Network Security

Routing and Firewalls

Radboud University, The Netherlands

Spring 2019

Slow Loris

https://www.youtube.com/watch?v=XiFkyR35v2Y

A short recap

- IP spoofing by itself is easy
- 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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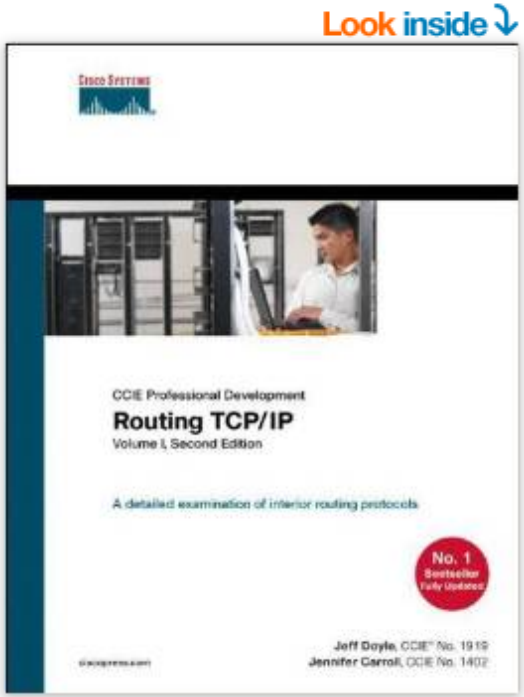
- Can also fingerprint the OS of the target
- Portknocking can hide open ports from scanner
- Various approaches, most recent one: TCP Stealth

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



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

by Jeff Doyle (Author), Jennifer Carroll (Author)

★★★★★ 64 customer ratings | 33 customer reviews

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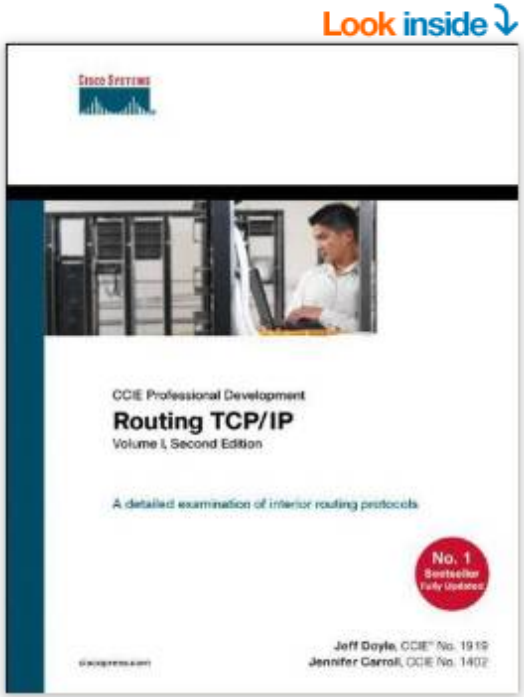
Routing



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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)*
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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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- 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
```

`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
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Detailed explanation, e.g, on
http://www.cyberciti.biz/faq/what-is-a-routing-table/

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- Static routing is often not enough:
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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
- HMAC-SHA1 and HMAC-SHA2 authentication added in 2007 in RFC 4822

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INFOWORLD TECH WATCH

By Serdar Yegulalp, Senior Writer, InfoWorld | JUL 1, 2015

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Obsolete Internet protocol once again becomes an attack vector

The RIPv1 routing protocol is being used to launch DDoS attacks against many hosts on the Internet, according to an Akamai threat report

Dagohbert / Deviant Art

https://www.infoworld.com/article/2942749/obsolete-internet-protocol-once-again-becomes-an-attack-vector.html

"Akamai claims that 53,693 devices on the Internet responded to RIPv1, although only a small number of them were actually leveraged for the attack."

Open Shortest Path First – OSPF

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- 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!

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

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- BGP security vulnerabilities have their own RFC (RFC 4272)
- 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

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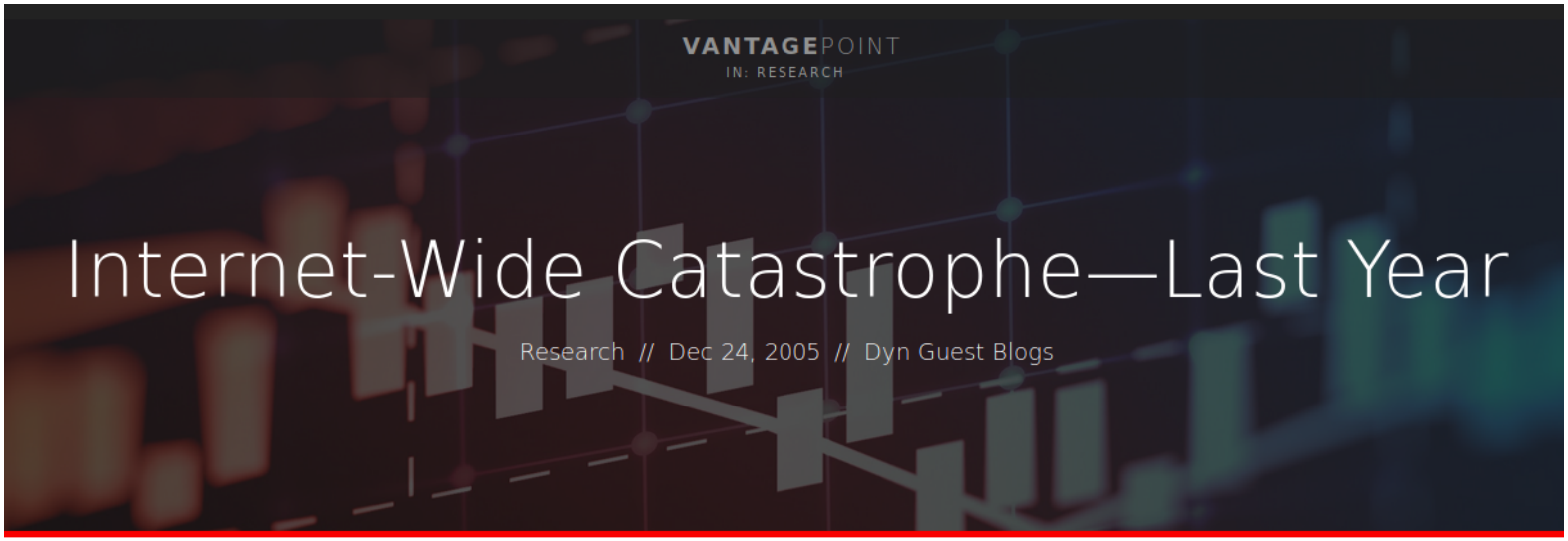
YouTube was knocked offline for two hours Sunday when Pakistan Telecom claimed its IP addresses, sparking a debate about whether the outage was a botched effort to block Pakistanis' access to the site, or a deliberate political IP hijacking. David Ulevitch of OpenDNS said that YouTube was down "because 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



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.

Early Christmas Eve morning 2004, TTNet (AS9121) started announcing what appeared to be a full table (well over 100,000 entries) of Internet routes to all of their transit providers. I was on call that Christmas (as I am this Christmas; I'm sensing a bad pattern here). So around 4:30 in the morning US Eastern Standard Time, I started getting paged.

Source: https://dyn.com/blog/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)
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Source routing is evil

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

ICMP redirect

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- `arya`'s route to www.google.com goes through `bran`, then `tyrion`

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- Attack scenario:
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  - Tells `arya` to route through `cersei`
  - Now `cersei` is MitM between `arya` and www.google.com

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  - Tells `arya` to route through `cersei`
  - Now `cersei` 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 imporantly: 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:
  - Block access to network ports
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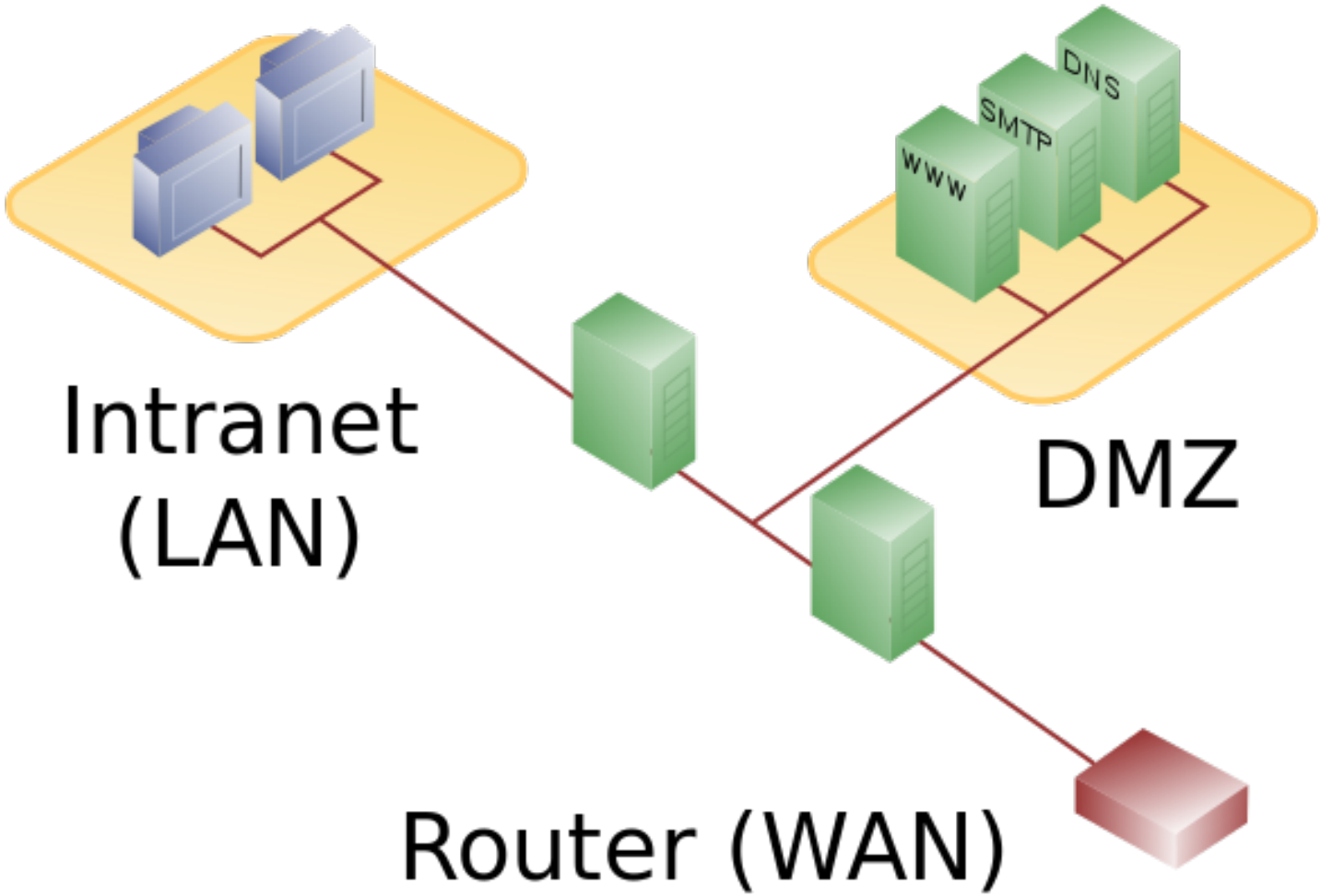
  - Can typically use an allowed application (web browser) to send data out
- Potentially dangerous: additional piece of software with very highly privileged access!

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)

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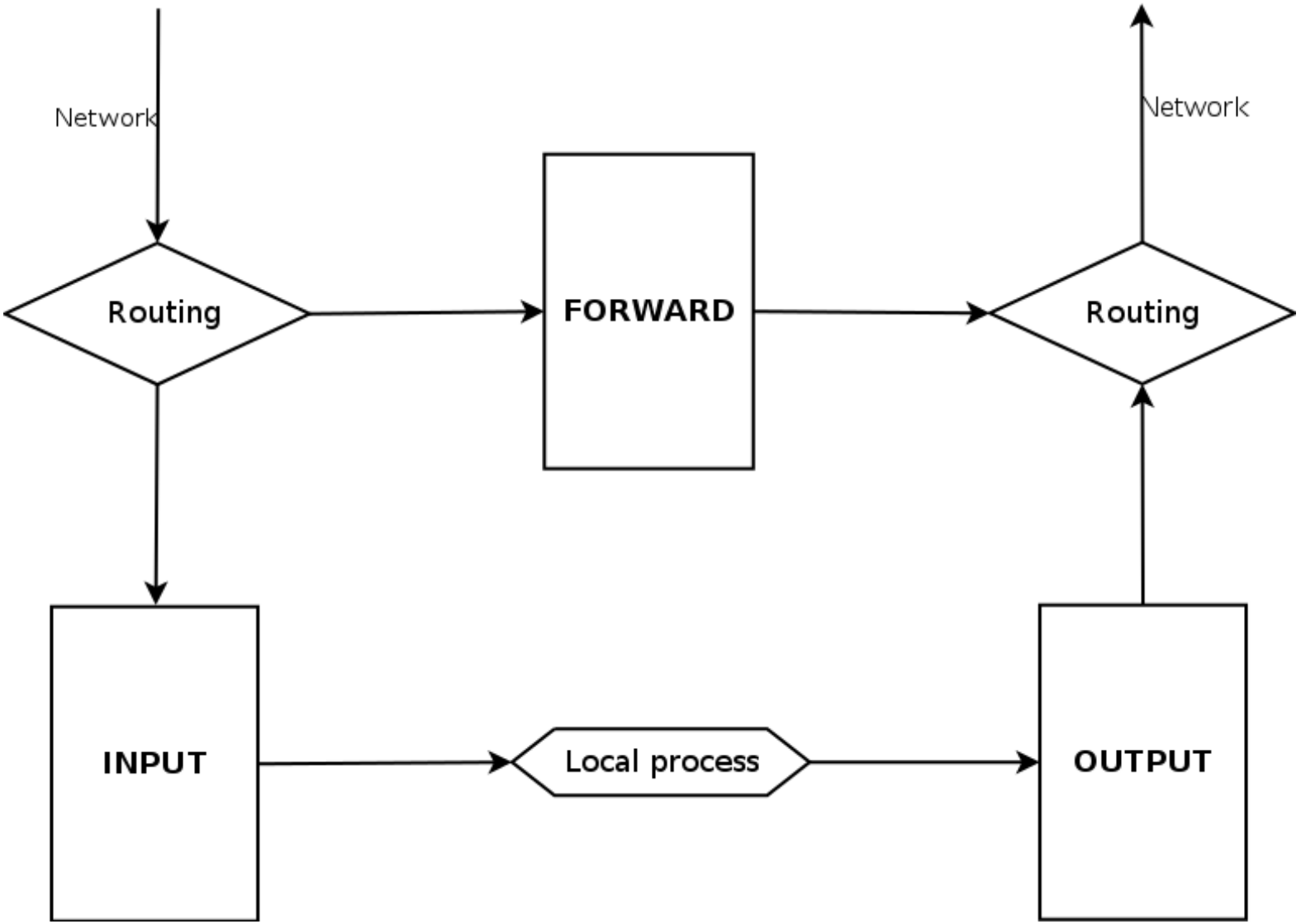
- Additional to rules, each of the 3 chains also has a *policy*
- The policy defines the default behavior (if no rule matches)

Packet processing with the `filter` table



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- Allow outbound DNS requests:

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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
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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

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  - Multiple hosts in a local network (e.g., 192.168.0.0/16 or 10.0.0.0/8)
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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
  - `bran` 192.168.42.3
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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)

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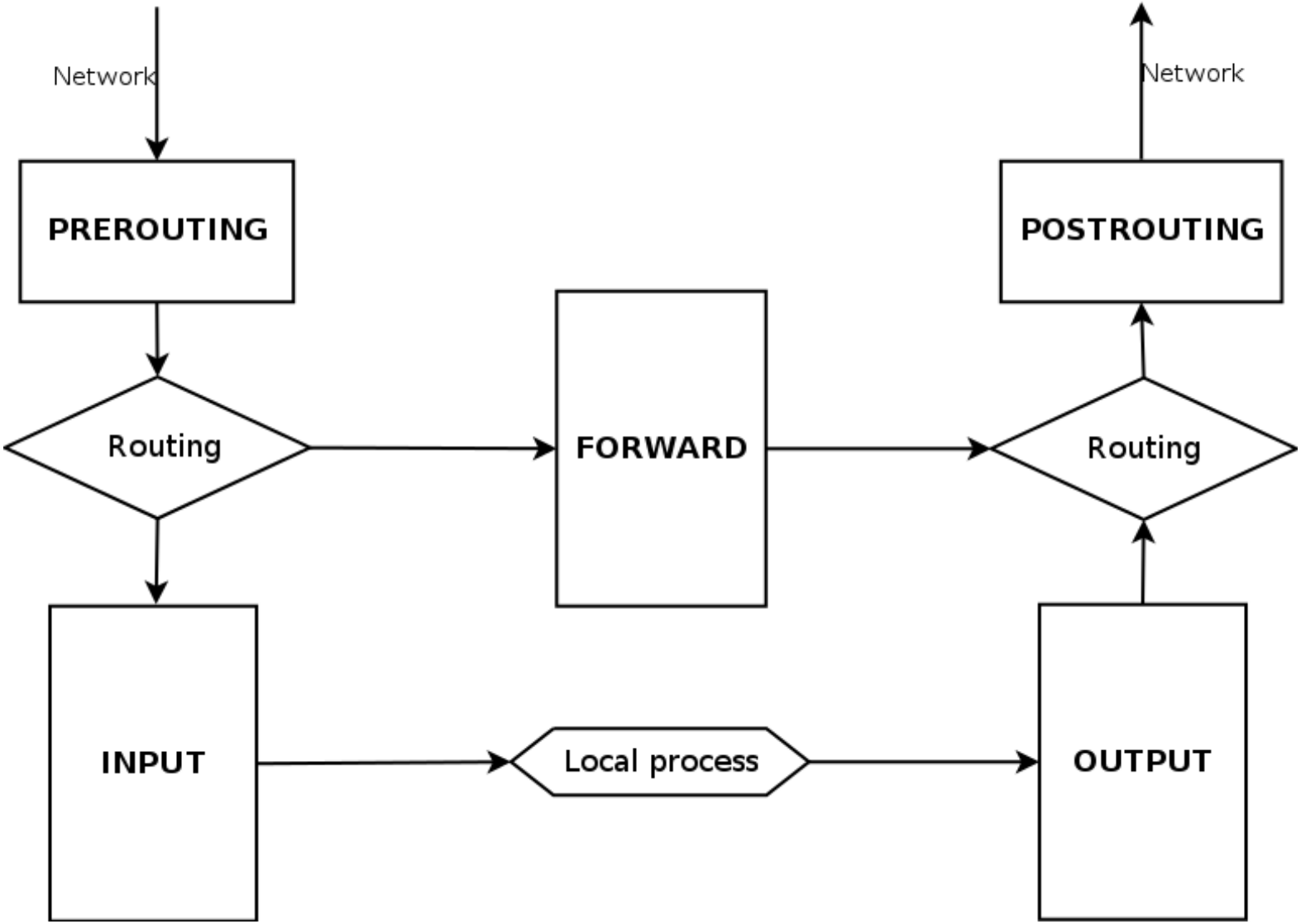
- How about a server running inside a NAT network?
- Can forward incoming connections to a server
- This is called *port forwarding* or *destination NAT*

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

```
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         --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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  - 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`
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  - Circumvent country filters (e.g., of Netflix)
  - This last case needs SSH access to an unblocked country

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