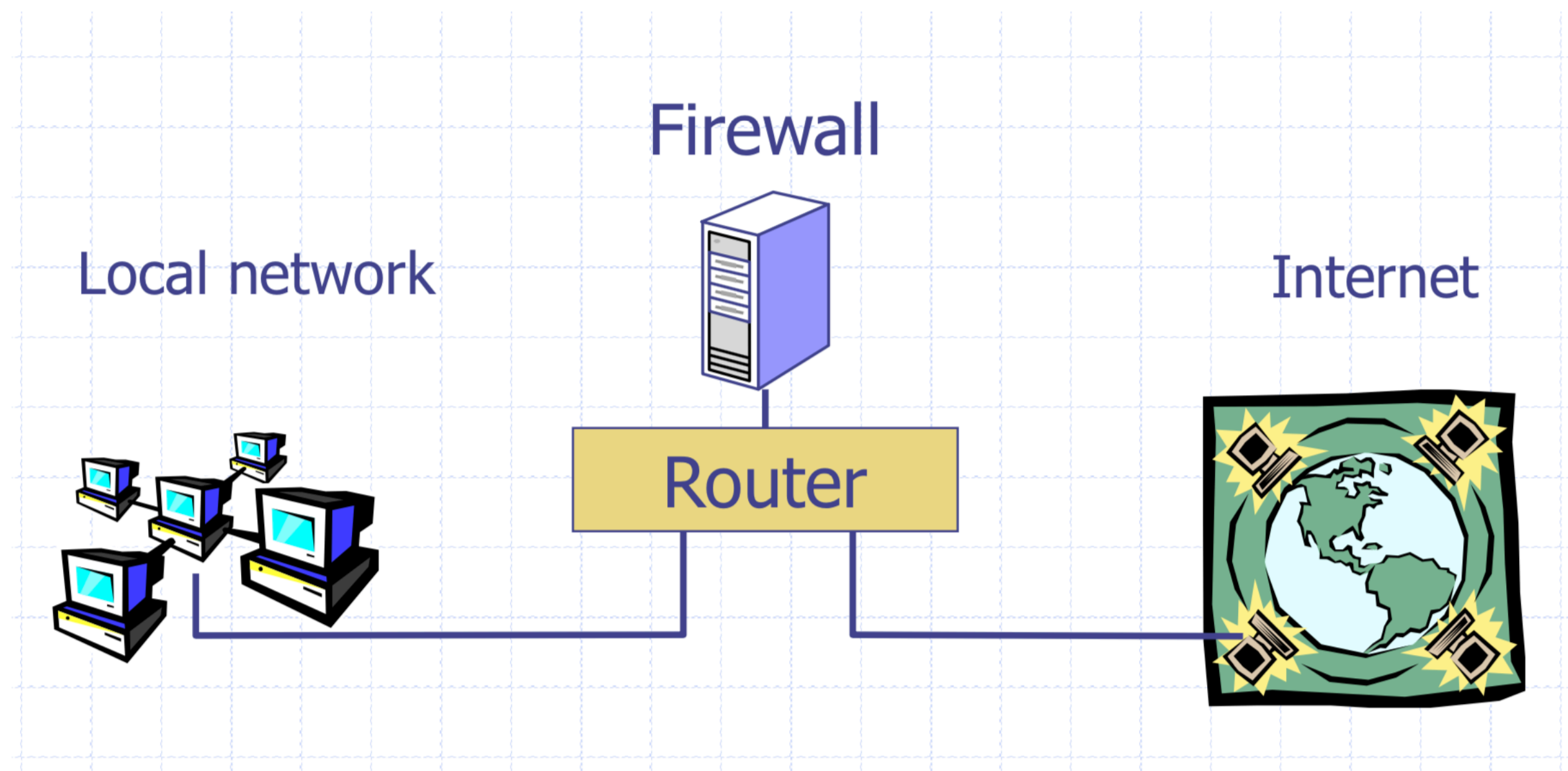
Recursive DNS Resolvers: allows attackers to mount DDoS attacks

Windows File Sharing: historically full of vulnerabilities. What if a local machine doesn't have a secure password on it?

Firewall

Separate local area network (LAN) from the Internet. Only allow some traffic to transit.

Sometimes rules on a router. Sometimes a standalone device.



Basic Packet Filtering

Uses transport and IP layer information only

- IP Source Address, Destination Address
- Protocol (TCP, UDP, ICMP, etc.)
- TCP and UDP source and destination ports

Examples:

- “Do not allow external hosts to connect to Windows File Sharing”
-> DROP ALL INBOUND PACKETS TO TCP PORT 445

What's the rule?

What if you have a network with lots of servers but only want outsiders to be able to access a web server?

What's the rule?

What if you have a network with lots of servers but only want outsiders to be able to access a web server?

DROP ALL INBOUND PACKETS IF DEST PORT \neq 80

Problem with Blacklisting

All outbound connections also have a source port! Their responses will be blocked!

IANA Port Numbering

System or Well-Known Ports [1,1023]:

Common services, e.g., HTTP -> 80, SSH -> 22

User or registered ports [1024, 49151]

Less well-known services

Ephemeral/Dynamic/Private Ports [49152, 65535]

Short lived connections

Only Blocking Well Known Ports

What if you have a network with lots of servers but only want outsiders to be able to access a web server?

DROP ALL INBOUND PACKETS IF
(DEST PORT \neq 80 AND DEST PORT $<$ 49152)

Reality

Recommended Today

System or Well-Known Ports [1,1023]:

Common services, e.g., HTTP -> 80

User or registered ports [1024, 49151]

Less well-known services

Ephemeral/Dynamic Ports [49152, 65535]

Short lived connections

Reality (Ephemeral)

Original BSD: [1024, 5000]

Current Linux: [32768, 61000]

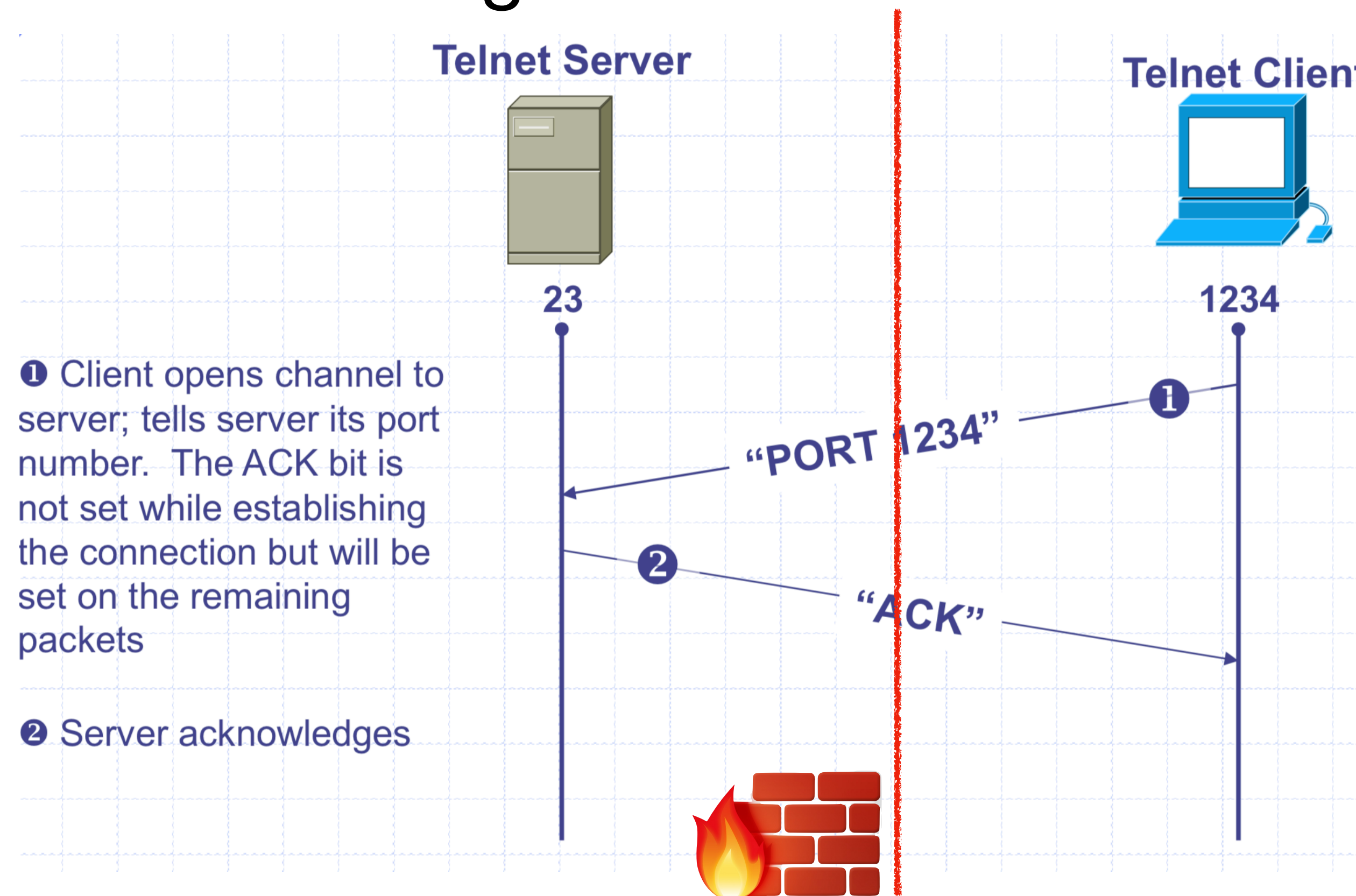
Windows Pre Vista: [1024, 5000]

Windows Server 2008: [1025–60000]

Modern Windows: [49152, 65535]

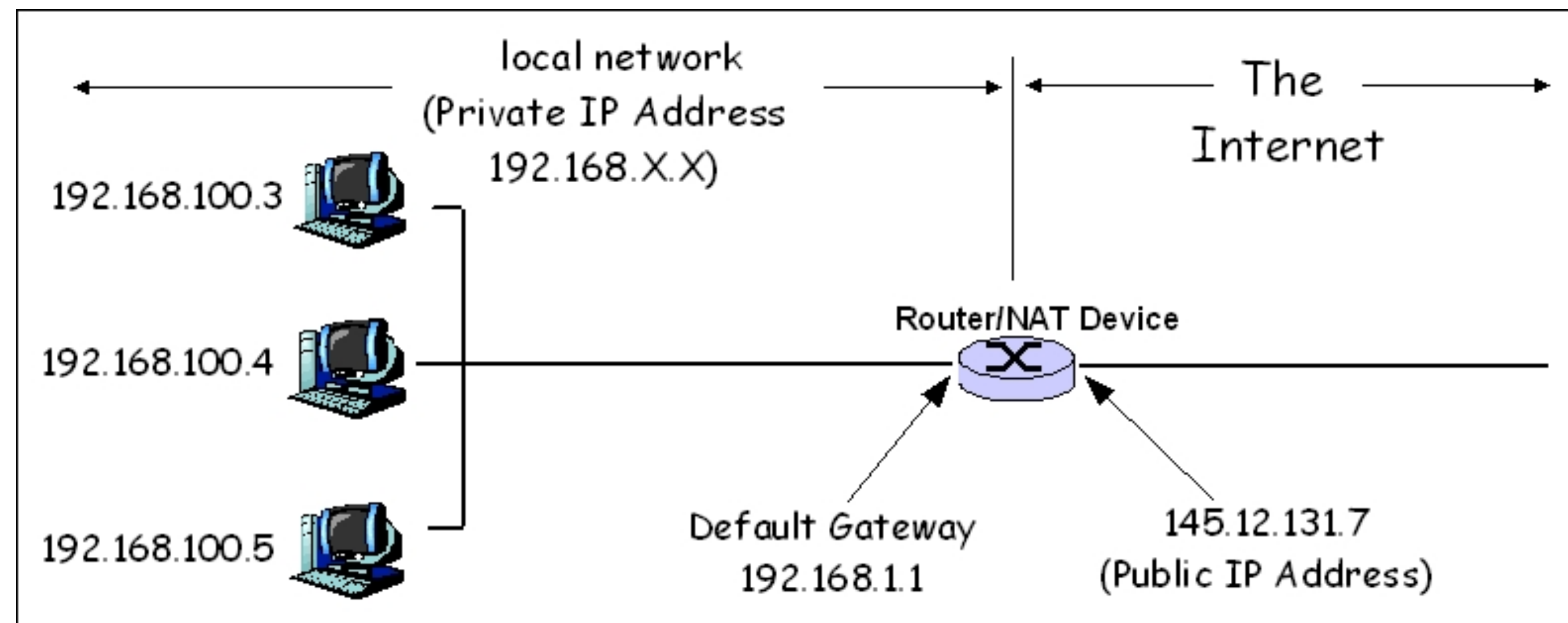
Stateful Filtering

Firewall tracks outgoing connections and allows associated inbound traffic back through



Network Address Translation (NAT)

NATs map between two different address spaces. Most home routers are NATs and firewalls.



Private Subnets

10.0.0.0 – 10.255.255.255

172.16.0.0 – 172.31.255.255

192.168.0.0 – 192.168.255.255

Local vs Network Firewall

Firewalls we've discussed so far have all been network firewalls. Most have lived at the edge of the organization.

Firewalls also run on individual hosts. Linux servers use **iptables**.

Typically have a combination of network and host firewalls

```
sudo iptables -A INPUT -m conntrack --ctstate ESTABLISHED,RELATED -j ACCEPT
```

```
sudo iptables -A INPUT -p tcp --dport 22 -m conntrack --ctstate NEW,ESTABLISHED -j ACCEPT
```

Application Layer Filtering

Enforce protocol-specific policies:

- Virus scanning for SMTP
 - Need to understand protocol, MIME encoding, ZIP files, etc
- Look for SQL injection attacks in HTTP POSTs

Outbound Too!

Organizations will often inspect outbound traffic as well

- Block access to sites with known malicious behavior
- Prevent exfiltrating data
- Block services like bit torrent

Be careful on enterprise networks! Sometimes companies will even install their own root certificates on employee workstations to monitor TLS traffic.

Intrusion Detection Systems (IDS)

Software/device to monitor network traffic for attacks or policy violations

Violations are reported to a central security information and event management (SIEM) system where analysts can later investigate

Signature Detection: maintains long list of traffic patterns (rules) associated with attacks

Anomaly Detection: attempts to learn normal behavior and report deviations

Open Source IDS

Three Major Open Source IDS (and a *tremendous* number of commercial products)

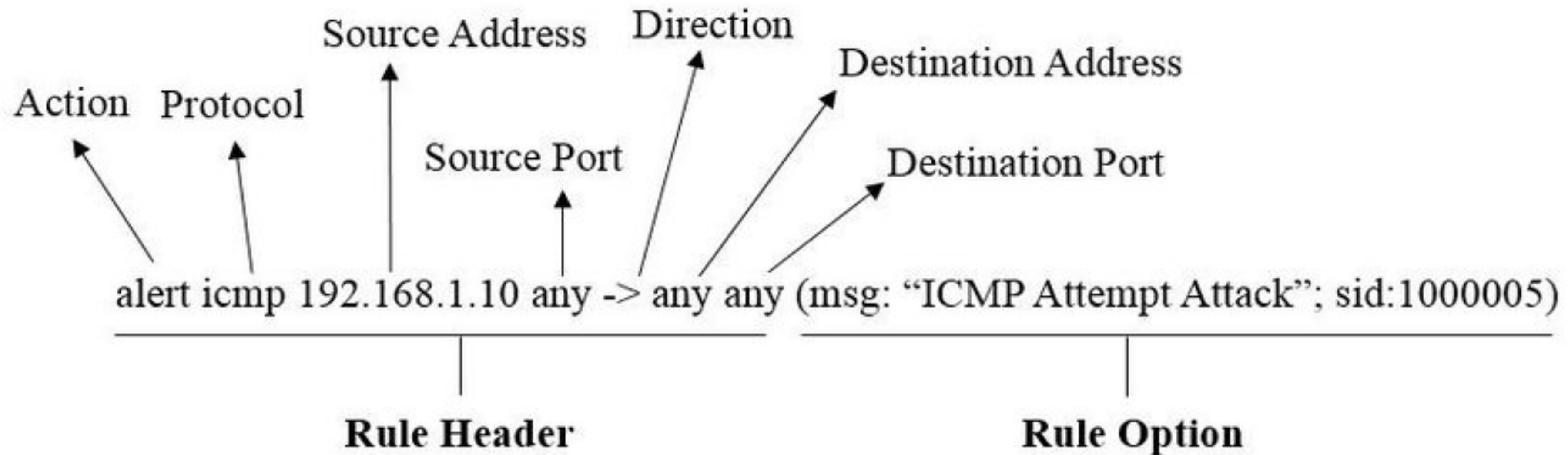
Snort

Bro Zeek

Suricata



Example Snort Rule



Remote Access

Virtual Private Networks (VPNs)

Problem: How do you provide secure communication for non-TLS protocols across the public Internet?

VPNs create a fake shared network on which traffic is encrypted

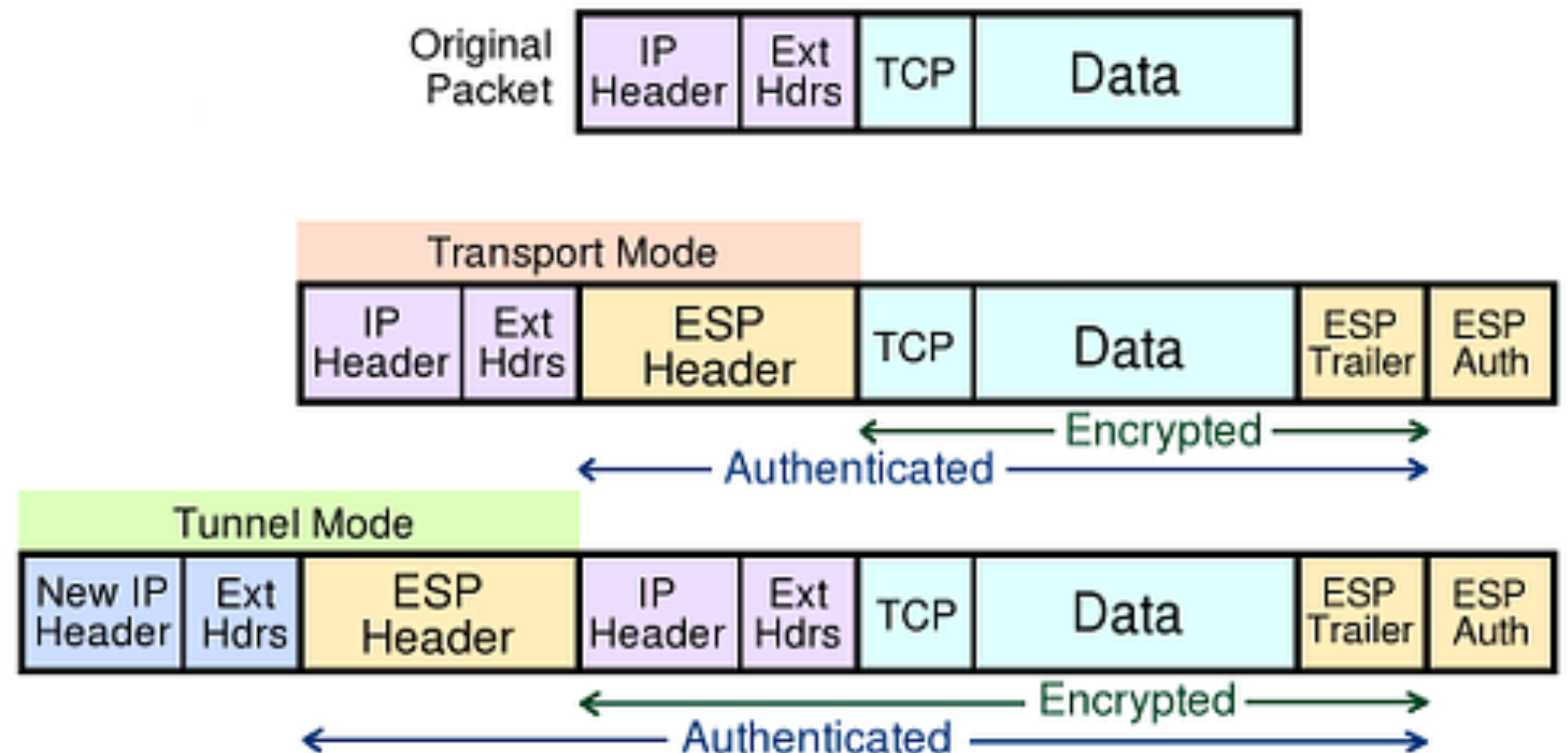
Two Broad Types:

- Remote client (e.g., traveler with laptop) to corporate network
- Connect two remote networks across Internet

IPSec

Several VPN protocols exist (PPTP, L2TP, IPsec, OpenVPN)

Most popular is IPsec. OpenVPN is open source.



Cisco AnyConnect

Stanford and many other organizations use Cisco AnyConnect

Encapsulates traffic in TLS! Initial handshake uses normal TCP-based TLS for initial handshake and then DTLS (UDP-based TLS) to transport data

BeyondCorp

VPNs support the idea of having a secure internal network and untrusted public Internet. Unfortunately, attacker has a ton of access once the network perimeter is breached.

Unfortunately, internal networks aren't *that* secure. Computers are compromised all the time and attackers have free reign.

Google: assume internal network is *also* out to get you. Remove privileged intranet and put all corporate applications on the Internet.

Access depends solely on device and user credentials, regardless of a user's network location