Università degli Studi Roma Tre
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netkit lab

rip

Version	2.2
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Description	experiences with the ripv2 distance vector routing protocol

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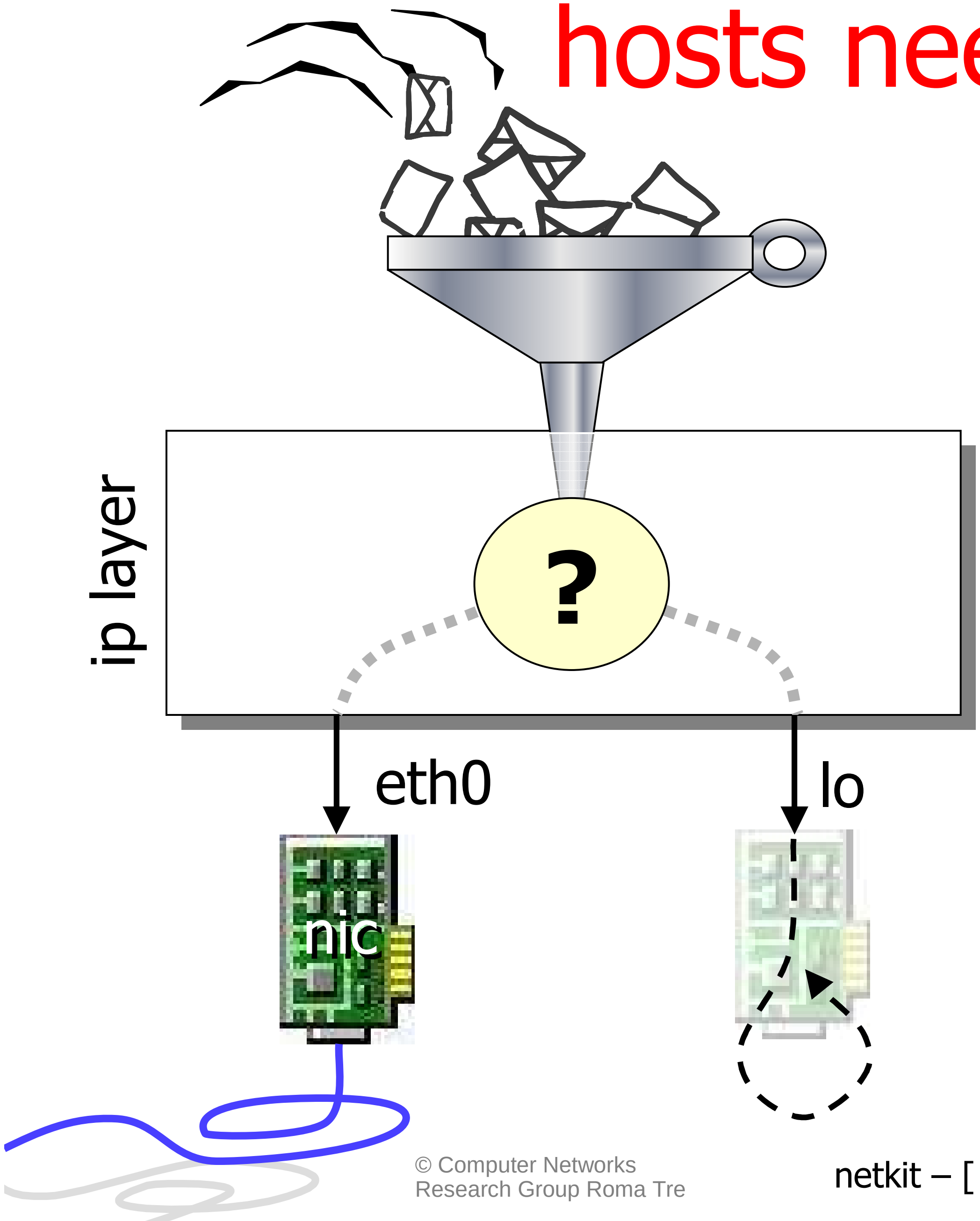
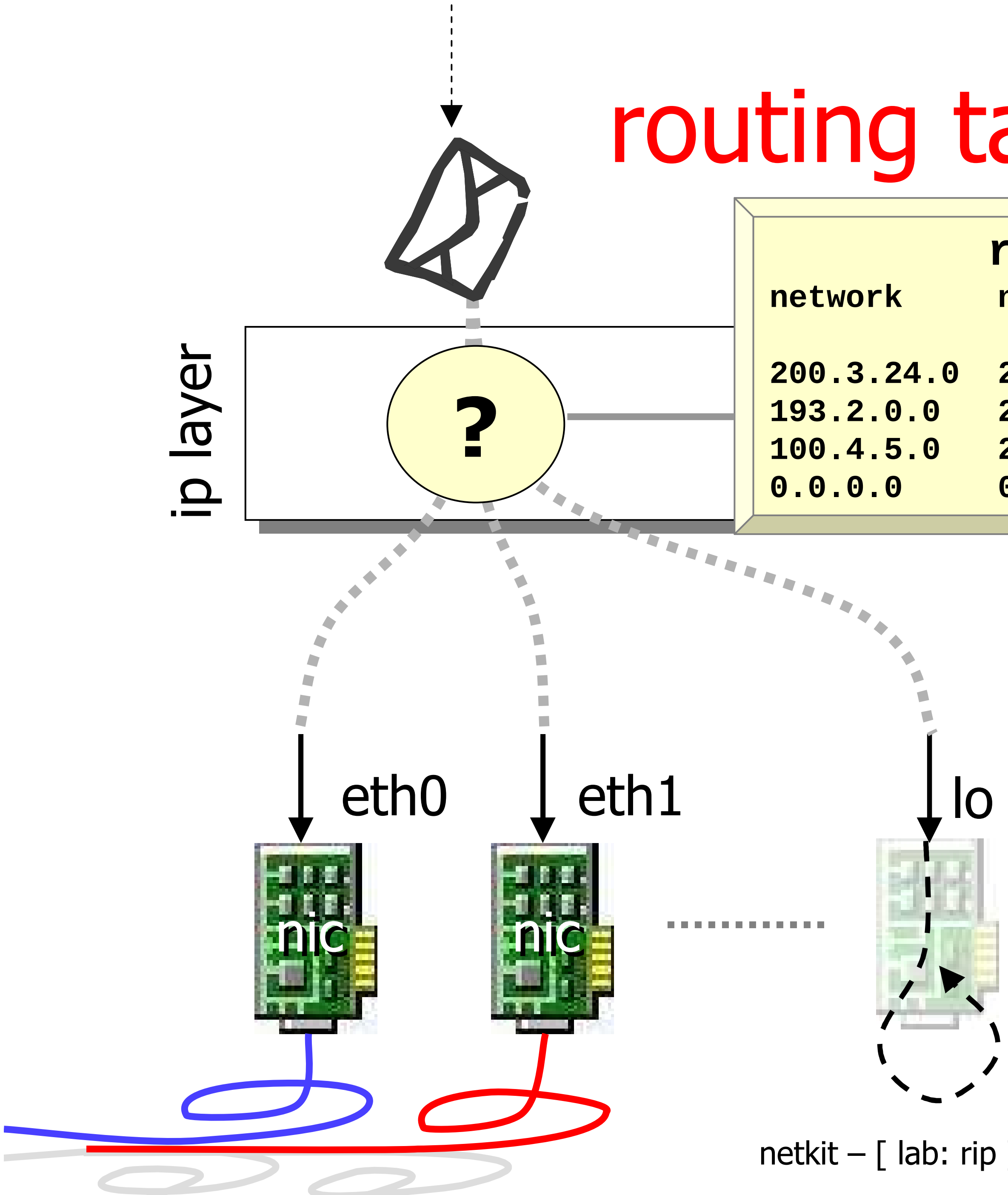
hosts need routing



- each host with a network stack performs some elementary routing
- at the very least, the network stack may be used to access local services (e.g., XWindows)
- the host must decide when a packet needs to be sent to the network interface card (nic) and when it needs to be bounced to the loopback interface (lo)

routing table

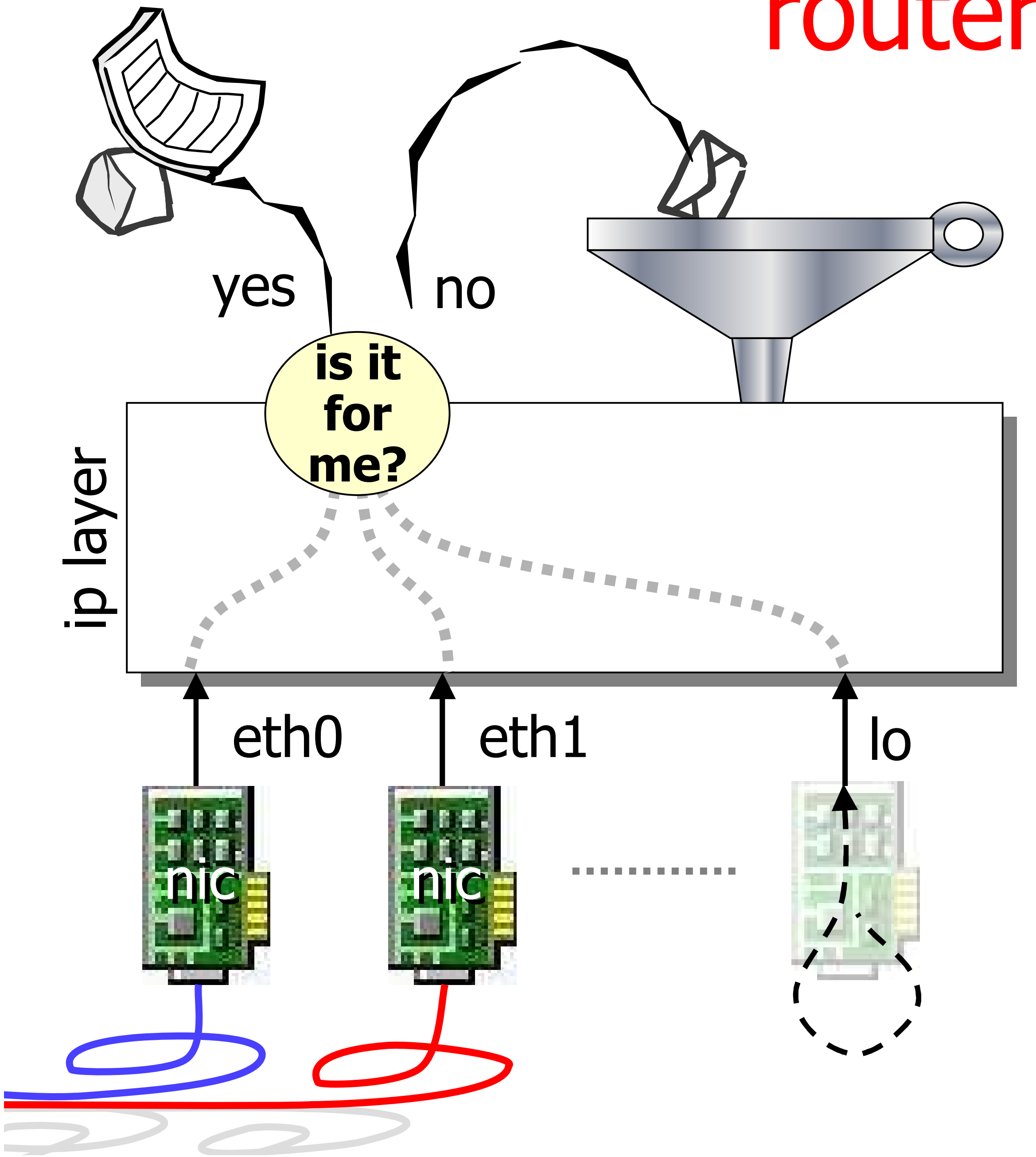


routing table

network	nmask	nexthop	int
200.3.24.0	255.255.255.0	12.0.0.4	eth1
193.2.0.0	255.255.248.0	11.0.0.2	eth0
100.4.5.0	255.240.0.0	11.0.0.3	eth0
0.0.0.0	0.0.0.0	11.0.0.2	eth0

- the ip layer uses a routing table to decide which is the interface the packet needs to be forwarded to

routers

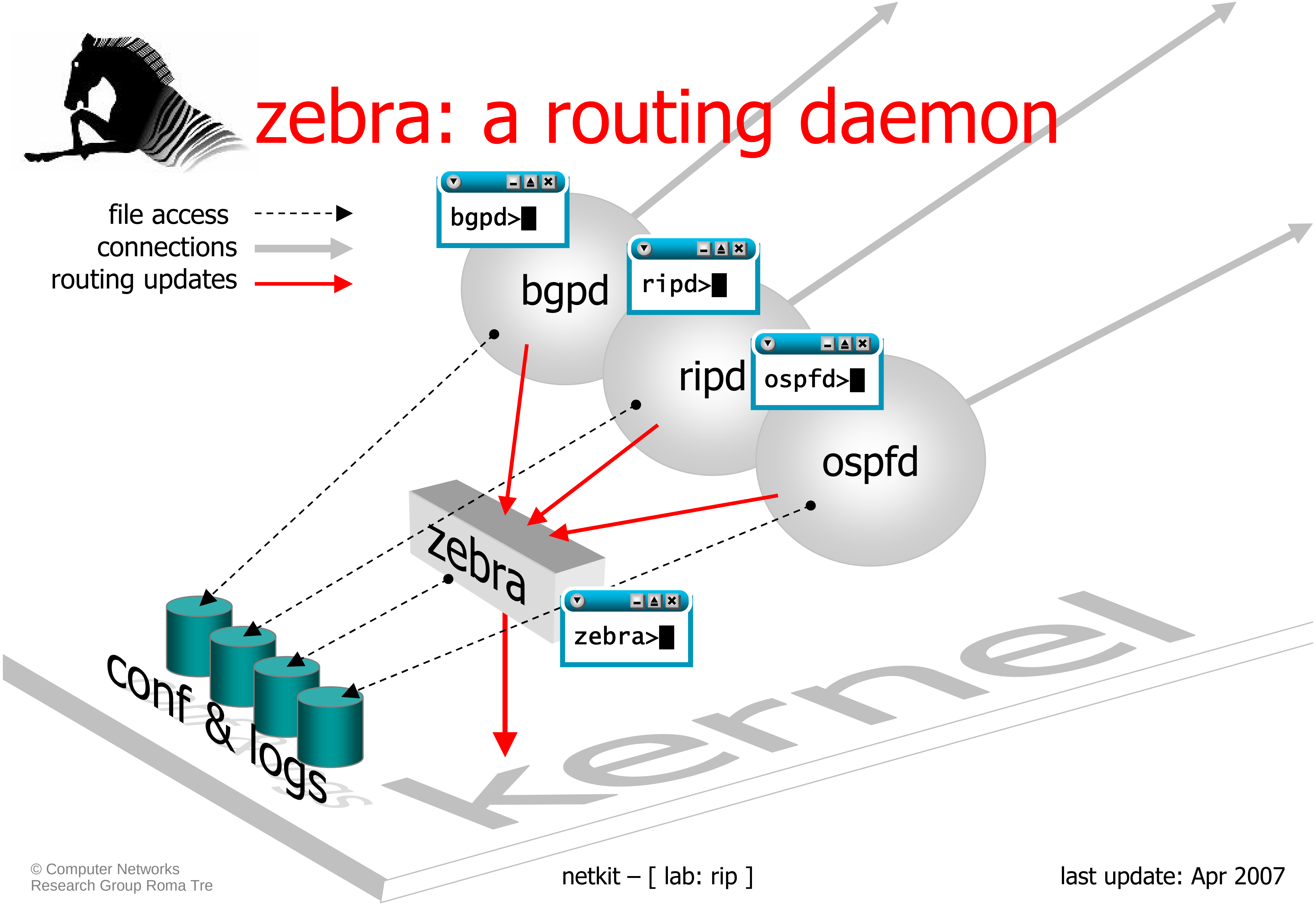


- a router (also called gateway or intermediate-system)
  - has more than one network interface card
  - feeds incoming ip packets (that are not for the router itself) back in the routing process
    - this operation is called relaying or forwarding

routing protocols

- routing protocols are used to automatically update the routing tables
- they fall into two main cathegories:
  - link-state routing protocols
    - approach: send the minimum information to everyone
    - each router reconstructs the whole network graph and computes a shortest path tree to all destinations
    - examples: is-is, ospf
  - distance-vector routing protocols
    - approach: send all your information to a few
    - update your routing information based on what you hear
    - examples: rip, bgp
- in this lab we will see an example of RIPv2 protocol on zebra boxes

zebra: a routing daemon



inspecting zebra configuration files

virtual machine

```
pc1:~# cd /etc/zebra/
pc1:/etc/zebra# ls
bgpd.conf            ospf6d.conf          ripd.conf            vtysh.conf
bgpd.conf.sample     ospf6d.conf.sample   ripd.conf.sample     vtysh.conf.sample
bgpd.conf.sample2    ospfd.conf           ripngd.conf          zebra.conf
daemons              ospfd.conf.sample    ripngd.conf.sample   zebra.conf.sample
pc1:/etc/zebra# █
```

- when zebra is started, each daemon checks these files to read the starting configuration

sample **daemons** file

virtual machine

```
pc1:/etc/zebra# less daemons
# This file tells the zebra package
# which daemons to start.
# Entries are in the format: <daemon>=(yes|no|priority)
# where 'yes' is equivalent to infinitely low priority, and
# lower numbers mean higher priority. Read
# /usr/doc/zebra/README.Debian for details.
# Daemons are: bgpd zebra ospfd ospf6d ripd ripngd
zebra=yes
bgpd=no
ospfd=no
ospf6d=no
ripd=yes
ripngd=no
daemons (END)
```

the zebra main daemon will be started

the rip daemon will be started too

sample zebra configuration file (**zebra.conf**)

virtual machine

```
pc1:/etc/zebra# less zebra.conf
! -*- zebra -*-
!
! zebra sample configuration file
!
! $Id: zebra.conf.sample,v 1.14 1999/02/19 17:26:38 developer
Exp $
!
hostname Router
password zebra
enable password zebra
!
! interface lo
zebra.conf
```

the prompt of the zebra interface

the password to connect to the daemon

administrative password

sample ripd configuration file (**ripd.conf**)

virtual machine

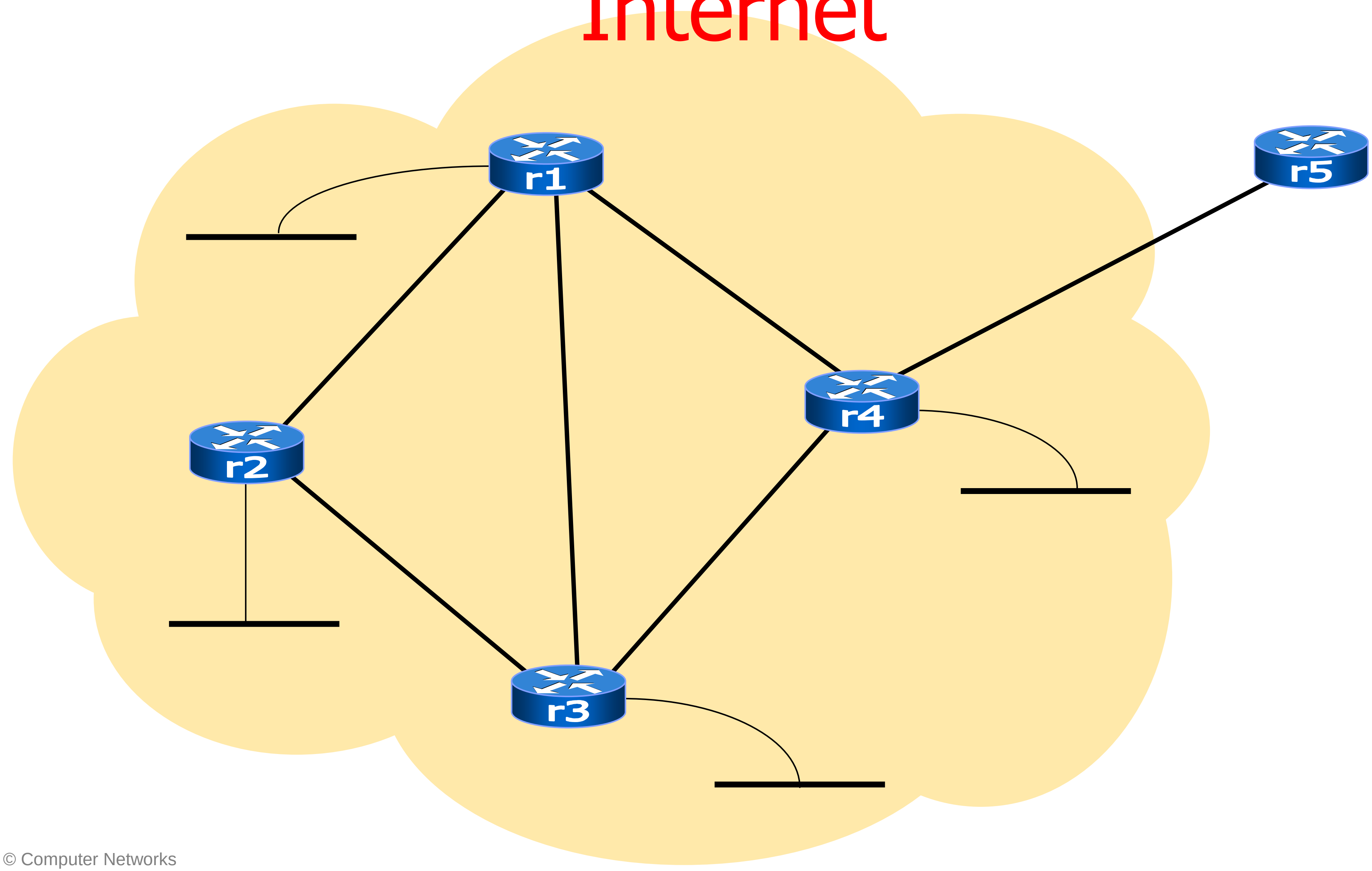
```
pc1:/etc/zebra# cat ripd.conf
!
hostname ripd
password root
enable password root
!
router rip
redistribute connected
network 100.1.0.0/16
!
log file /var/log/zebra/ripd.
pc1:/etc/zebra#
```

talk rip on some interface

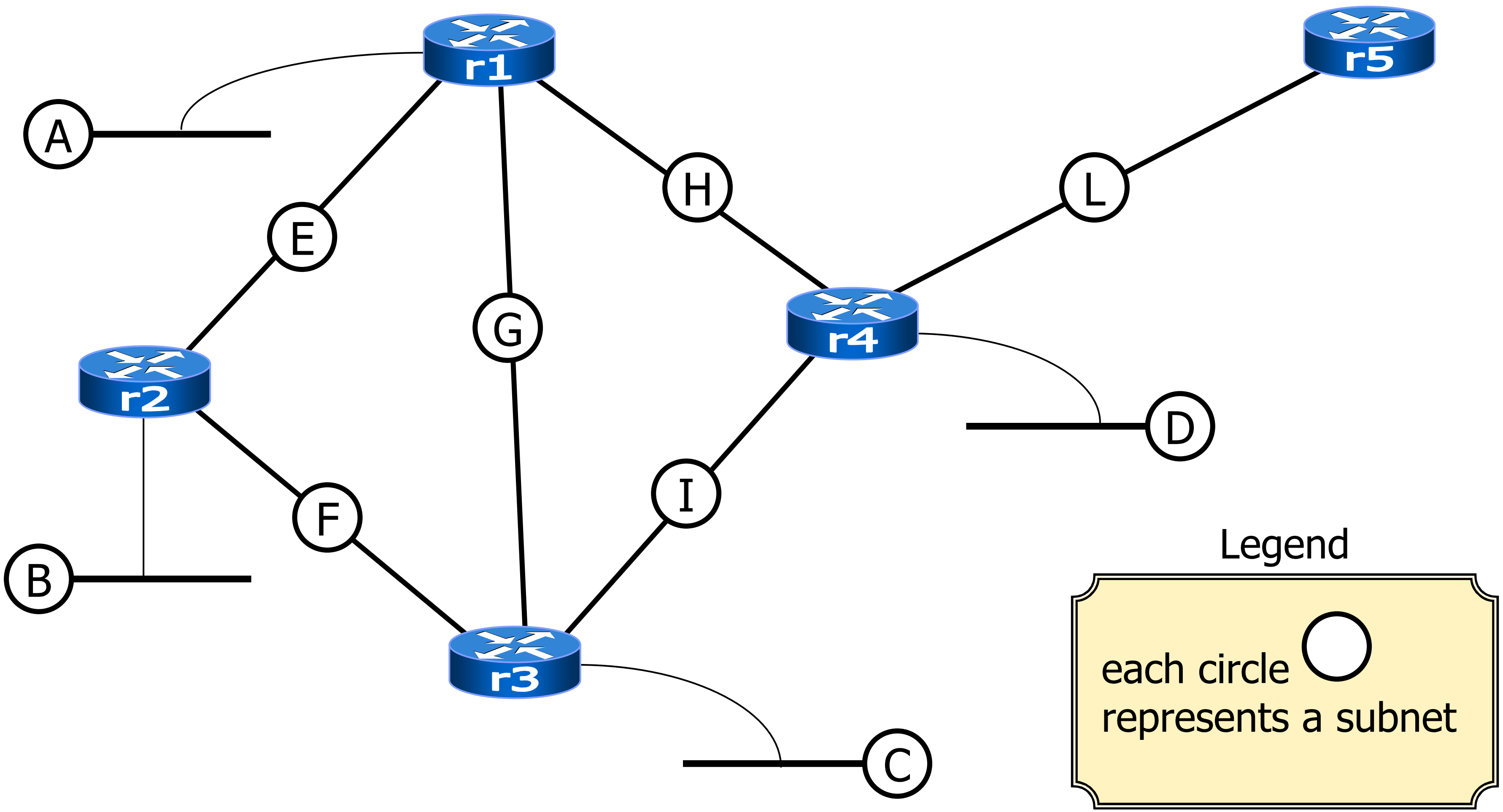
redistribute to rip neighbors information about all directly connected subnets

send rip multicast packets to interfaces falling into this prefix

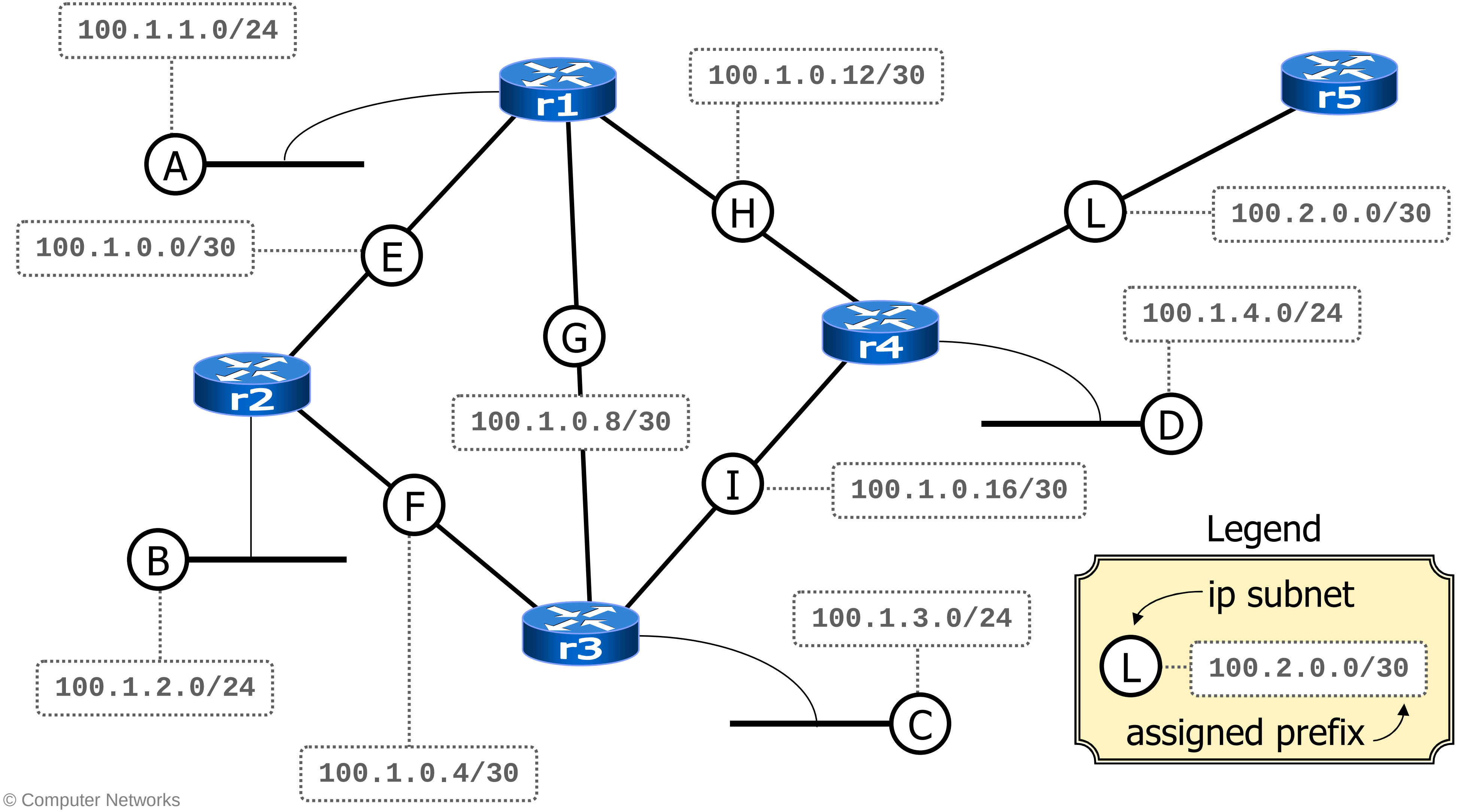
a small network connected to the Internet



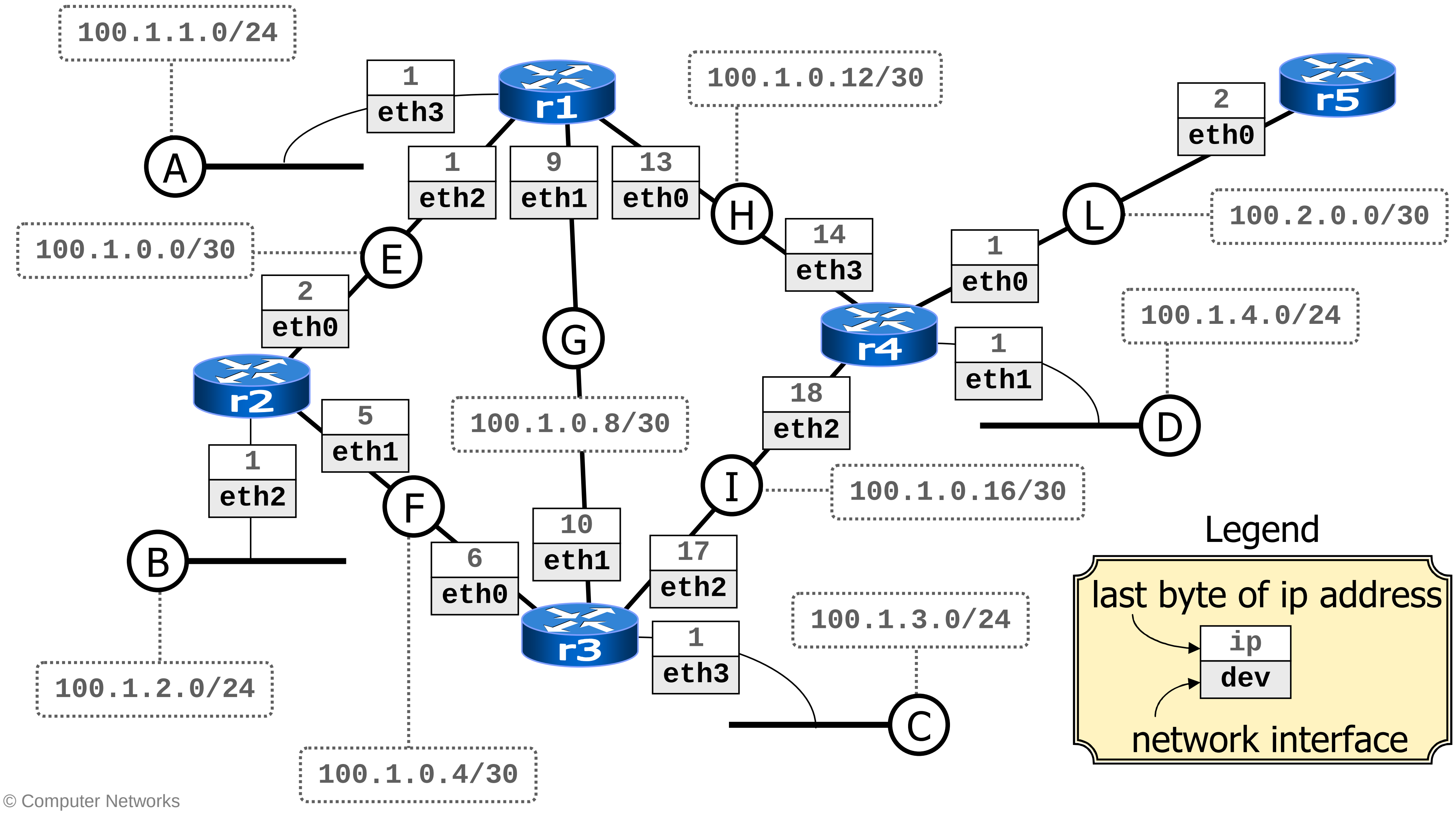
the involved ip subnets



assigning ip numbers to subnets



assigning ip numbers to interfaces



launching the lab script

host machine

```
user@localhost:~$ cd netkit-lab_rip
user@localhost:~/netkit-lab_rip$ lstart
```

- the lab configuration is such that
  - five virtual hosts are created and connected to the right collision domains (virtual hubs)
  - for each virtual host
    - network interfaces are automatically configured
    - configuration files **`/etc/zebra/daemons`**, **`/etc/zebra/zebra.conf`**, and **`/etc/zebra/ripd.conf`** are updated
  - the zebra routing daemon is not automatically started

checking connectivity

- towards a directly connected destination

r4

```
r4:~# ping 100.1.0.13
PING 100.1.0.13 (100.1.0.13) 56(84) bytes of data.
64 bytes from 100.1.0.13: icmp_seq=1 ttl=64 time=1.23 ms
64 bytes from 100.1.0.13: icmp_seq=2 ttl=64 time=0.592 ms
64 bytes from 100.1.0.13: icmp_seq=3 ttl=64 time=0.393 ms

--- 100.1.0.13 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2032ms
rtt min/avg/max/mdev = 0.393/0.741/1.238/0.360 ms
r4:~#
```

checking connectivity

- towards a remote destination

r4

```
r4:~# ping 100.1.2.1
connect: Network is unreachable
r4:~#
```

- what's going on?

examining the kernel routing table

```
r4:~# route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
100.1.0.16      *               255.255.255.252 U     0      0        0 eth2
100.2.0.0       *               255.255.255.252 U     0      0        0 eth0
100.1.0.12      *               255.255.255.252 U     0      0        0 eth3
100.1.4.0       *               255.255.255.0   U     0      0        0 eth1
r4:~#
```

- since no routing daemon is currently running, only directly connected destinations are known to the router

starting the routing daemons

- on each router (but **r5**) issue the following command:

```
r4:~# /etc/init.d/zebra start
Starting Zebra daemons (prio:10): zebra ripd.
r4:~# █
```

checking connectivity (again)

- towards a remote destination

```
r4:~# ping 100.1.2.1
PING 100.1.2.1 (100.1.2.1) 56(84) bytes of data.
64 bytes from 100.1.2.1: icmp_seq=1 ttl=63 time=0.743 ms
64 bytes from 100.1.2.1: icmp_seq=2 ttl=63 time=0.875 ms
64 bytes from 100.1.2.1: icmp_seq=3 ttl=63 time=0.685 ms

--- 100.1.2.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2005ms
rtt min/avg/max/mdev = 0.685/0.767/0.875/0.085 ms
r4:~#
```

- after a while, all remote destinations are reachable

checking the routing table

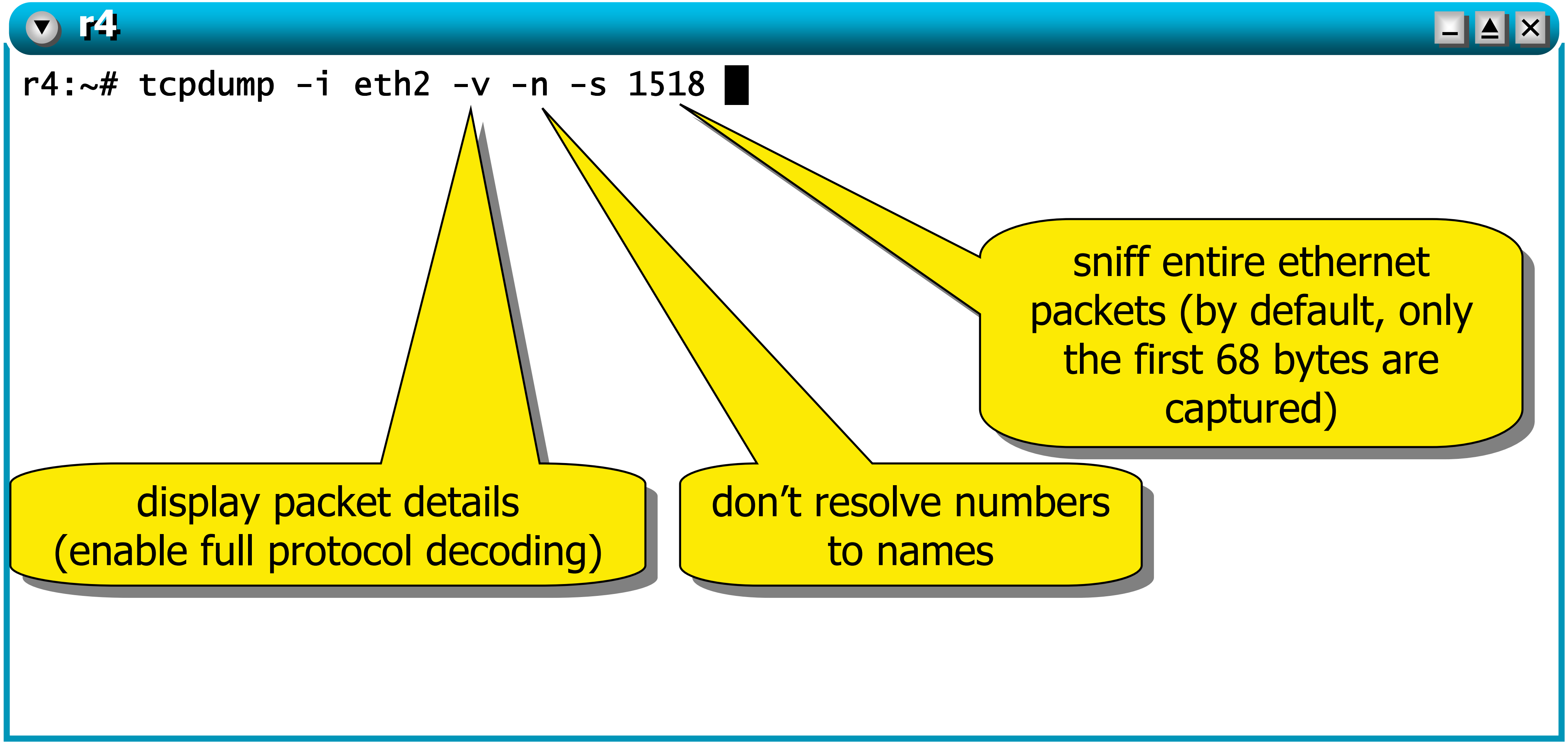
- the routing table is now updated

r4

```
r4:~# route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
100.1.0.16      *               255.255.255.252 U     0      0        0 eth2
100.1.0.0       100.1.0.13      255.255.255.252 UG    2      0        0 eth3
100.1.0.4       100.1.0.17      255.255.255.252 UG    2      0        0 eth2
100.2.0.0       *               255.255.255.252 U     0      0        0 eth0
100.1.0.8       100.1.0.17      255.255.255.252 UG    2      0        0 eth2
100.1.0.12      *               255.255.255.252 U     0      0        0 eth3
100.1.4.0       *               255.255.255.0   U     0      0        0 eth1
100.1.2.0       100.1.0.17      255.255.255.0   UG    3      0        0 eth2
100.1.3.0       100.1.0.17      255.255.255.0   UG    2      0        0 eth2
100.1.1.0       100.1.0.13      255.255.255.0   UG    2      0        0 eth3
r4:~#
```

a look at ripv2 packets

- let's sniff ripv2 packets



a look at ripv2 packets

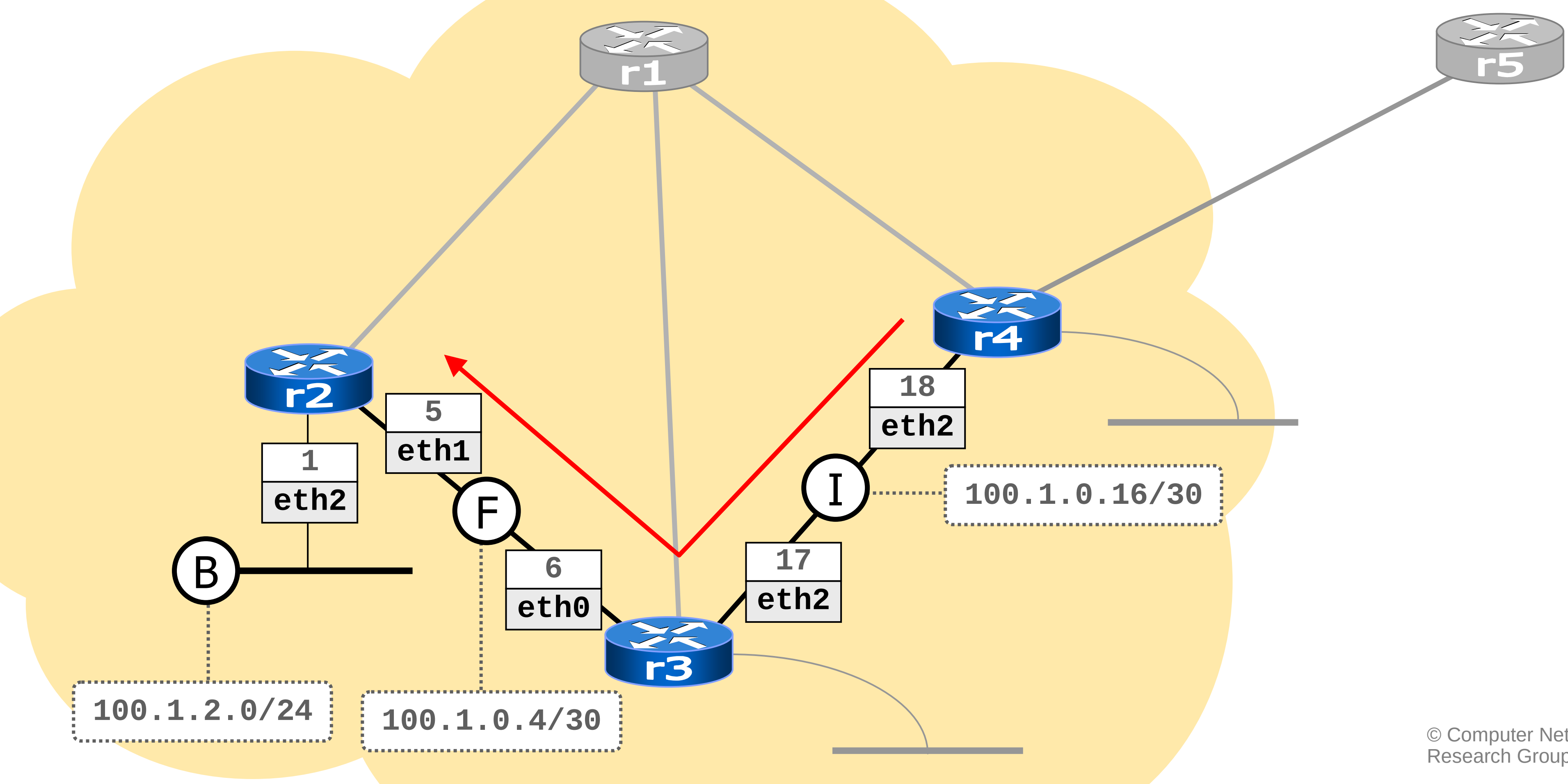
- let's sniff ripv2 packets

```
r4:~# tcpdump -i eth2 -v -n -s 1518
tcpdump: listening on eth2, link-type EN10MB (Ethernet), capture size 1518
bytes
16:47:48.333986 IP (tos 0x0, ttl   1, id 0, offset 0, flags [DF], length: 152)
100.1.0.17.520 > 224.0.0.9.520: [udp sum ok]
        RIPv2, Response, length: 124, routes: 6
          AFI: IPv4:       100.1.0.0/30, tag 0x0000, metric: 2, next-hop: self
          AFI: IPv4:       100.1.0.4/30, tag 0x0000, metric: 1, next-hop: self
          AFI: IPv4:       100.1.0.8/30, tag 0x0000, metric: 1, next-hop: self
          AFI: IPv4:       100.1.1.0/24, tag 0x0000, metric: 2, next-hop: self
          AFI: IPv4:       100.1.2.0/24, tag 0x0000, metric: 2, next-hop: self
          AFI: IPv4:       100.1.3.0/24, tag 0x0000, metric: 1, next-hop: self

1 packets captured
1 packets received by filter
0 packets dropped by kernel
r4:~#
```

a traceroute

r4

```
r4:~# traceroute 100.1.2.1
traceroute to 100.1.2.1 (100.1.2.1), 64 hops max, 40 byte packets
 1  100.1.0.17 (100.1.0.17)  10 ms  3 ms  1 ms
 2  100.1.2.1 (100.1.2.1)  15 ms  1 ms  1 ms
r4:~#
```



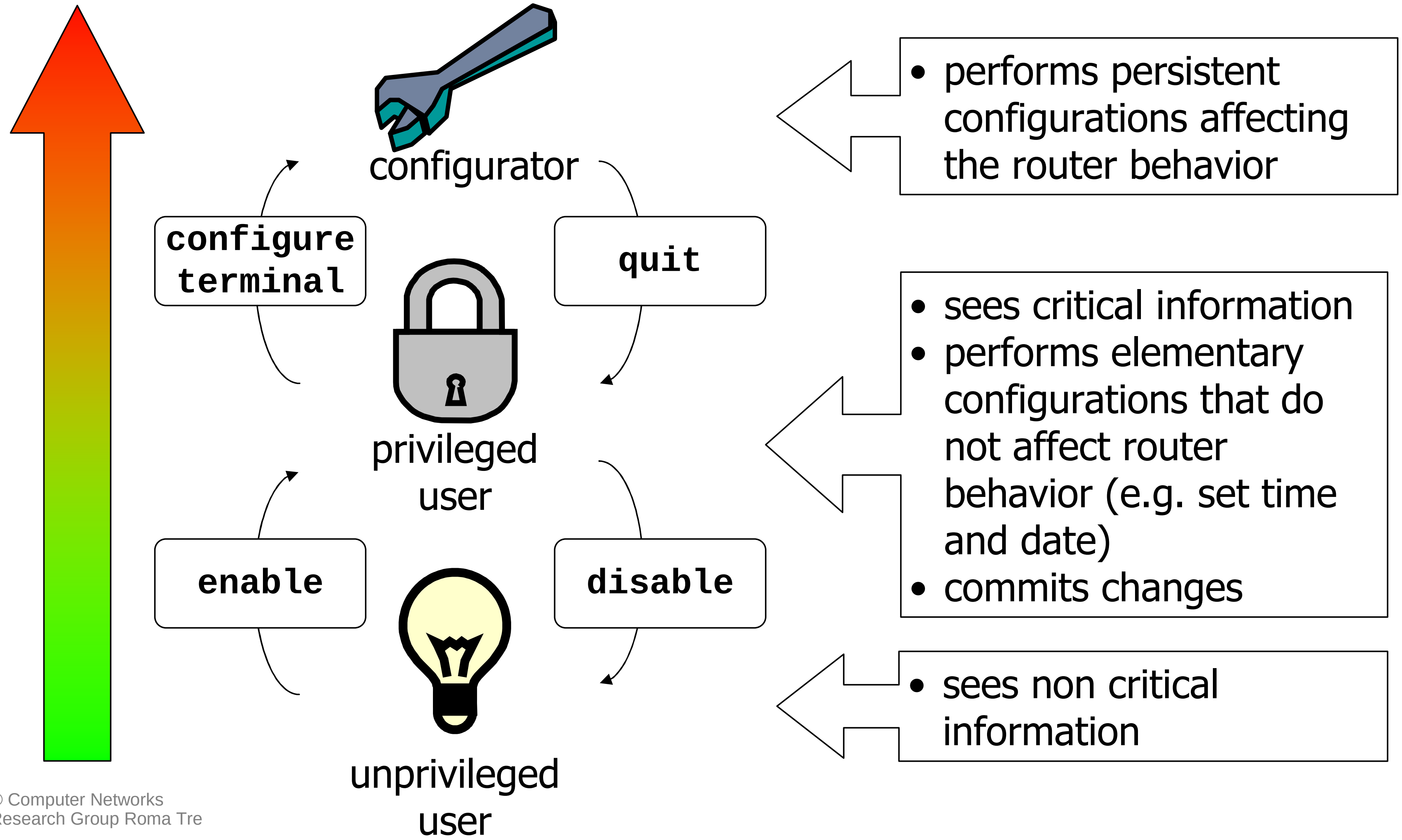
connecting to the main zebra daemon

r4

```
r4:~# telnet localhost zebra
Trying 127.0.0.1...
Connected to r4.
Escape character is '^]'.

Hello, this is zebra (version 0.94).
Copyright 1996-2002 Kunihiro Ishiguro.


User Access Verification

Password: zebra
zebra>
```

we are
unprivileged users

privileges on a router



available commands

- press '?' at the command prompt…

r4

```
zebra>
  enable    Turn on privileged mode command
  exit      Exit current mode and down to previous mode
  help      Description of the interactive help system
  list      Print command list
  quit      Exit current mode and down to previous mode
  show      Show running system information
  terminal  Set terminal line parameters
  who       Display who is on vty
zebra>
```

- …or…

available commands

- …type ‘list’ (an excerpt of the output follows)

r4

```
zebra> list
  enable
  exit
  help
  list
  quit
  show interface [IFNAME]
  show ip forwarding
  show ip route
  show ipv6 forwarding
  show ipv6 route
  show memory
  show version
  terminal length <0-512>
  terminal no length
  who
zebra>
```

inspecting interfaces

r4

```
zebra> show interface eth0
Interface eth0
  index 1 metric 1 mtu 1500 <UP,BROADCAST,RUNNING,MULTICAST>
  HWaddr: fe:fd:64:02:00:01
  inet 100.2.0.1/30 broadcast 100.2.0.3
  inet6 fe80::fcfd:64ff:fe02:1/64
    input packets 5, bytes 308, dropped 0, multicast packets 0
    input errors 0, length 0, overrun 0, CRC 0, frame 0, fifo 0, missed 0
    output packets 6, bytes 488, dropped 0
    output errors 0, aborted 0, carrier 0, fifo 0, heartbeat 0, window 0
    collisions 0
zebra>
```

- this roughly corresponds to using **`ifconfig`** at the shell prompt

inspecting the zebra routing table

r4

```
zebra> show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP, O - OSPF,
       B - BGP, > - selected route, * - FIB route

R>* 100.1.0.0/30 [120/2] via 100.1.0.13, eth3, 01:28:42
R>* 100.1.0.4/30 [120/2] via 100.1.0.17, eth2, 01:28:52
R>* 100.1.0.8/30 [120/2] via 100.1.0.17, eth2, 01:28:52
C>* 100.1.0.12/30 is directly connected, eth3
C>* 100.1.0.16/30 is directly connected, eth2
R>* 100.1.1.0/24 [120/2] via 100.1.0.13, eth3, 01:28:42
R>* 100.1.2.0/24 [120/3] via 100.1.0.17, eth2, 01:28:47
R>* 100.1.3.0/24 [120/2] via 100.1.0.17, eth2, 01:28:52
C>* 100.1.4.0/24 is directly connected, eth1
C>* 100.2.0.0/30 is directly connected, eth0
C>* 127.0.0.0/8 is directly connected, lo
zebra>
```

- FIB entries from this table (marked with a '>') are injected into the kernel routing table

altering zebra configuration

- unprivileged user mode
- privileged user mode
- configurator mode

r4

```
zebra> enable
Password: zebra
zebra# configure terminal
zebra(config)# hostname zebra-r4
zebra-r4(config)# password foo
zebra-r4(config)# enable password foo
zebra-r4(config)# quit
zebra-r4# write file
Configuration saved to /etc/zebra/zebra.conf
zebra-r4# disable
zebra-r4> exit
Connection closed by foreign host.
r4:~#
```

- `zebra> enable` — enter privileged user mode
- `zebra# configure terminal` — start editing configuration
- `hostname zebra-r4`, `password foo`, `enable password foo` — edit configuration
- `quit` — stop editing configuration
- `write file` — write changes to file
- `disable` — exit privileged user mode
- `exit` — exit

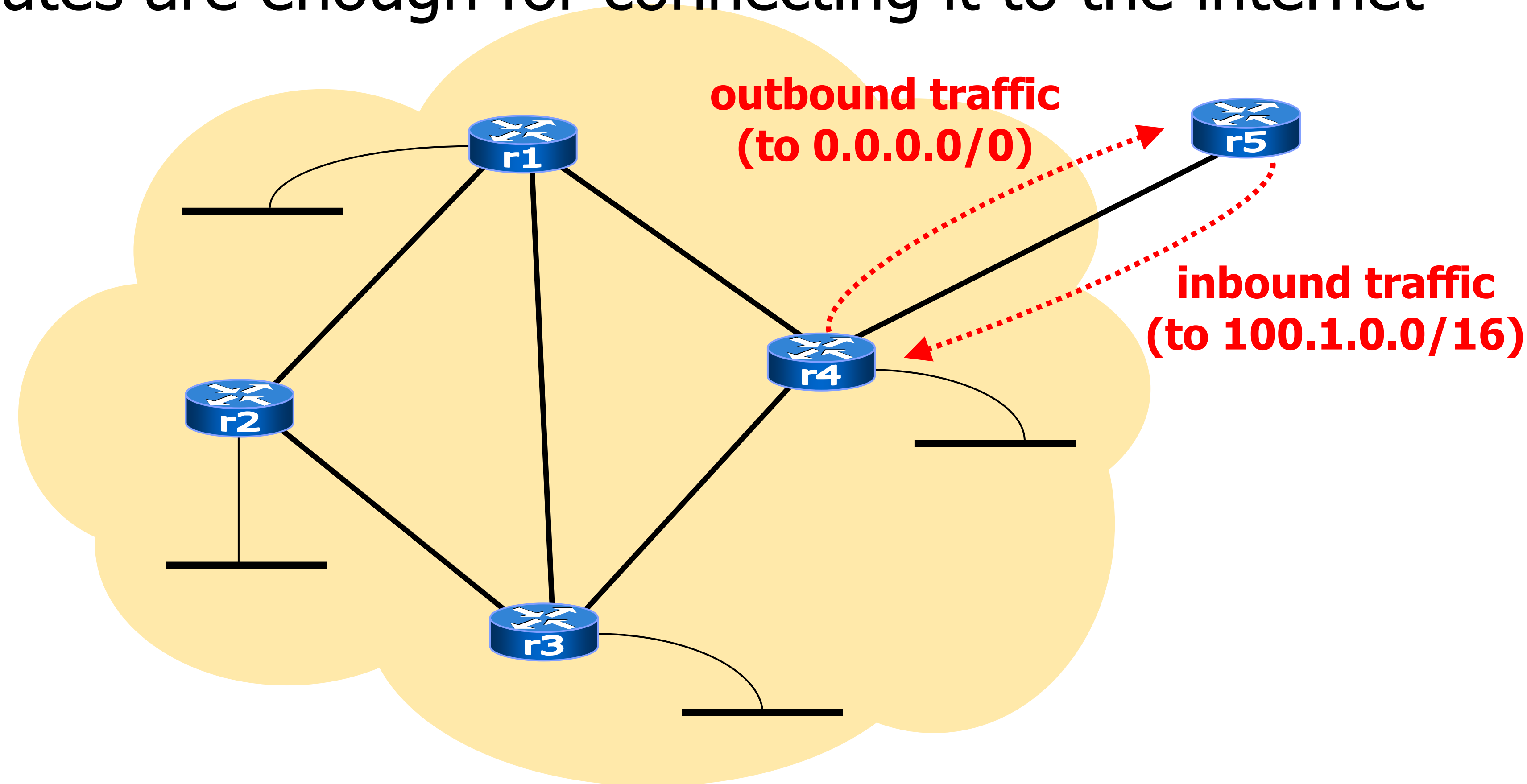
inspecting the rip routing table

r4

```
r4:~# telnet localhost ripd
......
Password: zebra
ripd> show ip rip
Codes: R - RIP, C - connected, O - OSPF, B - BGP
      (n) - normal, (s) - static, (d) - default, (r) - redistribute,
      (i) - interface

     Network            Next Hop         Metric From            Time
R(n) 100.1.0.0/30       100.1.0.13            2 100.1.0.13      02:43
R(n) 100.1.0.4/30       100.1.0.17            2 100.1.0.17      02:46
R(n) 100.1.0.8/30       100.1.0.17            2 100.1.0.17      02:46
C(i) 100.1.0.12/30      0.0.0.0               1 self
C(i) 100.1.0.16/30      0.0.0.0               1 self
R(n) 100.1.1.0/24       100.1.0.13            2 100.1.0.13      02:43
R(n) 100.1.2.0/24       100.1.0.17            3 100.1.0.17      02:46
R(n) 100.1.3.0/24       100.1.0.17            2 100.1.0.17      02:46
C(i) 100.1.4.0/24       0.0.0.0               1 self
C(r) 100.2.0.0/30       0.0.0.0               1 self
ripd> █
```

static routing

- our network is a stub network (i.e., it has just one connection to an external router, **`r5`**); hence, static routes are enough for connecting it to the internet

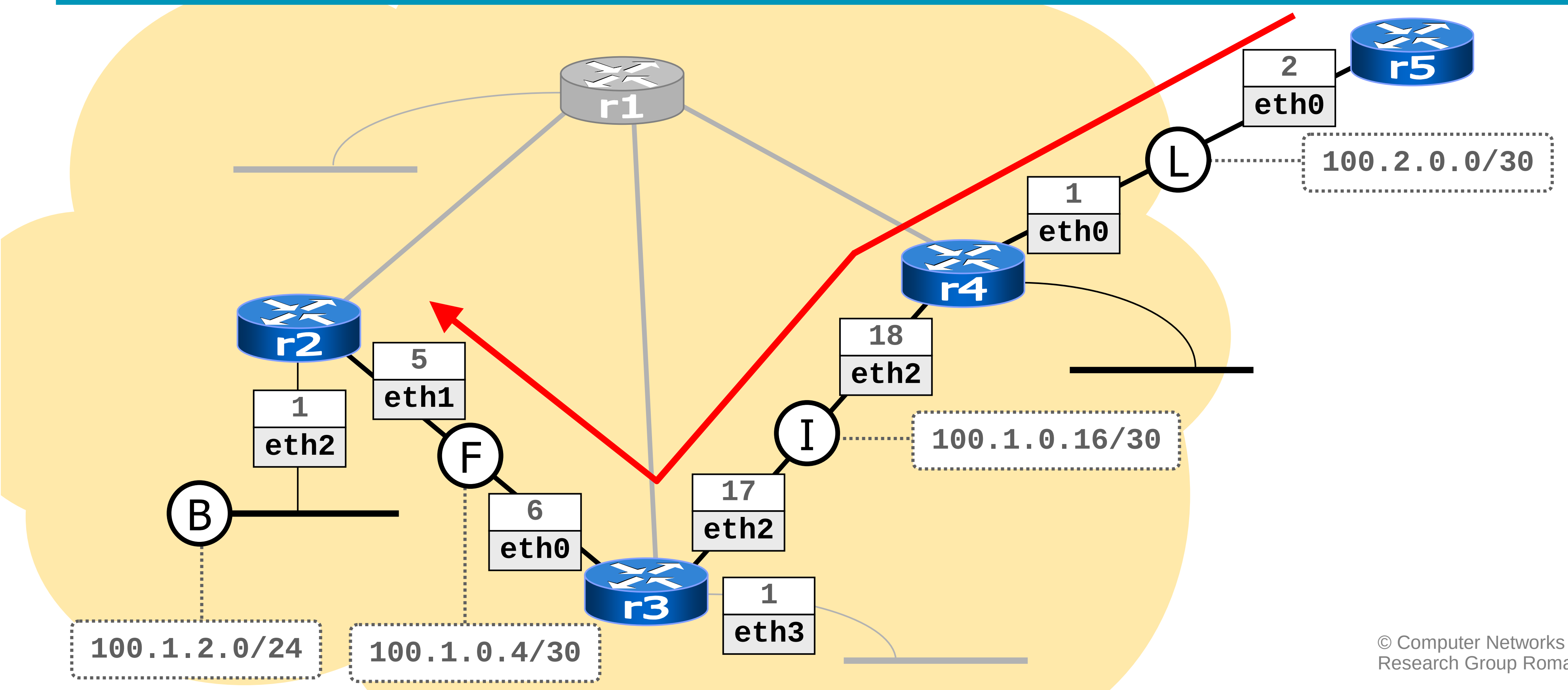


adding a static route to **r5**

```
r5:~# route add -net 100.1.0.0/16 gw 100.2.0.1
r5:~# ping 100.1.2.1
PING 100.1.2.1 (100.1.2.1) 56(84) bytes of data.
64 bytes from 100.1.2.1: icmp_seq=1 ttl=62 time=24.1 ms
64 bytes from 100.1.2.1: icmp_seq=2 ttl=62 time=1.11 ms

--- 100.1.2.1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1023ms
rtt min/avg/max/mdev = 1.117/12.634/24.151/11.517 ms
r5:~#
```

checking connectivity

```
r5:~# traceroute 100.1.2.1
traceroute to 100.1.2.1 (100.1.2.1), 64 hops max, 40 byte packets
 1  100.2.0.1 (100.2.0.1)  75 ms  1 ms  2 ms
 2  100.1.0.17 (100.1.0.17)  7 ms  1 ms  1 ms
 3  100.1.2.1 (100.1.2.1)  24 ms  3 ms  1 ms
r5:~#
```



configuring r4

- step 1: configuring the default route

r4

```
r4:~# route add default gw 100.2.0.2
r4:~# route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
100.1.0.16      *               255.255.255.252 U     0      0        0 eth2
100.1.0.0       100.1.0.13      255.255.255.252 UG    2      0        0 eth3
100.1.0.4       100.1.0.17      255.255.255.252 UG    2      0        0 eth2
100.2.0.0       *               255.255.255.252 U     0      0        0 eth0
100.1.0.8       100.1.0.17      255.255.255.252 UG    2      0        0 eth2
100.1.0.12      *               255.255.255.252 U     0      0        0 eth3
100.1.4.0       *               255.255.255.0   U     0      0        0 eth1
100.1.2.0       100.1.0.17      255.255.255.0   UG    3      0        0 eth2
100.1.3.0       100.1.0.17      255.255.255.0   UG    2      0        0 eth2
100.1.1.0       100.1.0.13      255.255.255.0   UG    2      0        0 eth3
default         100.2.0.2       0.0.0.0         UG    0      0        0 eth0
r4:~# █
```

configuring r4

- step 2: propagating the default route into rip

r4

```
r4:~# telnet localhost ripd
Trying 127.0.0.1...
Connected to r4.
Escape character is '^]'.

Hello, this is zebra (version 0.94).
Copyright 1996-2002 Kunihiro Ishiguro.


User Access Verification

Password: zebra
ripd> enable
Password: zebra
ripd# configure terminal
ripd(config)# router rip
ripd(config-router)# route 0.0.0.0/0
ripd(config-router)# quit
ripd(config)# quit
ripd# disable
ripd> exit
```

- work as a privileged user
- begin configuration
- configure the rip protocol
- statically configure the default route
- end of rip configuration
- end configuration
- abandon privileges

the default route

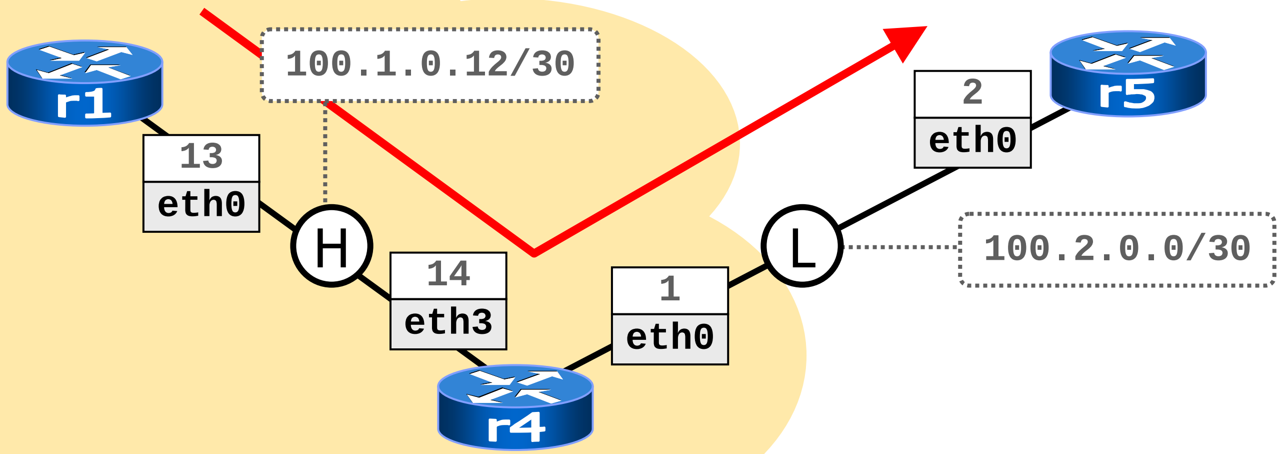
- after a while, the default route has been injected (via rip) into the network

```
r1
r1:~# route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
100.1.0.16      100.1.0.10      255.255.255.252 UG    2      0        0 eth1
100.1.0.0       *               255.255.255.252 U     0      0        0 eth2
100.2.0.0       100.1.0.14      255.255.255.252 UG    2      0        0 eth0
100.1.0.4       100.1.0.2       255.255.255.252 UG    2      0        0 eth2
100.1.0.8       *               255.255.255.252 U     0      0        0 eth1
100.1.0.12      *               255.255.255.252 U     0      0        0 eth0
100.1.4.0       100.1.0.14      255.255.255.0   UG    2      0        0 eth0
100.1.2.0       100.1.0.2       255.255.255.0   UG    2      0        0 eth2
100.1.3.0       100.1.0.10      255.255.255.0   UG    2      0        0 eth1
100.1.1.0       *               255.255.255.0   U     0      0        0 eth3
default         100.1.0.14      0.0.0.0         UG    2      0        0 eth0
r1:~#
```

checking connectivity

```
r1:~# ping 193.204.161.1
PING 193.204.161.1 (193.204.161.1) 56(84) bytes of data.
From 100.2.0.2 icmp_seq=1 Destination Net Unreachable
From 100.2.0.2 icmp_seq=2 Destination Net Unreachable

--- 193.204.161.1 ping statistics ---
2 packets transmitted, 0 received, +2 errors, 100% packet loss,
time 999ms

r1:~#
```

any (even non-existing) destination



checking connectivity

- **r5** is actually receiving echo request packets

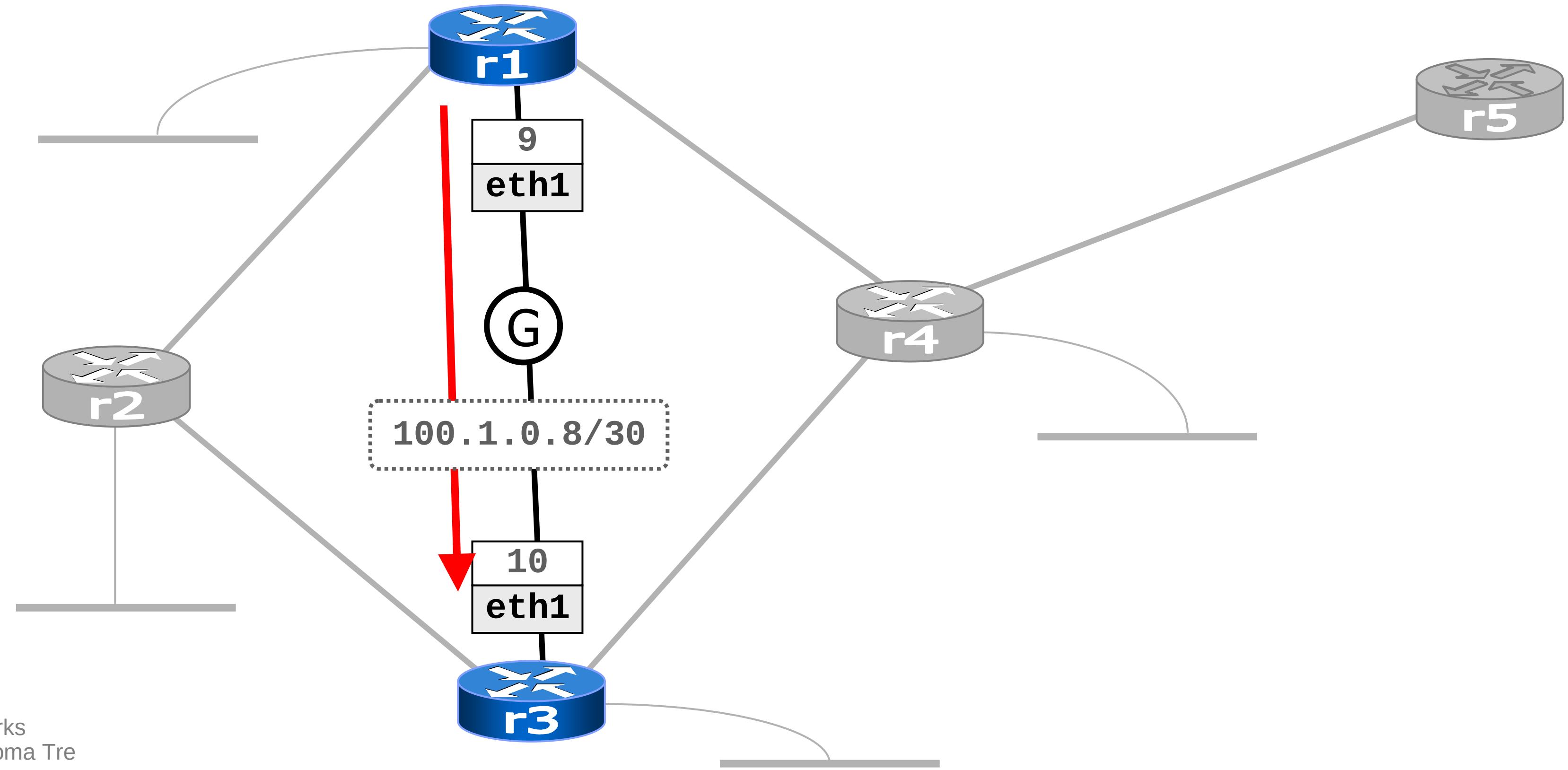
r5

```
r5:~# tcpdump -i eth0 -n -s 1518
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on eth0, link-type EN10MB (Ethernet), capture size 1518 bytes
11:38:43.822503 arp who-has 100.2.0.2 tell 100.2.0.1
11:38:43.824221 arp reply 100.2.0.2 is-at fe:fd:64:02:00:02
11:38:43.825890 IP 100.1.0.13 > 193.204.161.1: icmp 64: echo request seq 1
11:38:43.827139 IP 100.2.0.2 > 100.1.0.13: icmp 92: net 193.204.161.1
unreachable
11:38:44.841566 IP 100.1.0.13 > 193.204.161.1: icmp 64: echo request seq 2
11:38:44.841651 IP 100.2.0.2 > 100.1.0.13: icmp 92: net 193.204.161.1
unreachable

6 packets captured
6 packets received by filter
0 packets dropped by kernel
r5:~#
```

shutting down an interface

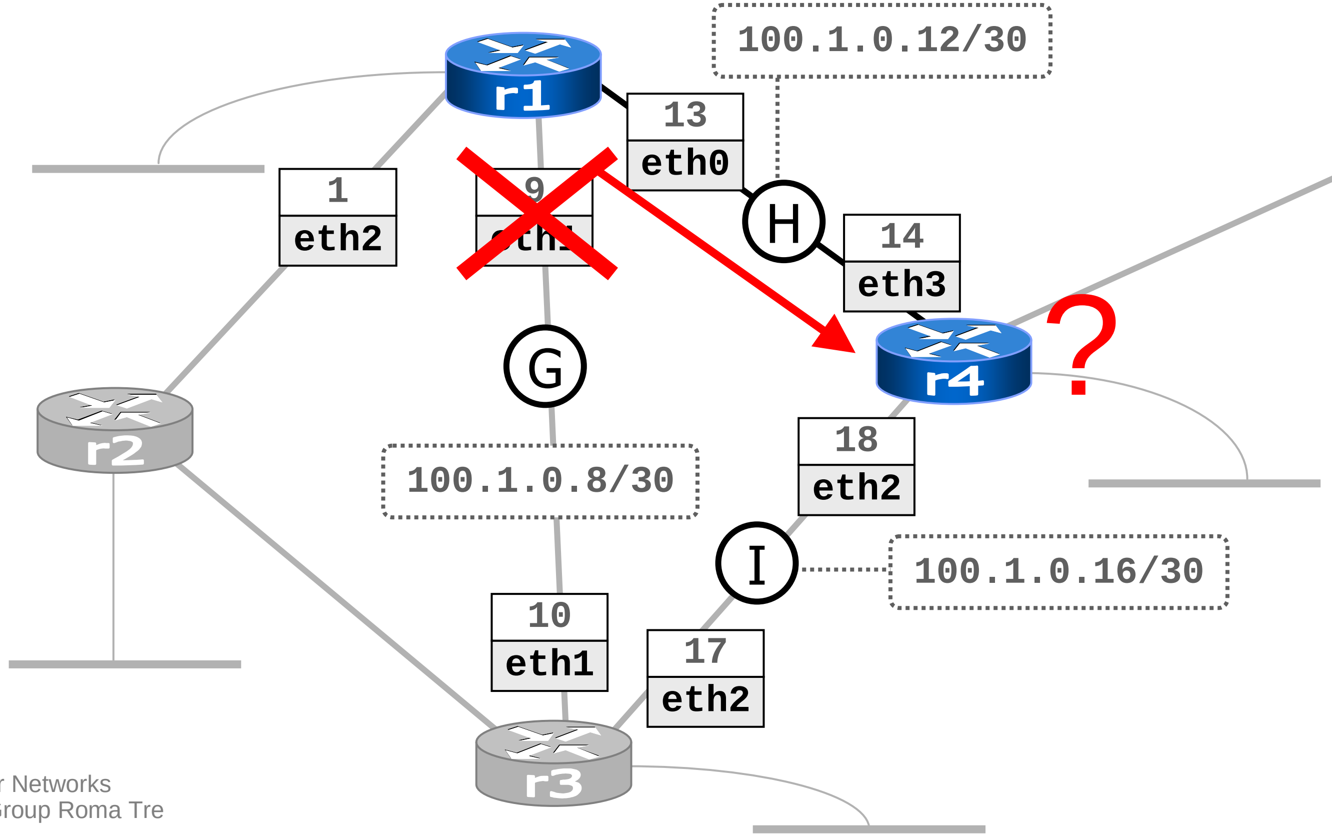
r1

```
r1:~# traceroute 100.1.0.10
traceroute to 100.1.0.10 (100.1.0.10), 64 hops max, 40 byte packets
 1  100.1.0.10 (100.1.0.10)  24 ms  1 ms  1 ms
r1:~# ifconfig eth1 down
```



shutting down an interface

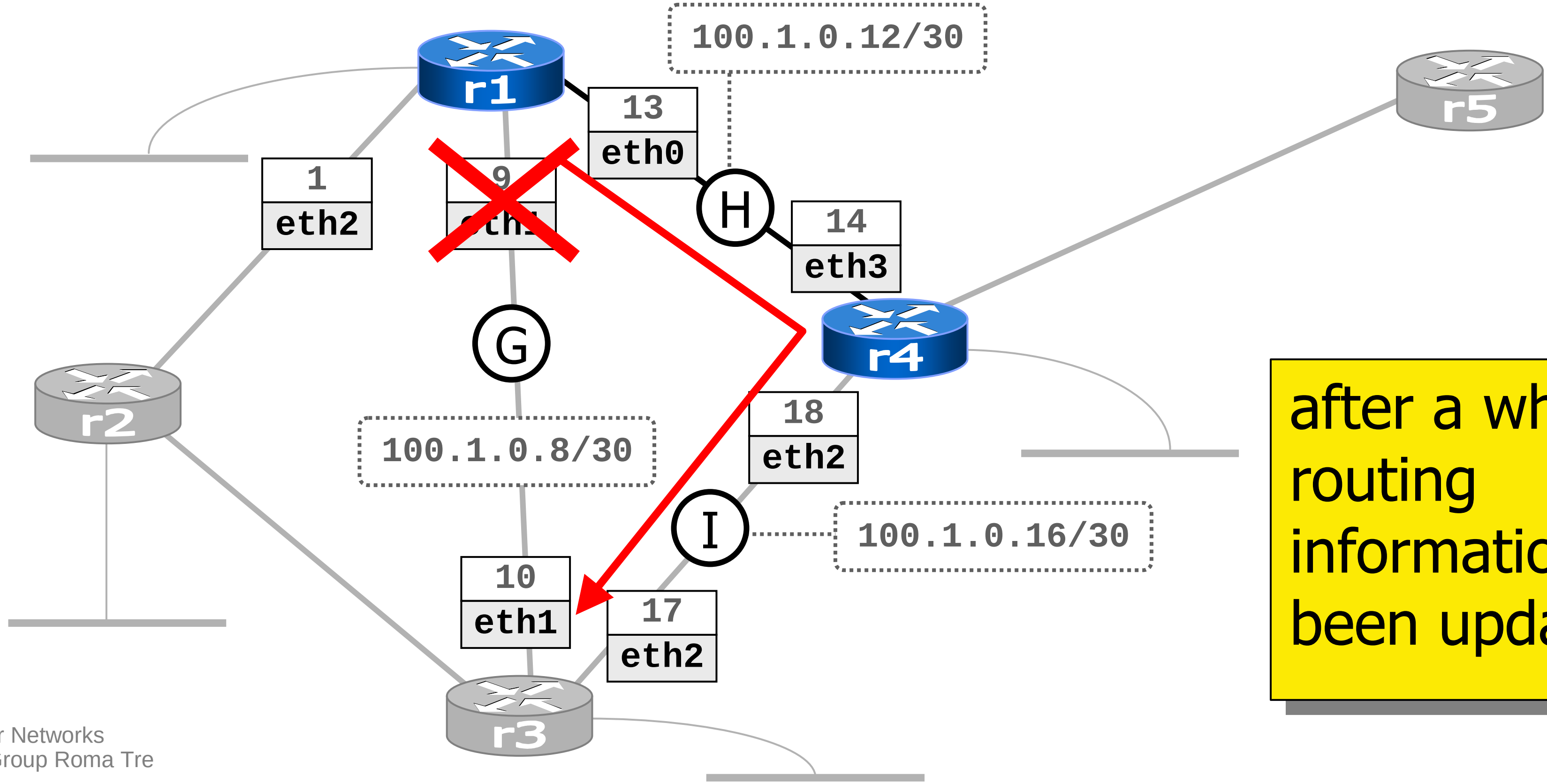
```
r1:~# traceroute 100.1.0.10
traceroute to 100.1.0.10 (100.1.0.10), 64 hops max, 40 byte packets
 1  100.1.0.14 (100.1.0.14)  1 ms  1 ms  1 ms
 2  * * *
 3  * * *
```



r1 attempts forwarding the packet using the default route

shutting down an interface

```
r1:~# traceroute 100.1.0.10
traceroute to 100.1.0.10 (100.1.0.10), 64 hops max, 40 byte packets
 1  100.1.0.14 (100.1.0.14)  1 ms  1 ms  1 ms
 2  100.1.0.10 (100.1.0.10)  5 ms  2 ms  1 ms
r1:~#
```



after a while, routing information has been updated

shutting down an interface

- **r1**'s routing table has been updated

```
r1:~# route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
100.1.0.16      100.1.0.14      255.255.255.252 UG    2      0        0 eth0
100.1.0.0       *               255.255.255.252 U     0      0        0 eth2
100.2.0.0       100.1.0.14      255.255.255.252 UG    2      0        0 eth0
100.1.0.4       100.1.0.2       255.255.255.252 UG    2      0        0 eth2
100.1.0.8       100.1.0.14      255.255.255.252 UG    3      0        0 eth0
100.1.0.12      *               255.255.255.252 U     0      0        0 eth0
100.1.4.0       100.1.0.14      255.255.255.0   UG    2      0        0 eth0
100.1.2.0       100.1.0.2       255.255.255.0   UG    2      0        0 eth2
100.1.3.0       100.1.0.14      255.255.255.0   UG    3      0        0 eth0
100.1.1.0       *               255.255.255.0   U     0      0        0 eth3
default         100.1.0.14      0.0.0.0         UG    2      0        0 eth0
r1:~#
```