

Network Security

Routing and Firewalls

Radboud University, The Netherlands



Spring 2017

A short recap

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- ▶ Typically used in conjunction with other attacks, e.g.:
 - ▶ DOS attacks (e.g., SYN flooding)
 - ▶ TCP session stealing
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- ▶ Discovers open ports
- ▶ Various different approaches to (stealthy) scanning
- ▶ Can also fingerprint the OS of the target

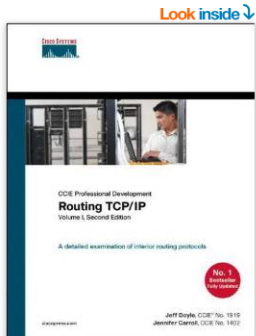
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- ▶ Can also fingerprint the OS of the target
- ▶ Portknocking can hide open ports from scanner
- ▶ Various approaches, most recent one: TCP Stealth

Routing

- ▶ IP is responsible for delivering packets from one host to another host
- ▶ *Routing* is the process of finding a path to the destination
- ▶ Routers are (specialized) computers that forward packets between networks
- ▶ Routing is a very extensive and complex topic

Routing



Look inside ↓

Routing TCP/IP, Volume 1 (2nd Edition) Hardcover – October 29, 2005

by [Jeff Doyle](#) (Author), [Jennifer Carroll](#) (Author)

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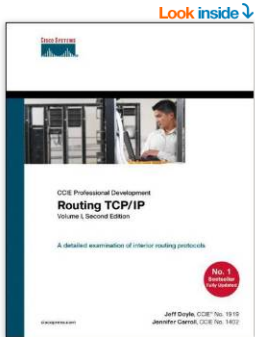
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 - ▶ ...
- ▶ Can use UDP packets, ICMP echo requests (ping), or TCP SYN
- ▶ What really matters is only the TTL in the IP header

Routing on the Internet (highly simplified)

- ▶ The Internet is divided into multiple *Autonomous Systems (AS)*
- ▶ Currently about 52,000 Autonomous Systems

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- ▶ Think of an AS as all networks under the control of one Internet Service Provider (ISP)

Routing attacks

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- ▶ Detaching a target from the network (DOS)
- ▶ Flooding a target with requests (DOS)
- ▶ Becoming MitM

Static routing

- ▶ Simplest form of routing: manage all routes by hand (static routing)
- ▶ Linux supports multiple routing tables
- ▶ Most important routing table: `main`
- ▶ Show current routes with

```
route -n
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or

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- ▶ Add route with `ip route add`, e.g.:

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ip route add 10.38.0.0/16 via 192.168.42.5
```
- ▶ Most important use of static routes: set a default gateway:

```
ip route add default via 192.168.42.1
```


Example of Linux routing table

```
route -n
```

| Destination | Gateway | Genmask | Flags | Metric | Ref | Use | Iface |
|---------------|---------------|---------------|-------|--------|-----|-----|--------|
| 0.0.0.0 | 192.168.178.1 | 0.0.0.0 | UG | 0 | 0 | 0 | wlan0 |
| 172.16.4.0 | 0.0.0.0 | 255.255.255.0 | U | 0 | 0 | 0 | vmnet8 |
| 172.16.51.0 | 0.0.0.0 | 255.255.255.0 | U | 0 | 0 | 0 | vmnet1 |
| 192.168.178.0 | 0.0.0.0 | 255.255.255.0 | U | 0 | 0 | 0 | wlan0 |

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ip route show
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```
default via 192.168.178.1 dev wlan0
172.16.4.0/24 dev vmnet8 proto kernel scope link src 172.16.4.1
172.16.51.0/24 dev vmnet1 proto kernel scope link src 172.16.51.1
192.168.178.0/24 dev wlan0 proto kernel scope link src 192.168.178.55
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| 192.168.178.0 | 0.0.0.0 | 255.255.255.0 | U | 0 | 0 | 0 | wlan0 |

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Detailed explanation, e.g, on

<http://www.cyberciti.biz/faq/what-is-a-routing-table/>

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- ▶ Build a table of efficient routes dynamically from this information
- ▶ Can combine static and dynamic routing
- ▶ Example: use dynamic routing, but configure one static default route (as backup)

Routing Information Protocol (RIP)

- ▶ RIP is the traditional routing protocol of the Internet ([RFC 1058](#) from 1988)
- ▶ Uses hop-count as metric (max hop-count: 15)
- ▶ Control messages on UDP, port 520
- ▶ RIPv2 introduced in 1993, latest RFC from 1998: [RFC 2453](#)
- ▶ Originally easily vulnerable to attacks (no authentication)
- ▶ MD5 authentication added in 1997 in [RFC 2082](#)

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- ▶ LSAs are re-authenticated when flooding through network
- ▶ When receiving a spoofed LSA, the legitimate router will send a “fight-back” LSA
- ▶ Fight-back LSAs have higher (newer) sequence numbers
- ▶ Fight-back LSAs overwrite illegitimate, spoofed LSAs

A persistent attack against OSPF

- ▶ Assume insider attacker (control over one router)
- ▶ Usually only very local attacks
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- ▶ Exploit OSPF duplicate detection: LSA is duplicate if
 - ▶ sequence numbers are the same
 - ▶ checksum is the same
 - ▶ age field differs by < 15 minutes
- ▶ Duplicate LSAs are simply ignored
- ▶ Actual link information is not used for duplicate detection!

A persistent attack against OSPF

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- ▶ Full paper:
<http://crypto.stanford.edu/~dabo/papers/ospf.pdf>

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- ▶ BGP routing can be political, see “Schengen routing”

Pakistan knocks Youtube offline

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Downtime

YouTube Offline, Pakistan Telecom Blamed

BY RICH MILLER ON FEBRUARY 24, 2008 [ADD YOUR COMMENTS](#)

3 Likes 0 Tweets 0 LinkedIn Shares 0 Google+ Shares

YouTUBE was knocked offline for two hours Sunday when Pakistan Telecom claimed its IP addresses, sparking a debate about whether the outage was a botched effort to block Pakistanis' access to the site, or a deliberate political IP hijacking. [David Ulevitch of OpenDNS](#) said that YouTube was down "because Pakistan Telecom has decided to (accidentally probably) hijack their IP address space which means that nobody in the world can reach Youtube." Posts

Source: <http://www.datacenterknowledge.com/archives/2008/02/24/youtube-offline-pakistan-telecom-blamed/>

TTNet claims to be the Internet



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Internet-Wide Catastrophe—Last Year

24 DEC, 2005 | 2:21 PM | BY TODD UNDERWOOD

One year ago today TTNNet in Turkey (AS9121) pretended to be the entire Internet. And unfortunately for the rest of the Internet, many large network providers believed them (or at least believed them in part). As far as anyone knows, it was a mistake, not a malicious act. But the consequences were far from benign: for several hours a large number of Internet users were unable to reach a large number of Internet sites. Twelve months later we can take a look at what happened, and whether we've learned much in the intervening time.

Source: <http://www.renesys.com/2005/12/internetwide-nearcatastrophela/>

SCION

- ▶ Ongoing research: Replacement for BGP
- ▶ Scalability, Control, and Isolation on Next-Generation Networks (SCION)
- ▶ Mainly developed at ETH Zurich
- ▶ Completely clean-slate design
- ▶ Can switch from BGP to SCION step-by-step
- ▶ Know more: <http://www.scion-architecture.net/>

Source routing

- ▶ IP Header has SSRR and LSRR options
- ▶ SSRR (strict source and record route): Specify the complete routing path (go through only these hosts in exactly this order)
- ▶ LSRR (loose source and record route): Specify the a loose routing path (the specified hosts must be visited in the specified order)
- ▶ Idea in both cases: *The source specifies the route*
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Source routing is evil

- ▶ Imagine that joffrey wants to IP spoof the address of arya
- ▶ joffrey can use LSRR and put himself into the route
- ▶ Now, the IP spoofing is not blind anymore: joffrey gets all the answers

ICMP redirect

- ▶ Consider three hosts, arya, tyrion, and hodor in the same network
- ▶ arya's route to `www.google.com` goes through hodor, then tyrion

ICMP redirect

- ▶ Consider three hosts, `arya`, `tyrion`, and `hodor` in the same network
- ▶ `arya`'s route to `www.google.com` goes through `hodor`, then `tyrion`
- ▶ More efficient: route directly through `tyrion`
- ▶ `hodor` can notice this and inform `arya` about this through *ICMP redirect*

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- ▶ `arya`'s route to `www.google.com` goes through `hodor`, then `tyrion`
- ▶ More efficient: route directly through `tyrion`
- ▶ `hodor` can notice this and inform `arya` about this through *ICMP redirect*
- ▶ Attack scenario:
 - ▶ `joffrey` spoofs IP address of `hodor` in ICMP redirect
 - ▶ Tells `arya` to route through `joffrey`
 - ▶ Now `joffrey` is MitM between `arya` and `www.google.com`

ICMP redirect

- ▶ Consider three hosts, arya, tyrion, and hodor in the same network
- ▶ arya's route to `www.google.com` goes through hodor, then tyrion
- ▶ More efficient: route directly through tyrion
- ▶ hodor can notice this and inform arya about this through *ICMP redirect*
- ▶ Attack scenario:
 - ▶ joffrey spoofs IP address of hodor in ICMP redirect
 - ▶ Tells arya to route through joffrey
 - ▶ Now joffrey is MitM between arya and `www.google.com`
- ▶ Some limitations of this attack:
 - ▶ ICMP redirects will only be accepted for a route to a recently contacted host
 - ▶ 10 minutes time frame
 - ▶ arya needs to accept ICMP redirect, this is configured in `/proc/sys/net/ipv4/conf/*/accept_redirects`

DHCP

- ▶ Typical way to hand out IP addresses: Dynamic Host Configuration Protocol (DHCP)
- ▶ When entering a network, a computer asks for an IP (and other information)
- ▶ Sends DHCP discovery packets; DHCP server answers
- ▶ Client requests various information
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Rogue DHCP

- ▶ Attacker can answer DHCP requests faster
- ▶ Knock clients offline by providing unroutable IP addresses
- ▶ More importantly: communicate himself as *default gateway*
- ▶ Can become MitM between the requesting client and the outside

Firewalls

Definition

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- ▶ Firewalls can separate networks on different levels
- ▶ Most common: packet filtering on the internet and transport layers
- ▶ Often combined with filters on application level
- ▶ Finally: There are filters on lower level (e.g., MAC filters)

“Personal Firewalls”

- ▶ Many software products called “Personal Firewall” or “Desktop Firewall”
- ▶ Intended to protect against certain attacks on a local machine
- ▶ Typical things those products do:
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 - ▶ Allow/deny network access only to certain applications
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 - ▶ Monitor network access of applications
- ▶ Central problem: Most users don't have a concept
- ▶ Questionable how useful the features are:
 - ▶ If I want a port closed, I don't open it in the first place
 - ▶ Can typically use an allowed application (web browser) to send data out

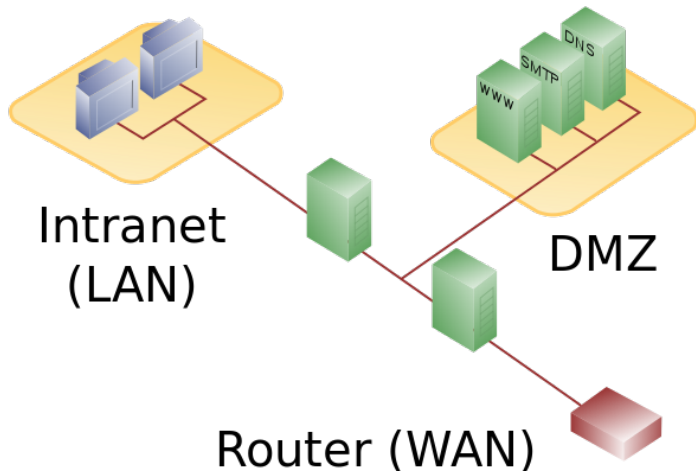
“Personal Firewalls”

- ▶ Many software products called “Personal Firewall” or “Desktop Firewall”
- ▶ Intended to protect against certain attacks on a local machine
- ▶ Typical things those products do:
 - ▶ Block access to network ports
 - ▶ Allow/deny network access only to certain applications
 - ▶ Monitor network access of applications
- ▶ Central problem: Most users don't have a concept
- ▶ Questionable how useful the features are:
 - ▶ If I want a port closed, I don't open it in the first place
 - ▶ Can typically use an allowed application (web browser) to send data out
- ▶ Potentially dangerous: additional piece of software with very highly privileged access!

Firewall layout and DMZs

- ▶ Common firewall layout separates three networks
 - ▶ The Internet
 - ▶ The Local Area Network
 - ▶ A de-militarized zone (DMZ)
- ▶ DMZ contains the servers that are accessible from the Internet

Firewall layout and DMZs



Source: [http://en.wikipedia.org/wiki/DMZ_\(computing\)](http://en.wikipedia.org/wiki/DMZ_(computing))

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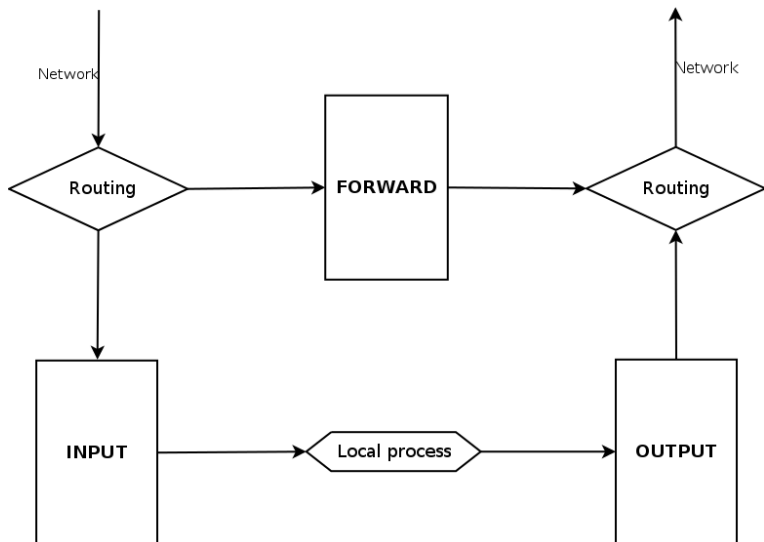
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- ▶ `--reject-with` specifies what error message to send (e.g., `icmp-port-unreachable` or `tcp-reject`)
- ▶ Additional to rules, each of the 3 chains also has a *policy*
- ▶ The policy defines the default behavior (if no rule matches)

Packet processing with the filter table



Simple iptables examples

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- ▶ Allow outbound DNS requests:

```
iptables -A OUTPUT -p udp -o eth0 --dport 53 -j ACCEPT
```

```
iptables -A INPUT -p udp -i eth0 --sport 53 -j ACCEPT
```

Stateful firewalls with iptables

- ▶ So far, the rules are stateless (don't know context)
- ▶ Most firewalls need stateful behaviour (in particular, for TCP):
 - ▶ I don't want external hosts to connect to port 12345
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- ▶ iptables has multiple modules, use conntrack module for stateful firewall
- ▶ Example: Allow all incoming packets that belong to established or related connection:

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- ▶ Most important connection states:
 - ▶ NEW: first packet of a connection
 - ▶ ESTABLISHED: Have seen packets of this connection before
 - ▶ RELATED: New connection, which is "related" to an ESTABLISHED connection

NAT

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- ▶ Short term work-around: Network Address Translation (NAT):
 - ▶ Multiple hosts in a local network (e.g., 192.168.0.0/16 or 10.0.0.0/8)
 - ▶ Only one host (the *gateway*) has an IP address routed in the Internet
 - ▶ "Shares" Internet connection to other hosts by rewriting the source IP address for outgoing packets
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 - ▶ Remembers connection (IP+Port) to rewrite destination IP address on incoming packets
- ▶ Strictly speaking, NAT is a more general concept
- ▶ This kind of NAT is also known as *IP Masquerading*

NAT example

- ▶ Three nodes in a local network:
 - ▶ tyrion 192.168.42.1
 - ▶ arya 192.168.42.2
 - ▶ hodor 192.168.42.3
- ▶ tyrion additionally has the (external) address 123.45.67.89
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- ▶ Answer: `tyrion` also rewrites the port

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Tethering

- ▶ Many (Android) phones offer sharing an Internet connection through *tethering*
- ▶ Tethering uses NAT (IP Masquerading)

Port forwarding

- ▶ So far, we can only establish connections from within the NAT network
- ▶ This is also known as “source-NAT”
- ▶ How about a server running inside a NAT network?

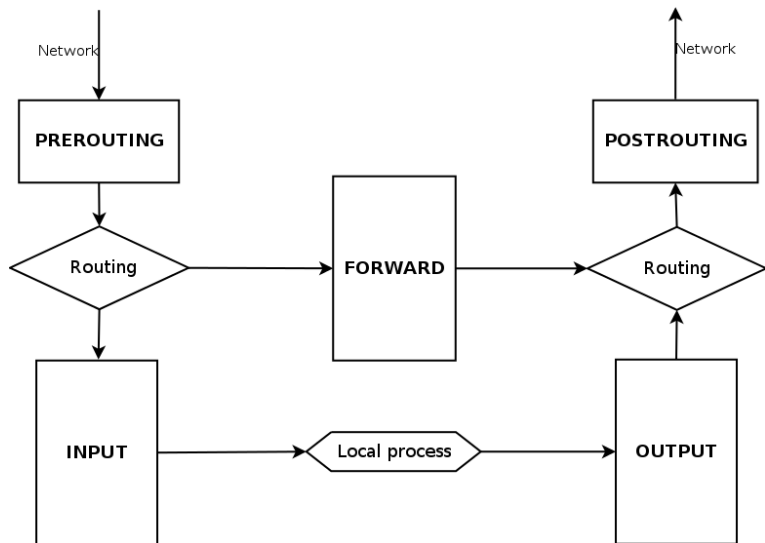
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- ▶ How about a server running inside a NAT network?
- ▶ Can forward incoming connections to a server
- ▶ This is called *port forwarding* or *destination NAT*

NAT and port forwarding with iptables

- ▶ iptables has a nat table
- ▶ Three chains in this table: PREROUTING, POSTROUTING, and OUTPUT
- ▶ For now, only consider chains PREROUTING, and POSTROUTING

NAT and port forwarding with iptables



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- ▶ Enabling NAT (IP Masquerading) through iptables:

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- ▶ Port forwarding from tyrion, port 1234 to arya, port 22:

```
iptables -A PREROUTING -t nat -p tcp \  
    --dport 1234 -j DNAT --to 192.168.42.2:22  
iptables -A FORWARD -p tcp -d 192.168.42.2 \  
    --dport 22 -j ACCEPT
```


Tunneling

- ▶ iptables looks at traffic on the TCP/IP level
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 - ▶ SSH will forward the connection to `mail.somedomain.com`, port 465
 - ▶ To `mail.somedomain.com`, the connection looks like coming from `mysshhost.nl`

sshuttle

- ▶ Tunneling every connection separately is a hassle
- ▶ Often want to tunnel *all* traffic through SSH
- ▶ Extremely convenient tool: `sshuttle`
- ▶ Modify local firewall rules to tunnel all traffic through SSH:
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 - ▶ Circumvent country filters (e.g., watch a German stream of the worldcup in NL)
 - ▶ This last case needs SSH access to an unblocked country

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- ▶ Can place proxies/ALGs in DMZ, then have no traffic go directly from the LAN to the Internet

Tunneling through an HTTP proxy

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                    DESTINATION_IP DESTINATION_PORT"
```

- ▶ Additional homework: `apt-get install sshuttle corkscrew` (some day you'll thank me ;-))