Networking 3

Books

The Internet Book, by Douglas Comer..$32. A good, not-too-technical guide on how the Internet works.

Internet Core Protocols, by Eric Hall. O'Reilly, 2000. $40. A more detailed, low-level discussion of TCP/IP for the curious.

Recall

Ethernet
Babel of incompatible LANs
Solution:
1. Hardware: Router
2. Software: TCP/IP

TCP/IP Standard

Deal with heterogeneity -- everything different
Provide a single, standard language everyone can use
Very successful

TCP/IP has taken over the world. It's a standard, and its "network effect" has beaten out all the better-funded, proprietary/vendor-specific protocols. There's a lesson there.

1. Naming Standard: IP Address

IP Addr

IP address :4 bytes: 24.13.45.123 (4 billion total addresses)
Like a phone number
Every host and router on the Internet has its own IP address which uniquely identifies it for sending/receiving packets. (We will introduce NAT later which allows computers to share IP addrs.)

Subnet vs. Host

The left parts of the IP address identify the neighborhood (subnet), and the right numbers identify the host in that subnet . For example the machines in my office have IP addresses 171.64.64.171, and 171.64.64.250. The left three numbers are the same because the machine are in the same subnet. That subnet is known as 171.64.64.0. The hosts there have addresses in the range 171.64.64.1 to 171.64.64.255. In this case, the left 3 bytes are the subnet part of the address. However, networks can be set up with the subnet taking up more or less of the IP addr.

Note: move a host to a different subnet, it will need a different IP address (just like phone numbers if you move towns). This is

inconvenient for portable computers -- they need different IP addrs in different locations.

2. Packet Standard: IP Datagram

A standard format for a packet

Contains the IP addr of the source and dest, the data, and some other misc. routing information.

Classic standards problem: boring, but you really need all the computers to just agree on one.

3. Routing Standard: TCP

Problem

Suppose I send a packet to some IP addr (250.5.3.240) -- how does my local router know how to forward it on?

It is not the case that the router knows where every other computer in the world is.

Next Hop

Each router has a table of "next hops" -- where to forward a packet based on its subnet.

Typically, a router will know about a few subnets that are near it, and other traffic will be forwarded to a "superior" router that knows more and is more connected than the local router.

A routing table giving the next hop for various net numbers might 50,000 rows.

"Pass the buck" strategy

"Best Effort" Delivery

The routers will try to forward the packet to the destination, but it's not guaranteed.

No Global Picture

No router has a global, end-to-end picture of the route a datagram should take.

Decentralized - NOT a central super Yellow Pages for the whole world. There's a hierarchy of routers, each responsible for keeping track of routing and addresses in its local area.

Router Protocol

The routers are constantly talking to each other to collectively decide which routes are best. They can dynamically adjust things as congestion appears or if a link or router goes down.

It's a fascinating area, but 193i will focus on higher level services that use TCP/IP -- take CS244 for a more detailed view TCP/IP implementation.

TCP / IP in action

1. IP datagram
   - Sender formats the data as a standard IP datagram.
   - The datagram has the IP address of the sender and the ultimate recipient.
2. Send to router
   - Send the IP datagram to the closest router
   - Send the datagram **inside** whatever sort of packet the physical LAN uses. The sender and router are on the same LAN -- use whatever sort of packet that LAN provides
3. Route - hop hop hop
   - The router unpacks the datagram, looks at the IP address of the destination, and sends it on one further hop to a router one closer to the destination.
4. Final router
   - Eventually it gets to a router that is on the same physical LAN as the destination. That last router forwards it on its last hop to the recipient.

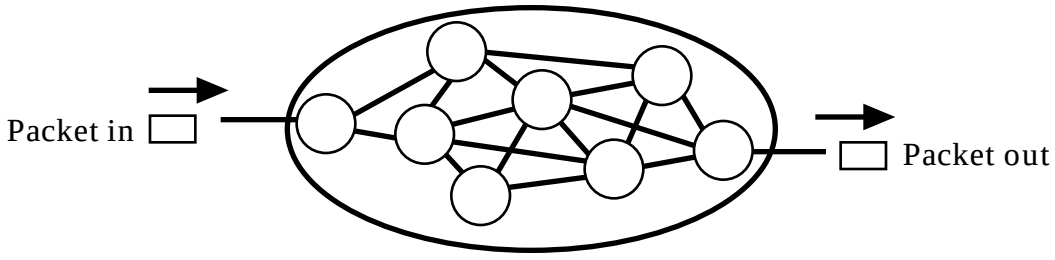
IP Key Points

IP Addresses
- Standard namespace for computers participating in TCP / IP

IP Datagram
- Standard packet format for TCP / IP communication
- Uses IP addresses for sender and recipient

IP "Best Effort Delivery"
- For the most part, IP is about hopping a single IP datagram to the destination -- more complex communication is built with TCP (below).

IP Datagram Routing -- Hops



Routing of the packet
-- router by router --
hop by hop

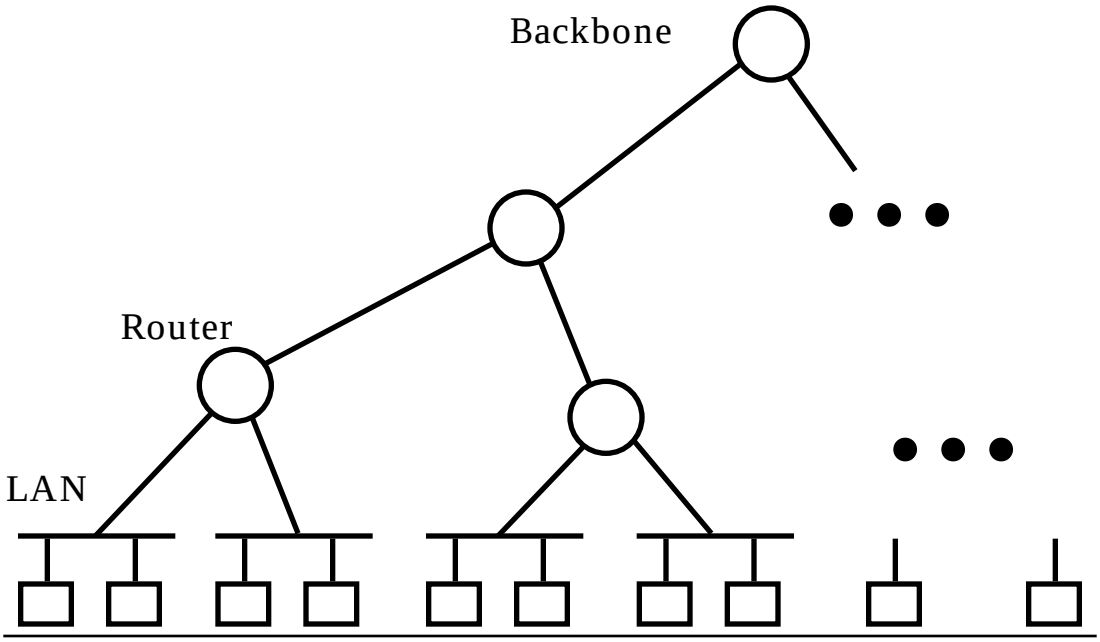
IP Routing Hierarchy

Local vs. Backbone

There are two vague directions -- "downstream" or "local" towards networks smaller than the ones connected to the router, and "upstream" or "backbone" towards larger networks

Up Then Down

In this model, traffic hops upstream until it is high enough that it can get to its destination by hopping down.



Not Really That Simple

The Internet does not look like the tidy hierarchy above. It was grown ad-hoc, and is much more connected, redundant, and ambiguous -- but there are approximate upstream and downstream directions from any point.