Computer Communication Networks

Internet Addressing and Routing

Review

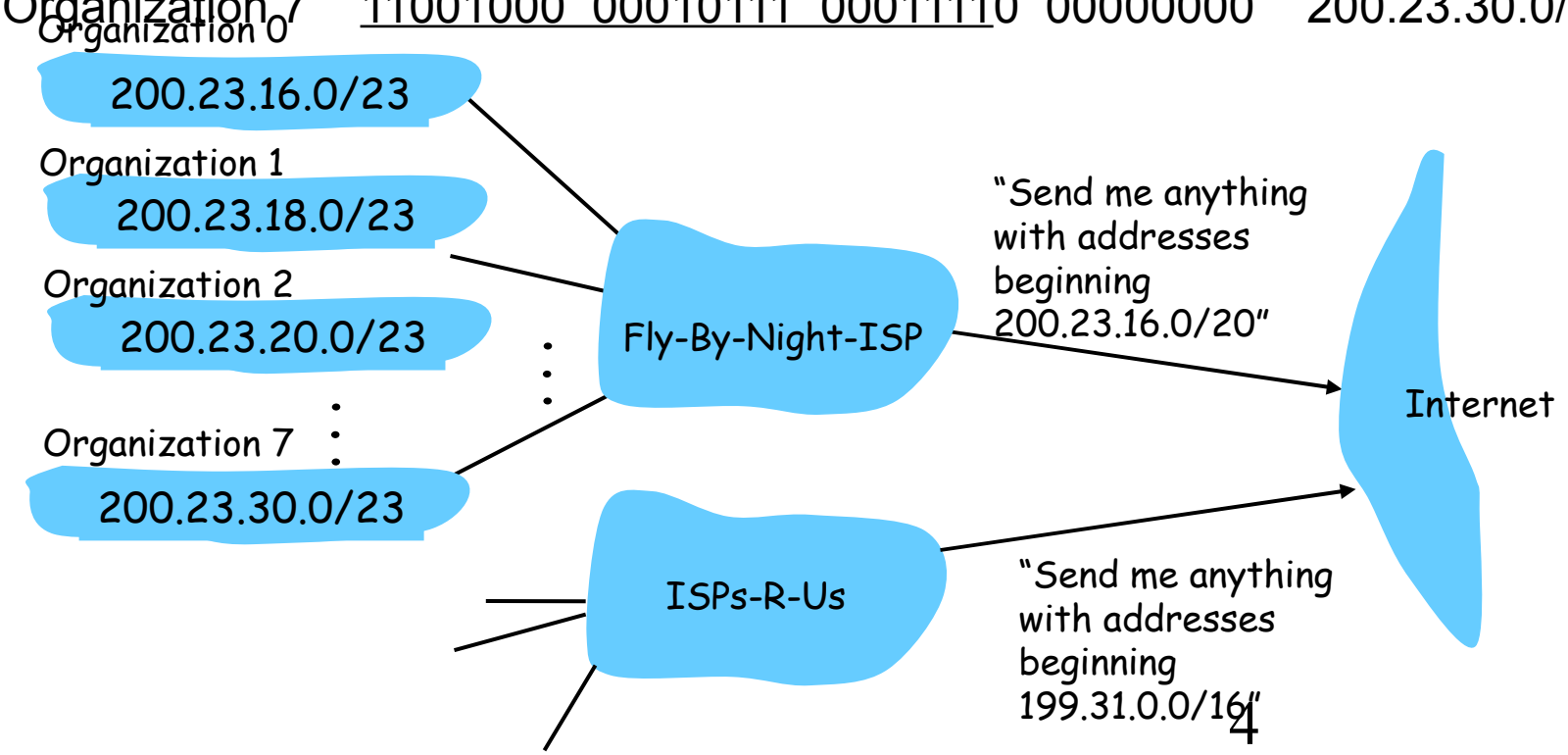
- IP
  - IP header
  - addressing
    - class, classless
  - routing
    - link state, distance vector
- What really happens on the Internet?!

Internet addressing

- Currently IPv4
  - IPv6 designed and implemented
    - 128-bit address space
  - 6Bone: experimental IPv6 networks over IPv4
- Address allocation
  - was class-based allocation
    - class A, B, and C
  - now hierarchical allocation with CIDR
    - classless

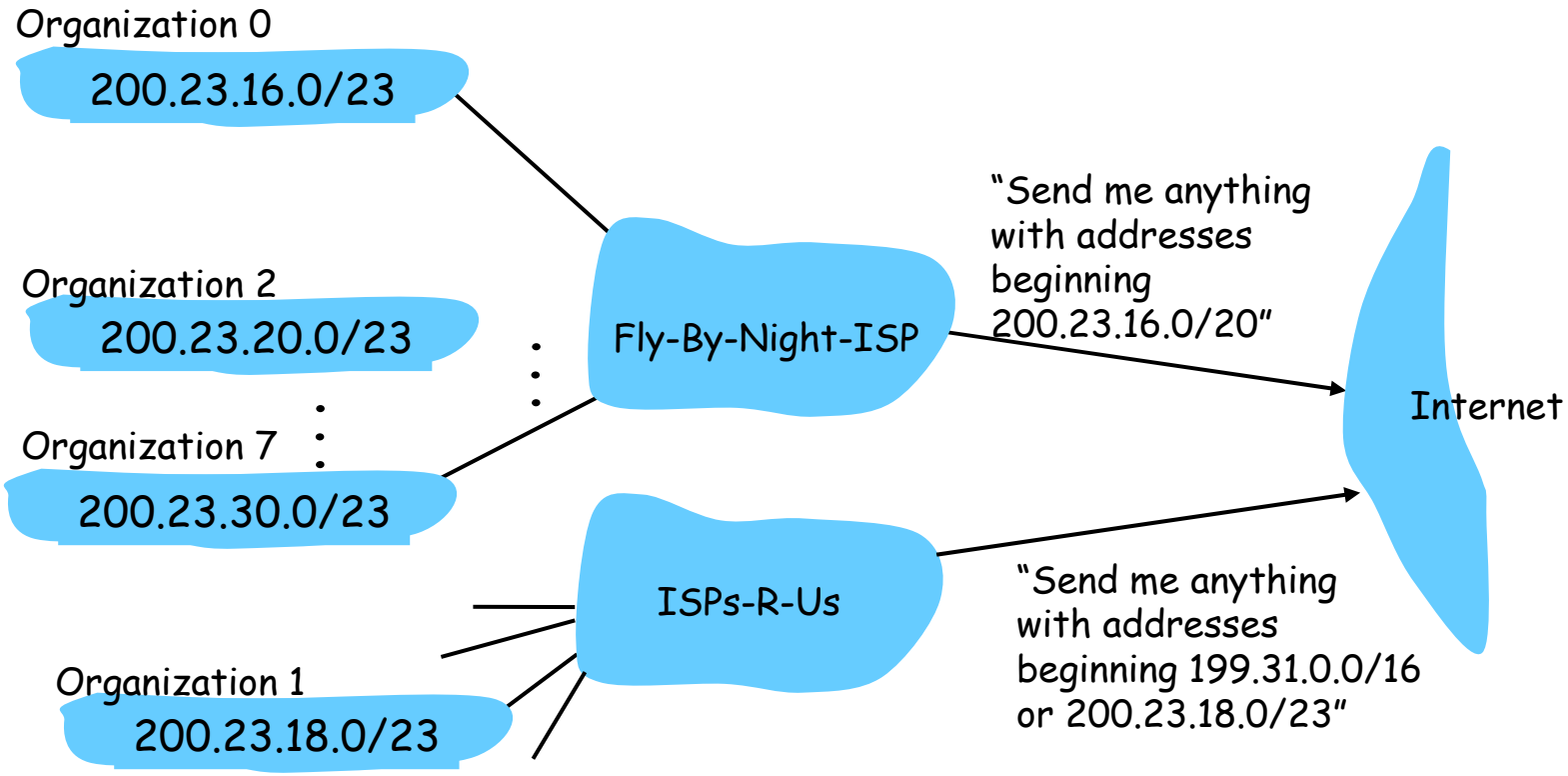
Hierarchical addressing

ISP's block	11001000 00010111 00010000	00000000	200.23.16.0/20
Organization 0	11001000 00010111 00010000	00000000	200.23.16.0/23
Organization 1	11001000 00010111 00010010	00000000	200.23.18.0/23
...	.....	....	....
Organization 7	11001000 00010111 00011110	00000000	200.23.30.0/23

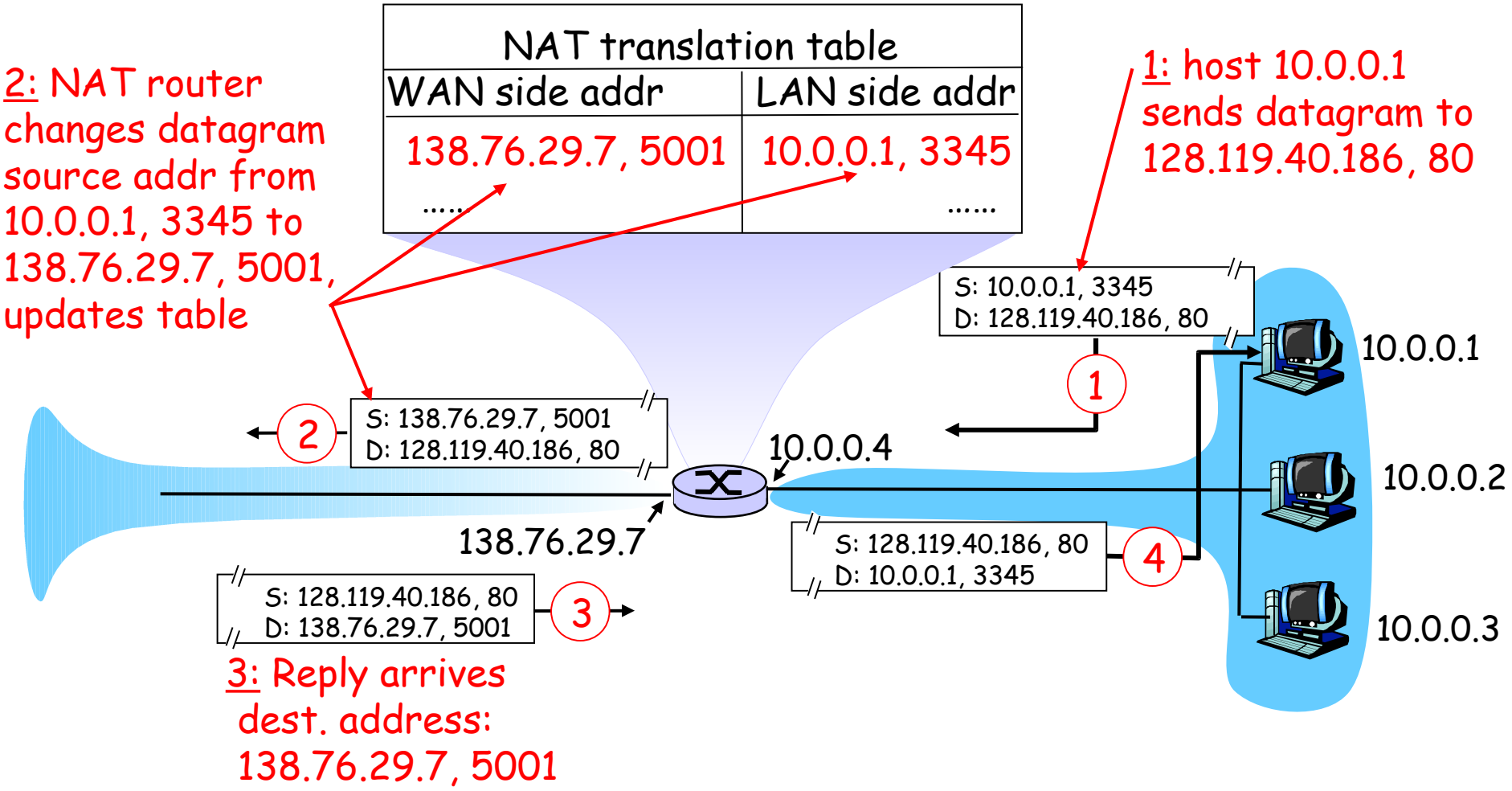


Hierarchical addressing: more

- Longest-prefix match



Network address translation



NAT: more

- NAT: mapping created by outgoing packets
  - (srcIP, srcPt, dstIP, dstPt) => (natIP, natPt, dstIP, dstPt)
- 16-bit port-number field:
  - 64,000 simultaneous connections with a single LAN-side address!
- NAT is controversial:
  - routers should only process up to layer 3
  - violates layered architecture
    - NAT possibility must be taken into account by app designers, eg, P2P applications
  - address shortage should instead be solved by IPv6

Internet routing protocols

- Intra-AS routing protocols
  - Routing information protocol (RIP)
  - Open shortest path first protocol (OSPF)
  - …
- Inter-AS routing protocols
  - Border gateway protocol (BGP)

Routing information protocol (RIP)

- RIP: using distance vector routing algorithm
  - included in BSD Unix in 1982; max hops: 15
- Distance vector
  - exchanged between neighbors every 30s
    - up to 25 destinations within an RIP packet (UDP 520)
  - if no advertisement for 180s: neighbor is dead
    - invalidate routes going through the neighbor
    - poisoned reverse to speed up “bad news”
      - infinite: 16 hops

Open shortest path first (OSPF)

- OSPF: using link state routing algorithm
  - link state dissemination
    - flooding, directly over IP
  - topology map at each node
  - Dijkstra's algorithm at each node
- Hierarchical OSPF
  - intra-domain areas: backbone and areas
    - flooding in an area
    - area border routers

OSPF “advanced” features (not in RIP)

- Security: all OSPF messages authenticated
- Multiple same-cost paths allowed (only one path in RIP)
- For each link, multiple cost metrics for different TOS (e.g., satellite link cost set “low” for best effort; high for real time)
- Integrated uni- and multicast support:
  - Multicast OSPF (MOSPF) uses same topology data base as OSPF
- Hierarchical OSPF in large domains.

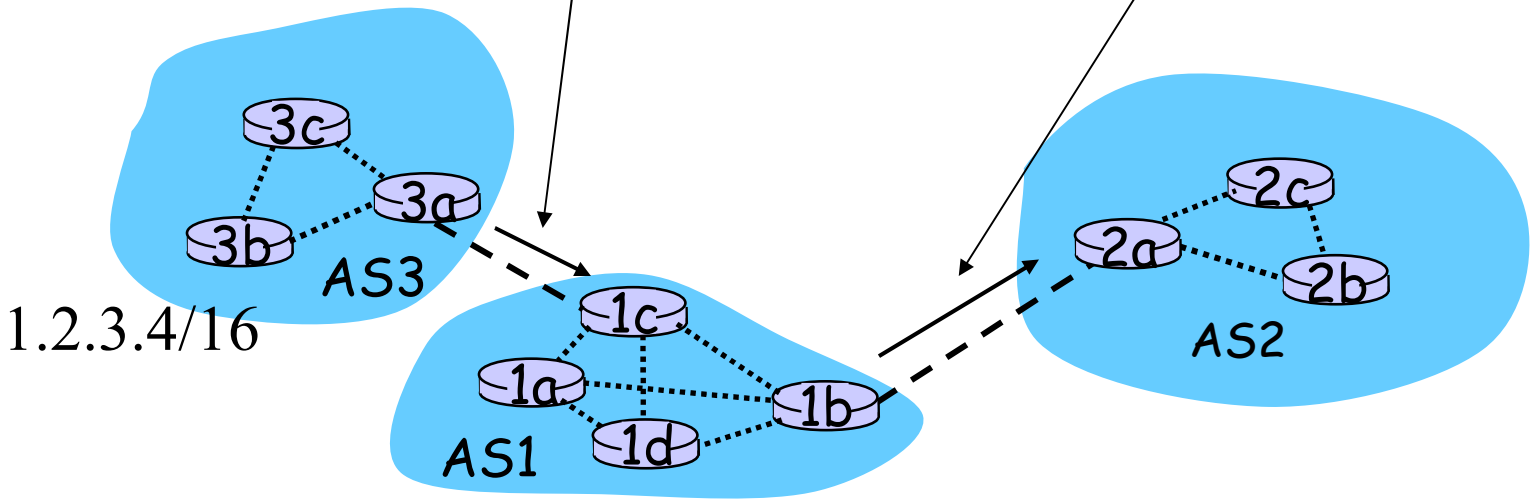
Border gateway protocol (BGP)

- BGPv4: based on distance vector
  - the de facto inter-domain routing standard
  - heavily policy-influenced, over TCP
- Reachability information
  - “you can reach X through me”
- AS path
  - “with a path of AS numbers”
  - AS: autonomous system (e.g., ISP domains)

BGP advertisement

- Prefix:
- AS Path:
- Next-hop:

1.2.3.4/16	1.2.3.4/16
AS3	AS3, AS1
3a	1b



BGP: more

- BGP routing
  - longest-prefix match
    - e.g., 1.2.3.4/16 vs 1.2.3.4/24
  - multiple AS path
    - e.g., shortest AS path
  - multiple next-hop router
    - e.g., nearest next-hop router; “hot potato”
- BGP security
  - prefix authenticity; AS path authenticity

Internet control message protocol

- used by hosts & routers to communicate network-level information
  - error reporting: unreachable host, network, port, etc.
  - echo request/reply (used by ping)
- network-layer "above" IP: ICMP msgs carried in IP datagrams

Type	Code	description
0	0	echo reply (ping)
3	0	dest. network unreachable
3	1	dest host unreachable
3	2	dest protocol unreachable
3	3	dest port unreachable
3	6	dest network unknown
3	7	dest host unknown
4	0	source quench (congestion control - not used)
8	0	echo request (ping)
9	0	route advertisement
10	0	router discovery
11	0	TTL expired
12	0	bad IP header

Using ICMP

- Ping
  - ICMP echo request
  - ICMP echo reply
- Traceroute
  - UDP with small, increasing TTL
    - ICMP TTL expires (type 11, code 0)
  - UDP with unusual port number
    - ICMP destination port unreachable (type 3, code 3)
    - Stop probing after receiving this ICMP

Summary

- Internet addressing and routing
  - addressing: hierarchical, NAT
  - routing: RIP, OSPF, BGP
  - control: ICMP
- Explore further
  - NAT traversal
  - routing security