2021-03-02

Denial of Service Attacks

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Denial of Service

Goal: harm availability

- Strain software, hardware, or network links beyond their capacity
- Shut down a service or degrade its quality

Not always the result of an attack

- Flash crowds, "Slashdot effect"

Motives

- Protest/attention
- Financial gain/damage
- Revenge
- Blackmail
- Evasion/diversion

DoS Attack Characteristics

Attack source: single vs. many

- More than a single source: Distributed DoS (DDoS)

Overload vs. complete shutdown

- Degradation vs. completely disabling software or equipment or destroying data
- Crash, restart, bricking, data loss, website defacement, …

Consumed resource

- Network bandwidth, CPU, memory, sockets, disk storage, battery, human time, …

Amplification factor: symmetric vs. asymmetric attacks

- Broadcast addresses, large protocol responses, exponential propagation, …

Algorithmic complexity attacks

- Induce worst-case behavior by triggering corner cases when processing input

Spoofing: hide the true source(s) of the attack

Lower Layer DoS

Physical layer

- Wirecutting, equipment manipulation, physical destruction
- RF jamming, interference

Link Layer

- MAC flooding: overload switch (CAM table exhaustion) or network
- ARP poisoning: send fake ARP responses to insert erroneous MAC–IP address mappings in existing systems' caches
- DHCP starvation
- WiFi Deauthentication

Spectrum Blames Vandal ×

gothamist.com/2017/09/15/hackers_hit_spectrum_mainframe.php

gothamist

TIPS

Spectrum Blames Vandals For Internet Outages In Brooklyn, Queens

BY SCOTT HEINS IN NEWS ON SEP 15, 2017 11:11 AM

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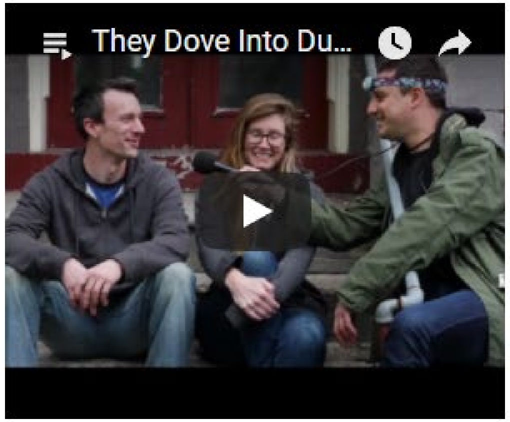
Damage to Spectrum's fiberoptic cables led to widespread internet loss throughout Queens and Brooklyn this morning. (Getty Images)

GOTHAMIST FILMS



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Dynamic Host Configuration Protocol (DHCP)

Used by hosts to request IP configuration parameters

IP address, gateway, DNS server, domain name, time server, …

UDP, no authentication: no way to validate a DHCP server's identity

DHCP exhaustion

Prevent clients from receiving IPs by consuming all available addresses in the DHCP server's pool

DHCP relies on a client's MAC address: *spoof it!* [tool: DHCPwn]

Rogue DHCP server *(may come after DHCP exhaustion)*

Provide incorrect information to clients, causing disruption

Worse: MitM attack

Defenses [example: Cisco Catalyst switches]

DHCP snooping: the switch blocks bogus DHCP offers (real server is assigned a *trusted* switch port)

Dynamic ARP Inspection (DAI): prevents ARP spoofing by validating IP-to-MAC address bindings (derived from DHCP snooping)

Deauth Attacks

Send a spoofed deauth frame to the access point with the victim's address *(no authentication!)*

- Client is disassociated from the access point
- Can also use the broadcast address to disassociate all clients at once
- *They may then connect to an "evil twin" access point…*

Deauthentication is also sometimes used as a protection mechanism

- Prevent the operation of rogue access points

Tools: `aireplay-ng` (aircrack-ng), `deauth` (metasploit)

Also possible: auth attacks

- Flood with spoofed random addresses to authenticate and associate to a target access point → exhaust AP resources

FCC Marriott to Pay $600K to R ×

www.fcc.gov/document/marriott-pay-600k-resolve-wifi-blocking-investigation

FCC Federal Communications Commission

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Take Act

Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

News Media Information 202 / 418-0500
Internet: http://www.fcc.gov

This is an unofficial announcement of Commission action. Release of the full text of a Commission order constitutes official action. See MCI v. FCC. 515 F 2d 385 (D.C. Cir. 1974).

FOR IMMEDIATE RELEASE:
October 3, 2014

NEWS MEDIA CONTACT:
Neil Grace, 202-418-0506
E-mail: Neil.Grace@fcc.gov

MARRIOTT TO PAY $600,000 TO RESOLVE WIFI-BLOCKING INVESTIGATION

Hotel Operator Admits Employees Improperly Used Wi-Fi Monitoring System to Block Mobile Hotspots; Agrees to Three-Year Compliance Plan

Washington, D.C. –Marriott International, Inc. and its subsidiary, Marriott Hotel Services, Inc., will pay $600,000 to resolve a Federal Communications Commission investigation into whether Marriott intentionally interfered with and disabled Wi-Fi networks established by consumers in the conference facilities of the Gaylord Opryland Hotel and Convention Center in Nashville, Tennessee, in violation of Section 333 of the Communications Act. The FCC Enforcement Bureau's investigation revealed that Marriott employees had used containment features of a Wi-Fi monitoring system at the Gaylord Opryland to prevent individuals from connecting to the Internet via their own personal Wi-Fi networks, while at the same time charging consumers,

Network Layer DoS

Flooding: bombard target with network packets

Saturate the available network bandwidth (aka "volumetric" attacks)

Long ICMP packets, UDP/TCP packets with garbage data, …

IP spoofing: conceal the attack source

Makes it more difficult to block the attack

Ingress and egress filtering limit its applicability, but not universally deployed

Applicable only when connection establishment is not needed: ICMP, UDP, TCP SYN, …

Broadcast Amplification

One packet generates many more packets

ICMP Smurf Attack (spoofed broadcast Echo request)

IP hijacking (covered in previous lecture)

False BGP route advertisements to attract and drop traffic or cause connectivity instability

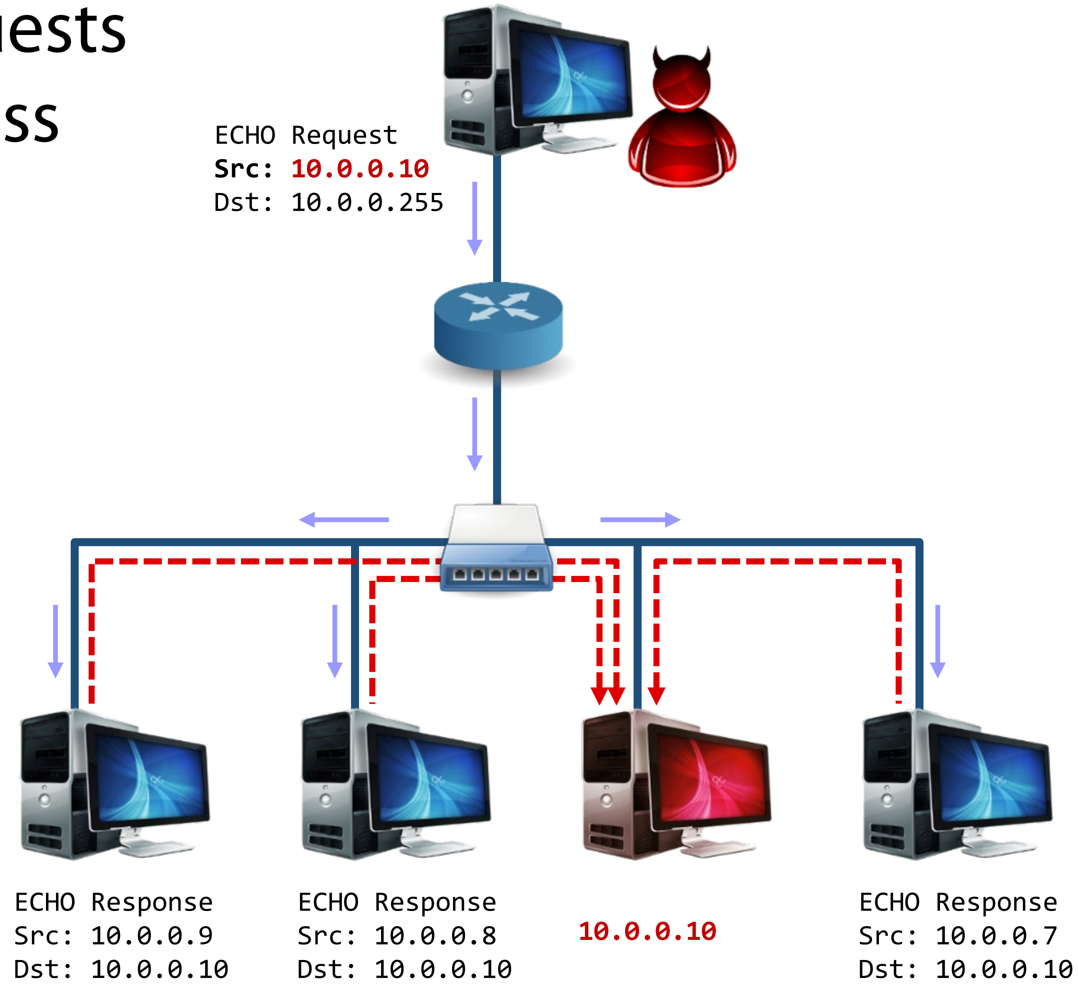
Amplification Example: Smurf Attack (90's)

Attacker sends spoofed ICMP Echo requests to the victim's network broadcast address

- Src IP == victim's IP
- Victim machine is flooded with responses from all internal hosts
- Initial form of ***amplification***

Mitigation

- Configure hosts to not respond to broadcast ICMP requests
- Configure routers to not forward packets destined to broadcast addresses



Transport Layer DoS

SYN flooding

- Server-side resource exhaustion
- Source IP address can be spoofed
- Can be combined with normal flooding to also saturate the link

Connection termination

- RST injection
- Mostly used for blocking specific unwanted traffic

SYN Flooding

Flood server with spoofed connection initiation requests (SYN packets)

- Saturate the max number of concurrent open sockets the server can sustain: no more connections can be accepted
- Each half-open connection consumes memory resources
- Server sends SYN/ACKs back, but ACKs never return…

Mitigation

- Drop old half-open connections after reaching a certain threshold (e.g., in FIFO order or randomly)
- SYN cookies: eliminate the need to store state per half-open connection

SYN Cookies

Always reply to SYN packets

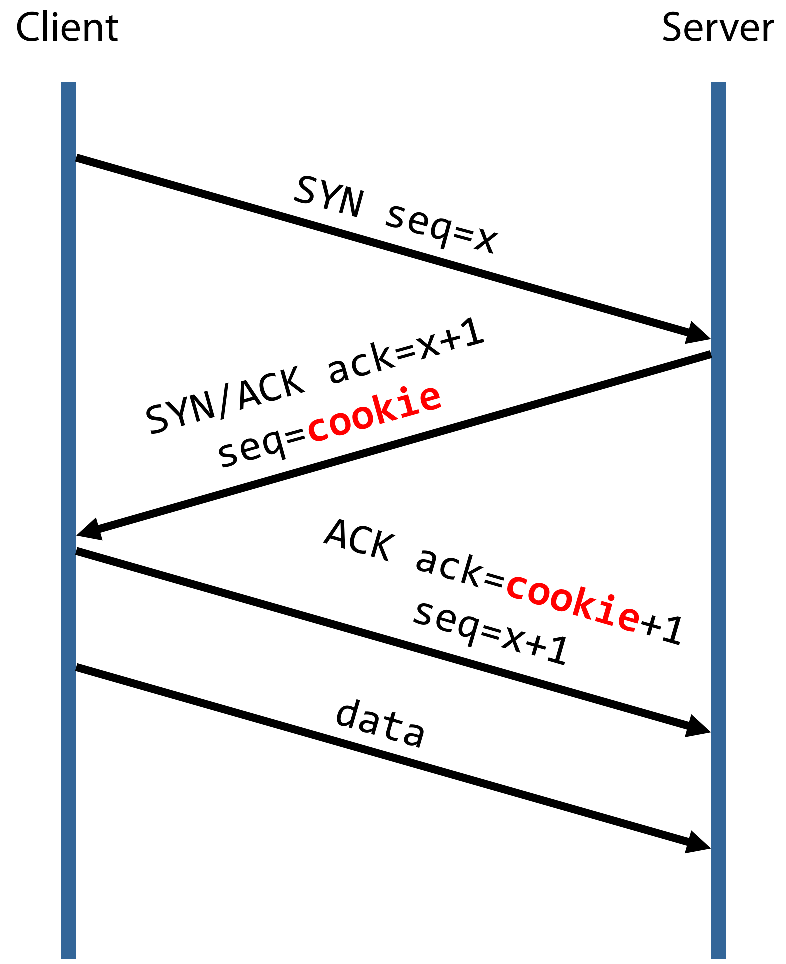
- No need to keep per-connection state
- No need for half-open connection quota

Send SYN/ACK with a special "cookie" seq

- Secret function of the src/dst IP, src/dst port, coarse timestamp
- Encodes the SYN queue entry that would otherwise need to be maintained

Stateless!

- The SYN queue entry is rebuilt based on the returned cookie value in the ACK



TCP Connection Termination

FIN: this side is done sending, but can still receive ➔ "Half-closed" state

- Should be sent by each side and acknowledged by the other

RST: this side is *done sending and receiving*

- No more data will be sent from this source on this connection
- Program closed, abort established connection, …

A MotS attacker can easily terminate connections by sending spoofed RSTs

- 5-tuple (src/dst IP/port and protocol) must match, and seq should be *in window*
- More strict stacks will only accept RSTs *in sequence* to prevent blind TCP RST injection

Legitimate and not so legitimate uses

- Censorship, blocking of non-standard port traffic (e.g., P2P protocols), termination of malicious or unwanted connections, …

Comcast settles P2P thrott ×

arstechnica.com/tech-policy/2009/12/comcast-throws-16-million-at-p2p-throttling-settlement/

LAW & DISORDER / CIVILIZATION & DISCONTENTS

Comcast settles P2P throttling class-action for $16 million

Comcast got itself in hot water when it decided to use reset packets to slow …

by Jacqui Cheng - Dec 22, 2009 4:22pm EST

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Comcast has agreed to settle a class-action lawsuit over the throttling of P2P connections that had users up in arms in late 2007 and 2008. The company still stands behind its controversial methods for "managing" network traffic, but claims that it wants to "avoid a potentially lengthy and distracting legal dispute that would serve no useful purpose."

It was more than two years ago when Comcast subscribers began finding evidence that the broadband provider was blocking packets—particularly those being sent through BitTorrent. When the complaints mounted, the Associated Press went ahead with its own investigation and came to the same conclusion: downloads through BitTorrent were either being blocked altogether or being slowed down significantly.

At that time, Comcast vehemently denied that it had anything to do with these mysterious slowdowns. This was despite the fact that numerous customers reported that their Comcast connections were sending reset packets out to the rest of the Internet—the AP discovered that nearly half of the reset packets being received by cable competitor Time Warner were coming from Comcast. Eventually, Comcast acknowledged that it had engaged in "traffic management" techniques in order to keep its network speedy, which eventually resulted in an FCC investigation and a subsequent abandoning of its P2P hatin' ways in favor of a more neutral congestion management system.

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FEATURE STORY (2 PAGES)

That Dragon, Cancer and how the digital age talks about death

The advent of high technology has changed the conversation about our mortality.

WATCH ARS VIDEO

Application Layer DoS

Connection flooding

Reflection

Software vulnerabilities

Algorithmic complexity attacks

- Trigger worst-case input processing (e.g., hashtable collisions, regular expression backtracking)

Exhaustion of server resources

- Example: fill up an FTP server's disk space with junk files

Spam can be considered as a DoS attack on our time…

- As well as server resources

Connection Flooding

Saturate the server with many established connections

- Can’t use spoofing: just use bots…

For forking servers, the whole system might freeze (process exhaustion)

Slowloris attack: slowly send a few bytes at a time to keep many concurrent connections open

- Keep the server busy with “infinite-size” HTTP requests by periodically sending more and more bogus HTTP headers
- Alternatives: read response slowly, POST data slowly, …
- Requires minimal bandwidth

Amplification/Reflection Attacks

Abuse network services that reply to certain types of requests with *much larger* responses

- Attacker sends a *small* packet with a forged source IP address
- Server sends a *large* response to the victim (forged IP address)

UDP: connectionless protocol ➔ easy to spoof

Used by many services

- NTP, DNS, SSDP, SNMP, NetBIOS, QOTD, CharGen, …

Technical Details Behind a
https://blog.cloudflare.com/technical-details-behind-a-400gbps-ntp-amplification-ddos-attack/

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Technical Details Behind a 400Gbps NTP Amplification DDoS Attack

13 Feb 2014 by Matthew Prince.

On Monday we mitigated a large DDoS that targeted one of our customers. The attack peaked just shy of 400Gbps. We've seen a handful of other attacks at this scale, but this is the largest attack we've seen that uses NTP amplification. This style of attacks has grown dramatically over the last six months and poses a significant new threat to the web.

CloudFlare blog

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Amplification Factor

Protocol	BAF all	BAF 50%	BAF 10%	PAF all	Scenario
SNMP v2	6.3	8.6	11.3	1.00	*GetBulk* request
NTP	556.9	1083.2	4670.0	10.61	Request "monlist" statistics
DNS_{NS}	54.6	76.7	98.3	2.08	ANY lookup at author. NS
DNS_{OR}	28.7	41.2	64.1	1.32	ANY lookup at open resolv.
NetBios	3.8	4.5	4.9	1.00	Name resolution
SSDP	30.8	40.4	75.9	9.92	*SEARCH* request
CharGen	358.8	n/a	n/a	1.00	Character generation request
QOTD	140.3	n/a	n/a	1.00	Quote request
BitTorrent	3.8	5.3	10.3	1.58	File search
Kad	16.3	21.5	22.7	1.00	Peer list exchange
Quake 3	63.9	74.9	82.8	1.01	Server info exchange
Steam	5.5	6.9	14.7	1.12	Server info exchange
ZAv2	36.0	36.6	41.1	1.02	Peer list and cmd exchange
Sality	37.3	37.9	38.4	1.00	URL list exchange
Gameover	45.4	45.9	46.2	5.39	Peer and proxy exchange

TABLE III: Bandwidth amplifier factors per protocols. *all* shows the average BAF of all amplifiers, 50% and 10% show the average BAF when using the worst 50% or 10% of the amplifiers, respectively.

Evil Packets

Trigger a server-side bug to crash a process/the kernel (system restart)

- Typically just a single packet/request

Ping of death (1996)

- Typical ICMP Echo request (ping) packet size: 84 bytes
- Max IPv4 packet size: 65,535 bytes
- Oversized ICMP ping packets would trigger a buffer overflow

LAND (1997)

- Spoofed TCP SYN with target IP == source IP
- TCP stack gets confused and eventually crashes

Teardrop (1997)

- Specially crafted overlapping IP fragments would trigger an IP defragmentation bug

FreeBSD Patches Kernel Pa ×

Kaspersky Lab ZAO [RU] https://threatpost.com/freebsd-patches-kernel-panic-vulnerability/116001/

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Welcome > Blog Home > Vulnerabilities > FreeBSD Patches Kernel Panic Vulnerability

by Michael Mimoso Follow @mike_mimoso

January 25, 2016 , 12:13 pm

FreeBSD has patched a denial-of-service vulnerability affecting versions configured to support SCTP and IPv6, the default configurations on later version of the open source OS.

Researchers at Positive Technologies in the U.K. said versions 9.3, 10.1 and 10.2 are affected and can be exploited by a specially crafted ICMPv6 packet, which will cause a kernel panic; kernel panics are the UNIX equivalent of a Windows Blue Screen of Death.

An advisory from FreeBSD says kernels compiled without support for SCTP or IPv6 are not

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January 14, 2016 , 11:15 am

Time Warner Cable Urges 320,000 Customers to Change Passwords
January 7, 2016 , 1:54 pm

Denial-of-Service Flaw Patched in DHCP
January 13, 2016 , 10:00 am

Inexpensive Webcam Turned into Backdoor

Evil Packets/Requests/Inputs

WinNuke (1997)

String of out-of-band data to NetBIOS service (port 139) → Blue screen on Windows NT/95

Internet worms (future lecture) would often crash infected hosts

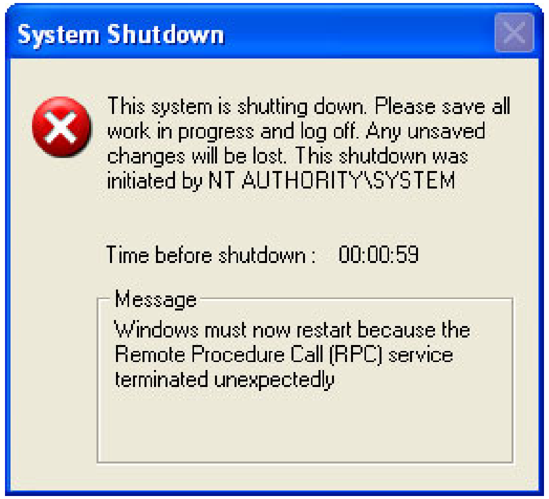
Besides the network flooding due to their rapid propagation and occasional DDoS activity

Morris worm (1988): internet was partitioned for several days…

CodeRed (2001): DoS against `www.whitehouse.gov`

Blaster (2003): DoS against `windowsupdate.com`, system instability causing endless reboots

Witty (2004): Single UDP packet, slow disk corruption leading to crash



Malware can even brick the system

Erroneous firmware update, BIOS flashing, driver malfunction, data corruption, …

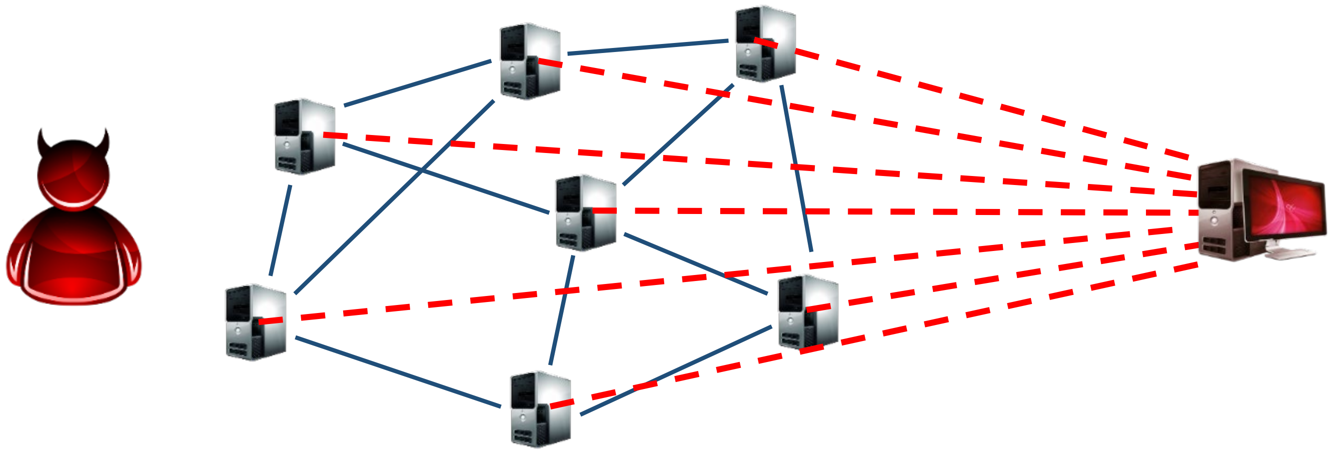
Distributed Denial of Service (DDoS)

Any DoS attack that originates from multiple sources

- Early internet worms were the first instances of DDoS

These days usually launched by botnets

- Networks of compromised systems ("bots") controlled by an attacker ("botmaster")
- Not only PCs/servers: mobile and IoT devices equally useful (e.g., Mirai IoT botnet)
- Can be rented through online marketplaces ("booter" or "stresser" services)



DDoS attack on Dyn cam

https://www.computerworld.com/article/3135434/security/ddos-attack-on-dyn-came-from-100000-infected-devices.html

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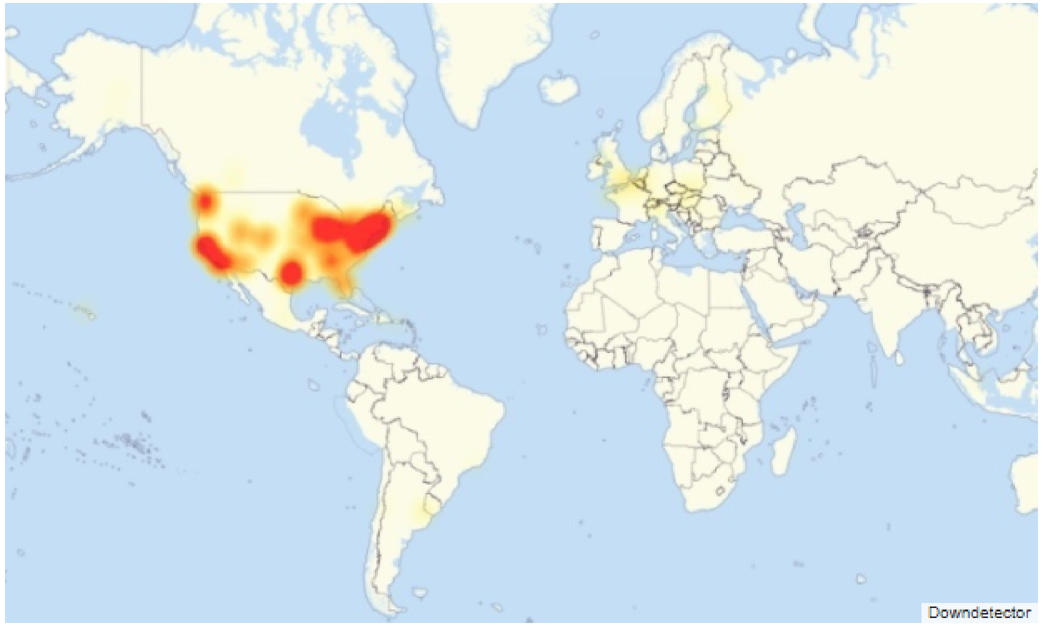
NEWS

DDoS attack on Dyn came from 100,000 infected devices

DNS service provider Dyn says Mirai-powered botnets were the primary source for Friday's disruption

By Michael Kan

U.S. Correspondent, IDG News Service | OCT 26, 2016 2:21 PM PT



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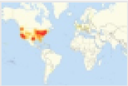
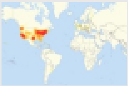
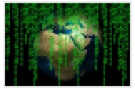


Chinese firm admits its hacked products were behind Friday's DDOS attack



An IoT botnet was partly behind Friday's massive DDOS attack



DDoS attack with Mirai malware 'killing business' in Liberia

VIDEO

Tech Talk: Pricey iPhones, intent-based networks, GPS spoofing and smartwatches

Puppetnets: Browser-based Bots

Browsers can be indirectly misused to attack others

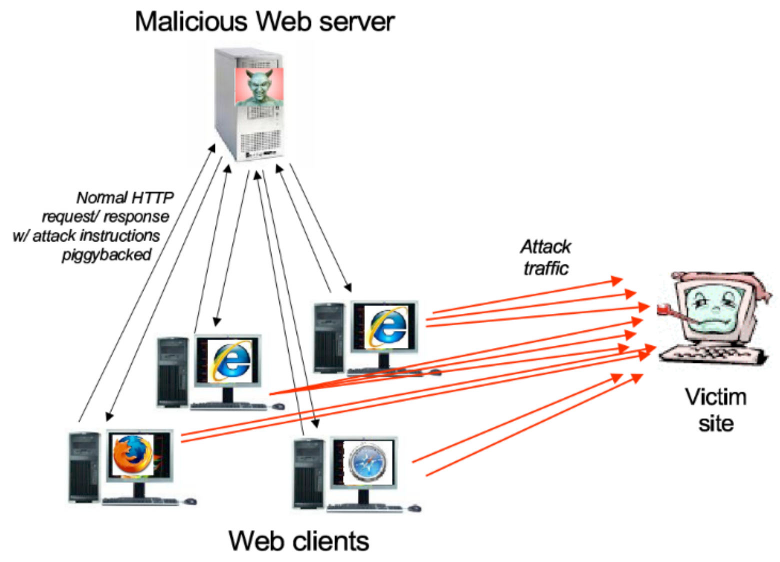
- JS code running in the browsers of unsuspecting visitors

Continuously fetch images or other large files from the victim's server

- Can masquerade as "good" bots (e.g., Googlebot, Baiduspider, other legitimate spiders) using a spoofed User-Agent

Many injection ways

- Compromised websites
- Ad networks
- MitM/MotS attacks



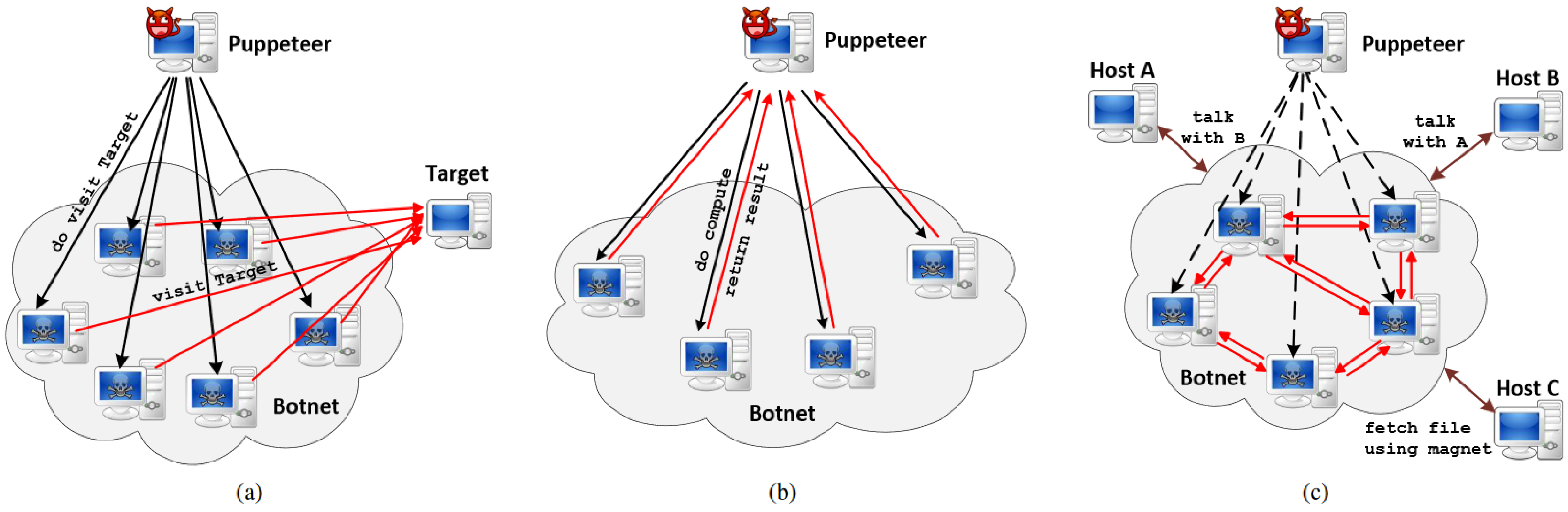
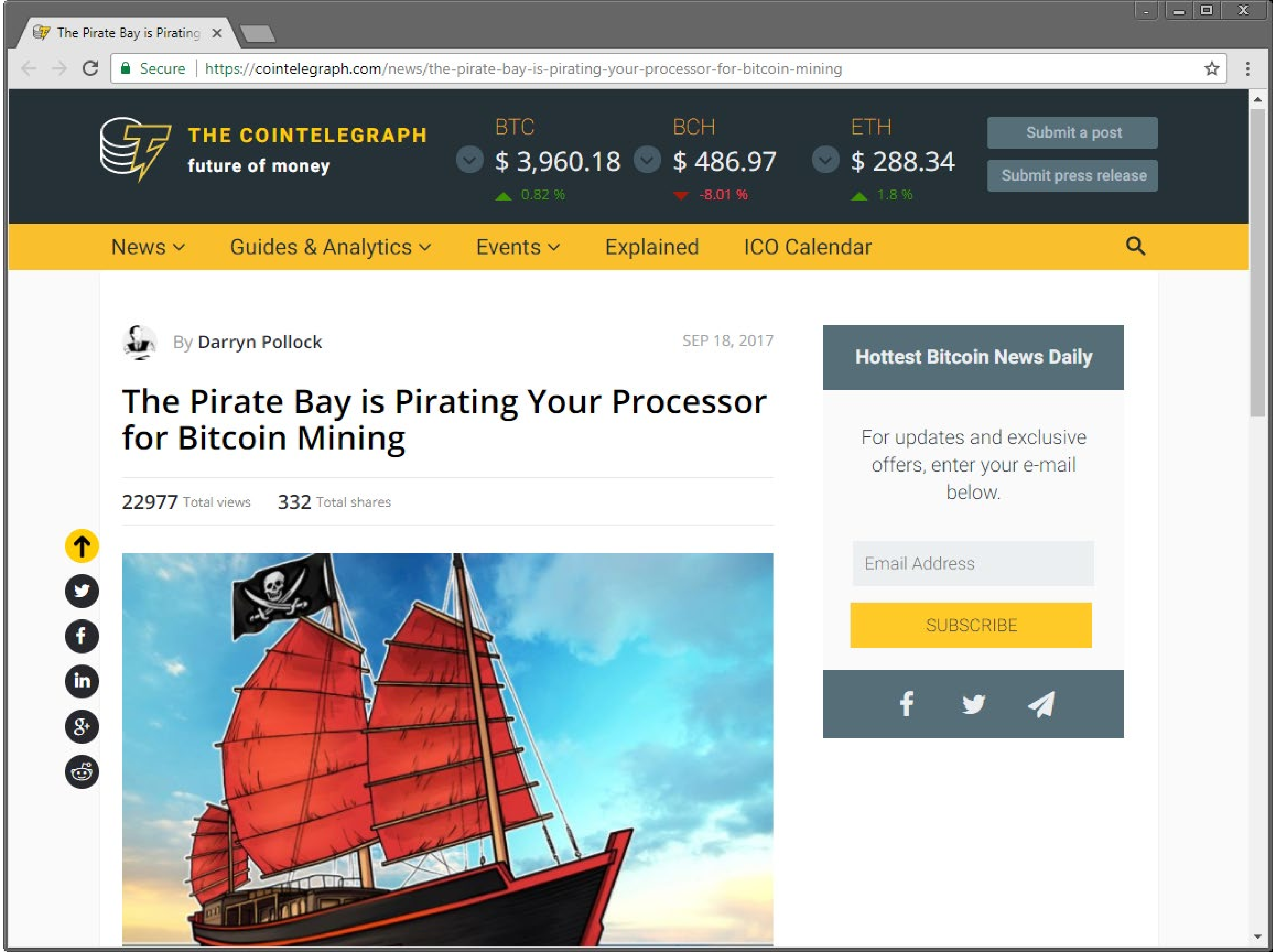


Fig. 2: Different use cases of MarioNet. After victims get compromised, the attacker can instrument them to perform (a) visits to a selected server or URL, for DDoS attack or fake ad-impressions, (b) requested computations, such as cryptocurrency mining or password cracking, and (c) illegal services, such as illicit file hosting or hidden/anonymized communications.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Github Attack Perpetrated

https://threatpost.com/github-attack-perpetrated-by-chinas-great-cannon-traffic-injection-tool/1121

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Welcome > Blog Home > Government > Github Attack Perpetrated by China's Great Cannon Traffic Injection Tool

by Brian Donohue Follow @TheBrianDonohue April 10, 2015 , 1:06 pm

Chinese attackers used the Great Firewall's offensive sister-system, named the Great Cannon, to launch a recent series of distributed denial of service attacks targeting the anti-censorship site, GreatFire.org, and the code repository, Github, which was hosting content from the former.

The first set of DDoS attacks hit GreatFire.org on March 16. On March 26, Github

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Critical Yahoo Mail Flaw Patched, $10K Bounty Paid
January 19, 2016 , 10:02 am

BlackEnergy APT Group Spreading Malware via Tainted Word Docs
January 28, 2016 , 7:00 am

Curious Tale of a Microsoft Silverlight Zero Day
January 13, 2016 , 9:01 am

Oracle to Kill Java Browser Plugin
January 28, 2016 , 12:43 pm

Apple's 'Targeted' Gatekeeper Bypass Patch Leaves OS X Users Exposed
January 15, 2016 , 8:00 am

Data Theft Hole Identified in LG G3 Smartphones

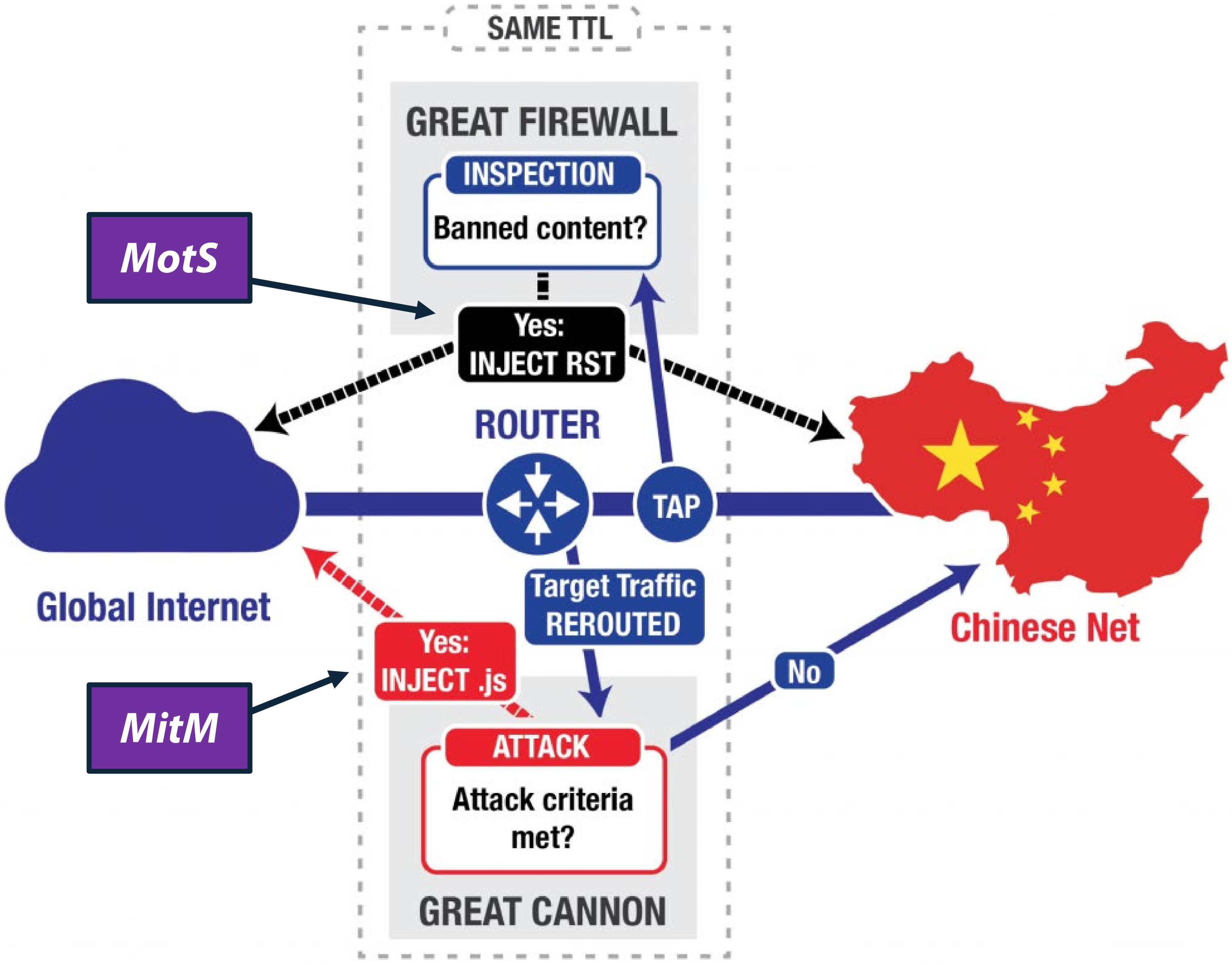
March 16 and 26, 2015

DoS targets:

`GreatFire.org`

Two related GitHub pages (anti-censorship project)

DoS attack script injected into 1.75% of the requests to Baidu's analytics/ad scripts (probabilistic injection)



China's Great Cannon - https://citizenlab.org/2015/04/chinas-great-cannon/

Energy DoS

Strain the power source of mobile, IoT, sensor devices

Battery exhaustion

- Consume battery by performing power-hungry operations in the background
- Computation, radio activity, …

Denial of sleep

- Specific to energy-constrained embedded systems that wake up periodically for data transmission or other operations
- An attack can force radios to remain constantly active
- Can reduce battery life by orders of magnitude

DoS Defenses

No absolute solution

- Asymmetry: little effort for the attacker, big impact for the victim
- Any public service can be abused by the public
- Prank phone calls, road blockades, …

General strategies

- Filter out bad packets
- Improve processing of incoming data
- Hunt down and shut down attacking hosts
- Increase hardware and network capacity and redundancy

DoS Defenses

Ingress/egress filtering

Ensure that incoming/outgoing packets actually come from the networks they claim to originate from ➔ drop spoofed packets

Content delivery networks (CDNs) and replication

Distribute load across many servers

Client challenges: present a CAPTCHA whenever the system is under stress

Other (mostly academic) approaches

IP Traceback: each router "marks" the forwarded packets with its own IP address to facilitate determining the actual origin of packets

Pushback filtering: iteratively block attacking network segments by notifying upstream routers

Overlay-based systems: proactive defense based on secure overlay tunneling, hash-based routing, and filtering

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