ELEC / COMP 177 – Fall 2013

Computer Networking → Dynamic Host Configuration (DHCP)

Some slides from Kurose and Ross, *Computer Networking*, 5th Edition

Upcoming Schedule

- **Project 2 – Python HTTP Server++**
  - Work day: Next Tuesday (Oct 8th)
  - **Due Thursday, October 10th by 11:55pm**
  - **Questions?**

Upcoming Schedule

- **Midterm Exam**
  - Tuesday, October 15th
  - Bring laptop / USB key
- Open notes, open computer, open internet
- 1 programming problem using Python
  - Something to do with HTTP…
  - If you have your web server from projects 1/2 handy, you can repurpose it quickly…

Dynamic Host Configuration Protocol (DHCP)

DHCP Overview

- How does a host obtain its IP address?
  - DHCP – Dynamic Host Configuration Protocol
- DHCP is an application
  - But it is interested in IP address information
  - That is part of the network layer! (two layers down!)

Assignment of IP Addresses

- How does a host computer gets its IP address?
- Static assignment
  - Requires **user** involvement to set in OS
  - We configure hosts in the lab statically
    - It’s “educational!” (plus, to make each lab work, you have to be very careful about what IP addresses you use)
  - Datacenters might configure servers statically since they rarely change addresses
- Dynamic assignment
  - Requires no user involvement
  - Represents the bulk of hosts on the Internet

Dynamic Host Configuration Protocol (DHCP)

- Goals of DHCP
  - Plug and play!
    (Can’t trust grandma to set her IP address, netmask, and default gateway correctly…)
  - Allow host to *dynamically* obtain its IP address from network server when it joins network
  - Allow host to renew its lease on in-use address
  - Allow reuse of addresses (if you disconnect your host, someone else can use that address)

DHCP

- DHCP packet nested inside UDP, IP, and Ethernet frame
- Four stages to DHCP
  1. Discover *(new host only)*
  2. Offer *(new host only)*
  3. Request
  4. Acknowledge

Step 1 – DHCP Discover

- "Discover DHCP servers on the network"
- (New host only) Host **broadcasts** "DHCP discover" message to entire subnet
    - **What is broadcast?**
    - Subnet = Anywhere on Ethernet you can reach without going through a router
    - DHCP server either located on same subnet, or router has been configured to intercept and forward DHCP messages
    - Router might **be** the DHCP server!

Step 2 – DHCP Offer

- "DHCP servers offer client an IP assignment"
- (New host only) DHCP server responds directly to client with "DHCP offer" message
- Message contains
  - IP address of DHCP server
  - A lease offer to the client
    - IP address
    - Subnet mask
    - Lease duration
- Might get several offers from different DHCP servers

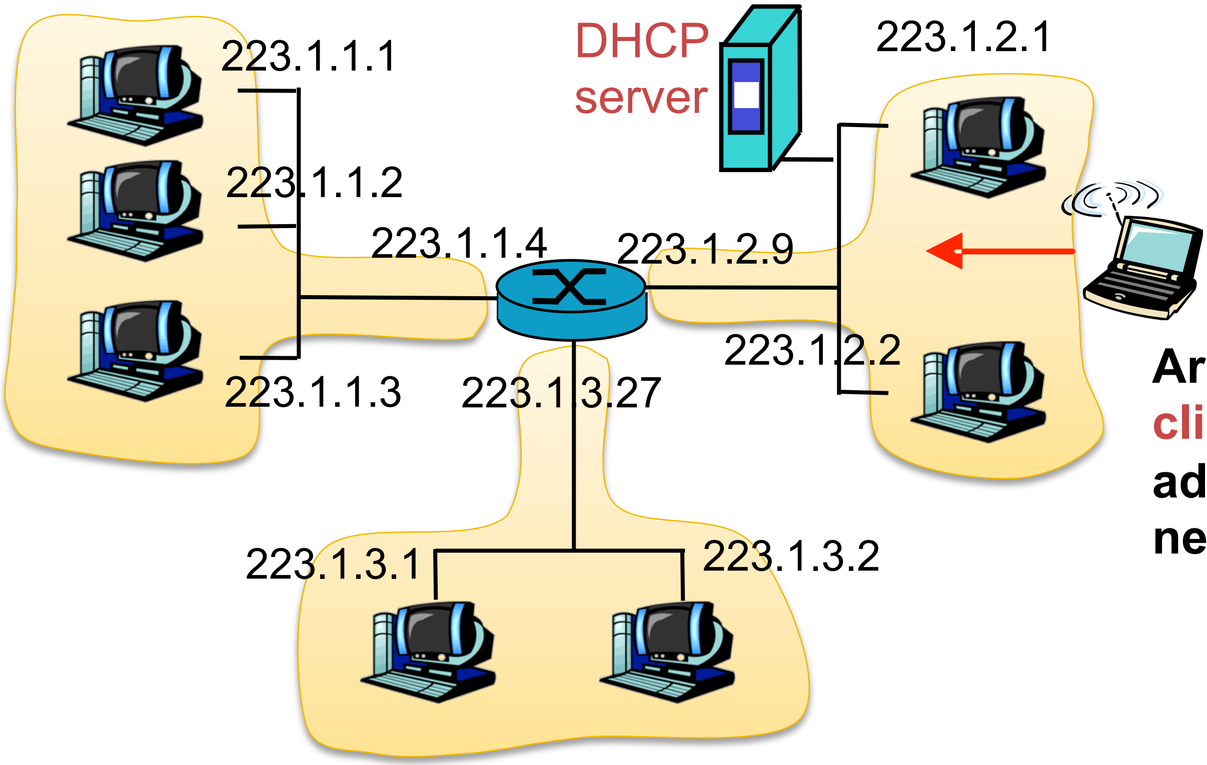
Step 3 – DHCP Request

- “Host requests the best offer”
- Host picks the DHCP offer it likes best
- Host requests IP address with a “DHCP request” message
  - Message is **broadcast across subnet**. **Why?**
    - May have received multiple offers from multiple servers
    - Servers are reserving an IP address for you
    - Need to let all servers know, even the ones you didn’t accept (so they can return the address to the pool)

Step 4 – DHCP Ack

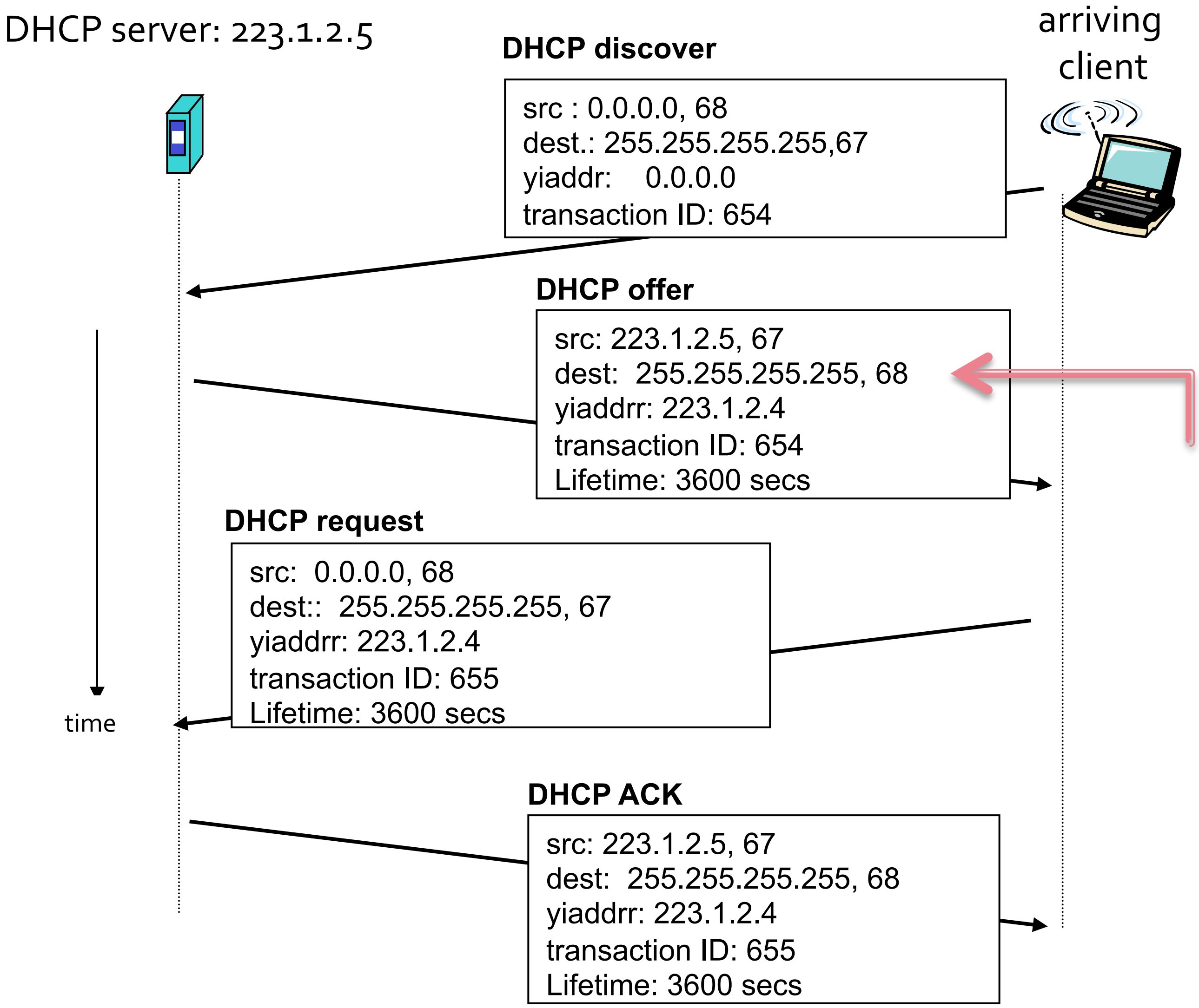
- "DHCP server confirms accepted offer, and sends other information."
- Only the server whose lease the client requested sends back a "DHCP Ack" message
- Re-confirms the lease information

DHCP Client-Server Scenario



Arriving DHCP client needs address in this network

DHCP client-server scenario



DHCP discover

src : 0.0.0.0, 68
dest.: 255.255.255.255,67
yiaddr: 0.0.0.0
transaction ID: 654

DHCP offer

src: 223.1.2.5, 67
dest: 255.255.255.255, 68
yiaddrr: 223.1.2.4
transaction ID: 654
Lifetime: 3600 secs

DHCP request

src: 0.0.0.0, 68
dest:: 255.255.255.255, 67
yiaddrr: 223.1.2.4
transaction ID: 655
Lifetime: 3600 secs

DHCP ACK

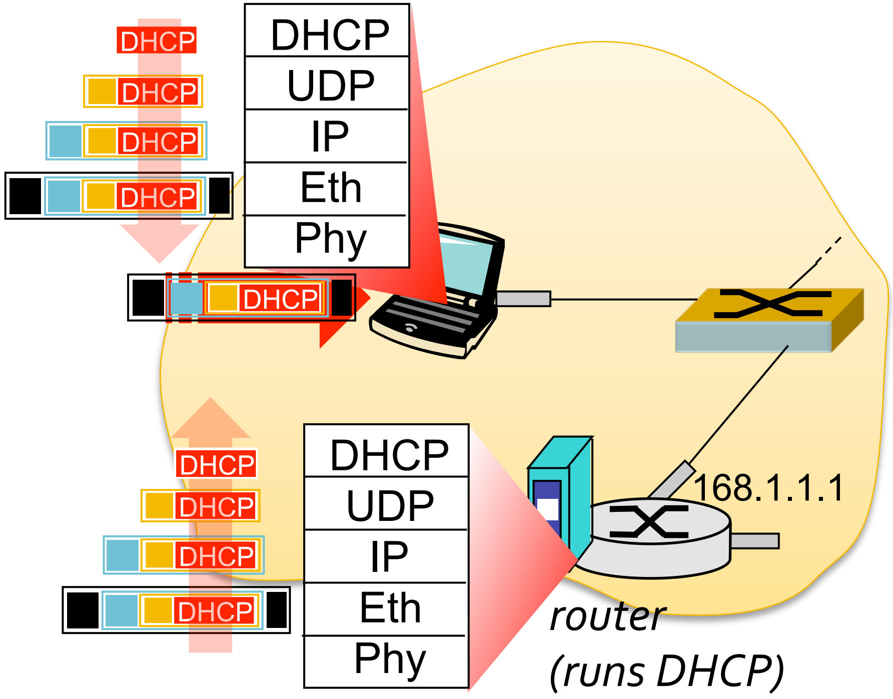
src: 223.1.2.5, 67
dest: 255.255.255.255, 68
yiaddrr: 223.1.2.4
transaction ID: 655
Lifetime: 3600 secs

Why is this broadcast?

DHCP – More Than Just IP Address

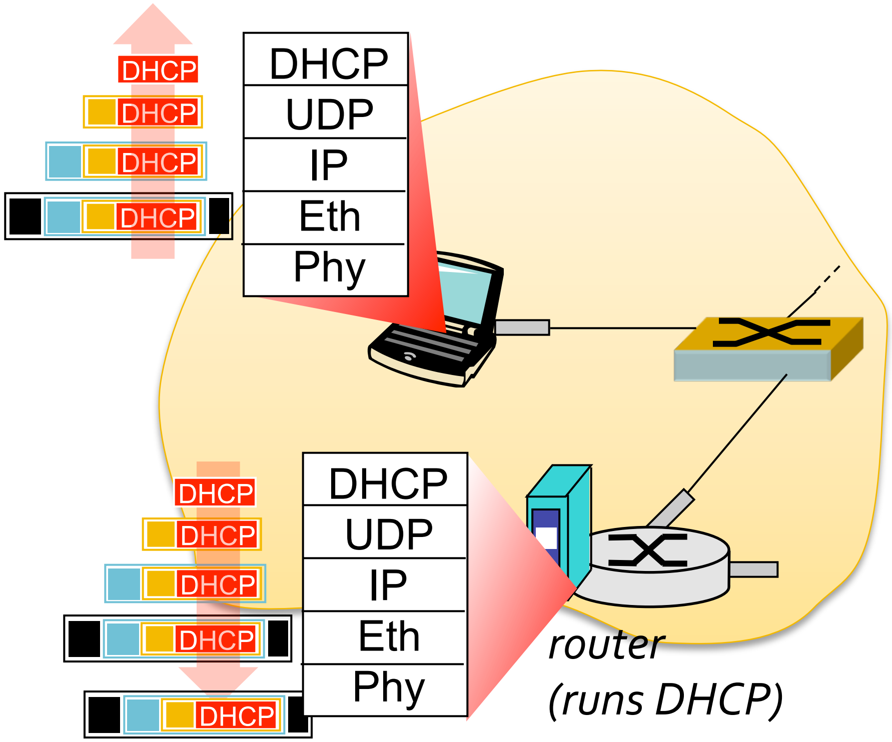
- DHCP can return more than just allocated IP address on subnet
  - Address of gateway router for client
  - Name and IP address of DNS sever(s)
  - Network mask (indicating network versus host portion of address)
  - NTP server (network time)
  - LDAP server (address book)
  - SIP server (Voice-over-IP server)
  - … and many many more possibilities!

DHCP: example



- Connecting laptop needs its IP address, addr of first-hop router, addr of DNS server
  - Use DHCP!
- DHCP request encapsulated in UDP, encapsulated in IP, encapsulated in Ethernet
- Ethernet frame broadcast (dest: FFFFFFFFFFFF) on LAN, received at router running DHCP server
- Ethernet unpacked (to IP, then UDP, then DHCP)

DHCP: example



- DCP server formulates DHCP ACK containing client's IP address, IP address of first-hop router for client, name & IP address of DNS server
- Encapsulation of DHCP ACK at server, frame forwarded to client, demux'ing up to DHCP at client
- Client now knows its IP address, name and IP address of DNS server, IP address of its first-hop router

DHCP Wireshark Output @ Pacific
(Shortened, and I already had an old IP)

DHCP REQUEST

```
Ethernet II, Src: 7c:6d:62:8c:c2:df, Dst: Broadcast
      (ff:ff:ff:ff:ff:ff)
IP, Src: 0.0.0.0, Dst: 255.255.255.255
UDP, Src Port: bootpc (68), Dst Port: bootps (67)
Bootstrap Protocol
  Message type: Boot Request (1)
  Hardware type: Ethernet
  Transaction ID: 0x73487c67
  Bootp flags: 0x0000 (Unicast)
  Client IP address: 0.0.0.0 (0.0.0.0)
  Your (client) IP address: 0.0.0.0 (0.0.0.0)
  Next server IP address: 0.0.0.0 (0.0.0.0)
  Relay agent IP address: 0.0.0.0 (0.0.0.0)
  Client MAC address: Apple_8c:c2:df (7c:6d:62:8c:c2:df)
  Magic cookie: DHCP
  Option: (t=53,l=1) DHCP Message Type = DHCP Request
  Option: (t=55,l=10) Parameter Request List
  Option: (t=57,l=2) Maximum DHCP Message Size = 1500
  Option: (t=61,l=7) Client identifier
  Option: (t=50,l=4) Requested IP Address = 10.10.207.20
  Option: (t=51,l=4) IP Address Lease Time = 90 days
  Option: (t=12,l=18) Host Name = "MacBookPro-Pacific"
```

DHCP ACK

```
Ethernet II, Src: Cisco_53:3f:fc (00:05:dc:53:3f:fc), Dst: 7c:6d:
      62:8c:c2:df
IP, Src: 10.10.207.254, Dst: 10.10.207.20
UDP, Src Port: bootps (67), Dst Port: bootpc (68)
Bootstrap Protocol
  Message type: Boot Reply (2)
  Hardware type: Ethernet
  Transaction ID: 0x73487c67
  Bootp flags: 0x0000 (Unicast)
  Client IP address: 0.0.0.0 (0.0.0.0)
  Your (client) IP address: 10.10.207.20 (10.10.207.20)
  Next server IP address: 0.0.0.0 (0.0.0.0)
  Relay agent IP address: 10.10.207.254 (10.10.207.254)
  Client MAC address: Apple_8c:c2:df (7c:6d:62:8c:c2:df)
  Magic cookie: DHCP
  Option: (t=53,l=1) DHCP Message Type = DHCP ACK
  Option: (t=54,l=4) DHCP Server Identifier = 10.10.4.226
  Option: (t=51,l=4) IP Address Lease Time = 1 day
  Option: (t=1,l=4) Subnet Mask = 255.255.254.0
  Option: (t=3,l=4) Router = 10.10.207.254
  Option: (t=6,l=8) DNS= 10.10.4.2.226, 10.10.4.227
  Option: (t=15,l=15) Domain Name = "eng.pacific.edu"
  Option: (t=44,l=8) NetBIOS over TCP/IP Name Server
  Option: (t=46,l=1) NetBIOS over TCP/IP Node Type = H-node
```

How to Allocate Addresses?

- DHCP server has a pool of addresses
  - How to we give them out to clients?
- Randomly?
  - First-come, first-serve
  - Host might get a different address each time
- Persistently?
  - Look at host MAC address, and try to give it the same address it had last time
- Statically?
  - Reserve an IP address only for a specific client with a specific MAC address

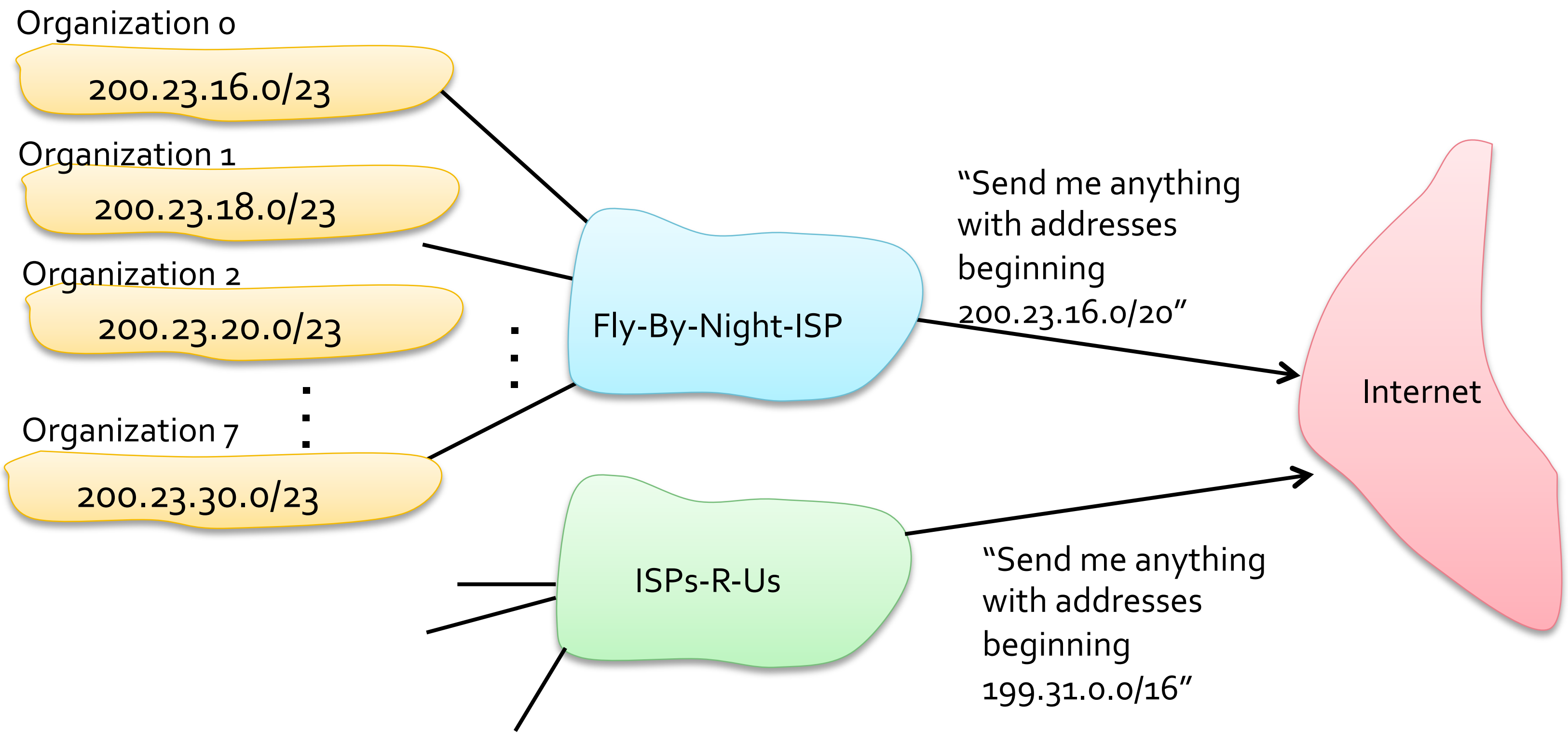
Source of IP Addresses

- How do the network DHCP servers know what pool of IP addresses to use?
  - One way: Your network is allocated portion of its provider ISP’s address space

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 2	11001000 00010111 00010100 00000000	(200.23.20.0/23)
...	....	....
Organization 7	11001000 00010111 00011110 00000000	(200.23.30.0/23)

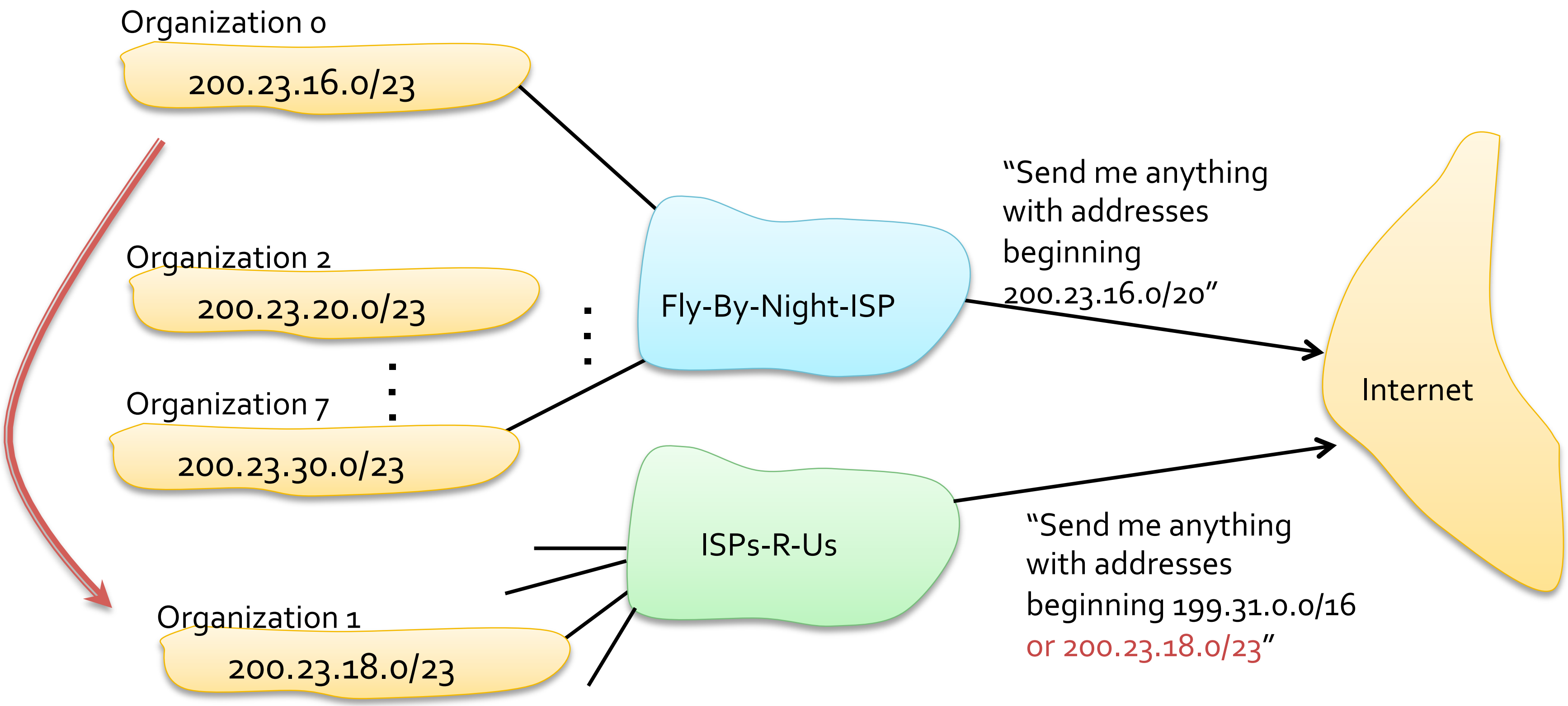
Hierarchical Addressing: Route Aggregation

Hierarchical addressing allows efficient advertisement of routing information:



Hierarchical Addressing: More Specific Routes

Let’s say Organization 1 switches ISPs. What happens?
ISPs-R-Us announces a more specific route to Organization 1



How Does an ISP Get IP Addresses?

- ICANN: **I**nternet **C**orporation for **A**ssigned **N**ames and **N**umbers
  - Used to be the US Government!
  - Now a non-profit corporation
- Role of ICANN
  - Allocates addresses (actually gives large blocks of IPs to regional registries)
  - Manages DNS (actually delegates this job too)
  - Assigns domain names, resolves disputes