Calculate the total time required to transfer a 1.5 MB file in the following cases, assuming a RTT of 80 ms, a packet size of 1 KB data, and an initial 2×RTT of "handshaking" before data is sent.

(a) The bandwidth is 10 Mbps, and data packets can be sent continuously.

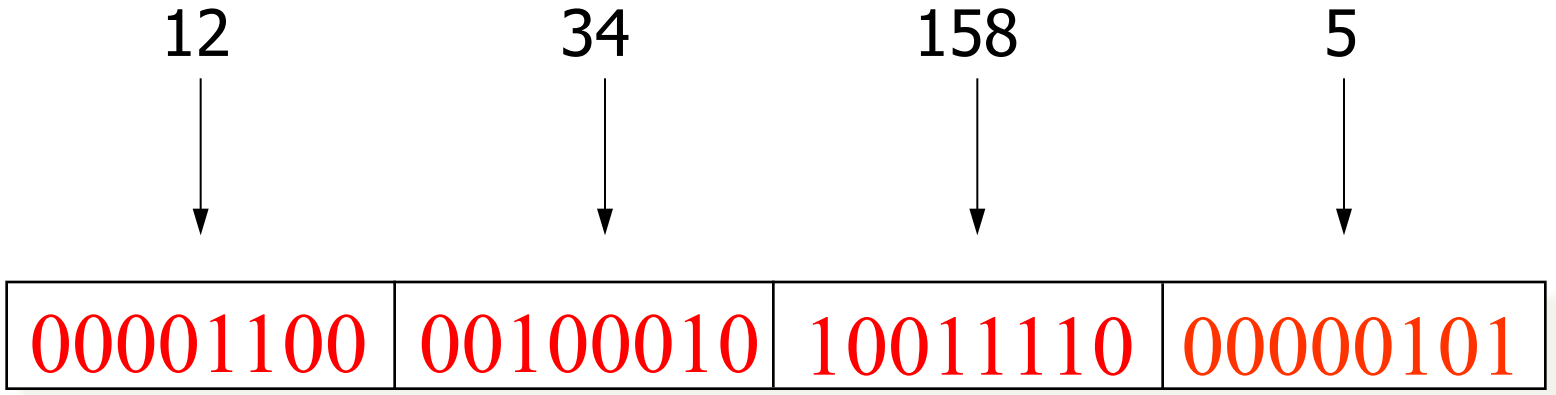
(b) The bandwidth is 10 Mbps, but after we finish sending each data packet we must wait one RTT before sending the next.

(c) The link allows infinitely fast transmit, but limits bandwidth such that only 20 packets can be sent per RTT.

(d) Zero transmit time as in (c), but during the first RTT we can send one packet, during the second RTT we can send two packets, during the third we can send four = 2^3−1, and so on.

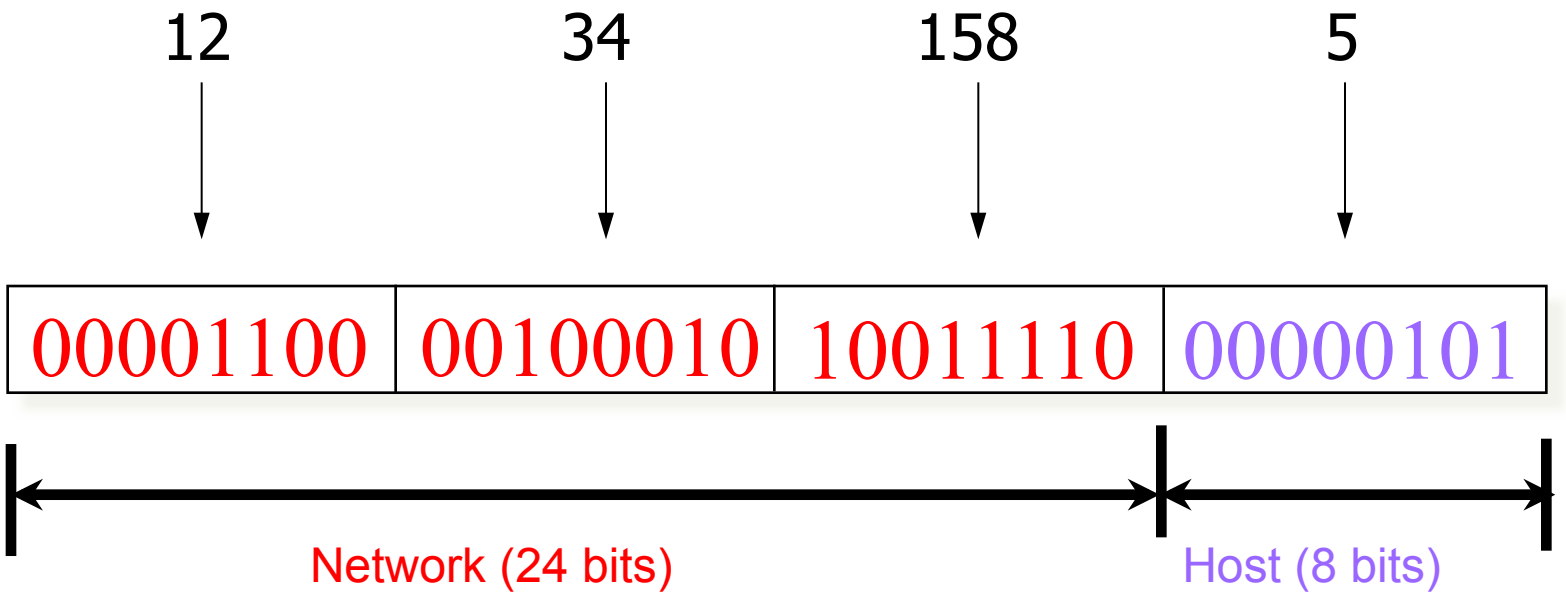
IP Address (IPv4)

- A unique 32-bit number
- Identifies an interface (on a host, on a router, …)
- Represented in dotted-quad notation



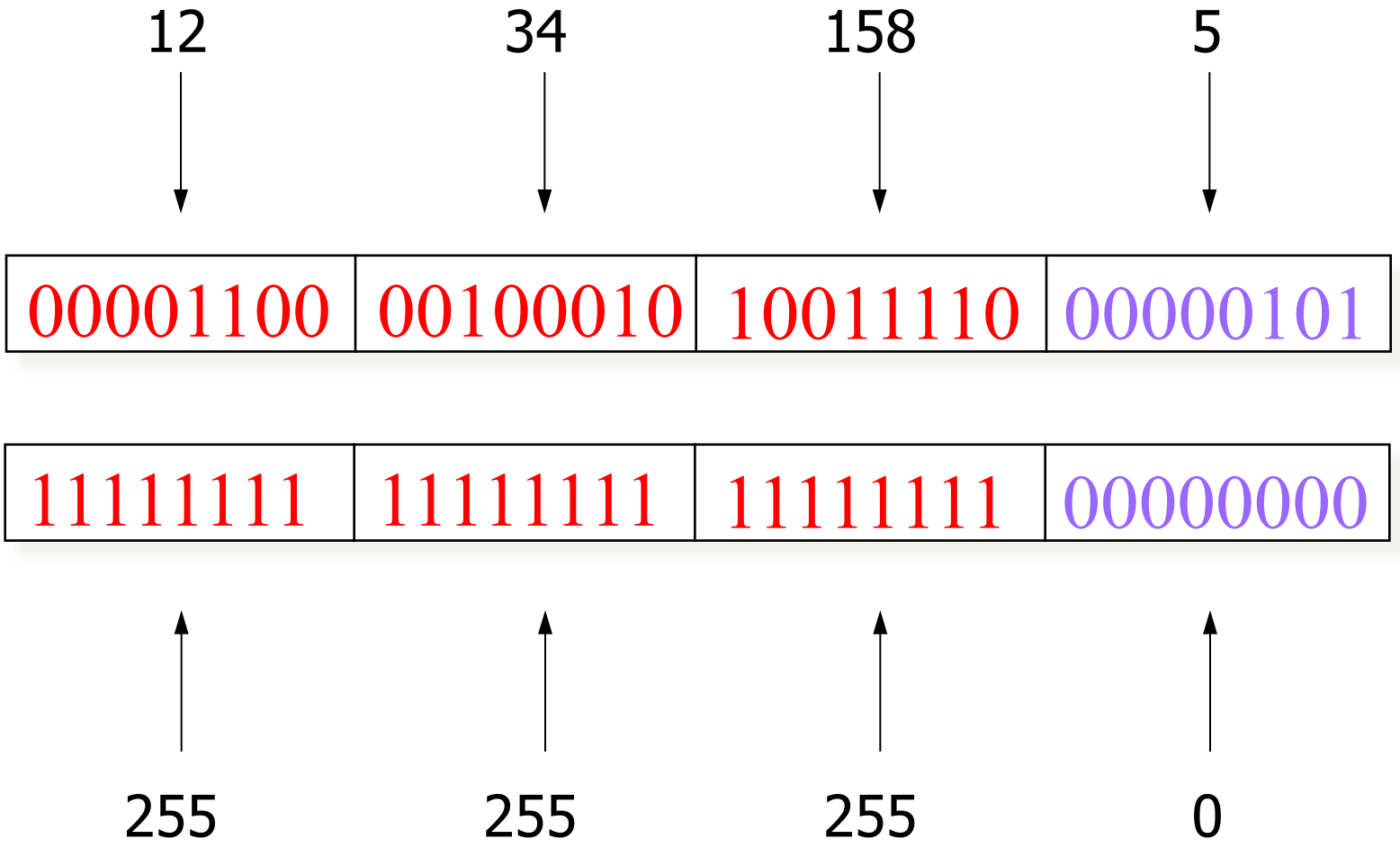
Hierarchical Addressing: IP Prefixes

- Divided into network & host portions (left and right)
- 12.34.158.0/24 is a 24-bit prefix with 2^8 addresses



A subnet mask

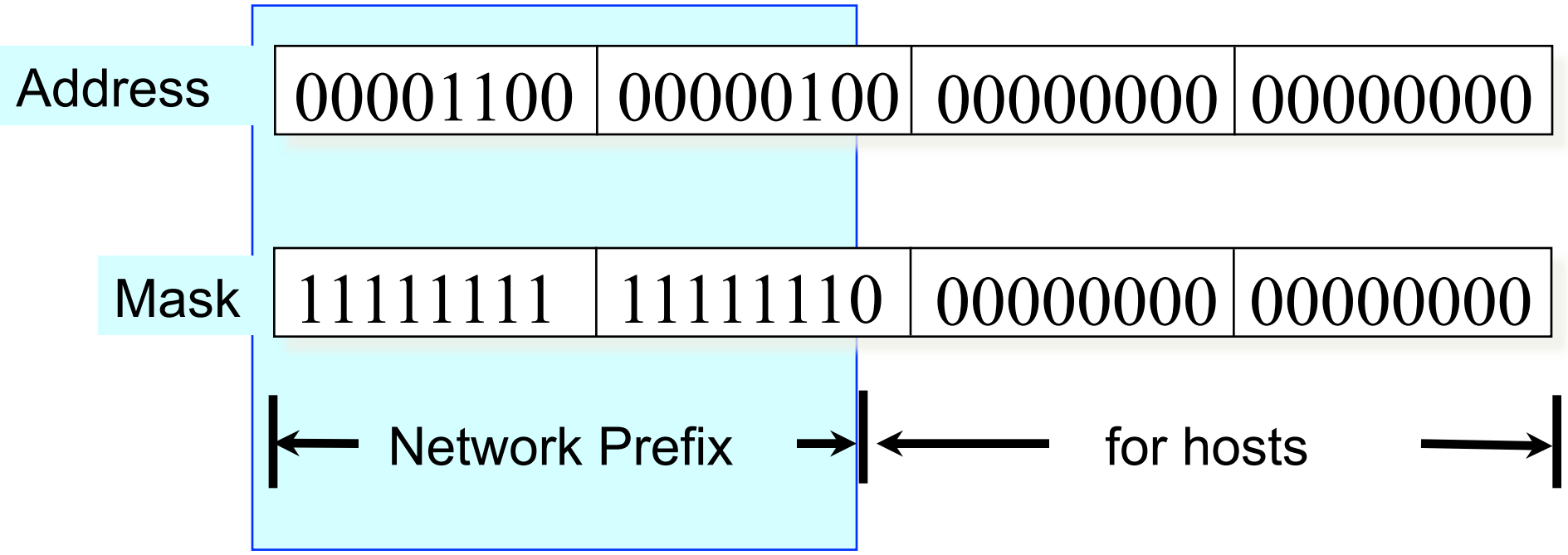
Take an IP address, & it with a subnet mask, gives the network part



Classless Inter-Domain Routing (CIDR)

Use two 32-bit numbers to represent a network.
Network number = IP address + Mask

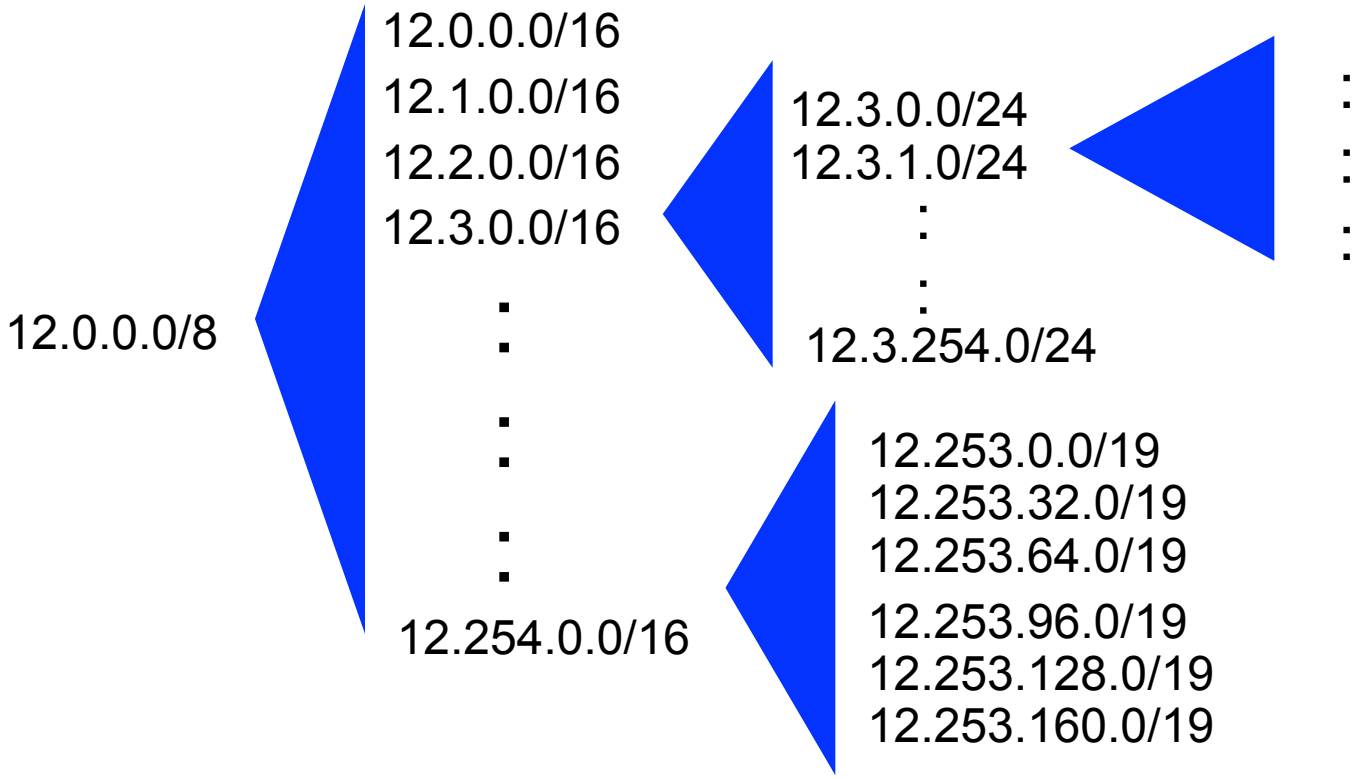
IP Address : 12.4.0.0 IP Mask: 255.254.0.0



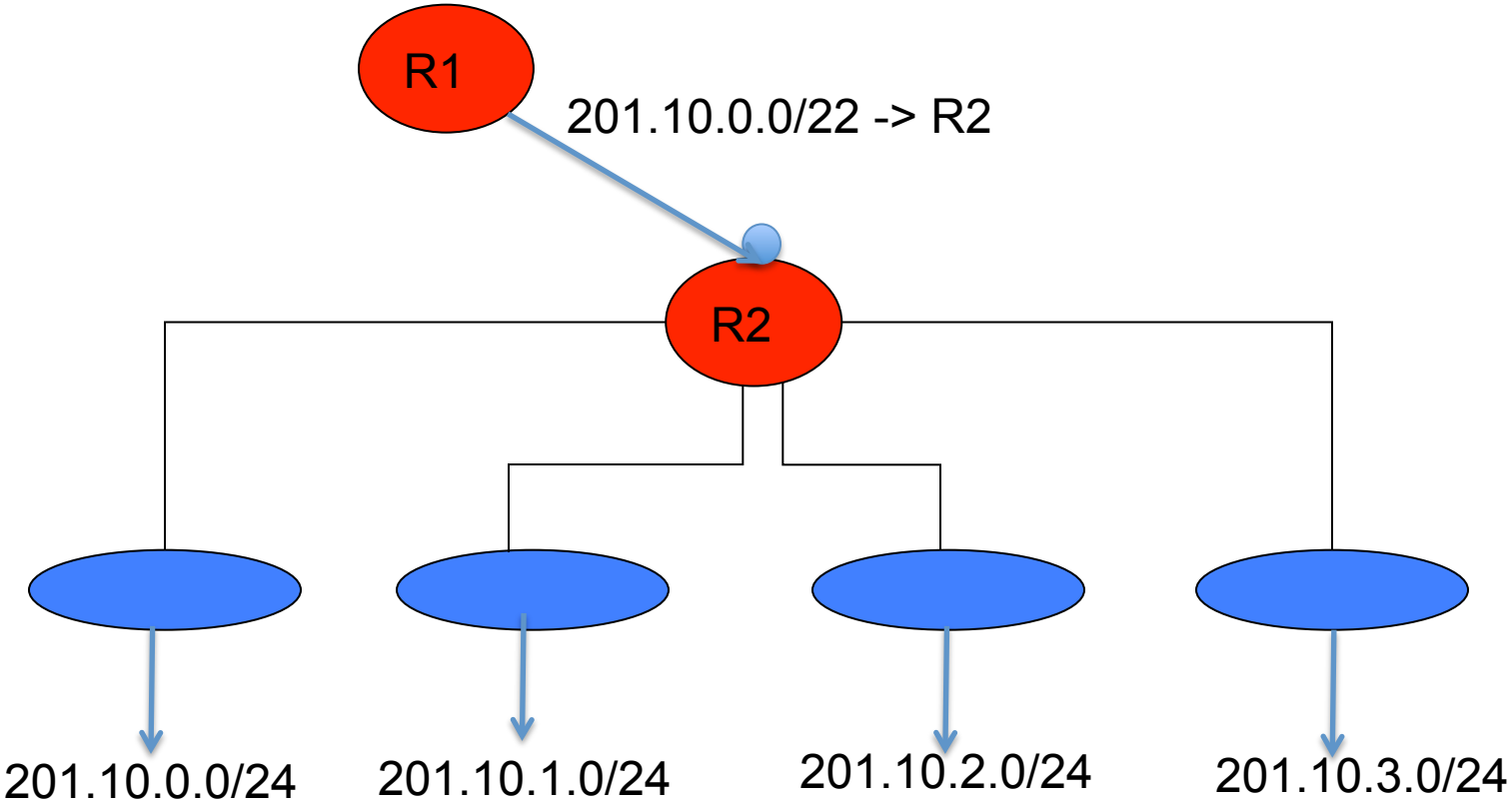
Written as 12.4.0.0/15

CIDR: Hierarchal Address Allocation

- Prefixes are key to Internet scalability
  - Address allocated in contiguous chunks (prefixes)
  - Routing protocols and packet forwarding based on prefixes
  - Today, routing tables contain ~150,000-200,000 prefixes

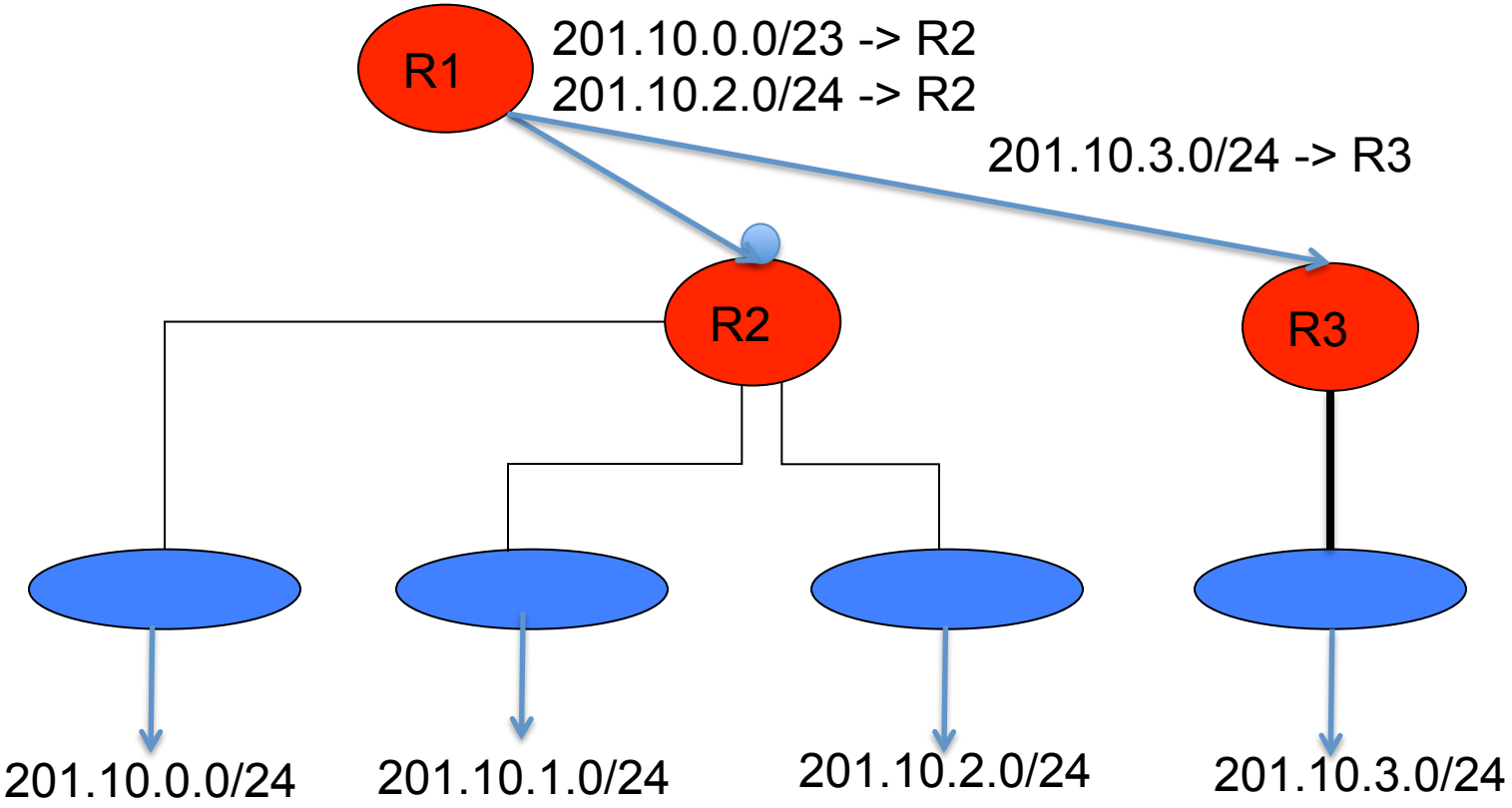


Scalability: Address Aggregation



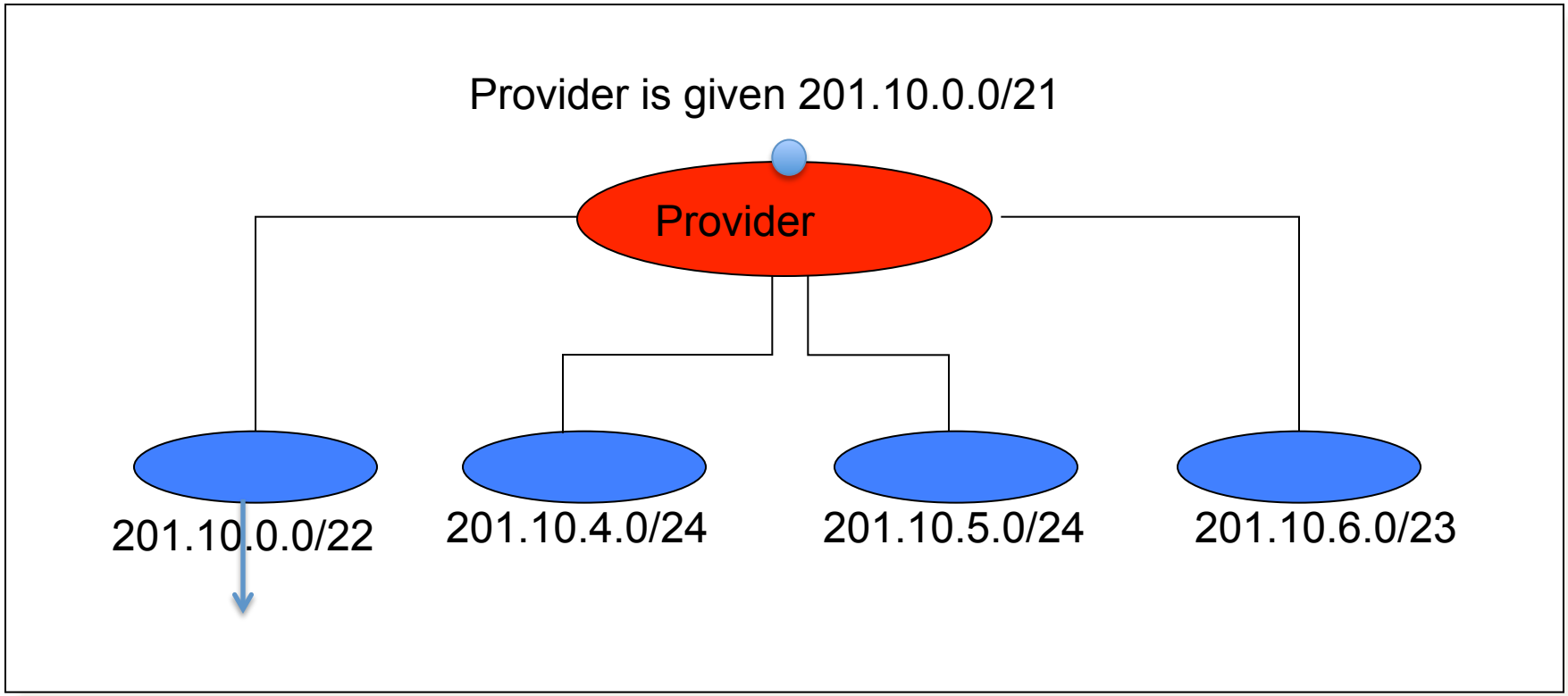
R1 just needs to have a single rule which says 201.10.0.0/23 -> R2.

But aggregation not always possible



R1 just needs to have a single rule which says 201.10.0.0/23 -> R2.

Scalability: Address Aggregation



Routers in the rest of the Internet just need to know how to reach 201.10.0.0/21. The provider can direct the IP packets to the appropriate customer.

Longest Prefix Match Forwarding

- Try some forwarding actions