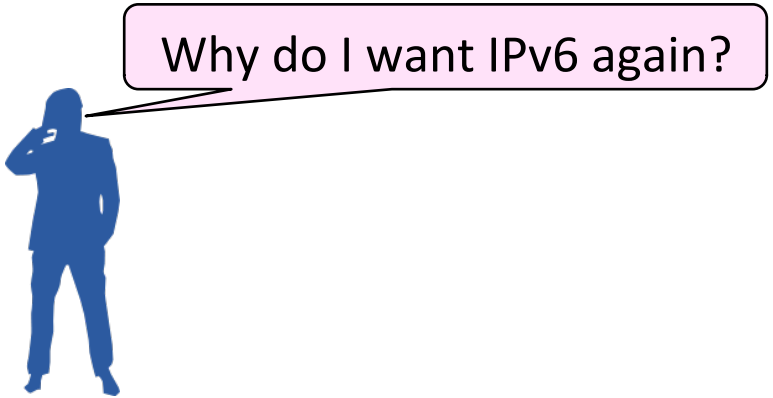
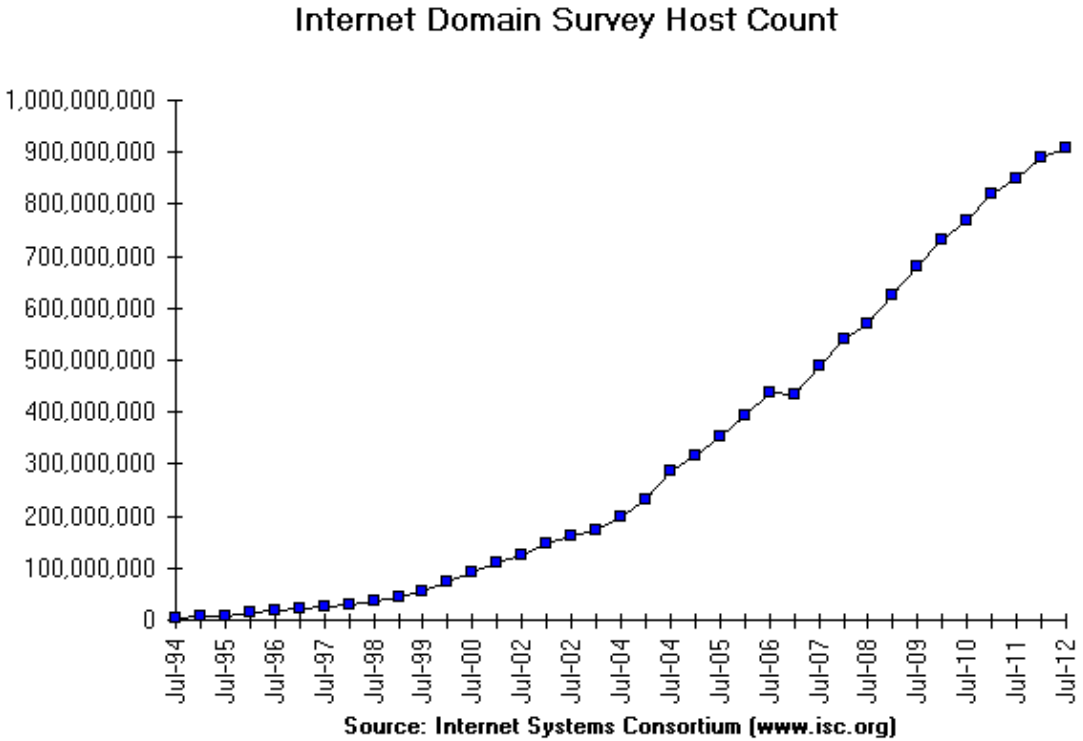
Topic

- IP version 6, the future of IPv4 that is now (still) being deployed



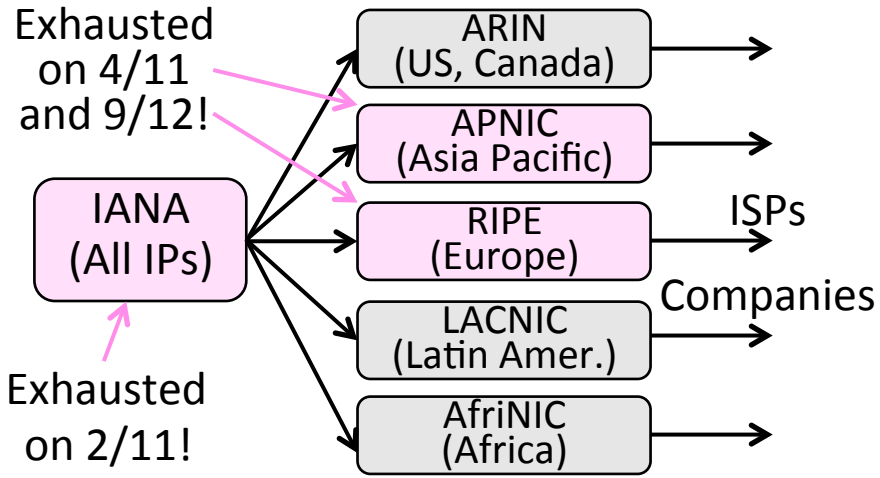
Internet Growth

- At least a billion Internet hosts and growing …
- And we're using 32-bit addresses!



The End of New IPv4 Addresses

- Now running on leftover blocks held by the regional registries; much tighter allocation policies

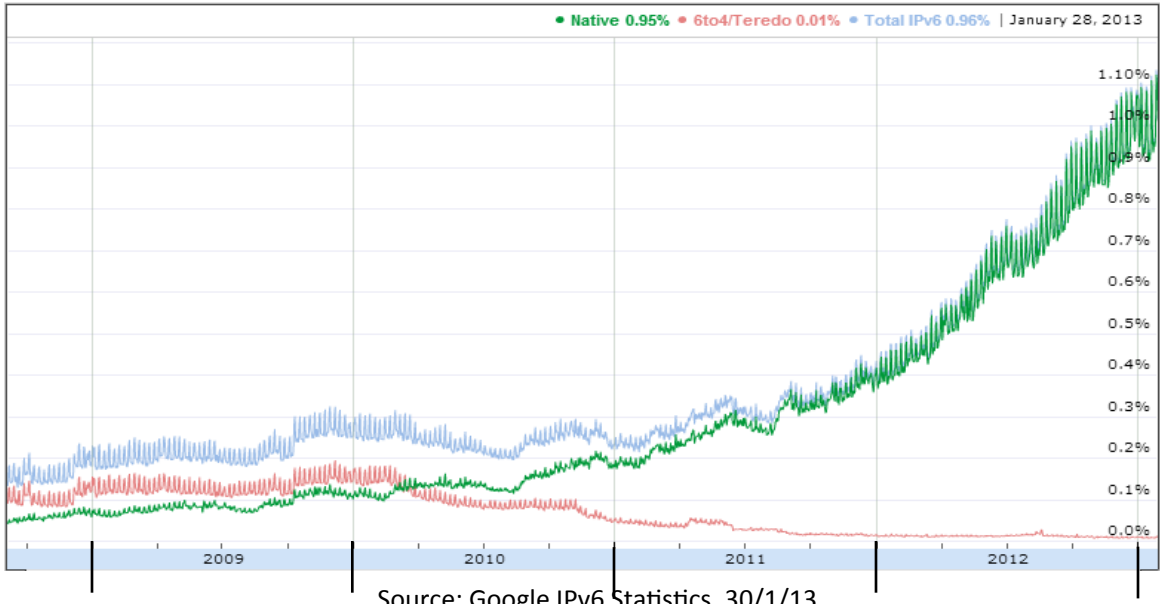


IP Version 6 to the Rescue

- Effort started by the IETF in 1994
  - Much larger addresses (128 bits)
  - Many sundry improvements
- Became an IETF standard in 1998
  - Nothing much happened for a decade
  - Hampered by deployment issues, and a lack of adoption incentives
  - Big push ~2011 as exhaustion looms

IPv6 Deployment

Percentage of users accessing Google via IPv6

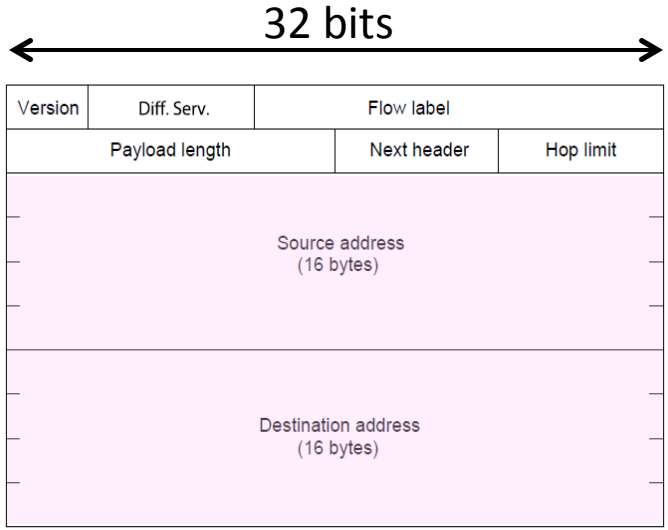


Source: Google IPv6 Statistics, 30/1/13

Time for growth!

IPv6

- Features large addresses
  - 128 bits, most of header
- New notation
  - 8 groups of 4 hex digits (16 bits)
  - Omit leading zeros, groups of zeros



Ex: 2001:0db8:0000:0000:0000:ff00:0042:8329

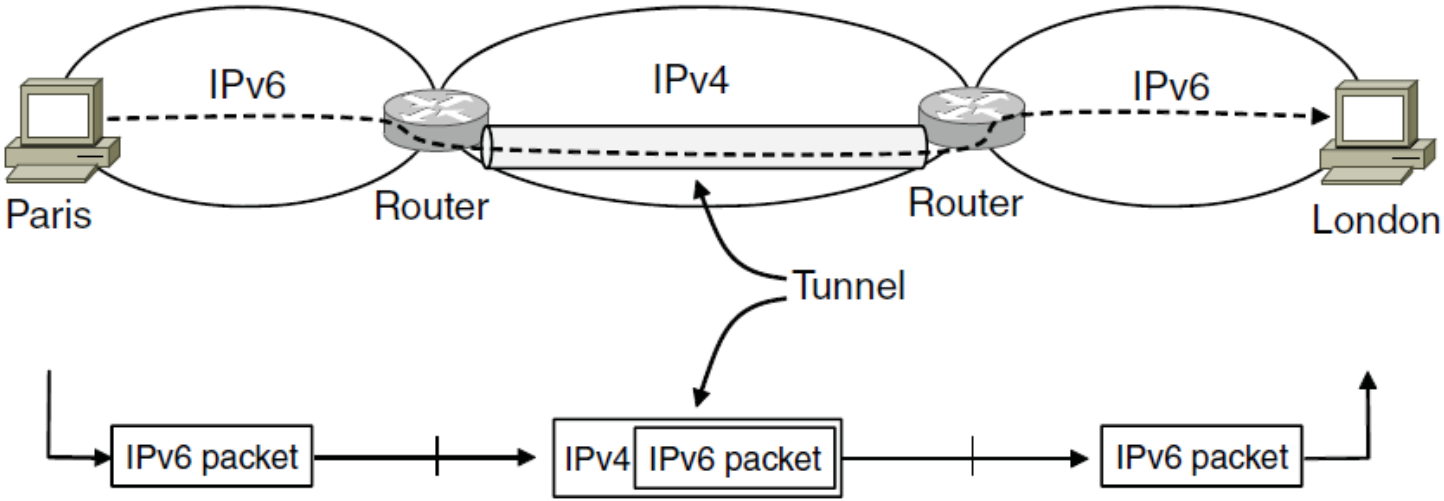
→

IPv6 Transition

- The Big Problem:
  - How to deploy IPv6?
  - Fundamentally incompatible with IPv4
- Dozens of approaches proposed
  - Dual stack (speak IPv4 and IPv6)
  - Translators (convert packets)
  - Tunnels (carry IPv6 over IPv4) »

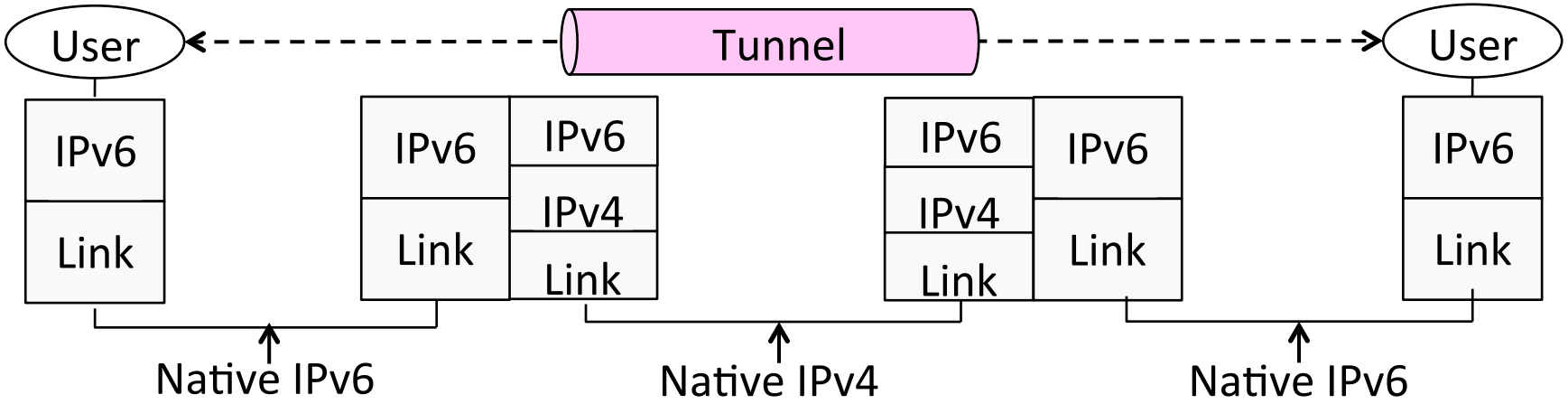
Tunneling

- Native IPv6 islands connected via IPv4
  - Tunnel carries IPv6 packets across IPv4 network



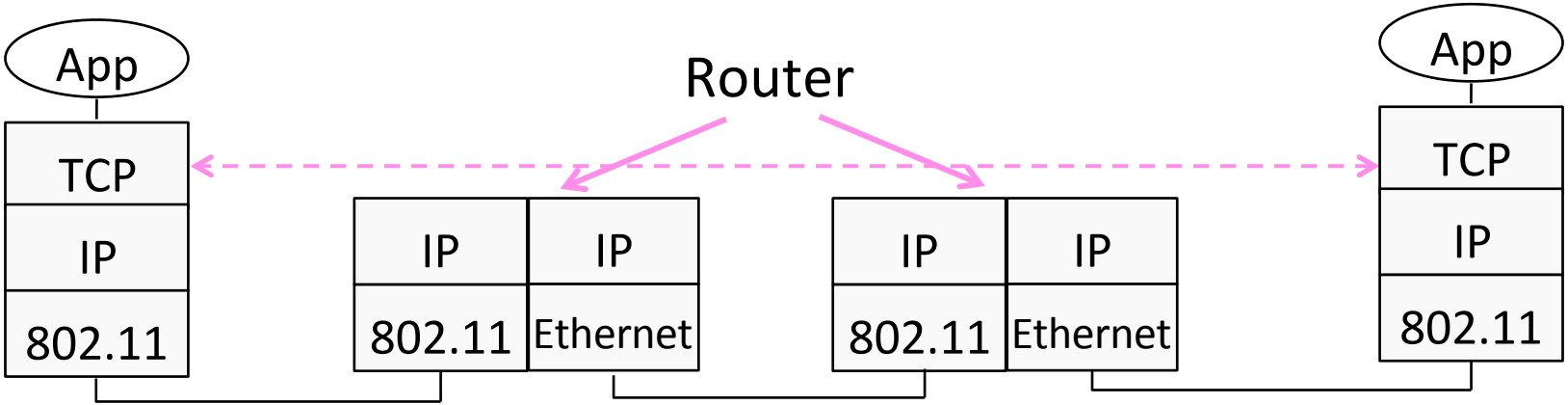
Tunneling (3)

- Tunnel acts as a single link across IPv4 network
  - Difficulty is to set up tunnel endpoints and routing



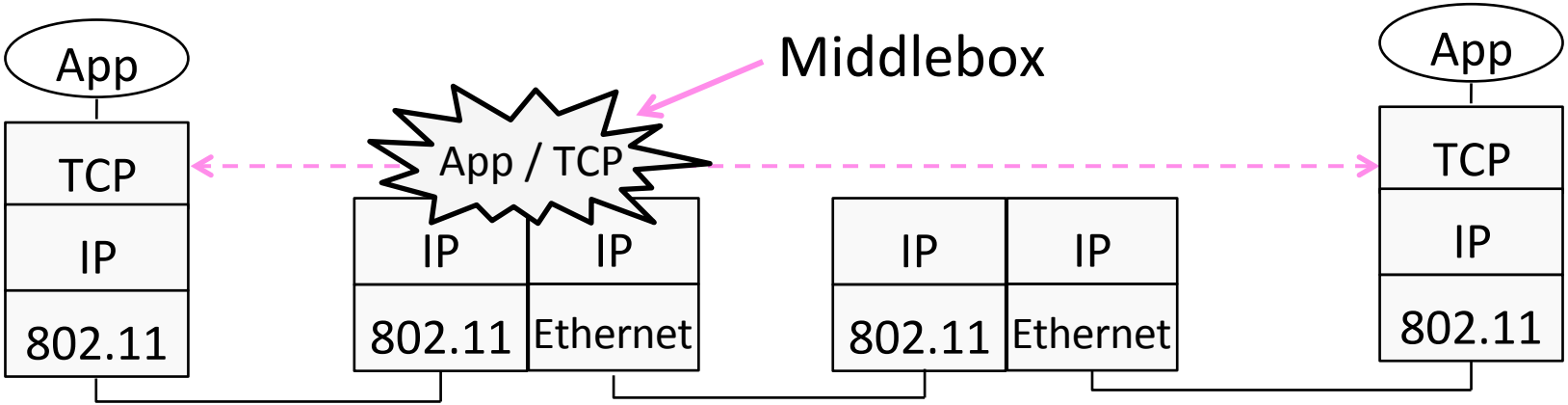
Layering Review

- Remember how layering is meant to work?
  - "Routers don't look beyond the IP header." Well …



Middleboxes

- Sit "inside the network" but perform "more than IP" processing on packets to add new functionality
  - NAT box, Firewall / Intrusion Detection System



Middleboxes (2)

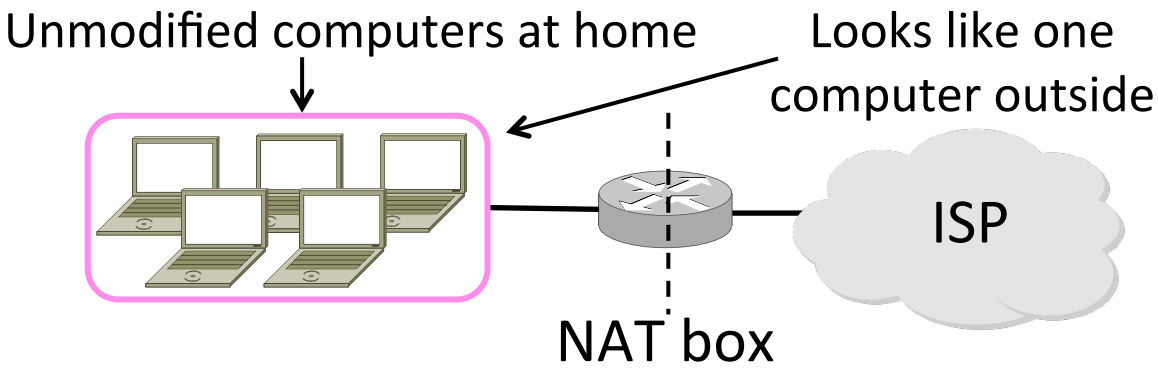
- Advantages
  - A possible rapid deployment path when there is no other option
  - Control over many hosts (IT)
- Disadvantages
  - Breaking layering interferes with connectivity; strange side effects
  - Poor vantage point for many tasks

NAT (Network Address Translation) Box

- NAT box connects an internal network to an external network
  - Many internal hosts are connected using few external addresses
  - Middlebox that “translates addresses”
- Motivated by IP address scarcity
  - Controversial at first, now accepted

NAT (2)

- Common scenario:
  - Home computers use “private” IP addresses
  - NAT (in AP/firewall) connects home to ISP using a single external IP address



How NAT Works

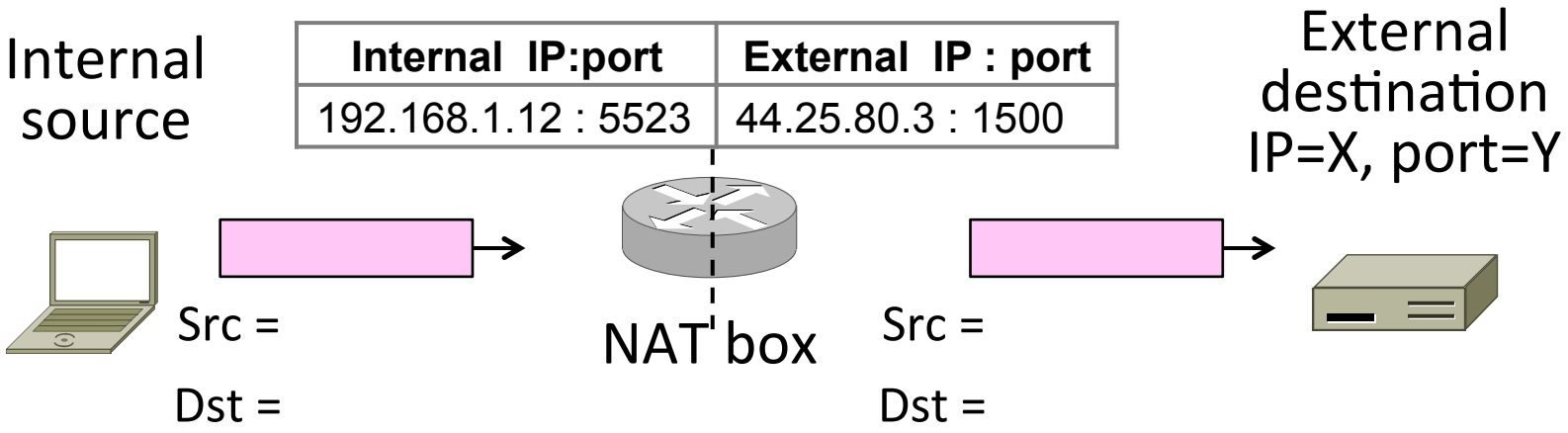
- Keeps an internal/external table
  - Typically uses IP address + TCP port
  - This is address and port translation

What host thinks	What ISP thinks
Internal IP:port	**External IP : port**
192.168.1.12 : 5523	44.25.80.3 : 1500
192.168.1.13 : 1234	44.25.80.3 : 1501
192.168.2.20 : 1234	44.25.80.3 : 1502

- Need ports to make mapping 1-1 since there are fewer external IPs

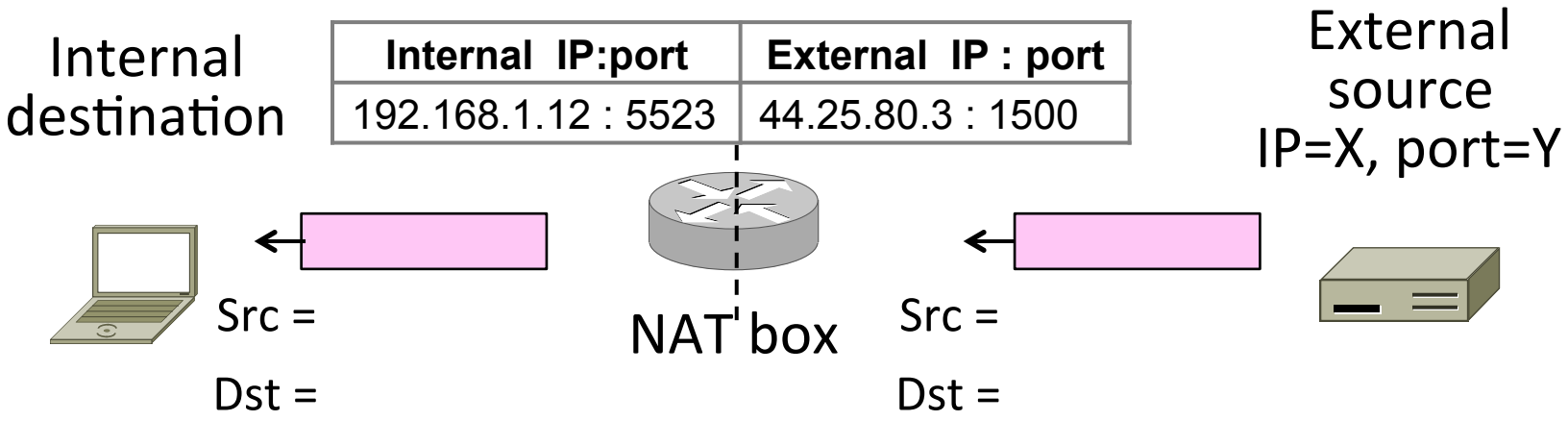
How NAT Works (2)

- Internal → External:
  - Look up and rewrite Source IP/port



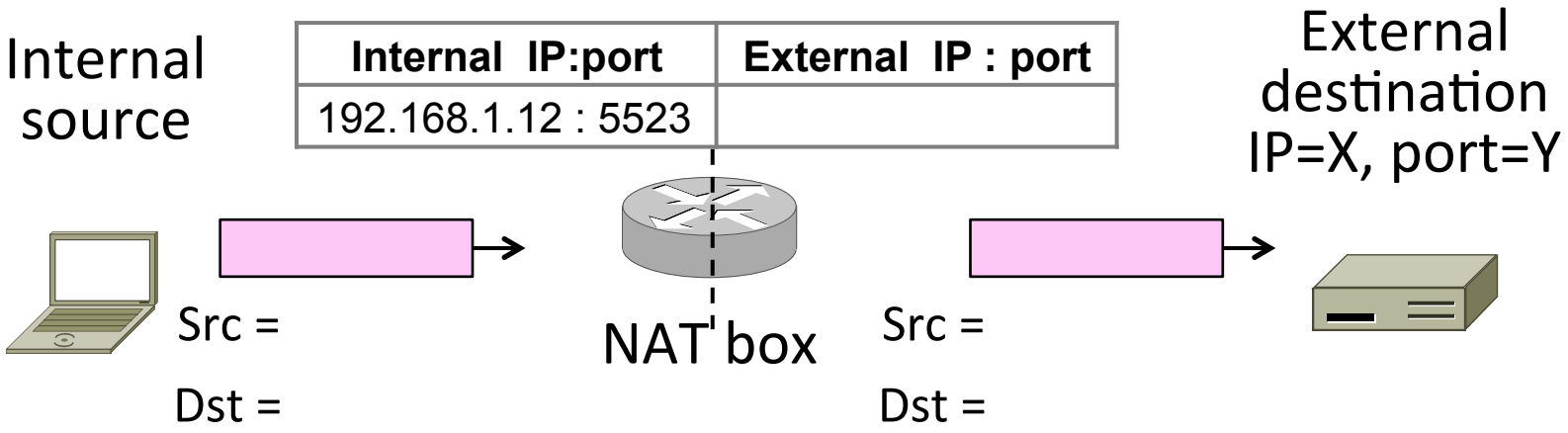
How NAT Works (3)

- External → Internal
  - Look up and rewrite Destination IP/port



How NAT Works (4)

- Need to enter translations in the table for it to work
  - Create external name when host makes a TCP connection



NAT Downsides

- Connectivity has been broken!
  - Can only send incoming packets after an outgoing connection is set up
  - Difficult to run servers or peer-to-peer apps (Skype) at home
- Doesn't work so well when there are no connections (UDP apps)
- Breaks apps that unwisely expose their IP addresses (FTP)

NAT Upsides

- Relieves much IP address pressure
  - Many home hosts behind NATs
- Easy to deploy
  - Rapidly, and by you alone
- Useful functionality
  - Firewall, helps with privacy

- Kinks will get worked out eventually
  - "NAT Traversal" for incoming traffic