Network Security

Routing and Firewalls

Radboud University Nijmegen, The Netherlands

Autumn 2014

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
  - Ping of death (classic, could say: historic)

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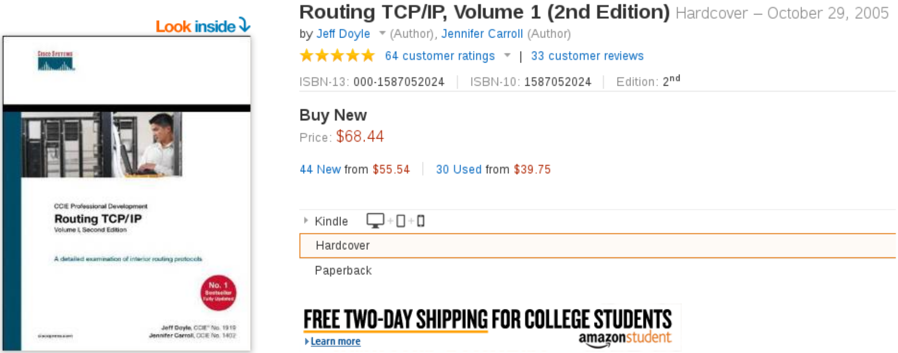
- Portknocking can hide open ports from scanner
- Various approaches, most recent one: TCP Stealth

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



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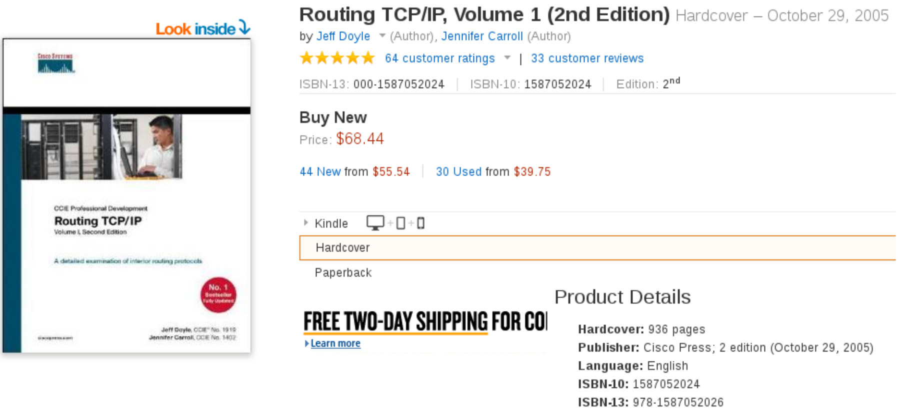
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- Can use UDP packets, ICMP echo requests (ping), or TCP SYN
- What really matters is only the TTL in the IP header

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

Routing on the Internet (highly simplified)

The classic definition of an Autonomous System is a set of routers under a single technical administration, using an interior gateway protocol and common metrics to route packets within the AS, and using an exterior gateway protocol to route packets to other ASes.

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> *The classic definition of an Autonomous System is a set of routers under a single technical administration, using an interior gateway protocol and common metrics to route packets within the AS, and using an exterior gateway protocol to route packets to other ASes. Since this classic definition was developed, it has become common for a single AS to use several interior gateway protocols and sometimes several sets of metrics within an AS. The use of the term Autonomous System here stresses the fact that, even when multiple IGPs and metrics are used, the administration of an AS appears to other ASes to have a single coherent interior routing plan and presents a consistent picture of what networks are reachable through it.*
>
> —*RFC 1930*

Routing attacks

- Changing routes enables three kinds of attacks:
  - 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`
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- Most important use of static routes: set a default gateway:

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

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  - Large risk of human error
  - Complex to configure for many/large networks
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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)

RIP, OSPF, and IS-IS

Routing Information Protocol

- 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)
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Open Shortest Path First

- Very commonly used in corporate Networks
- Uses IP (protocol number 89)
- Supports authentication

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Intermediate System to Intermediate System

- De facto standard for ISPs
- Control messages on link layer
- Supports authentication

BGP

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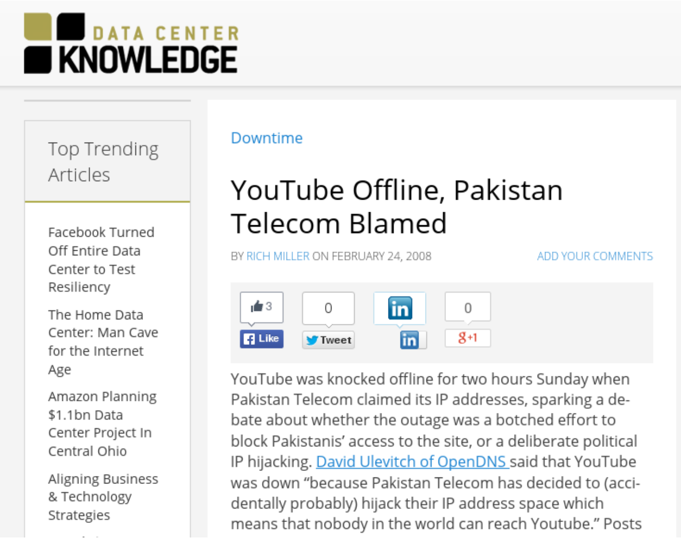
- BGP routing can be political, see "Schengen routing"

Pakistan knocks Youtube offline



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Downtime

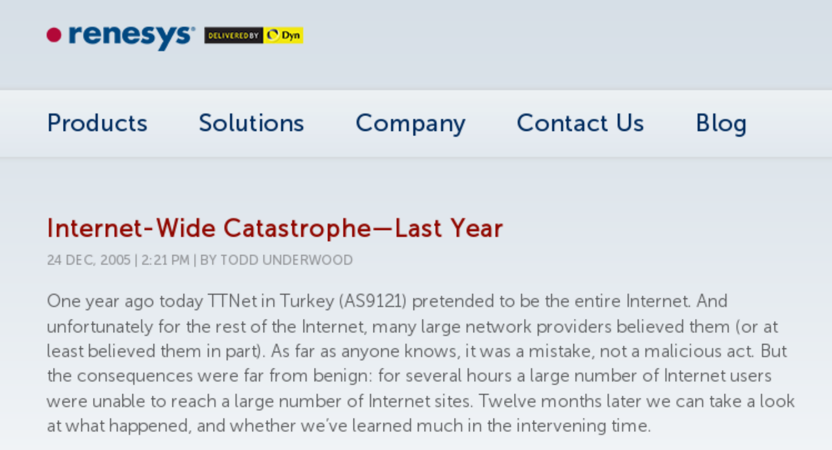
YouTube Offline, Pakistan Telecom Blamed

BY RICH MILLER ON FEBRUARY 24, 2008 ADD YOUR COMMENTS

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



Internet-Wide Catastrophe—Last Year

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

One year ago today TTNet 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/

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

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- Some limitations of this attack:
  - ICMP redirects will only be accepted for a route to a recently contacted host
  - 10 minutes
  - `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)
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Rogue DHCP

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

Firewalls

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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
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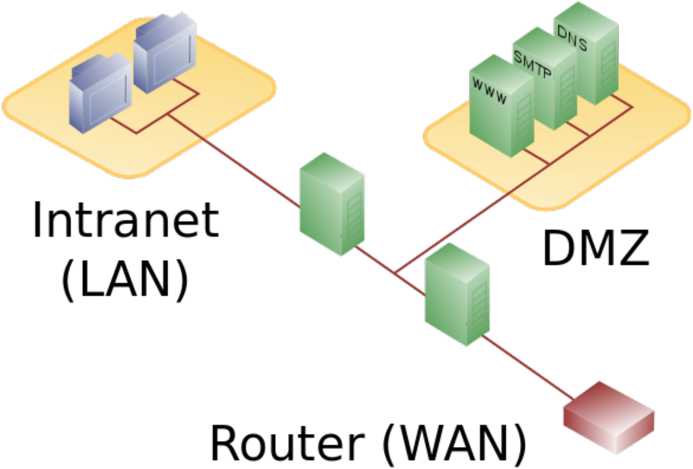
- Potentially dangerous: additional piece of software with very highly privileged access!

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)

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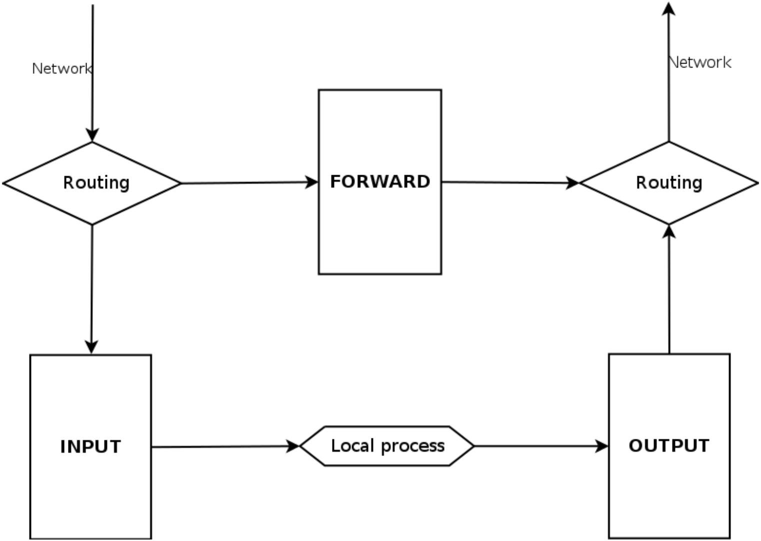
- Additional to rules, each of the 3 chains also has a *policy*
- The policy defines the default behavior (if no rule matches)

Packet processing with the `filter` table



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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):
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  - I do want external hosts to send data back to client port 12345
- iptables has multiple modules, use conntrack module for stateful firewall
- Example: Allow all incoming packets that belong to established or related connection:

```
iptables -A INPUT -m conntrack \
         --ctstate RELATED,ESTABLISHED -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
  - I do want external hosts to send data back to client port 12345
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- 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
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- 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
- `arya` and `hodor` use `tyrion` as default gateway

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- Incoming packets from `www.google.com` with dest. port 11111: Rewrite destination address to 192.168.42.2
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- What happens if both `hodor` and `arya` connect to www.google.com with the *same* destination port?

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
- arya and hodor use tyrion as default gateway
- arya connects (through tyrion) to www.google.com, Port 80, using source port 11111
- hodor connects (through tyrion) to www.google.com, Port 80, using source port 22222
- tyrion rewrites source address for both connections to 123.45.67.89
- Incoming packets from www.google.com with dest. port 11111: Rewrite destination address to 192.168.42.2
- Incoming packets from www.google.com with dest. port 22222: Rewrite destination address to 192.168.42.3
- What happens if both hodor and arya connect to www.google.com with the *same* destination port?
- Answer: tyrion also rewrites the port

Some NAT remarks

NAT and ICMP

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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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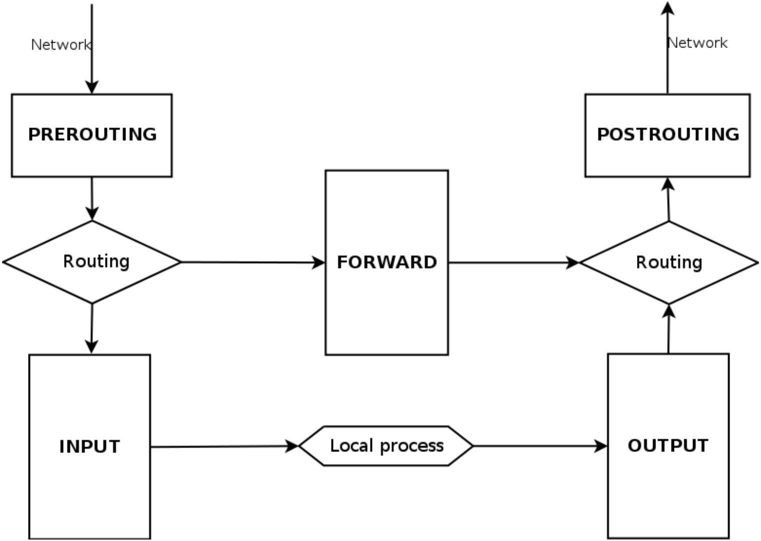
- So far, we can only establish connections from within the NAT network
- This is also known as “source-NAT”
- How about a server running inside a NAT network?
- Can forward incoming connections to a server
- This is called *port forwarding* or *destination NAT*

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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echo 1 > /proc/sys/net/ipv4/ip_forward
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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
- `iptables` cannot distinguish between HTTP going to port 80 and SSH going to port 80
- Running an SSH server on ports 53 (DNS), 80 (HTTP), and 443 (HTTPS) gets SSH through some firewalls

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      ssh -p 80 -L 52428:mail.somedomain.com:465 mysshhost.nl
      ```

    - Connect to `localhost` at port 52428
    - SSH will forward the connection to `mail.somedomain.com`, port 465

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  - Connect to `localhost` at port 52428
  - 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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  - Tunnel everything through a firewall (once you have SSH access to somewhere)
  - Tunnel from an untrusted network to a (more) trusted network (VPN, later this lecture)
  - Circumvent country filters (e.g., watch a German stream of the worldcup in NL)
  - This last case needs SSH access to an unblocked country

Proxy Servers

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  - Application-level proxy (understands high-level protocols, such as HTTP)
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- Similar to Proxy: *Application-level gateway (ALG)*
- Both (application-level) proxy and ALG can filter high-level protocols
- Can place proxies/ALGs in DMZ, then have no traffic go directly from the LAN to the Internet

Tunneling through an HTTP proxy

- Most common form of proxies: HTTP(S) proxies
- Fairly common restrictive firewall configuration:
  - Allow only HTTP(S) traffic (and DNS through UDP)
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- Additional homework: `apt-get install sshuttle corkscrew` (some day you'll thank me ;-))