Worksheet 9

Linux as a router, packet filtering, traffic shaping

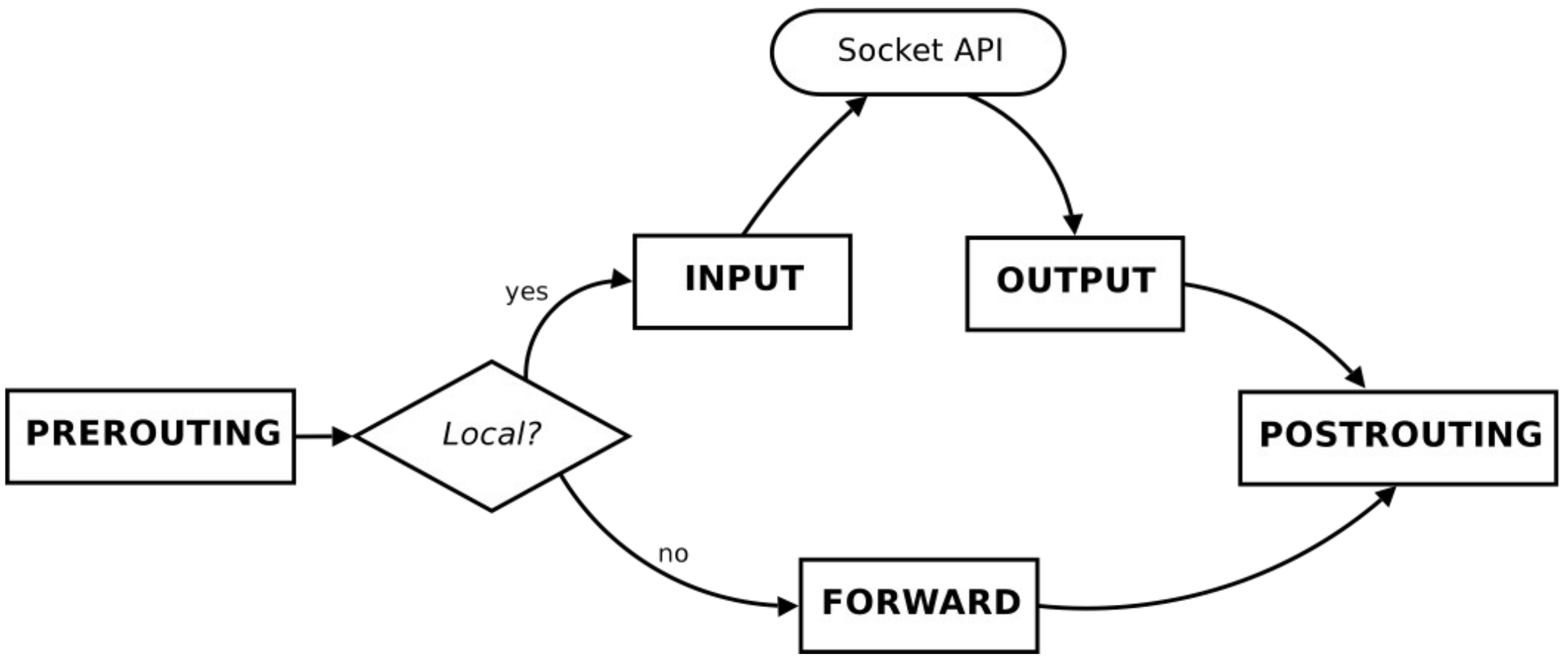
Linux as a router

- Capable of acting as a router, firewall, traffic shaper
- (so are most other modern operating systems)
- Tools:
  - netfilter/iptables
  - tc

Netfilter / Iptables

- The Linux Packet filtering framework
  - 2 axes of organisation:
    - Chains - **when** does the interception occur?
    - Tables - **what** can be done (functionality)?

Graphical Overview



Iptables: Chains

- Chains - when?
  - **PREROUTING** - before remote/local decision
  - **INPUT** - before locally destined traffic is admitted
  - **OUTPUT** - before locally generated traffic is routed
  - **FORWARD** - non-local packets
  - **POSTROUTING -** before packet leaves system

Iptables: Tables

- Tables: functionality
  - **filter (default)** - block packets on **INPUT, OUTPUT, FORWARD**
  - **nat** - change packet src/dst address/port on **PREROUTING , POSTROUTING**
  - ...

The Matrix - common uses

	PRE-ROUTING	INPUT	OUTPUT	FORWARD	POST-ROUTING
filter		filter incoming	filter outgoing	filter forwarded	
nat	DNAT				SNAT
mangle	mark, manipulate packets				

Anatomy of a chain

- Essentially a list of tuples <pattern, target>

Pattern	Target
-s 10.1.2.3	ACCEPT
-d 10.2.3.4 -p tcp --dport 3306	DROP
-s 10.2.3.4 -p tcp --dport 22 -m state --state=NEW	LOG
...	...

- First match wins!

Iptables invocation

- To add a rule to a chain:

```
iptables [-t <TABLE>] -A <CHAIN> <PATTERN>
   -j <TARGET>
```

- List existing rules

```
iptables [-t <TABLE>] -L [<CHAIN>] [-v] [-n]
```

- Delete a rule from a chain

```
iptables [-t <TABLE>] -D <CHAIN> rule num
```

- As always: **man iptables** is your friend

Some rule patterns

-s 1.2.3.4	from source IP 1.2.3.4
-d 1.2.3.5	to destination IP 1.2.3.5
-p tcp	protocol tcp
tcp/udp: **--[sd]port** 80	src/destination port 80
icmp: **--icmp-type** echo-request	*ping* echo request

Some rule targets

ACCEPT	accept packet for this stage
DROP	drop packet immediately (and silently)
LOG	log packet to syslog
REJECT	drop packet and send an ICMP error message to the source

Stateful Filtering

- Problem of stateless filters: Related packets flow in both directions - how to correlate
  - TCP - can look at TCP-state (and rely on the TCP state of the protected host to behave properly)
  - UDP - stateless...
- How would you create a rule that matches *„Answers to DNS queries that were sent out“*?
- => Stateful Filtering

Stateful Filtering: Principles

- The firewall tracks and maintains higher layer communication state
  - *„A has sent out a DNS query to B and is expecting an answer“*
- Rules can be built that match the protocol / correspondence state

Stateful Filtering in iptables

- Rules match communication state

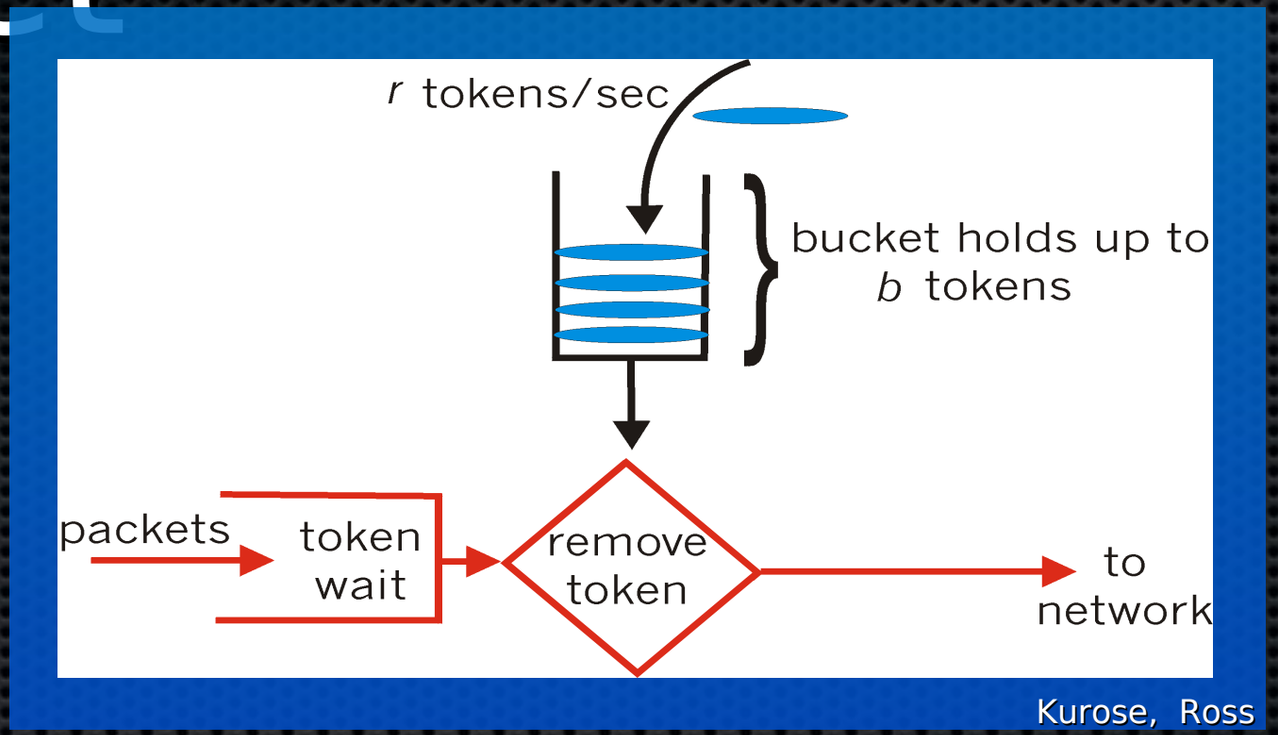
```
... -m state --state NEW|ESTABLISHED|RELATED
```

- State automatically tracked by the **conntrack** module
  - TCP state
  - UDP <src_ip,srcport,dst_ip, dst_port> tuples w/ timeout
  - application specific helper modules (FTP)

Traffic Shaping

- limit bandwidth allocation to specific classes of service
- by nature of the Internet: can only limit what you **send**, not what you **receive**
- ... but most of the bulky traffic will adapt! (TCP Slowstart)

The principle: Token bucket



- bucket can hold b tokens
- tokens generated at rate r token/sec unless bucket full
- only send packet if you have a token

Token buckets in Linux

- tc can be used with the **tbf** (token bucket) **qdisc** (queing discipline) to limit throughput on an interface:

```
tc qdisc add dev <DEV> root tbf rate <rate>kbit
   latency <latency>ms burst <burst_rate>kbit
```

- Parameters:
  - **rate** maximum allowed average bandwidth
  - **burst** - maximum allowed burst bandwidth

Classful Trafficshaping: HTB

- HTB := Hierarchical Token Bucket
- Can define a **hierarchy of traffic classes**, and assign limits
  - **rate** - the average allowed bandwidth
  - **ceil** - burst bandwidth allowed when buckets are present
  - **prio** - priority for spare bandwidth - classes with lower prios are offered the bandwidth first

Deploying HTB (I)

- 1. Enable *qdisc*(Queuing discipline) for the device and define a root class handle (1:0)

```
tc qdisc add dev <DEVICE> root handle 1:0
    htb default <default_class>
```

- 2. Define a class (1:10 here)

```
tc class add dev <DEVICE> parent 1:0 classid 1:10
    htb rate 100kbit ceil 150kbit prio 0
```

Deploying HTB (II)

3. Mark packets that should belong to the class, using iptables‘ mangle facility (there is other ways, but follow me on this)

4. Stuff marked packets with x into class x and assign to appropriate qdisc.

```
iptables -A POSTROUTING -t mangle <PATTERN>
   -j MARK --set-mark 10
```

```
tc filter add dev <DEV> parent 1:0 prio 0
   protocol ip handle 10 fw flowid 1:10
```

That‘s all!

- Worksheet 9 is due

Friday, July 3th, 2009, 08:00 am