Addressing and Forwarding

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Problem Statement

- Flat Addressing: N hosts needs N entries in the table (MAC addresses)
- Millions of hosts, address lookup in forwarding becomes a bottleneck
- Need a method of reducing entries in the forwarding table for scalability purposes

MAC
↓

Vijay, son of Ajay, grandson of Sanjay - . . . Air India flight

Rinki, daughter of Pinki, granddaughter of Dinky - . . . Air India flight

⋮ ⋮

IP → Lst of countries

India - Air India flight

⋮

India, Mumbai, Powai, B-4, Vijay

India, Delhi, Dwaraka, D-16, Rinki

⋮

Solution: Hierarchical Addressing

- Structure to addresses: Address captures location in the network topology
- IP address (32 bits) consists of two parts: network and host
  - Network part identifies the network to which host is connected
  - Host part uniquely identifies each host in the network
- How does this help? ← 30,000
  - An entire network (in some specific direction) could be represented by a single entry at a router → network Portion 1 entry

IP Address

- Size of network and host part are not the same
- Organizations obtain set of addresses of a given class
- Divided into five classes

  $2^7 = 128$ 2^{24}

  - Class A: 0, network(7), host(24); Mask 8

    32 bits

    31 bits
  - Class B: 10, network(14), host(16); Mask 16

    2^{16} host
  - Class C:110, network(21), host(8); Mask 24
  - Class D: 1110, bits-28 (Multicast)
  - Class E: 1111, bits 28 (Reserved)

IP Address

↱ not allocated to organizations

- Private IP addresses:
  - A: 10.0.0.0 through 10.255.255.255 ↱ IIT Bombay
  - B: 172.16.0.0 through 172.31.0.0
  - C: 192.168.0.0 through 192.168.255.0. ↗ wifi AP
  - 127.0.0.1 is loopback address.

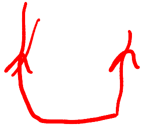
NAT

127.0.0.0 to 127.255.255.255

loopback address block

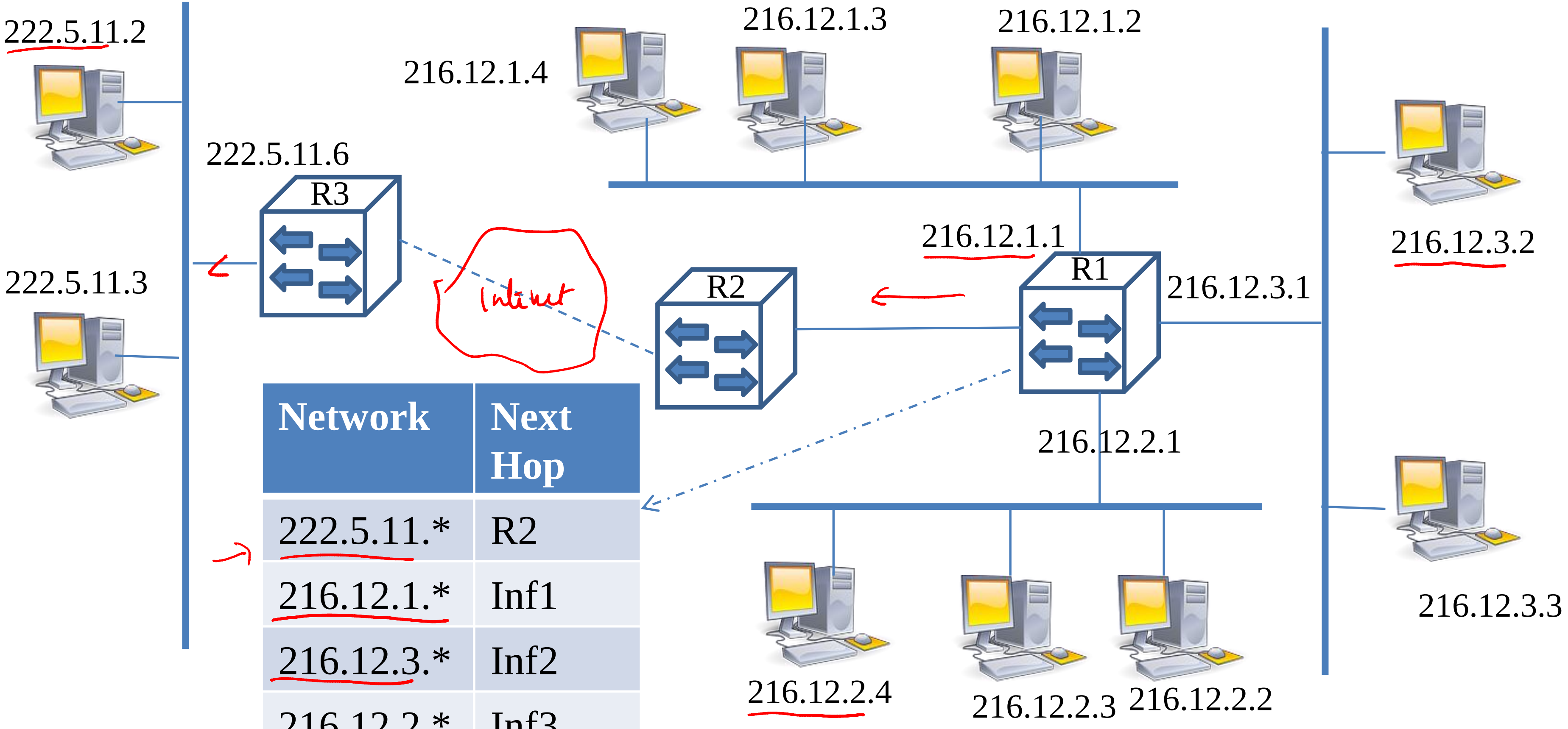
↳ with host

ifconfig lo



Example: Class C

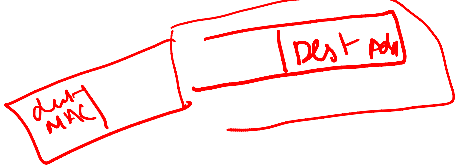
216.12.1.*



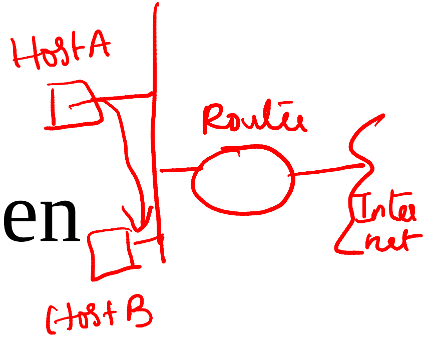
Network	Next Hop
222.5.11.*	R2
216.12.1.*	Inf1
216.12.3.*	Inf2
216.12.2.*	Inf3

Points to Note

- Every datagram contains IP address of destination host
  - Network part of IP address uniquely identifies a single physical network
- All nodes that share the same network part are connected to the same physical network
- Every physical network has at least one router that is connected to at least one other physical network.

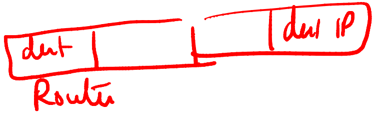


Forwarding at Host



- If (NetNum of Dest = my NetNum) then
  - deliver packet to destination directly
  - use ARP to get MAC address corresponding to dest IP address

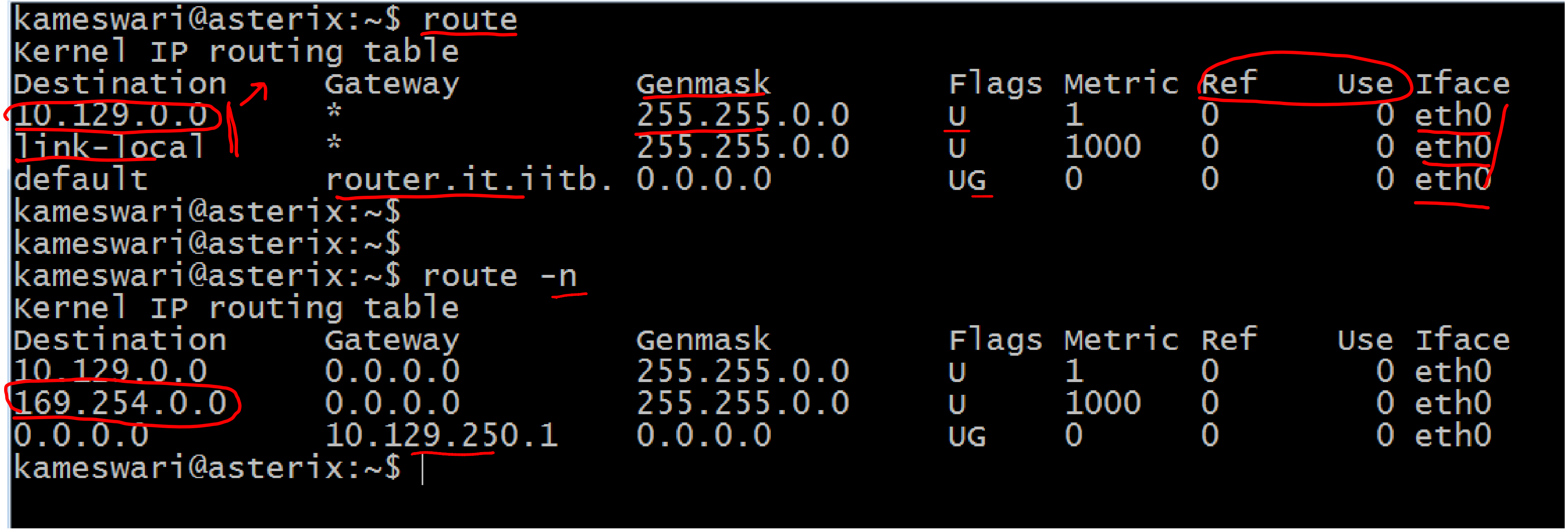
  Else deliver packet to default router
  - use ARP to get MAC address corresponding to router IP address



Linux Usage

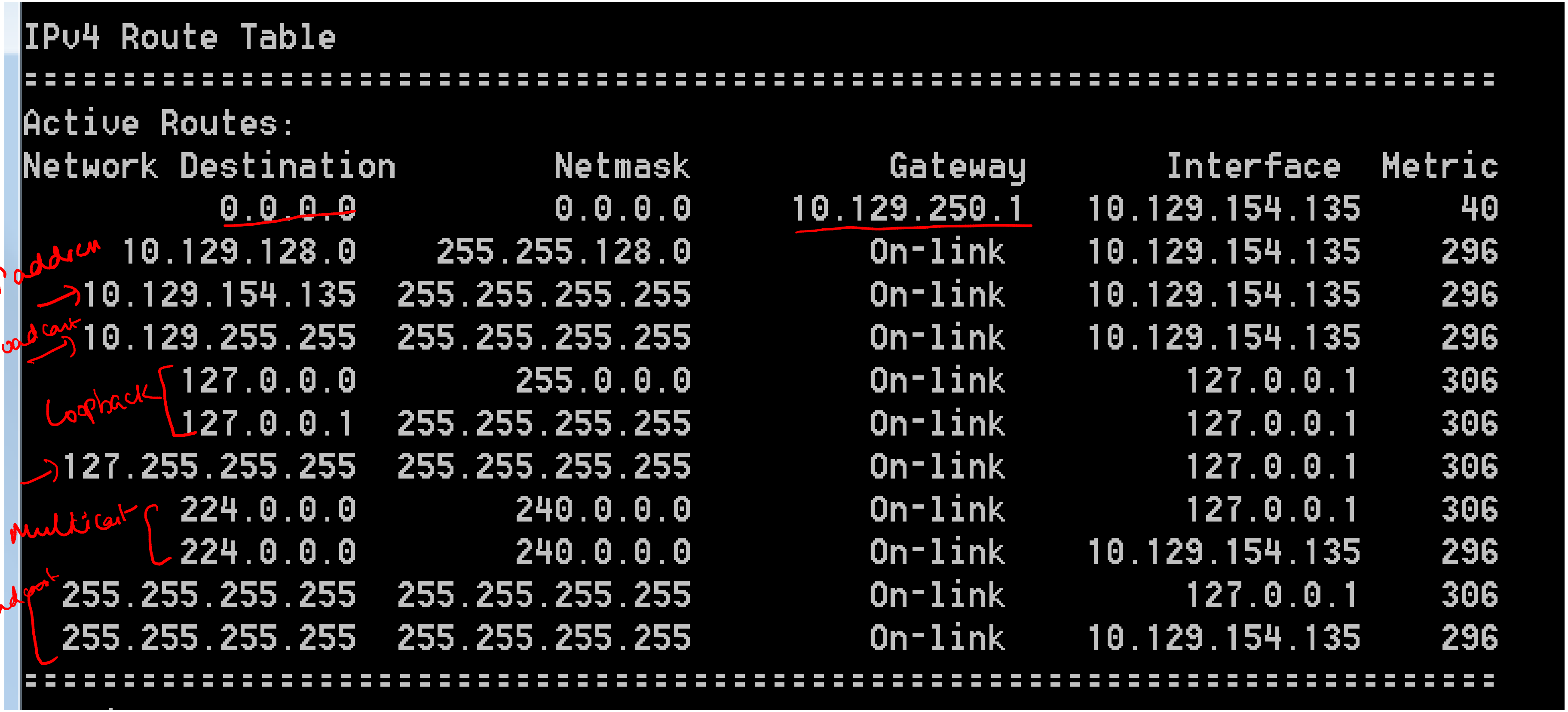
eth0 eth1

1 1000



```
kameswari@asterix:~$ route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.129.0.0      *               255.255.0.0     U     1      0        0 eth0
link-local      *               255.255.0.0     U     1000   0        0 eth0
default         router.it.iitb. 0.0.0.0         UG    0      0        0 eth0
kameswari@asterix:~$
kameswari@asterix:~$
kameswari@asterix:~$ route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.129.0.0      0.0.0.0         255.255.0.0     U     1      0        0 eth0
169.254.0.0     0.0.0.0         255.255.0.0     U     1000   0        0 eth0
0.0.0.0         10.129.250.1    0.0.0.0         UG    0      0        0 eth0
kameswari@asterix:~$
```

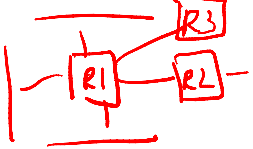
Windows Usage



```
IPv4 Route Table
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0     10.129.250.1  10.129.154.135     40
      10.129.128.0    255.255.128.0         On-link  10.129.154.135    296
    10.129.154.135  255.255.255.255         On-link  10.129.154.135    296
    10.129.255.255  255.255.255.255         On-link  10.129.154.135    296
         127.0.0.0        255.0.0.0         On-link       127.0.0.1    306
         127.0.0.1  255.255.255.255         On-link       127.0.0.1    306
   127.255.255.255  255.255.255.255         On-link       127.0.0.1    306
         224.0.0.0        240.0.0.0         On-link       127.0.0.1    306
         224.0.0.0        240.0.0.0         On-link  10.129.154.135    296
   255.255.255.255  255.255.255.255         On-link       127.0.0.1    306
   255.255.255.255  255.255.255.255         On-link  10.129.154.135    296
===========================================================================
```

Obtained via "route print" command

Forwarding at Router



- If (NetNum of Dest = NetNum of one of my interfaces) then
  - deliver packet to destination over that interface

  Else if (NetNum of Dest is in my forwarding table) then
  - deliver packet to NextHop router

  Else deliver packet to default router

Summary

- Top concern: Scalability
- Handled via hierarchical addressing
  - IP address has a network and a host part
  - Significantly reduces entries in forwarding table
- Looked at how forwarding is done at host and router based on the addressing scheme
- Ahead: Address assignment inefficiency