CSE331 Computer Security Fundamentals

10/31/2017 **Firewalls and Gateways**

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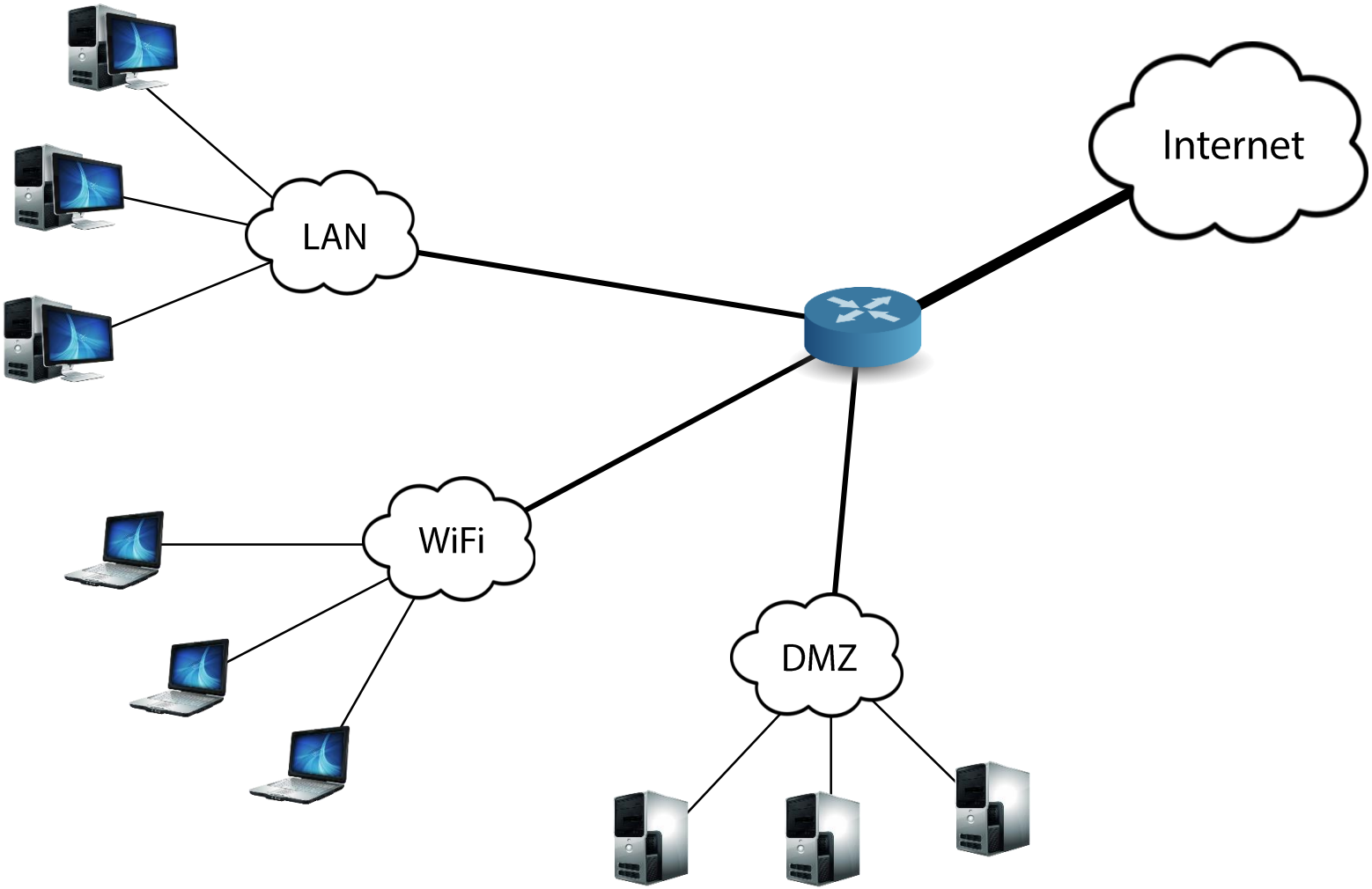
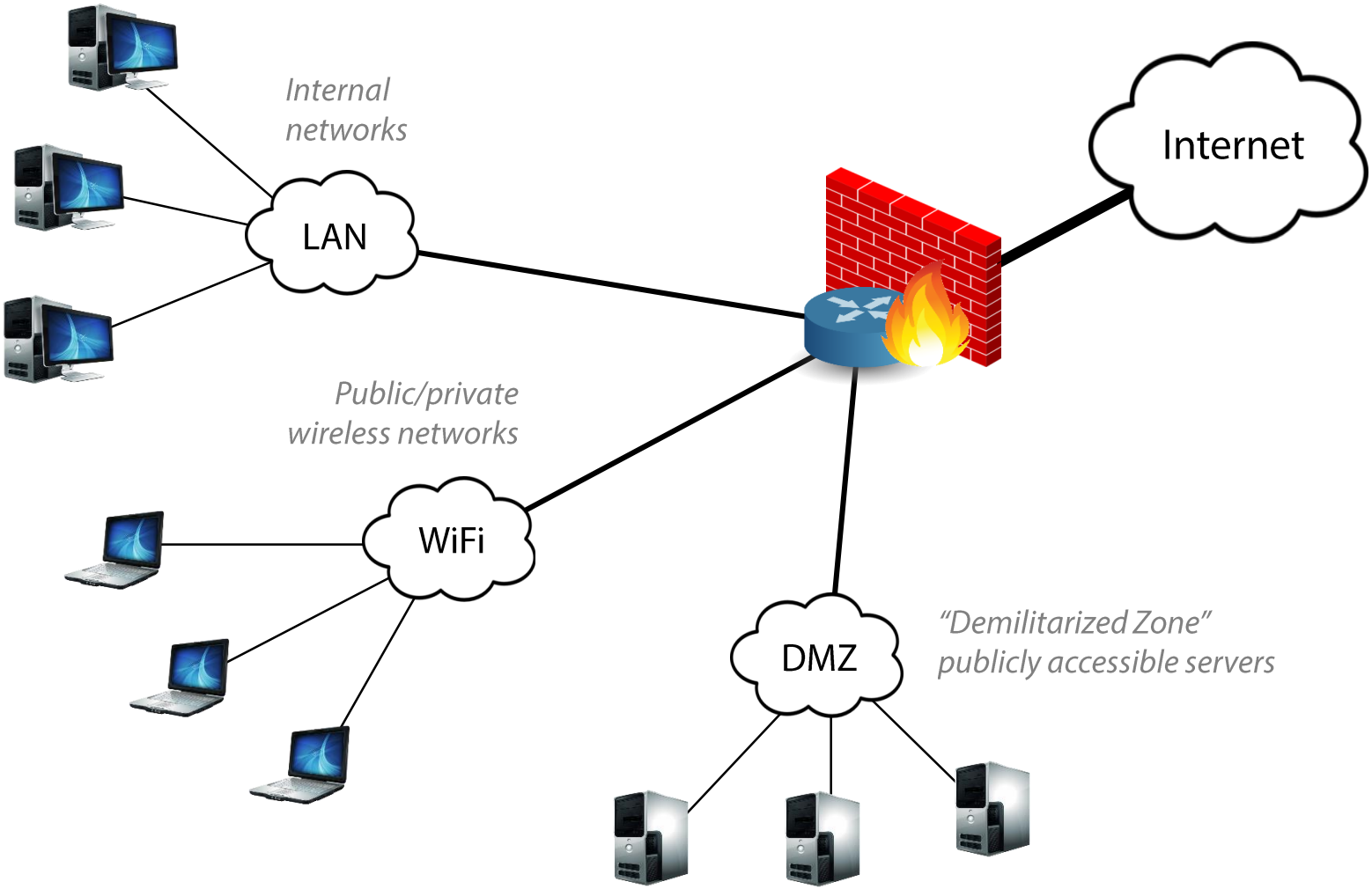
Stony Brook University

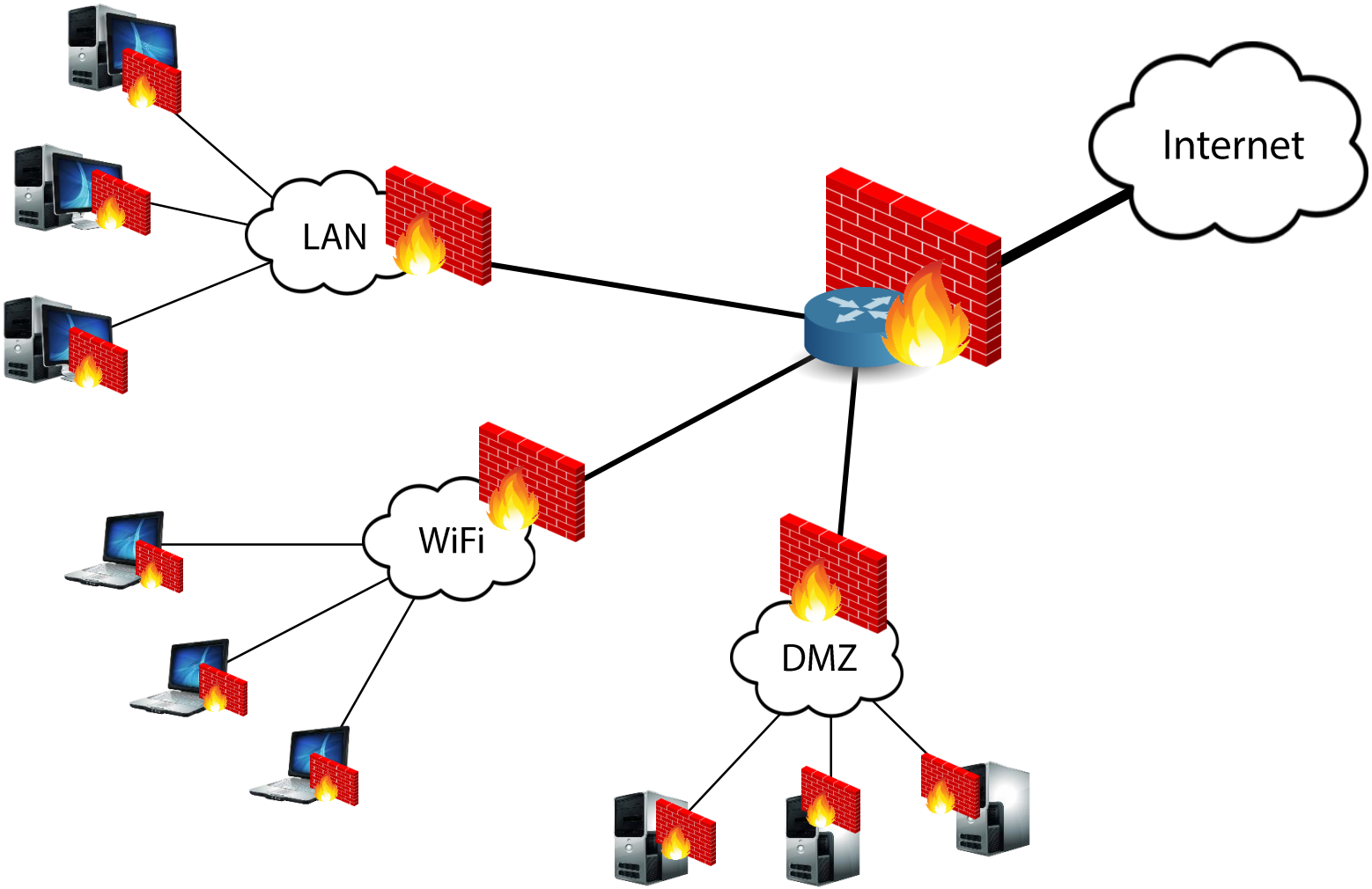
Typical Network Topology



Firewalls: separate local networks from the Internet



Firewalls: Reality



Firewalls

Filter traffic according to a predefined *policy*

- Mostly statically defined, but dynamic updates are possible (e.g., to block an ongoing DoS attack)

Barrier between administrative domains

- Internal networks vs. the outside world
- Mission-specific subnets/VLANs (publicly accessible servers, machine clusters, user groups, printers, VoIP, …)
- Less trusted segments (guest WiFi network, contractors, …)

Main strategies

- Default-deny: drop everything unless explicitly allowed
- Default-allow: block specific protocols/hosts/ports/…

Firewalls: why are they needed?

Hosts may run vulnerable services: prevent outside attackers from accessing them

- Limit the "attack surface" ➔ expose less services

Internal hosts may get compromised: damage control

- Prevent propagation, outgoing attacks, exfiltration, …

No reason to reveal the structure of private networks: hinder network reconnaissance

- Block port scanning, service fingerprinting, …

Network intelligence: log interesting events

- Troubleshooting, monitoring/tuning, auditing, forensics, …

Simply block unwanted traffic: **policy enforcement**

- Noise, backscatter, spoofed packets, DoS attacks, brute-force password guessing, Bittorrent, Facebook, …

A Theory of Firewalls (Bellovin)

Three properties must hold for a firewall to be effective

The firewall should be placed at a topological chokepoint

- Not always true in modern enterprises: links to suppliers/contractors, cellular connectivity, VPN/proxy software, …

"Inside" nodes share the same security policy

- Do they? BYOD, IoT, …

"Inside" nodes are trusted, "outside" hosts are untrusted

- BYOD: an already infected device may appear inside the network
- Internal hosts can be infected due to client-side attacks (e.g., drive-by download attacks, malware, phishing, …)
- Insider threats, disgruntled employees, …

Stateless Filtering

Decide by considering each packet in isolation

- Rules mostly based on network and transport layer fields
- Simple implementation: no need to keep state

Limitations

- Dynamically negotiated/non-standard port numbers (FTP, SIP, BitTorrent, …)
- Connectionless protocols (e.g., UDP): cannot distinguish between queries and replies
- IP fragmentation: port numbers are present only in 1st fragment
- Rule sets can get complex and hard to understand

Still useful for simple scenarios

- Ingress/egress filtering, strict configurations, …

Stateless Firewalls and TCP

Common configuration: block incoming but allow outgoing connections

- Incoming (externally initiated) connections should be blocked
- Incoming packets of established connections should be allowed

Can be achieved without keeping state

- Block incoming SYN-only packets
- Allow incoming packets with the ACK bit set

Not an ideal solution

- Cannot distinguish between unsolicited and legitimate ACK packets

Stateful Filtering

Firewall keeps per-connection state

- Track TCP three-way handshake, UDP query/responses, …
- Decisions are made by considering each packet in the context of the connection/session it belongs to

Most common firewall type

More flexible policies

- Internally vs. externally initiated connections/sessions

Still cannot handle dynamically negotiated port numbers and higher-level protocol semantics

- Missing application-level context

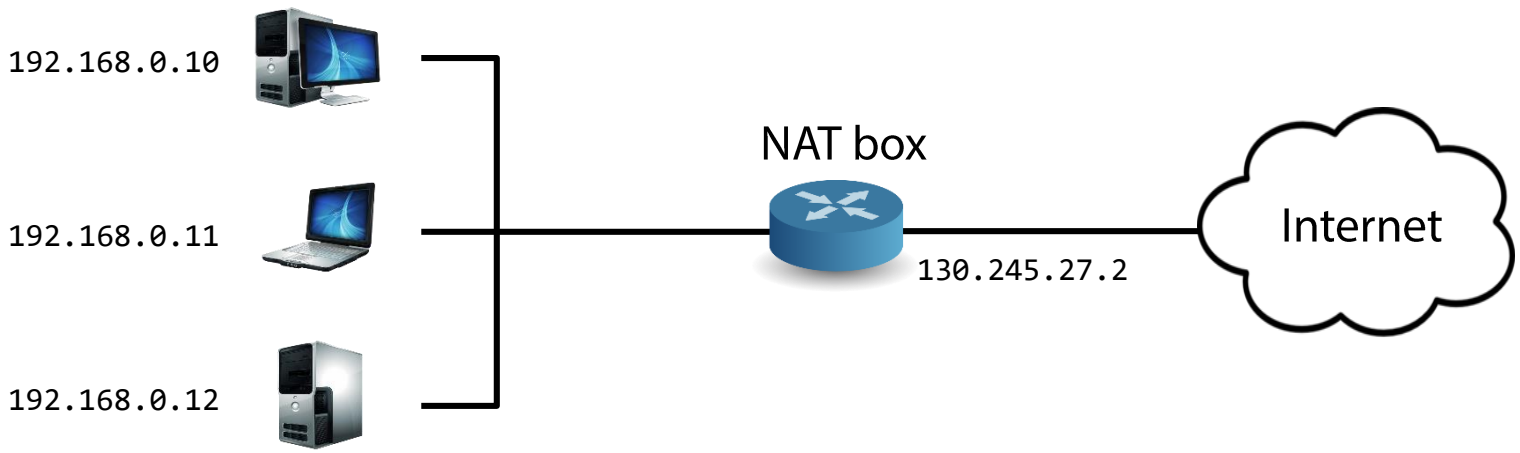
Network Address Translation

Share a public IP address with many internal hosts

- In general: remap an IP address space into another
- Global shortage of IPv4 addresses
- Widely used (home networks, wireless networks, …)

Rewrite packet address and port information

- Keep per-connection state



NAT vs. Stateful Firewall

Similar functionality and state

NAT **modifies** packets: performs address/port translation

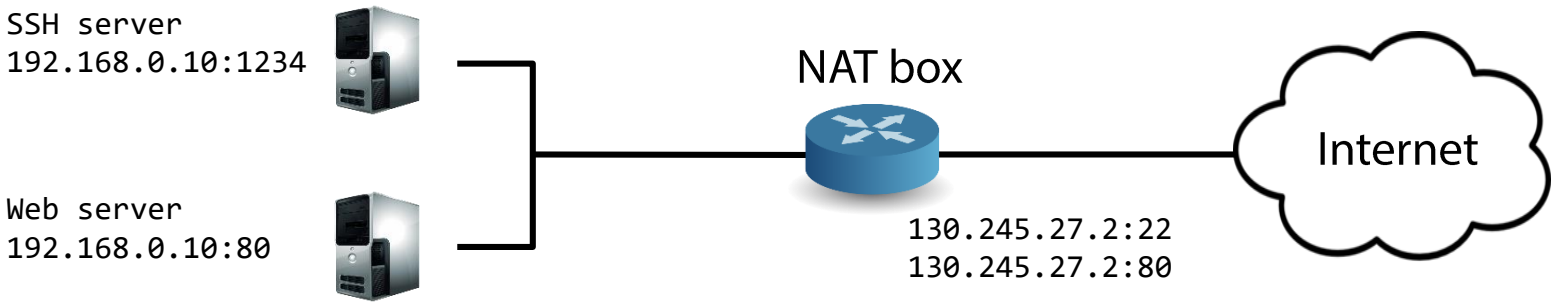
Are NATs firewalls?

Not in the strict sense, as they do not fully track the TCP 3-way handshake or any other higher-layer state

But they *do* provide some protection: allow only outgoing connections

Internal hosts can become accessible through *port forwarding*

Explicitly map a local IP:port to a public IP:port



UPnP

Universal Plug and Play

Widely supported protocol by home routers to enable device discovery and NAT traversal

- “Please allow external hosts to reach me on port 12345”
- Skype, Bittorrent, games, …

No authentication!

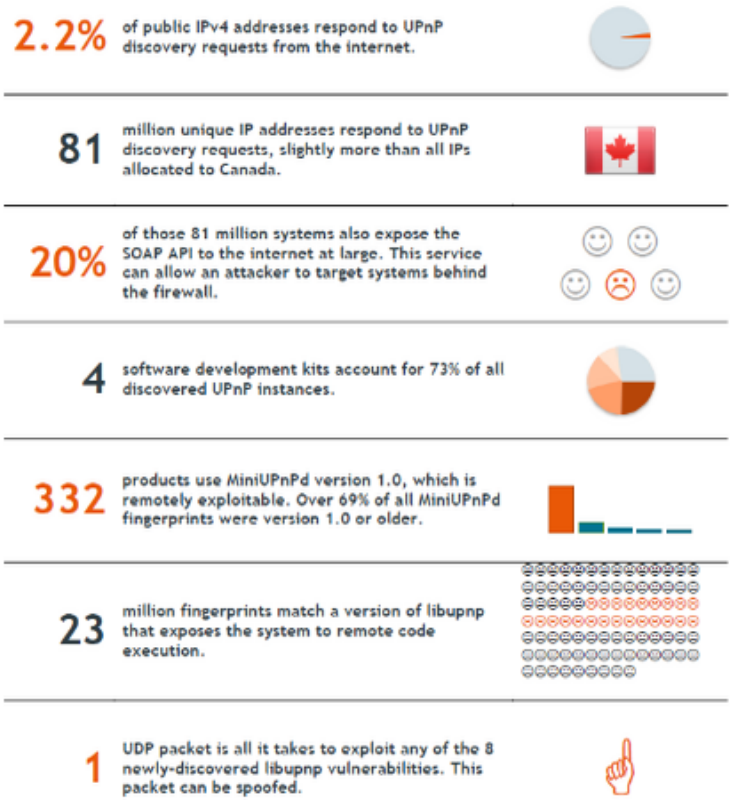
- Malware can easily punch holes
- Worse: Flash, XSS, …
- Even worse: external requests (!)

Information Security

Security Flaws in Universal Plug and Play: Unplug, Don't Play

Posted by HD Moore in Information Security on Jan 29, 2013 4:05:19 AM

This morning we released a whitepaper entitled Security Flaws in Universal Plug and Play. This paper is the result of a research project spanning the second half of 2012 that measured the global exposure of UPnP-enabled network devices. The results were shocking to the say the least. Over 80 million unique IPs were identified that responded to UPnP discovery requests from the internet. Somewhere between 40 and 50 million IPs are vulnerable to at least one of three attacks outlined in this paper. The two most commonly used UPnP software libraries both contained remotely exploitable vulnerabilities. In the case of the Portable UPnP SDK, over 23 million IPs are vulnerable to remote code execution through a single UDP packet. All told, we were able to identify over 6,900 product versions that were vulnerable through UPnP. This list encompasses over 1,500 vendors and only took into account devices that



Generic Port Forwarding

Bypass firewall policies!

Example: connect from a private network to a host that is blocked by a local firewall

Remote host: `nc -l -p 12345 -c 'nc blocked.com 80'`

Local host: `wget remote.edu:12345`

Or using SSH local port forwarding

```
ssh -L 12345:blocked.com:80 remote.edu
```

Also the other way around: remote port forwarding

Example: allow public access to a server running in a private network

```
ssh -R 8080:localhost:80 remote.edu
```

Proxies

Intermediate "stepping stones"

- Operate at the application layer
- Act as both a client and a server

Application-level filtering

- Example: HTTP-level filtering (domains, URLs, ads, …)

Many non-security/policy uses as well

- HTTP content caching (one of the first uses of web proxies)
- Reverse proxies (in front of application servers): quickly serve the same dynamically-generated content
- Transcoding

Explicit vs. transparent proxies

- The former require application configuration

SOCKS Proxies

Also known as circuit-level gateways

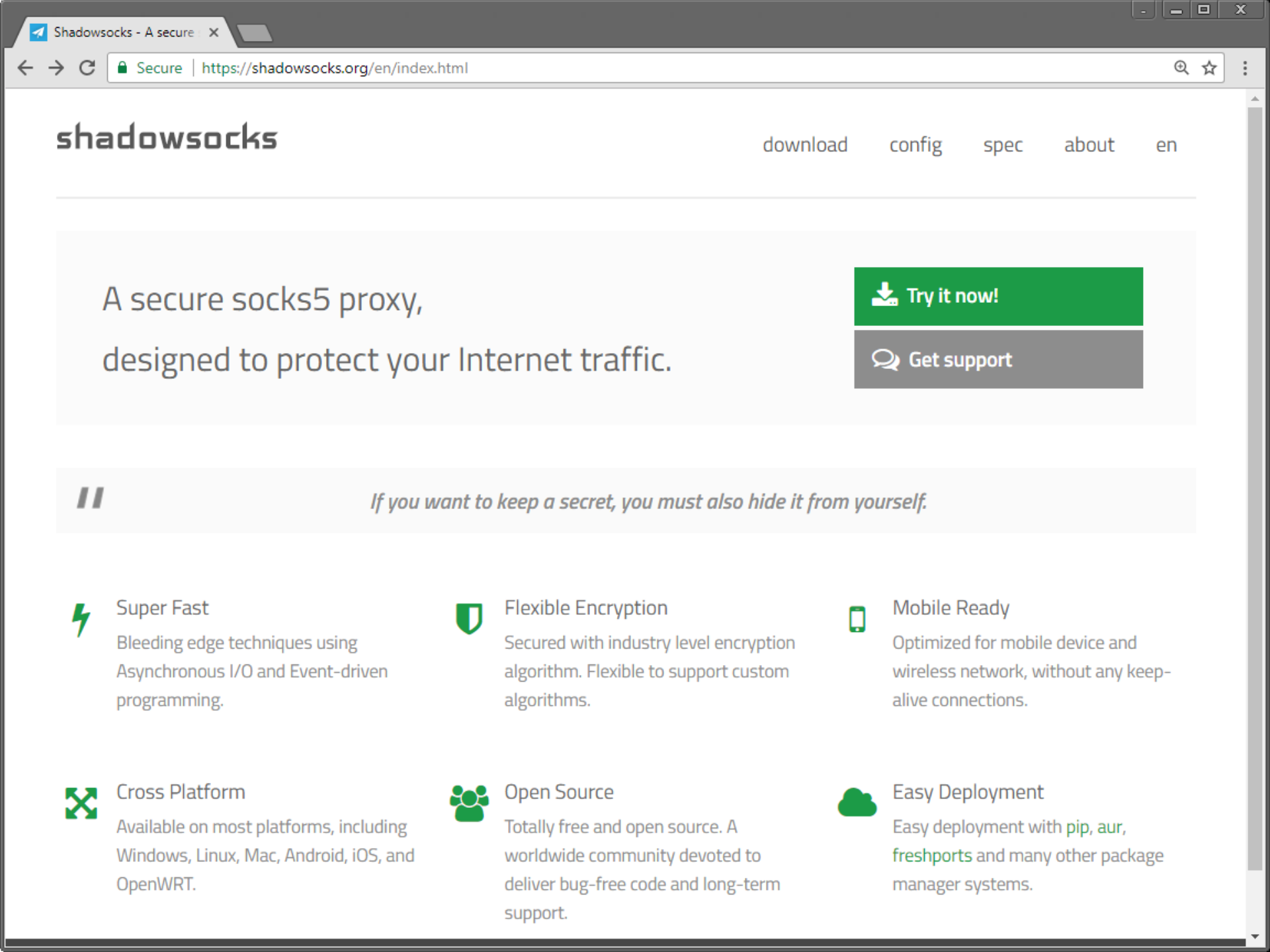
Socket Secure (SOCKS): protocol for generic forwarding of packets through a proxy

Supported by many applications and protocols

HTTP, FTP, SMTP, POP3, NNTP, …

Example: dynamic application-level port forwarding

```
ssh –D 12345 sshserver.com
chrome --proxy-server='socks://localhost:12345'
```


Shadowsocks - A secure
Secure
https://shadowsocks.org/en/index.html
shadowsocks
download
config
spec
about
en
A secure socks5 proxy,
designed to protect your Internet traffic.
Try it now!
Get support
If you want to keep a secret, you must also hide it from yourself.
Super Fast
Bleeding edge techniques using Asynchronous I/O and Event-driven programming.
Flexible Encryption
Secured with industry level encryption algorithm. Flexible to support custom algorithms.
Mobile Ready
Optimized for mobile device and wireless network, without any keep-alive connections.
Cross Platform
Available on most platforms, including Windows, Linux, Mac, Android, iOS, and OpenWRT.
Open Source
Totally free and open source. A worldwide community devoted to deliver bug-free code and long-term support.
Easy Deployment
Easy deployment with pip, aur, freshports and many other package manager systems.

Application-level "Firewalls"

Similar to proxies, but less generic

- Application-specific filtering
- Often built into applications

Example: SMTP

- Spam filtering, phishing detection, attachment scanning, …

Begin to overlap with more generic *intrusion detection systems* (future lecture)

Recent buzzword: web application firewalls (WAF)

- Server-side HTTP filtering for common attack patterns (XSS, SQL injection, …)
- A specific instance of application-level filtering/scanning

Host-based Firewalls

Firewalls running on end hosts

- Windows firewall
- IPtables

"Personal" firewalls: apply common-sense policies (deny incoming, allow outgoing)

- Particularly important for home users, laptops, etc.

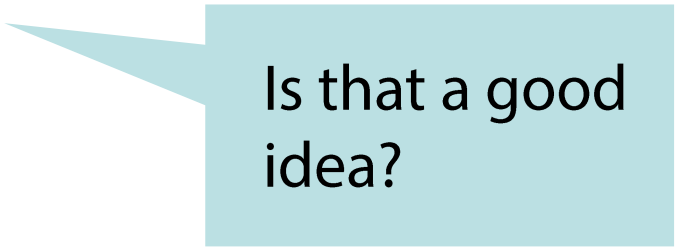
On-by-default client firewall deployment contributed significantly in ending the era of internet worms

Simple IPtables Example

```
# flush all chains
iptables -F
iptables –X

# defaults for predefined chains
iptables -P INPUT DROP
iptables -P OUTPUT DROP
iptables -P FORWARD DROP

# allow anything on localhost interface
iptables -A INPUT -i lo -j ACCEPT
iptables -A OUTPUT -o lo -j ACCEPT

# allow all traffic from specific subnets
iptables -A INPUT -s 128.59.0.0/255.255.0.0 -j ACCEPT
iptables -A INPUT -s 160.39.0.0/255.255.0.0 -j ACCEPT
```

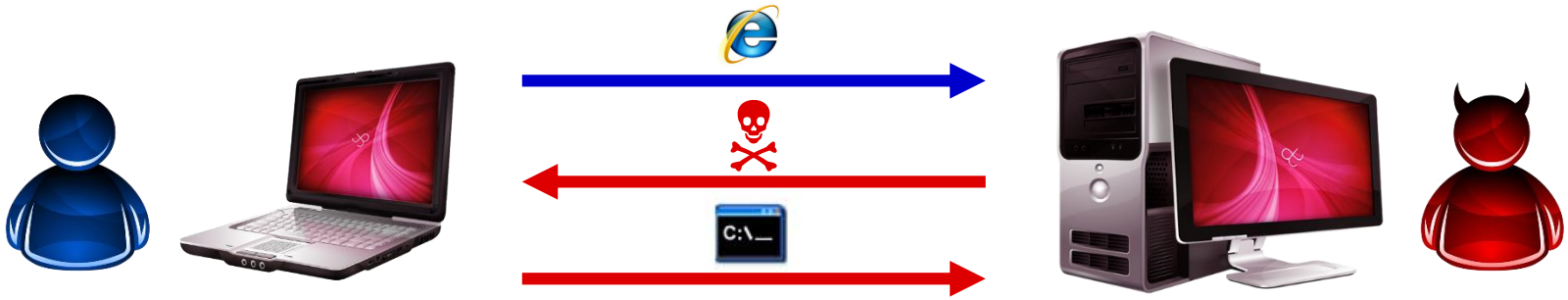
Simple IPtables Example

```
# allow all inbound traffic for specific services
iptables -A INPUT -p tcp -m tcp --syn --dport 22 -j ACCEPT
iptables -A INPUT -p tcp -m tcp --syn --dport 80 -j ACCEPT

# allow inbound established and related outside communication
iptables -A INPUT -m conntrack --ctstate ESTABLISHED,RELATED -j
ACCEPT

# allow ICMP
iptables -A INPUT -p icmp -j ACCEPT

# allow all outgoing traffic
iptables -A OUTPUT -j ACCEPT
```



Before Host-based Firewalls:

After Host-based Firewalls:



Per-process Firewall

Most "personal" firewalls still allow all outgoing traffic by default

- Severe usability problems otherwise

Do all programs really need to communicate with the outside world?

- What about auto-update functionality?

Deny by default and whiltelist only what is needed

- No easy solution for this in most OSes – need to rely on hacks or third party solutions

Virtual Private Networks

Users may not always be behind the firewall, but still need full access to an internal network

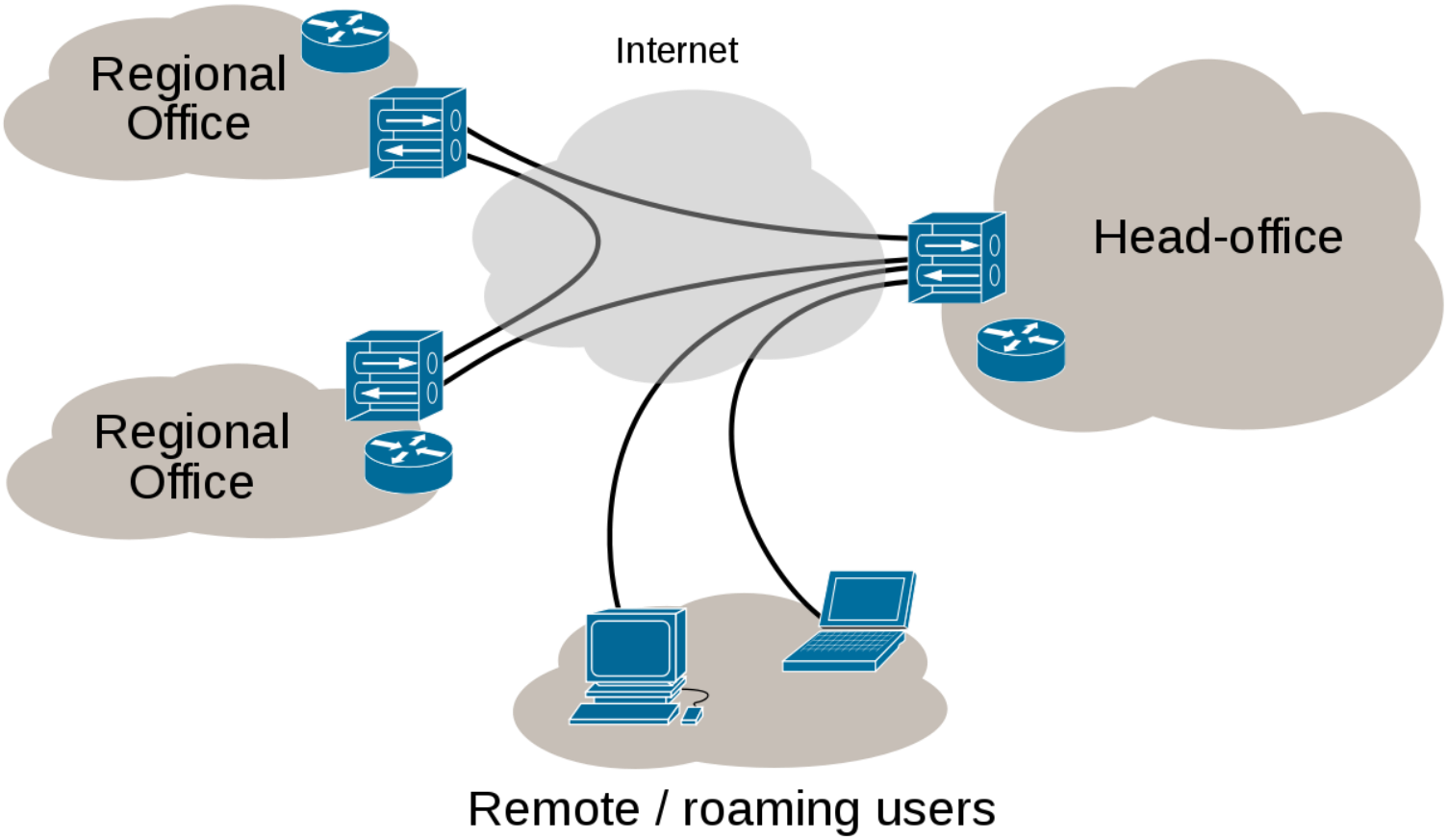
- Offices at different locations, employees on the move, remote access to home "cloud," …

VPNs bridge private networks across a public (untrusted) network

- Virtual point-to-point secure connections (encryption)
- Create a *trusted* shared network among them

Remote host/network virtually becomes part of the local network

VPN Examples



VPN Implementations

Tunneling/encapsulation: packets of one network protocol are transferred as data over another protocol

Three major families in wide use today:

PPTP: L2, commonly used in Windows

- *Broken*

IPsec: L3, widely supported

- Authenticate and encrypt IP packets of a communication session
- Completely transparent to applications
- Tunnel is handled directly by the TCP/IP stack

SSL: Application layer – OpenVPN

- User-space implementation, multiplatform
- Typically requires installation of a software client

Algo VPN

chat on gitter | Follow @AlgoVPN | build passing

Algo VPN is a set of Ansible scripts that simplify the setup of a personal IPSEC VPN. It uses the most secure defaults available, works with common cloud providers, and does not require client software on most devices. See our release announcement for more information.

Features

- Supports only IKEv2 with strong crypto: AES-GCM, SHA2, and P-256
- Generates Apple profiles to auto-configure iOS and macOS devices
- Includes a helper script to add and remove users
- Blocks ads with a local DNS resolver (optional)
- Sets up limited SSH users for tunneling traffic (optional)
- Based on current versions of Ubuntu and strongSwan
- Installs to DigitalOcean, Amazon EC2, Microsoft Azure, Goog

Trivially easy to set up a personal IPsec VPN in the cloud!
No excuse for not using a VPN when you are in a public WiFi!

Anti-features

- Does not support legacy cipher suites or protocols like L2TP, IKEv1, or RSA
- Does not install Tor, OpenVPN, or other risky servers
- Does not depend on the security of TLS
- Does not require client software on most platforms
- Does not claim to provide anonymity or censorship avoidance
- Does not claim to protect you from the FSB, MSS, DGSE, or FSM

“Secure Gateways”

Nowadays most of the discussed technologies are consolidated into a single box

- Routing, Firewall, NAT, VPN, Proxy, …

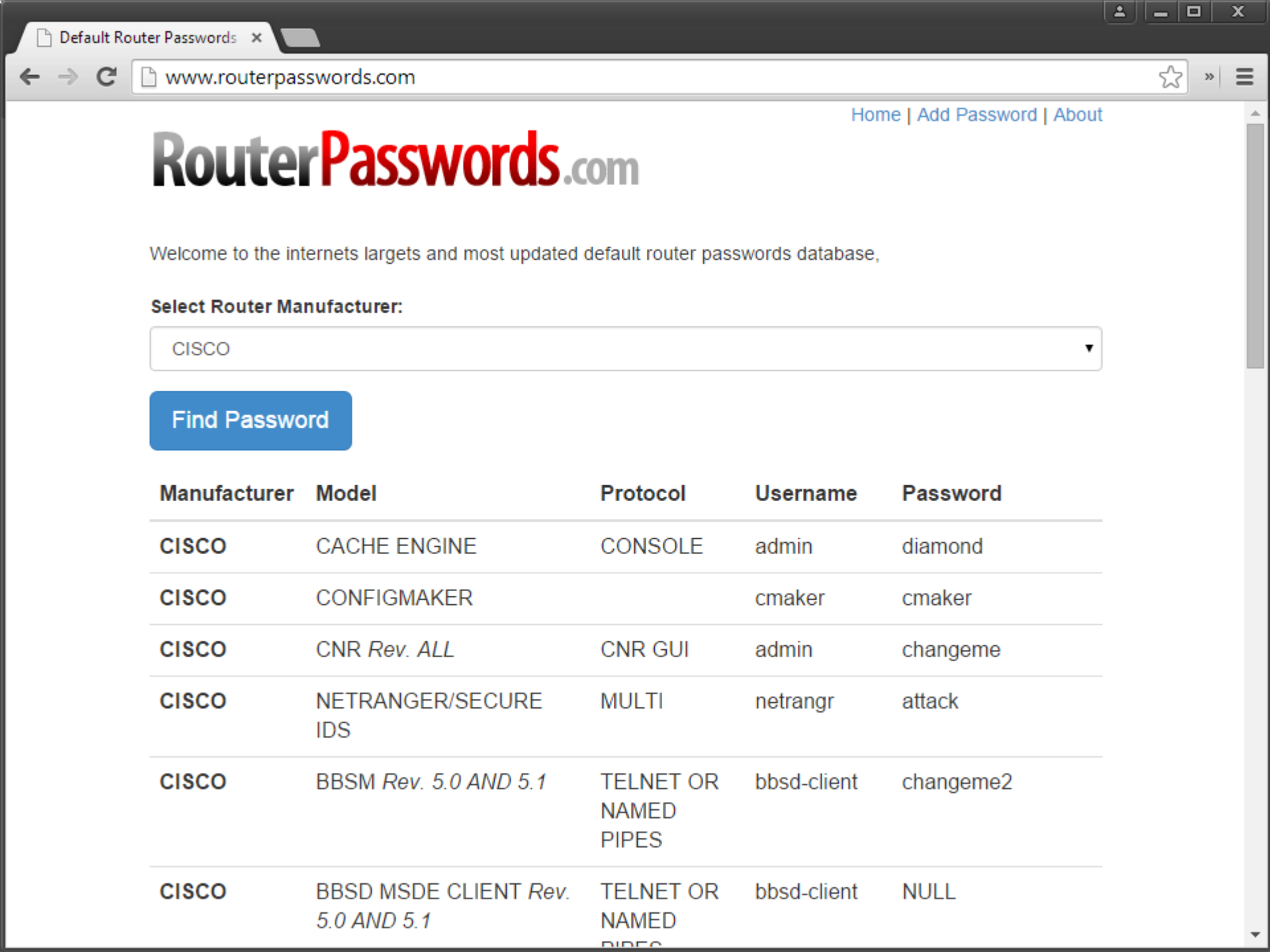
Common in home and enterprise settings

Routers and firewalls used to be “simple” devices – not anymore

- Features ➔ complexity ➔ security issues

Critical hosts in the network that need to be protected

- Administrative interface, OS patches/updates, service vulnerabilities, …


Default Router Passwords
www.routerpasswords.com
Home | Add Password | About
RouterPasswords.com
Welcome to the internets largets and most updated default router passwords database,
Select Router Manufacturer:
CISCO
Find Password
Manufacturer
Model
Protocol
Username
Password
CISCO
CACHE ENGINE
CONSOLE
admin
diamond
CISCO
CONFIGMAKER
cmaker
cmaker
CISCO
CNR Rev. ALL
CNR GUI
admin
changeme
CISCO
NETRANGER/SECURE IDS
MULTI
netrangr
attack
CISCO
BBSM Rev. 5.0 AND 5.1
TELNET OR NAMED PIPES
bbsd-client
changeme2
CISCO
BBSD MSDE CLIENT Rev. 5.0 AND 5.1
TELNET OR NAMED
bbsd-client
NULL

SHODAN - Computer Sea

www.shodanhq.com/search?q=cisco-ios

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SHODAN cisco-ios Search

Results 1 - 10 of about 75932 for cisco-ios

Services

HTTP	35,848
HTTPS	26,003
SNMP	6,488
SIP	5,509
Telnet	1,968

Top Countries

United States	17,838
Turkey	5,905
China	3,731
Mexico	3,455
United Kingdom	3,110

71.181.180.236
Verizon Internet Services
Added on 12.11.2013
Wilkes Barre

pool-71-181-180-236.sctnpa.east.verizon.net

HTTP/1.0 401 Unauthorized
Date: Tue, 16 Jul 2002 14:51:33 GMT
Server: cisco-IOS
Connection: close
Accept-Ranges: none
WWW-Authenticate: Basic realm="level_1

65.107.40.46
XO Communications
Added on 12.11.2013

65.107.40.46.ptr.us.xo.net

Cisco IOS Software, 2400 Software (C2430-IK9O3S-M), Version 12.4(15)T7, RELEASE SOFTWARE (fc3)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2008 by Cisco Systems, Inc.
Compiled Wed 13-Aug-08 15:51 by prod_rel_team

190.148.8.222
Telgua
Added on 12.11.2013

HTTP/1.0 401 Unauthorized
Date: Mon, 09 May 2011 03:13:41 GMT
Server: cisco-IOS

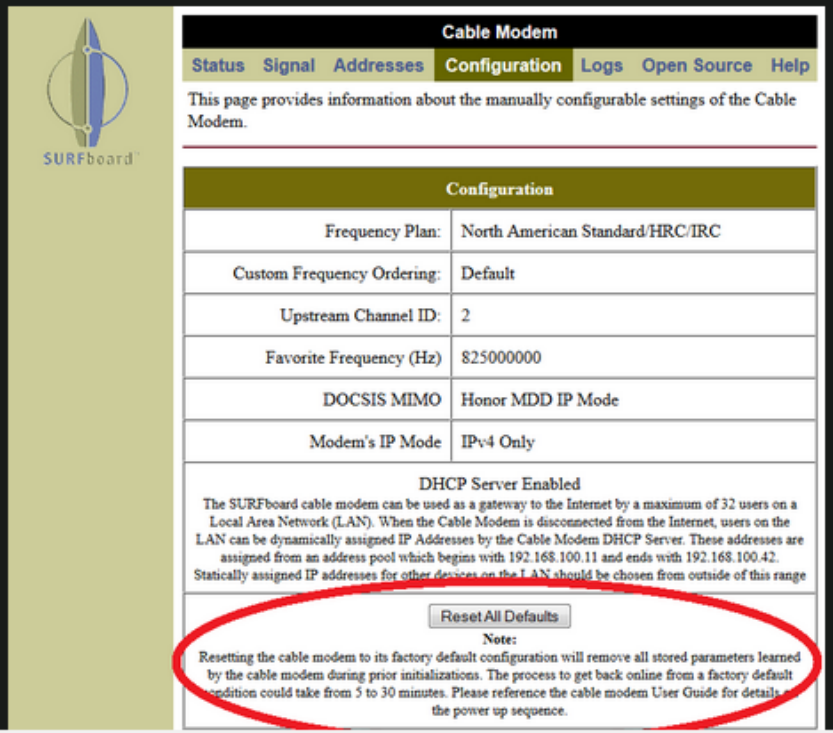
Owning Modems And Routers Silently

Jan 17 2015

Modems

Do you have cable internet? Own a surfboard modem? Since most of my buddies in AZ do, I sent them to this page and to my amusement, they got knocked off the net for a few minutes. How? Javascript. Specifically a CSRF in the Motorolla Surfboard.

The Surfboard cable modem offers little in functionality besides rebooting unless of course I wanted to be malicious and remove all settings on the cable modem and essentially turn it into a door stop until the thing can be activated again by the ISP.



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